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Compression Index for cohesive soils from Quasi-static Cone Tests

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APPROVAL

The undersigned approve that they have read and hereby recommend for submission to the Graduate School of Kyambogo University, a dissertation entitled: Compression Index from Quasi-Static Cone Tests in fulfillment of the requirements for the award of Master of Science in Structural Engineering Degree of Kyambogo University.

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Abstract

Compression index is an important soil parameter in the design of foundations of structures yet the Oedometer test used for its determination is time consuming, cumbersome and very costly. This prompted a number of studies to be done to address the above limitations by relating Atterberg limits to compression index. However, determination of Atterberg limits has limitations which include stress-strain effects during penetration for the fall cone, human reliability errors for the Casagrande method of liquid limits determination and Health & safety issues in handling contaminated soil material for Plastic limits. The aim of this research was to develop a simple, fast and accurate method of determining the compression index of cohesive soils using the Quasi-static cone test which addresses all the above limitations. 51 soil samples were collected from three districts of Uganda (Area = 1230km²) and tested for the compression index using Oedometer test, liquid limit using fall cone and Plastic limit using thread rolling. The Atterberg limits were correlated to compression index using regression analysis. The same soil samples were tested using the quasi static method and forces close to 1020gf and 60gf were obtained for plastic and liquid limit respectively at 20mm penetration depth. The empirical relationships relating the force from the quasi static method and compression index was found to be 98% accurate compared to the compression index from Oedometer test.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

When a soil is subjected to mechanical load, it can shrink in volume. This property is known as soil compressibility (Gupta et al., 2002). Consolidation is the process through which the volume of partially or completely saturated soil changes in response to an increase in pressure. A static load or a dynamic load can both be considered external loads. When a load is applied to a soil with limited permeability, the water present in the pores of a saturated soil first carries the load, causing the pore water pressure to rise quickly. As water drains from the soil's voids, the excess water pressure is released, and the pressure is then transferred to the soil Skelton, which gradually contracts and causes settlement. Up till the extra pore water pressure has subsided, the consolidation process continues. Natural loads or an increase in applied stress can both produce consolidation (such as sedimentation process, or human made loads as in the construction of a building or an embankment above a soil mass or even the lowering of the ground water table).

The one-dimensional consolidation is the most basic case of consolidation studied. The lateral strain of the soil mass is disregarded in this situation. The Oedometer test, which measures the vertical displacement of a cylindrical, saturated soil sample submitted to a vertical force while it is radially confined, is a testing process to quantify the important soil parameters involved with soil consolidation. Consolidation tests should be performed both during the structural integrity study and at the proposal stages of building a project.

In a baseline survey with the Kampala Capital City Authority (KCCA), it was discovered that only two of the 100 soil investigation reports for the buildings under study had consolidation tests done.

The arguments put forth included the fact that the test is expensive, time-consuming, and expensive, as well as the idea that a consolidation test is not required if the original soil test results for CBR and soil strength parameters meet the minimum requirements.

One Dimensional Consolidation test is used to calculate the compression index, which is employed in the estimation of settlement, a vital component in the construction of the structure (called Oedometer test). Clause 4 of BS 1377 (Part 5) standardizes the test technique. Researchers and engineers have long been deeply interested in the compressibility of soils. In fact, one of the difficulties in structural design is the soil consolidation of engineering projects like foundations and embankments under load; therefore, great effort will have been made to predict settlement, prevent it, or at the very least limit it to acceptable levels.

Construction mistakes that cost time and money might result from a lack of knowledge of the soil's qualities. It is best to judge a soil's suitability for a certain purpose on the basis of its technical qualities rather than a visual evaluation or an apparent similarity to other soils. Since a normal consolidation test can be completed in three weeks at most, determining the compression index from those experiments is expensive, laborious, and time-consuming (Jain et al., 2015). Because of the time and cost of the Oedometer test, efforts have been made to derive a relationship between compression index and consistency limits through testing. However, the current approaches suffer from the following limitations:

- Penetration stress-strain effects in the fall cone tests;
- Reliability associated with thread rolling in plastic limit test; and
- Health and safety issues in handling contaminated soil materials.

In order to address the above issues, this research focused on developing alternative methods of consistency limits testing using quasi static cone penetration tests and relating these to compression index values.

1.2 PROBLEM STATEMENT

Structure settlement is assessed using the compression index. The Oedometer test is mostly utilized to evaluate the compression index. However, since a normal consolidation test can be completed in up to 3 weeks, determining the compression index from an Oedometer test is costly, laborious, and time-consuming (Jain et al., 2015). Despite research suggesting a rough relationship between a normally consolidated clay's liquid limit and its compression index, fall cone test approaches were limited by their inherent inability to control the cone's penetration rate during testing, which resulted in the fall cone's strain effects on the sample (Koumoto and Houlsby, 2001). Furthermore, the thread rolling in plastic limit test is not consistently reliable since it depends on human factors and where the soil is contaminated it possess Healthy and safety risks. Therefore, there was need to come up with Quasi-static cone test approach to relate the penetration force to the compression index which addressed the limitations of stress-strain effects, the health hazard and time taken for the test.

1.3 OBJECTIVES OF THE STUDY

1.3.1 General Objective

The general objective of this study was to develop a simple, fast and accurate method of determining the compression index of cohesive soils using the quasi-static cone test.

1.3.2 Specific Objectives

The specific objectives were:

1. To determine conventionally derived consistency limits which include plastic limit and liquid limit of cohesive soils of low plasticity to high plasticity.

2. To determine Quasi-static consistency limits of cohesive soils of low plasticity to high plasticity
3. To determine Compression index using Oedometer test and moisture content
4. To develop empirical relationship between quasi static cone consistency limits and compression index.

1.4 RESEARCH QUESTIONS

- a) What are the values of conventionally derived consistency limits which include plastic limit and liquid limit of cohesive soils of low plasticity to high plasticity?
- b) What are the values of Quasi-static consistency limits of cohesive soils of low plasticity to high plasticity?
- c) What are the values of compression index determined using Oedometer test and moisture content?
- d) What are the empirical relationships between quasi static cone consistency limits and compression index?

1.5 JUSTIFICATION

The research was an opportunity to gain very important knowledge in the civil engineering practice. Several methods had been developed in determining compression index. The most common method was the One-dimensional consolidation test. The test was time consuming since it required up to 3 weeks to complete one test per sample. The Casagrande cup method was adopted and used to determine liquid limit and correlated with compression index but had a limitation of being essentially a dynamic shear test (Casagrande, 1958). It was attempted to utilize the fall cone method to establish the liquid limit and correlate it with the compression index, but this had the inherent drawback of being unable to control the cone's penetration rate during testing, which resulted in strain effects. The thread rolling method for determining plastic limit suffers the limitation that the

results are affected by human performance factors and health risks for contaminated soils. The limitations of older techniques are removed by the quasi-static cone penetration approach, which also establishes the liquid and plastic limits.

1.6 SIGNIFICANCE

The importance of the research was to develop a small-scale laboratory method which gave results in a single day hence addressing the challenge of time involved and cost incurred in determination of compression index for cohesive soils using Oedometer test, stress-strain effects limitations associated with the fall cone for measuring liquid limit, reliability associated thread rolling, health and safety issues in handling contaminated soils material in plastic limit tests.

1.7 SCOPE

The research involved carrying out experimental tests on consistency limits which included determination of plastic limit using thread rolling and fall cone approach. One-Dimensional Consolidation Test and Moisture Content Experiments were conducted in the Districts of Masaka, Mpigi, and Luwero on soil samples. Quasi-static consistency limit tests were carried out on 51 samples as seen in (Jain et al., 2015) and involved controlled penetration cone at a rate of 1mm/s as seen in (Kyambadde, 2010). The approach was used to get plastic and liquid limit and then develop empirical relationships with the compression index from one dimensional consolidation test.

1.8 CONCEPTUAL FRAMEWORK

The experiment was carried out on 51 samples so as to cover all the plastic ranges. Here we looked at dependent, intervening and independent variables. The dependent variables were compression indices, the independent variables were quasi-static consistency limits and the conventionally derived consistency limits and the intervening variables were moisture content. So, a relationship

which includes intervening, dependent variable and independent variable as seen in Figure 1.1 was established.

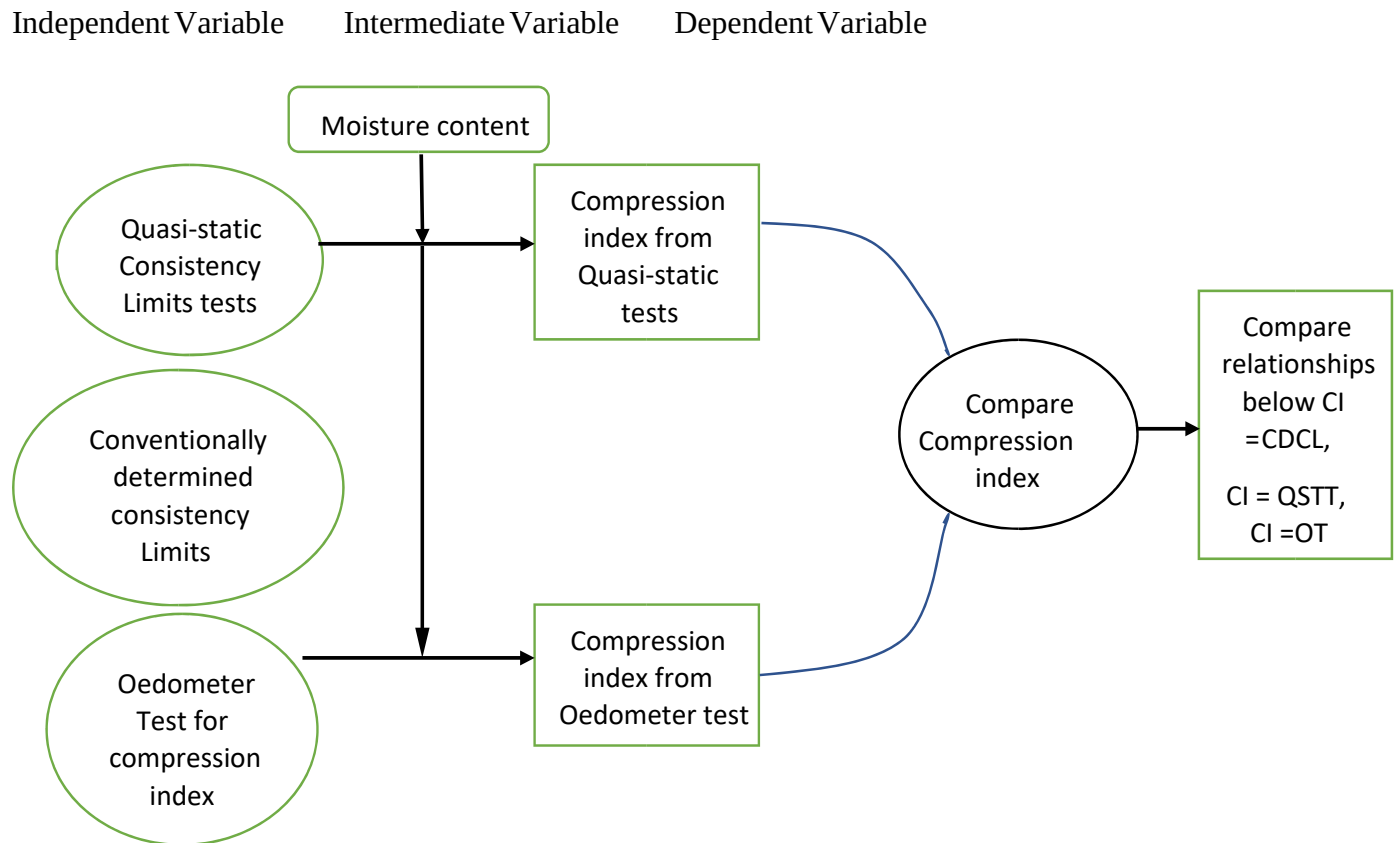


Figure 1.1: Shows the conceptual framework for Quasi Static Consistency Limits as independent variables and CI as dependent variable

Note; CI = Compression index, CDCL = conventionally derived consistency limits, QSTT = Quasi-static tests and OT= Oedometer test

CHAPTER TWO

LITERATURE REVIEW

This chapter mainly involves the reviews of related literature in line with the study. This includes the consistency limits, Atterberg limits, one dimensional consolidation and the new approach known as the quasi-static cone tests for determining the consistency limits.

2.1 CONSISTENCY LIMITS

According to the water content, fine-grained soils like clays and silts exhibit substantial changes in behavior and strength. Albert Atterberg (1911) a Swedish soil scientist, created a set of restrictions relating to the water content of certain kinds of soils to quantify these behavioral changes. Later, in 1958, Arthur Casagrande improved them. Based on the amount of water present, the Atterberg limits system determines four states of consistency for these fine-grained soils: solid, semisolid, plastic, and liquid. The weight of the water in the soil sample (W_w) is divided by the weight of the soil sample without any water (w_s), and the result is multiplied by 100 to give the water content (w), which is then expressed as a percentage (Brownjor, 2016).

2.1.1 Liquid limits (LL)

According to ASTM D 4318, the liquid limit (LL) was arbitrarily defined as the water content, in percent, at which a portion of soil in a standard cup with a groove of standard dimensions overflowed together at the base of the groove for a distance of 13 mm after being subjected to 25 shocks from the cup that was dropped 10 mm. According to (Jefferson and Rogers 1998) stated that the liquid limit was found useful in the investigation of the effects of temperature on soil behavior. It ideally determines the upper limit of a soil's plasticity, and was herein denoted as LL in the case of conventional determination from the BS 1377-2: 1990 fall-cone test. According to Taylor (1948),

liquid limit made a very good correlation with the compression index and also according to (Jain, et al, 2015), plasticity index made a very good correlation to compression index.

2.1.2 Determination of Liquid Limit

One-point cone penetrometer, Casagrande device, and cone penetrometer method (definitive method) were the three methods described in BS 1377: Part 2 for determining the liquid limit of soil;

2.1.3 Cone Penetrometer Method

Cones, using both displacements controlled and load-controlled penetration devices, were widely investigated for measuring the liquid limit according to (Koumoto, 1990). Cone penetrometer testing, according to Houlsby (1982), was quicker and simpler than cup testing and eliminated the subjectivity involved with the Casagrande cup test. However, the methodology test presupposed a constant undrained shear strength of 1.7 kPa, which corresponds to the liquid limit for all types of soils (Hrubesova, 2016).

According to Hansbo theory the undrained shear strength c_u was inversely proportional to the square of the cone penetration d and can be expressed in the form (Hrubesova, 2016). In order to establish the cone mass, apex angle, surface roughness, and penetration depth at the LL, a fall-cone LL setup that is internationally standardized was adopted. Koumoto and Houlsby (2001) stated that “Although the 60° cone was less sensitive to variations in cone roughness and, as a result, can arguably produce greater repeatability between geotechnical laboratories, the 30° cone is in much wider use and from this consideration will be the more obvious choice for international standardization”. Additionally, Koumoto (1990) proposed that the liquid limit be defined globally as the water content at which a 600, 60g fall cone could penetrate 10 mm.

The undrained shear strength can be calculated quickly and easily using the fall cone test, which can be understood in terms of basic mechanics. The angle of the cone tip, the roughness of the cone's surface, and the rate of shear strain during penetration are all factors that affect fall cone penetration. While the K factor for the 300 cone is slightly higher than the value acquired from experimental data, the theoretical fall cone factor $K = 0.31$ estimated here for the 600 cone matches well with published experimental findings. Because it is less susceptible to cone roughness than the 300 cone, the 600 cone is suggested as being more appropriate to determine strength. Theoretical undrained shear strengths are compatible with experimentally measured values at the liquid limit. The fall cone approach is restricted by the effects of strain rates, which are roughly $2.5 \times 10^6\%/hr$. Kunomoto (2001).

2.1.4 One-Point Cone Penetrometer Method

The procedure is the same as that stated in the fall cone test, with the exception that only one point is necessary. This test offers an alternative way to the fall cone method for finding the liquid limit. This results in a fairly quick test. The soil's water content is ascertained after the average penetration for the point has been established. The liquid limit is then calculated by multiplying the water content by a certain amount. Both the cone penetration and the range of water content that the measured water content falls within affect the factor's value. By performing experiments, the factors were identified (Clayton and Jukes, 1978).

2.1.5 Casagrande Apparatus

The equipment used to establish the liquid limit consists of a semi-spherical brass cup that is repeatedly dropped from a height of 10 mm onto a hard rubber base. This equipment was created by Arthur Casagrande in 1932, and the test's protocol is known as the Casagrande cup method provided under ASTM D 4318. The Casagrande apparatus method may also be used to determine the liquid

limit from a single point measurement, as shown in clause 4.6 of BS 1377-2: 1990, where limited soil samples are available.

The limitations of the percussion cup device led Casagrande (1958) to recommend the use of a simple shear test such as static penetration to offer a better approach to the determination of the liquid limit (Kyambadde, 2010). The British Standards Institution only accepted this approach as a means of determining liquid up to 1975. Although it is still widely used, cone penetration techniques have mostly replaced the test (Smith, 2014). The cup method, which determines the liquid limit, has a number of drawbacks, including the propensity of low plasticity soils to slide and liquefy with shock in the cup rather than flow plastically, and sensitivity to operator technique and to minor variations in gear.

2.2 PLASTIC LIMITS

The point at which a soil transitions from a semisolid to a plastic form is known as the water content (Budhu, 2000). In addition, it is described as the percentage of moisture at which the soil crumbles when rolled into threads that are 4.2 mm in diameter (Das, 2014). Plastic limits are established using arbitrary test methods, which are fully described in BS 1377. (Part 2) Clause 2 and Craig (2004) propose combining the test soil with distilled water until it becomes sufficiently plastic to be shaped into a ball in order to ascertain the plastic limit. Terzaghi (1948) correlated compression with the plastic limit.

2.2.1 Determination of the Plastic Limit

For cohesive soils containing coarse fractions smaller than 0.425 mm, it is not possible to obtain the thread rolling plastic limit according to BS 1377-2: 1990 since the presence of the coarse particles interferes with the rolling process. Thus, alternative methods, in particular cone penetration, may have the advantage that they can at least be employed directly for mixed soils. (Kyambadde, 2003).

The plastic limit test is straightforward and is carried out by repeatedly rolling a soil mass the size of an ellipsoid by hand on a glass plate that has been crushed. ASTM provides instructions for the plastic limit test in Test Designation D-4318.

Approximately 20g of soil should be mixed with water, and then the soil ball should be rolled by hand on the rolling surface with just enough pressure to generate an elongated thread, as per the standard Test procedure manual 2000, to determine the plastic limit. A sample of soil is taken to test the moisture content, which is the plastic limit, if it can be rolled to a thread 3mm thick without disintegrating.

2.2.2 Thread Rolling Plastic Limit Devices

By rolling a little amount of clay into threads and measuring the water content at which the thread, which is about 3mm in diameter, begins to crumble, the plastic limits can be found (Budhu, 2000). The soil becomes less flexible and transitions to a semisolid form at this water concentration. The drawback of this method is that it is reliant on the experimenter or sample roller.

Bobrowski and Grievspoor (1992) devised a simple Plexiglas based device; in which soil specimens are rolled into threads to obtain the plastic limit, as an improvement over the hand thread rolling procedure. Variations of this device have been fabricated elsewhere (see for example Rashid et al (2008), and include mechanized versions such as cited in Temyingyong, et, al (2002).

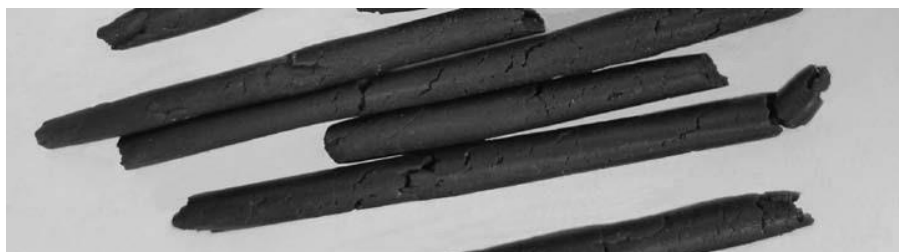


Figure 2.1: Shows thread rolled soil sample from (Das, 2014)

2.3.1 Fall Cone Method to Determine Plastic Limits

A fall cone test, popular in Europe and Asia, appears to offer a more accurate (less prone to operator's errors) method of determining both the liquid and plastic limits. In the fall cone test a cone with an apex angle of 30° and total mass of 80 grams is suspended above, but just in contact with, the soil sample. The cone is permitted to fall freely for a period of 5 seconds. The challenge of obtaining the plastic limit from a single test necessitates four or more tests at various water volumes. Water content (ordinate, logarithmic scale) vs penetration (abscissa, logarithmic scale) are shown as the results, and the plastic limit is calculated by projecting the best fit-straight line backward to cross the water content axis at a penetration depth of 1 mm. At this depth of penetration (1 mm), the water content is C (Budhu, 2000).

The formula for the plastic limit is;

$$PL = C(2)^m \dots\dots\dots \text{Equation 1}$$

where m is the slope (taken as positive), the straight line with the best fit. Using a spreadsheet tool, you can find C and m using the best-fit equation's power trend line function. The fall-cone approach is also limited by the range of 80 gf penetration depths achievable at moisture contents close to the plastic limit. Only a few millimeters may be obtained, rendering a relatively small proportion of the specimen involved in the test.

The fall-cone approaches of determining the plastic limit have limitations that impede their application as alternatives to the thread rolling procedure like may be difficult to interpret on the statistical approach (Campbell, 1976). (Kyambadde and Stones, 2007) also suggested that there are also difficulties in controlling the rate of penetration during fall-cone tests which complicates their use over the entire plastic range, particularly close to the plastic limit, where slight variations in moisture content may significantly affect the soil strength.

2.3 PLASTICITY INDEX

A measurement of a soil's plasticity is the plasticity index (PI). The range of water contents where the soil displays plastic qualities is measured by the plasticity index. The PI ($PI = LL - PL$) is the difference between the liquid and plastic limits (Das, 2006). Clay predominates in soils with a high PI, silt predominates in soils with a low PI, and little to no clay predominates in soils with a PI of 0 (non-plastic).

2.4 CONSOLIDATION

Consolidation happens when saturated clay soils with a low coefficient of permeability are loaded. Because of the soil's low permeability, the pore water pressure will immediately increase, but there will be a delay between the application of the load and the pore water extrusion that causes the settlement (Das, 2014). The mechanical process through which soil progressively changes volume in response to a change in pressure is known as soil consolidation.

This occurs as a result of soil being a two-phase substance made up of soil grains and pore fluid, typically groundwater. Due to the high volumetric stiffness of water relative to the soil matrix, when pressure is increased on soil that is saturated with water, the water initially absorbs the entire rise in pressure without changing volume, leading to excessive pore water pressure. The soil matrix gradually absorbs the pressure change and contracts in volume as water diffuses away from areas of high pressure as a result of seepage. Thus, the diffusion equation, the idea of effective stress, and hydraulic conductivity are all tightly tied to the theoretical framework of consolidation. Consolidation, when used narrowly, refers solely to this delayed volumetric reaction to pressure change brought on by water's slow flow away from the loaded area.

Additionally, Consolidation is sometimes used in publications to refer to any process where soil changes volume as a result of a change in applied pressure. Some soil types, especially those high in organic matter, exhibit significant creep, which a slower volume change is caused by a constant effective stress over a longer period of time than consolidation through water diffusion. "Primary consolidation" denotes consolidation brought on by the dissipation of excess water pressure, whereas secondary consolidation denotes the creep process.

The consequences of consolidation are particularly noticeable when a structure is built over a layer of low-stiffness, low-permeability soil, like marine clay, which causes significant settlement over an extended period of time. Land reclamation, building embankments, and clay-based tunnel and basement excavation such exhibits over consolidation. Oedometers are used by geotechnical engineers to measure the effects of consolidation. In an oedometer test, a thin disc of soil sample is subjected to a series of known pressures, and the change in sample thickness over time is recorded.

2.4.1 Oedometer Test (One Dimensional Consolidation Test)

Clause 4 of BS 1377 (Part 5) describes the test technique and requires that the Oedometer be of the fixed ring variety. The kind of soil will determine the starting pressure, which will be followed by a series of doubled-up pressures on the specimen.

The soil sample is enclosed in a steel cutting ring and is typically 75 mm in diameter and 20 mm thick. The sample is placed in the oedometer and covered with porous discs that have been saturated with airless water. After that, a vertical force is applied, and the compression that results is measured using a transducer at regular intervals, with values being logged until the sample has fully consolidated (usually for a period of 24 hours).

The process is then repeated with further load increments until the test has covered the whole stress range anticipated in situ. To avoid pore suction, the test sample is typically flooded with water shortly after the application of the first load increment. The pressure is gradually reduced over a period of 24 hours once the sample has condensed under its last load increment. The sample is then allowed to expand.

An expansion to time curve can likewise be obtained in this manner. The final thickness of the sample, from which it is feasible to determine the void ratio of the soil for each stage of consolidation under the load increments, can be acquired after the loading has been entirely removed. The graph depicting the relationship between the void ratio and the consolidation pressure can then be created. Because the extra pore pressures are zero after consolidation and the applied stress increment is equal to the effective stress increment, it should be emphasized that the values of σ_v prefer to effective stress (Smith, 2014).

2.4.2 Compression Index

The slope of the linear portion on the e -log plot for any two points is the compression index (C_c) and is dimensionless (Craig, 2004). In a plot of the logarithm of vertical effective stress versus void ratio, it can be described as the slope of the normal consolidation line (Budhu, 2000) Compression index can be used to assess a structure's settling, as demonstrated in the (Das, 2014).

2.4.3 Determination of Compression Index

It has been demonstrated by Terzaghi and Peck (1948) that the liquid limit of a regularly consolidated clay and its compression index roughly correlate. This connection was discovered through experimentation and is

$$C_c = 0.009(W_L - 10\%)$$

Skempton (1944) also proposed the empirical expression shown below for the compression index for clays that have not been disturbed:

$$C_c = 0.009(LL-10)$$

2.5 QUASI-STATIC CONE SYSTEMS

The limitations of using the fall cone apparatus may be ideally overcome if the penetration rate can be controlled such that rate effects are more effectively accounted for (Kyambadde, 2010). Kyambadde (2010) suggests that Quasi-static cone systems (in which displacement control occurs at slow rates, ideally at 1 mm/s) may provide a better alternative in overcoming limitations of fall-cone penetration approaches, such as Strain rate effects.

Koumoto and Houlsby's (2001) analysis of the quasi-static cone penetration event suggests that the expression in equation may be used to relate the undrained shear strength (S_u) and penetration depth (h);

$$S_u = K_{qc} \left(\frac{F_{qc}}{h^2} \right)$$

CHAPTER THREE

METHODOLOGY

3.0 INTRODUCTION

The materials (soils), techniques/procedures, and tools employed in this investigation are described in this chapter. The innovative equipment and recording mechanisms used are presented, Figures are also presented where appropriate.

3.1 EXPERIMENTAL MATERIALS

3.1.1 Fine Soils

Experimental materials comprised 51 samples of soil ranging from low plasticity to high plasticity. The goal of the experimental programme was to compare the Oedometer test and the Quasi-static cone penetrometer in terms of how simple, quick, and inexpensive it was to determine the compression index. An essential soil metric used to estimate the structure's settlement is the compression index.

The soil was tested in remoulded state with any particles larger than 0.425 mm diameter removed by sieving as appropriate. Particular care was taken to breakdown aggregated particles by using mortar and pestle. Remoulding was done by kneading with palette knives as recommended in BS 1377-2: 1990. Classification properties of the fine cohesive soils was obtained from a unified soil classification system which was in accordance with BS 1377-2: 1990.

3.2 FALL-CONE TESTS

Because it is simpler to operate, the Fall-cone method was used to establish the liquid limit instead of the Casagrande apparatus approach. The fall-cone apparatus has a solenoid release mechanism that

releases the cone so that the 80 g 30° cone can be penetrated by self-weight over a predetermined time of 5 seconds. The fall-cone test procedures were employed in the experimental programme in accordance with clause 4.3 of BS EN ISO 17892-12: 2018.



Figure 3.1: Fall cone penetrometer

3.3 FALL CONE TESTS PROCEDURES

Fall cone penetration tests in accordance with BS EN ISO 17892-12: 2018 were used to ascertain the compression and consistency limit of fine cohesive soils and combinations of clay soils and fine gravel. 30° smooth cone was used for both fall cone and quasi-static cone tests in the experimental programme, Adhesion effects were minimized throughout the testing programme, by lightly oiling the cones as recommended by Houlsby (1982).

A sample of about 100 g from the soil paste was taken, prepared and placed on the glass plate. The paste was thoroughly mixed with distilled water using the two palette knives. The moisture content was adjusted so that it corresponds to a cone penetration of between 15 mm and 25 mm, and as close as possible to 20 mm and this was checked with the cone penetrometer device. The sample was mixed for at least 10 min.

A portion of the mixed soil was Pushed into the cup with a palette knife, taking care not to trap air. Excess soil was removed off with the straightedge to give a smooth surface. Then the cone was locked in the raised position lowering the supporting assembly so that the tip of the cone just touches the surface of the soil. After the cone had been put in the correct position, a slight movement of the cup adjusted the mark of the soil surface.

The dial gauge reading was recorded to the nearest 0.1 mm. The cone was released for a period of 5s. After locking the cone in position then, the dial gauge was lowered to the new position of the cone shaft and the reading was noted to the nearest 0.1 mm. The difference between the beginning and end of the drop recorded as the cone penetration. The cone was then lifted out and cleaned to avoid scratching. Again more little wet soil was to the cup, taking care not to trap air, the surface was made smooth as specified and the process was repeated until four consecutive tests give cone penetration readings within 14 to 28 mm. The bulk of the soil was removed, including the zone penetrated by the cone, from the cup, placed in a suitable container and its moisture content was determined.

3.4 PLASTIC LIMIT TESTS PROCEDURES

A plastic limit test was undertaken in accordance with the procedure set out in clause 5 of BS EN ISO 17892-12: 2018 for thread rolling. The plastic limit test was carried out by repeatedly rolling a soil mass the size of an ellipsoid by hand on a glass plate that had been ground until cracks developed in the sample.

A sample of about 20 g was taken from the soil paste, prepared and placed on the glass mixing plate. The soil was allowed to dry partially on the plate until it became plastic enough to be shaped into a ball. The soil was moulded into ball between the fingers and rolled between the palms of the hands

until the heat of the hands had dried the soil sufficiently for slight cracks to appear on its surface. The sample was divided into two subsamples of about 10 g each and a separate determination was carried out on each portion by dividing each subsample into four more or less equal parts and was treated each part as specified.

The soil was moulded in the fingers to equalize the distribution of moisture and then form the soil into a thread of about 6 mm diameter between the first finger and thumb of each hand. The thread was then rolled between the fingers, from the finger-tip to the second joint, of one hand and the surface of the glass rolling plate. Enough pressure was used to reduce the diameter of the thread to about 3 mm in five to 10 complete, forward and back, movements of the hand. The pressure was maintained uniformly as the thread diameter approaches 3 mm.

The soil was Picked up, moulded between the fingers to dry it further, formed it into a thread and roll it out again. The process was repeated until the thread sheared both longitudinally and transversely when it has been rolled to about 3 mm diameter, as gauged by the rod. The crumbled soil threads were gathered, transferred to a suitable container and replaced the lid immediately. The process was repeated on the other three portions of soil, placing them all in the same container. Then moisture content of the soil in the container was determined.

3.5 QUASI-STATIC CONE TESTS

The quasi-static cone penetration consisted of the 20mm bar connected to a cone shaped rod similar to that fall cone penetrometer. The bar was attached to the frame similar to tri axial frame as shown in Figure 3.2. The frame was made in such a way that it moved the soil sample in a cup to be penetrated by a cone at constant penetration of 1.3mm per second. The force applied was determined using a

load cell placed at the bottom of the cylindrical cup containing the specimen. The penetration was determined using Ultra sound sensor attached at the bottom of the frame.

The load cell and ultra sound sensor were both connected to Urduino mother board which acts as data logger. The results were read directly from the computer using urduino mother board so as to improve on the accuracy of reading the penetration and force at the same time. The approach was similar to that used by (Kyambadde, 2010) the only difference was that he used a data logger and Linear Voltage displacement traducers (LVDT) to read the results on the computer.

Quasi penetration tests were carried out on each sample at plastic limit and liquid limit determined conventionally by using thread rolling and fall cone method respectively. A Table of results is shown in chapter 4, and plotted graphs are shown in Figure 4.2. Values were recorded for a depth of penetration of 10mm, 20mm and 30mm, these were plotted and 20mm depth was found to be consistent. Therefore, a depth of penetration of 20mm was used. A graph of force versus depth of penetration and force versus penetration squared were plotted to get curves at different moisture content. The plastic and liquid limit, a force corresponding to a 20 mm depth of penetration, and the quasi-consistency limits were established for the identical soil samples.

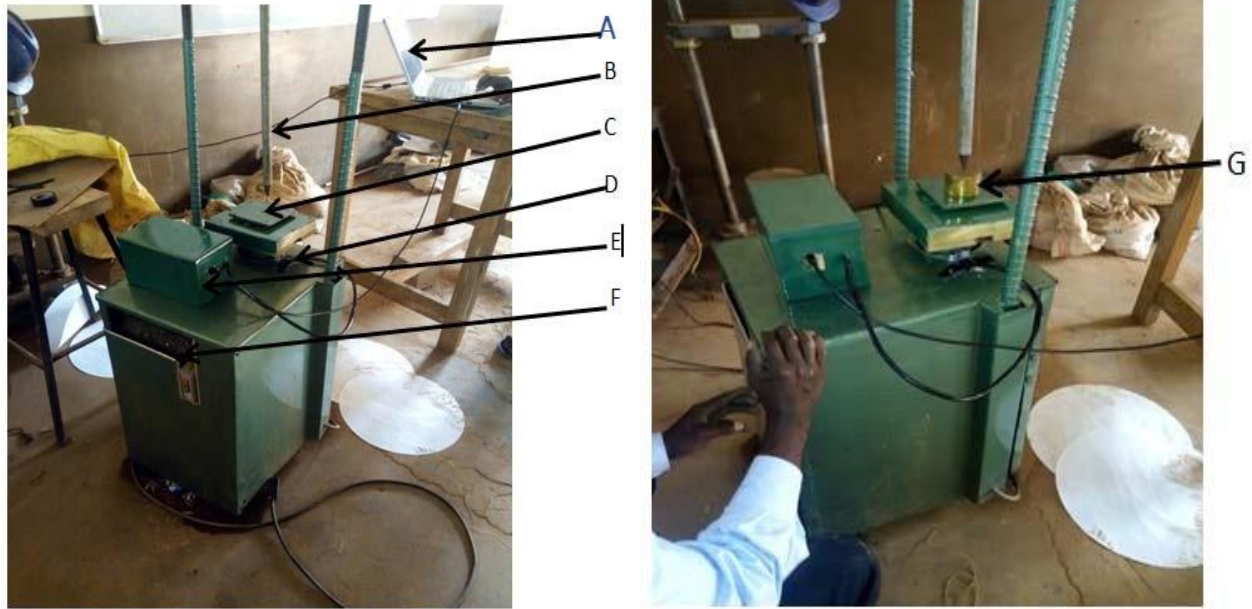


Figure 3.2 Quasi static penetrometer

A is a computer for displaying of results.

B is the vertical bar of 20mm diameter with a 30° conical shaped end used to penetrate the soil sample.

C is used to measure force applied on the soil sample by a load cell that is mounted on top of the piston.

D is an ultrasonic sensor which measures distance at a given interval

E is the Arduino mother board encased in the metal case used to transfer the data to computer.

F is the switch board where there is the operating switches used to switch on and off the machine and used to operate the machine to move up and down.

G is a cup of 50mm diameter 40mm height to be filled with the soil sample.

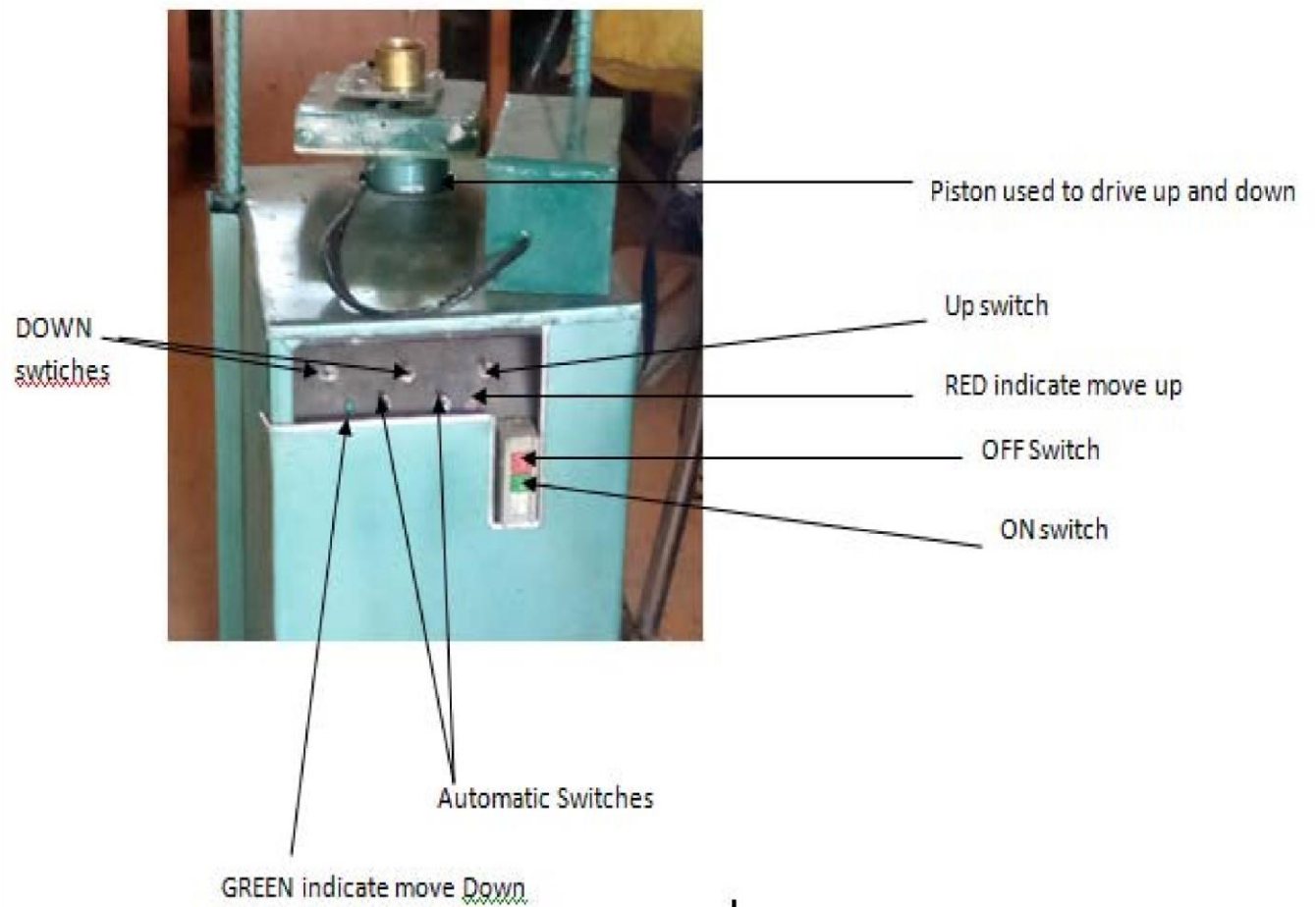


Figure 3.3: Detail of switch board for quasi static cone penetrometer

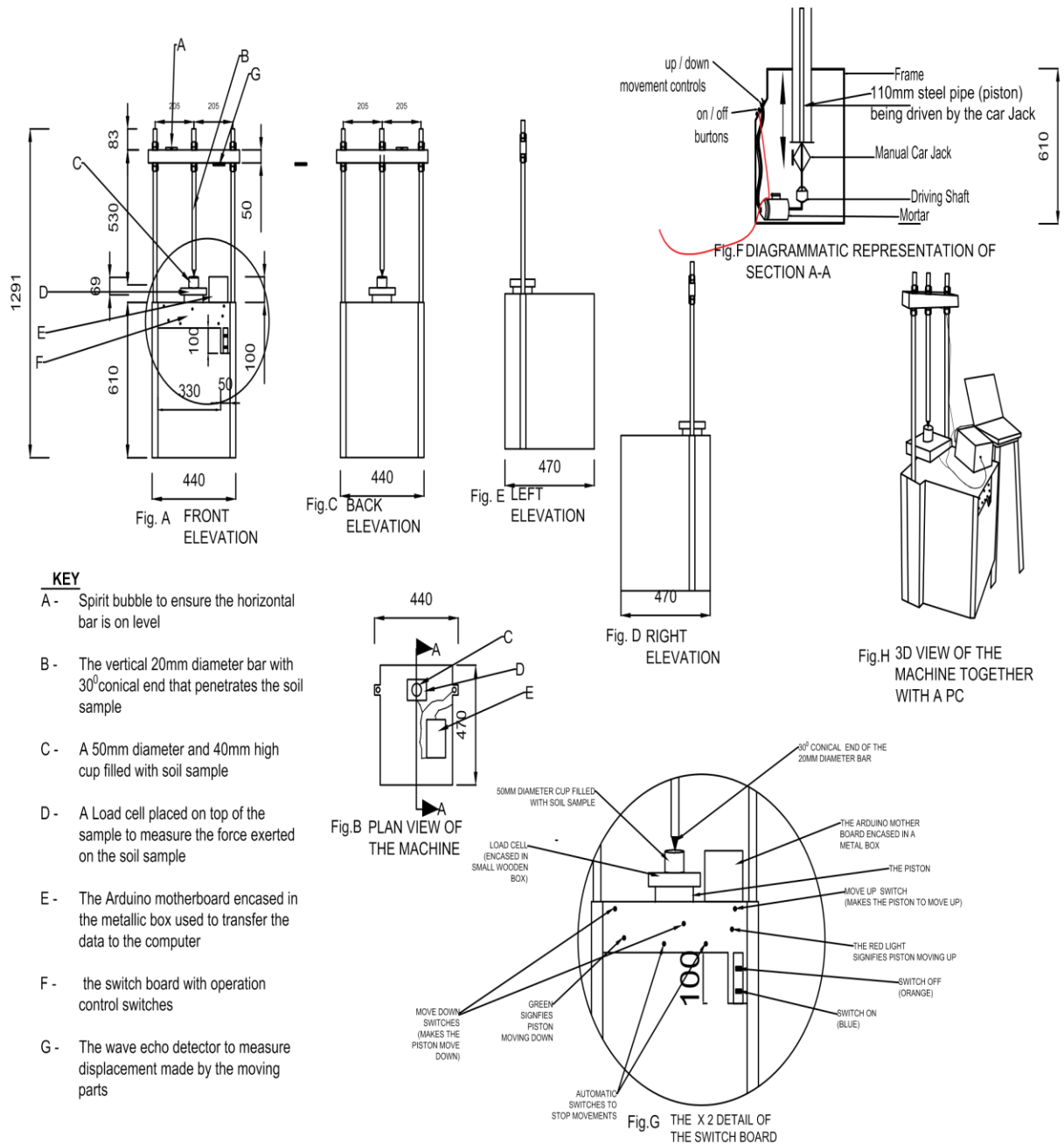


Figure 3.4: Detail of quasi static cone penetrometer machine

3.6 ONE DIMENSIONAL CONSOLIDATION TEST (OEDOMETER TEST)

The Oedometer must be of the fixed ring type, according to the test procedure of BS EN ISO 17892-12: 2018. The kind of soil determined the starting pressure, which was followed by a series of doubled-up pressures on the specimen. Each pressure was held steady for a whole day. Each sample was tested for an average of 3 days and for 51 samples it took 155days. Throughout this time, compression values were taken at regular intervals. The applied pressure is equal to the effective vertical tension in the specimen at the conclusion of the increment period, when the extra pore water pressure has fully dissipated.

The plastic limit, liquid limit, optimum moisture content were tabulated and for each sample determined during the laboratory testing.

A regression analysis was performed using the findings, and it was then possible to establish an empirical relationship between consistency limits and CI. To develop the empirical relationship between quasi static cone penetrations and compression index. Basing on the results got from the quasi static cone penetrations and the Compression Index corresponding to consistency limits, the empirical relationship was determined using a regression analysis.



Figure 3.5: Oedometer apparatus

3.7 ONE DIMENSIONAL CONSOLIDATION TEST PROCEDURE

Two porous stones were saturated by keeping them submerged in the distilled water for 4 to 8 hours, excess water was wiped away and the fittings of the Oedometer had been moist. The Oedometer was assembled, with the soil specimen and porous stones at top and bottom of specimen, providing a filter paper between the soil specimen and porous stone. The pressure pad was positioned centrally on the top porous stone. The mould assembly was mounted on the loading frame, centered and load applied was axial.

The dial gauge was positioned and measured the vertical compression of the specimen. The dial gauge holder was set such that the dial gauge was in the beginning of its releases run and allowing sufficient margin for the swelling of the soil. The mould assembly was connected to the water reservoir and the sample was allowed to saturate. The level of the water in the reservoir was at about the same level as the soil specimen. An initial load was applied to the assembly. The magnitude of this load was chosen by trial, such that there is no swelling. It was not less than 50 g/cm^3 . The load was

allowed to stand until there is no change in dial gauge readings for two consecutive hours or for a maximum of 24 hours. The final dial reading was noted under the initial load.

The first load of intensity 0.1 kg/cm^2 was applied and started the stop watch simultaneously. The dial gauge readings were recorded at various time intervals. The readings recorded until more than 90% consolidation was reached. At the end of the period, specified dial readings and time readings were taken, the load intensity was doubled and the dial readings at various time intervals was taken. This procedure was repeated for successive load increments. After the last loading was completed, the load was reduced and the value of the last load was allowed to stand for 24 hrs.

The load was further reduced to the previous intensity till an intensity of 0.1 kg/cm^2 was reached. The final reading of the dial gauge was recorded. The load was reduced to the initial load, kept for 24 hours and the final readings of the dial gauge were noted. The specimen assembly was dismantled and the excess water on the soil specimen in oven was removed and the dry weight of the sample was noted.

CHAPTER FOUR

4.0 ANALYSIS, DISCUSSION AND PRESENTATION OF RESULTS

This chapter presents results, conventional BS fall-cone liquid limit, thread rolling plastic limit consistency limit, and quasi-static cone penetration tests are analyzed and discussed. Also, the analysis is concerned with the derivation of empirical relationships between Atterberg limits and quasi-static cone penetration tests and their subsequent use for laboratory compression index determination. The development of alternative plasticity index parameters based on quasi-static cone penetration tests will provide upper and lower strength indices similar to the conventional BS 1377 liquid limit (LL) and plastic limit (PL).

4.1 FALL-CONE TESTS

Fall-cone tests were conducted for 51 test soils samples from districts of Masaka, Mpigi and Luwero. Fall-cone tests were conducted in accordance with the BS 1377-2: 1990 procedure, generally over entire liquid limit ranges of the soils in 95 cm³ specimen cups with the cone lightly oiled to minimize effects of adhesion. The liquid limit (LL) was recorded for each of the 51 soil samples and results entered in Table 4.6.

From Table 4.1 and Figure 4.1, 11 of all the 51 samples (22%) tested soils lay within the low plasticity i.e liquid limits less than 35 %, 40 of the 51 samples (78%) of the tested soil sample lay with in intermediate i.e liquid limits between 35 - 50 % and none of the 51 tested soil sample lay within high plasticity (of liquid limits greater than 50 %) soils classification according to BS 14688- 2: 2004.

Table 4.1: showing all the samples soils were classified with Unified Soil Classification System

Sample Name	Soil Classification
	Unified Soil Classification System
C4	CL-ML (Silt clay with sand)
C6	CL-ML (silty clay)
C5	CL (Lean Clay with sand)
K2	CL (Lean clay)
K12	CL-ML (Sandy silty Clay)
R5	CL (Sandy Lean Clay)
A5	CL (Sandy Lean Clay)
K1	CL (Lean Clay with Sand)
S6	CL (Lean Clay with sand)
A4	CL (Gravelly lean clay)
R7	CL (Lean Clay with Sand)
R1	CL (Lean Clay)
K10	CL (Lean Clay with Sand)
K11	CL (Sandy Lean Clay)
A3	CL (Lean Clay with Sand)
C1	CL (Sand Lean Clay with Gravel)
C2	CL (Sandy Lean Clay)
C3	CL-ML (Sandy silty Clay)
K16	CL (Gravelly lean clay)
R2	CL (Lean Clay with Sand)
k22	CL (Lean Clay with sand)
k23	CL (Gravelly lean clay)
A6	CL (Lean Clay with Sand)
B4	CL (Lean Clay)
B5	CL (Lean Clay with Sand)
B6	CL (Sandy Lean Clay)
B3	CL (Lean Clay with Sand)
R2	CL (Sand Lean Clay with Gravel)
R3	CL (Sandy Lean Clay)
A1	CL (Lean Clay with Sand)
Sample Name	Soil Classification
	Unified Soil Classification System

A2	CL (Lean Clay with sand)
K5	CL (Gravely lean clay)
K6	CL (Lean Clay with Sand)
C7	CL (Lean Clay)
C8	CL (Lean Clay with Sand)
K9	CL (Sandy Lean Clay)
K7	CL (Lean Clay with Sand)
N1	CL (Sand Lean Clay with Gravel)
N2	CL (Sandy Lean Clay)
N3	CL (Sandy Lean Clay)
R6	CL (Lean Clay with Sand)
K4	CL (Sand Lean Clay with Gravel)
K3	CL (Sandy Lean Clay)
K8	CL (Lean Clay with Sand)
MK1	CL (Lean Clay with sand)
MK2	CL (Gravely lean clay)
MK3	CL (Lean Clay with Sand)
MK4	CL (Lean Clay)
B1	CL (Lean Clay with Sand)
R10	CL (Lean Clay with Sand)
B2	CL (Sand Lean Clay with Gravel)

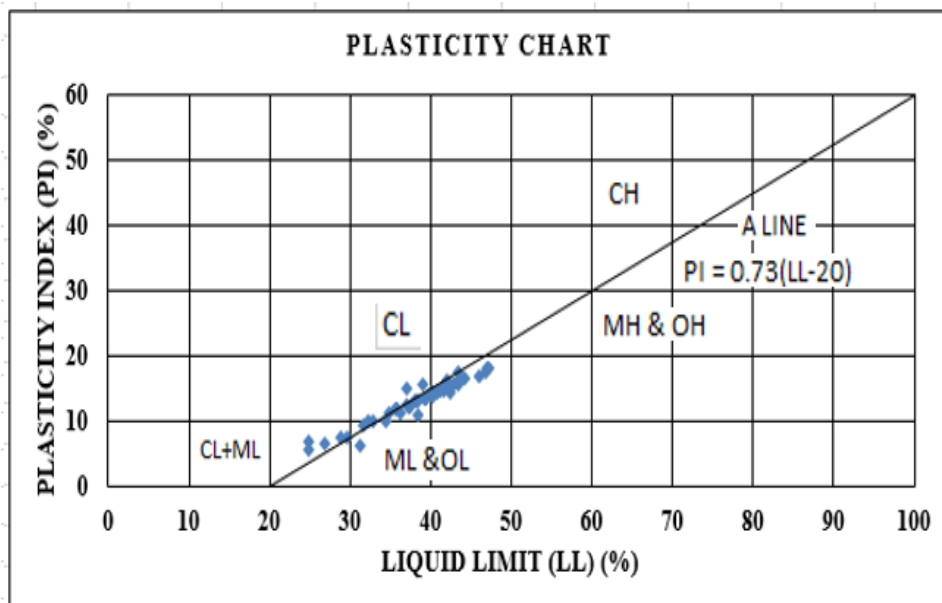


Figure 4.1: Plasticity chart showing all soils being classified

4.2 THREAD ROLLING

On 51 soil samples, thread rolling tests for plastic limits were conducted using the test method outlined in part 2 of BS 1377, 1990. For each of the test soils, at least four tests were undertaken and the average taken as the conventional plastic limit, PL. For all the test soils the PL ranged between 11 and 40, and are presented in Table 4.6.

4.3 PLASTICITY INDEX (PI)

Results of the plasticity index, which represents the distinction between the liquid and plastic limits, are presented in Table 4.6.

4.4 QUASI-STATIC CONE TESTS

The results of quasi-static cone experiments, from which quasi-static liquid and plastic limits, are presented in this section. Also presented are results of preliminary investigations on quasi-static cone penetration load versus depth relationships as shown in Table 4.4.

4.5 COMPRESSION INDEX FOR SOILS

All 51 samples underwent the Oedometer test, the details of which are described in Chapter 3. The compression index was determined from the Oedometer test and the results are tabulated in the Table 4.6

4.6 PRELIMINARY TESTS

4.6.1 Accuracy of Quasi-Static Equipment

The quasi-static equipment was tested for its accuracy (Standardization). This was done by comparing the LL values of the fall cone apparatus and that of the quasi-static equipment. These were found to be in agreement for the same sample of soil as shown in Table 4.2.

Table 4.2: Testing accuracy of quasi static equipment for Liquid Limit LL

Sample Test No	Fall cone test (LL) values	Quasi static equipment	Percentage accuracy
1	36.2	36.4	99%
2	40.8	40.1	98%
3	42.3	42.7	99%
4	38.7	38.1	98%
5	44.6	44.3	99%

Table 4.3: Testing accuracy of quasi static equipment for Plastic Limit PL

Sample Test No		Fall cone test (PL) values	Quasi static equipment	Percentage accuracy
1		15.8	16.2	98%
2		14.5	13.7	94%
3		17.4	16.3	94%
4		12.8	13.5	95%
5		16.5	15.6	95%

4.6.2 Quasi-static Cone Tests for Fine Soils

The 51 soils were tested using quasi-static cones in various plastic ranges. The results for a typical soil sample R3 are tabulated in Table 4.4 and a sample graph is plotted in Figure 4.2 and Figure 4.3 for soil sample R3 at moisture content 41% which is an example of the sample that was tested. Other samples results are attached in the appendix A.

4.6.3 Determination of Applied Force vs Depth and Depth²

For all sample tested, a plot of force vs depth of penetration and force vs depth² of penetration was produced for all the 51 samples and sample graphs are plotted as in Figure 4.2 and Figure 4.3. The graph of applied force vs depth of penetration squared were found to be more accurate and therefore were adopted and the rest of the graphs are given in appendix A. This is in line with the findings of Koumoto and Houlsby's study from 2001, which claims that the use of expressions for determining index strength is based on the linearity assumption of the relationships between penetration load and depth squared.

For some of the soils it is observed that some of the loads versus depth squared relationships are not entirely linear. This may be, among other factors, attributed to the load recording mechanism (load-cell) of the quasi-static cone devices. However, even with the curvature in the load versus depth squared relationships, linear regression curves indicated correlation factors (R) generally above 0.92.

Table 4.4: Applied force against penetration depth d and d²

Depth of penetration(d) mm	Depth d ²	Applied force
0	0.0	0
2.5	6.3	18.4
6.4	41.0	34.29
12.3	151.3	46.32
19.1	364.8	57.96
22.6	510.8	85.18
30.3	918.1	110.1
33.7	1135.7	145.73

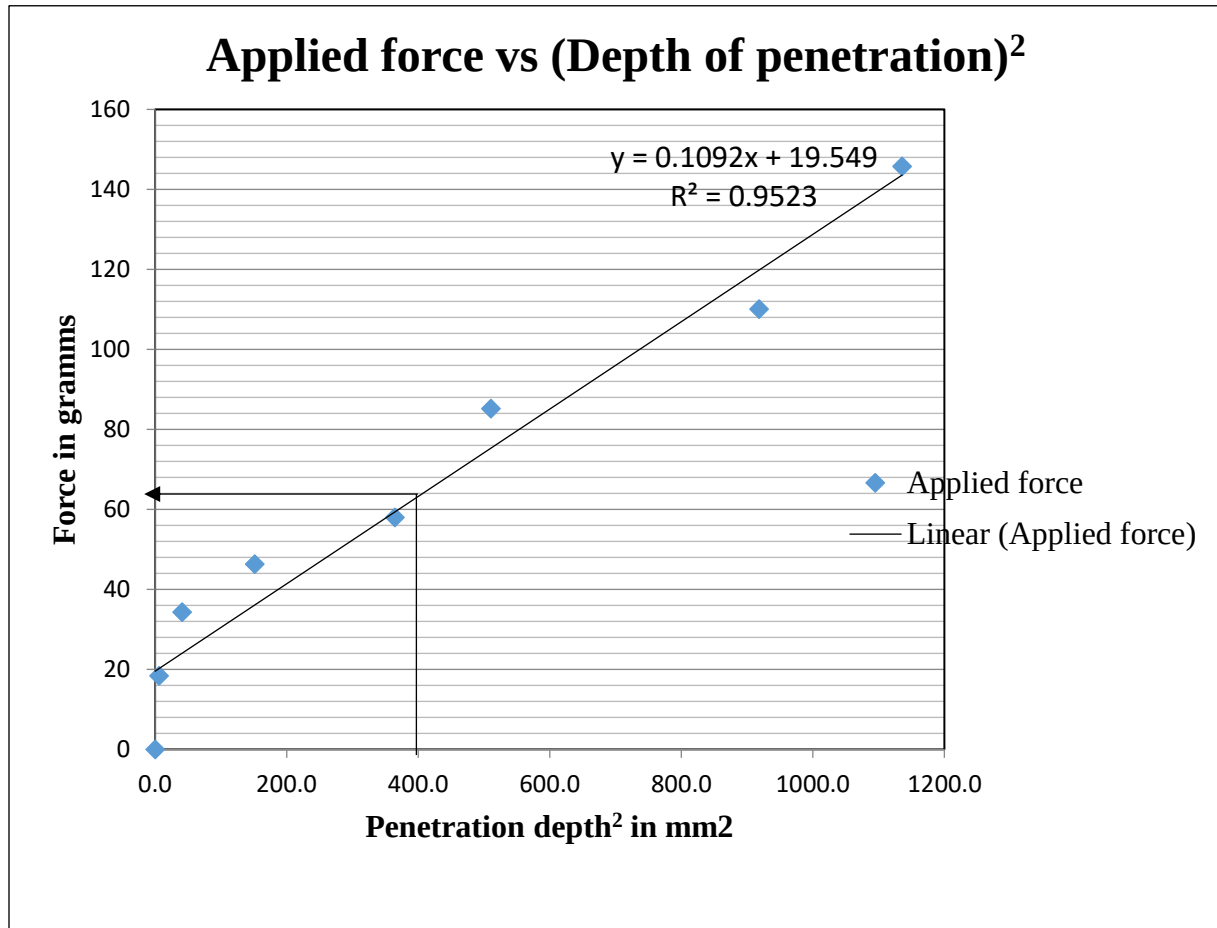


Figure 4.2: A graph of Applied force (N) vs Penetration depth²(mm)

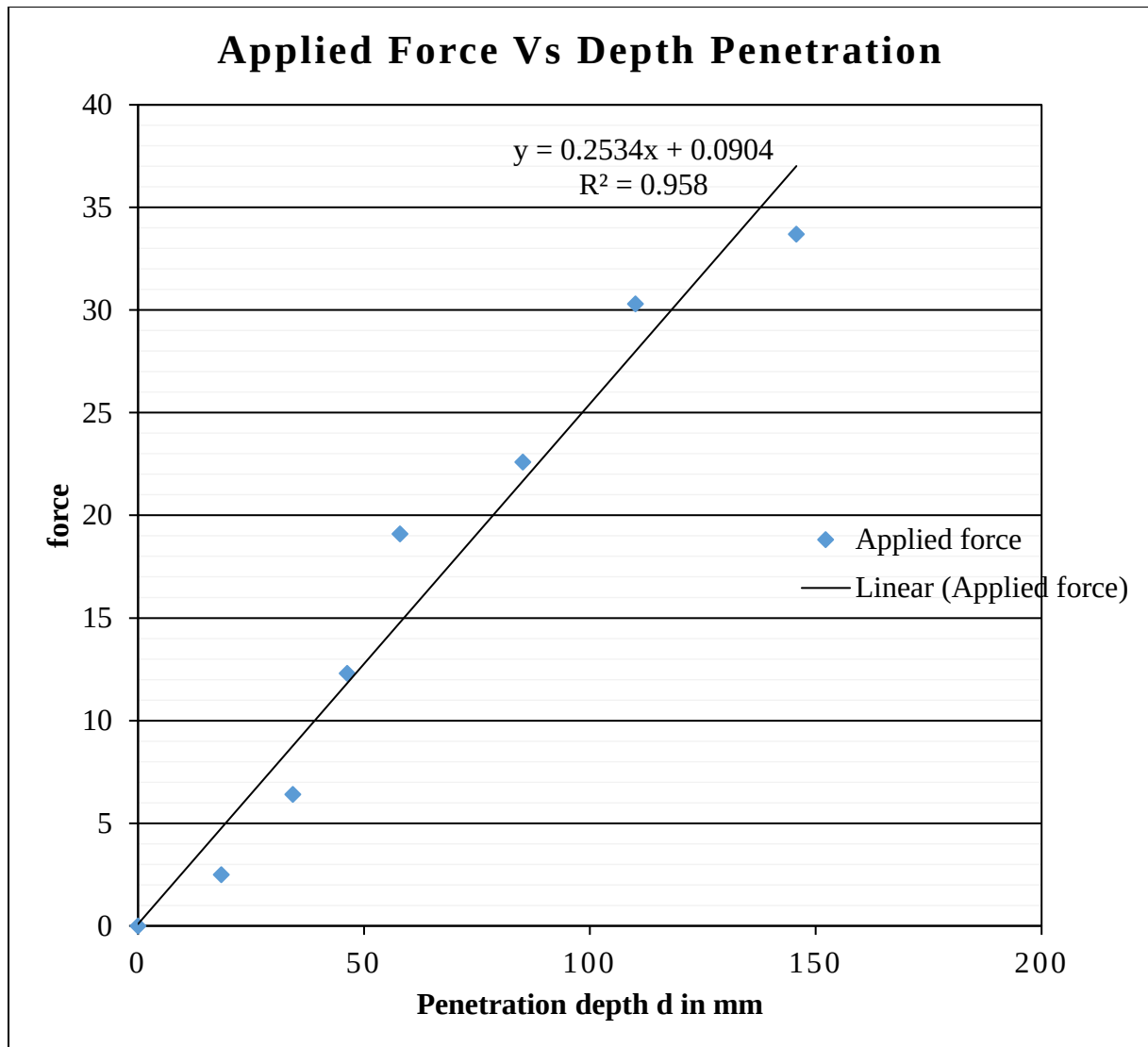


Figure 4.3: A graph of Applied force (N) vs Penetration depth (mm)

4.6.4 Determination of Appropriate Depth

A plot of force per sample for all the 51 samples was made as shown in figure 4.4 and figure 4.5 at 10mm, 20mm and 30mm depth of penetration on the same graph. The aim was to determine which of these penetration depths is consistent and therefore appropriate.

From figures 4.4 and 4.5, it is seen that the values for 20mm penetration is the most approximate for the straight horizontal line.

As a result, the determination of the liquid limit and plastic limit is best done at a penetration depth of 20 mm.

The use of static penetration load eliminates the need for extrapolation to larger loads, such as 80 gf required in earlier approaches (Stone and Kyambadde 2005 and 2007). The penetration load associated with a depth of 20mm is established by a line drawn vertically on horizontal axis towards the slope line and is correspondent to the line drawn horizontally towards the vertical axis interpolation from Applied force versus depth squared (d^2) relationship for a quasi-static cone test conducted at plastic and liquid limit of a cohesive soil.

4.6.5 Quasi-static Cone Penetration Load for Depth 20mm

Appropriate penetration depths associated with the quasi-static cone penetration loads were employed in order to evaluate alternative atterberg limit parameters from quasi-static cone tests that are directly similar to the traditional fall-cone liquid limit (LL) and thread rolling plastic limit (PL). The penetration depth associated with the quasi-static load was obtained by interpolation from quasi-static cone load versus depth squared relationships illustrated in the graph of Figure 4.2 and Appendix A.

For the entire 51 test soils, the quasi-static cone load versus depth at plastic relationships are presented in the graph of Figure 4.3; from which the load associated with depth at 20mm, were determined and a summary of forces at a given depth per sample is presented in the Table 4.5

Table 4.5: Quasi-Static Force at given Depth

No of Sample	Sample Name	Penetration depth @ d ² for PI			Penetration depth @ d ² for LL		
		100mm	400mm	900mm	100mm	400mm	900mm
1	k23	256	1021	2296	23	62	116
2	k22	533	1012	1810	31	62	113
3	R2	362	1021	2120	37	61	101
4	MK4	465	1035	1986	41	66	108
5	MK3	551	1030	1828	39	64	106
6	MK2	501	1030	1912	37	65	111
7	MK1	427	1031	2037	41	64	103
8	K12	262	953	2105	30	55	97
9	K11	471	1013	1915	37	60	99
10	N3	288	1027	2258	35	64	112
11	N2	340	1008	2121	27	63	123
12	N1	444	1030	2007	38	64	107
13	K9	331	1025	2182	32	61	109
14	C8	557	1042	1850	42	62	96
15	C7	536	1045	1894	33	63	113
16	K6	557	1048	1866	38	65	111
17	K5	572	1034	1804	35	60	103
18	K2	561	990	1706	31	58	104
19	C5	329	989	2089	33	55	92
20	C6	355	940	1915	22	53	104

No of Sample	Sample Name	Penetration depth @ d ² for PI			Penetration depth @ d ² for LL		
		100mm	400mm	900mm	100mm	400mm	900mm
21	C4	471	985	1842	23	54	105
22	K1	457	995	1891	23	51	97
23	C3	474	996	1867	35	58	96
24	C2	564	1011	1757	35	60	101
25	C1	496	1010	1869	30	57	103
26	R10	525	1061	1955	35	64	112
27	K16	546	1025	1824	25	61	120
28	K10	473	1011	1907	33	57	97
29	S6	460	1002	1905	32	58	102
30	R11	469	1013	1920	32	59	104
31	R1	472	1019	1931	29	61	114
32	B4	477	1034	1962	20	65	140
33	B6	494	1049	1973	38	65	111
34	B5	475	1039	1979	36	63	109
35	R7	613	1023	1706	32	64	117
36	B3	575	1044	1825	32	60	106
37	B2	370	1064	2221	19	63	137
38	B1	623	1082	1847	33	63	113
39	K7	661	1012	1596	36	63	107
40	K8	617	1028	1713	32	64	118

No of Sample	Sample Name	Penetration depth @ d ² for PI			Penetration depth @ d ² for LL		
		100mm	400mm	900mm	100mm	400mm	900mm
41	K3	507	1036	1917	24	65	134
42	K4	708	1026	1802	24	63	129
43	R6	555	1058	1897	30	61	113
44	A6	552	1035	1839	25	63	127
45	A5	507	988	1790	28	55	101
46	A4	614	1020	1697	32	60	106
47	R5	417	980	1919	34	55	90
48	A3	599	1010	1695	26	57	109
49	A2	587	1024	1752	30	64	121
50	A1	607	1030	1735	26	66	133
51	R3	644	1034	1684	30	63	118

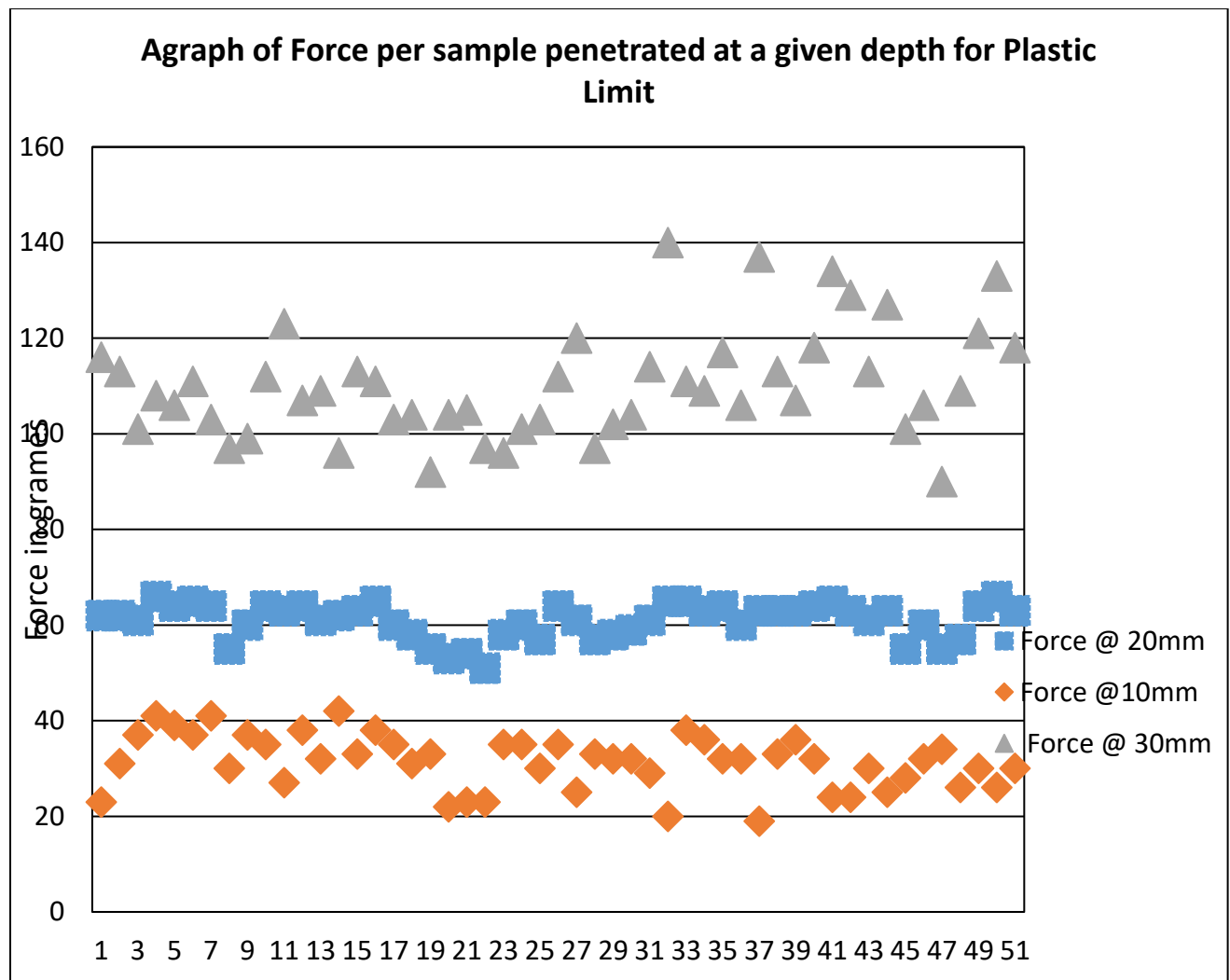


Figure 4.4: A graph of force per sample penetrated at a given depth of plastic limit.

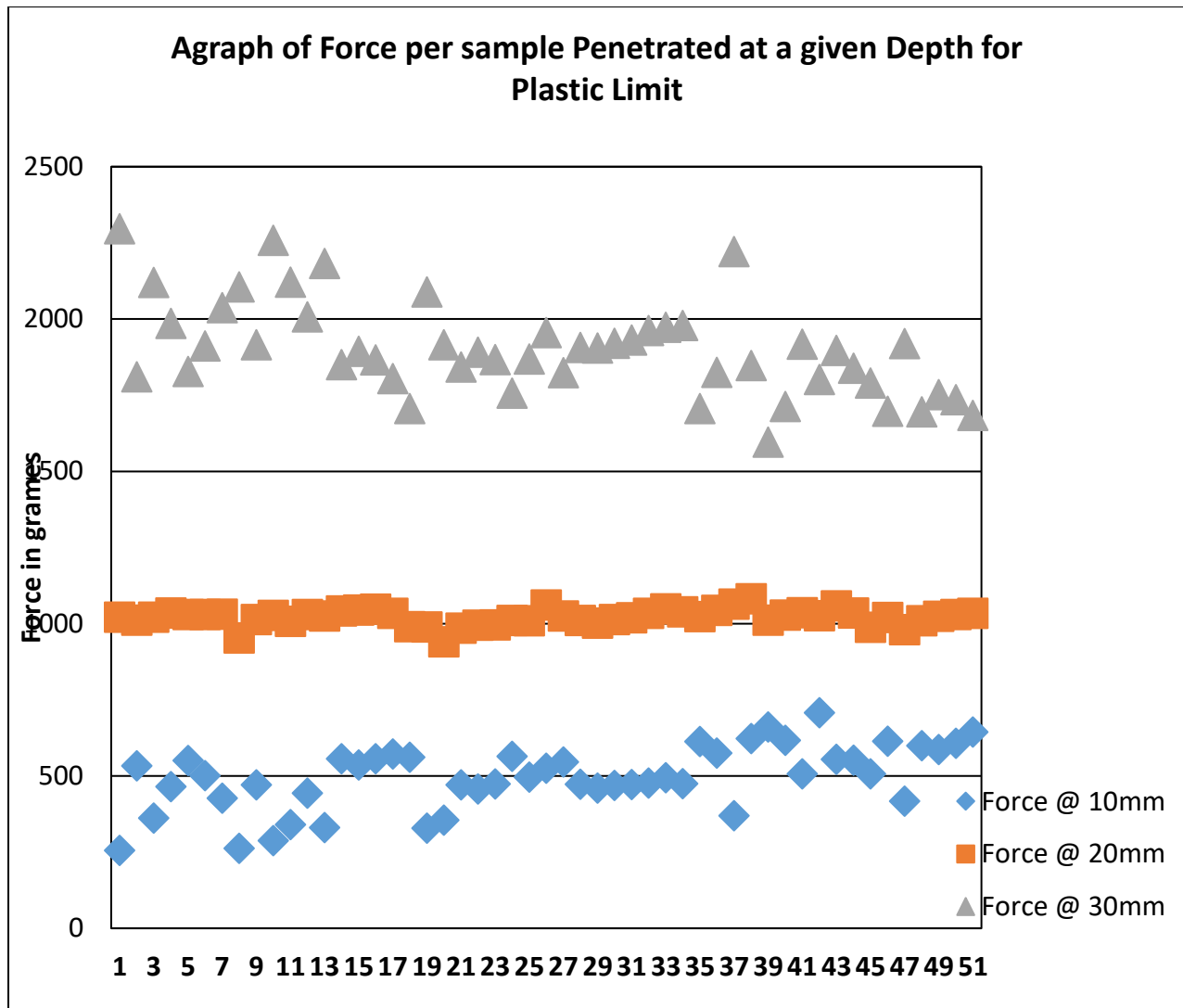


Figure 4.5: A graph of force per sample penetrated at a given depth of liquid limit.

The reason for a reference penetration depth of 20mm is based on Figure 4.4 and Figure 4.5, which shows forces penetrated at a given depth. The results indicate that there is a large variation in the forces at penetration depth of 30mm and 10mm but at 20mm there is an observable consistency in the forces for all the soil samples that were tested and also the depth of the BS 1377 fall-cone, enabling estimation of alternative quasi-static cone-based index parameters that may be directly comparable to the fall-cone liquid limit (LL).

4.7 ANALYSIS

Analyses of the results are presented in this section and the experimental testing programme reported from Figure 4.1 to Figure 4.8. The analysis is concerned with:

- I. The development of alternative method for determining Atterberg limits based on quasi-static cone penetration tests which provide upper and lower strength indices similar to the conventional BS 1377 liquid limit (LL) and plastic limit (PL)
- II. To develop the empirical relationship between conventionally derived consistency limits and Compression Index.
- III. To develop the empirical relationship between Quasi static cone Penetrations and Compression Index.

Table 4.6: Atterberg limits, Compression Index and Quasi-static force

Sample Name	Liquid Limit(LL)	Plastic Limit (PL)	Plasticity Index (PI)	CI	Quasi-static cone tests		Predicted PL	Predicted LL	Predicted PI	Predicted CI
					(plastic limit)Force at 20mm	(liquid limit)Force at 20mm				
C4	24.9	19.4	5.6	0.296	985	54	20.1	27.7	7.6	0.314
C6	24.8	17.9	7	0.2879	940	54	19.4	27.6	8.1	0.312
C5	31.6	22.3	9.3	0.345	989	55	23.0	34.5	11.5	0.364
K2	32.2	22.3	9.9	0.3456	990	58	23.0	33.3	10.3	0.357
K12	26.8	20.2	6.6	0.3098	953	55	21.6	29.2	7.6	0.328
R5	28.9	21.5	7.4	0.3324	980	55	22.4	31.5	9.1	0.344
A5	29.7	22.3	7.4	0.3456	988	55	23.0	32.4	9.4	0.351
K1	32.9	23	9.9	0.3545	995	51	23.6	38.7	15.1	0.391
S6	34.8	23.7	11.1	0.3678	1002	58	24.1	36.0	11.9	0.376
				CI	Quasi-static cone tests					

Sample Name	Liquid Limit(LL)	Plastic Limit (PL)	Plasticity Index (PI)		(plastic limit)Force at 20mm	(liquid limit)Force at 20mm	Predicted PL	Predicted LL	Predicted PI	Predicted CI
A4	38.1	24.9	13.1	0.389	1020	60	24.9	38.1	13.2	0.391
R7	39	23.5	15.5	0.3987	1023	64	23.4	36.6	13.1	0.378
R1	38.5	25.3	13.2	0.3956	1019	61	25.3	37.9	12.5	0.391
K10	34.4	24.4	10	0.3797	1011	57	24.6	36.2	11.6	0.379
K11	37.3	25	12.3	0.3867	1013	60	25.2	37.3	12.1	0.387
A3	37.1	24.7	12.4	0.3852	1014	57	24.8	39.1	14.2	0.397
C1	36.3	25	11.3	0.3789	1010	57	25.2	38.2	13.0	0.393
C2	35.6	23.6	12	0.3665	1011	60	23.8	35.6	11.8	0.373
C3	31.3	25	6.3	0.3568	996	58	25.6	32.4	6.8	0.359
K16	37.1	22	15.1	0.3921	1025	61	21.9	36.5	14.6	0.373
R2	35.9	24.2	11.7	0.3762	1021	62	24.2	34.7	10.6	0.369
k22	38.3	25.1	13.2	0.3915	1011.8	62	25.3	37.1	11.8	0.386
k23	37.4	25.2	12.2	0.3945	1021	62	25.2	36.2	11.0	0.381
A6	39.3	25.8	13.5	0.4012	1035	63	25.4	37.4	12.0	0.389
B4	40.3	26.5	13.8	0.4156	1034	65	26.1	37.2	11.1	0.390
B5	42.8	27.2	15.6	0.4267	1039	63	26.7	40.8	14.1	0.413
B6	44.2	27.8	16.4	0.4368	1049	65	27.0	40.8	13.8	0.414
B3	43.5	26	17.5	0.4321	1044	60	25.4	43.5	18.1	0.425
R11	40.2	26	14.2	0.4079	1021	61	26.0	39.5	13.6	0.403
R3	38.5	27.7	10.8	0.4029	1034	63	27.3	36.7	9.3	0.390
A1	41.4	26.6	14.9	0.4167	1030	66	26.3	37.6	11.3	0.393
				CI	Quasi-static cone tests					

Sample Name	Liquid Limit(LL)	Plastic Limit (PL)	Plasticity Index (PI)		(plastic limit)Force at 20mm	(liquid limit)Force at 20mm	Predicted PL	Predicted LL	Predicted PI	Predicted CI
A2	42	25.9	16.1	0.4056	1024	64	25.8	39.4	13.6	0.402
K5	41.8	26.7	15.1	0.4198	1034	60	26.3	41.8	15.5	0.418
K6	43.4	27.9	15.6	0.4387	1048	65	27.2	40.1	12.9	0.410
C7	42.4	27	15.4	0.4237	1045	63	26.4	40.4	14.0	0.409
C8	42.4	27.9	14.5	0.4384	1042	62	27.3	41.0	13.7	0.416
K9	39.4	26	13.4	0.4021	1025	61	25.9	38.8	12.9	0.398
K7	43.2	27.3	15.9	0.4297	1012	63	27.5	41.1	13.6	0.417
N1	40.3	26.1	14.2	0.4086	1030	64	25.8	37.8	11.9	0.392
N2	40.2	26	14.2	0.4076	1008	63	26.3	38.3	12.0	0.397
N3	40.2	26	14.2	0.4079	1027	64	25.8	37.7	11.9	0.392
R6	46.1	29	17	0.4579	1058	61	28.0	45.3	17.4	0.444
K4	39.9	25.9	14	0.4057	1026	63	25.7	38.0	12.3	0.393
K3	41.3	26.5	14.8	0.4156	1035.5	65	26.1	38.1	12.0	0.395
K8	40.1	26	14.1	0.4067	1028	64	25.8	37.6	11.8	0.391
MK1	40.9	26.3	14.5	0.4125	1031	64	26.0	38.3	12.3	0.396
MK2	41.7	26.2	15.4	0.4112	1030	65	25.9	38.5	12.5	0.397
MK3	40.7	26.2	14.4	0.4111	1030	64	25.9	38.2	12.2	0.395
MK4	41.7	27	14.7	0.4187	1035	62	26.6	40.4	13.7	0.410
B1	47	29	18	0.4578	1082	62	27.3	45.5	18.1	0.443
R10	47.2	29.1	18.1	0.4589	1061	64	28.0	44.3	16.3	0.437
B2	46.9	29.5	17.4	0.4567	1064	63	28.3	44.7	16.4	0.441

4.7.1 20mm Depth Quasi-Static Cone Penetration Load at LL (LL_{qc})

Denoted LL_{qc}, the quasi-static cone load associated with LL is obtained from the load versus penetration depth squared at liquid limit in figure 4.2. For 51 test soils, LL_{qc} ranged from 51 gf to 66 gf: overall averaging about 60.88 gf. Values of LL_{qc} are summarized in Table 4.6. The above quasi-static force of 60.88 gf is approximately similar to Swedish fall cone of 60gf. From the experimental results we state that the LL_{qc} is the quasi-Static load associated LL at 60gf and can be denoted by QL₆₀.

Therefore, we define QL₆₀ (Quasi static liquid limit) as the moisture content in the soil sample at which the quasi-static force of 60gf can penetrate a soil sample up to a depth of 20mm.

4.7.2 20mm depth Quasi-static Cone Penetration load at PL (PL_{qc})

Denoted PL_{qc}, the quasi-static cone load associated with PL is obtained from the load versus penetration depth squared at Plastic limit in Table 4.4. For 51 test soils, PL_{qc} ranged from 940 gf to 1082 gf: overall averaging about 1020.93 gf. Values of PL_{qc} are summarized in Table 4.6. We can state that the PL_{qc} is 1020 gf and can be denoted by QP₁₀₂₀.

Therefore, we can define QP₁₀₂₀ (Quasi static Plastic limit) as the moisture content in the soil sample at which the quasi-static force of 1020gf can penetrate a soil sample up to a depth of 20mm.

4.7.3 Model 1; Correlation between Compression index and Liquid limit (LL).

The following single linear equation and its related coefficients represent the regression study associating Compression Index with LL.

$$CI = 0.0072LL + 0.118 \dots \dots \dots \text{Equation 2}$$

With $R = 0.990$, $R^2 = 0.979$.

The statistical output's specifics show that the association between liquid limit and CI has been developed and is statistically significant ($\alpha > 0.05$). This suggests that LL and CI have a significant association for all soil samples. According to the calculated Pearson's correlation coefficient (R), liquid limit is a reliable indicator of CI. According to the findings, as shown in Figure 4.6, the liquid limit rises as the compression index rises. This is seen in the Ofosu (2013) and Kok Shien Ng (2018) and a great number of studies have shown that there is a relationship between LL and CI with less uncertainties.

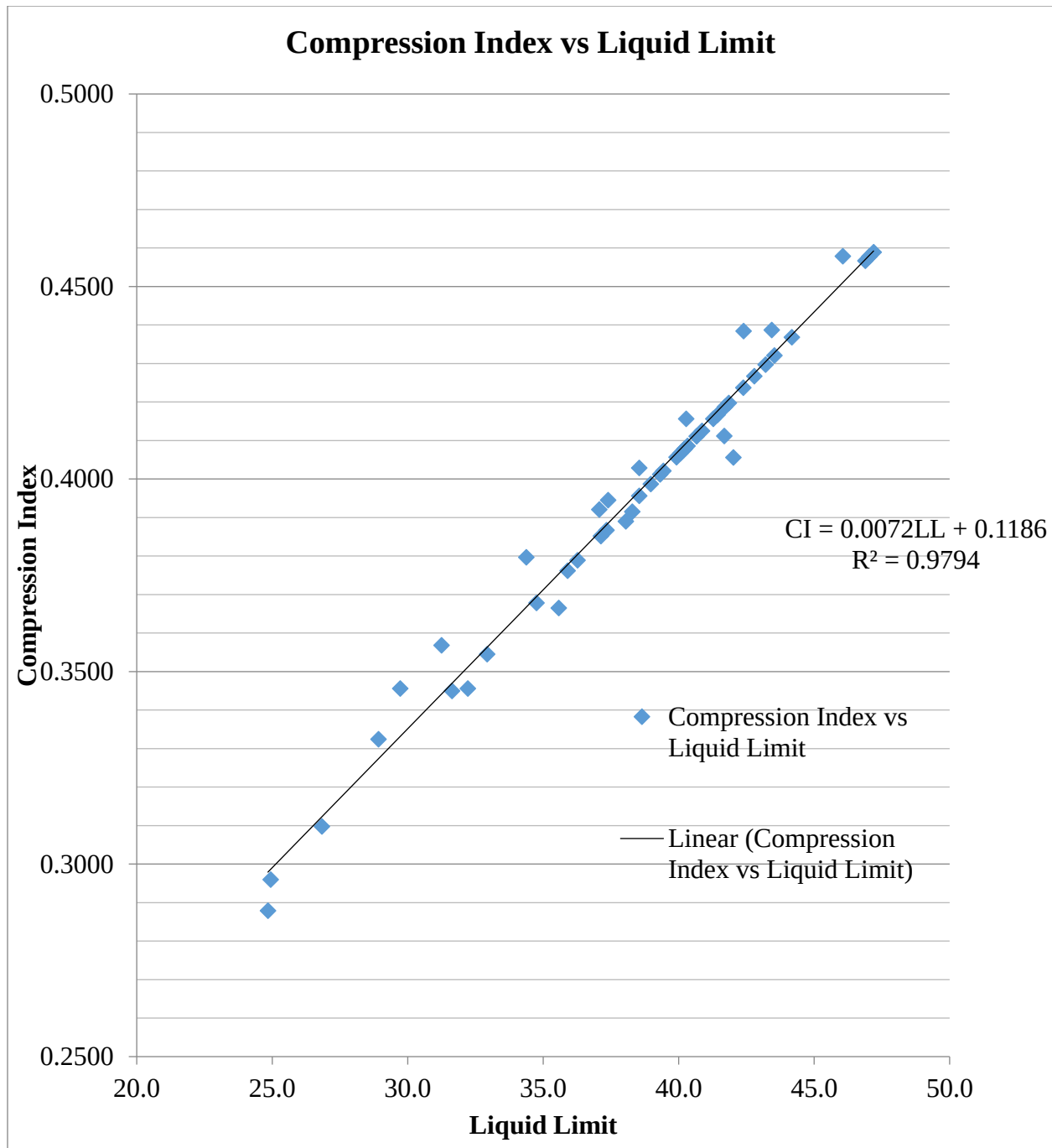


Figure 4.6: Shows compression index against liquid limit

4.7.4 Model 2: Correlation between Compression Index and Plastic Limit (PL)

The following single linear equation and its accompanying coefficient describe the regression analysis after connecting CI with PL.

$$CI = 0.0153PL + 0.010 \dots \dots \dots \text{Equation 3}$$

with $R = 0.956$, $R^2 = 0.913$.

Therefore, 95.6% of the variance in CI can be accounted for by PL. The details of the statistical output indicate that the relationship developed between plastic limit and CI is statistically significant ($\alpha > 0.05$). This implies there is a relationship between plastic limit and CI. The Pearson's correlation coefficient (R) obtained indicates that plastic limit is a good predictor for CI.

The graphs indicate there is a significant level of correlation. This means that there is high correlation between compression index and plastic index. From the graph presented in Figure 4.7, it is clear that plastic limit increases with an increase in compression index as seen in Ofosu (2013) and Kok Shien Ng (2018) clay soil exhibits this property to a high degree with high Plastic limit. This may explain why soil containing high plastic limit, possess high compression index.

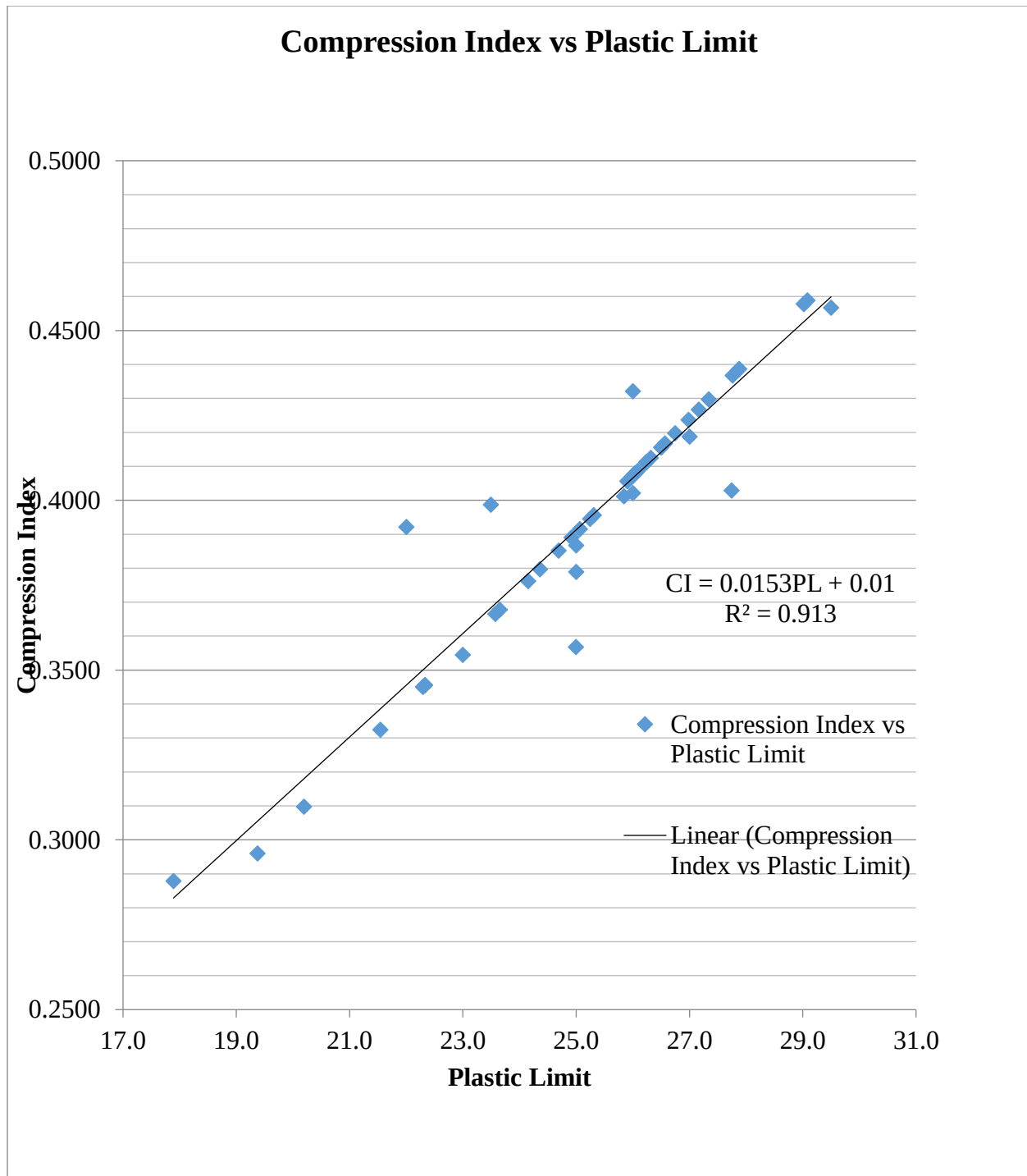


Figure 4.7: shows Graph of Compression Index vs Plastic Limit

4.7.5 Model 3: Correlation between Compression Index and Plasticity index (PI)

Following CI and plasticity index correlation, the regression analysis is given by the single linear equation and its associated coefficient as follows

$$CI = 0.0115PI + 0.245 \dots\dots\dots \text{Equation 4 with } R = 0.934, R^2 = 0.873.$$

Therefore, the PI can predict CI variable. The details of the statistical out-put indicates that the relationship developed between plasticity index and CI is significant ($\alpha > 0.05$). This suggests that PI and CI have a positive association. The Pearson's correlation coefficient (R) obtained indicates that plasticity index is a good predictor for CI.

The graphs indicate there is a significant level of correlation. This means that there is high correlation between compression index and plasticity index. From the graph presented in Figure 4.8, it is clear that plasticity index increases with an increase in compression index.

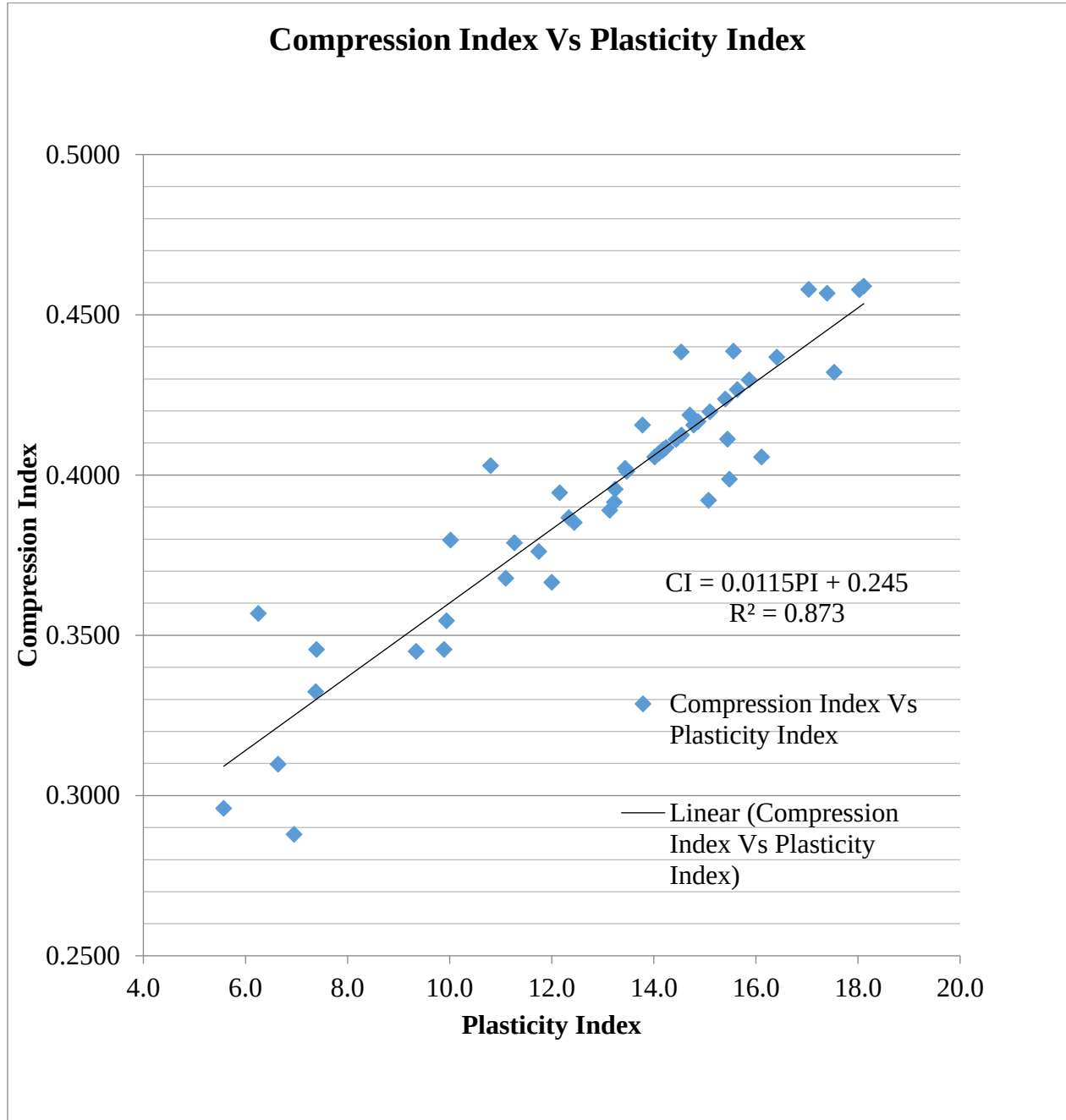


Figure 4.8: shows a graph of Compression index vs Plasticity index

4.7.6 Multiple Linear Regression Analysis

51 samples ($n = 51$) were subjected to a multiple linear regression analysis, and the following results were attained after a variety of potential predictor combinations were tested. Model 4: It was done to correlate the CI with the Plastic Index and Plastic Limit. A single linear expression with its matching coefficients makes up the regression model that was obtained.

$$CI = 0.006PI + 0.009PL + 0.088 \dots \dots \dots \text{Equation 5}$$

with $R = 0.993$, $R^2 = 0.985$.

Thus, predicting 98.5% of the variance in CI can be accounted for by the PI and PL. The details of the statistical out-put indicates that the relationship developed between plasticity index, Plastic limit and CI is statistically significant ($\alpha > 0.05$).

4.7.7 Model 5:

The correlation between the Plasticity Index, the CI, and the liquid limit was done. The final regression model is a single linear expression, and the related coefficients are as follows.

$$CI = 0.0092LL - 0.0035PI + 0.0876 \dots \dots \dots \text{Equation 6}$$

With $R = 0.993$, $R^2 = 0.985$

Thus, predicting 98.5% of the variance in CI can be accounted for by the PI and LL. The details of the statistical out-put indicate that the relationship developed between plasticity index, liquid limit and CI is statistically significant ($\alpha > 0.05$).

4.7.8 Model 6:

Correlation between CI and plastic limit and liquid limit was carried out.

The regression model that was produced is a single linear expression, and its corresponding coefficients are given by

$$CI = 0.006LL + 0.004PL + 0.088 \dots \dots \dots \text{Equation 7}$$

with $R = 0.993$, $R^2 = 0.985$.

Thus predicting 98.5% of the variance in CI can be accounted for by the LL and PL. The details of the statistical out-put indicate that the relationship developed between plasticity limit, liquid limit and ci is statistically significant ($\alpha < 0.05$).

4.7.9 Model 7:

Correlation between CI and plastic limit, Plasticity Index and liquid limit was carried out. The resulting regression model is a single linear expression, and its corresponding coefficients are as follows:

$$CI = 0.0099PL + 0.0064PI - 0.0007LL + 0.0871 \dots \dots \dots \text{Equation 8}$$

with $R = 0.993$, $R^2 = 0.985$.

Thus predicting 98.5% of the variance in CI can be accounted for by the PI, LL and PL. The details of the statistical out-put indicate that the relationship developed between plasticity limit, liquid limit and ci is statistically significant ($\alpha < 0.05$).

4.8 EMPIRICAL RELATIONSHIP BETWEEN COMPRESSION INDEX AND QUASI STATIC CONSISTENCY LIMITS.

The correlation between CI consistency indicate a statistically significant relationship. Empirical relationships were developed basing on replacing quasi static consistency limits with conventionally derived consistency limits developed in equations 1 to 6 as follows;

4.8.1 Model 8: Empirical Relationship between Compression Index and Quasi Static Liquid limits.

From the equation 1, $CI = 0.0072LL + 0.1186$ the empirical relationship between the CI and quasi static liquid limit was developed as shown in equation 9

$$CI = 0.0072QL_{60} + 0.1186 \dots\dots\dots \text{Equation 9}$$

where

CI = Compression Index.

QL_{60} = Quasi static Liquid limit (Moisture content in the soil sample at which the quasi-static force of 60gf penetrate the soil sample up to 20mm).

However, this was a weak relationship and therefore not good to predict the Compression Index.

4.8.2 Model 9: Empirical Relationship between Compression Index and Quasi static Plastic Limits.

From the equation 2; $CI = 0.0153PL + 0.010$ the empirical relationship between the CI and quasi static plastic limit was developed as shown in Equation 10

$$CI = 0.0153QP_{1020} + 0.010 \dots\dots\dots \text{Equation 10}$$

Where

CI = Compression Index

QP_{1020} = Quasi static plastic limit (Moisture content in soil sample at which the quasi-static force of 1020gf penetrate the soil sample up to 20mm

4.8.3 Model 10: Empirical Relationship between CI and Quasi static Plasticity Index.

From the equation 3; $CI = 0.0115PI + 0.245$ the empirical relationship between the CI and quasi static plasticity index was developed as shown in Equation 11

$$CI = 0.0115QPI + 0.245 \dots\dots\dots \text{Equation 11}$$

Where

CI = Compression Index.

QPI = Quasi static plasticity index ($QPI = QL_{60} - QP_{1020}$)

4.8.4 Model 11: Empirical Relationship between CI, Quasi static plastic limit and Quasi static Plastic Index.

From the equation 4; $CI = 0.006PI + 0.009PL + 0.088$ the empirical relationship between the CI, QP_{1020} and QPI was developed as shown in Equation 12

$$CI = 0.006QPI + 0.009QP_{1020} + 0.088 \dots\dots\dots \text{Equation 12}$$

4.8.5 Model 12: Empirical Relationship between CI, Quasi static Liquid Limit and Quasi static Plastic Index.

From the equation 5; $CI = 0.0092LL - 0.0035PI + 0.0876$ the empirical relationship between the CI, QP_{1020} and QPI was developed as shown Equation 13

$$CI = 0.0092QL_{60} - 0.0035QPI + 0.0876 \dots\dots\dots \text{Equation 13}$$

4.8.6 Model 13: Empirical Relationship between CI, Quasi static Liquid Limit and Quasi static Plastic Limit.

From the equation 6; $CI = 0.006LL + 0.004PL + 0.088$ the empirical relationship between the CI, QP_{1020} and QL_{60} was developed as shown Equation 14

$$CI = 0.005QP_{1020} + 0.006QL_{60} + 0.088 \dots\dots\dots \text{Equation 14}$$

4.8.7 Model 14: Empirical Relationship between CI, Quasi static Liquid Limit, Quasi static Plasticity Index and Quasi static Plastic Limit.

From the equation 6; $CI = 0.0099PL + 0.0064PI - 0.0007LL + 0.0871$ the empirical relationship between the CI, QP_{1020} , QPI and QL_{60} was developed as shown Equation 15

$$CI = 0.0099QP_{1020} + 0.0064QPI - 0.007QL_{60} + 0.088 \dots \dots \dots \text{Equation 15}$$

Table 4.7: Shows the Correlation between Compression index and the Atterberg limits

	CI	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)
CI	1	0.98975	0.95578	0.93442
Liquid Limit (LL)	0.98975	1	0.9396104	0.9641915
Plastic Limit (PL)	0.95578	0.9396104	1	0.815303985
Plasticity Index (PI)	0.93442	0.9641915	0.815303985	1

Each cell in the Table 4.7 clearly shows a Correlation Coefficient between two specific variables, which are strong and positive. The table also shows you that the strongest correlation is between Compression index and Liquid limit, which is 0.98975 and indicate a positive correlation. On the diagonal of the table 4.7, there exists a correlation coefficient 1, which simply means that all the parameter strongly correlate to each other positively.

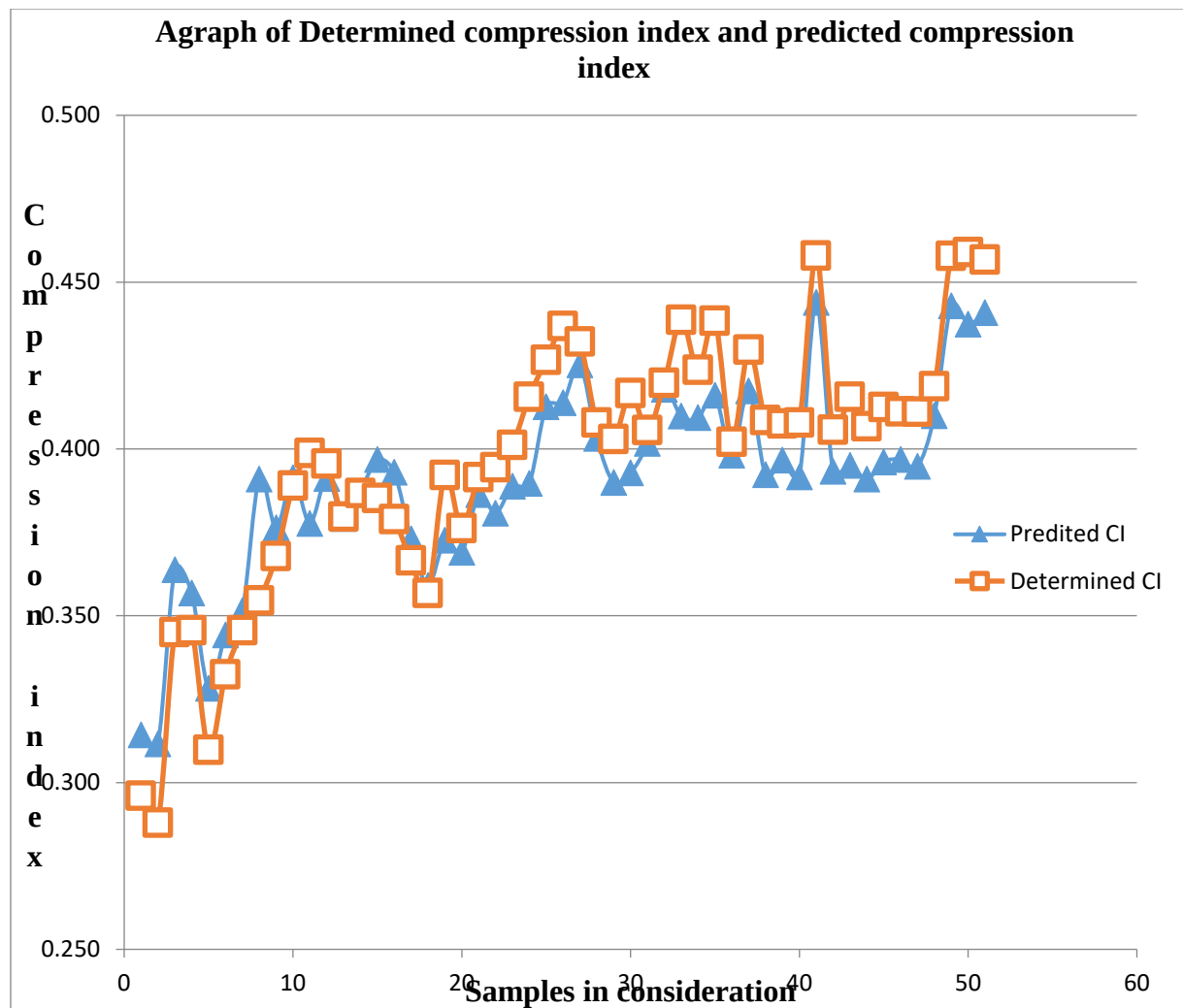


Figure 4.9: Show a Comparison of results of Oedometer test and Quasi-Static Tests

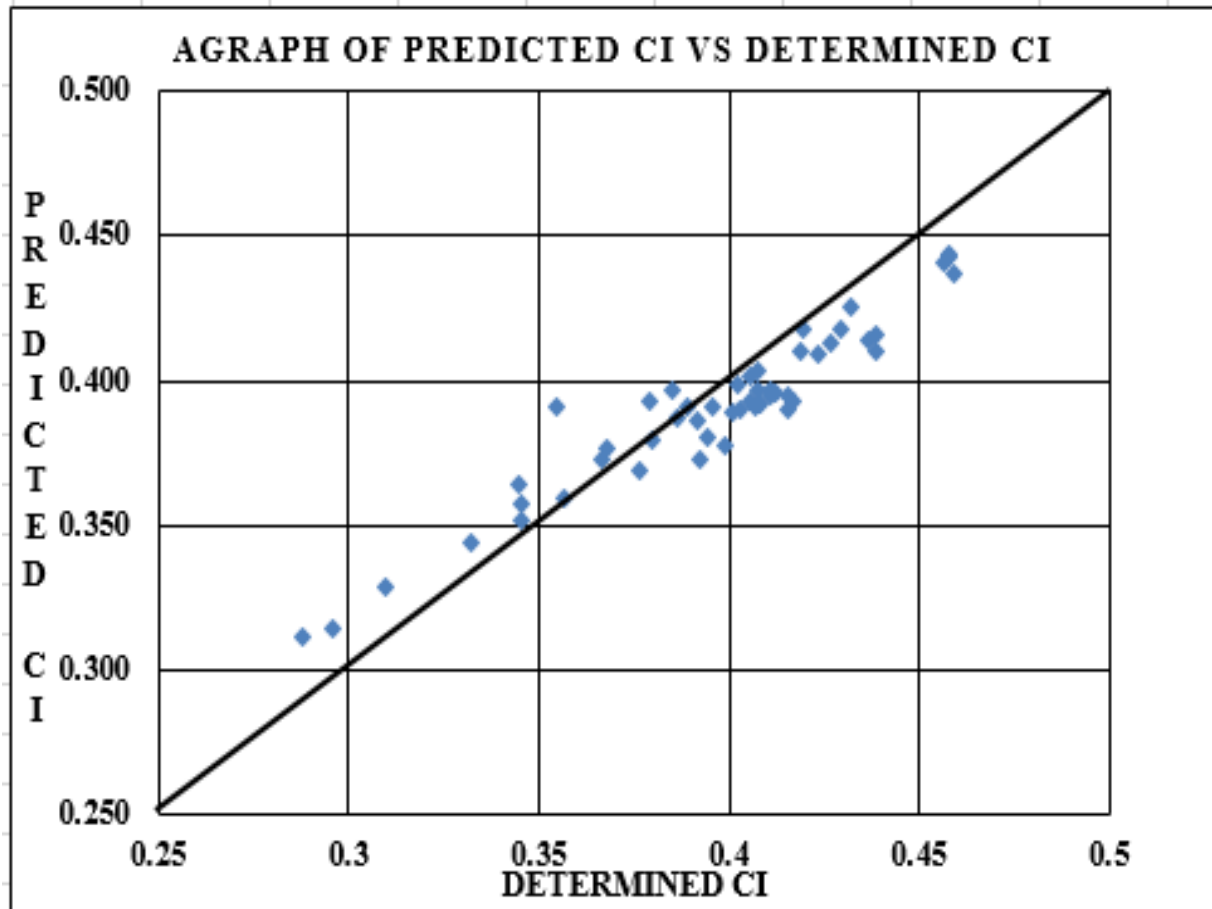


Figure 4.10: shows comparison between predicted CI and Determined CI

Figure 4.9 shows the performance of each sample between predicted CI and Determined CI. The best performance was observed to be sample K5 and the worst performance was also observed to be from sample K6. Therefore, sample K5 can be considered as optimum value for Quasi-static cone test. And Figure 4.10 shows the relationship between determined CI and predicted CI values obtained from Oedometer test and Quasi-Static Approach respectively. The model shows a very good correlation between Predicted CI and Determined CI and clearly shows that Predicted CI can be used to determine Laboratory results with a good prediction.

Table 4.8: Shows the results from RSV Consultants

Sample Test No	LL	PL	PI	CI	QUASI STATIC CI (Using Equation 12)	DIFF	Percentage Variation
A	44.7	35.1	9.6	0.434	0.4615	0.0275	6%
B	37.2	24.8	12.4	0.386	0.3856	0.0004	0%
C	33.5	24.4	9.1	0.360	0.3622	0.002	1%
D	33.5	23.4	10.1	0.358	0.3592	0.0012	0%
E	43.5	30.3	13.2	0.390	0.4399	0.050	13%
F	30.4	20.4	10	0.3422	0.3316	0.0106	3%
G	27.4	21.7	5.7	0.3244	0.3175	0.0069	2%
H	38.2	25.5	12.7	0.3982	0.3937	0.0045	1%
I	45.5	31.8	13.7	0.413	0.4564	0.043	11%
J	42.9	27.4	15.5	0.4355	0.4276	0.0079	2%

Table 4.8 below shows results from RSV consultants in comparison with the Quasi static results of compression index. Three of the samples which include A, E and I indicated that there was a big difference from the quasi-static result in relation with results from RSV however 7 samples showed a slight similarity of results. Based on the results in Table 4.8, this shows that of the three samples the difference in results could have been due to human errors associated with the thread rolling hence quasi static gave more accurate results. Figure 4.12 shows the performance of each sample between predicted CI and Determined CI from RSV laboratory. The best performance was observed be sample B and D and the worst performance was also observed to be of sample E. And Figure 4.11

shows the relationship between determined CI and predicted CI values obtained from Oedometer test and Quasi-Static Approach respectively. The model shows a very good correlation between Predicted CI and Determined CI and clearly shows that Predicted CI can be used to determine Laboratory results with a good prediction.

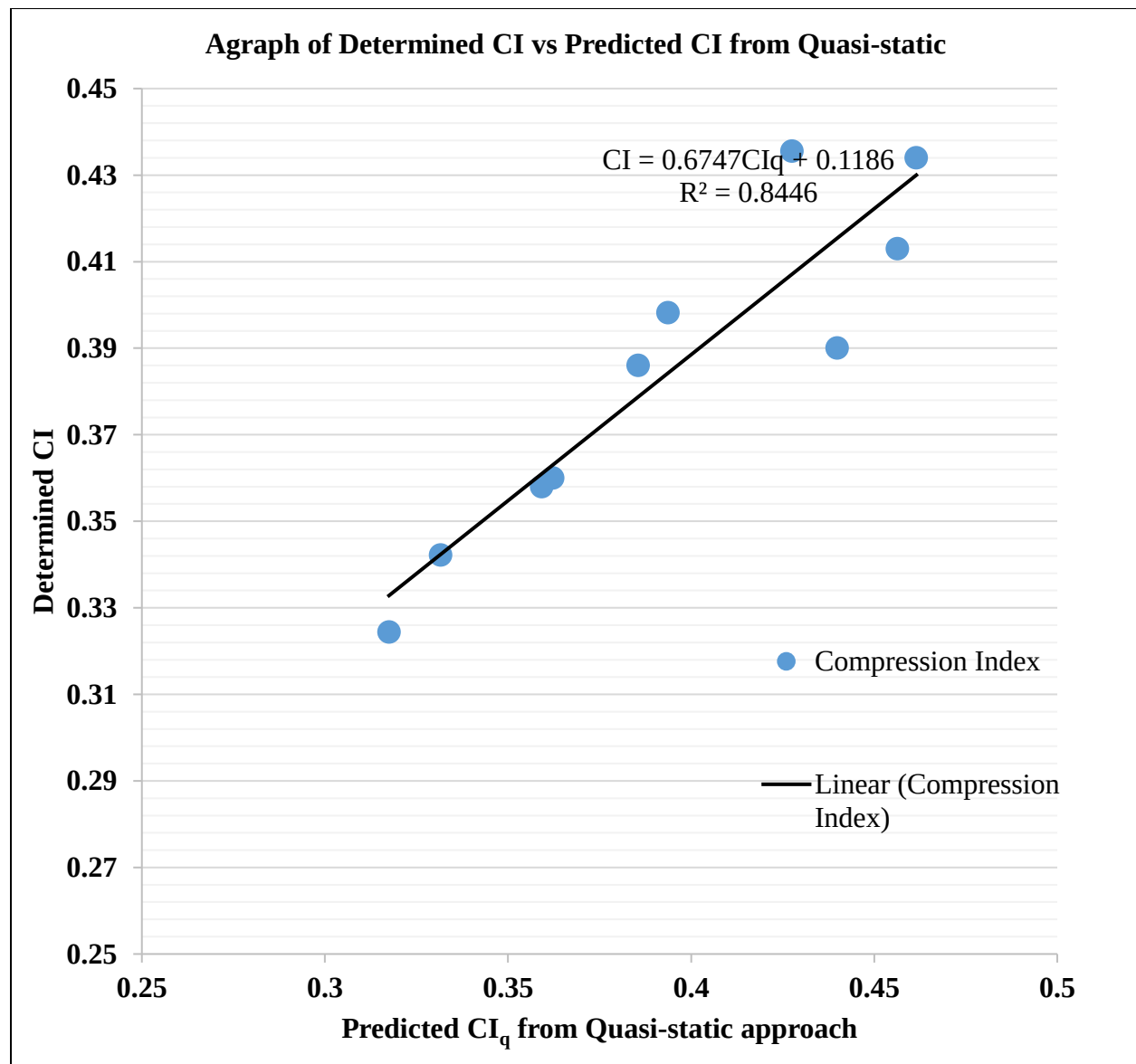


Figure 4.11: shows comparison between Determined CI and Predicted CI from quasi-static

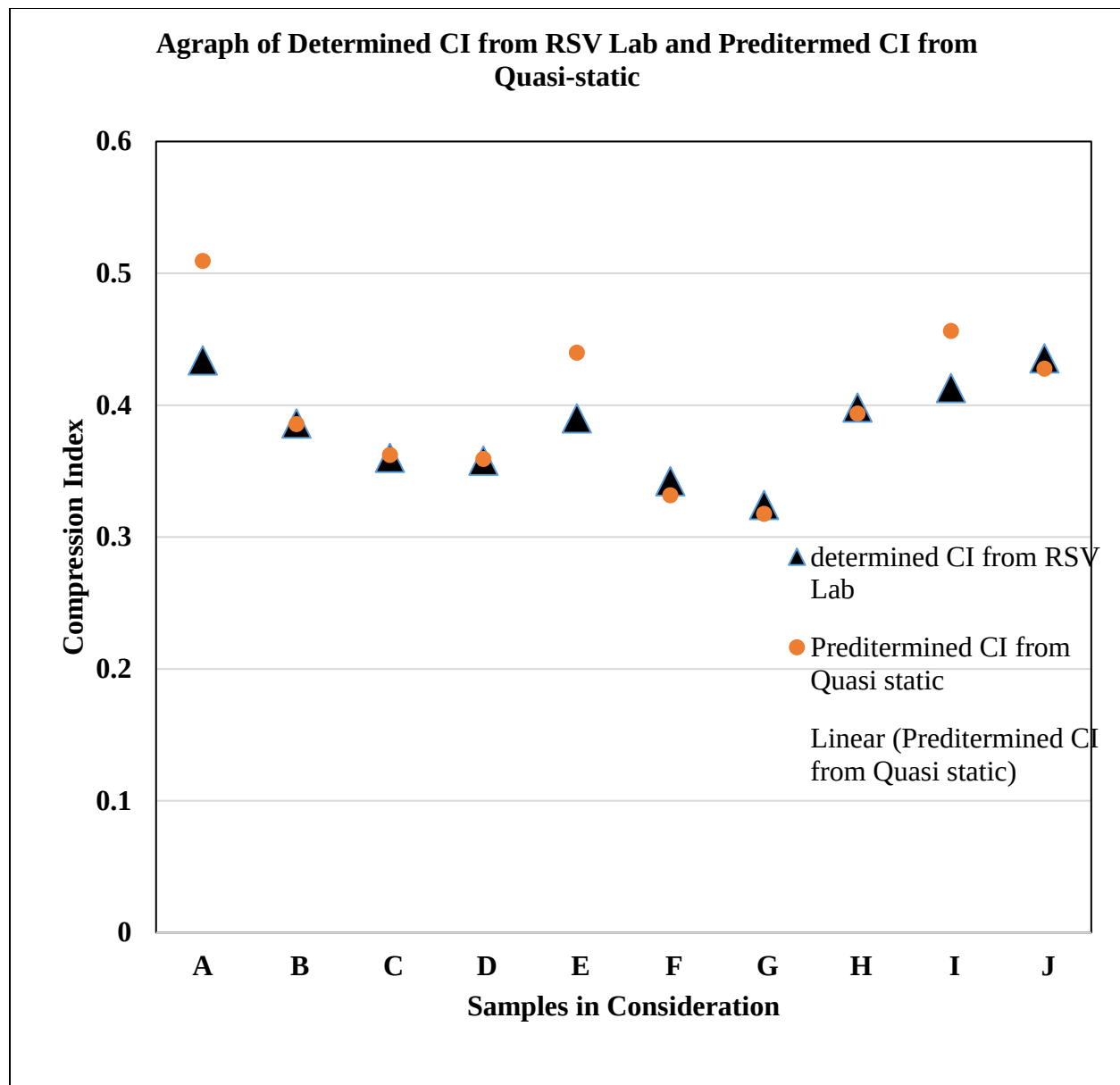


Figure 4.12: Show a simulation result for CI from Quasi static and RSV consultants

Table 4.9: Comparison between Quasi-static approach and Oedometer test.

Comparisons	Oedometer Test	Quasi-static Approach
Time	The experiment took 5 days to test a sample	All the 51 samples were tested on the same day
Cost	Each sample required Ushs160,000/= to be tested	The machine only costed Ushs1,500,000/= to fabricate and use.
Accuracy	The Oedometer test was very accurate	Quasi-static was very accurate as well
Stress-strain effects	There were more chances that Stress-strain effects affected the sample during both at preparation and at testing stages of the sample.	Quasi-static approach is not affected by Stress-strain effects.

From the table 4.9 shows the comparison between the Quasi-static approach and Oedometer test. The Oedometer test has shortcomings in terms of being expensive, time consuming and also it has chances that stress-strain effects will be experienced in the sample during testing and sample preparation for the experiment. Some studies have correlated Atterberg limits with compression index however the Atterberg limits have also short coming which include stress-strain effects affects the liquid limits, inaccuracies during thread rolling for plastic limit. This affects the general outcome of the compression index. Quasi-static Approach addresses all the above limitations.

4.8.8 Comparison of the developed empirical equation with previous equations

The following empirical equations were developed as a result of study by Ofuso (2013) and Kok Shien Ng et, al (2018). Ofuso 2013 established an estimation of compression index from physical properties of weathered Birimian phyllites; $CI = 0.004 - 0.03$ equation 16; with $R^2 = 0.784$ and Kok shien Ng et, al (2018) established a prediction of consolidation characteristics from index properties; $CI = 0.0062LL + 0.0165$ equation 17, $R^2 = 0.9241$. The above equations were compared with the developed equation (12) as shown in Table 4.9 and Figure 4.13 by using tested results got from RSV engineering Laboratory. Based on the analysis of the results in Table 4.9, the following observations were made; It was observed that the current empirical equation developed (12) was more accurate with an 3.34% average variation in results under consideration compared to other equations ie equation (16) had an average variation of 69%, equation (17) with an average variation of 35%.

Table 4.10: shows the comparison between the Quasi-Static Approach and the recent Approaches

Sample Name	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	CI	Predicted CI from Quasi-static approach	Percentage Variation	Ofuso (2013) Approach CI=0.004(LL-7.5)	Percentage Variation	Kok Shien Ng(2018) (CI=0.0062LL+0.0165)	Percentage Variation
A	44.7	35.1	17.6	0.434	0.5095	17.40%	0.1488	66%	0.29364	32%
B	37.2	24.8	12.4	0.386	0.3856	-0.10%	0.1188	69%	0.24714	36%
C	33.5	24.4	9.1	0.360	0.3622	0.61%	0.104	71%	0.2242	38%
D	33.5	23.4	10.1	0.358	0.3592	0.34%	0.104	71%	0.2242	37%
E	43.5	30.3	13.2	0.390	0.4399	12.79%	0.144	63%	0.2862	27%
F	30.4	20.4	10	0.3422	0.3316	-3.10%	0.0916	73%	0.20498	40%
G	27.4	21.7	5.7	0.3244	0.3175	-2.13%	0.0796	75%	0.18638	43%
H	38.2	25.5	12.7	0.3982	0.3937	-1.13%	0.1228	69%	0.25334	36%
I	45.5	31.8	13.7	0.413	0.4564	10.51%	0.152	63%	0.2986	28%
J	42.9	27.4	15.5	0.4355	0.4276	-1.81%	0.1416	67%	0.28248	35%
Average Variation						3.34%		69%		35%

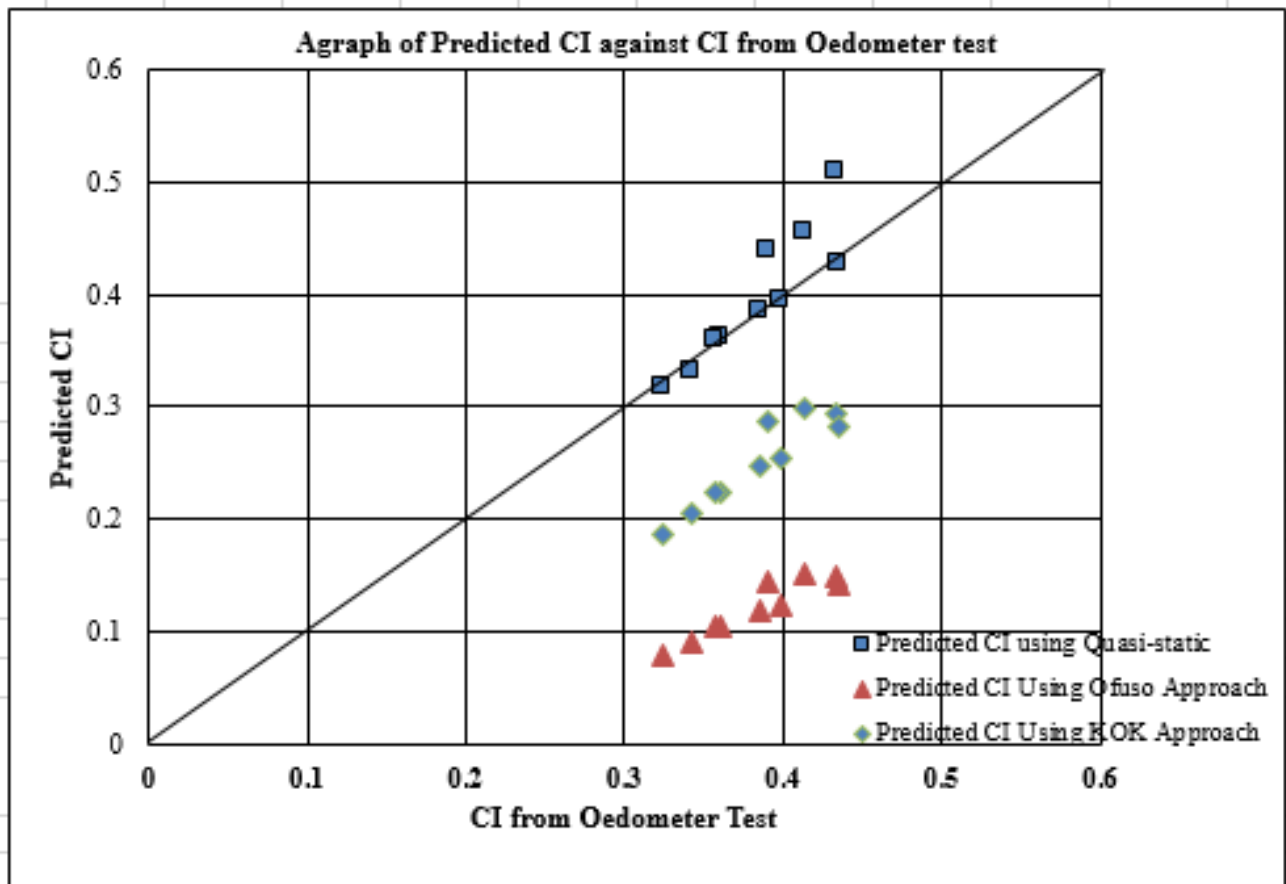


Figure 4.13: shows a graph of predicted CI of different approaches against CI from Oedometer Test

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This chapter contains two sections namely conclusion and recommendation. Conclusion provides major findings of the research in a concise manner based on objectives and gives succinct answer to each specific objective. The conclusion is given in logic, contextualized and workable suggestion for each specific objective.

5.2 RESEARCH SUMMARY

This research set out to address limitations of the current approaches used to determine the Compression index and consistency limits through testing. These limitations are summarized as follows

- Penetration rate effects in fall-cone tests,
- Reliability associated with the thread rolling plastic limit test,
- Health and safety issues in handling contaminated material,
- Time taken in carrying out compression index test.

From the experimental programme and analyses, significant conclusions concerning the application of quasi-static cone penetration tests for the strength and index testing of cohesive soils can be made.

5.3 CONCLUSIONS

The findings led to the following conclusions, which were restricted to the sample sizes and soils examined in this study. The database of soil samples comprised 51 soils in total. All 51 soils samples were used in determining Compression Index, plastic limit and liquid limits based on both conventionally derived methods and plastic and liquid limits using quasi-static cone tests.

The research program's findings can be summed up as follows:

An alternative quasi-static cone plastic limit (PL_{qc}) was suggested; it is defined as the amount of moisture corresponding to a 20 mm quasi-static cone penetration depth for a 1020 gf penetration force, and

roughly relates to the traditional thread rolling plastic limit for the 51 soils used. Up to 97.9% accuracy thus confirming reliability of the quasi-static method.

An alternative quasi-static cone liquid limit (LL_{qc}) was proposed and is defined as the moisture content corresponding to a 20 mm quasi-static cone penetration depth for a penetration load of 60 gf and correlates closely with conventional fall cone liquid limit for the 51 soils used. Up to 91.3% accuracy, thus the quasi-static approach is reliable.

Semi-empirical expressions were proposed for derivation of Compression Index and consistency limits.

Semi-empirical expressions were proposed for derivation of Compression Index and Quasi static consistency limits. These semi-empirical relationships are based on correlations of quasi-static liquid limit, plastic limit and plasticity index.

Quasi-static cone tests provide a simple a simple, fast and accurate method of determining Compression Index relationships, on applying appropriate consistency limits.

The plasticity may be entirely directly determined with quasi-static cone tests, through the PI_{qc} parameter ($=LL_{qc}-PL_{qc}$) by use of interpolation of quasi-static cone tastes carried out on the soil sample at different moisture contents.

The Compression Index of soil mixtures may be estimated directly from quasi-static cone tests using quasi-static consistency limits. This approach is satisfactory with 6 % variance.

5.4 FURTHER RESEARCH

The following recommendations are provided based on the research's findings for further developing quasi-static cone methods and equipment for testing cohesive fine and mixed soils' consistency limits and compression indices.

Undertaking extensive experimental programs for soils of varied geology and plasticity, which may provide improvements of the alternative quasi-static cone approaches developed in this research.

Further development should be undertaken to other penetrometer, accounting for more sensitive and simpler on-board load and travel monitoring over a wide range of soil geologies and plasticities. This is geared towards inferring its potential for rapid application of quasi-static cone approaches in the field without need for electric power.

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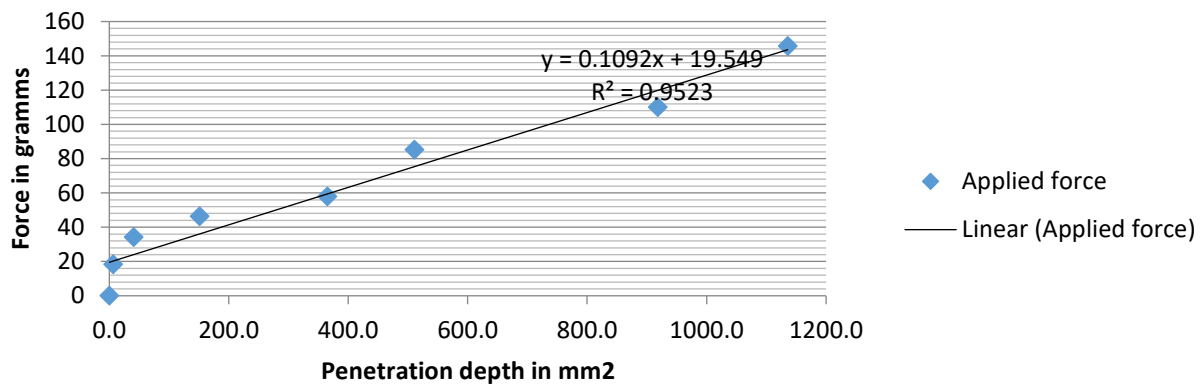
APPENDICES A: Results of Applied force with penetration depth d and d²

Results for Sample R3

Table of results for soil sample R3 at moisture content 41% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.5	240.05	0	0.0	0
48	258.45	2.5	6.3	18.4
51.9	274.34	6.4	41.0	34.29
57.8	286.37	12.3	151.3	46.32
64.6	298.01	19.1	364.8	57.96
68.1	325.23	22.6	510.8	85.18
75.8	350.15	30.3	918.1	110.1
79.2	385.78	33.7	1135.7	145.73

Applied force vs (Depth penetration)²



APPLIED FORCE VS DEPTH PENETRATION

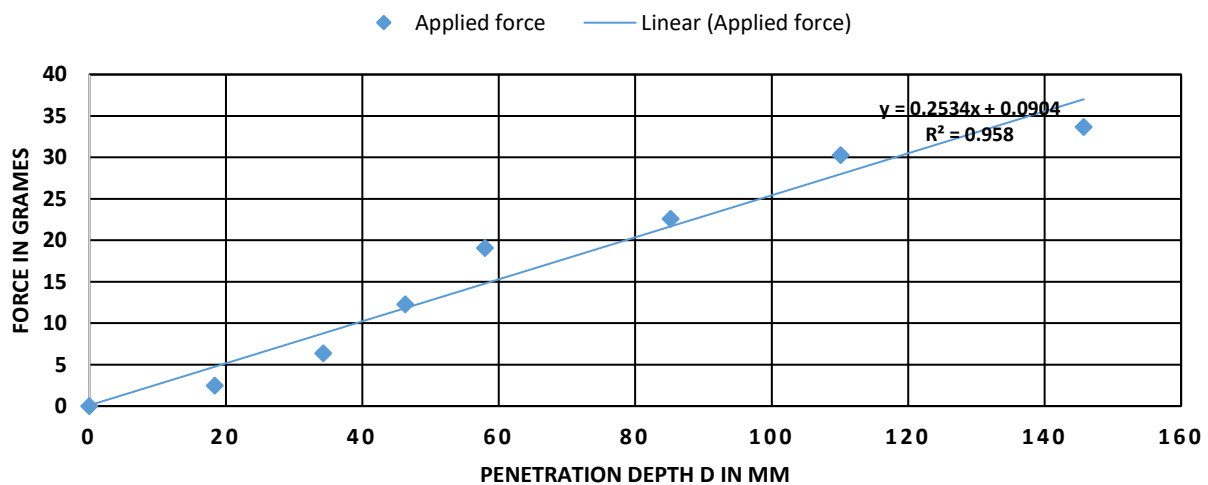
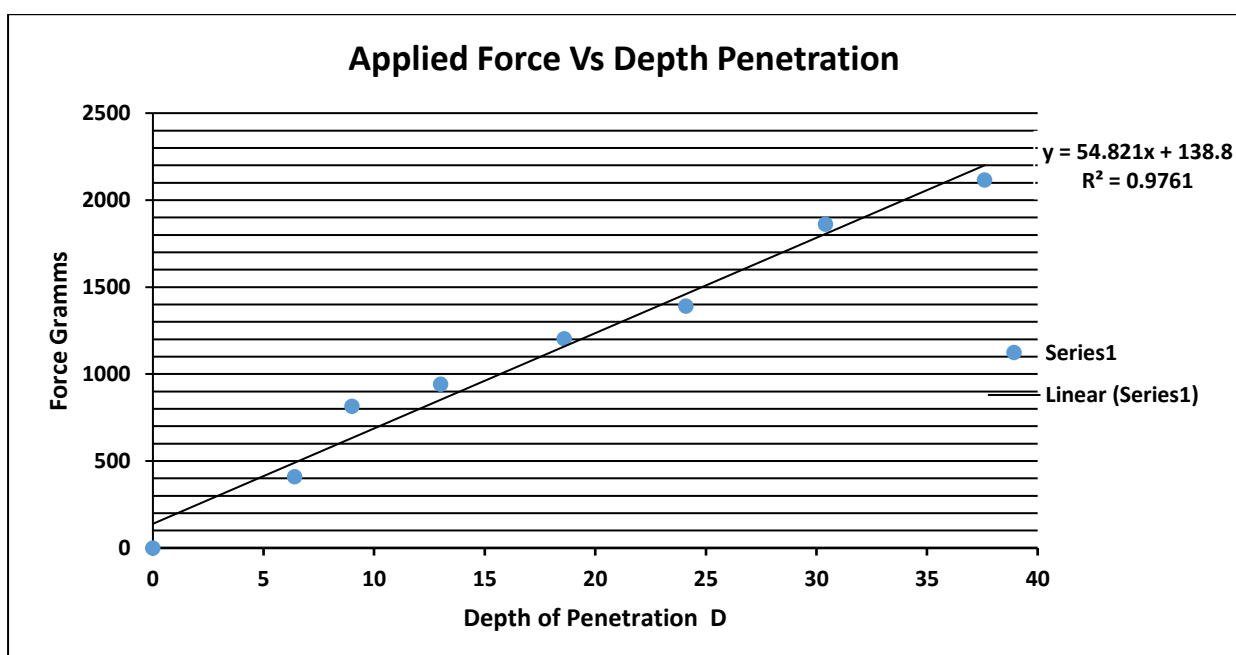
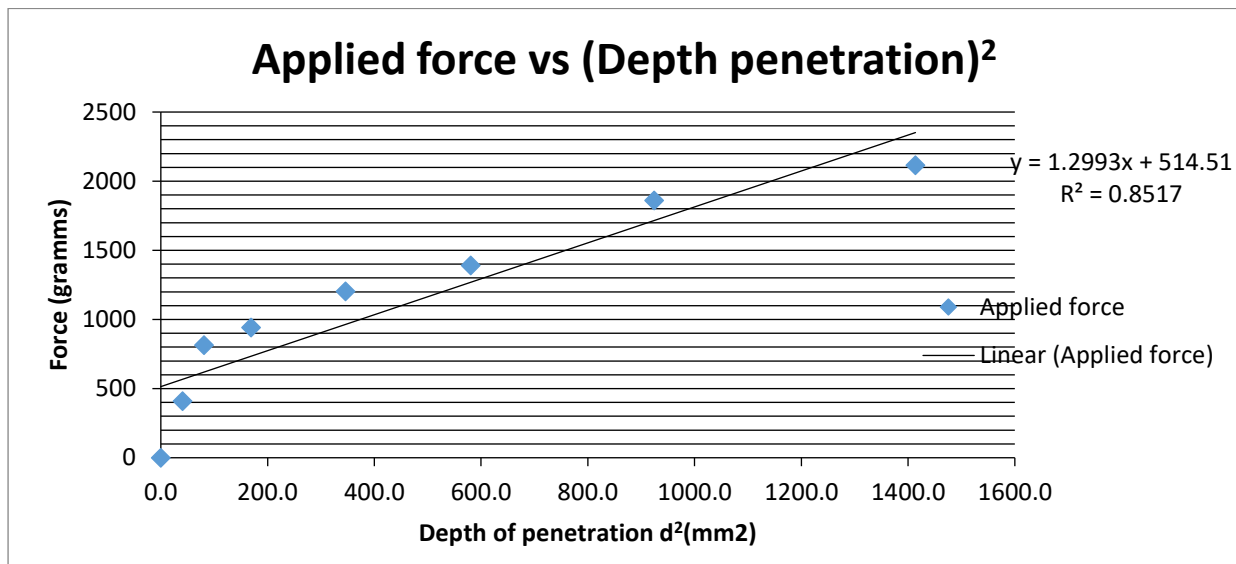


Table of results for soil sample R3 at moisture content 23.1% for Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.6	124.45	0	0.0	0
52	533.69	6.4	41.0	409.24
54.6	938.54	9	81.0	814.09
58.6	1065.49	13	169.0	941.04
64.2	1327.87	18.6	346.0	1203.42
69.7	1515.45	24.1	580.8	1391
76	1985.29	30.4	924.2	1860.84
83.2	2240.84	37.6	1413.8	2116.39



Results for Sample A1

Table of results for soil sample A1 at moisture content 24.1% for plastic limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
44	224.45	0	0.0	0
50	533.69	6	36.0	309.24
52.6	831.54	8.6	74.0	607.09
56.6	999.49	12.6	158.8	775.04
62.2	1447.87	18.2	331.2	1223.42
67.7	1915.45	23.7	561.7	1691
74	2190.29	30	900.0	1965.84
81.2	2240.84	37.2	1383.8	2016.39

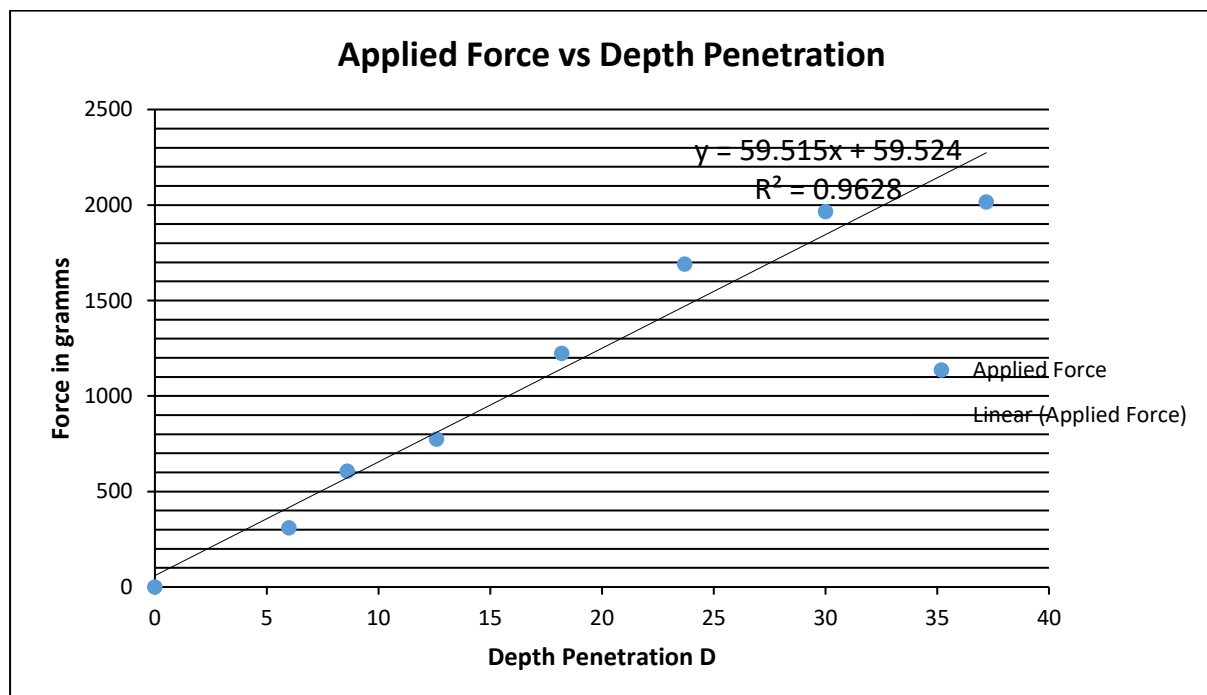
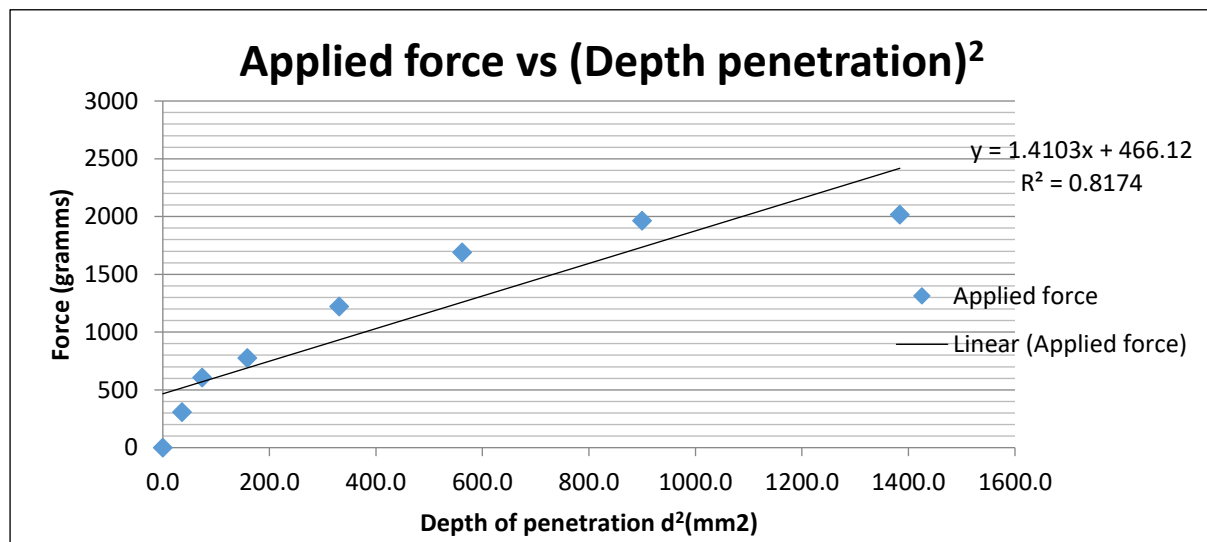
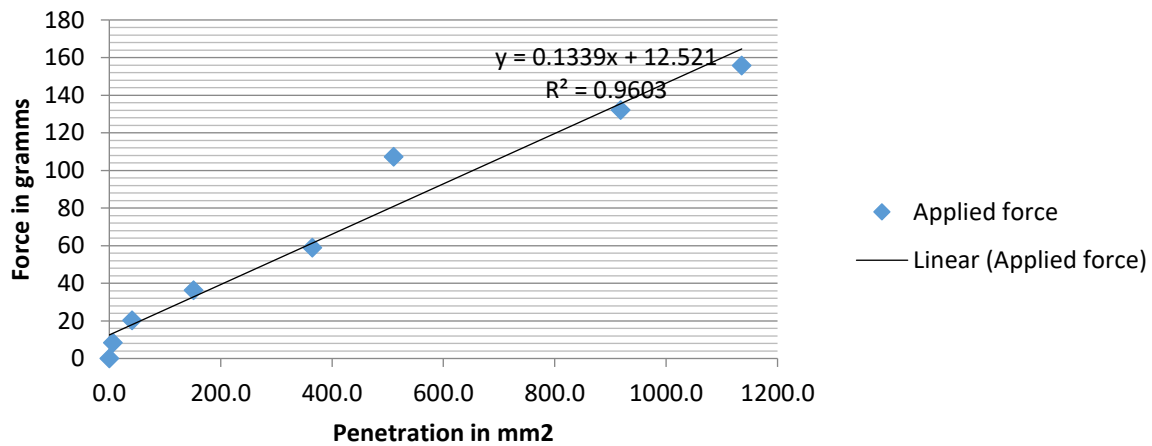


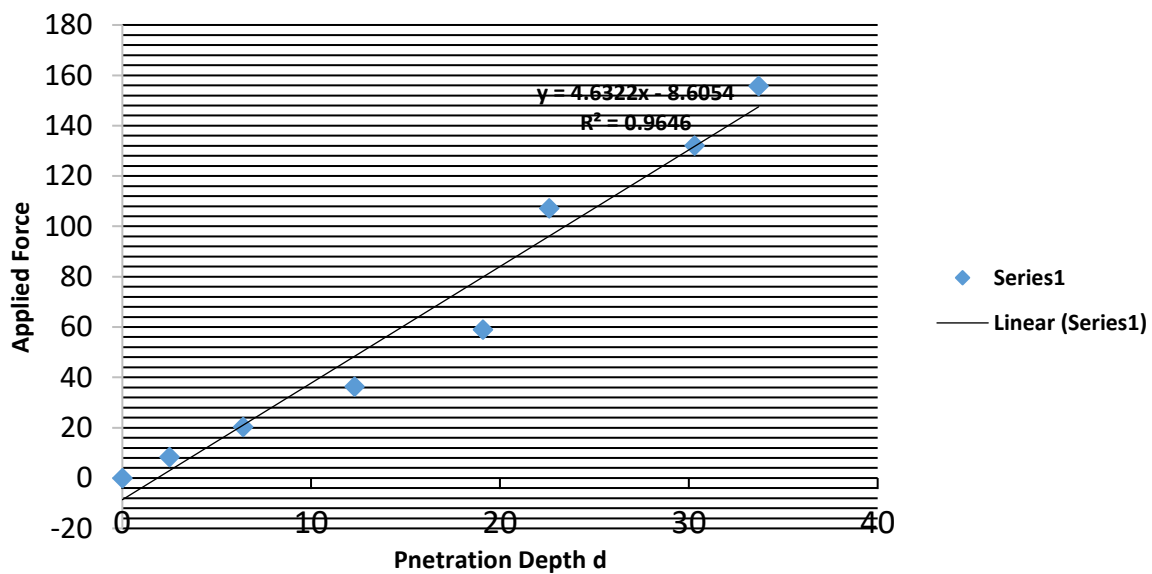
Table of results for soil sample A1 at moisture content 42.5% liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.5	240.05	0	0.0	0
48	248.45	2.5	6.3	8.4
51.9	260.34	6.4	41.0	20.29
57.8	276.37	12.3	151.3	36.32
64.6	299.01	19.1	364.8	58.96
68.1	347.23	22.6	510.8	107.18
75.8	372.15	30.3	918.1	132.1
79.2	395.78	33.7	1135.7	155.73

Applied force vs (Penetration depth)²



Applied Force Vs Penetration Depth



Results for Sample A2

Table of results for soil sample A2 at moisture content 22.5% for plastic limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42	240.96	0	0.0	0
48.5	527.38	6.5	42.3	286.42
52	842.17	10	100.0	601.21
54.6	1027.04	12.6	158.8	786.08
60.2	1685.72	18.2	331.2	1444.76
65.7	1703.47	23.7	561.7	1462.51
72	2087.28	30	900.0	1846.32
78.5	2335.92	36.5	1332.3	2094.96

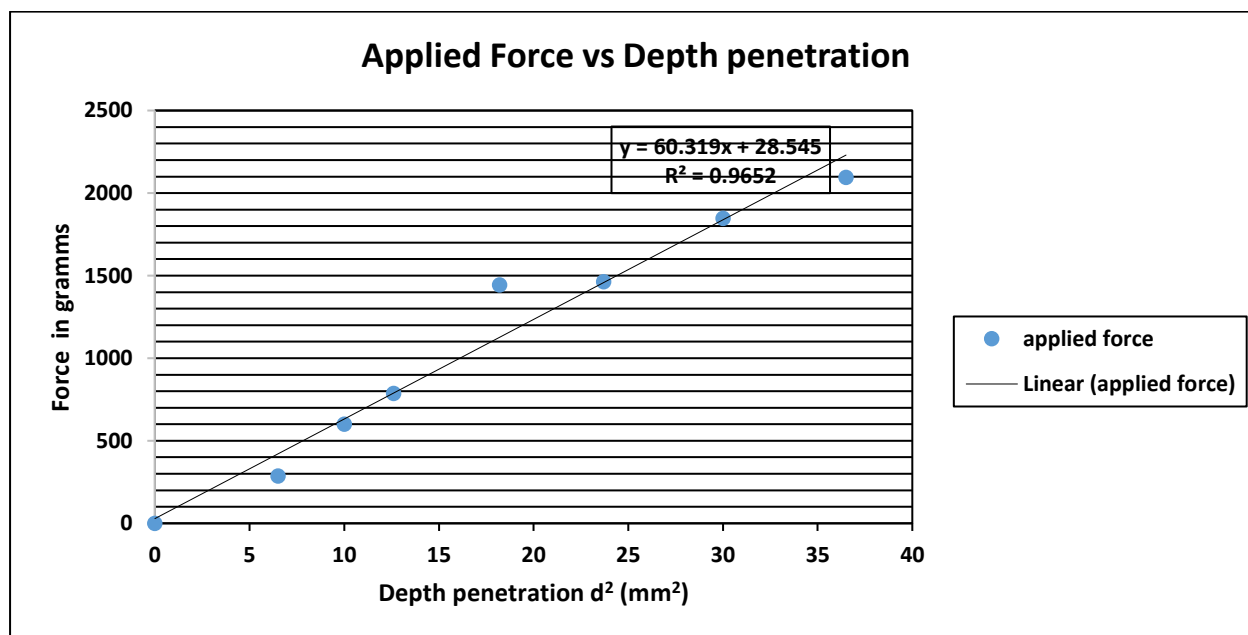
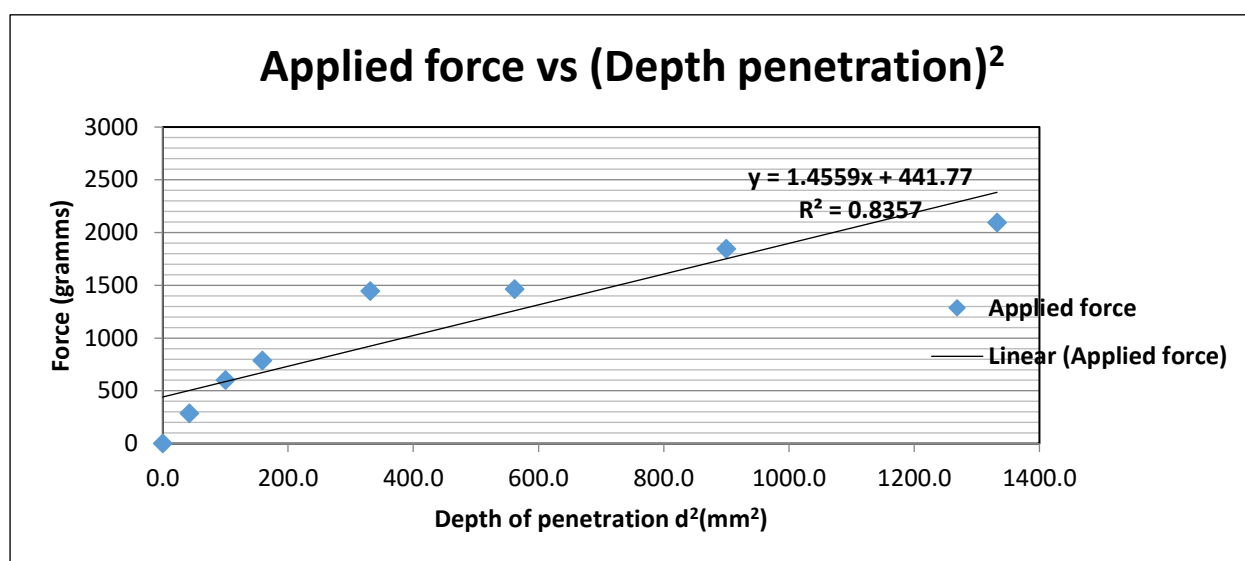
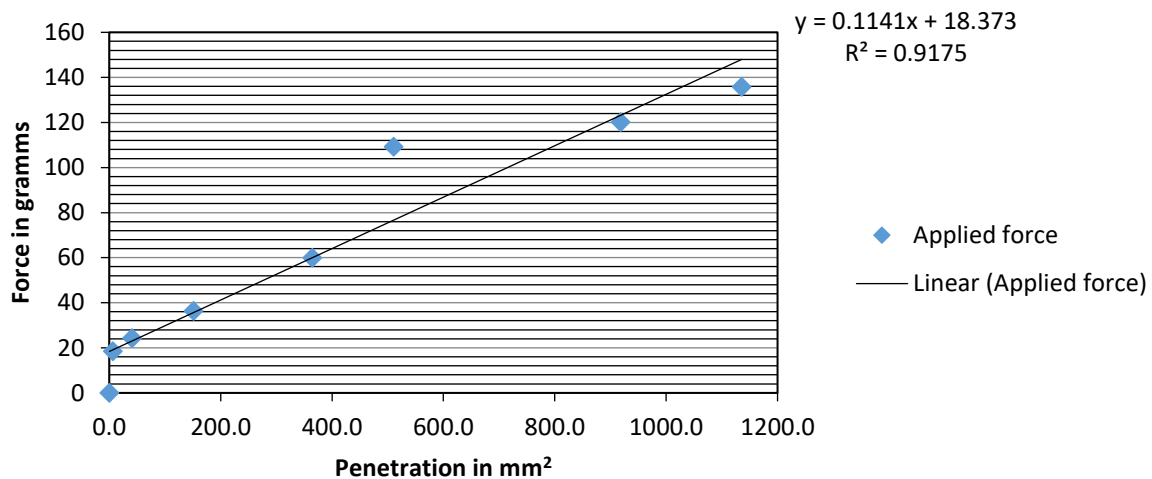


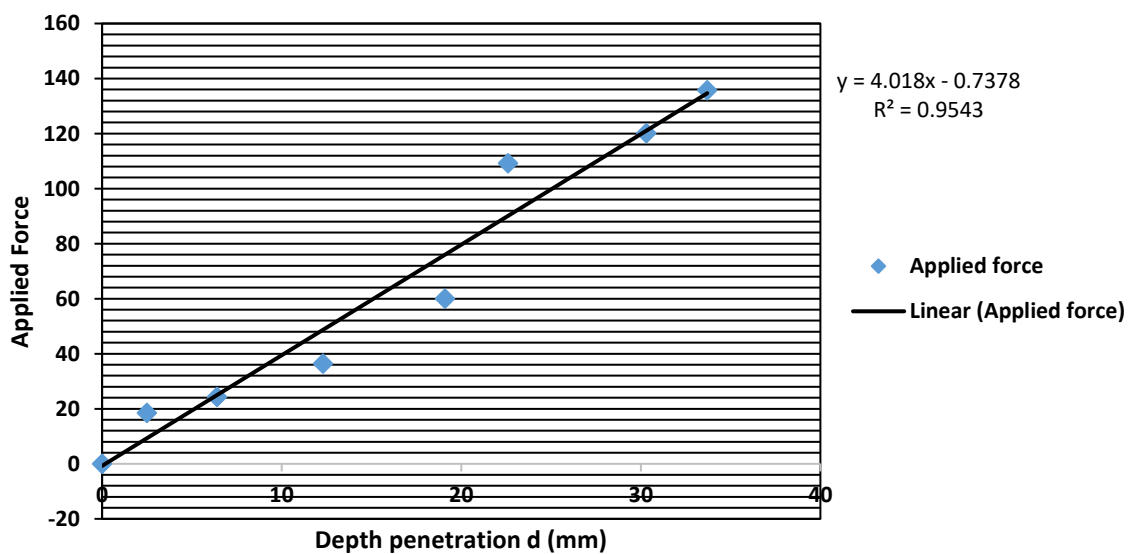
Table of results for soil sample A2 at moisture content 39.5% liquid limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.5	210.05	0	0.0	0
48	228.45	2.5	6.3	18.4
51.9	234.34	6.4	41.0	24.29
57.8	246.37	12.3	151.3	36.32
64.6	270.01	19.1	364.8	59.96
68.1	319.23	22.6	510.8	109.18
75.8	330.15	30.3	918.1	120.1
79.2	345.78	33.7	1135.7	135.73

Applied force vs (Penetration Depth)²



Applied force vs Depth penetration



Results for Sample A3

Table of results for soil sample A3 at moisture content 24.5%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42	240.96	0	0.0	0
48.5	527.38	6.5	42.3	286.42
52	842.17	10	100.0	601.21
54.6	1227.04	12.6	158.8	986.08
60.2	1485.72	18.2	331.2	1244.76
65.7	1760.47	23.7	561.7	1519.51
72	1940.28	30	900.0	1699.32
78.5	2293.92	36.5	1332.3	2052.96

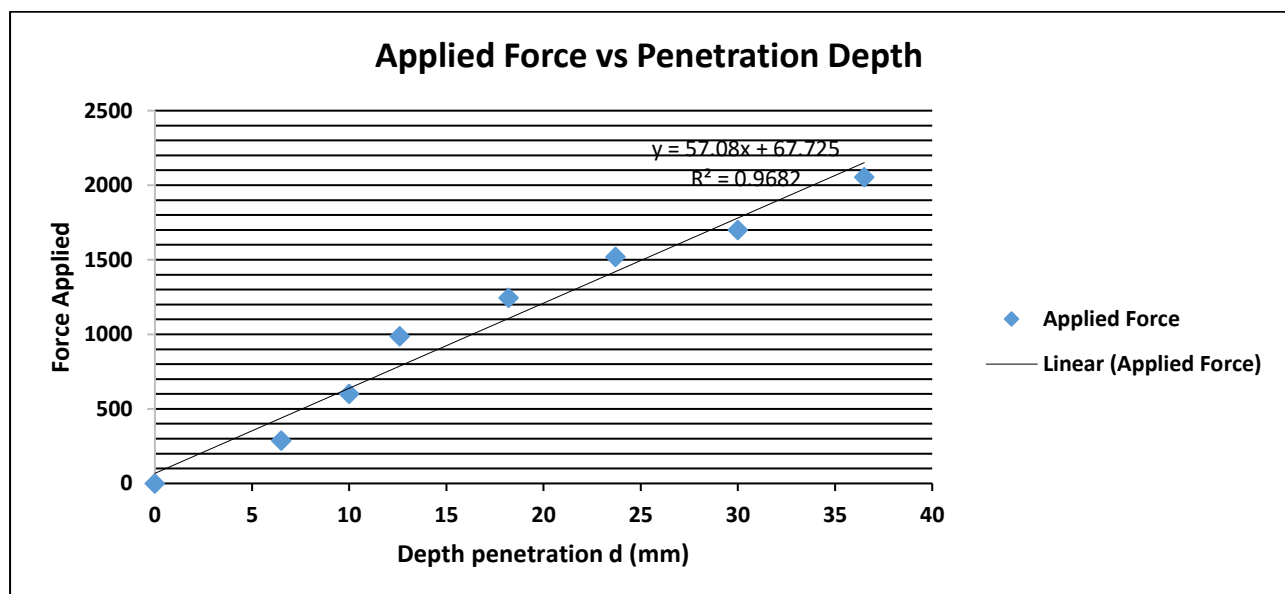
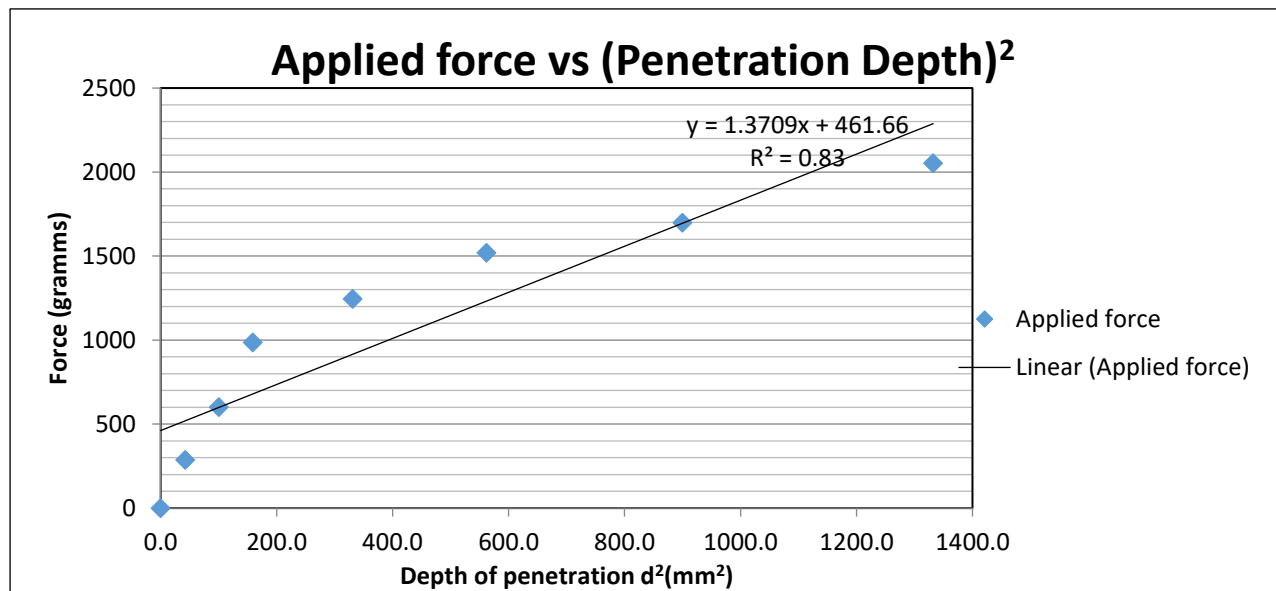
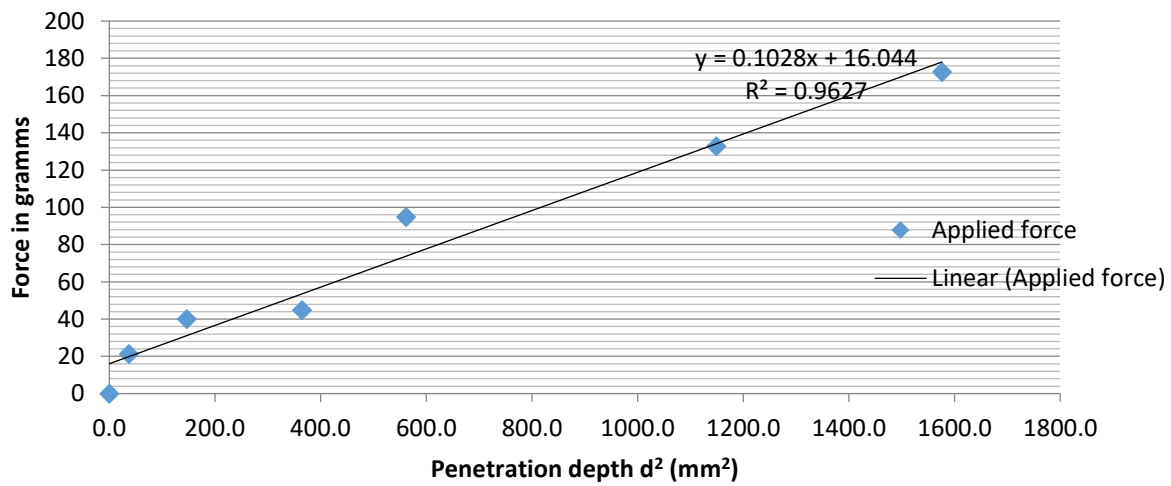


Table of results for soil sample A3 at moisture content 42.8%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
43.4	215.25	0	0.0	0
49.5	236.6	6.1	37.2	21.35
55.5	255.31	12.1	146.4	40.06
62.5	260.04	19.1	364.8	44.79
67.1	310.04	23.7	561.7	94.79
77.3	348.13	33.9	1149.2	132.88
83.1	387.87	39.7	1576.1	172.62

Applied force vs (Penetration Depth)²



Applied Force vs Penetration Depth

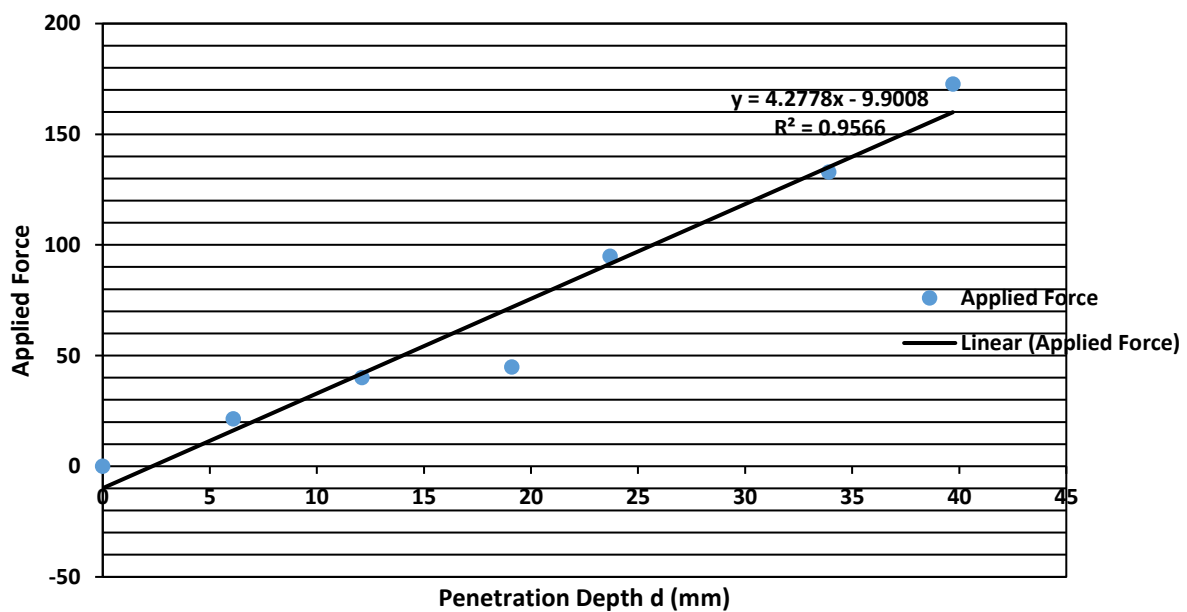


Table of results for soil sample R5 at moisture content 20.5%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
41.9	212.35	0	0.0	0
48.2	526	6.3	39.7	313.65
52.7	799.42	10.8	116.6	587.07
61	1186.22	19.1	364.8	973.87
65	1553.68	23.1	533.6	1341.33
71	2020	29.1	846.8	1807.65
75.3	2456.5	33.4	1115.6	2244.15

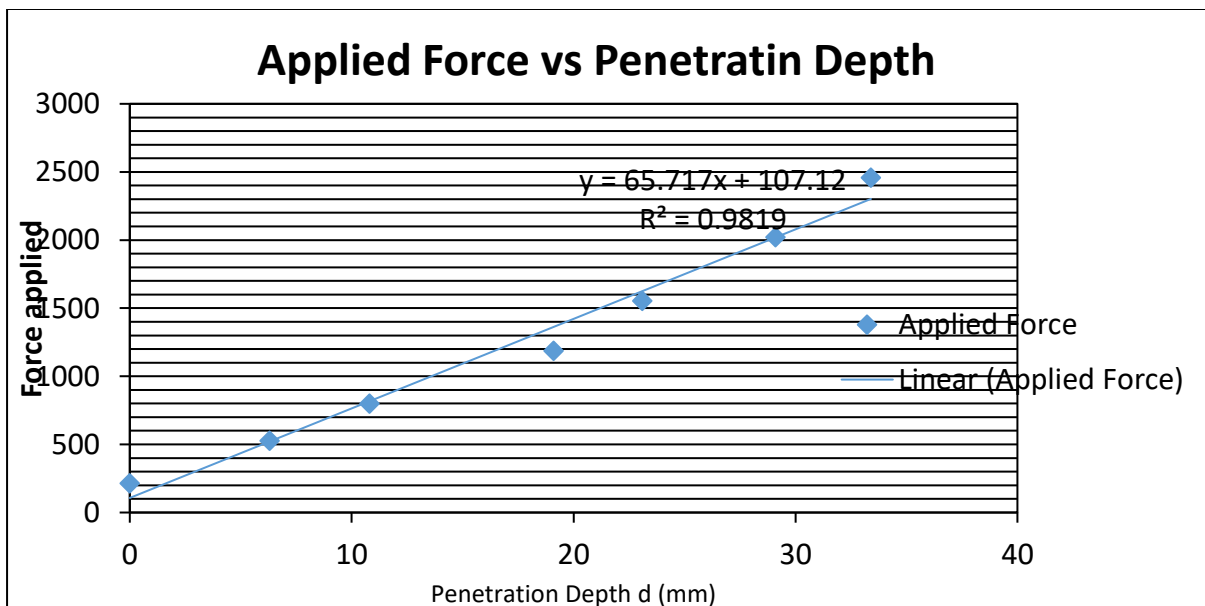
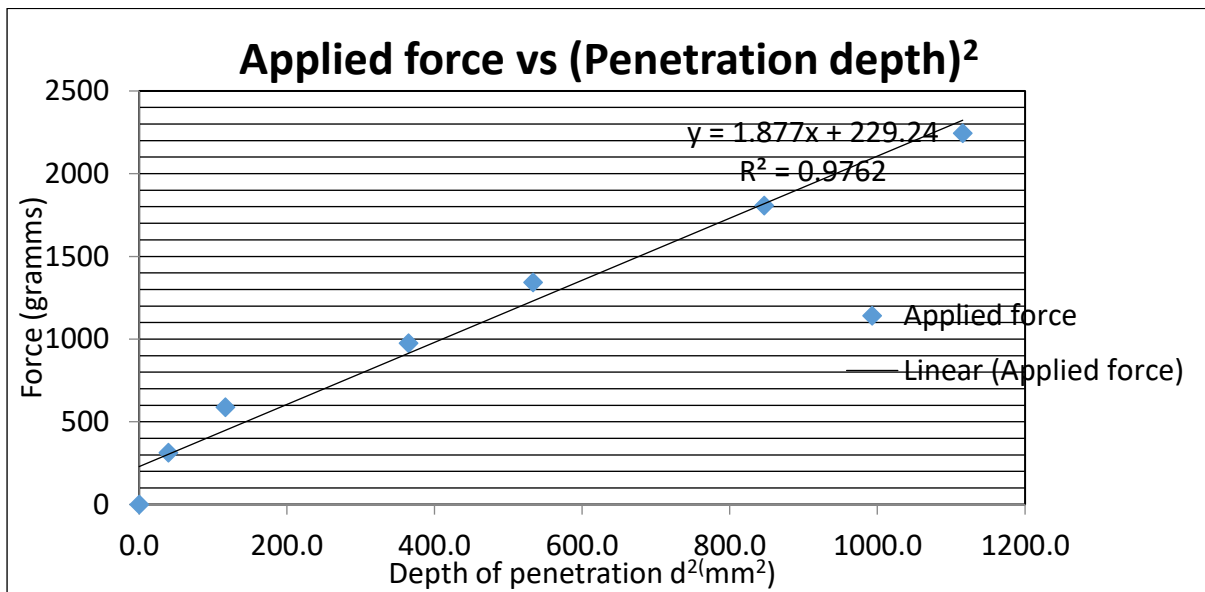


Table of results for soil sample R5 at moisture content 34.2%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.5	220.05	0	0.0	0
48	248.45	2.5	6.3	28.4
51.9	254.34	6.4	41.0	34.29
57.8	266.37	12.3	151.3	46.32
64.6	276.5	19.1	364.8	56.45
68.1	309.23	22.6	510.8	89.18
75.8	310.15	30.3	918.1	90.1
79.2	327.78	31.2	973.4	79.33

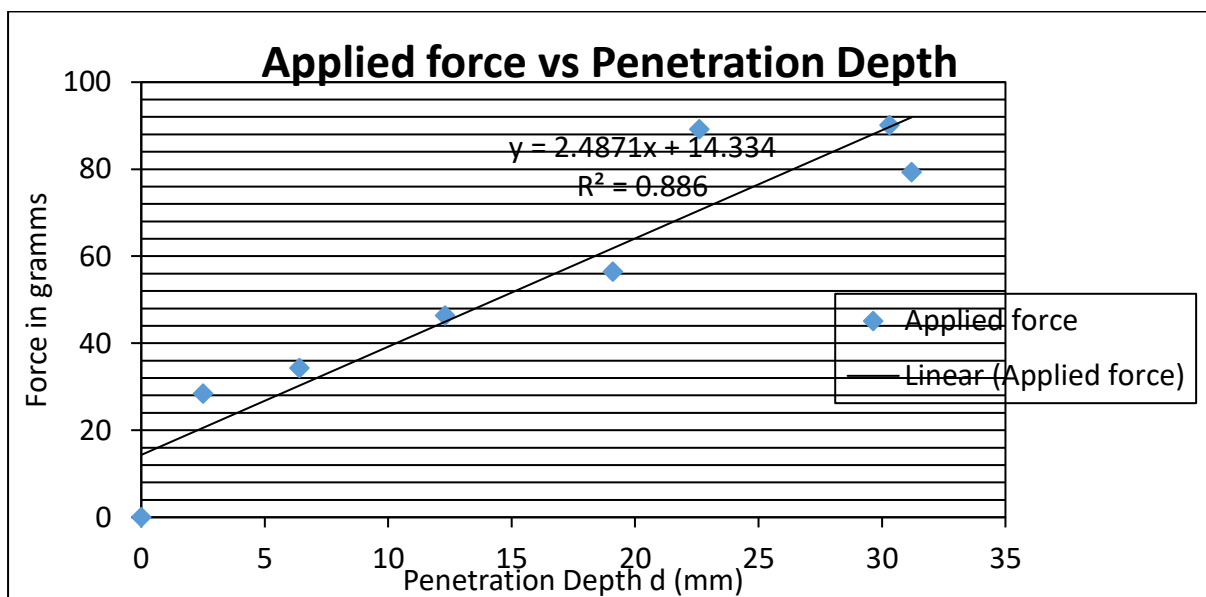
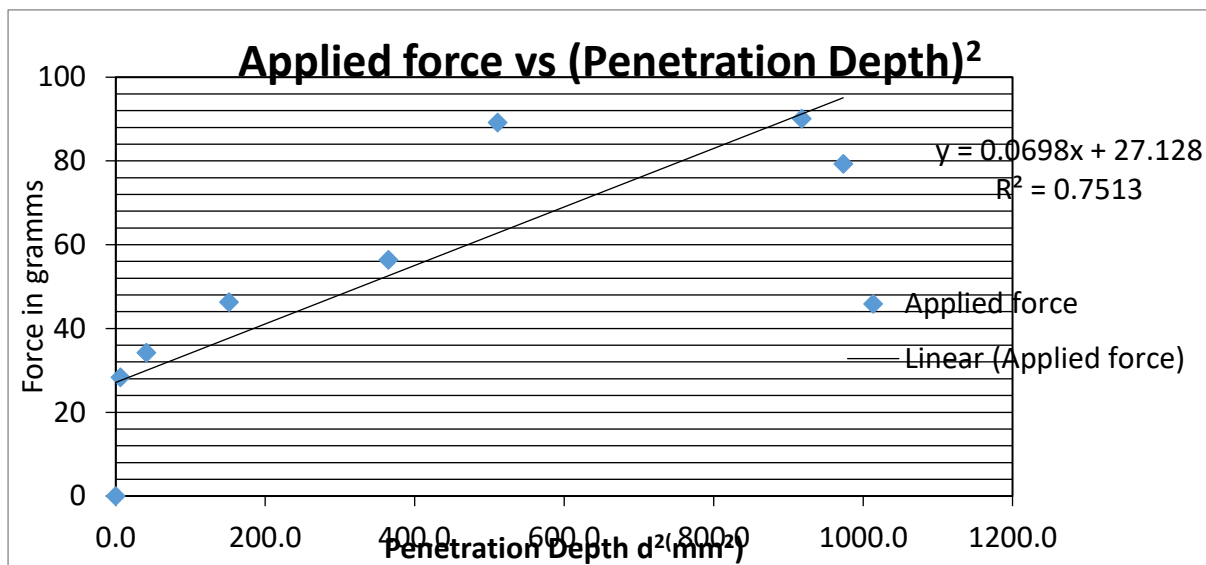


Table of results for soil sample A4 at moisture content 19.5% Plastic Limit

Reading length (cm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
43	240.96	0	0.0	0
48.5	527.38	5.5	30.3	286.42
52	908.17	9	81.0	667.21
54.6	1227.04	11.6	134.6	986.08
60.2	1385.72	17.2	295.8	1144.76
65.7	1660.47	22.7	515.3	1419.51
72	1840.28	29	841.0	1599.32
78.5	2241.92	35.5	1260.3	2000.96

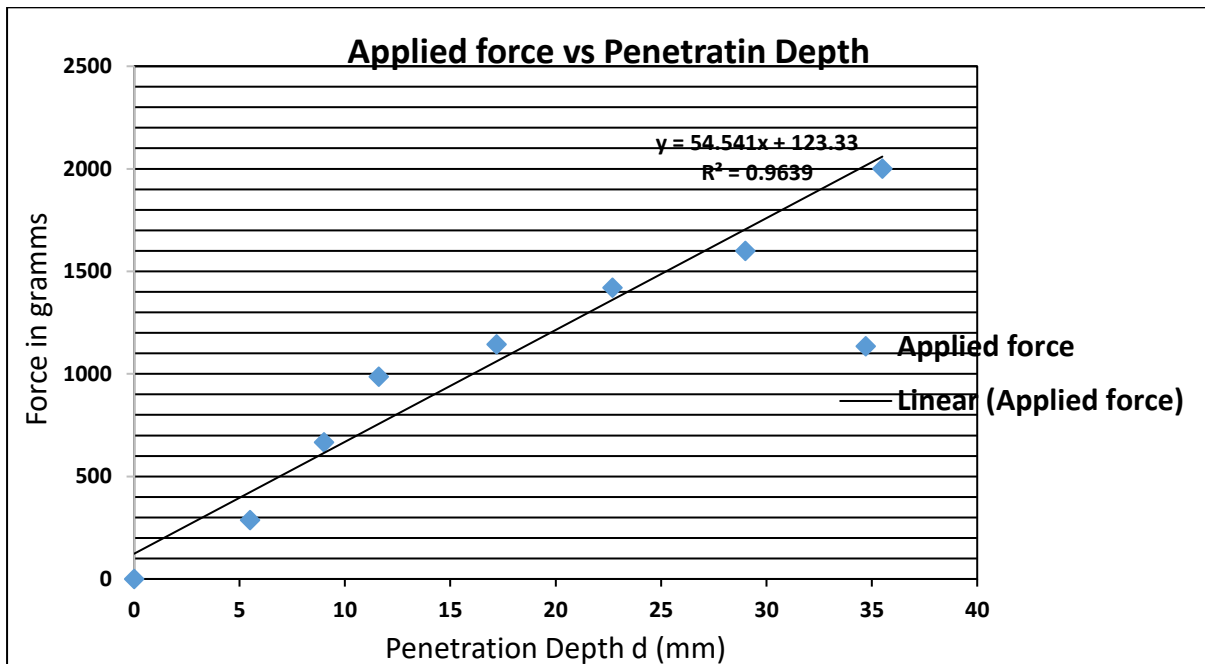
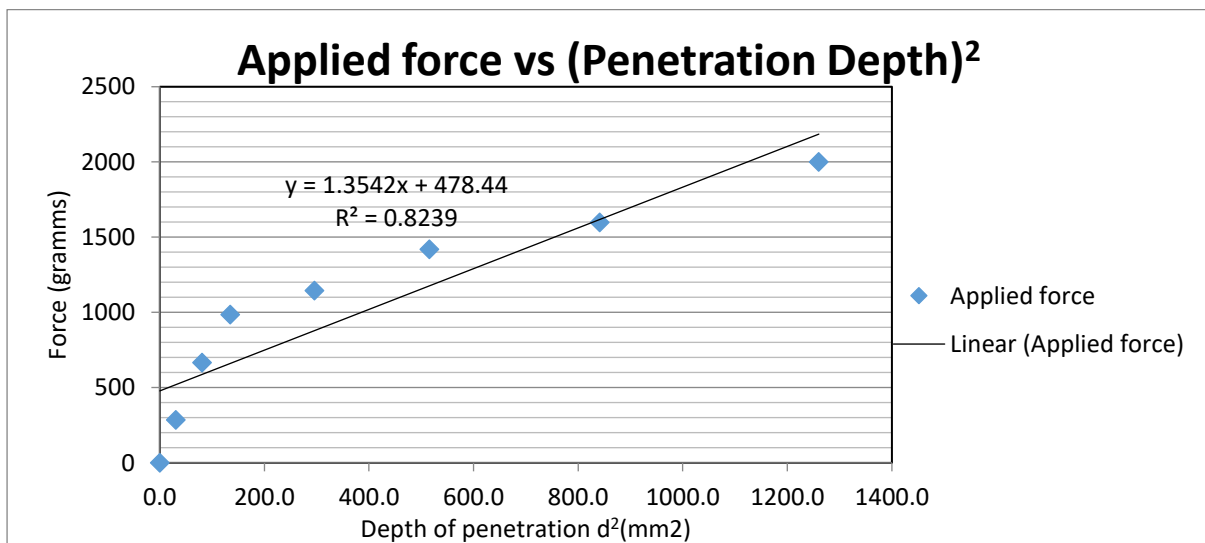


Table of results for soil sample A4 at moisture content 33.8% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.5	226.05	0	0.0	0
48	248.45	2.5	6.3	22.4
51.9	254.34	6.4	41.0	28.29
57.8	276.37	12.3	151.3	50.32
64.6	298.01	19.1	364.8	71.96
68.1	303.23	22.6	510.8	77.18
75.8	320.15	30.3	918.1	94.1
79.2	355.78	33.7	1135.7	129.73

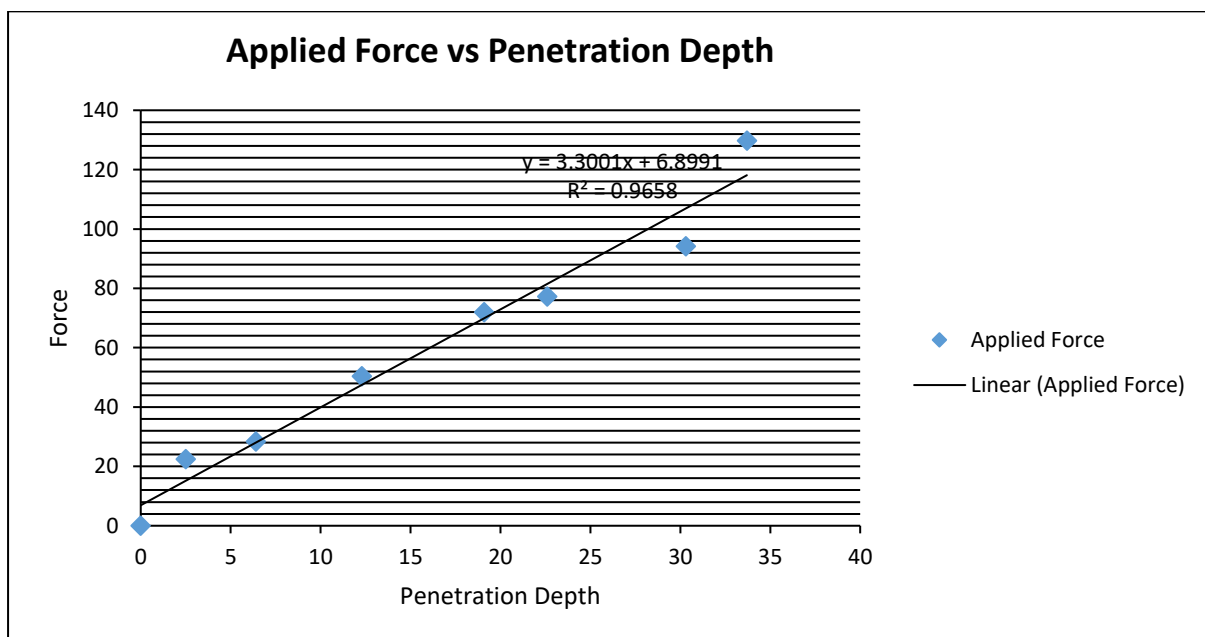
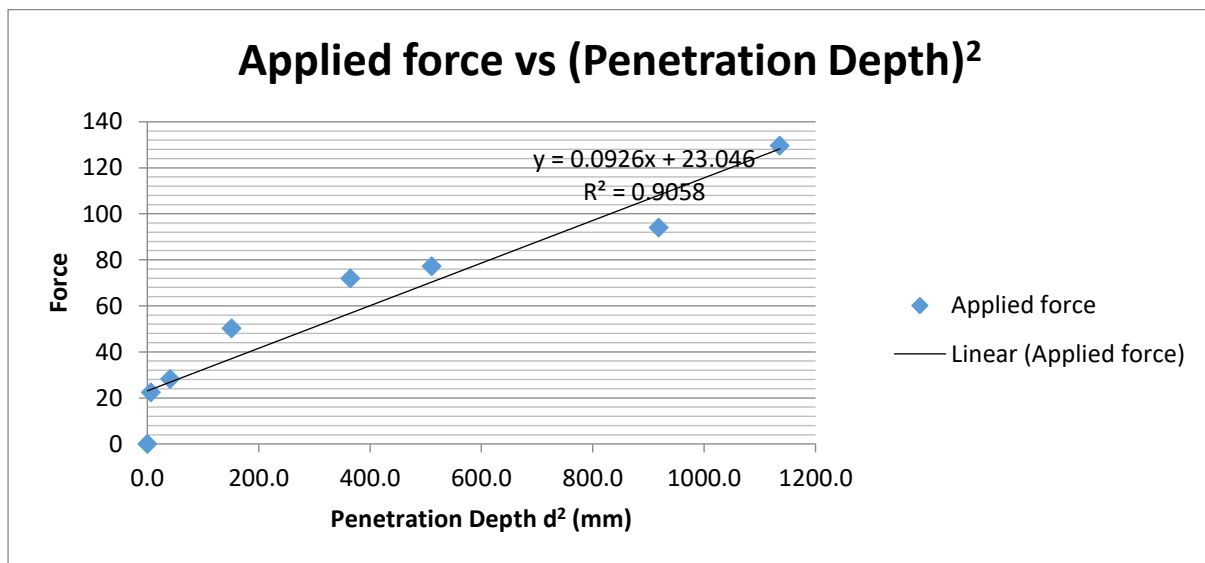


Table of results for soil sample A5 at moisture content 21.3% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
41.9	212.35	0	0.0	0
48.2	526	6.3	39.7	313.65
52.7	999.42	10.8	116.6	787.07
61	1186.22	19.1	364.8	973.87
65	1753.68	23.1	533.6	1541.33
71	1945	29.1	846.8	1732.65
75.3	2128.5	33.4	1115.6	1916.15

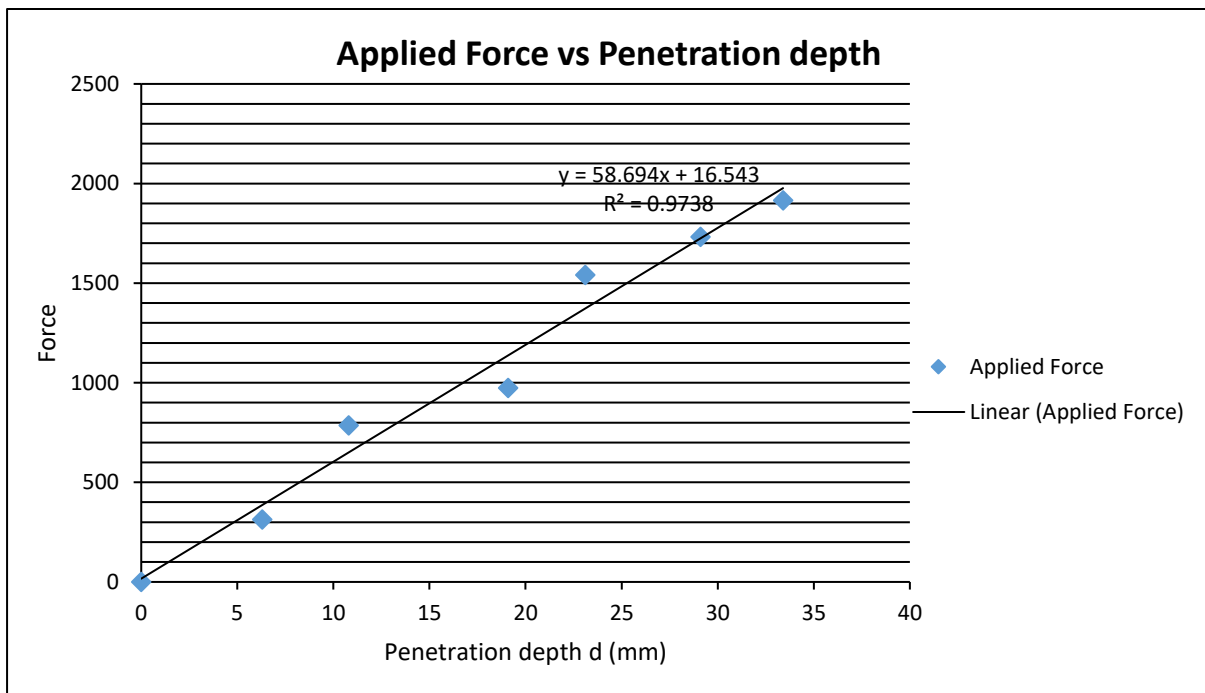
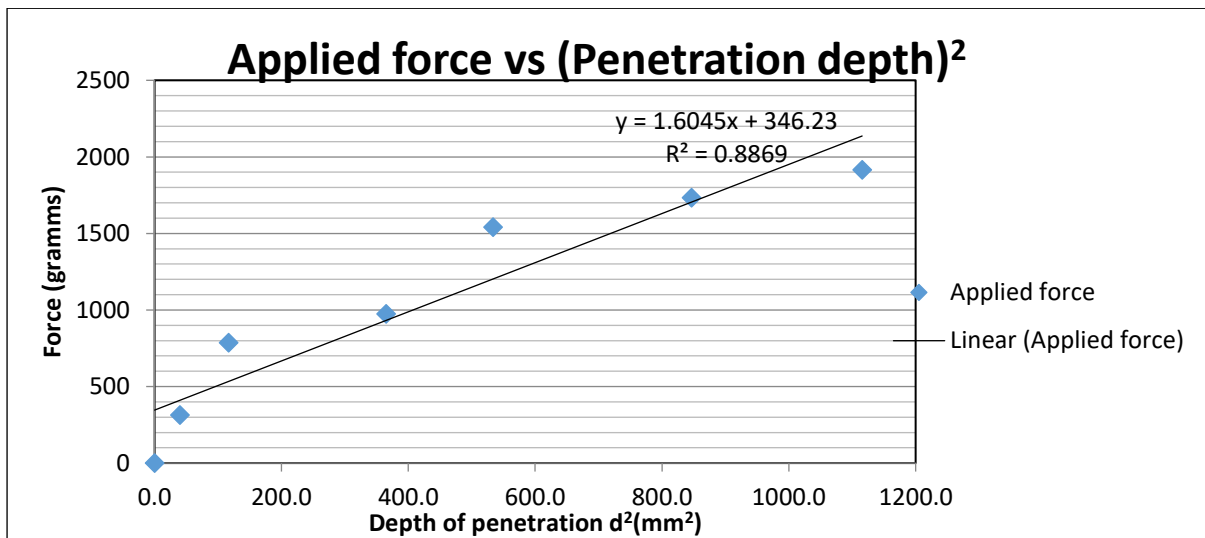


Table of results for soil sample A5 at moisture content 36.2% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.5	234.55	0	0.0	0
48	248.45	2.5	6.3	13.9
51.9	254.34	6.4	41.0	19.79
57.8	278.37	12.3	151.3	43.82
64.6	298.01	19.1	364.8	63.46
68.1	319.23	22.6	510.8	84.68
75.8	330.15	30.3	918.1	95.6
79.2	347.78	31.2	973.4	99.33

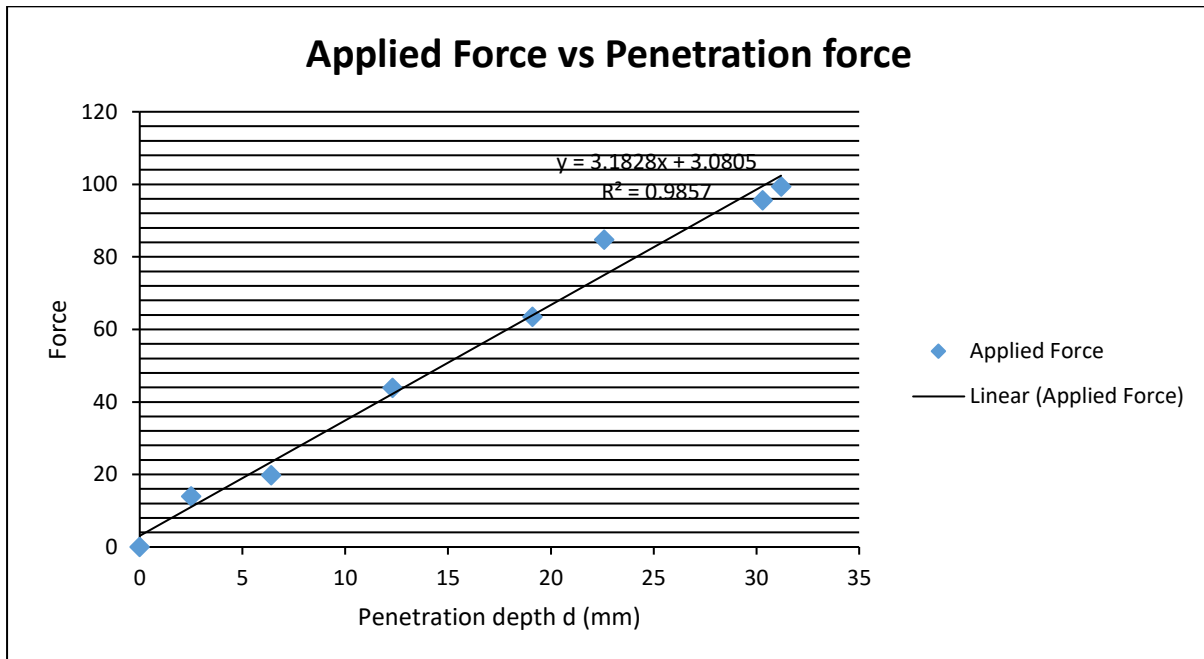
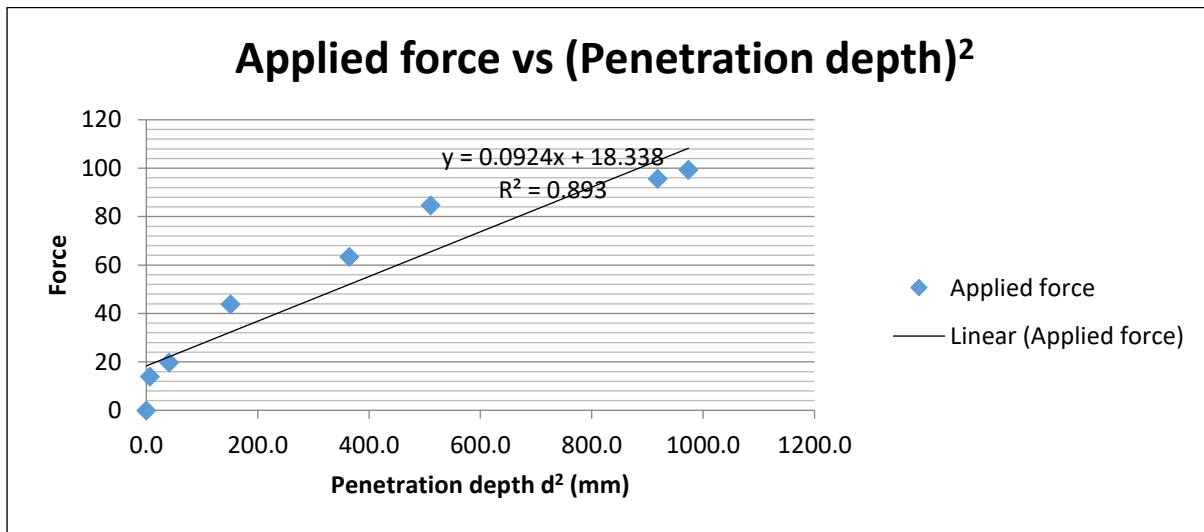
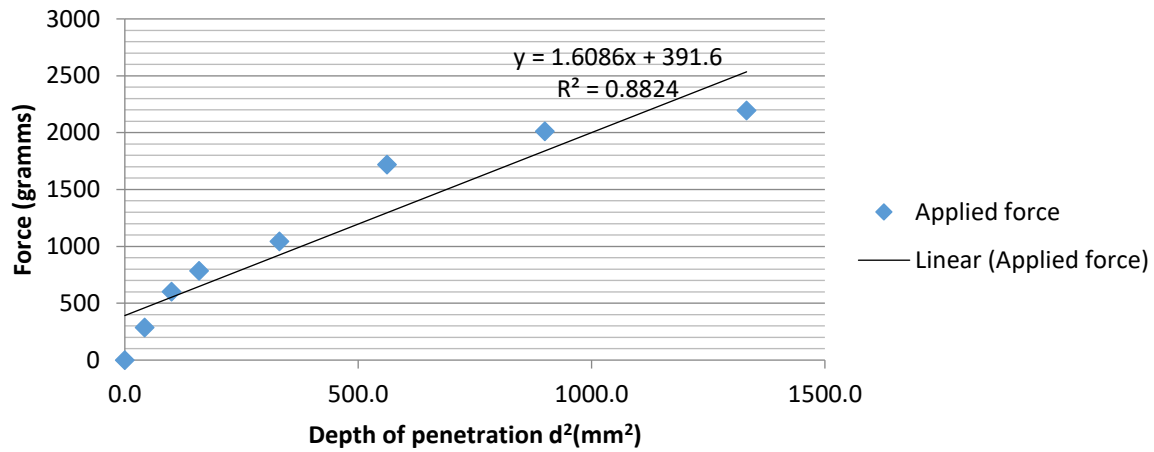


Table of results for soil sample A6 at moisture content 19.0% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42	240.96	0	0.0	0
48.5	527.38	6.5	42.3	286.42
52	842.17	10	100.0	601.21
54.6	1027.04	12.6	158.8	786.08
60.2	1285.72	18.2	331.2	1044.76
65.7	1960.47	23.7	561.7	1719.51
72	2252.28	30	900.0	2011.32
78.5	2435.92	36.5	1332.3	2194.96

Applied force vs (Penetration Depth)²



Applied Force vs Penetration Depth

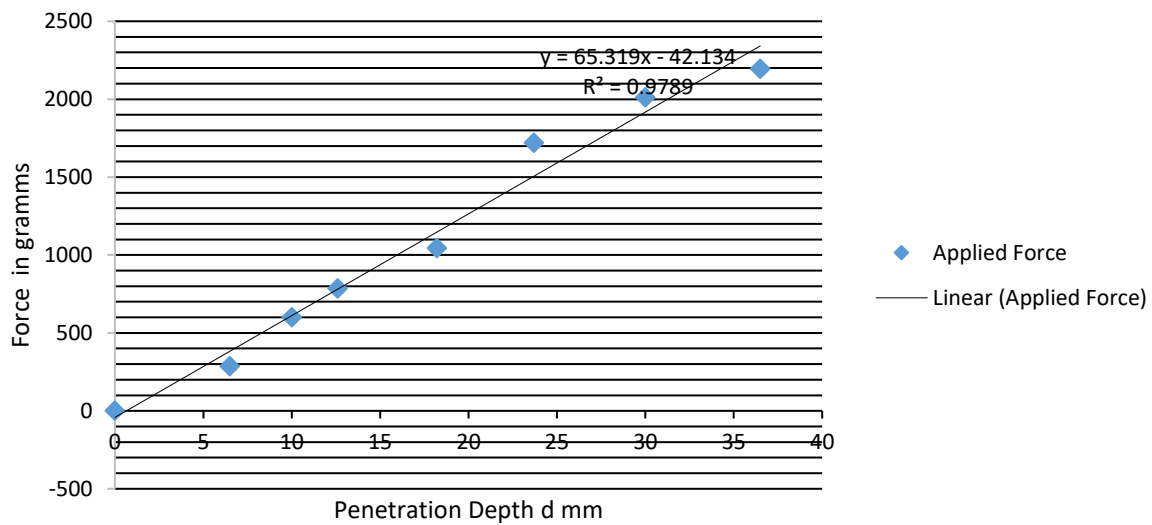
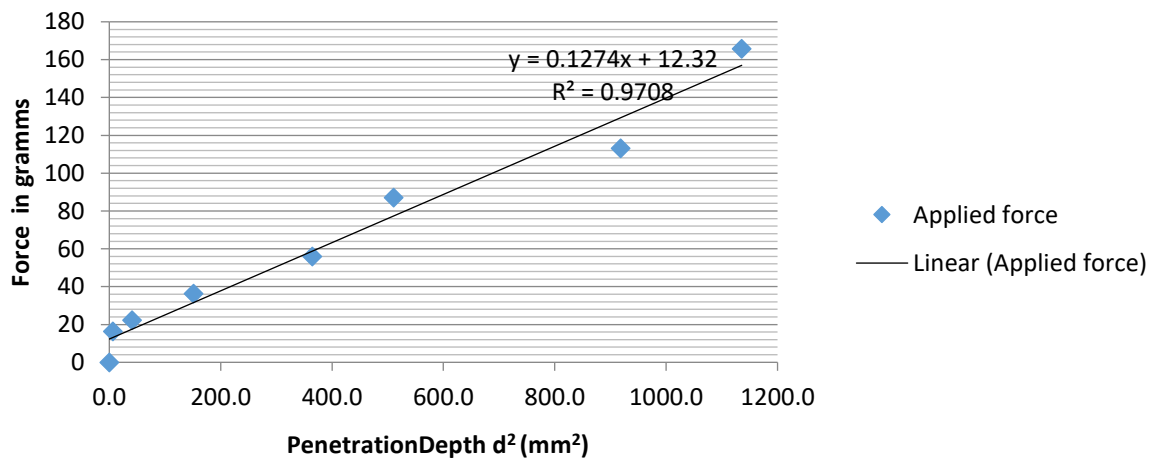


Table of results for soil sample A6 at moisture content 33.1% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) cm	d ²	Applied force
45.5	242.05	0	0.0	0
48	258.45	2.5	6.3	16.4
51.9	264.34	6.4	41.0	22.29
57.8	278.37	12.3	151.3	36.32
64.6	298.01	19.1	364.8	55.96
68.1	329.23	22.6	510.8	87.18
75.8	355.15	30.3	918.1	113.1
79.2	407.78	33.7	1135.7	165.73

Applied force vs (Penetration Depth)²



Applied force vs Penetration Depth

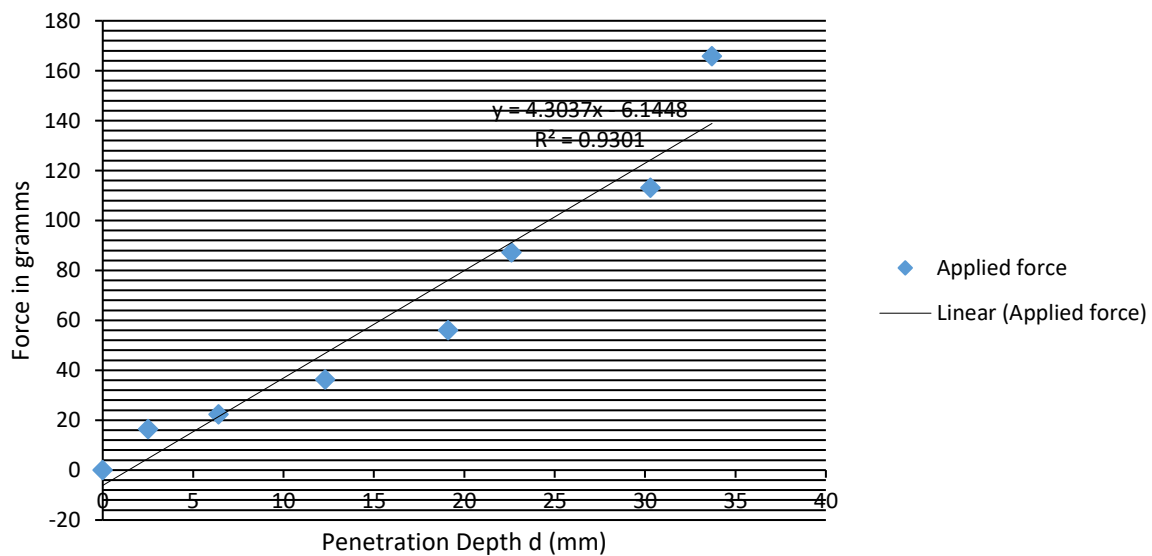


Table of results for soil sample R6 at moisture content 11% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
44	380.96	0	0.0	0
48.5	527.38	4.5	20.3	146.42
52	842.17	8	64.0	461.21
54.6	1127.04	10.6	112.4	746.08
60.2	1585.72	16.2	262.4	1204.76
65.7	1880.47	21.7	470.9	1499.51
72	2217.28	28	784.0	1836.32
78.5	2455.4	34.5	1190.3	2074.44

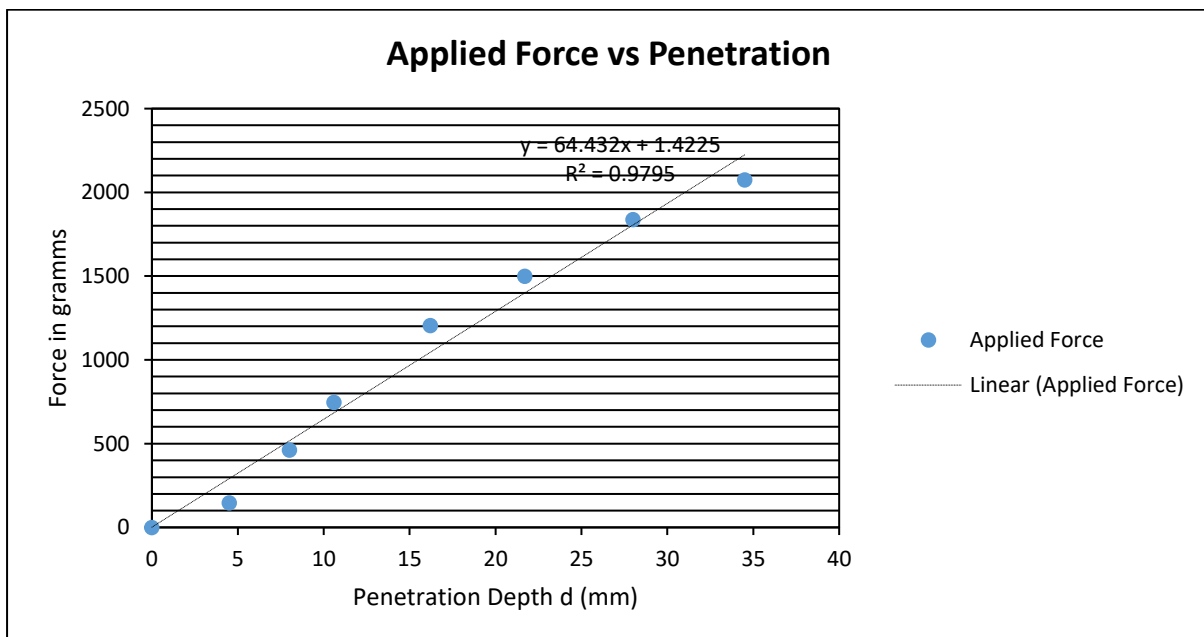
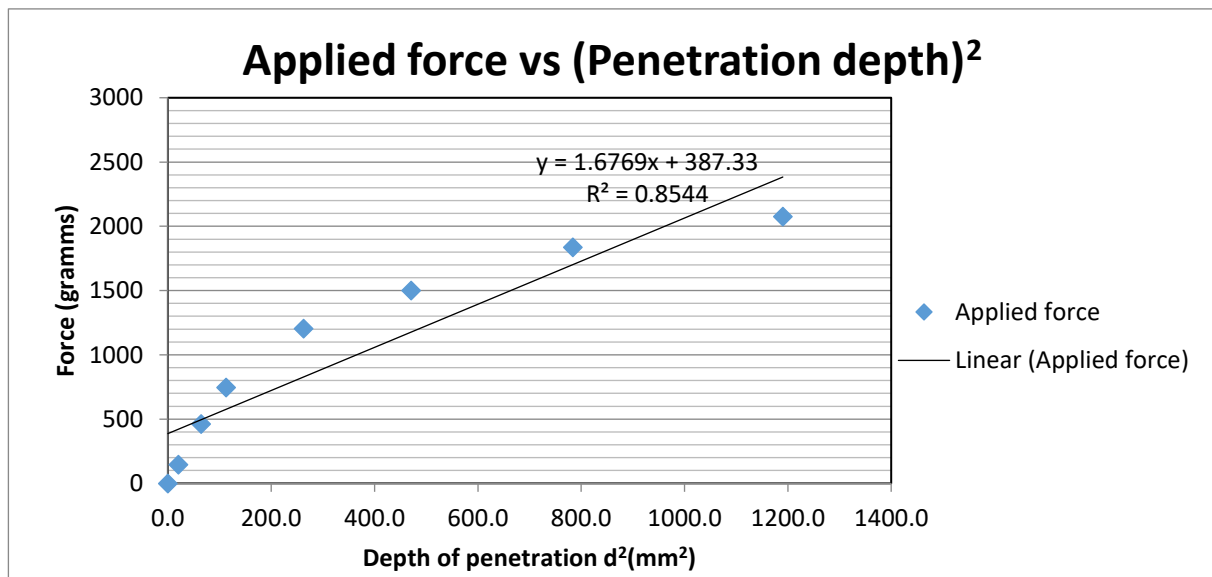
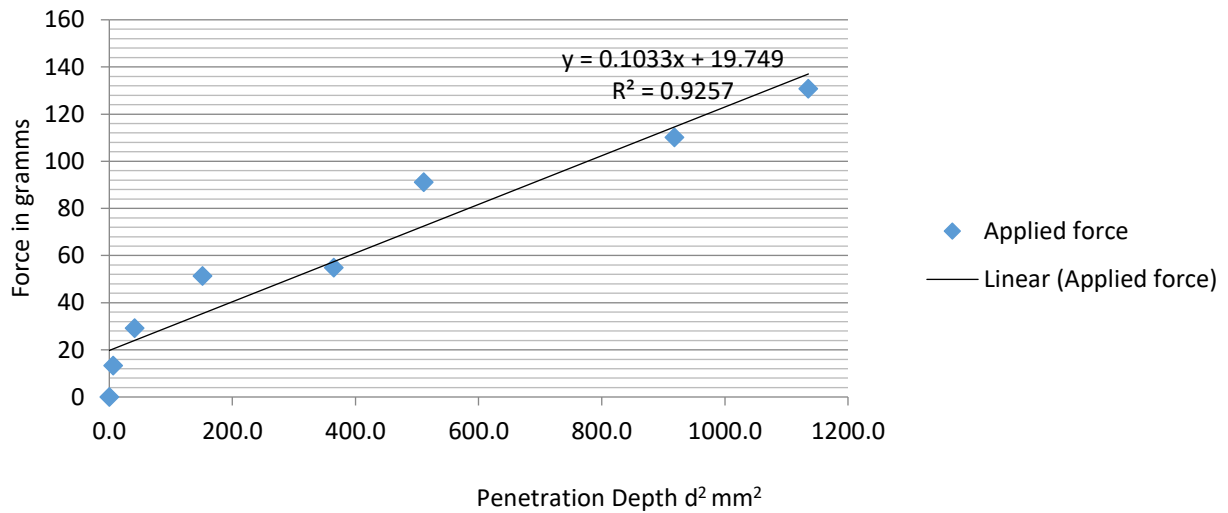


Table of results for soil sample R6 at moisture content 33.2% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) cm	d ²	Applied force
45.5	225.05	0	0.0	0
48	238.45	2.5	6.3	13.4
51.9	254.34	6.4	41.0	29.29
57.8	276.37	12.3	151.3	51.32
64.6	280.01	19.1	364.8	54.96
68.1	316.23	22.6	510.8	91.18
75.8	335.15	30.3	918.1	110.1
79.2	355.78	33.7	1135.7	130.73

Applied force vs (Penetration Depth)²



Force Applied vs Penetration Depth

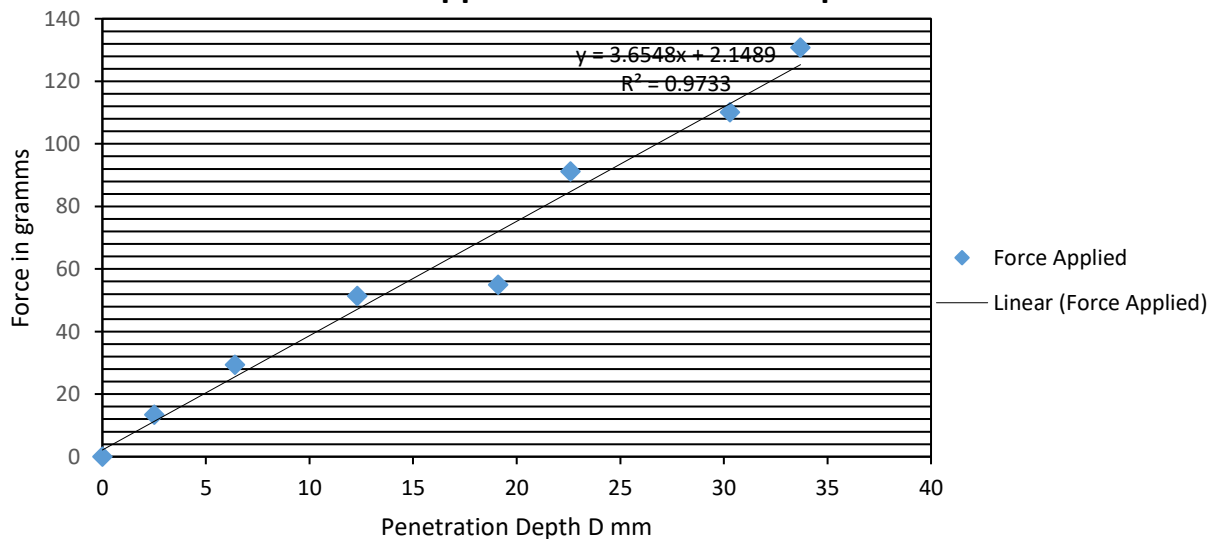


Table of results for soil sample K4 at moisture content 22% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42	296.46	0	0.0	0
48.5	527.38	6.5	42.3	230.92
52	842.17	10	100.0	545.71
54.6	1127.04	12.6	158.8	830.58
60.2	1585.72	18.2	331.2	1289.26
65.7	1880.47	23.7	561.7	1584.01
72	2217.28	30	900.0	1920.82
78.5	2455.4	36.5	1332.3	2158.94

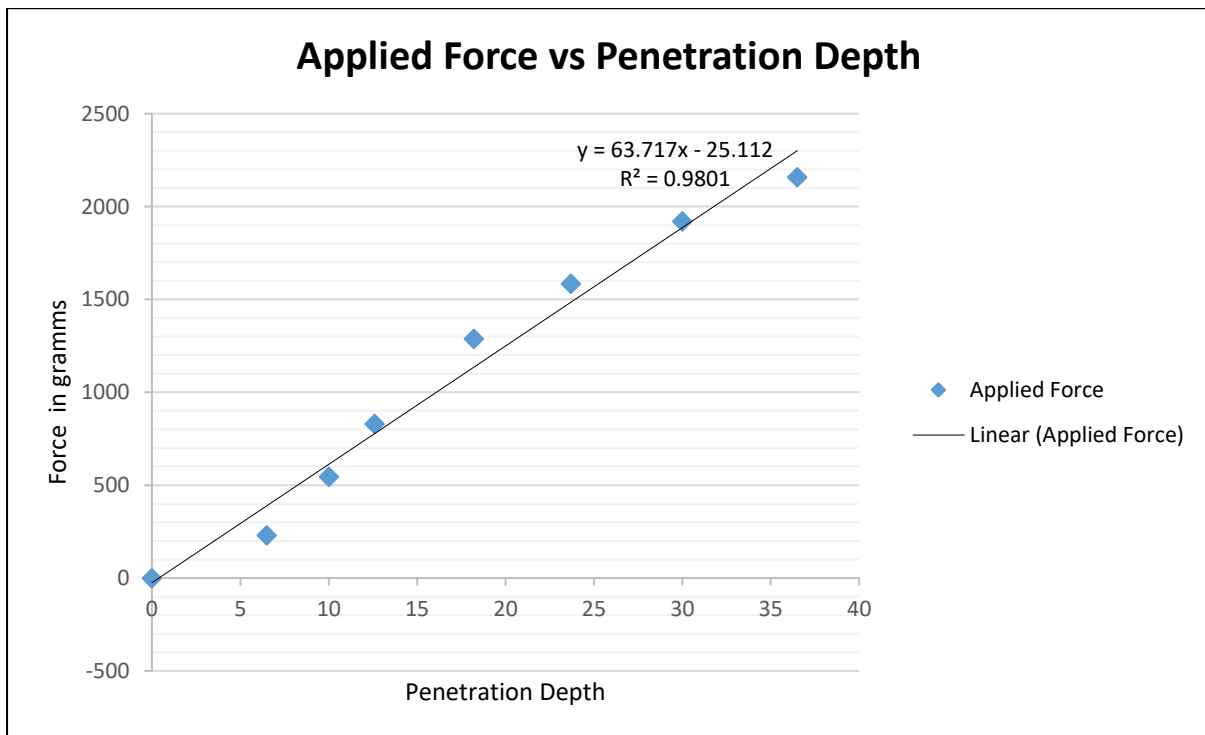
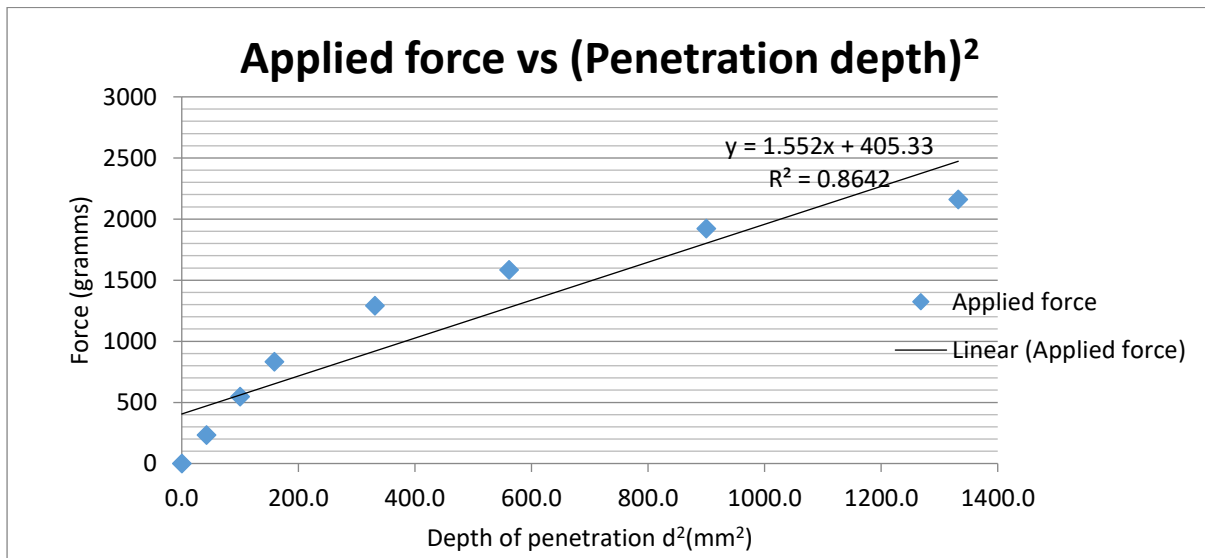


Table of results for soil sample K4 at moisture content 33.2% liquid limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.5	230.05	0	0.0	0
48	248.45	2.5	6.3	18.4
51.9	254.34	6.4	41.0	24.29
57.8	270.37	12.3	151.3	40.32
64.6	280.01	19.1	364.8	49.96
68.1	293.23	22.6	510.8	63.18
75.8	363.15	30.3	918.1	133.1
79.2	395.78	33.7	1135.7	165.73

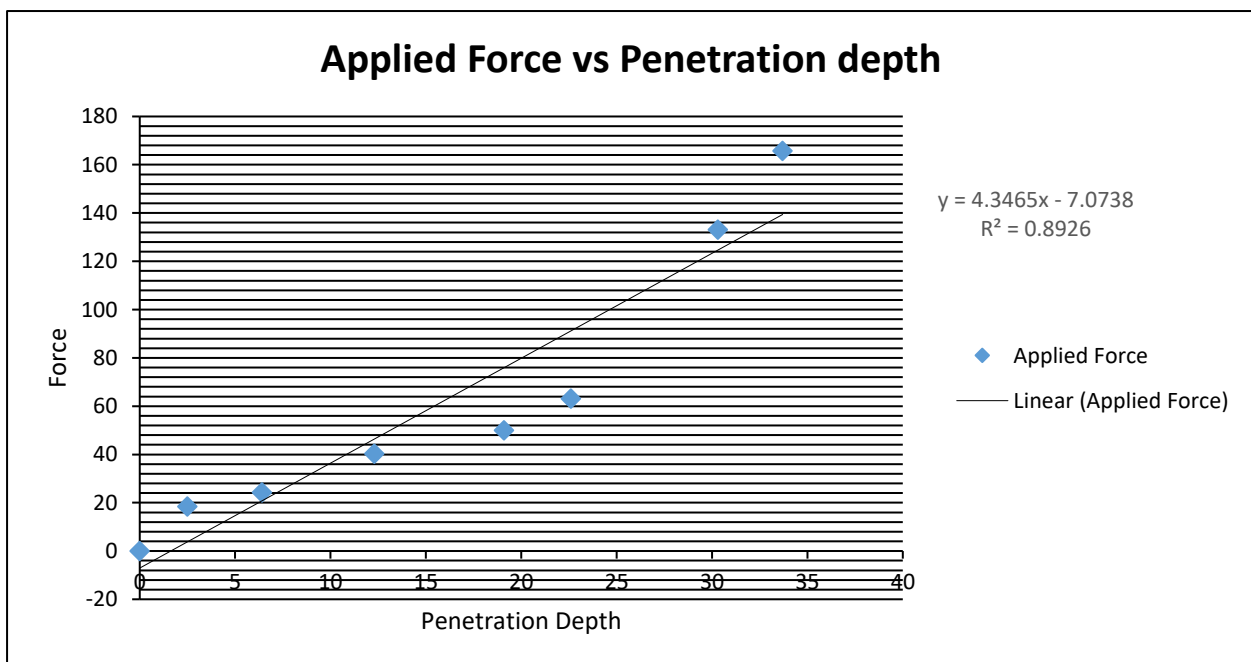
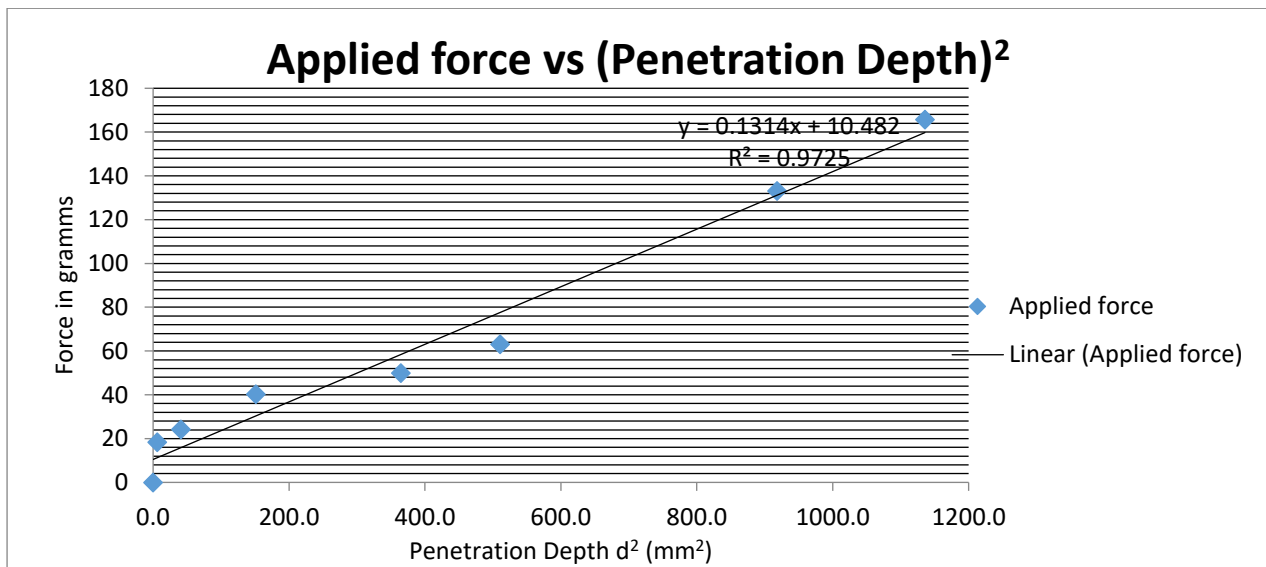


Table of results for soil sample K3 at moisture content 20% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42	340.96	0	0.0	0
48.5	527.38	6.5	42.3	186.42
52	895.17	10	100.0	554.21
54.6	1027.04	12.6	158.8	686.08
60.2	1685.72	18.2	331.2	1344.76
65.7	1860.47	23.7	561.7	1519.51
72	2236.28	30	900.0	1895.32
78.5	2837.7	36.5	1332.3	2496.74

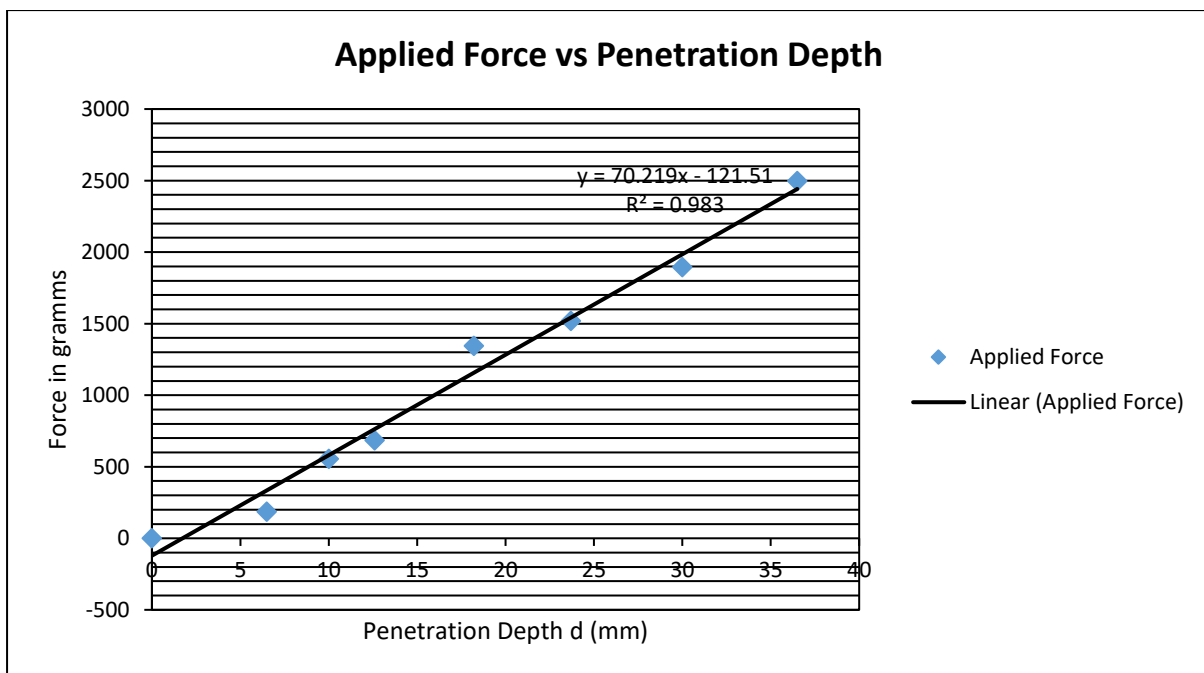
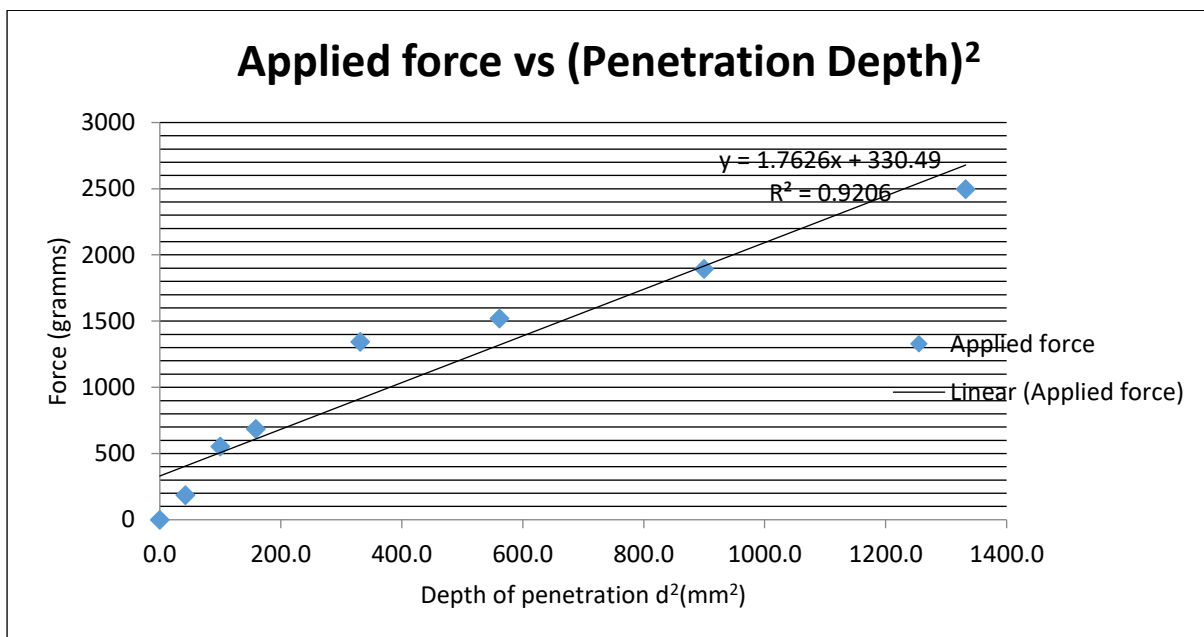


Table of results for soil sample K3 at moisture content 43.2% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.5	230.05	0	0.0	0
48	248.45	2.5	6.3	18.4
51.9	254.34	6.4	41.0	24.29
57.8	270.37	12.3	151.3	40.32
64.6	280.01	19.1	364.8	49.96
68.1	293.23	22.6	510.8	63.18
75.8	380.15	30.3	918.1	150.1
79.2	395.78	33.7	1135.7	165.73

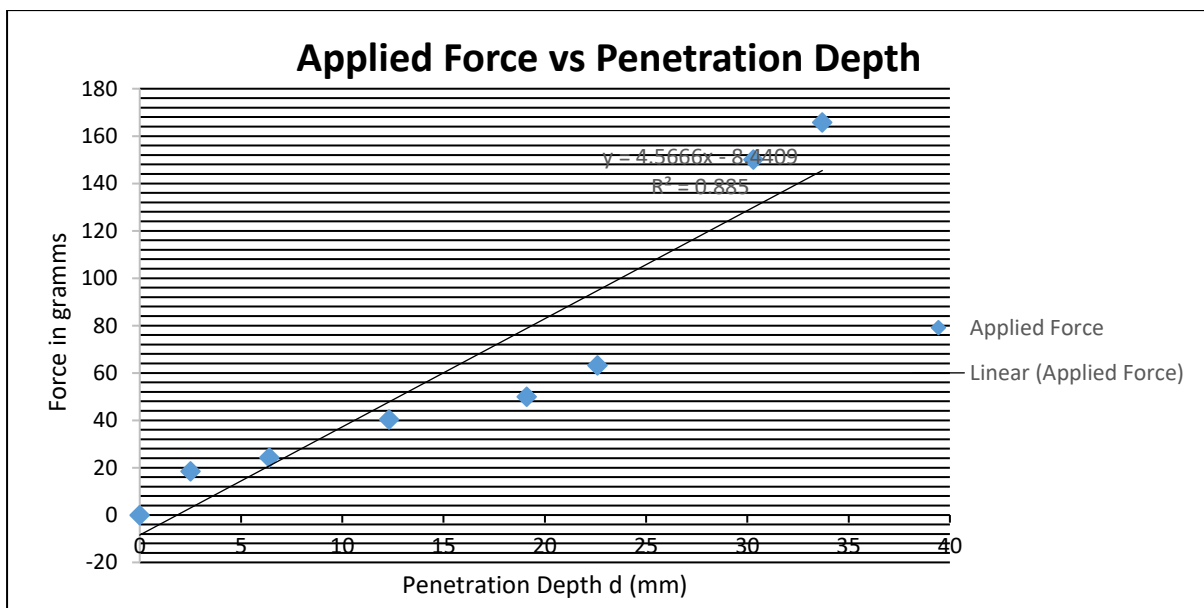
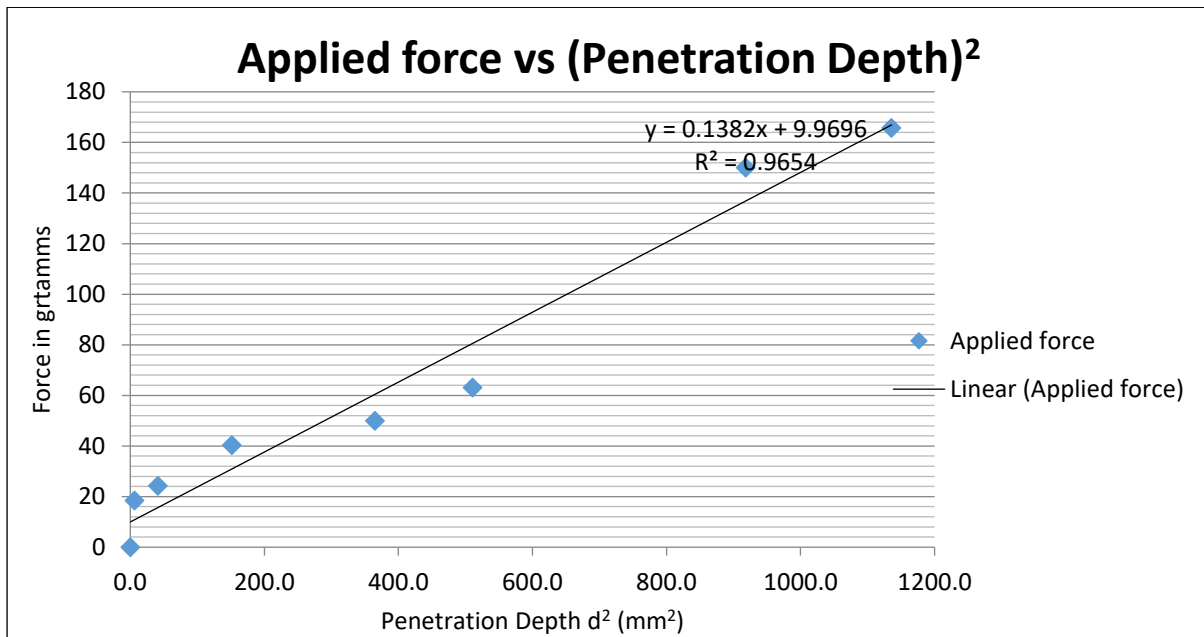


Table of results for soil sample K8 at moisture content 24% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42	240.96	0	0.0	0
48.5	527.38	6.5	42.3	286.42
52	842.17	10	100.0	601.21
54.6	1227.04	12.6	158.8	986.08
60.2	1485.72	18.2	331.2	1244.76
65.7	1860.47	23.7	561.7	1619.51
72	2069.28	30	900.0	1828.32
78.5	2208.92	36.5	1332.3	1967.96

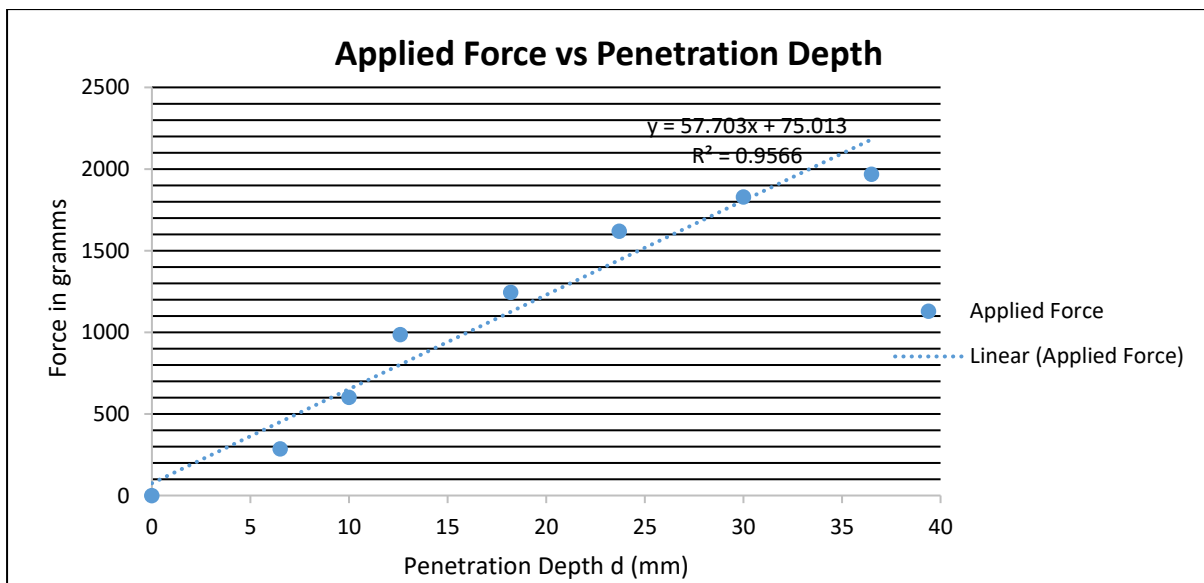
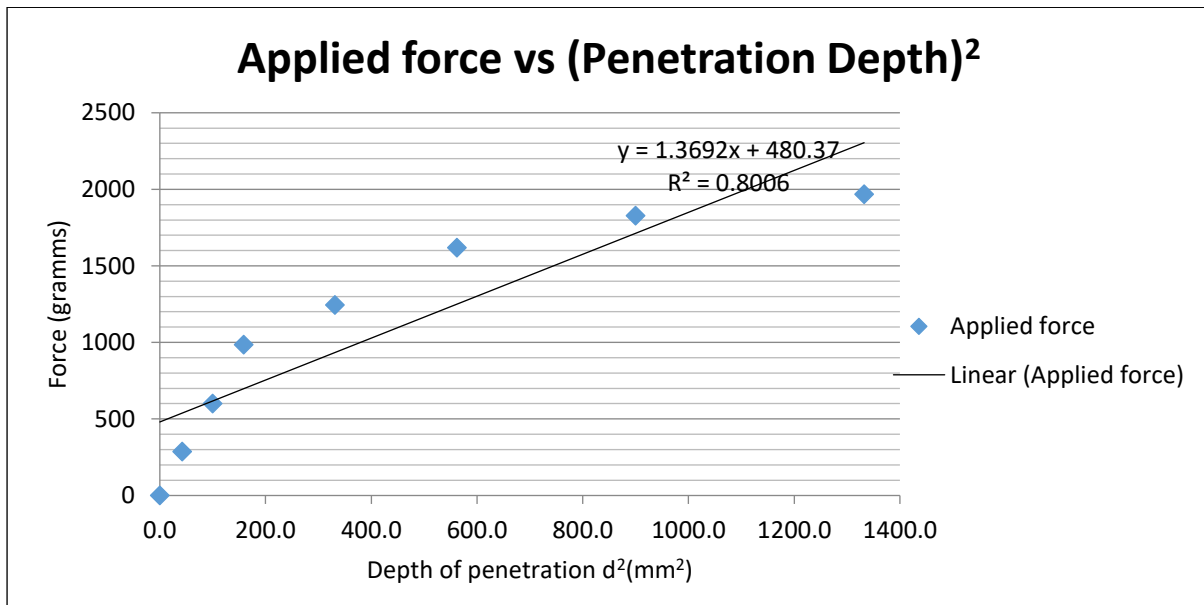


Table of results for soil sample K8 at moisture content 50% liquid limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.5	267.05	0	0.0	0
48	276.45	2.5	6.3	9.4
51.9	299.34	6.4	41.0	32.29
57.8	314.37	12.3	151.3	47.32
64.6	336.01	19.1	364.8	68.96
68.1	369.23	22.6	510.8	102.18
75.8	380.15	30.3	918.1	113.1
79.2	400.78	33.7	1135.7	133.73

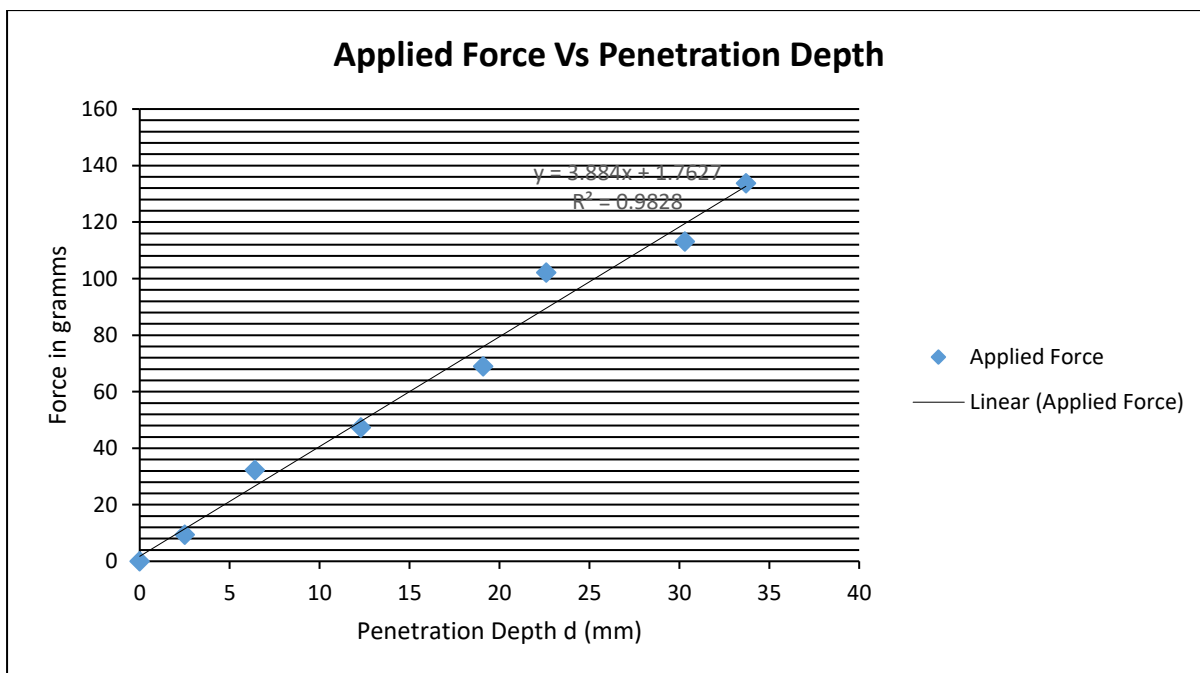
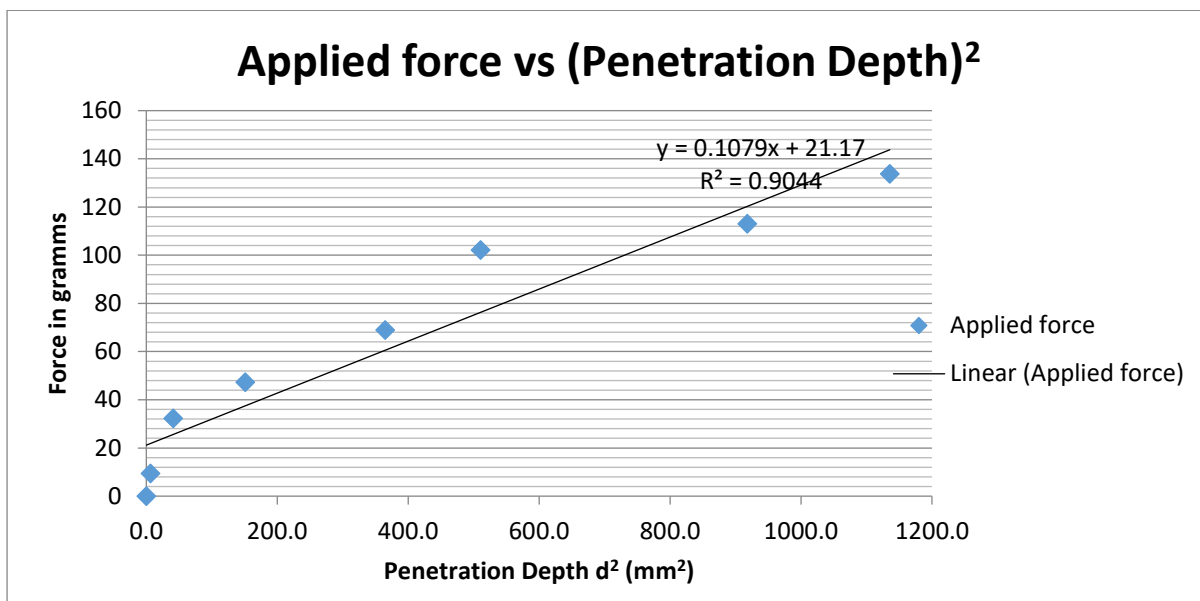


Table of results for soil sample K7 at moisture content 19.8% Plastic Limit

Reading (mm)	length	Reading (g)	Force	Depth of penetration(d) mm	d ²	Applied force
	45.6		224.45	0	0.0	0
	52		510.69	6.4	41.0	286.24
	54.6		1038.54	9	81.0	814.09
	58.6		1265.49	13	169.0	1041.04
	64.2		1447.87	18.6	346.0	1223.42
	69.7		1715.45	24.1	580.8	1491
	76		1990.29	30.4	924.2	1765.84
	83.2		2114.84	37.6	1413.8	1890.39

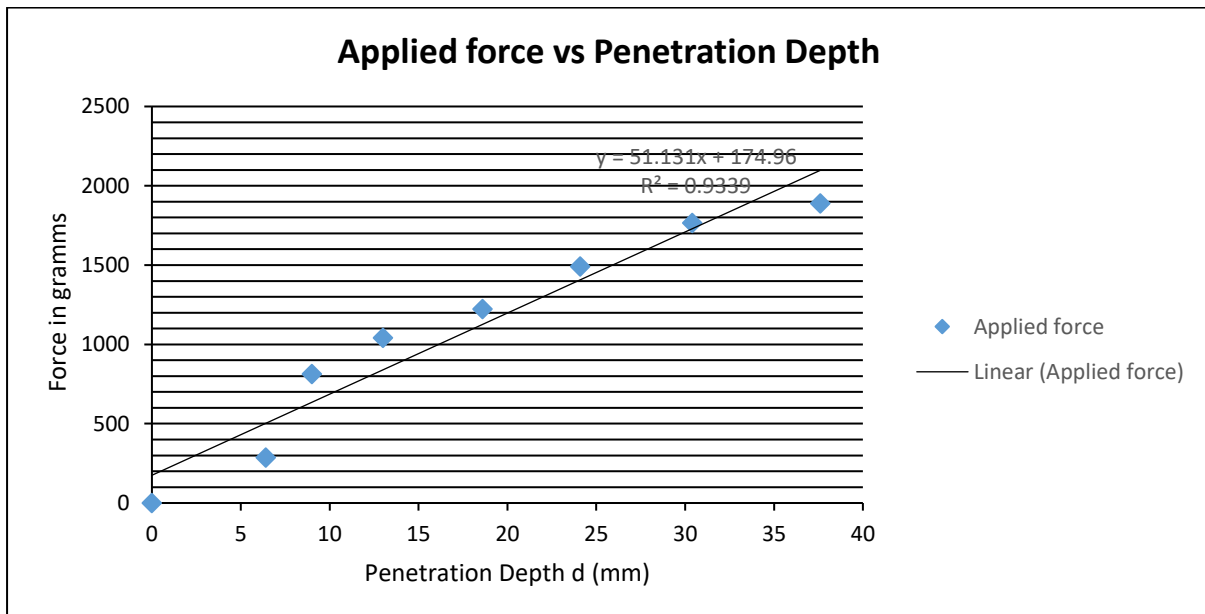
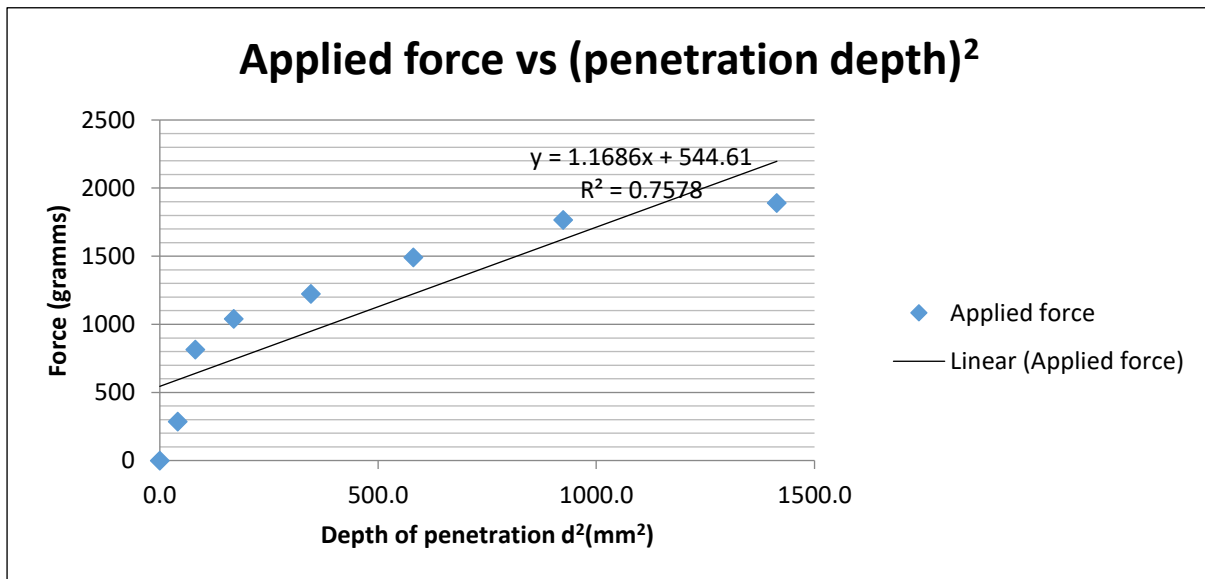


Table of results for soil sample K7 at moisture content 39.2% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.5	270.05	0	0.0	0
48	280.45	2.5	6.3	10.4
51.9	299.34	6.4	41.0	29.29
57.8	332.37	12.3	151.3	62.32
64.6	358.01	19.1	364.8	87.96
68.1	363.23	22.6	510.8	93.18
75.8	370.15	30.3	918.1	100.1
79.2	384.5	33.7	1135.7	114.45

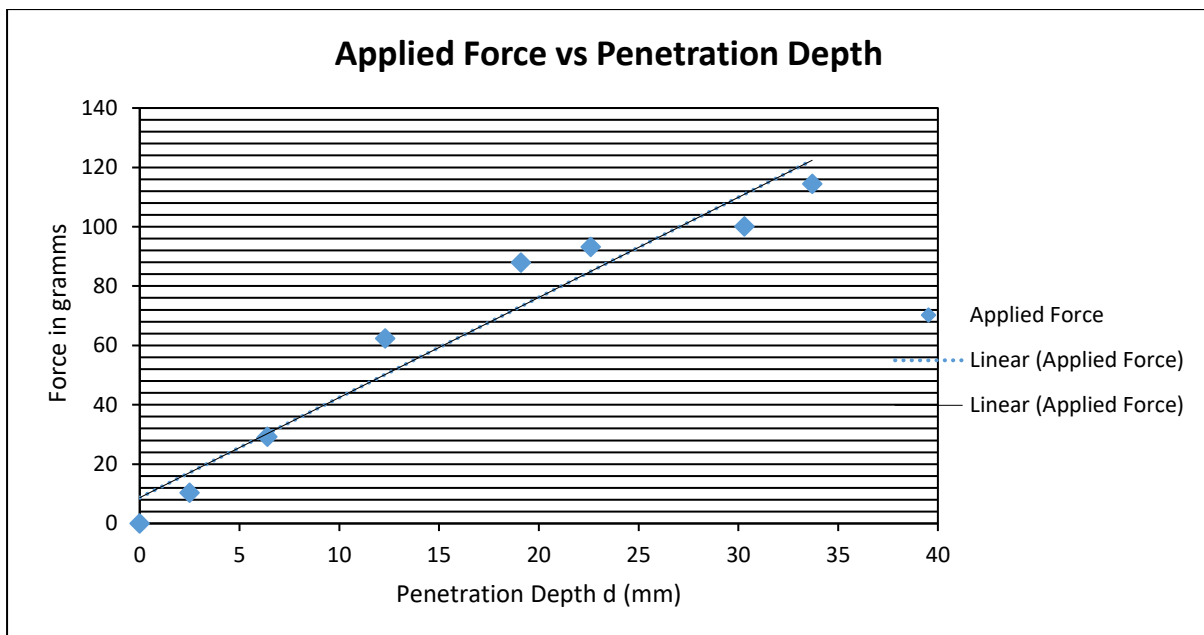
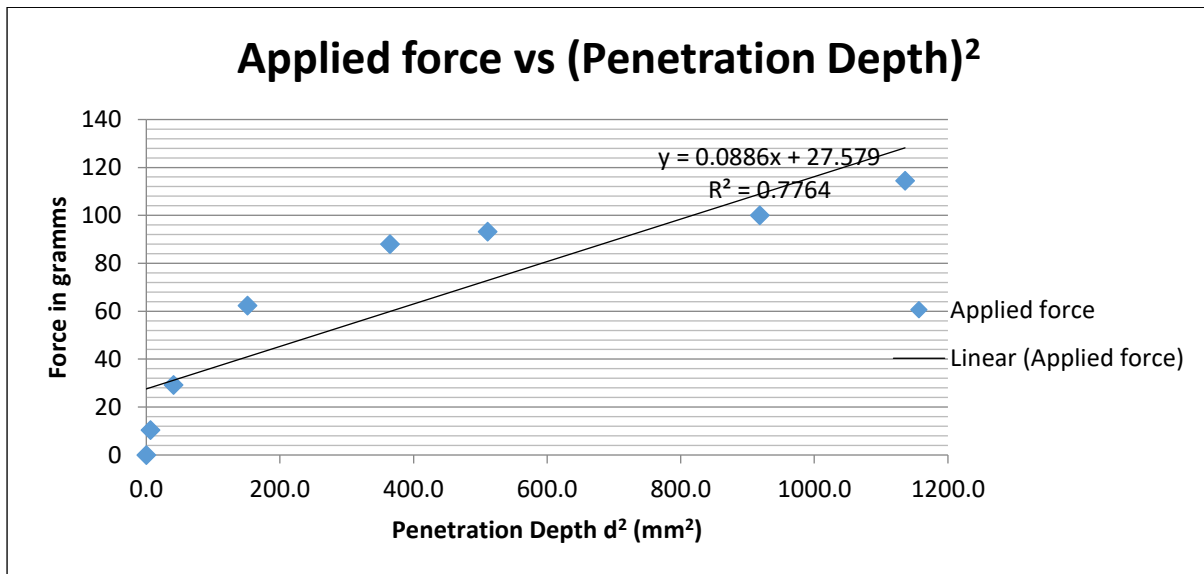


Table of results for soil sample B1 at moisture content 11.5% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42	240.96	0	0.0	0
48.5	657.38	6.5	42.3	416.42
52	1042.17	10	100.0	801.21
54.6	1127.04	12.6	158.8	886.08
60.2	1385.72	18.2	331.2	1144.76
65.7	1760.47	23.7	561.7	1519.51
72	2187.28	30	900.0	1946.32
78.5	2528.92	36.5	1332.3	2287.96

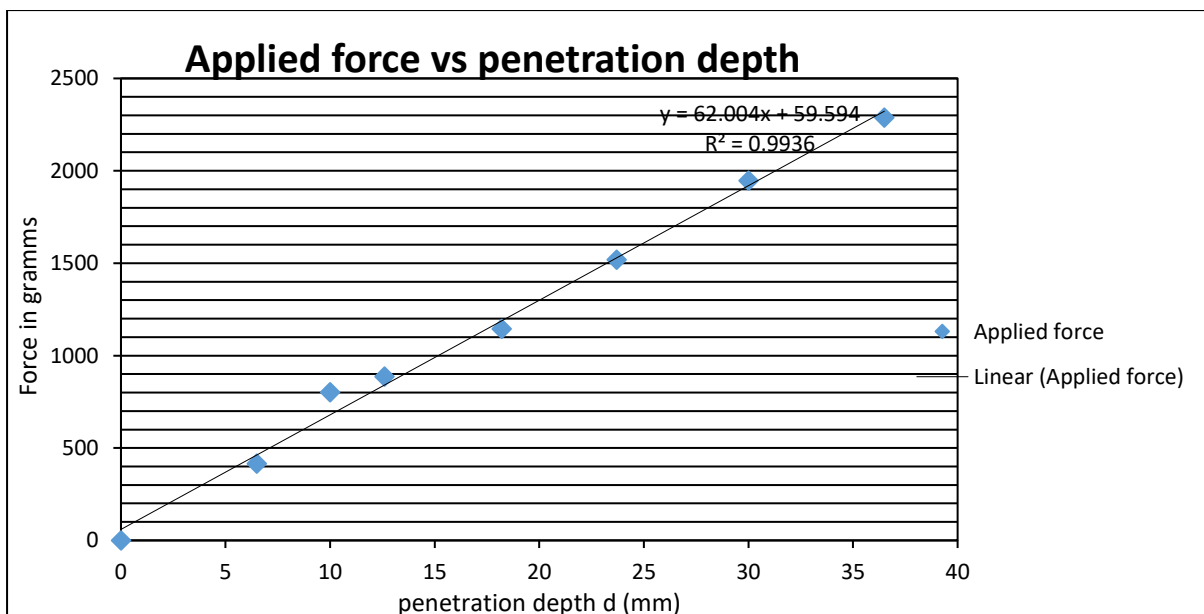
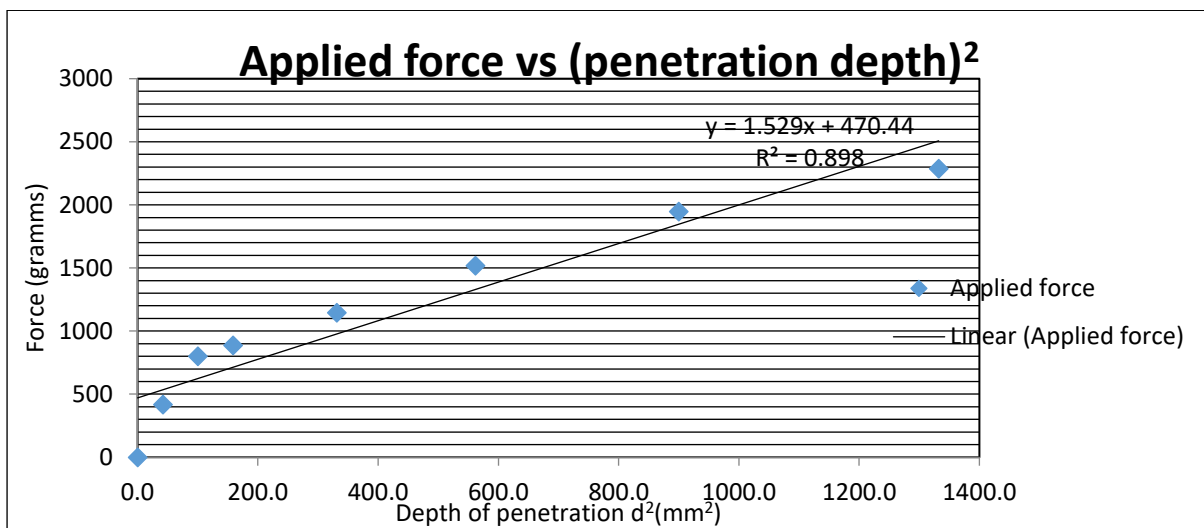


Table of results for soil sample B1 at moisture content 33.7% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
43.4	258.05	0	0.0	0
49.5	280.45	6.1	37.2	22.4
55.5	299.34	12.1	146.4	41.29
62.5	326.37	19.1	364.8	68.32
65.1	358.01	21.7	470.9	99.96
72.3	365.23	28.9	835.2	107.18
78.7	390.15	35.3	1246.1	132.1

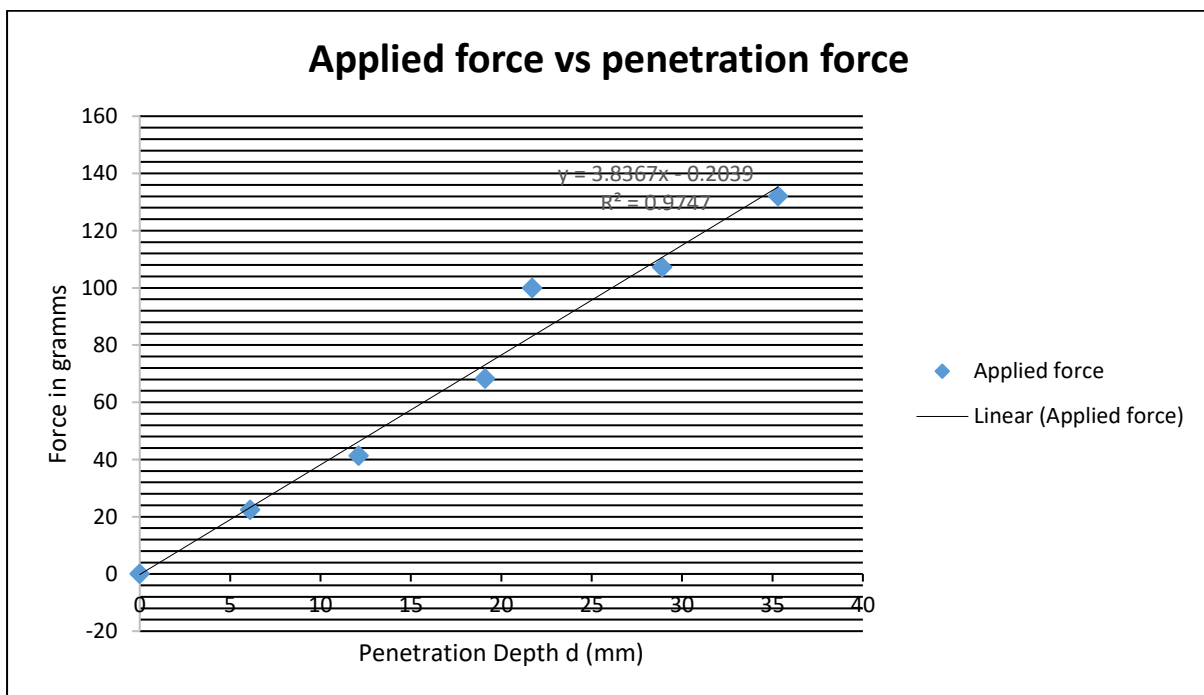
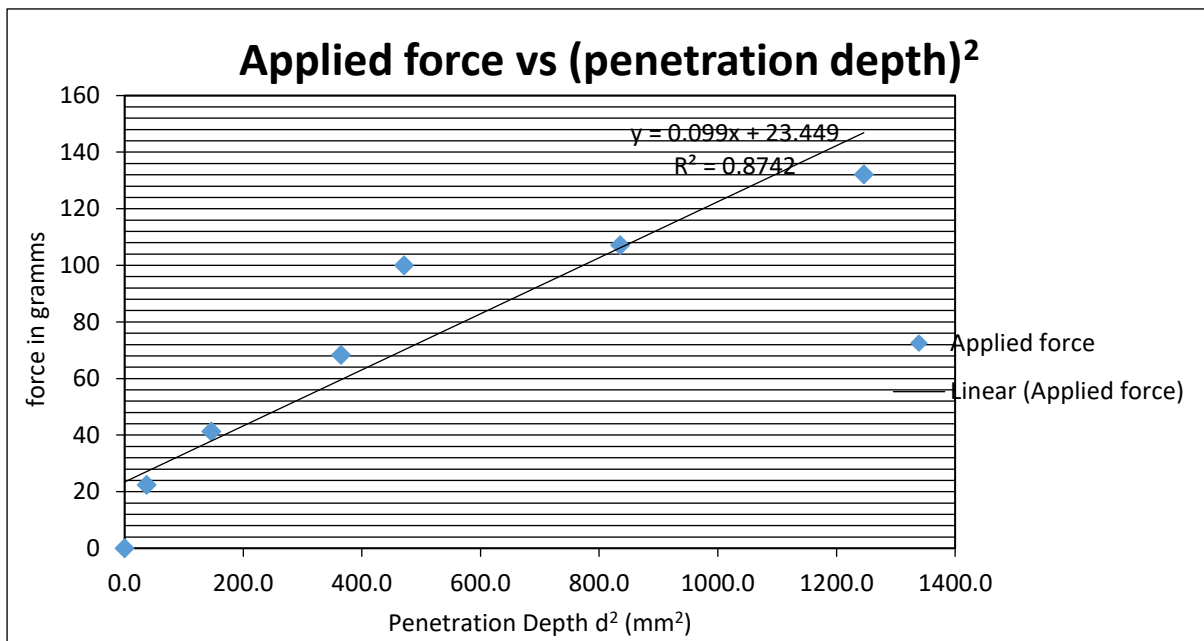


Table of results for soil sample B2 at moisture content 12% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
46.5	254	0	0.0	0
53.2	330.38	6.7	44.9	76.38
58	928.5	11.5	132.3	674.5
65.5	1273.35	19	361.0	1019.35
70.6	1910.07	24.1	580.8	1656.07
74.5	2270	28	784.0	2016
76.8	2310	30.3	918.1	2056

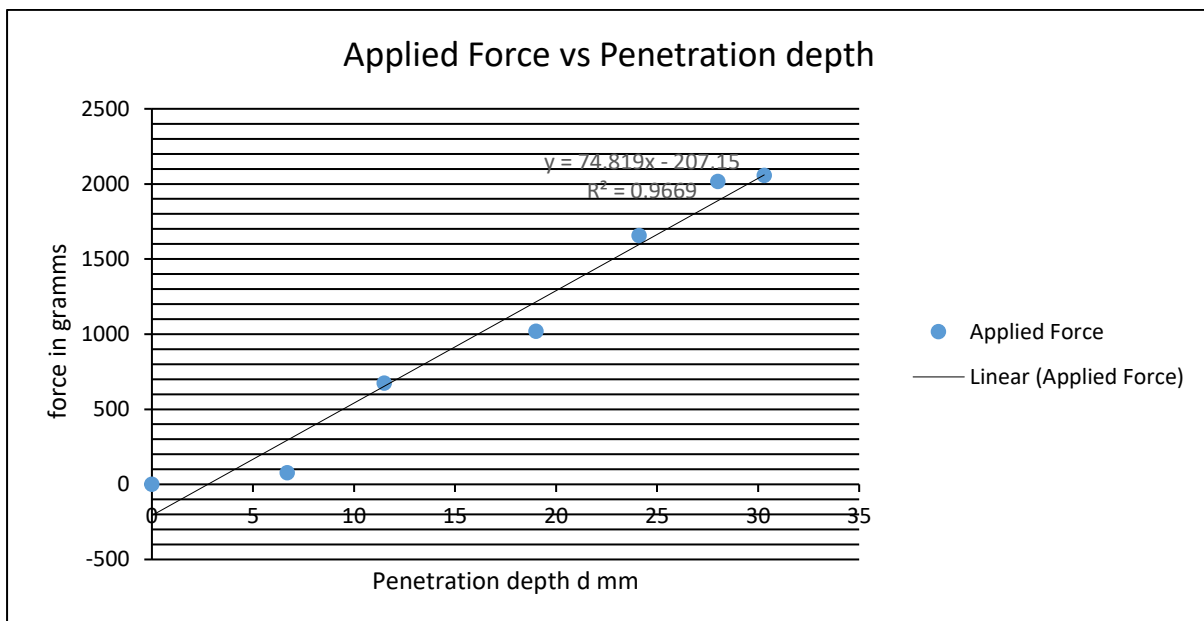
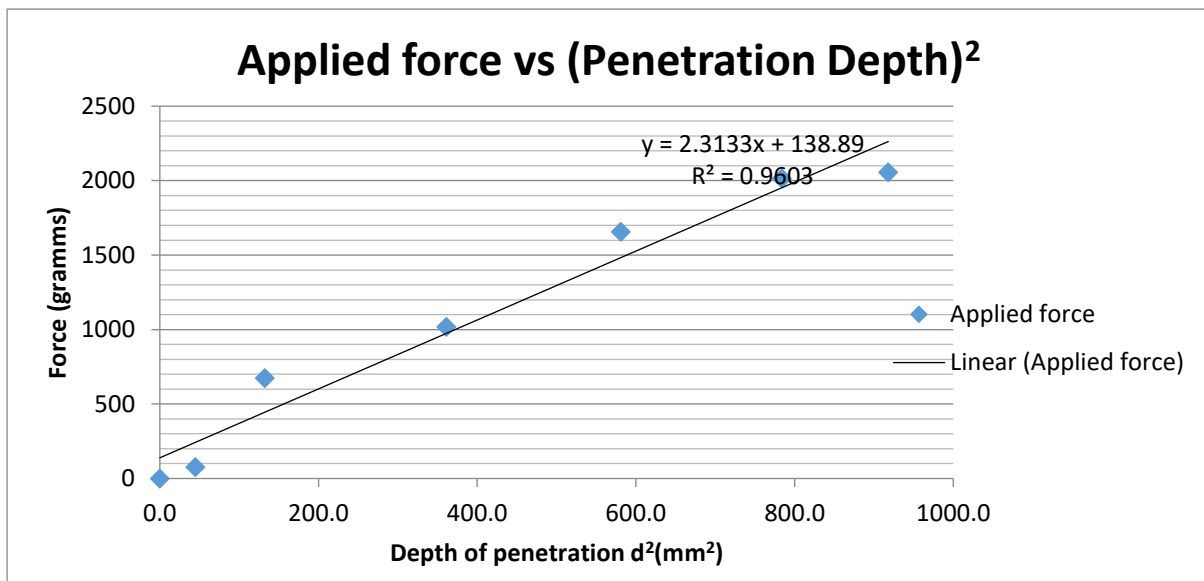


Table of results for soil sample B2 at moisture content 35.5% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42.5	240.05	0	0.0	0
45.5	248.45	3	9.0	8.4
48.8	254.34	6.3	39.7	14.29
54.8	266.37	12.3	151.3	26.32
61.6	270.01	19.1	364.8	29.96
65.1	349.23	22.6	510.8	109.18
72.8	380.15	30.3	918.1	140.1
76.2	406.78	33.7	1135.7	166.73

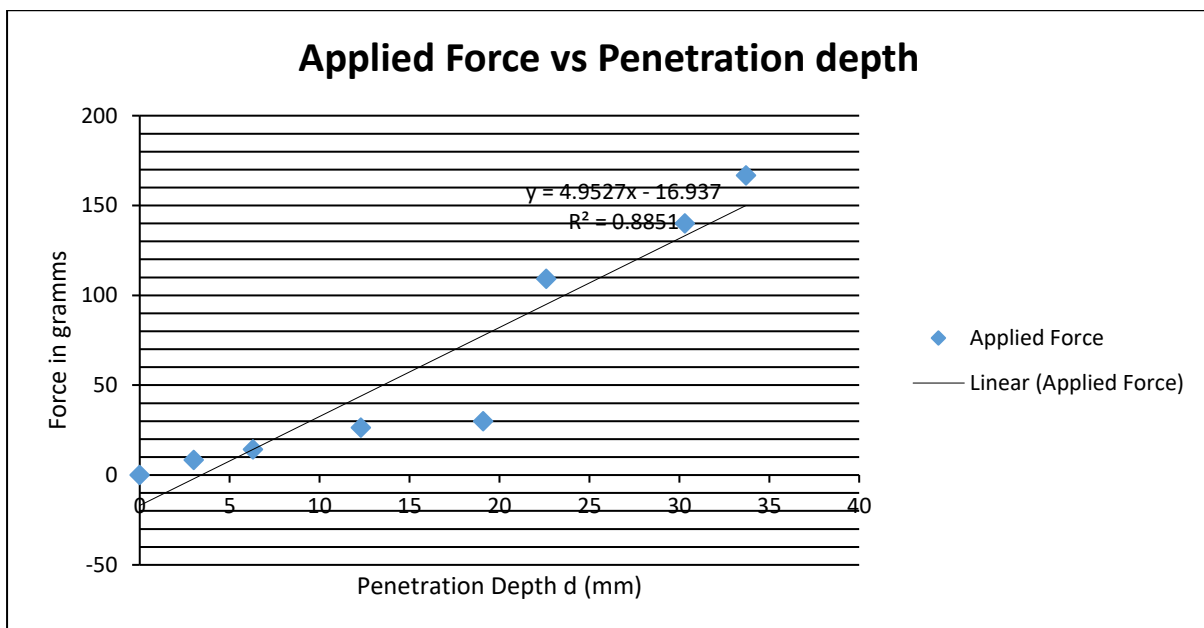
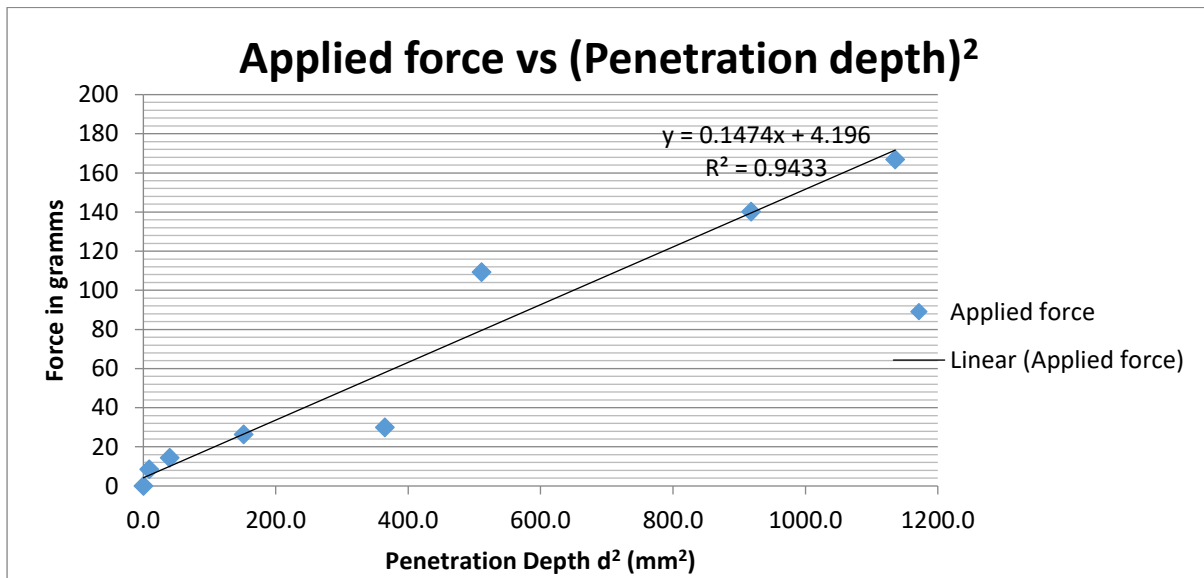


Table of results for soil sample B3 at moisture content 13% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.6	224.45	0	0.0	0
52	533.69	6.4	41.0	309.24
54.6	831.54	9	81.0	607.09
58.6	999.49	13	169.0	775.04
64.2	1447.87	18.6	346.0	1223.42
69.7	1915.45	24.1	580.8	1691
76	2190.29	30.4	924.2	1965.84
83.2	2560.84	37.6	1413.8	2336.39

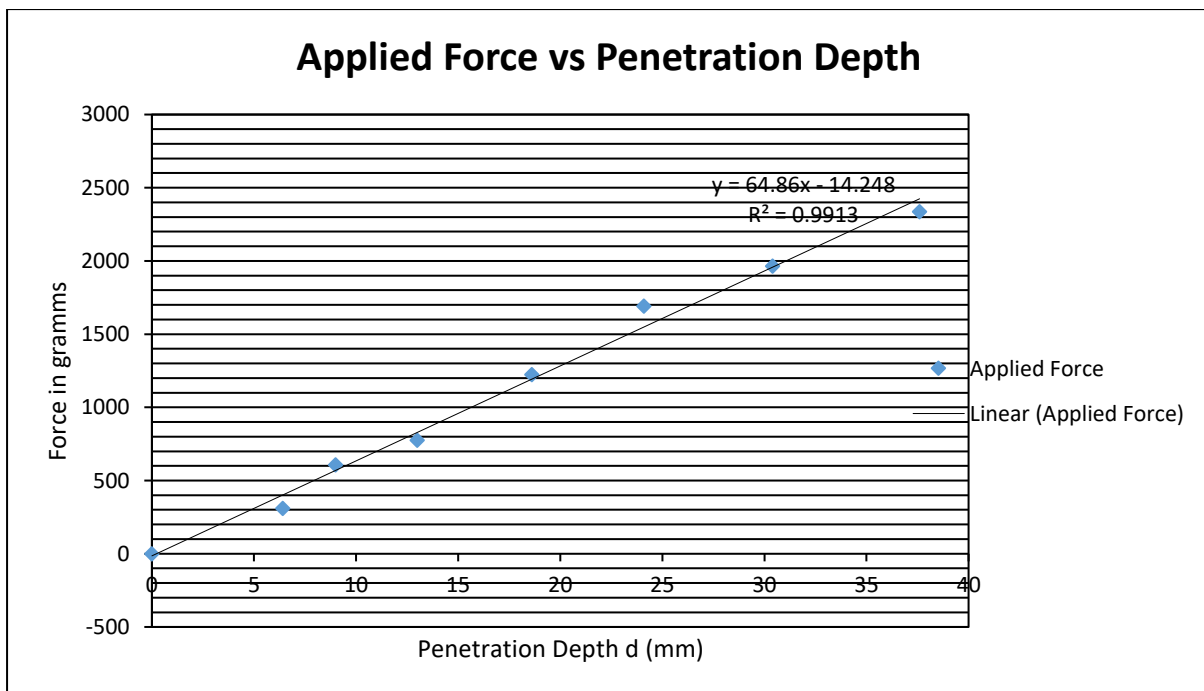
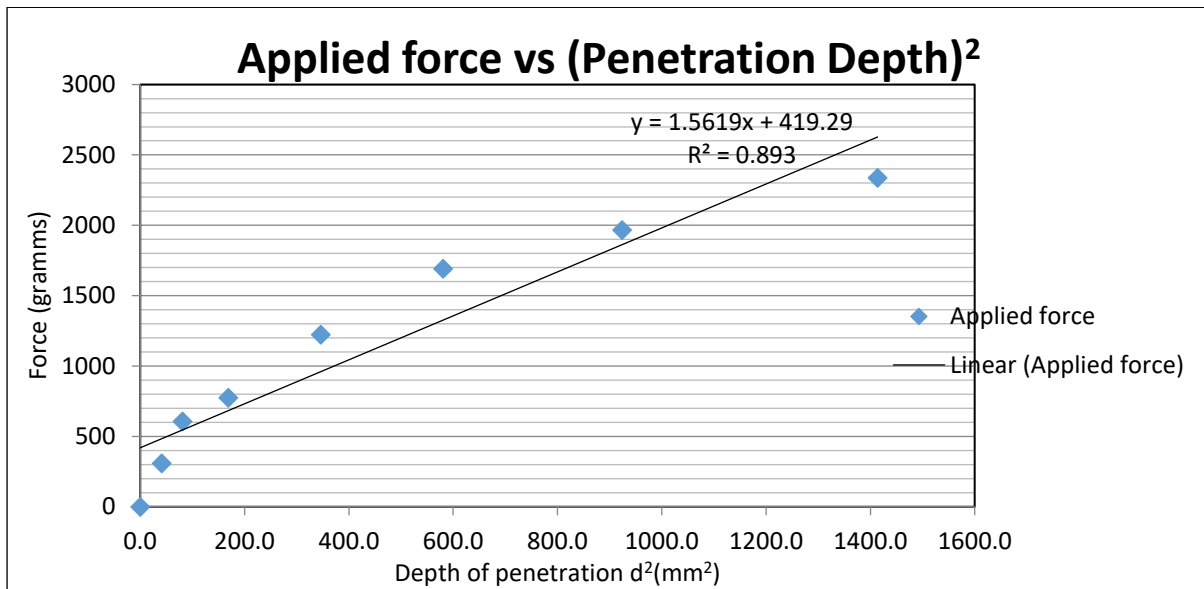


Table of results for soil sample B3 at moisture content 37.2% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.5	228.95	0	0.0	0
48	248.45	2.5	6.3	19.5
51.9	254.34	6.4	41.0	25.39
57.8	278.37	12.3	151.3	49.42
64.6	298.01	19.1	364.8	69.06
68.1	319.23	22.6	510.8	90.28
75.8	330.15	30.3	918.1	101.2
79.2	347.78	33.7	1135.7	118.83

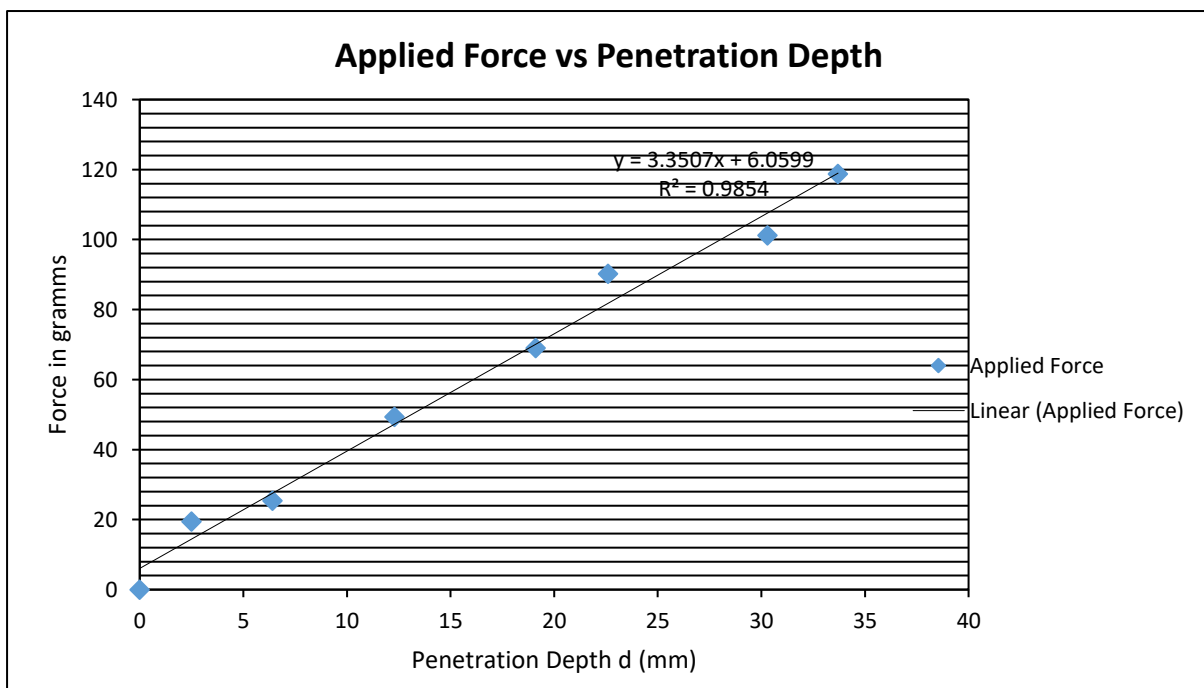
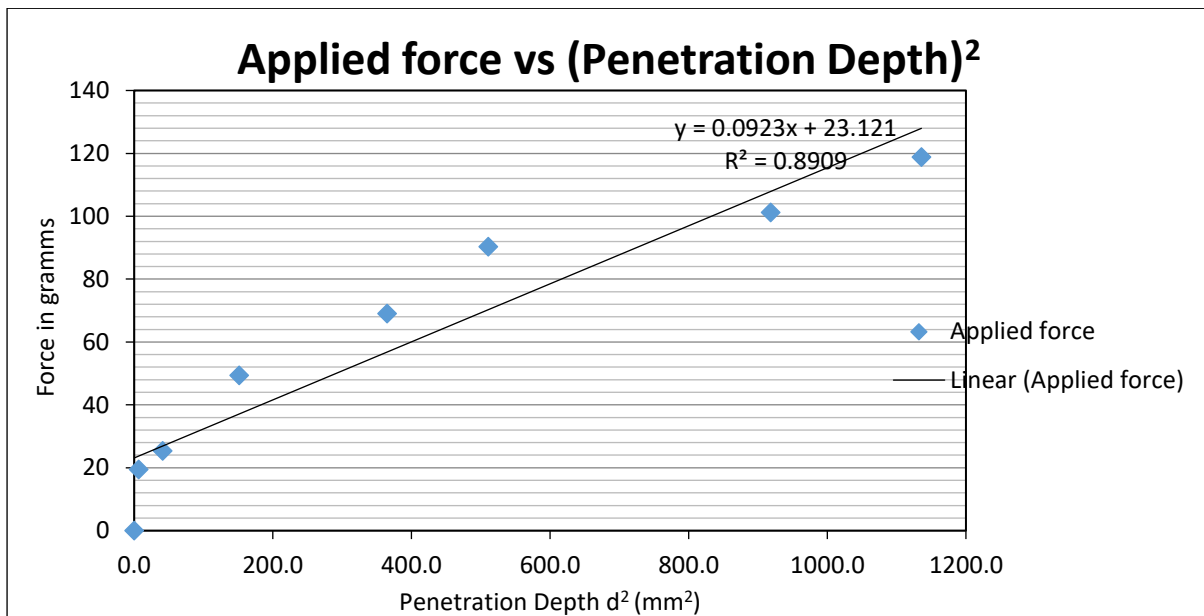


Table of results for soil sample R7 at moisture content 18.6% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42	240.96	0	0.0	0
48.5	527.38	6.5	42.3	286.42
52	815.17	10	100.0	574.21
54.6	1227.04	12.6	158.8	986.08
60.2	1485.72	18.2	331.2	1244.76
65.7	1860.47	23.7	561.7	1619.51
72	2069.28	30	900.0	1828.32
78.5	2195.92	36.5	1332.3	1954.96

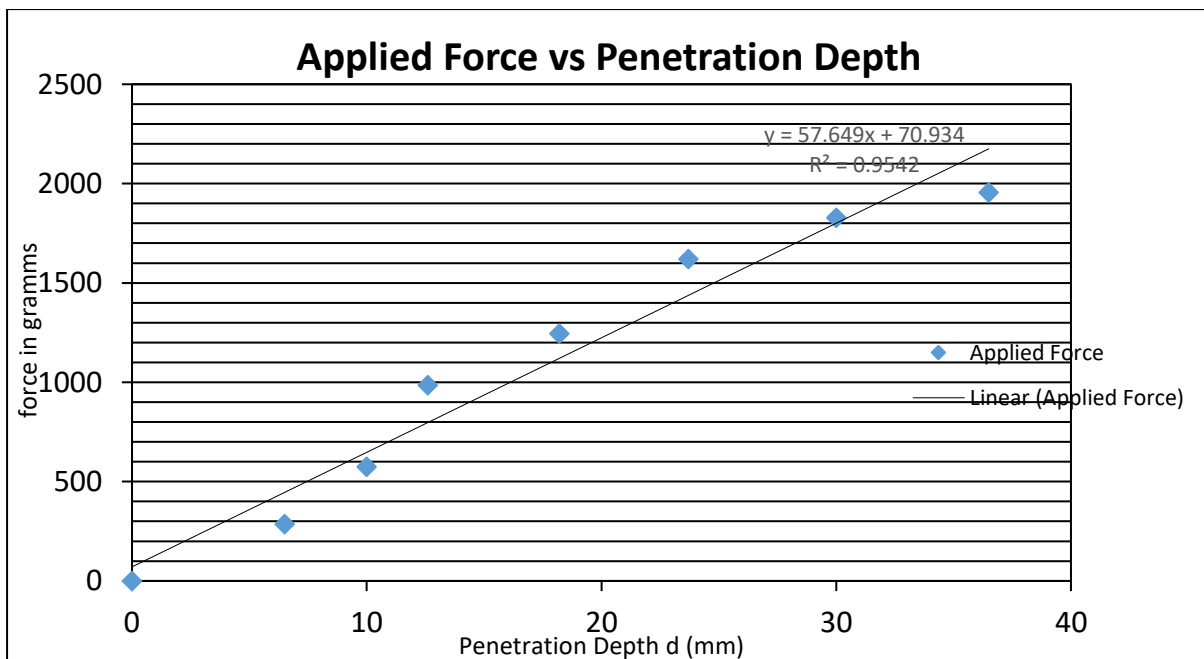
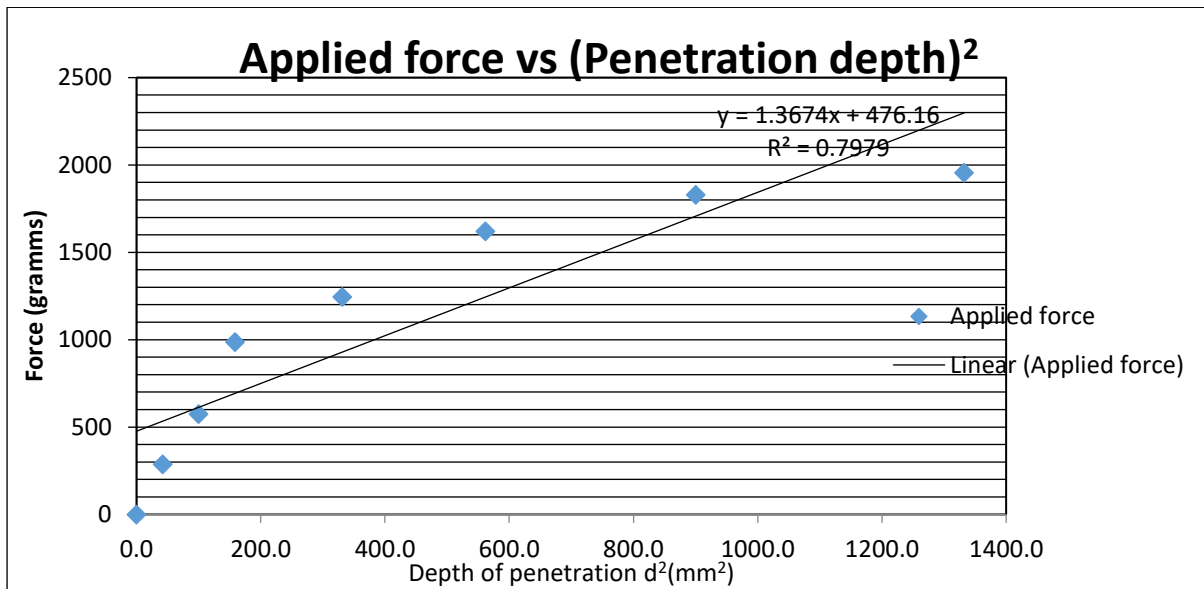


Table of results for soil sample R7 at moisture content 25% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.5	220.05	0	0.0	0
48	248.45	2.5	6.3	28.4
51.9	254.34	6.4	41.0	34.29
57.8	266.37	12.3	151.3	46.32
64.6	276.5	19.1	364.8	56.45
68.1	309.23	22.6	510.8	89.18
75.8	320.15	30.3	918.1	100.1
79.2	371.78	33.7	1135.7	151.73

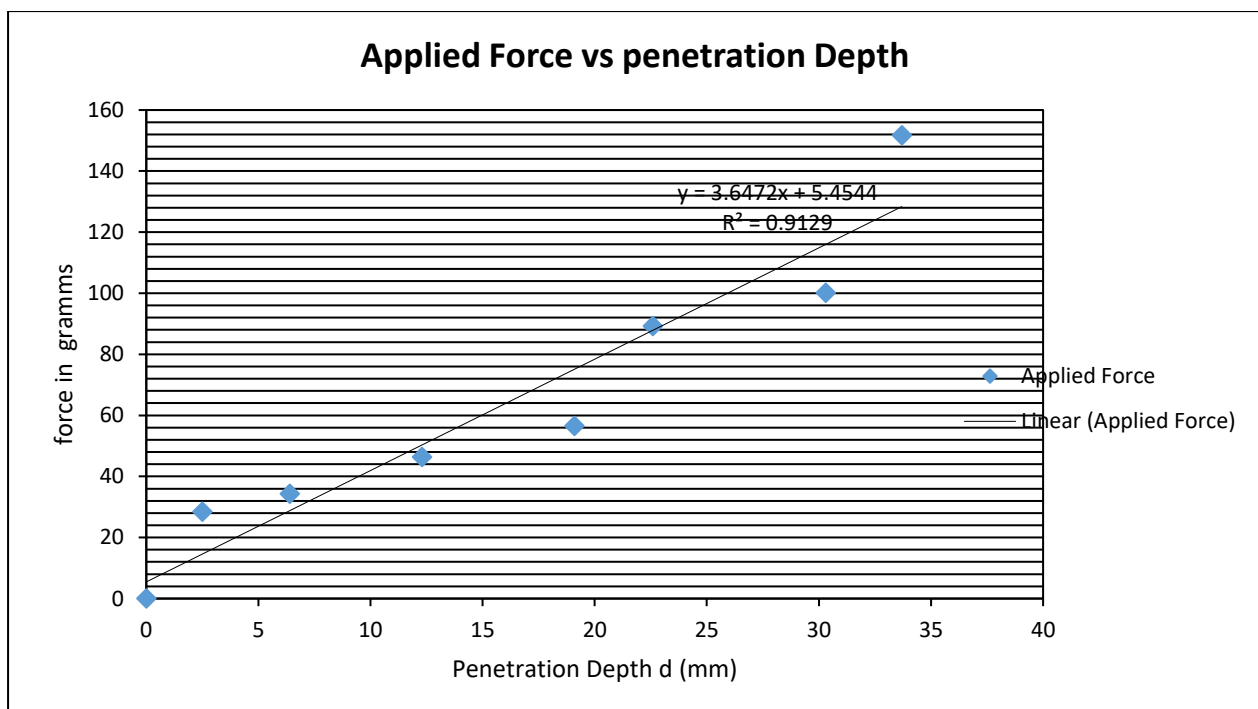
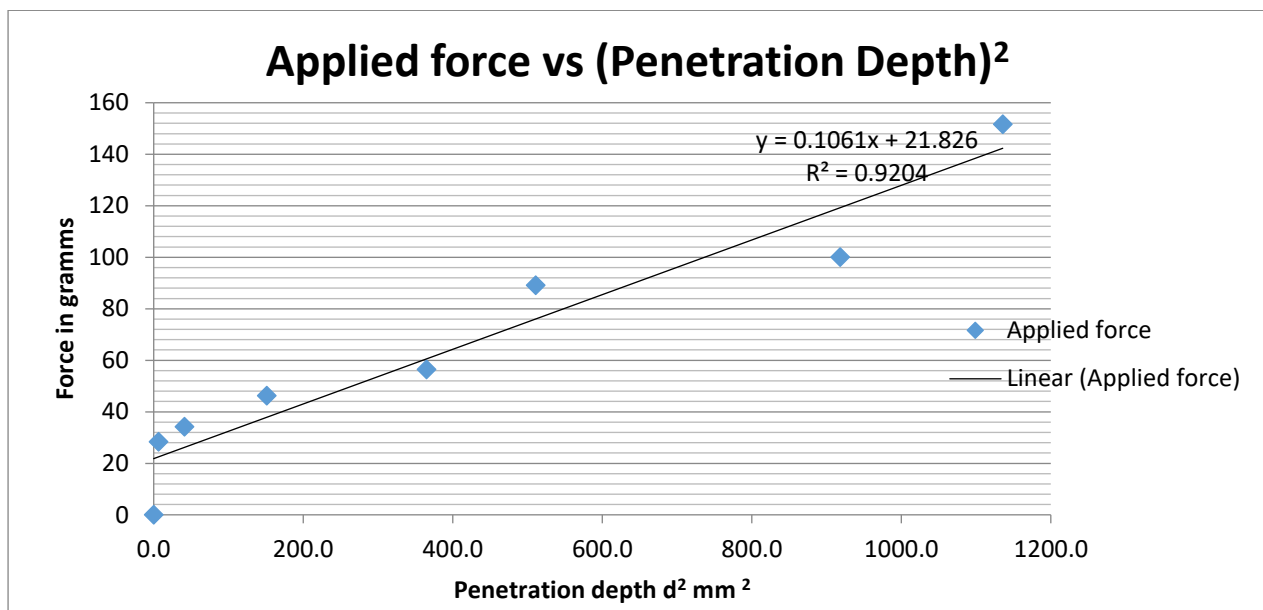


Table of results for soil sample B5 at moisture content 16.5% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
41.1	284	0	0.0	0
46.1	330.38	5	25.0	46.38
48.8	928.5	7.7	59.3	644.5
57.7	1273.35	16.6	275.6	989.35
62.1	1710.07	21	441.0	1426.07
69	2143	27.9	778.4	1859
73	2210	31.9	1017.6	1926

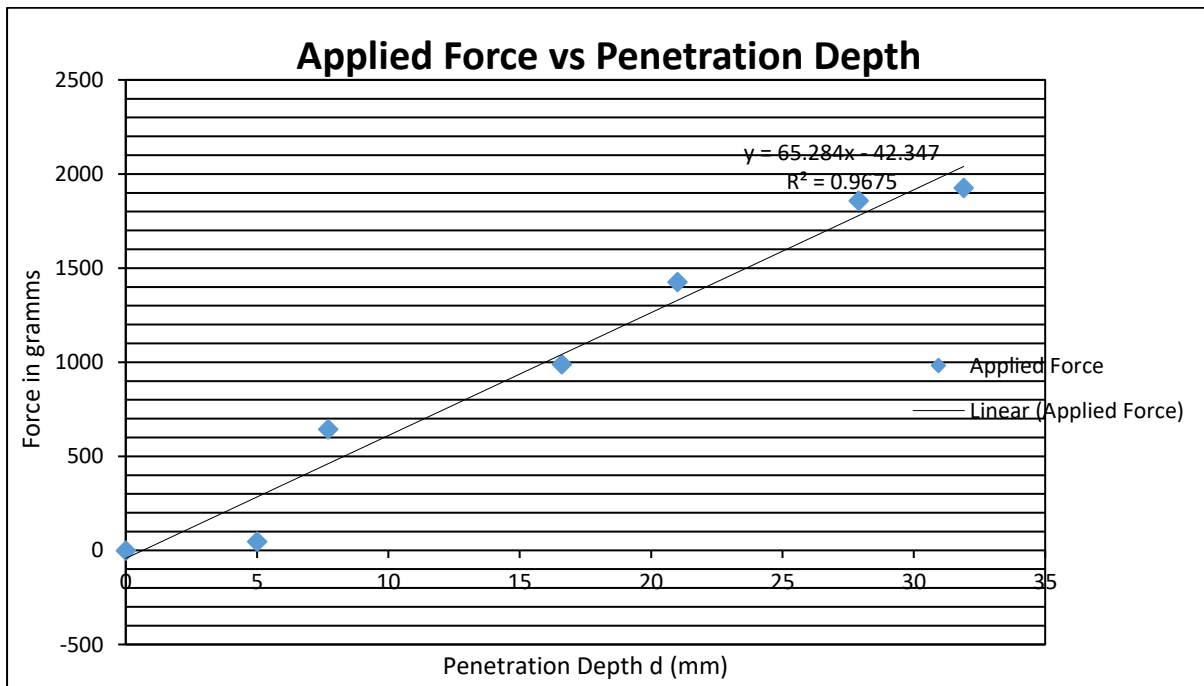
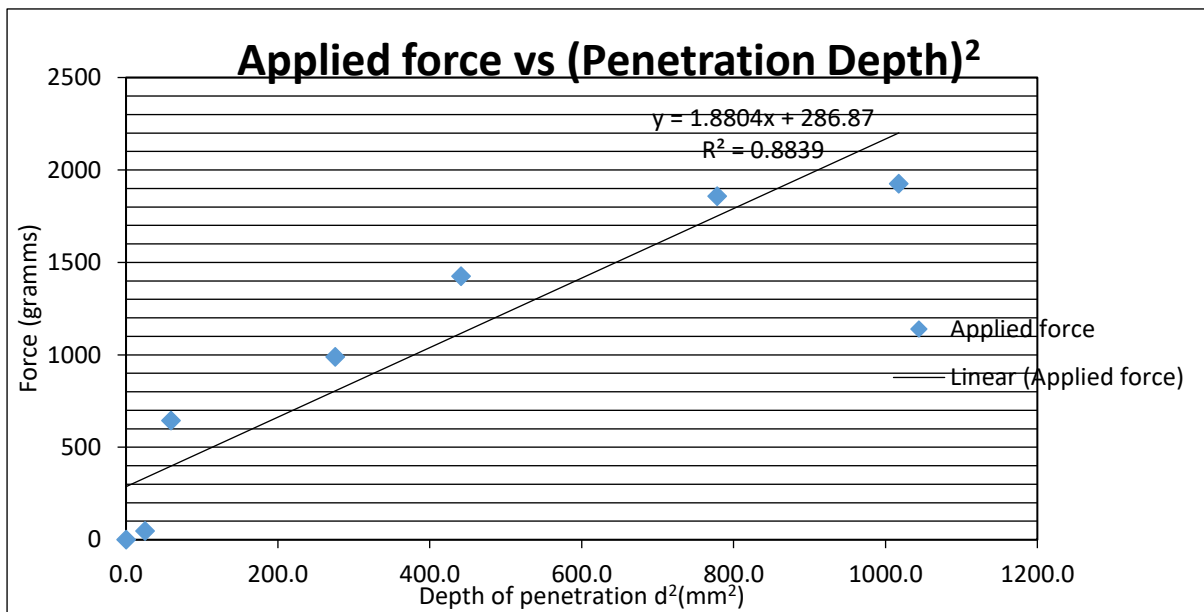


Table of results for soil sample B5 at moisture content 33.2%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
41.4	248.78	0	0.0	0
47.5	278.67	6.1	37.2	29.89
53.5	290.36	12.1	146.4	41.58
60.5	321.63	19.1	364.8	72.85
63.1	343.4	21.7	470.9	94.62
70.3	355.46	28.9	835.2	106.68
76.7	372.67	35.3	1246.1	123.89

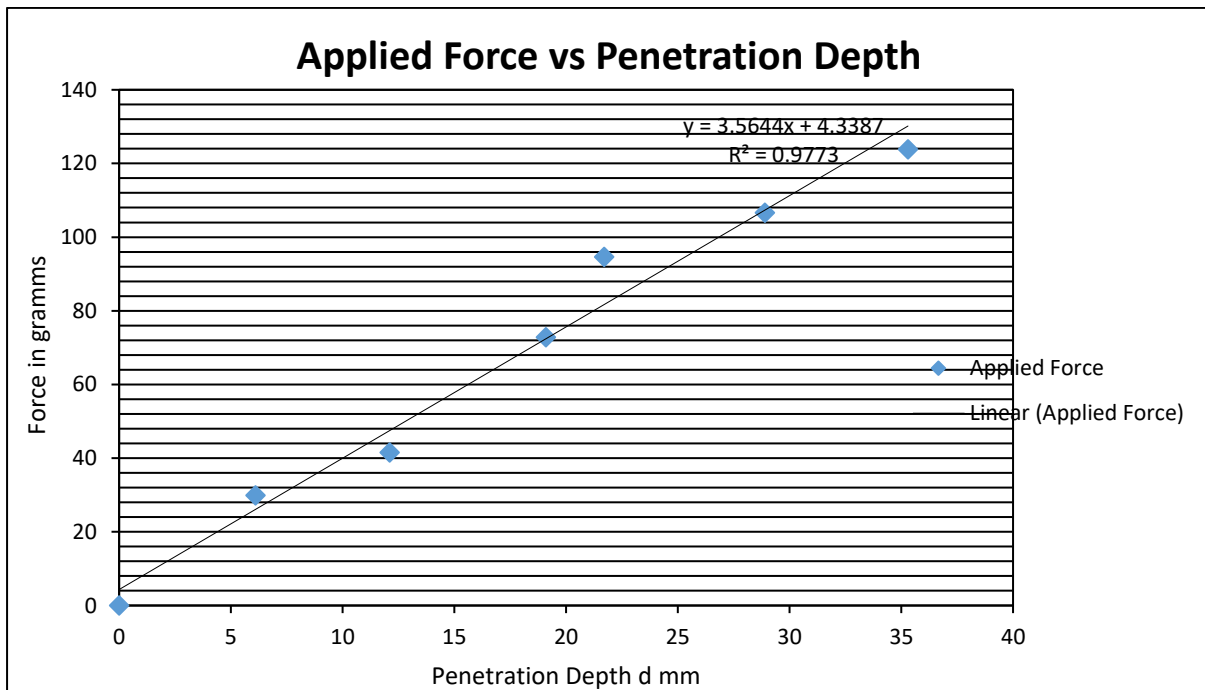
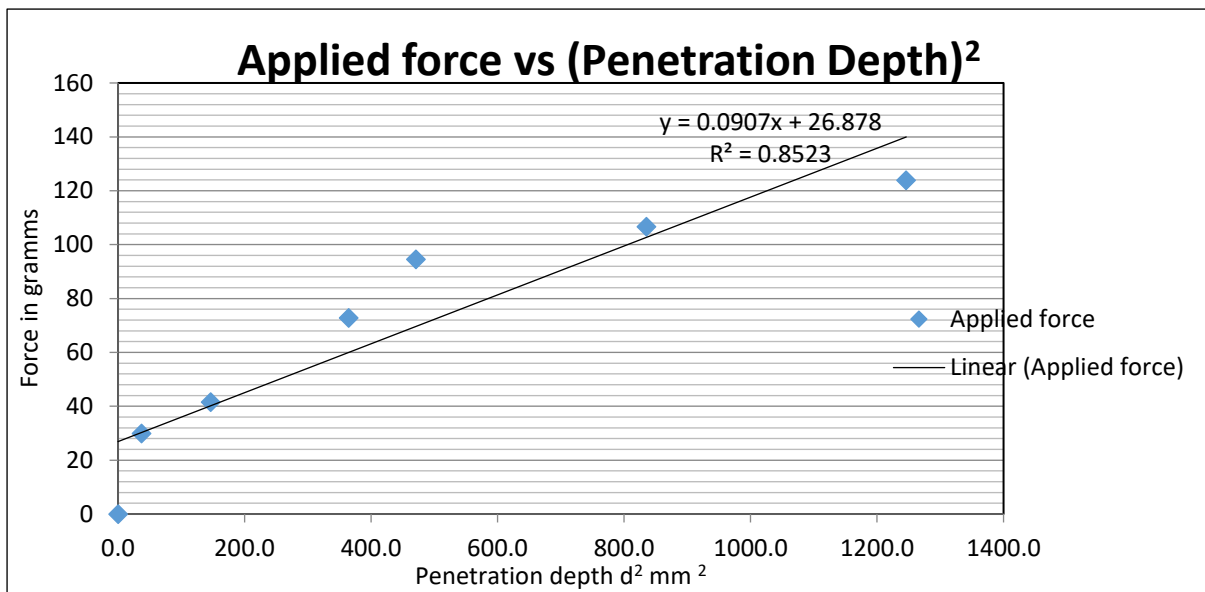


Table of results for soil sample B6 at moisture content 14.3% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
41.4	200.29	0	0.0	0
46.3	251.68	4.9	24.0	51.39
49.1	894.39	7.7	59.3	694.1
58	1180.71	16.6	275.6	980.42
62.4	1750.19	21	441.0	1549.9
72	2086.3	30.6	936.4	1886.01
73.3	2296.56	31.9	1017.6	2096.27

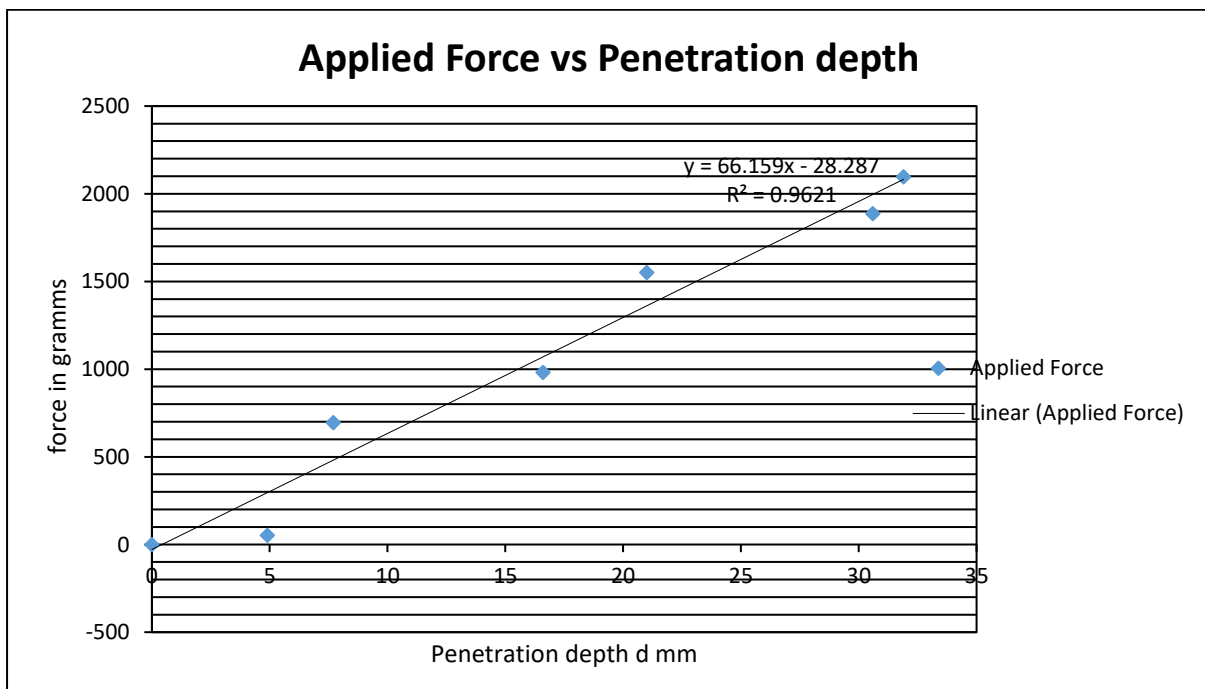
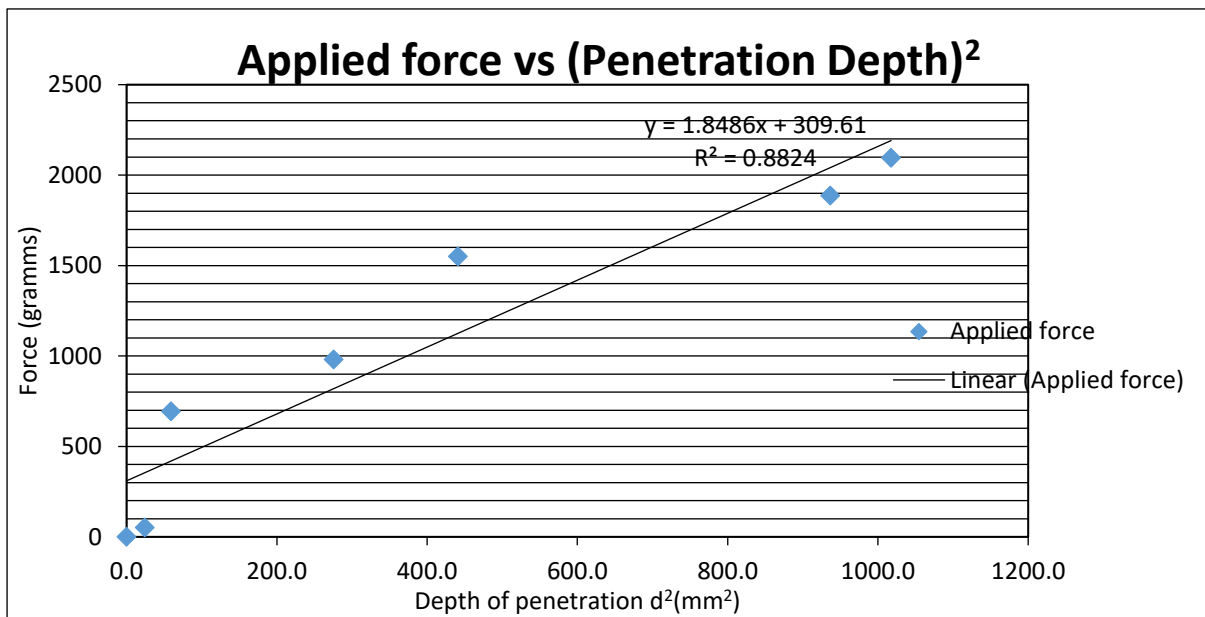


Table of results for soil sample B6 at moisture content 32.7% Liquid limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	D ²	Applied force
43.4	252.38	0	0.0	0
49.5	284.67	6.1	37.2	32.29
55.5	300.36	12.1	146.4	47.98
62.5	330.63	19.1	364.8	78.25
65.1	343.4	21.7	470.9	91.02
72.3	355.46	28.9	835.2	103.08
78.7	382.67	35.3	1246.1	130.29

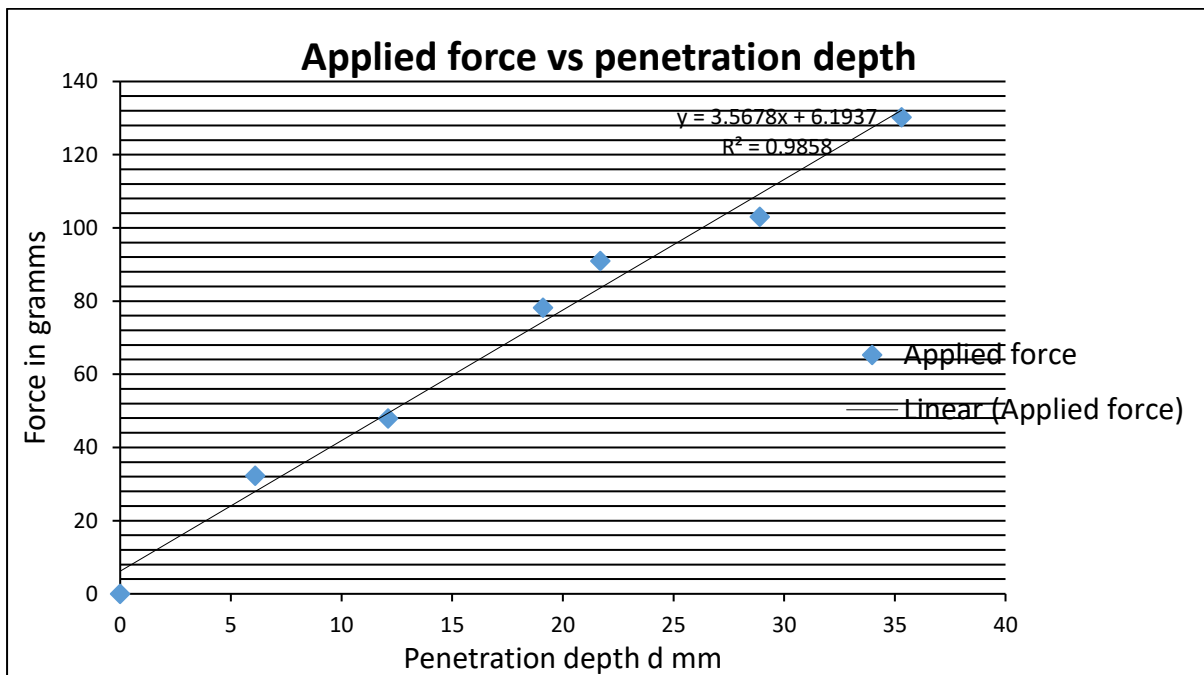
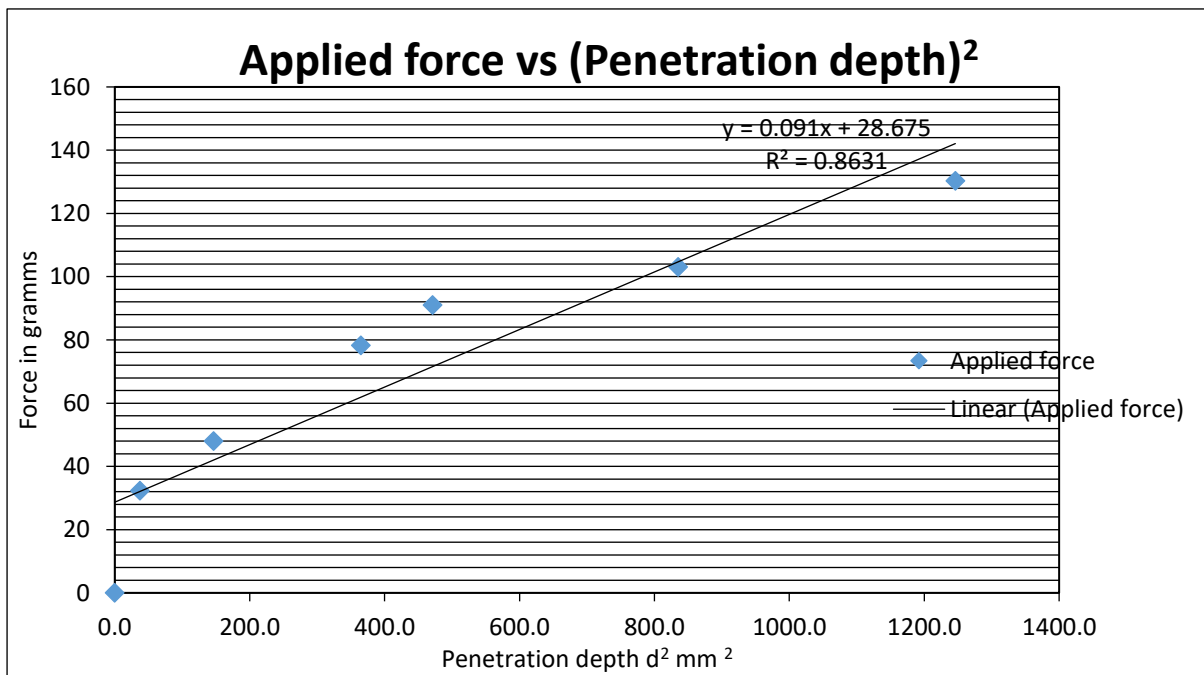


Table of results for soil sample B4 at moisture content 17.6% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42	251.1	0	0.0	0
47.1	307.68	5.1	26.0	56.58
50.2	899.39	8.2	67.2	648.29
59	1284.71	17	289.0	1033.61
64.2	1830.19	22.2	492.8	1579.09
70.8	2064.7	28.8	829.4	1813.6
75	2346.56	33	1089.0	2095.46

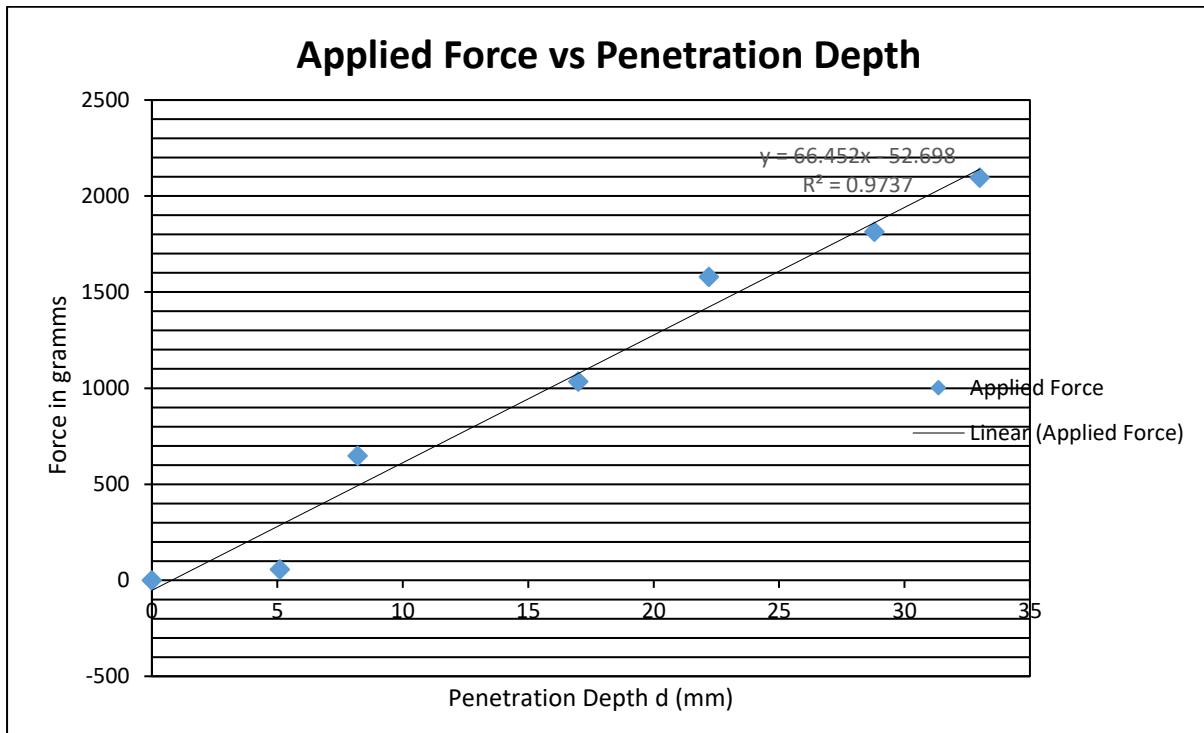
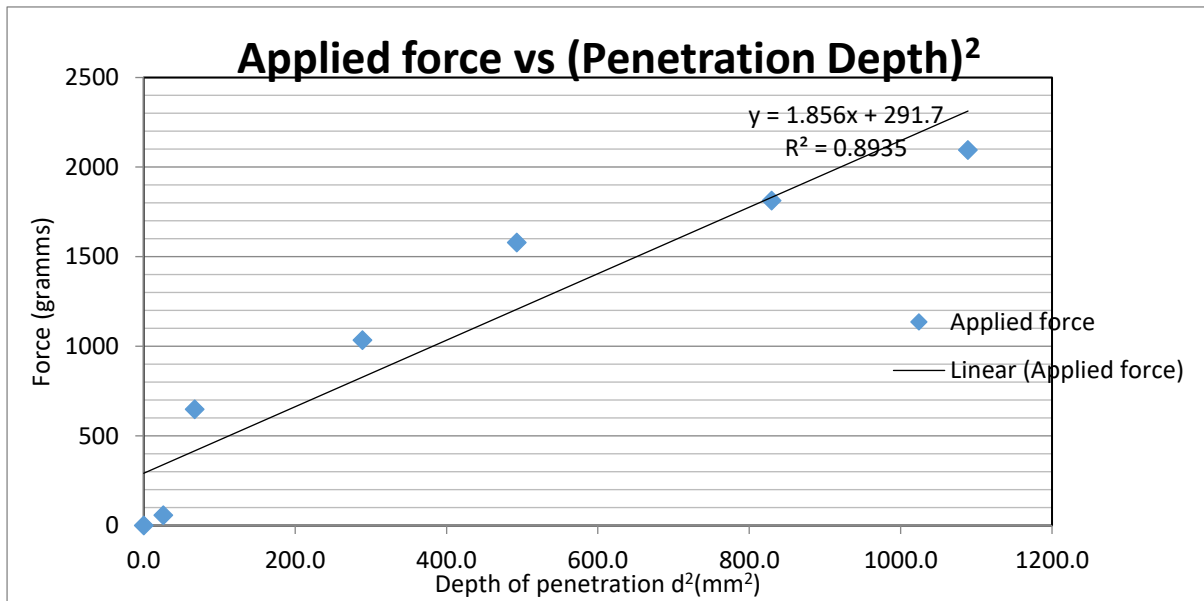


Table of results for soil sample B4 at moisture content 33.4% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42	220.05	0	0.0	0
48.5	248.45	6.5	42.3	28.4
54.5	254.34	12.5	156.3	34.29
61.5	270.37	19.5	380.3	50.32
64.1	280.01	22.1	488.4	59.96
71.3	363.23	29.3	858.5	143.18
77.7	419.74	35.7	1274.5	199.69

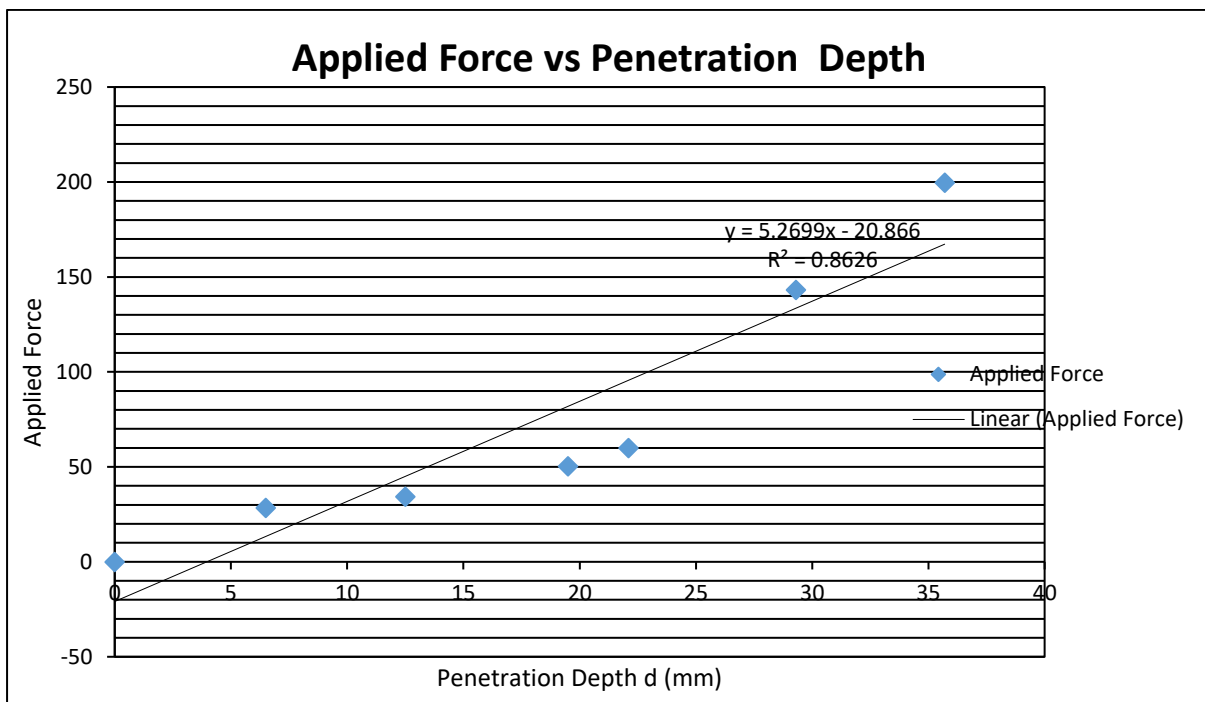
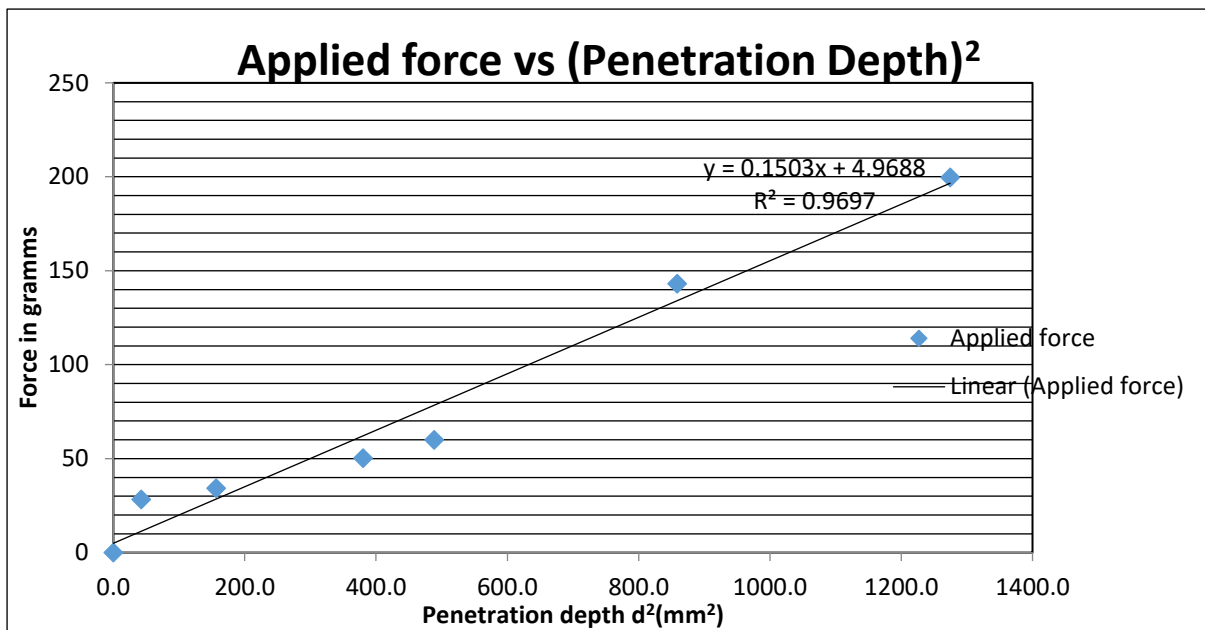


Table of results for soil sample R1 at moisture content 16.5% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
41.1	196.29	0	0.0	0
46.1	247.68	5	25.0	51.39
48.8	899.39	7.7	59.3	703.1
57.7	1144.71	16.6	275.6	948.42
62.1	1598.19	21	441.0	1401.9
69	1864.7	27.9	778.4	1668.41
73	2186.36	31.9	1017.6	1990.07

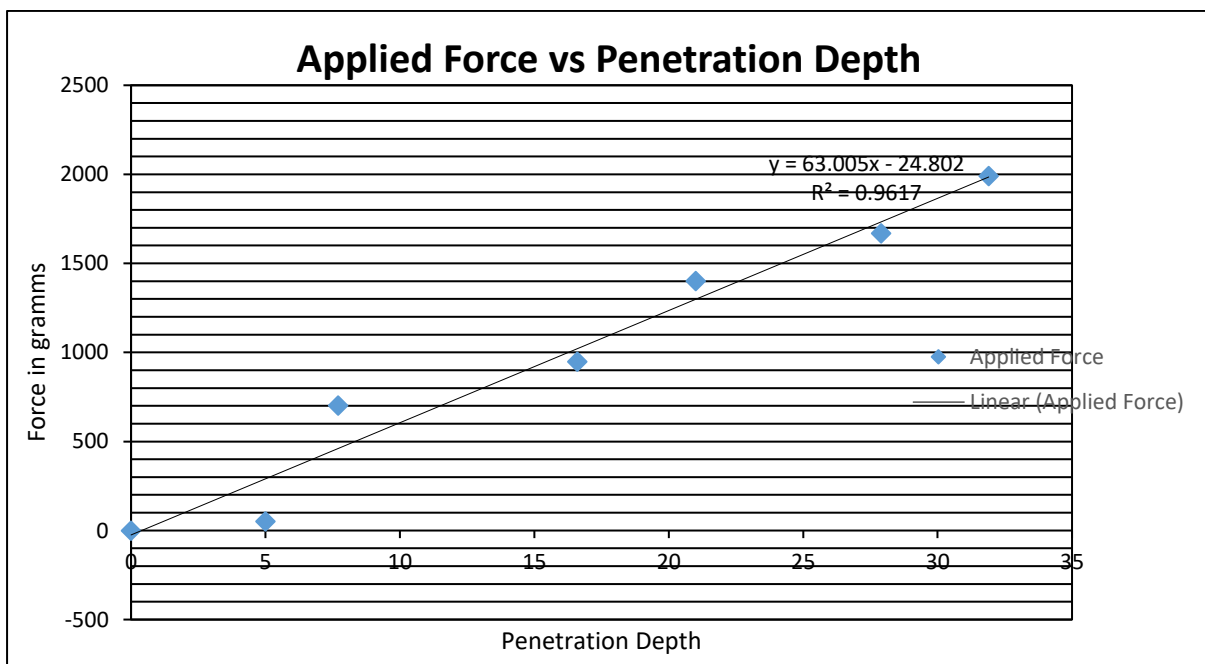
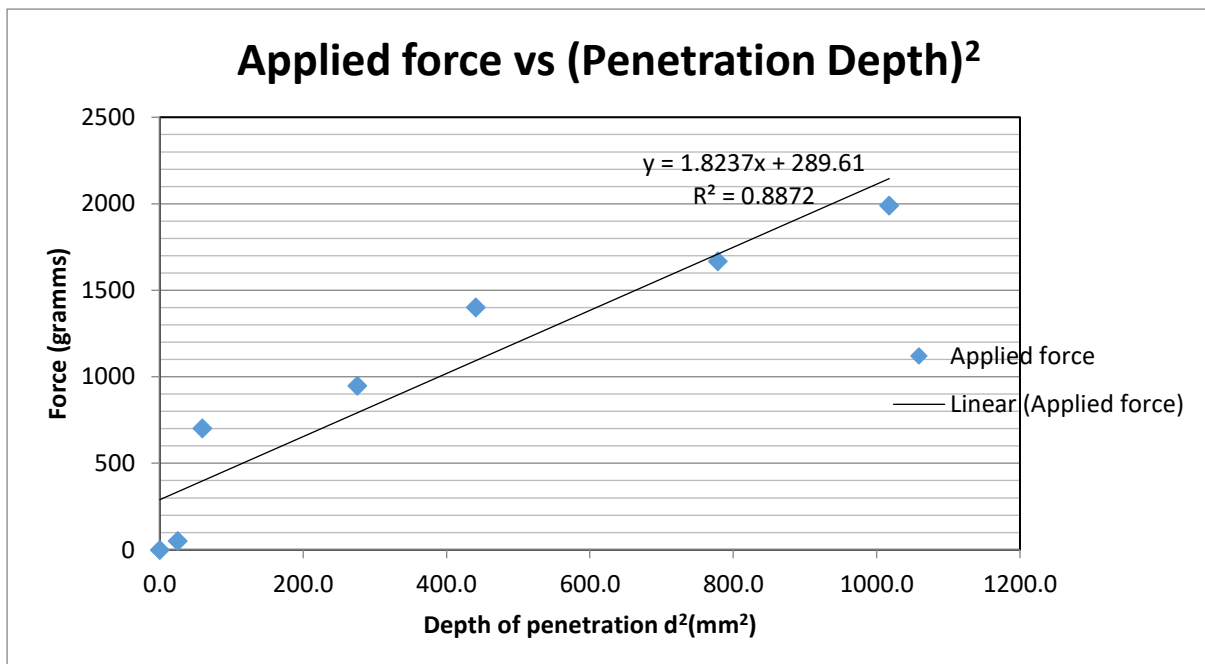


Table of results for soil sample R1 at moisture content 33.2% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
41.4	247.58	0	0.0	0
47.5	253.67	6.1	37.2	6.09
53.5	280.36	12.1	146.4	32.78
60.5	321.63	19.1	364.8	74.05
63.1	351.32	21.7	470.9	103.74
70.3	361.22	28.9	835.2	113.64
76.7	376.14	35.3	1246.1	128.56

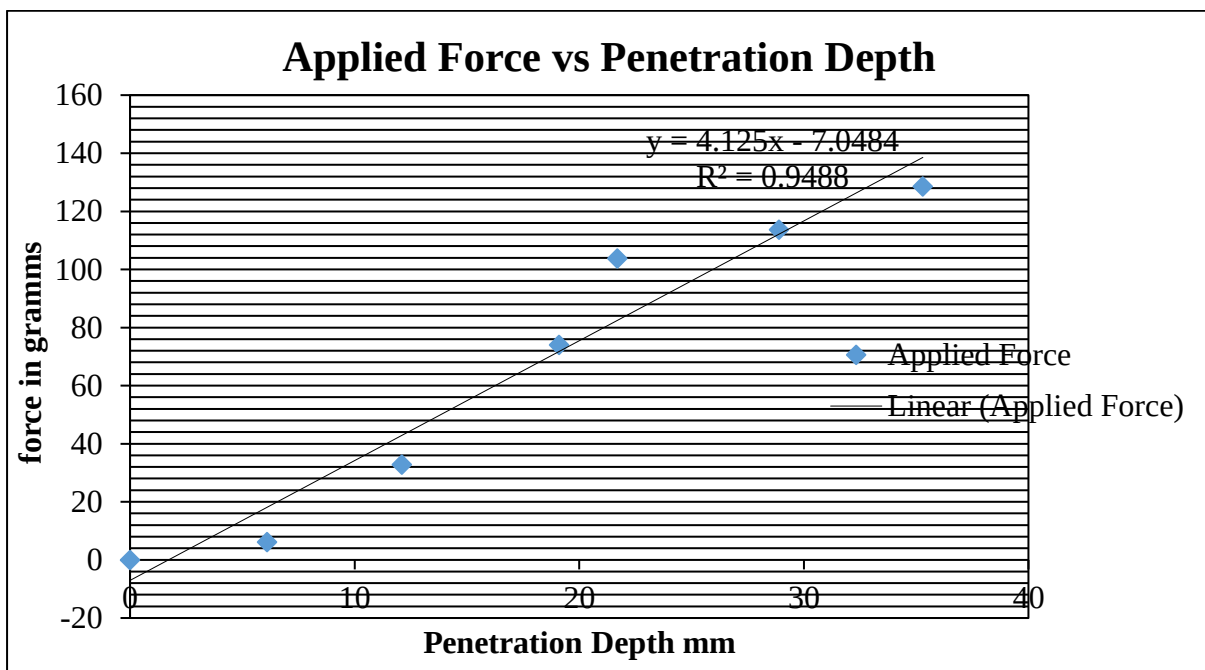
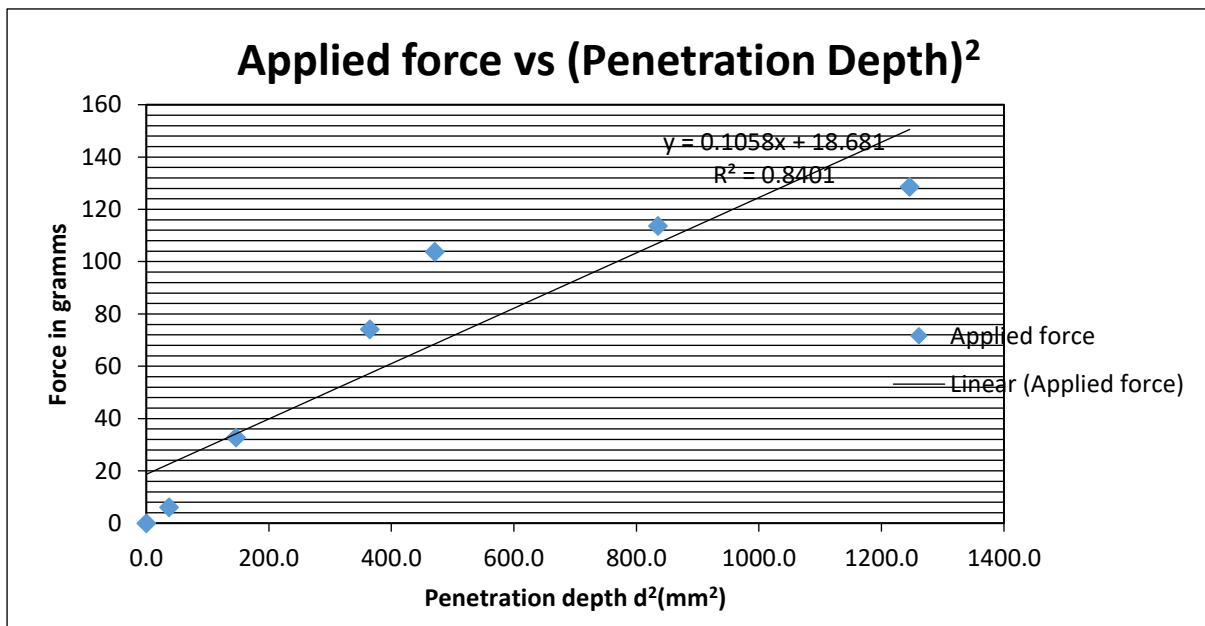


Table of results for soil sample R11 at moisture content 20.5% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
41.1	196.29	0	0.0	0
46.1	247.68	5	25.0	51.39
48.8	899.39	7.7	59.3	703.1
57.7	1184.71	16.6	275.6	988.42
62.1	1517.85	21	441.0	1321.56
69	1864.7	27.9	778.4	1668.41
73	2186.56	31.9	1017.6	1990.27

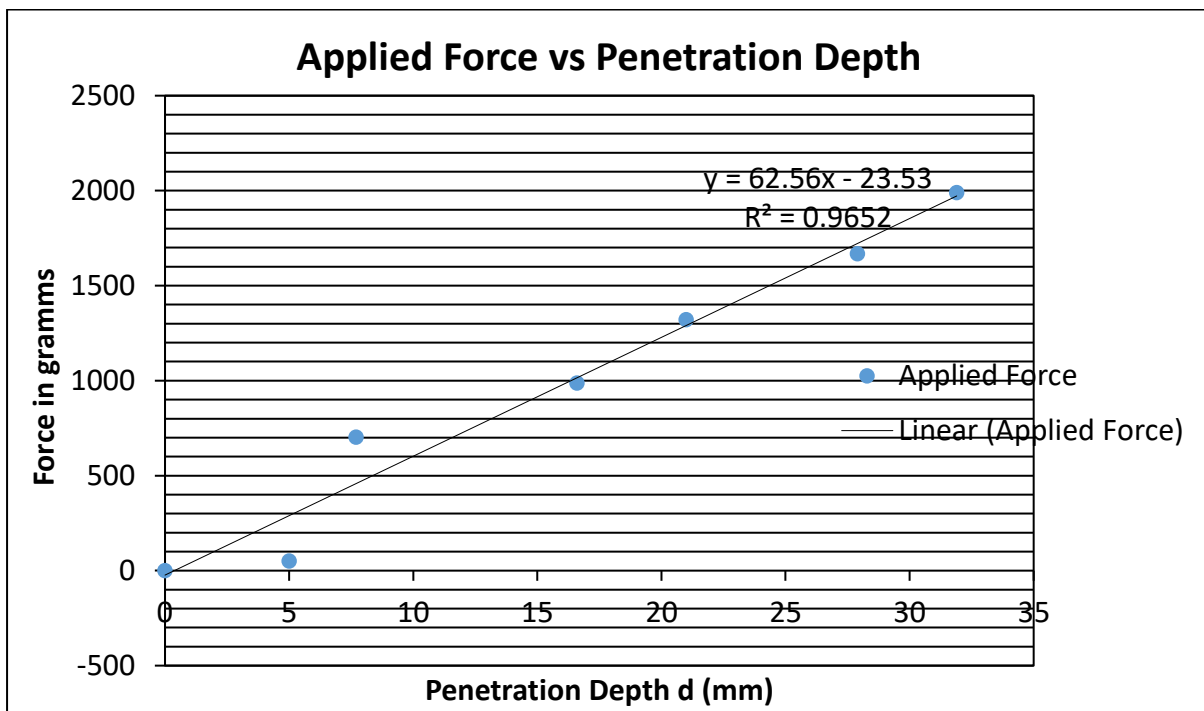
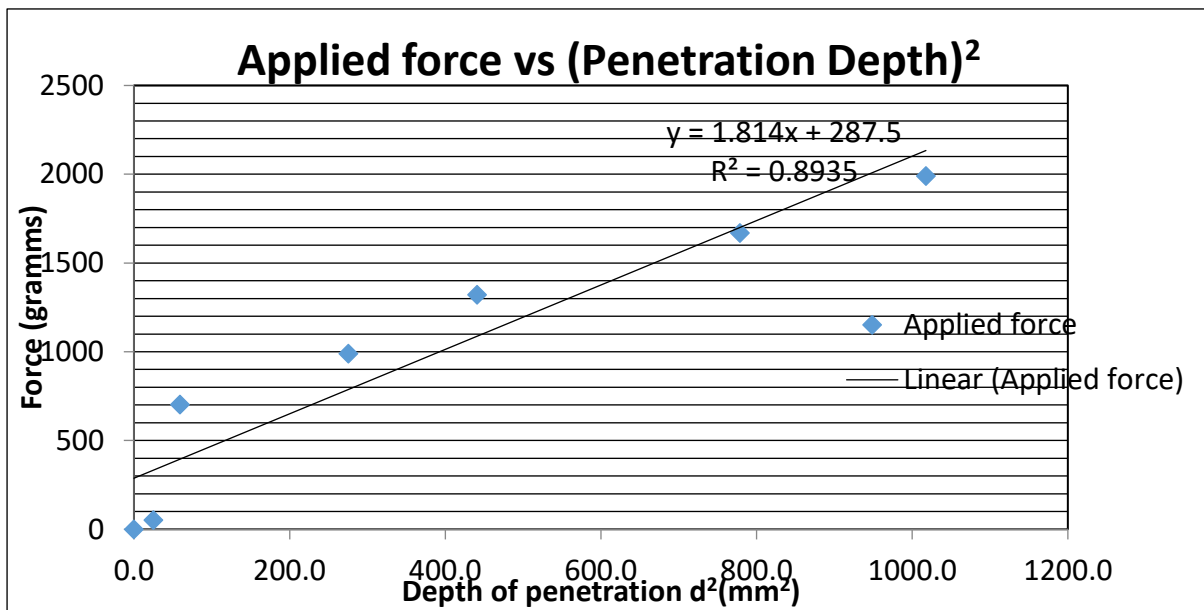


Table of results for soil sample R11 at moisture content 35.2% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
41.4	249.98	0	0.0	0
47.5	278.67	6.1	37.2	28.69
53.5	290.36	12.1	146.4	40.38
60.5	311.63	19.1	364.8	61.65
63.1	337.4	21.7	470.9	87.42
70.3	350.46	28.9	835.2	100.48
76.7	372.67	35.3	1246.1	122.69

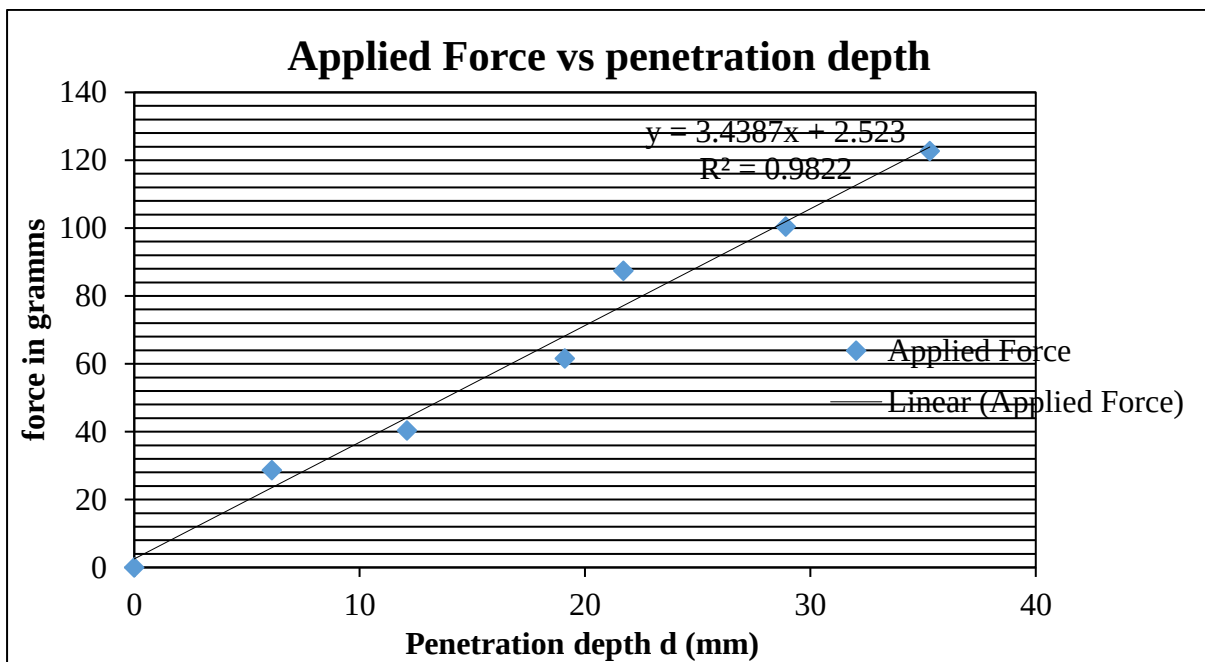
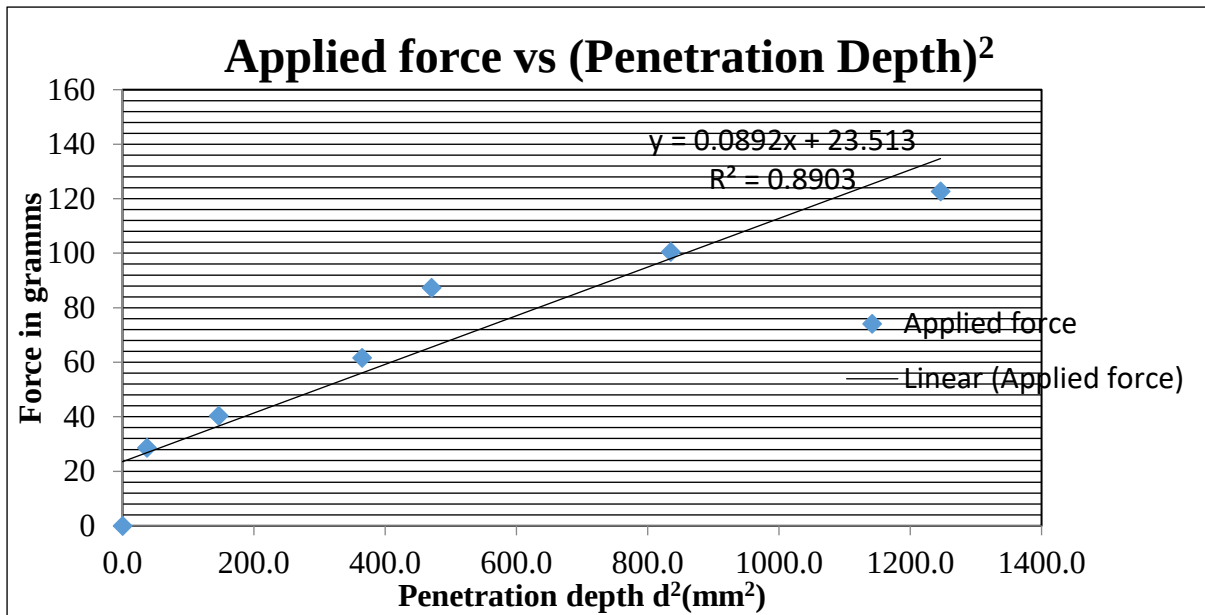


Table of results for soil sample S6 at moisture content 17.6% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42	256.29	0	0.0	0
47.1	447.68	5.1	26.0	191.39
50.2	699.39	8.2	67.2	443.1
59	1284.71	17	289.0	1028.42
64.2	1798.19	22.2	492.8	1541.9
70.8	2038.7	28.8	829.4	1782.41
75	2271.56	33	1089.0	2015.27

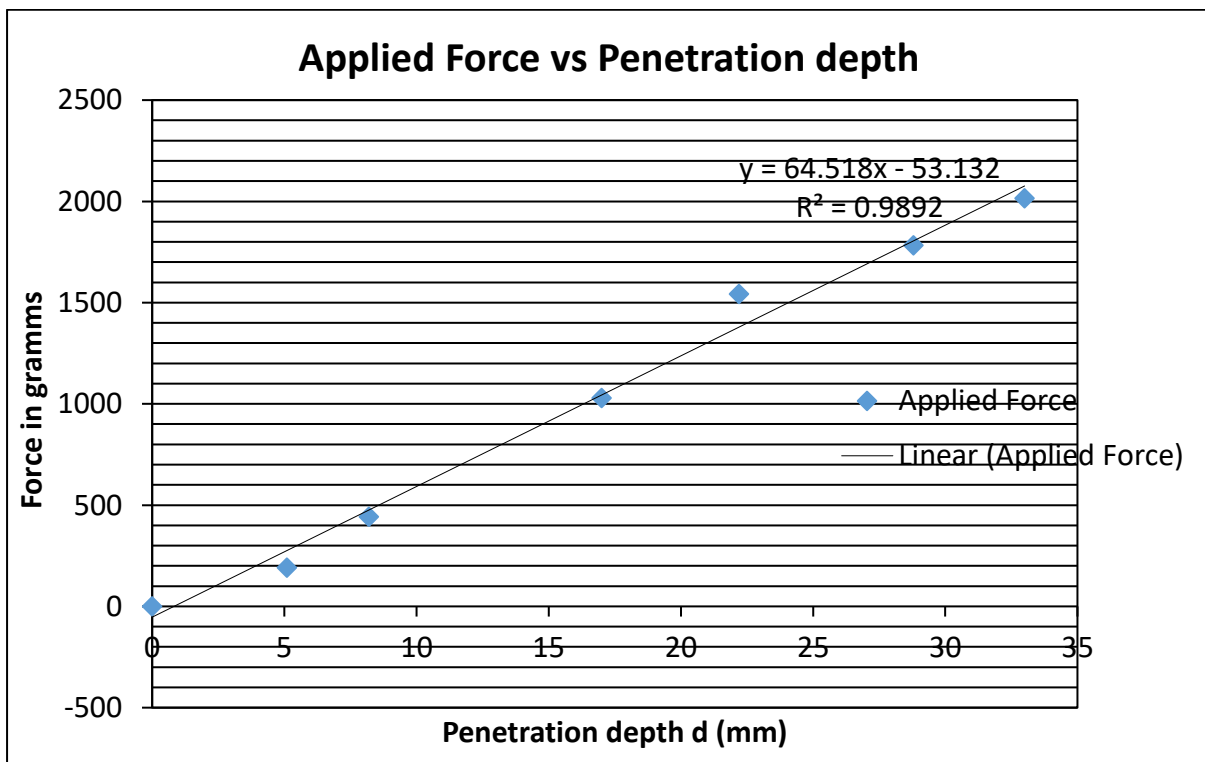
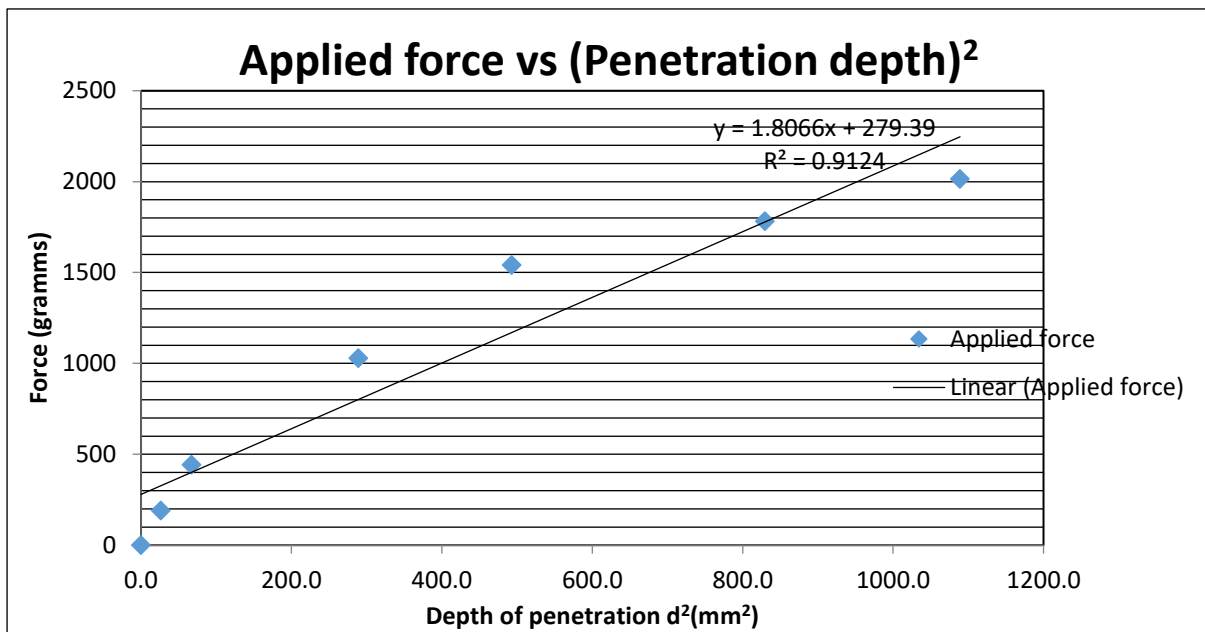


Table of results for soil sample S6 at moisture content 34.4%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42	249.98	0	0.0	0
48.5	278.67	6.5	42.3	28.69
54.5	290.36	12.5	156.3	40.38
61.5	311.63	19.5	380.3	61.65
64.1	337.4	22.1	488.4	87.42
71.3	350.46	29.3	858.5	100.48
77.7	372.67	35.7	1274.5	122.69

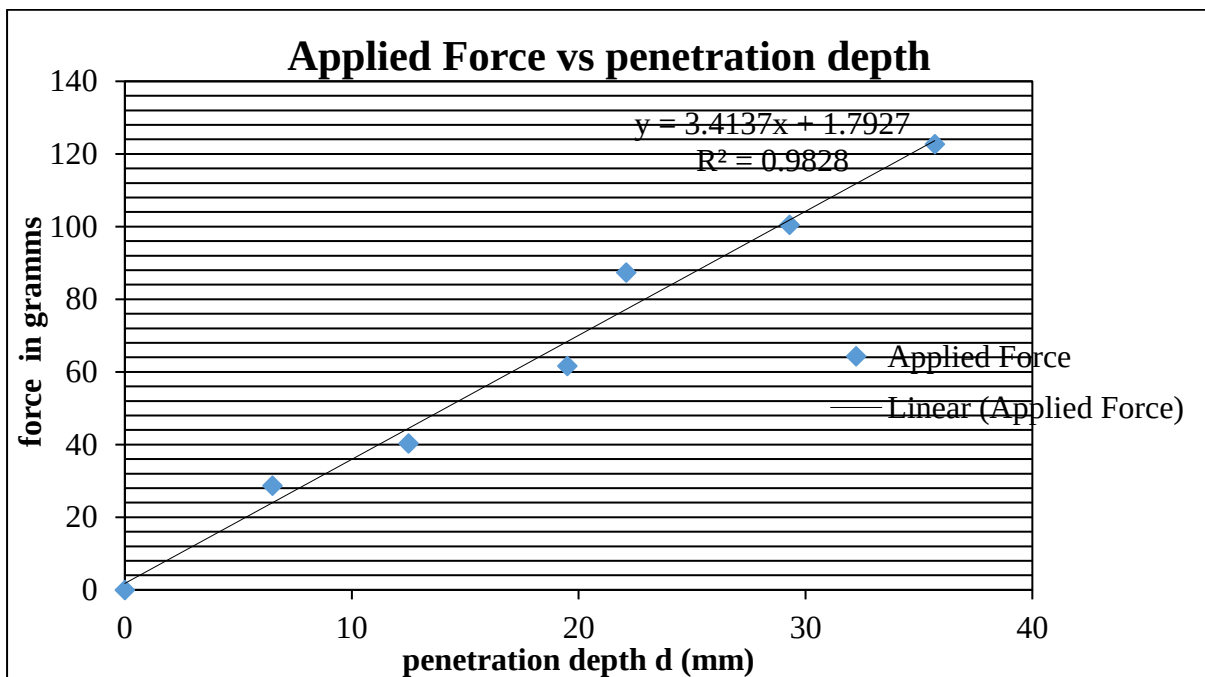
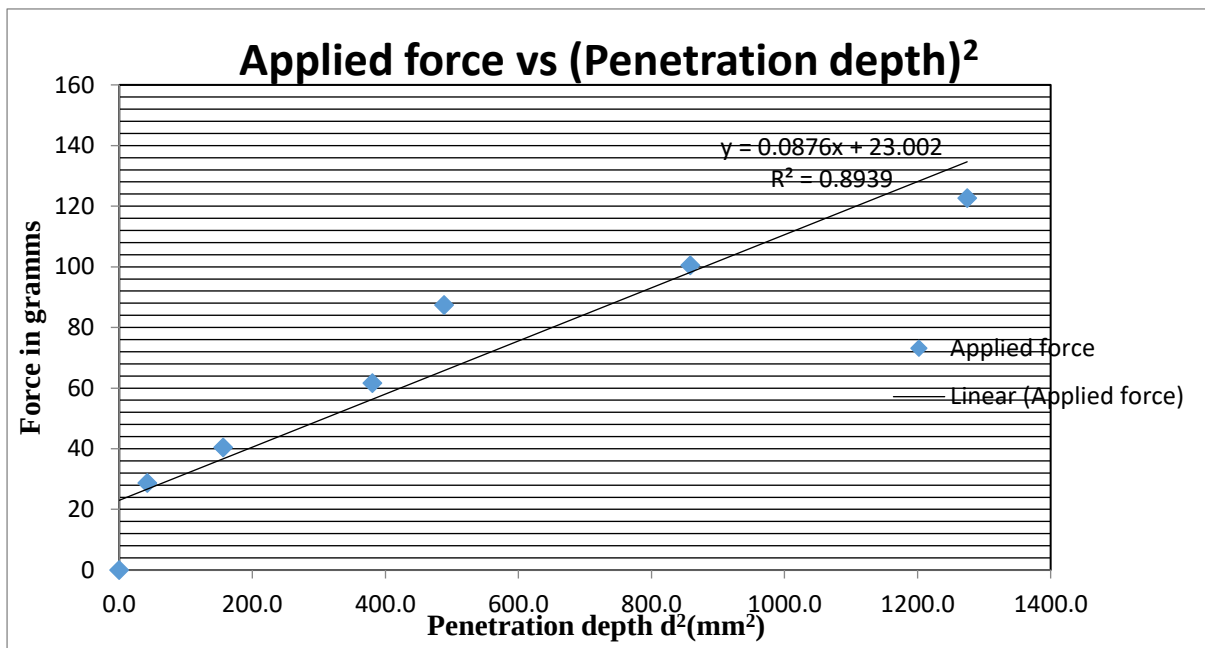


Table of results for soil sample K10 at moisture content 14.3% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
41.4	196.29	0	0.0	0
46.3	247.68	4.9	24.0	51.39
49.1	899.39	7.7	59.3	703.1
58	1144.71	16.6	275.6	948.42
62.4	1598.19	21	441.0	1401.9
72	2064.7	30.6	936.4	1868.41
73.3	2217.36	31.9	1017.6	2021.07

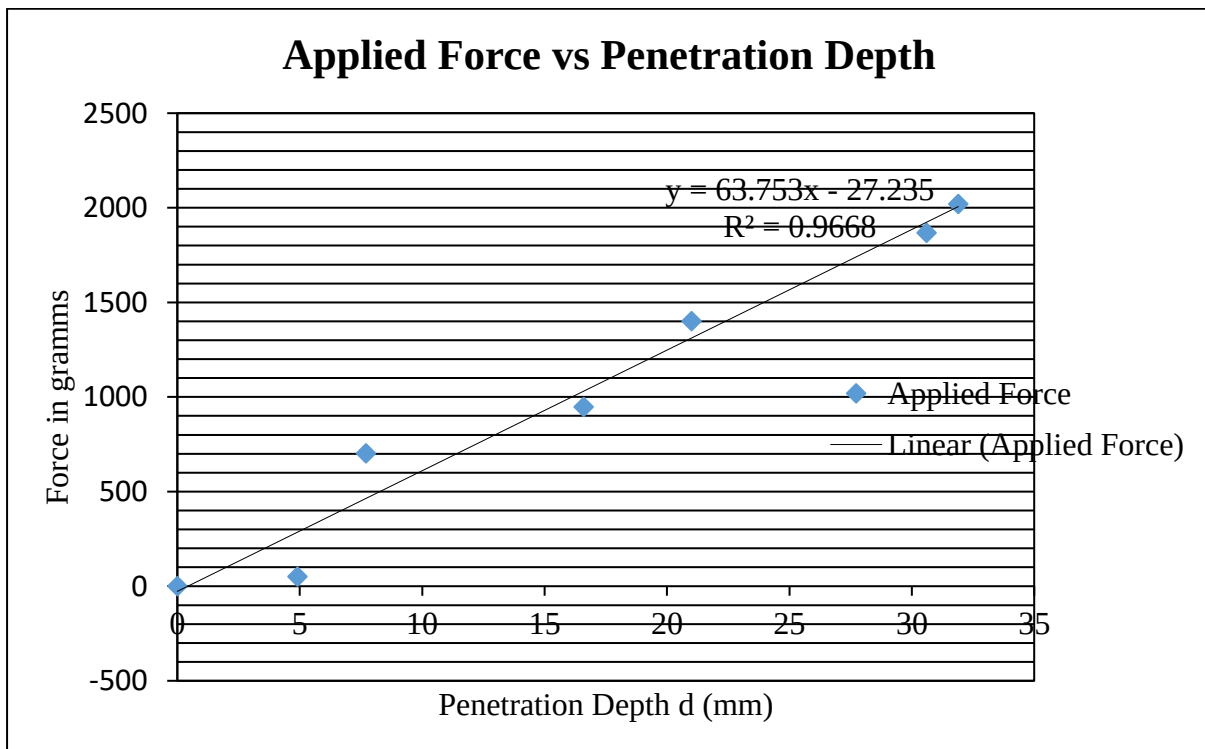
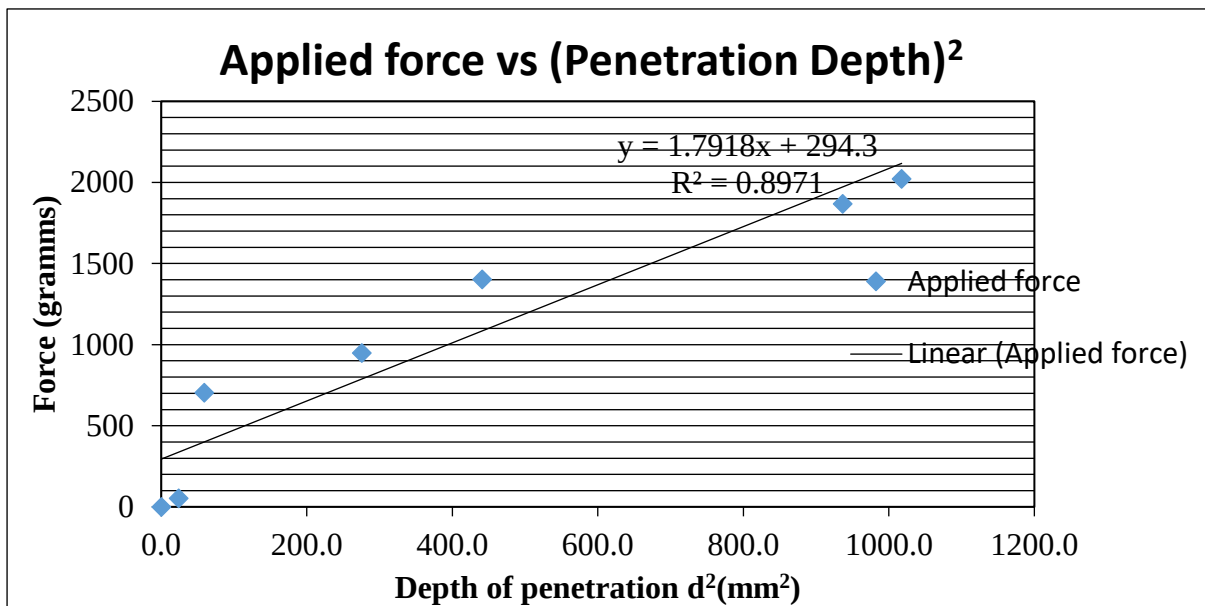


Table of results for soil sample K10 at moisture content 32.7% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
43.4	248.78	0	0.0	0
49.5	278.67	6.1	37.2	29.89
55.5	290.36	12.1	146.4	41.58
62.5	311.63	19.1	364.8	62.85
65.1	333.4	21.7	470.9	84.62
72.3	339.46	28.9	835.2	90.68
78.7	362.67	35.3	1246.1	113.89

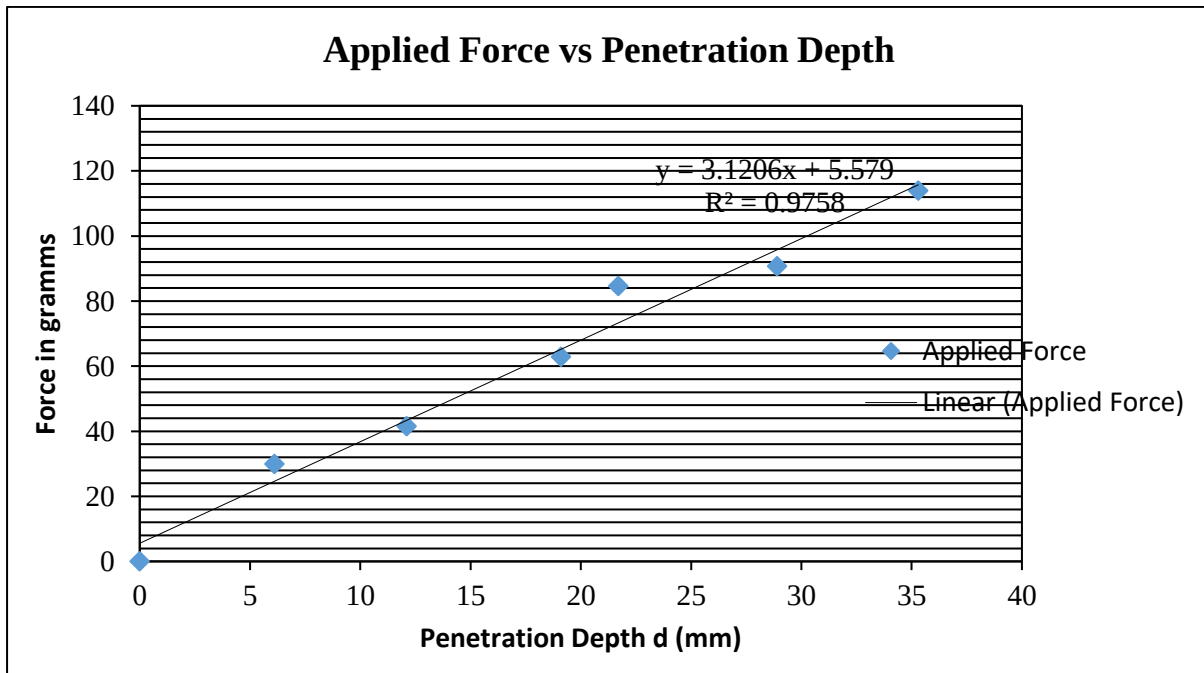
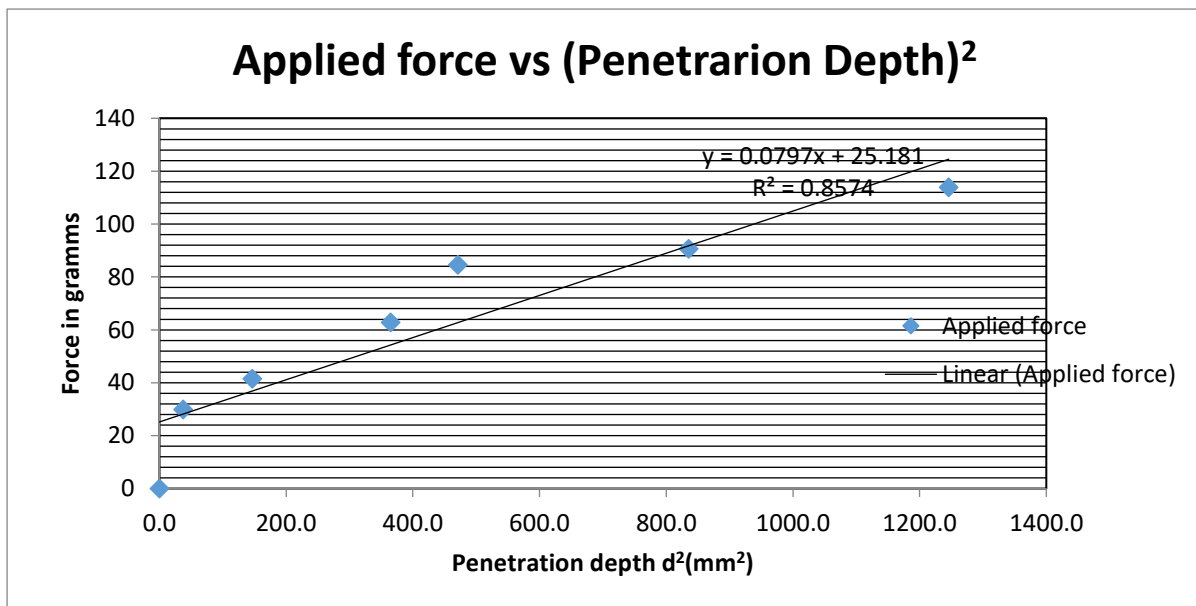


Table of results for soil sample k16 at moisture content 13.9% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.5	224.45	0	0.0	0
48	533.69	2.5	6.3	309.24
51.9	831.54	6.4	41.0	607.09
57.8	999.49	12.3	151.3	775.04
64.6	1247.87	19.1	364.8	1023.42
68.1	1715.45	22.6	510.8	1491
75.8	2067.29	30.3	918.1	1842.84
79.2	2260.84	33.7	1135.7	2036.39

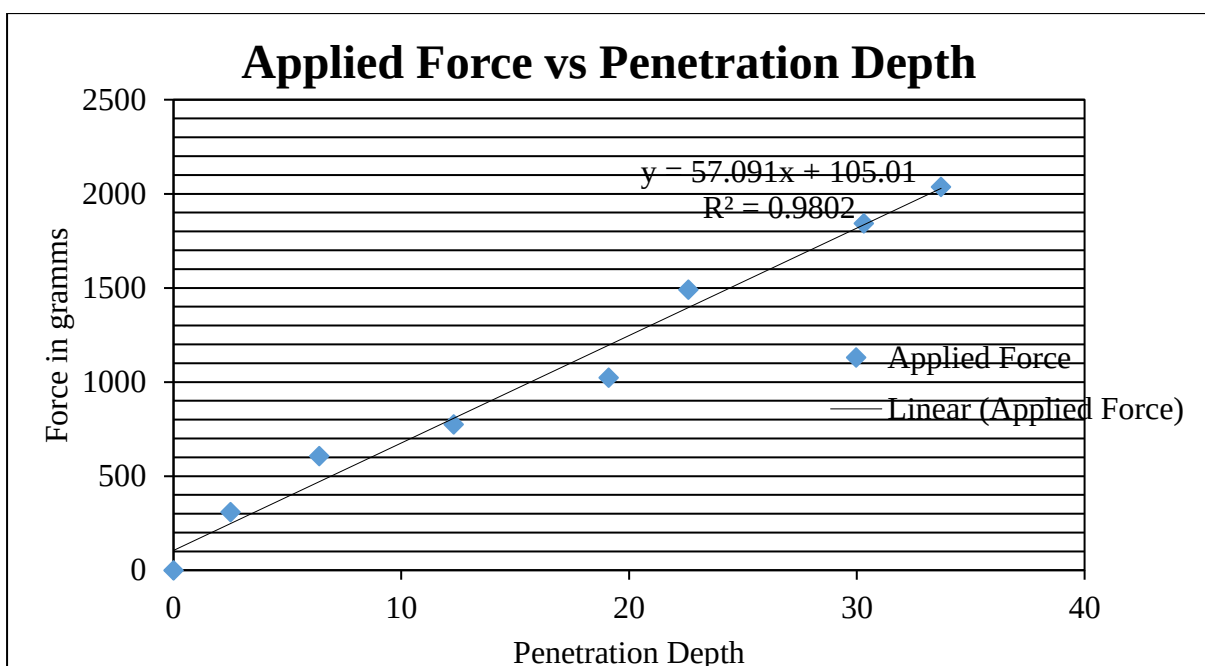
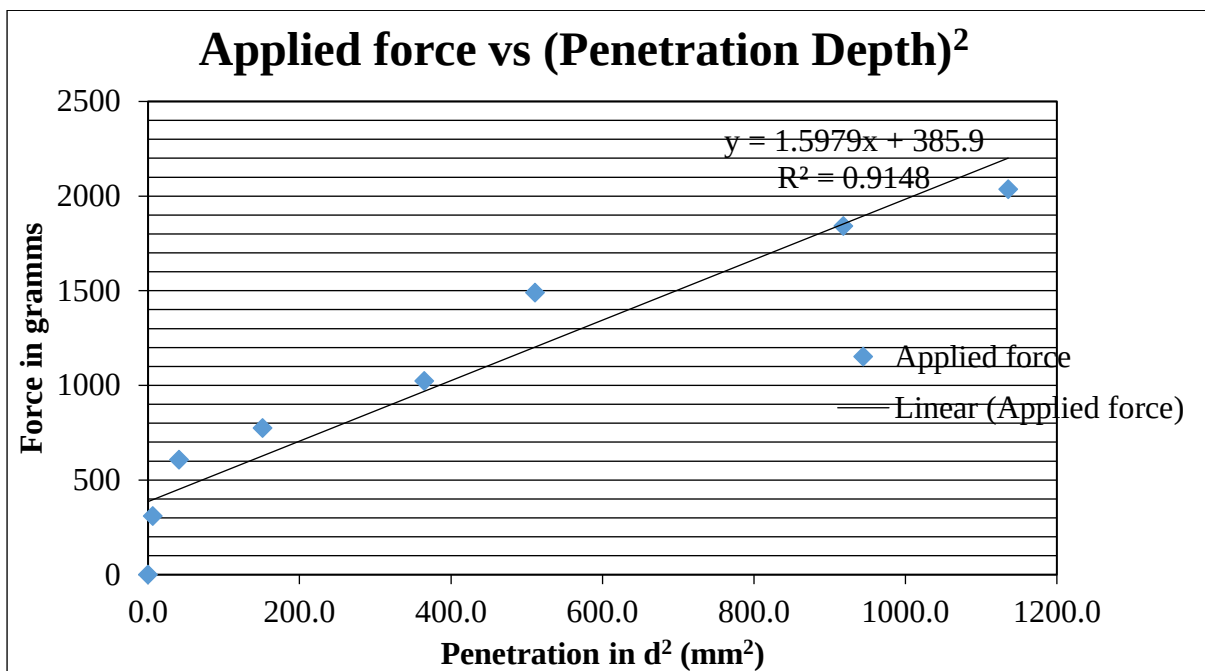


Table of results for soil sample k16 at moisture content 35% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
47.3	228.95	0	0.0	0
51.3	248.45	4	16.0	19.5
55.3	254.34	8	64.0	25.39
61.9	278.37	14.6	213.2	49.42
68.6	298.01	21.3	453.7	69.06
75.2	319.23	27.9	778.4	90.28
78.3	366.15	31	961.0	137.2

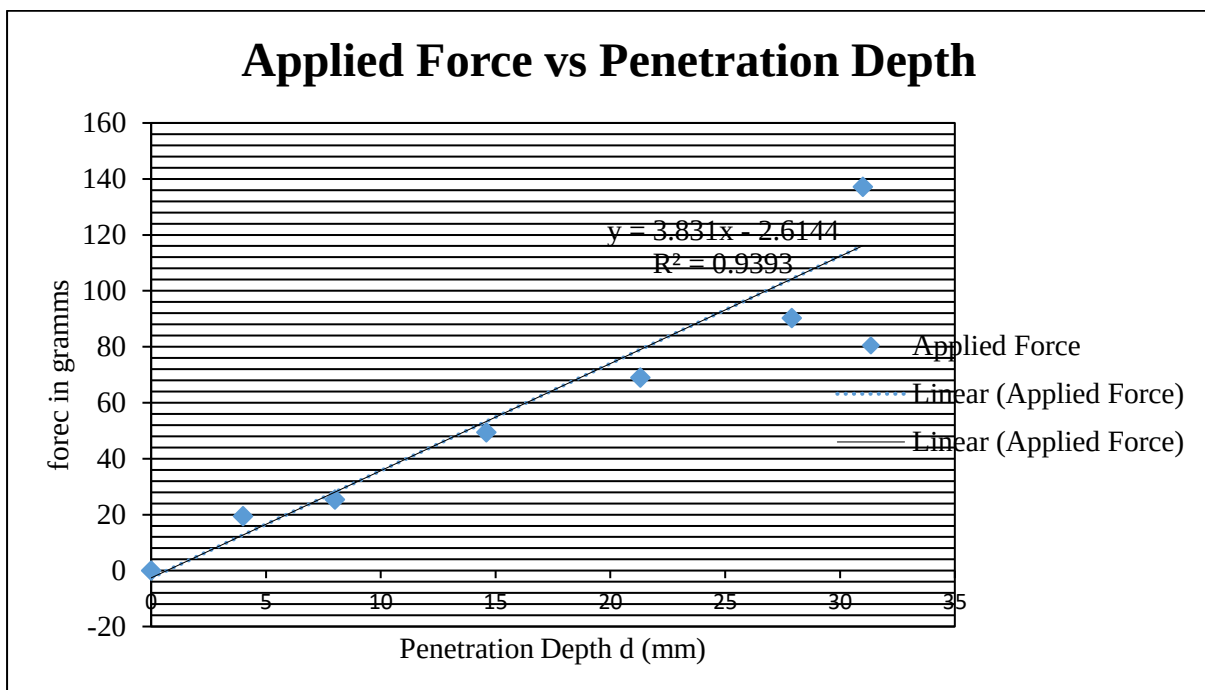
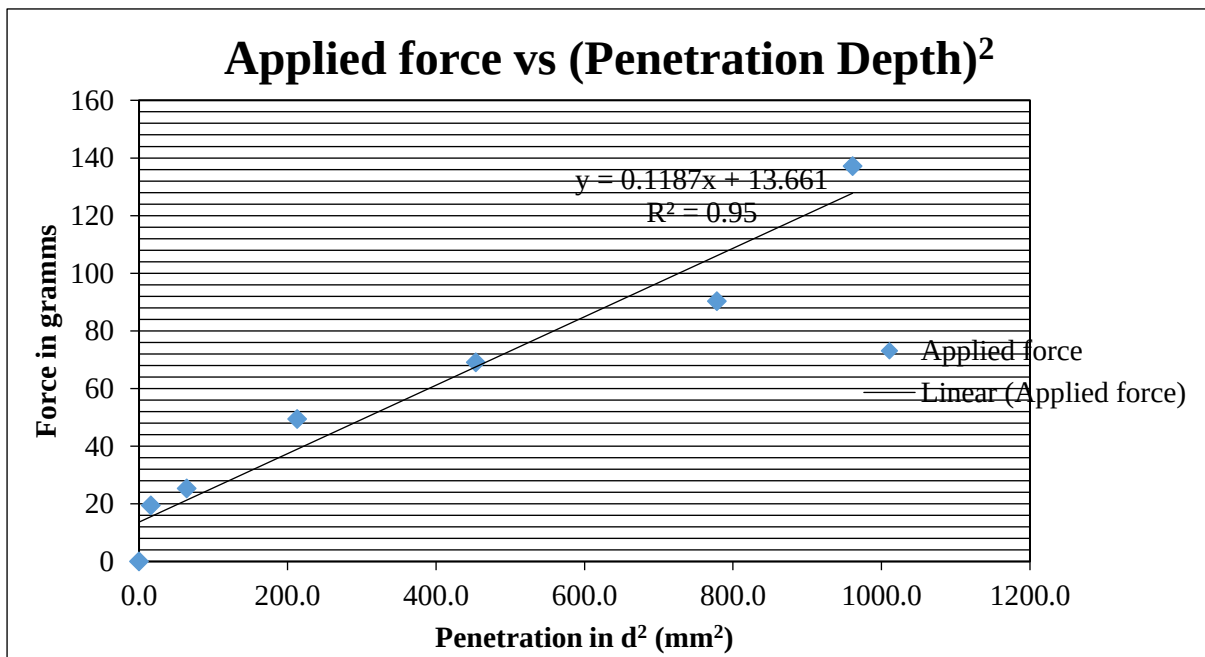


Table of results for soil sample R10 at moisture content 10.9% Plastic Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.6	200.29	0	0.0	0
51.1	858.78	5.5	30.3	658.49
60.7	1044.59	15.1	228.0	844.3
66.2	1380.71	20.6	424.4	1180.42
72.9	1795.19	27.3	745.3	1594.9
74.6	2066.7	29	841.0	1866.41
78.1	2422.56	32.5	1056.3	2222.27

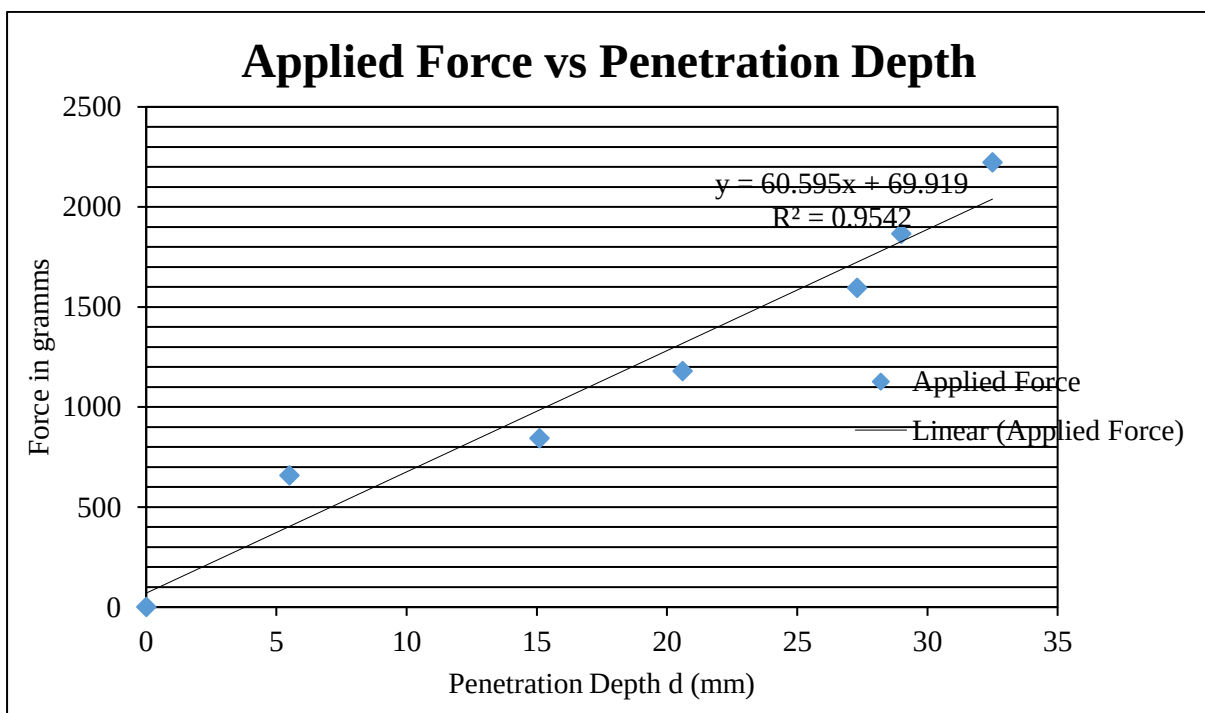
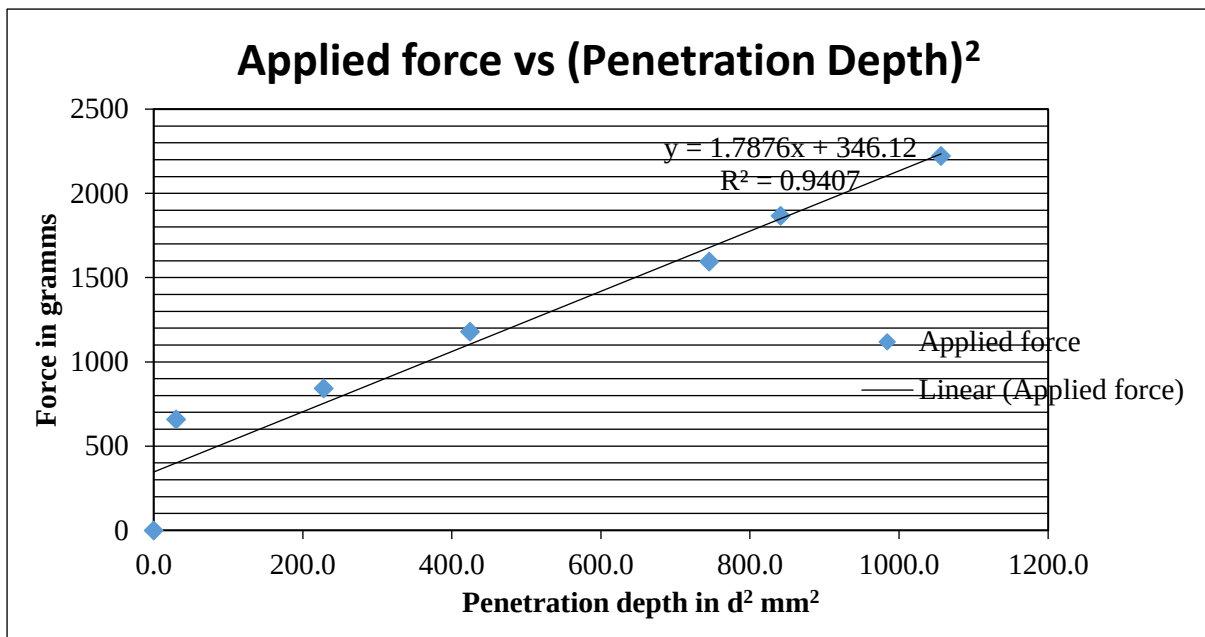


Table of results for soil sample R10 at moisture content 30% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
47.3	257.58	0	0.0	0
51.3	288.67	4	16.0	31.09
55.3	305.36	8	64.0	47.78
61.9	319.63	14.6	213.2	62.05
68.6	321.4	21.3	453.7	63.82
75.2	341.46	27.9	778.4	83.88
78.3	387.27	31	961.0	129.69

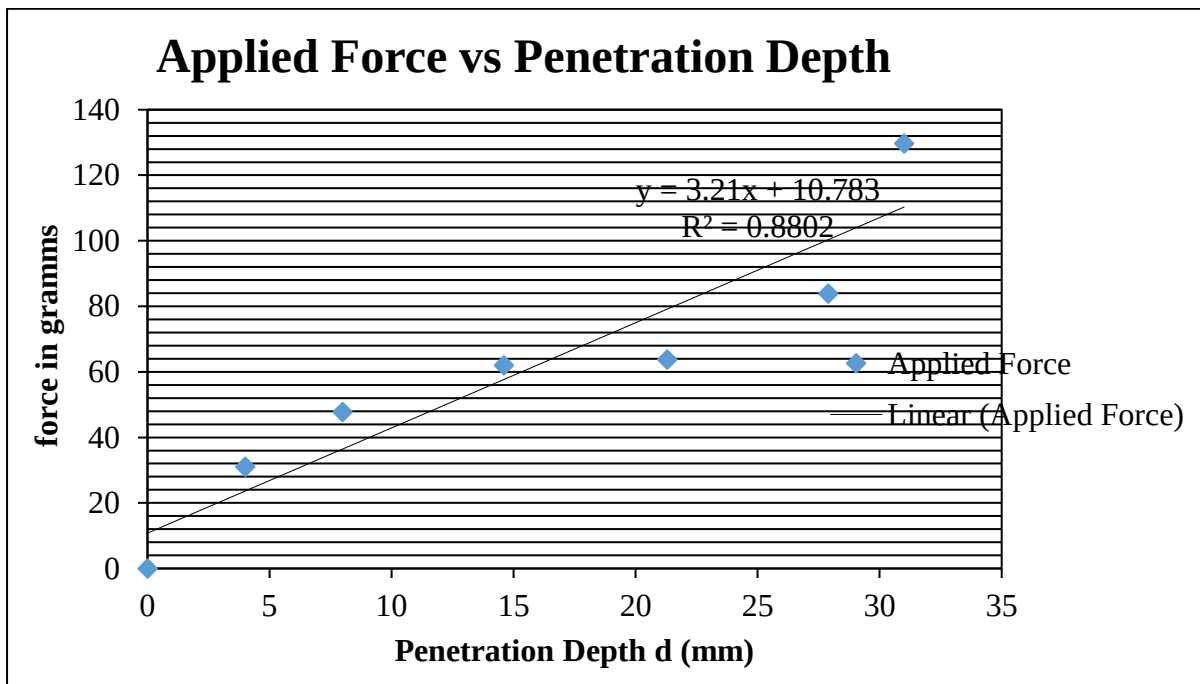
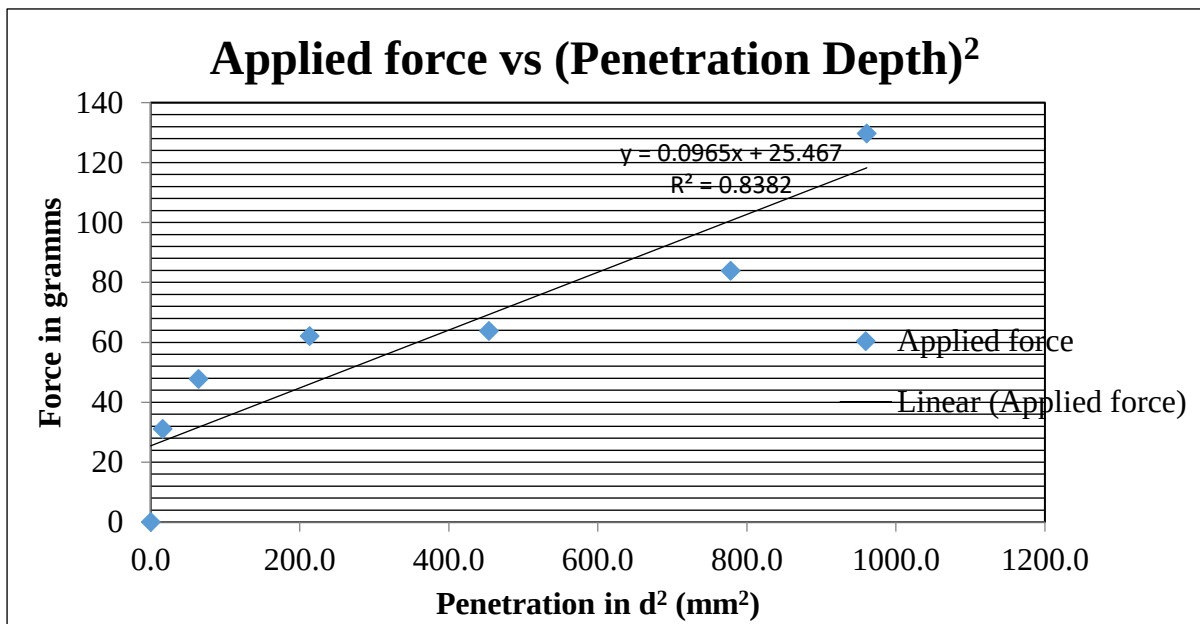


Table of results for soil sample C1 at moisture content 27%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
41.4	271.71	0	0.0	0
46.3	451.68	4.9	24.0	179.97
49.1	744.39	7.7	59.3	472.68
58	1373.71	16.6	275.6	1102
62.4	1795.19	21	441.0	1523.48
72	2066.7	30.6	936.4	1794.99
73.3	2196.56	31.9	1017.6	1924.85

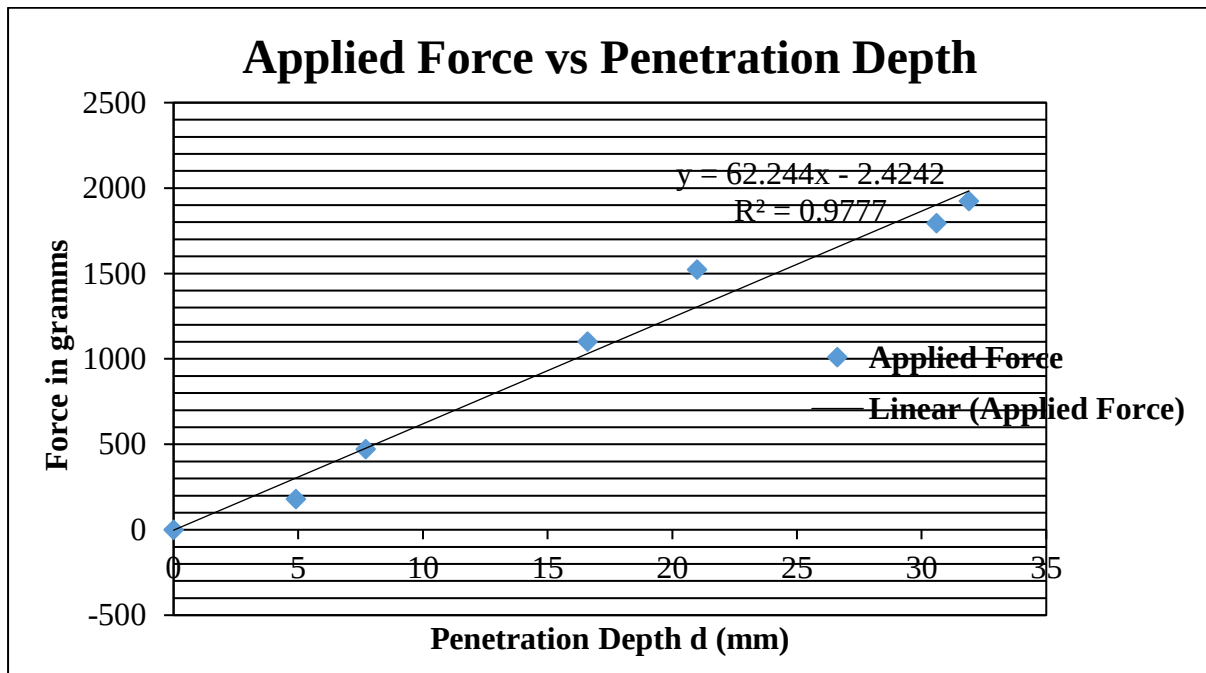
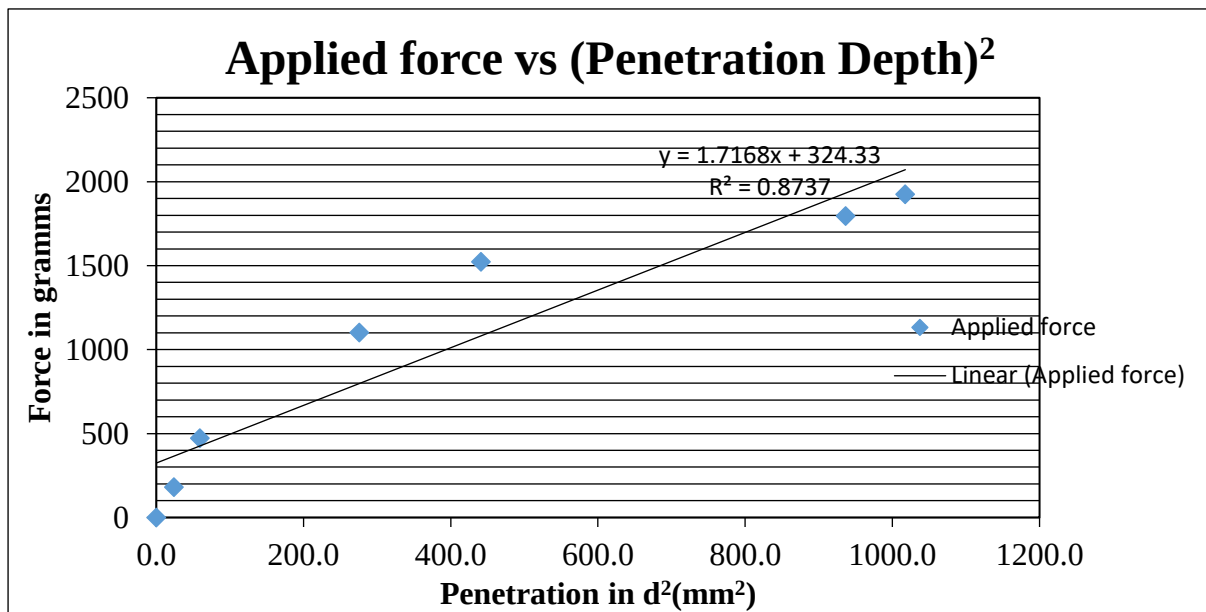


Table of results for soil sample C1 at moisture content 45.2% Liquid Limit

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.3	257.58	0	0.0	0
51	288.67	5.7	32.5	31.09
54.3	295.36	9	81.0	37.78
62.9	313.93	17.6	309.8	56.35
69.6	330.4	24.3	590.5	72.82
76.2	360.46	30.9	954.8	102.88
79.3	385.67	34	1156.0	128.09

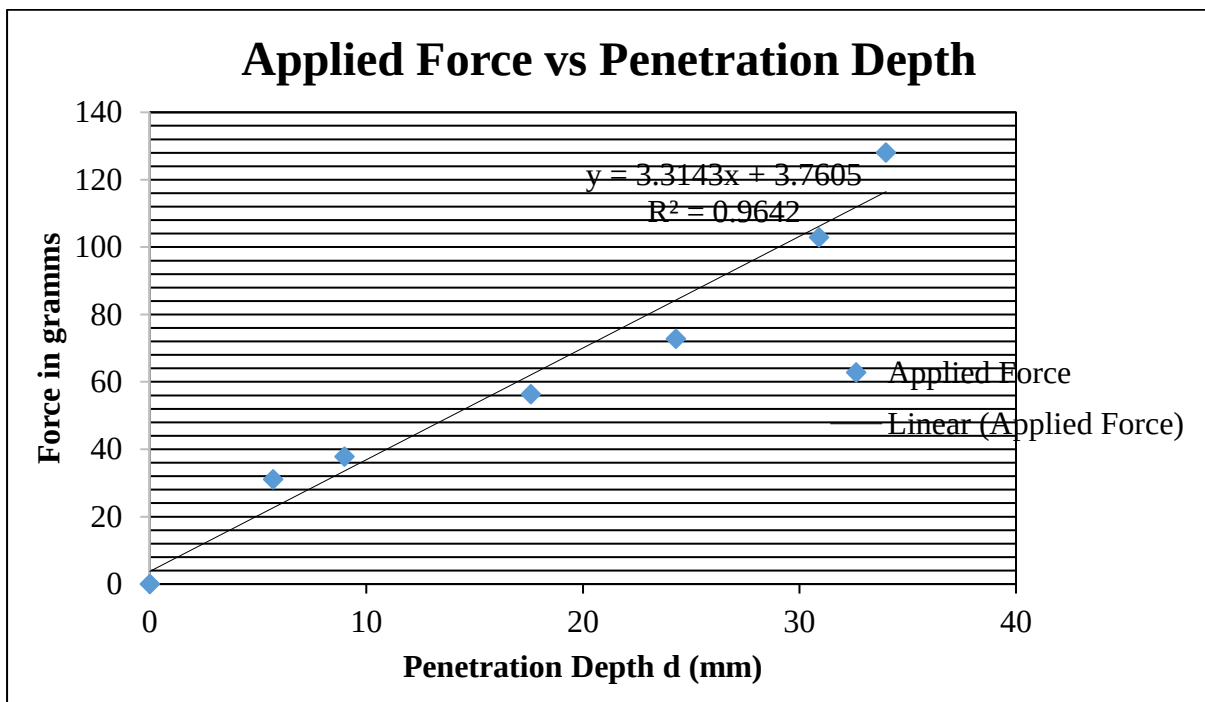
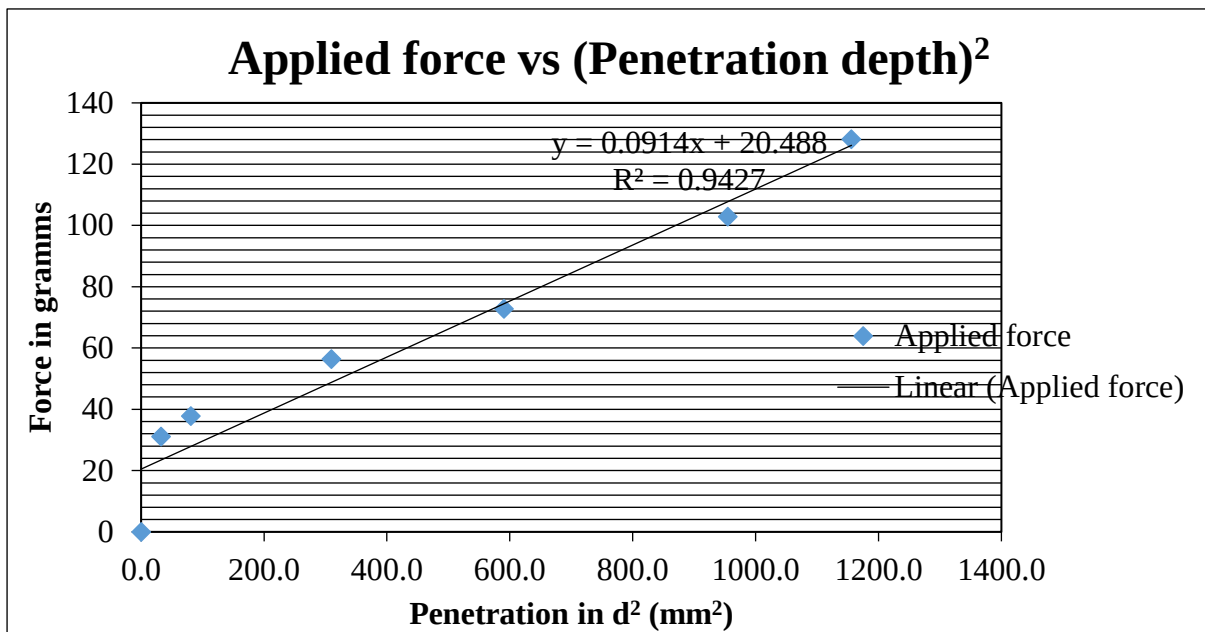


Table of results for soil sample C2 at moisture content 28.4%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.6	250.29	0	0.0	0
51.1	841.68	5.5	30.3	591.39
60.7	1244.39	15.1	228.0	994.1
66.7	1473.71	21.1	445.2	1223.42
72.9	1717.19	27.3	745.3	1466.9
74	1966.7	28.4	806.6	1716.41
79.1	2196.56	33.5	1122.3	1946.27

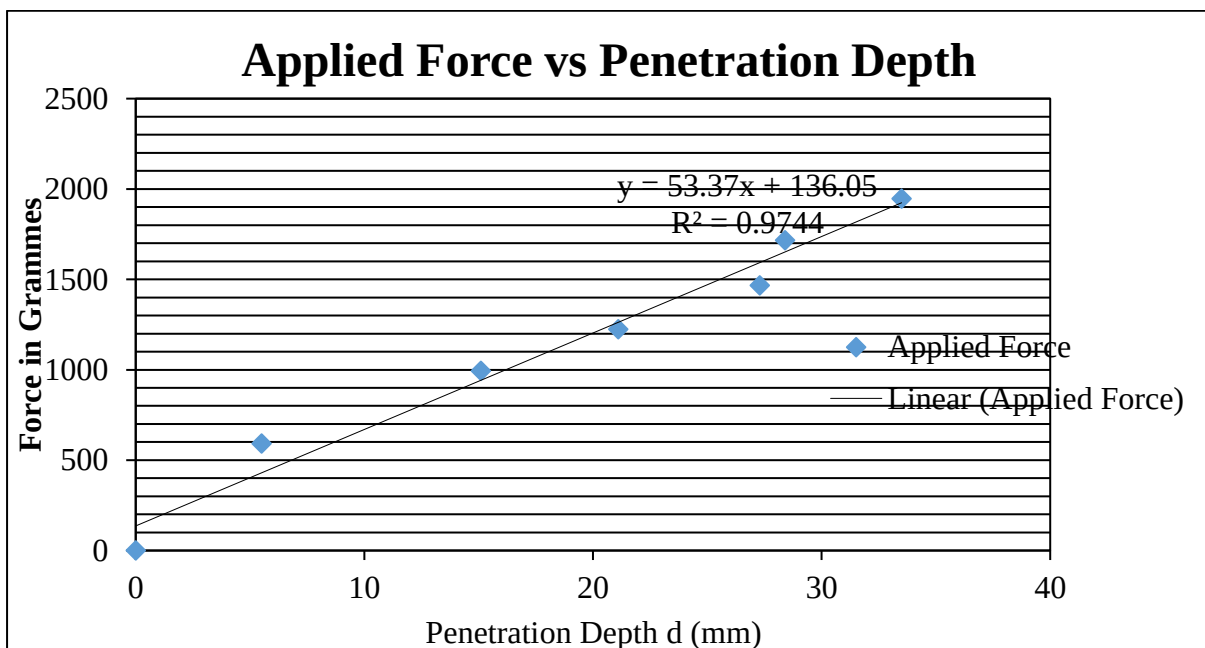
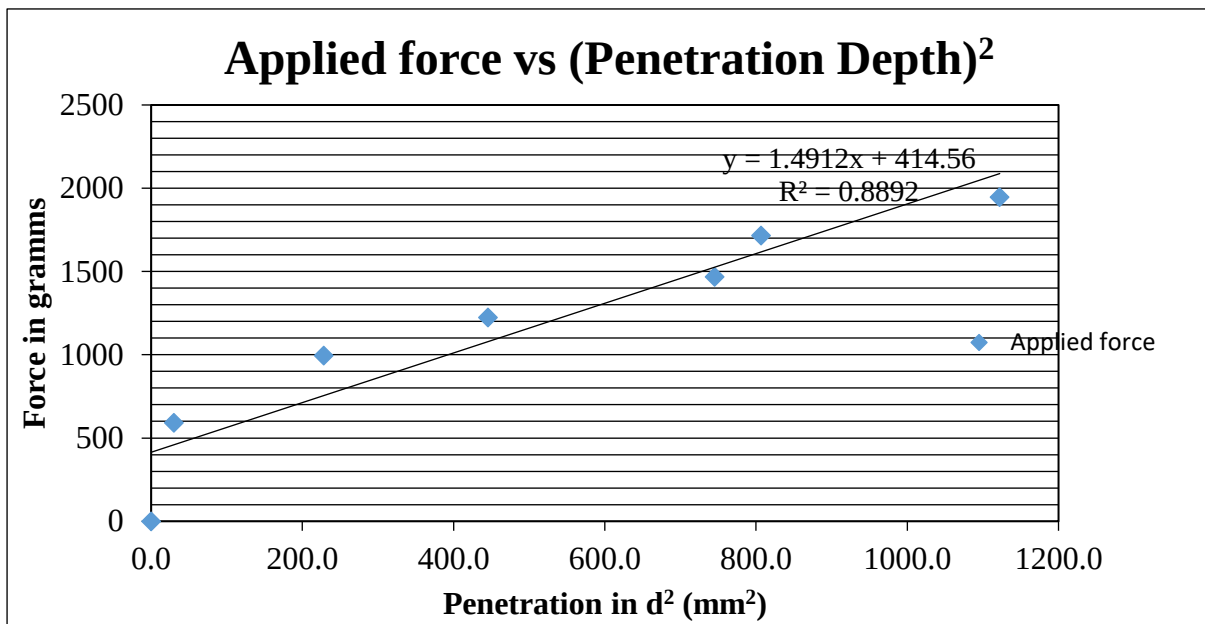


Table of results for soil sample C2 at moisture content 44.3%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42.3	247.58	0	0.0	0
48.1	288.67	5.8	33.6	41.09
51.3	295.36	9	81.0	47.78
63.6	310.93	21.3	453.7	63.35
66.6	333.4	24.3	590.5	85.82
75.7	355.46	33.4	1115.6	107.88
78.3	385.67	36	1296.0	138.09

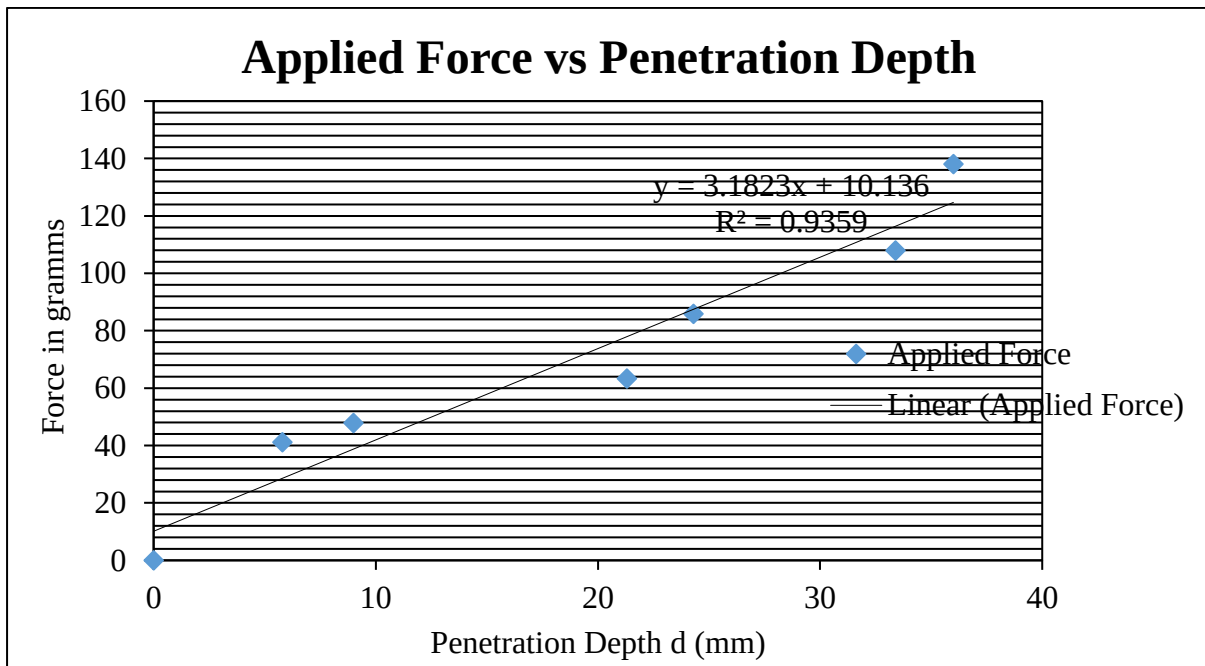
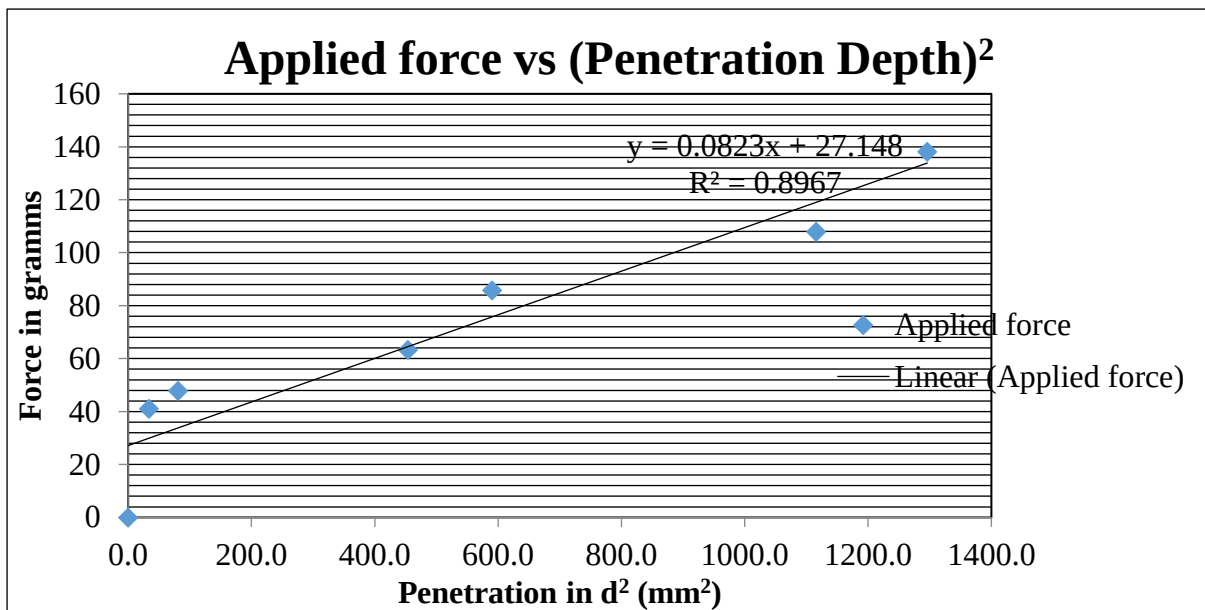


Table of results for soil sample C3 at moisture content 29.5%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42.6	200.29	0	0.0	0
47.7	801.68	5.1	26.0	601.39
60.1	1144.39	17.5	306.3	944.1
66.2	1373.71	23.6	557.0	1173.42
72.9	2047.19	30.3	918.1	1846.9
74.1	2366.7	31.5	992.3	2166.41
78.6	2696.56	36	1296.0	2496.27

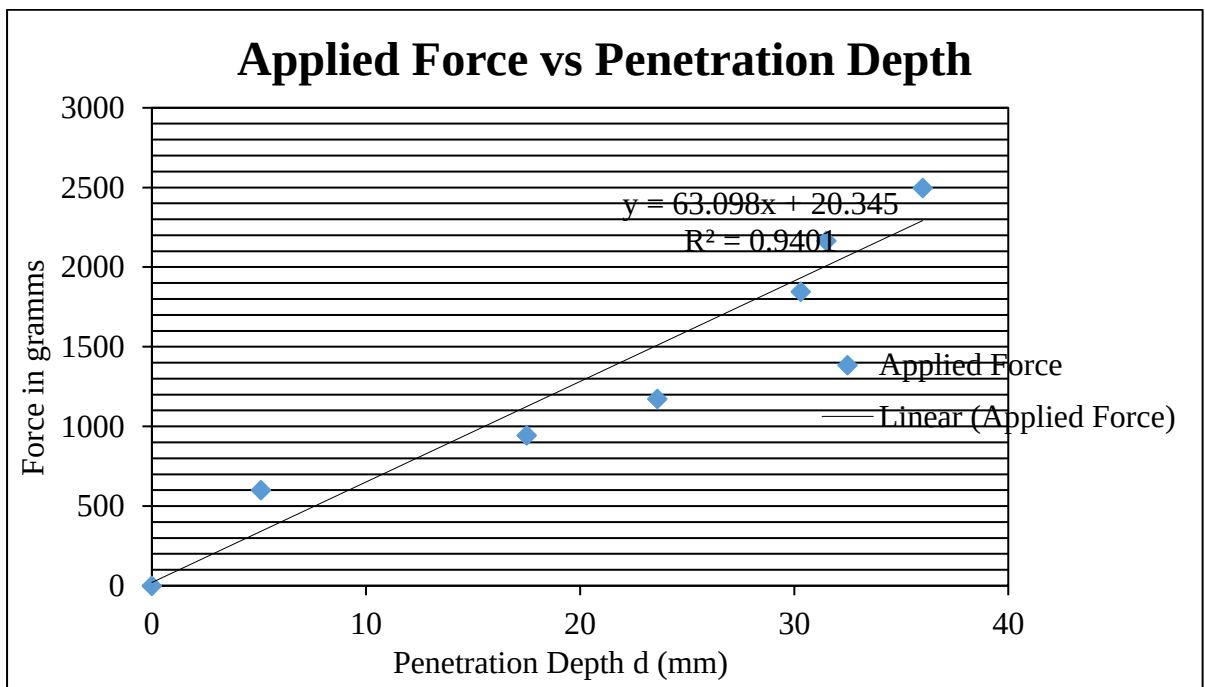
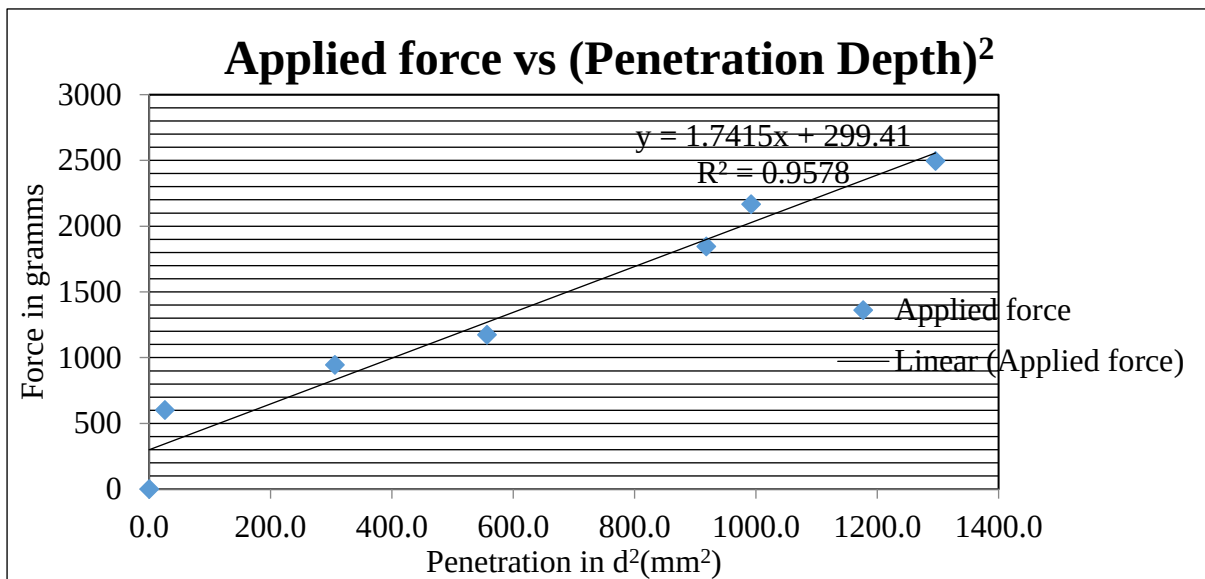


Table of results for soil sample C3 at moisture content 42.3%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42.3	247.58	0	0.0	0
48.1	288.67	5.8	33.6	41.09
51.3	295.36	9	81.0	47.78
63.9	316.93	21.6	466.6	69.35
66.6	323.4	24.3	590.5	75.82
75.7	350.46	33.4	1115.6	102.88
78.3	377.67	36	1296.0	130.09

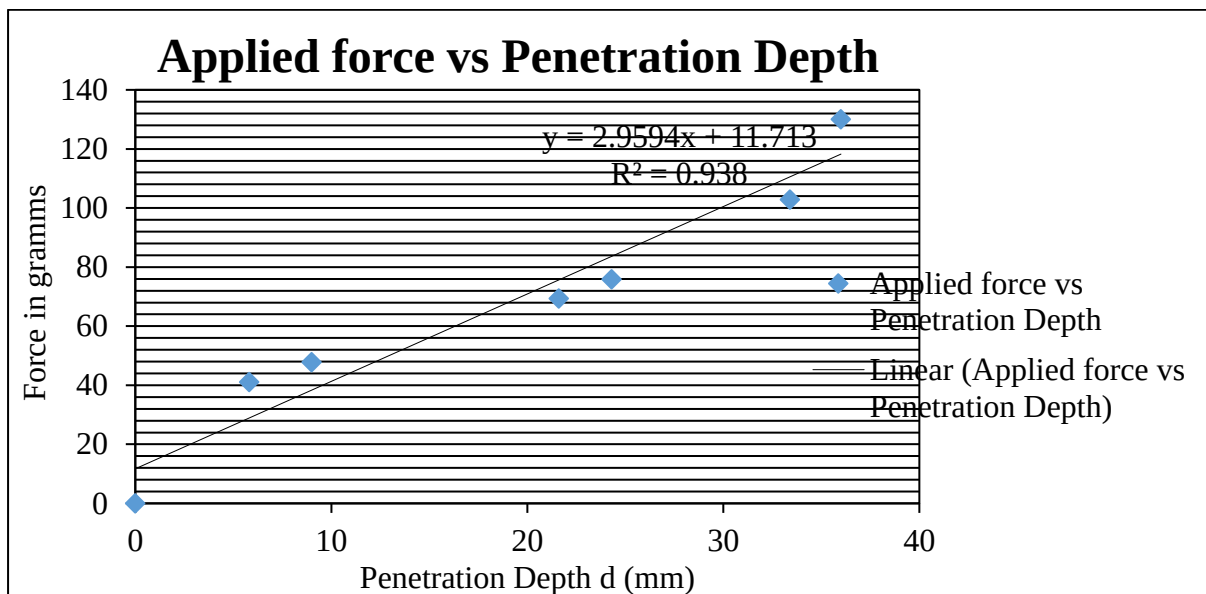
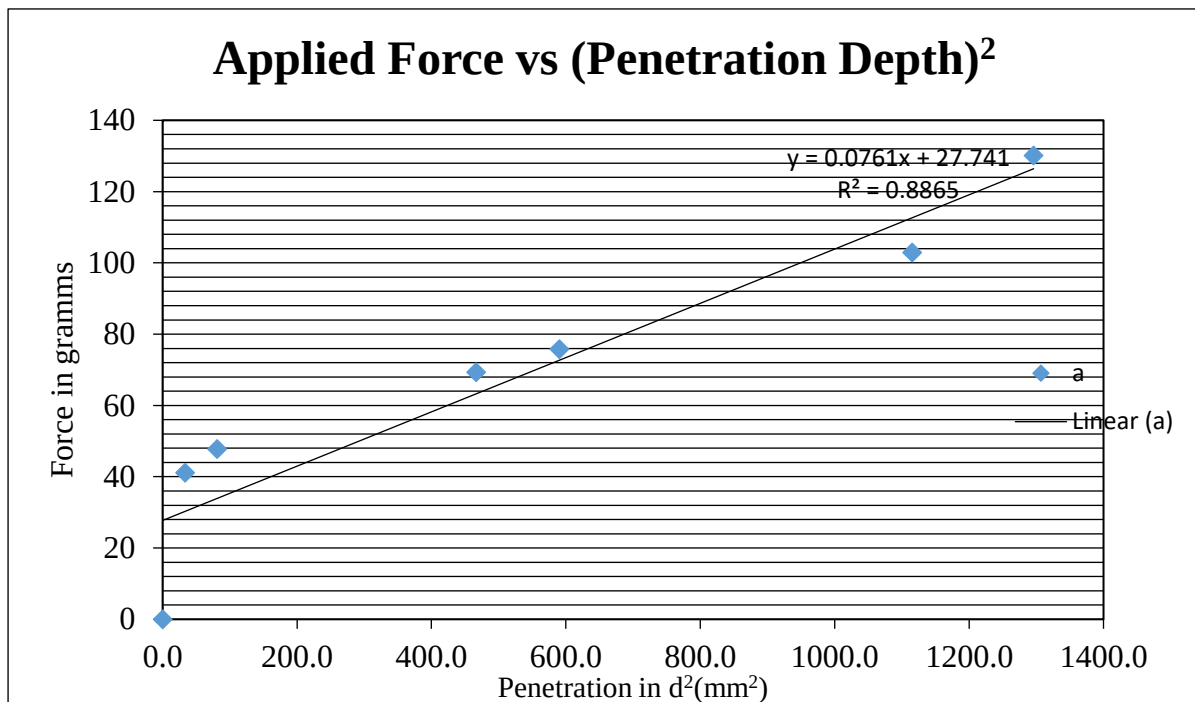


Table of results for soil sample k1 at moisture content 28.2%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.6	300.29	0	0.0	0
51.1	858.78	5.5	30.3	558.49
60.7	1044.59	15.1	228.0	744.3
66.7	1380.71	21.1	445.2	1080.42
72.9	1795.19	27.3	745.3	1494.9
74	2200.7	28.4	806.6	1900.41
79.1	2522.56	33.5	1122.3	2222.27

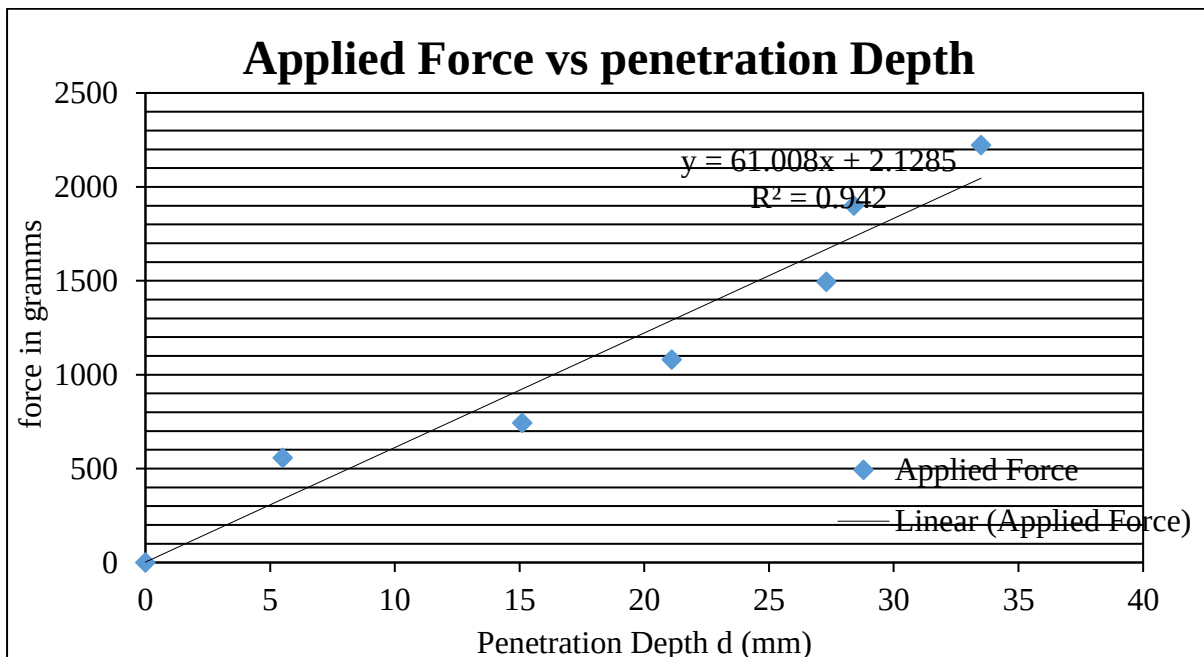
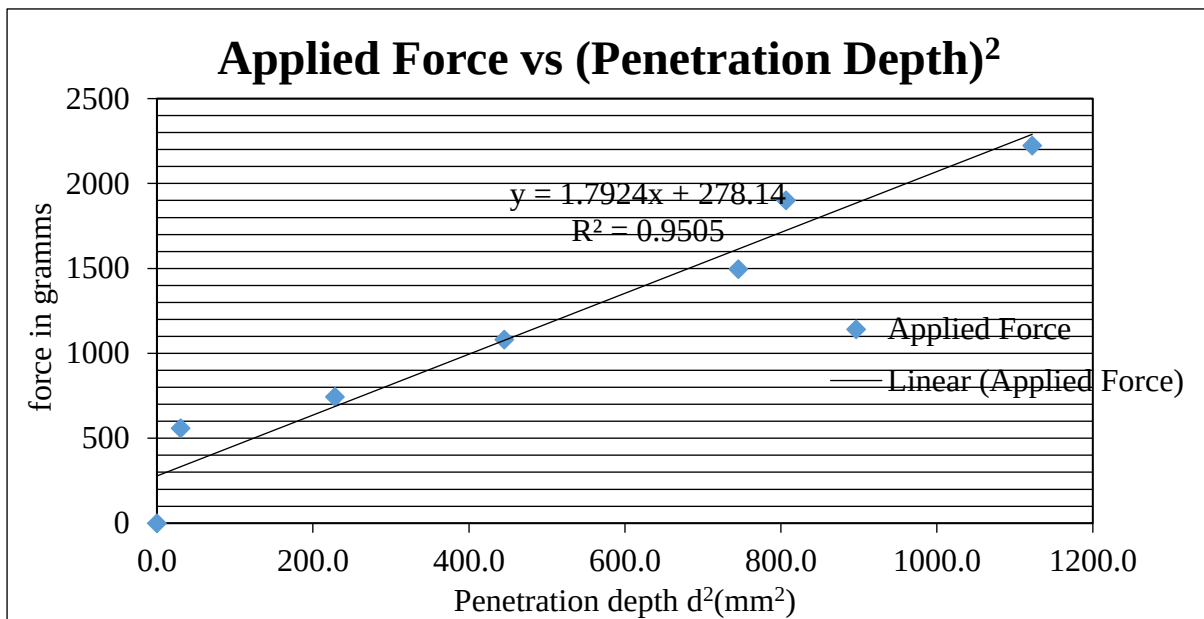


Table of results for soil sample k1 at moisture content 42.2%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42	252.21	0	0.0	0
47.1	267.37	5.1	26.0	15.16
50.2	274.77	8.2	67.2	22.56
59	298.36	17	289.0	46.15
64.2	325.62	22.2	492.8	73.41
69.8	345.08	27.8	772.8	92.87
75	354.12	33	1089.0	101.91
75.2	367.77	33.2	1102.2	115.56

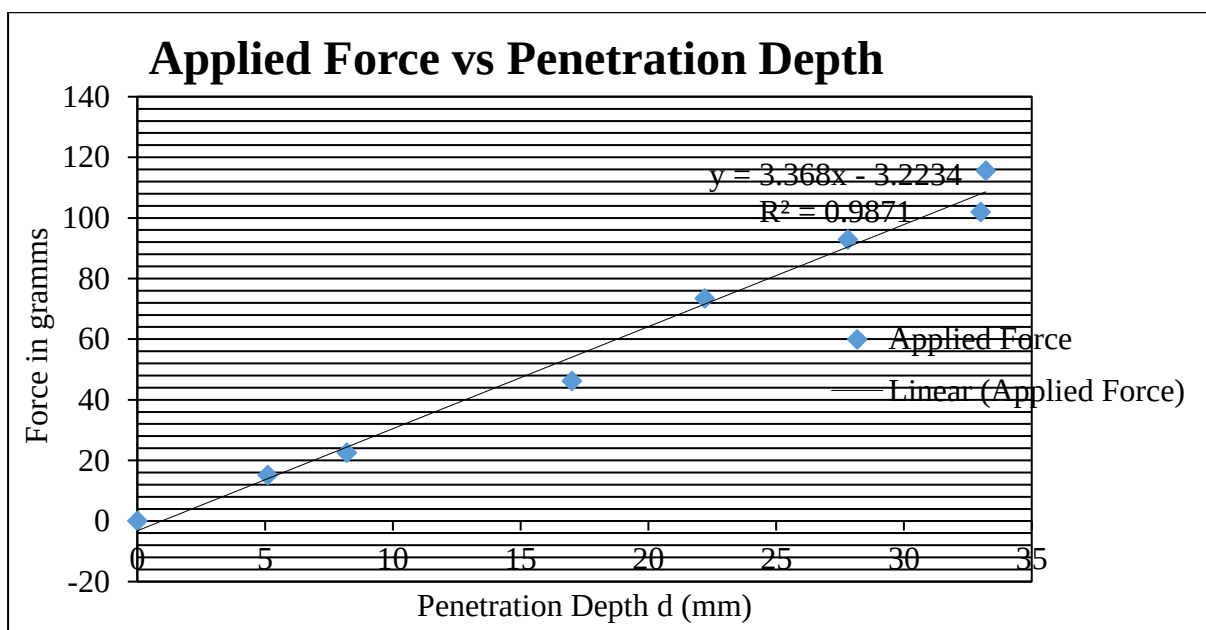
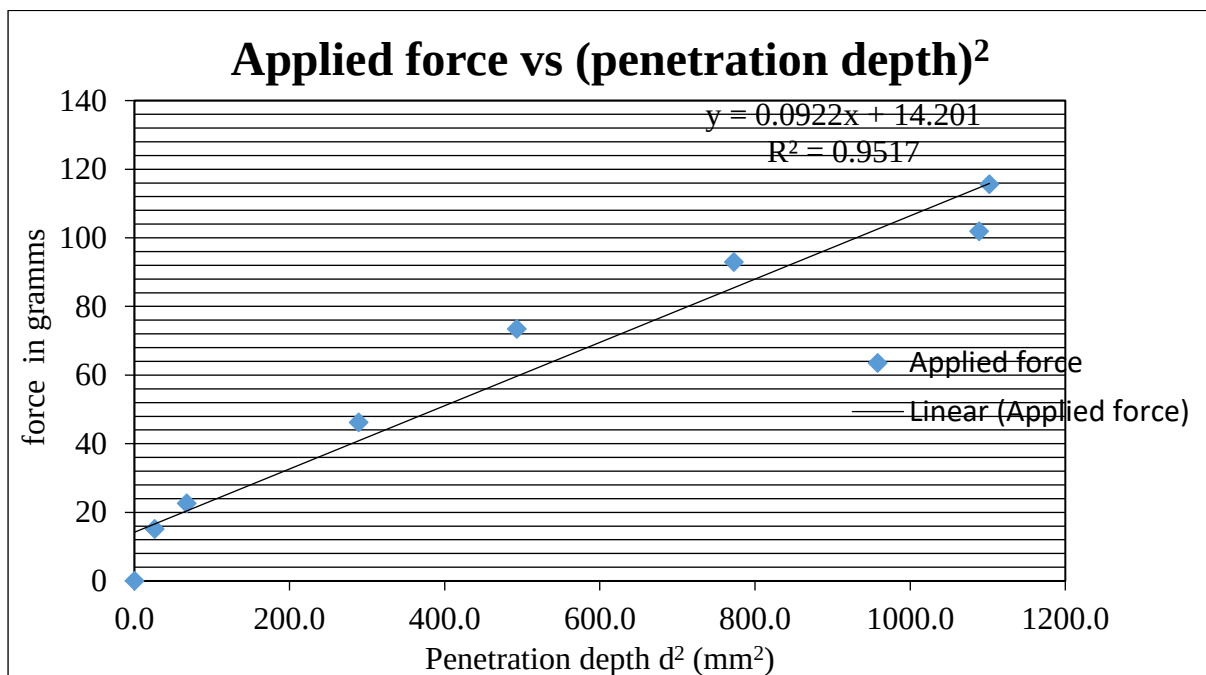


Table of results for soil sample C4 at moisture content 30.1%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
41.9	254.45	0	0.0	0
43.9	533.69	2	4.0	279.24
47.9	831.54	6	36.0	577.09
51.9	1099.49	10	100.0	845.04
65.9	1247.87	24	576.0	993.42
69.9	1715.45	28	784.0	1461
73.9	2335.29	32	1024.0	2080.84
77.9	2960.84	36	1296.0	2706.39

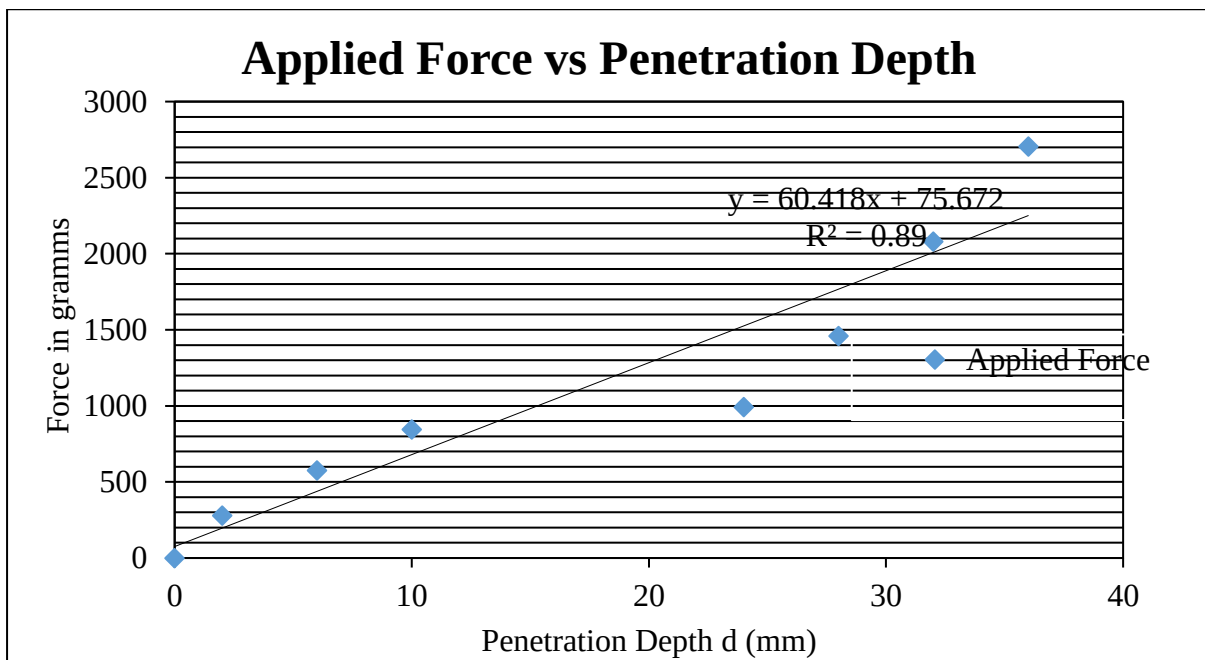
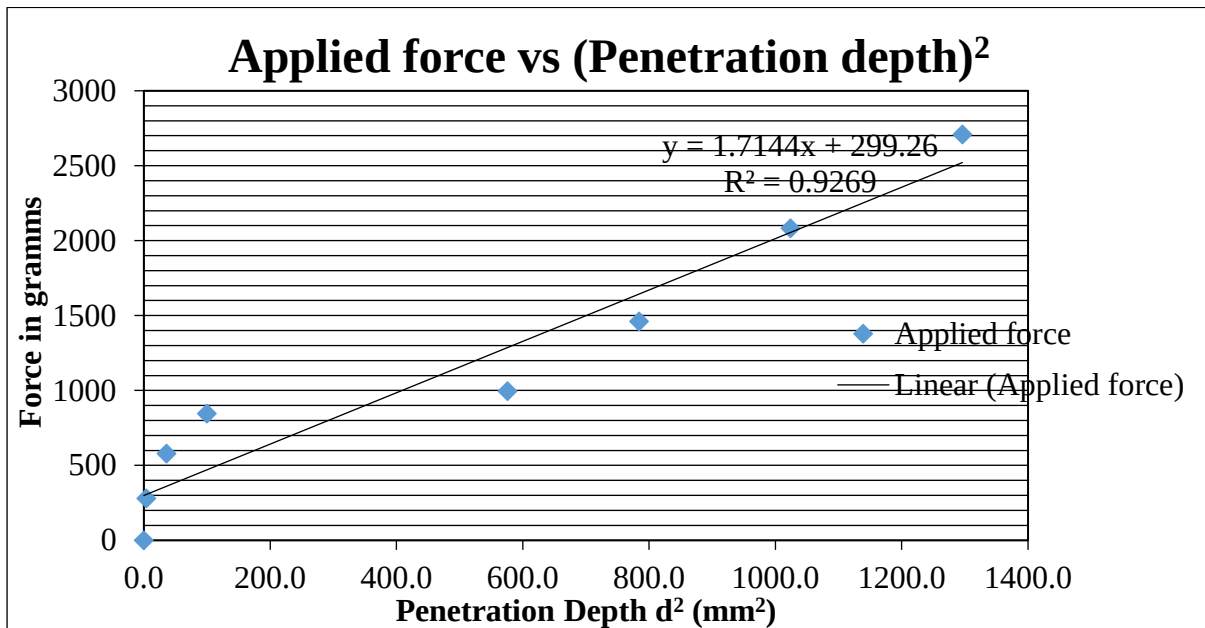


Table of results for soil sample C4 at moisture content 43.5%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.3	229.3	0	0.0	0
51	240.53	5.7	32.5	11.23
54.3	256.55	9	81.0	27.25
62.9	278.64	17.6	309.8	49.34
69.6	323.55	24.3	590.5	94.25
76.2	335.23	30.9	954.8	105.93
79.3	364.11	34	1156.0	123.58

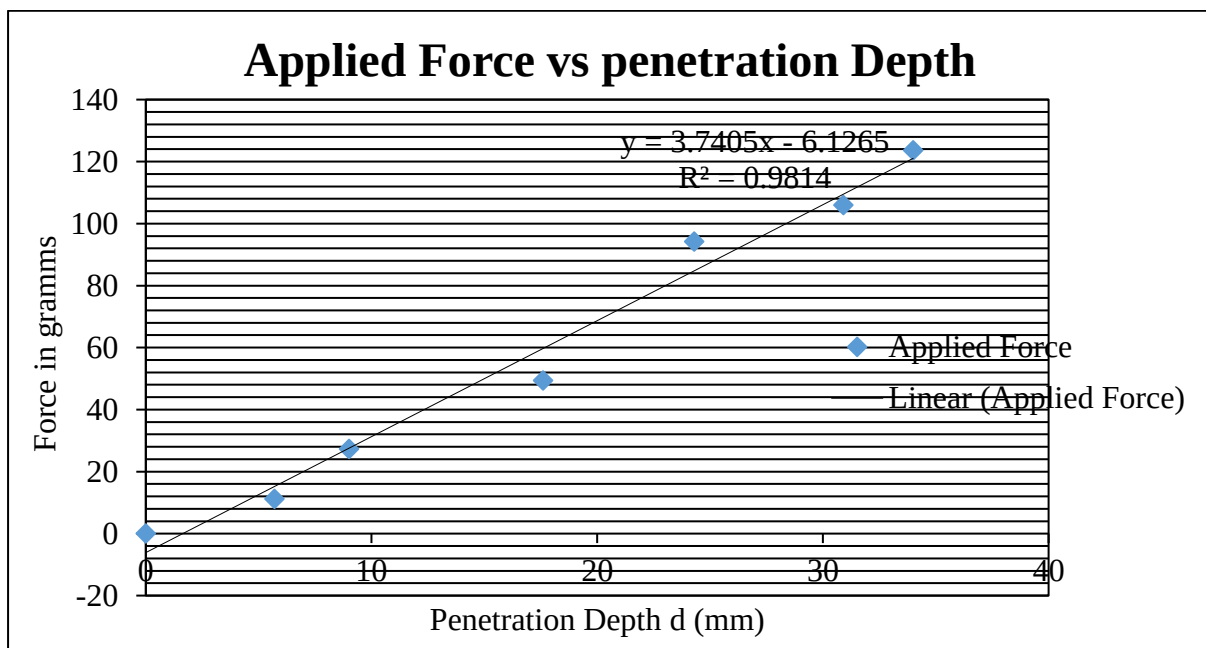
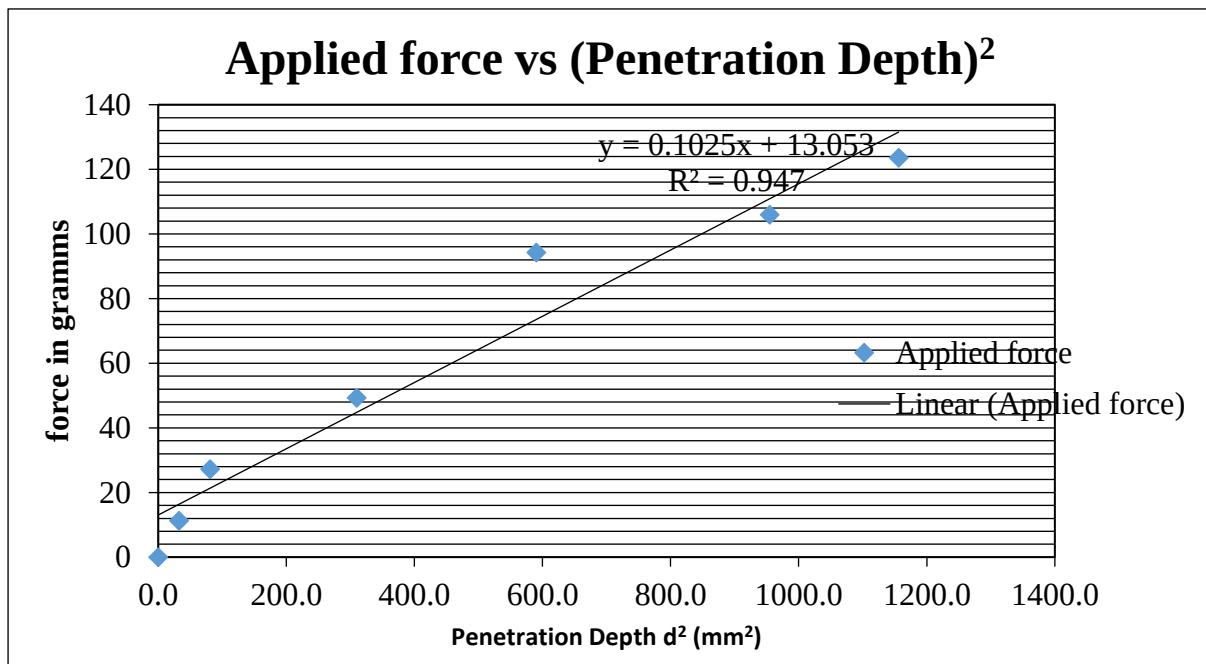


Table of results for soil sample C6 at moisture content 23.3%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
41.3	250.56	0	0.0	0
45.8	417.27	4.5	20.3	166.71
50.8	615.25	9.5	90.3	364.69
55.9	1059.4	14.6	213.2	808.84
62.4	1214.35	21.1	445.2	963.79
66.2	1706.26	24.9	620.0	1455.7
74.4	2139.71	33.1	1095.6	1889.15
75.5	3007.7	34.2	1169.6	2757.14

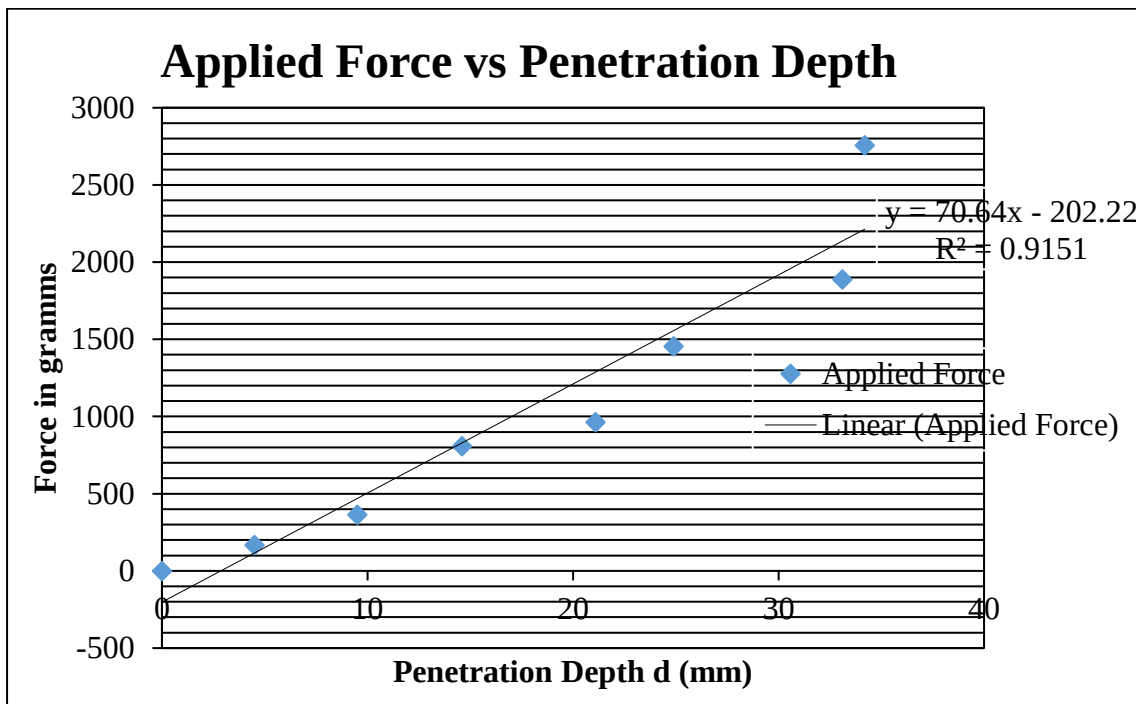
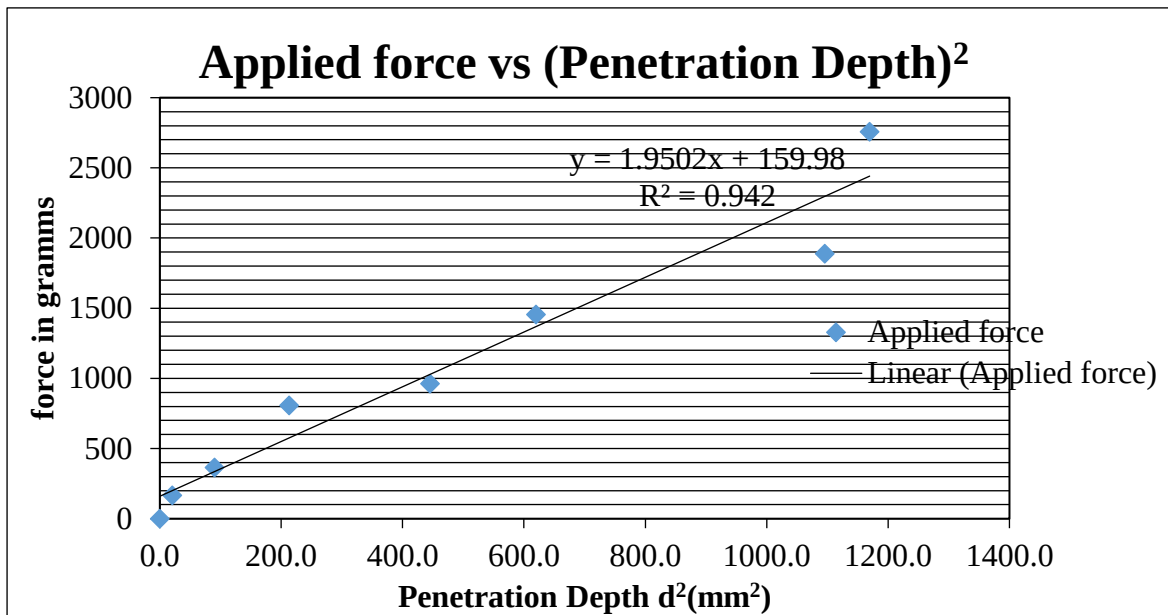


Table of results for soil sample C6 at moisture content 45.1%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.3	227.6	0	0.0	0
51	240.53	5.7	32.5	12.93
54.3	256.55	9	81.0	28.95
62.9	278.64	17.6	309.8	51.04
69.6	303.55	24.3	590.5	75.95
76.2	335.23	30.9	954.8	107.63
79.3	368.28	34	1156.0	127.75

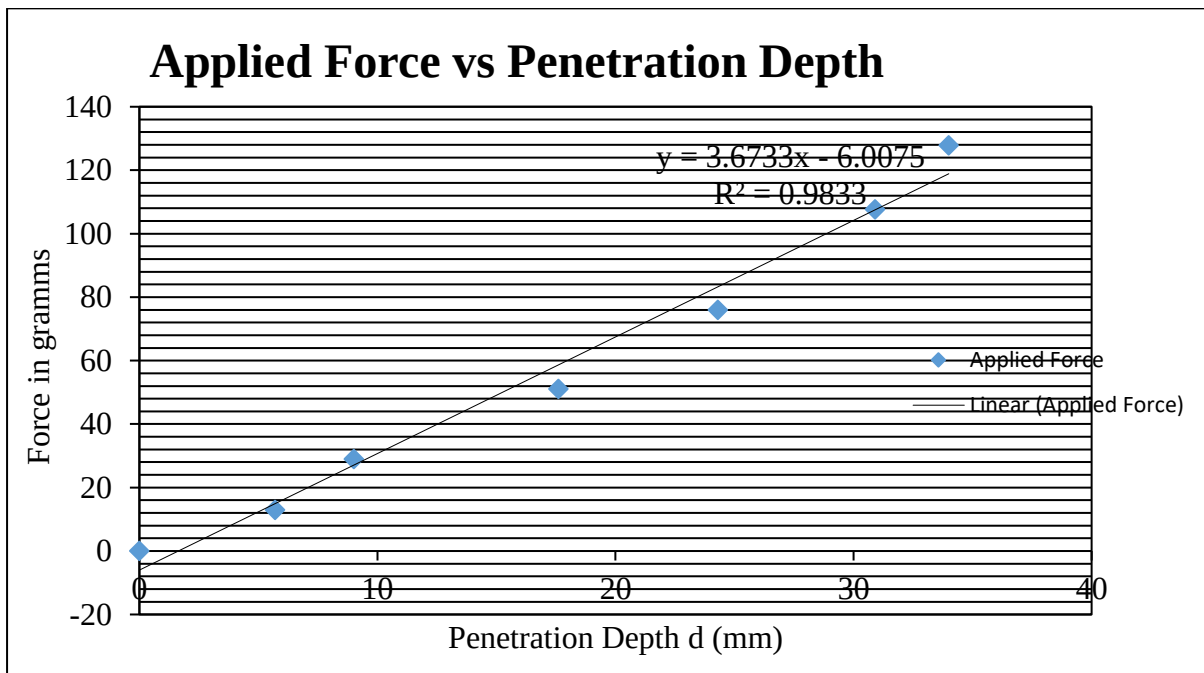
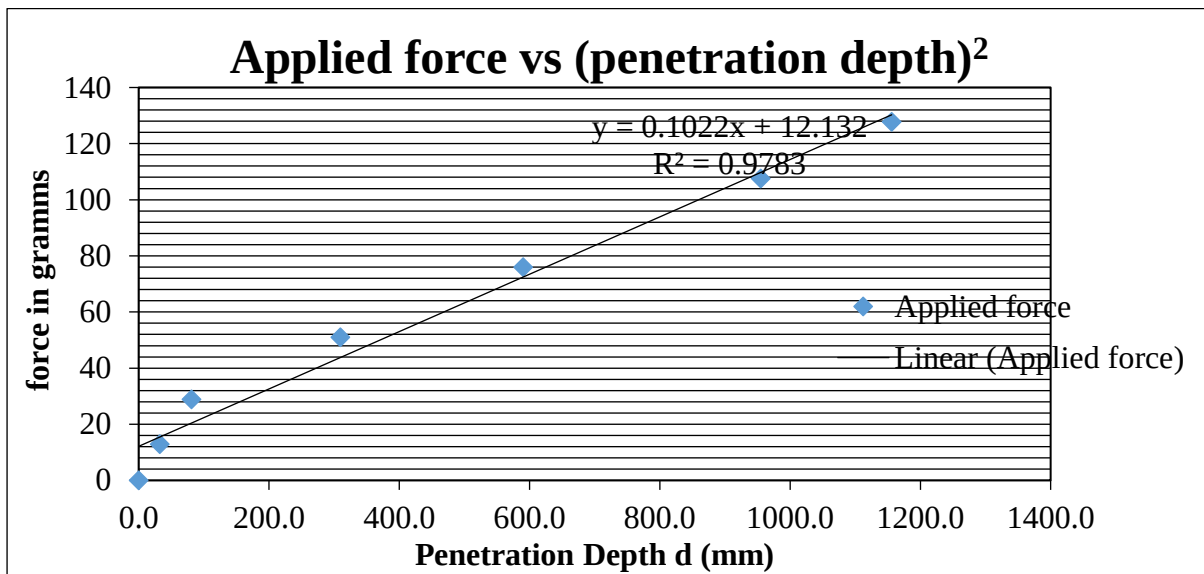


Table of results for soil sample C5 at moisture content 23.3%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.6	230.56	0	0.0	0
51.1	453.27	5.5	30.3	222.71
60.7	915.25	15.1	228.0	684.69
66.2	1311.4	20.6	424.4	1080.84
68.9	1614.35	23.3	542.9	1383.79
74.6	1906.26	29	841.0	1675.7
76.1	2439.71	30.5	930.3	2209.15
78.9	2878.7	33.3	1108.9	2648.14

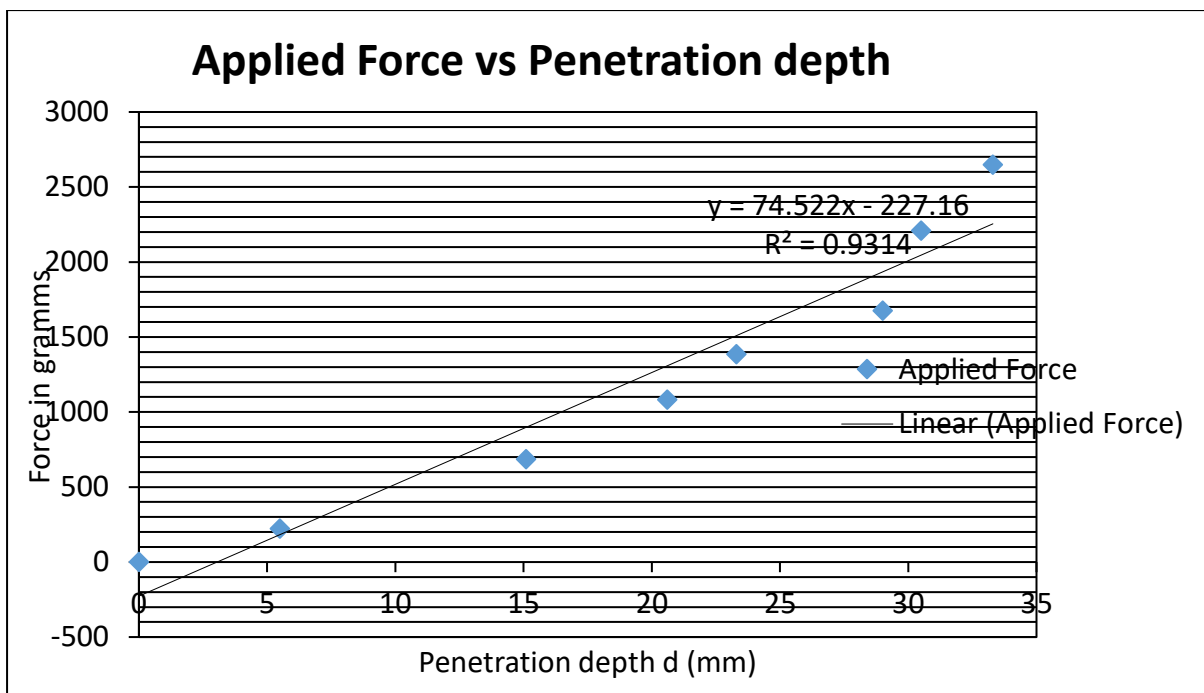
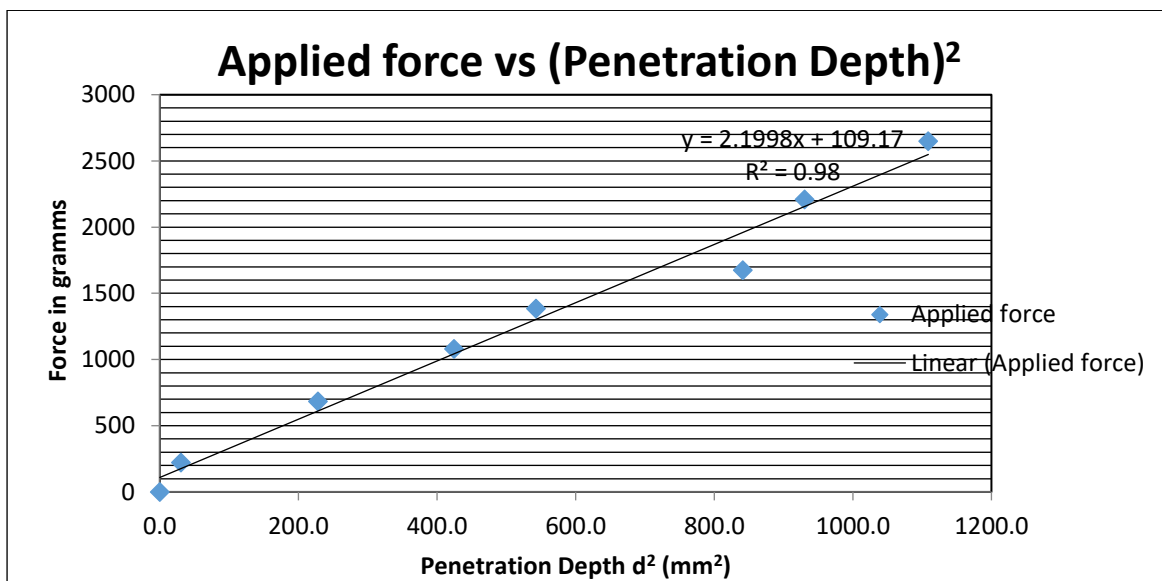


Table of results for soil sample C5 at moisture content 46.8%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
33.5	226.01	0	0.0	0
38.5	249.37	5	25.0	23.36
42.8	261.77	9.3	86.5	35.76
48.2	290.36	14.7	216.1	64.35
63	323.62	29.5	870.3	97.61
68.5	348.08	35	1225.0	122.07
74	362.12	40.5	1640.3	136.11
79.1	405.77	45.6	2079.4	179.76

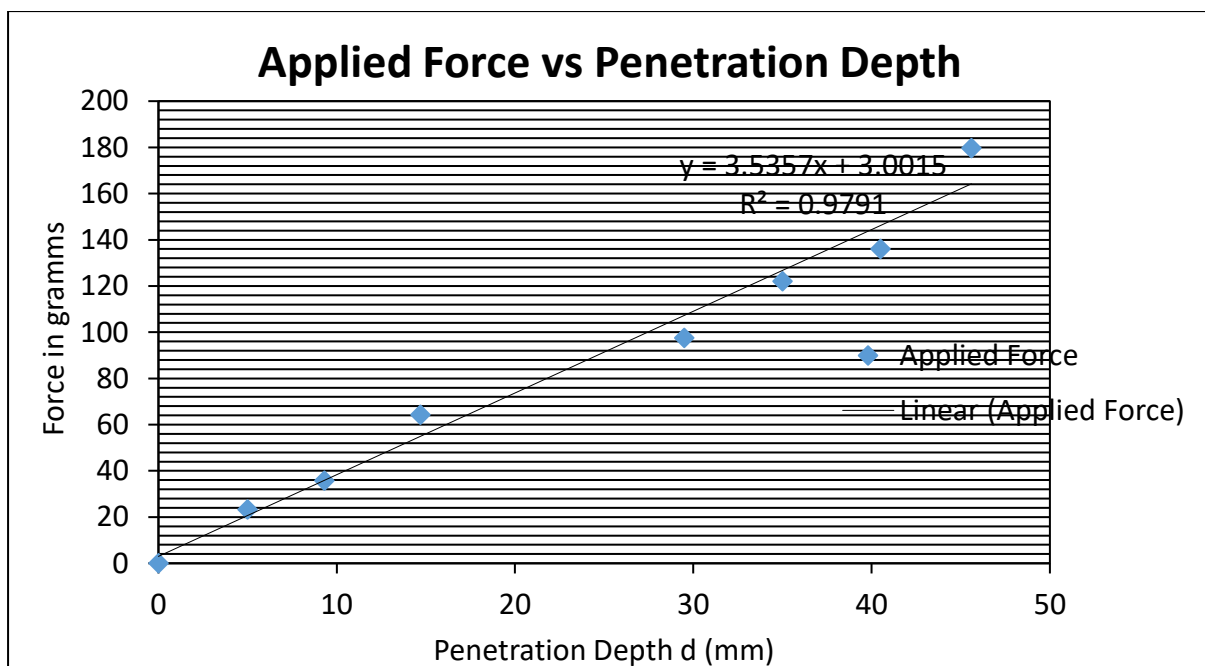
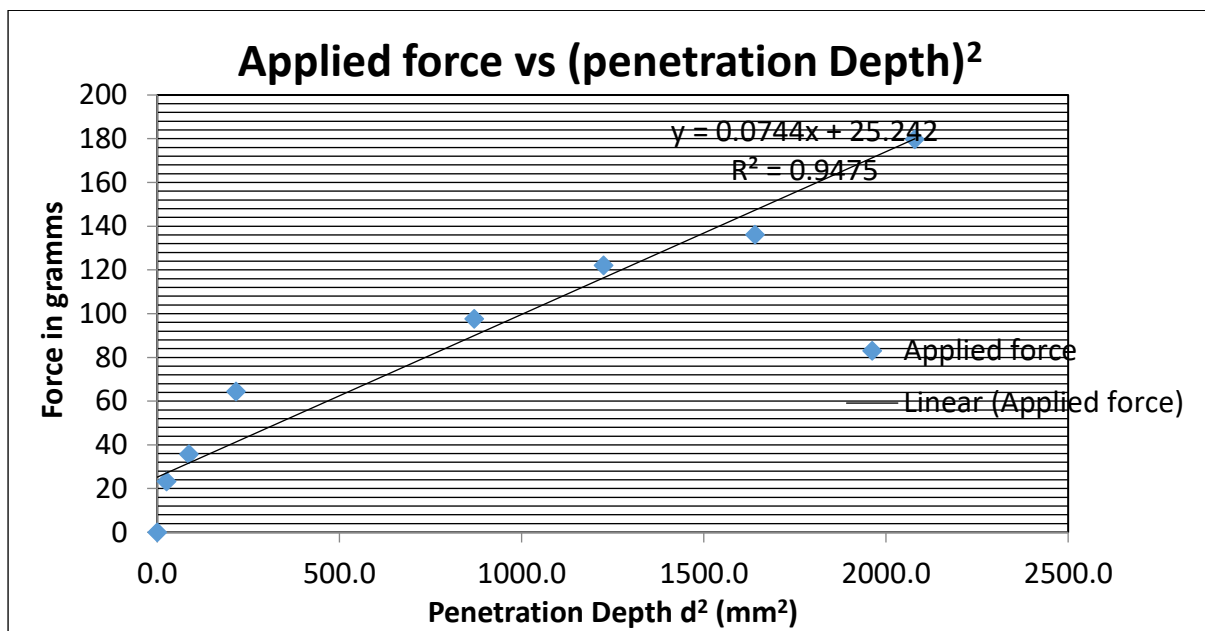


Table of results for soil sample K2 at moisture content 23.3%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
41.4	212.16	0	0.0	0
46.3	653.27	4.9	24.0	441.11
49.1	915.25	7.7	59.3	703.09
58	1117.4	16.6	275.6	905.24
62.4	1514.35	21	441.0	1302.19
72	1806.26	30.6	936.4	1594.1
73.3	2239.71	31.9	1017.6	2027.55
78.7	2512.7	37.3	1391.3	2300.54

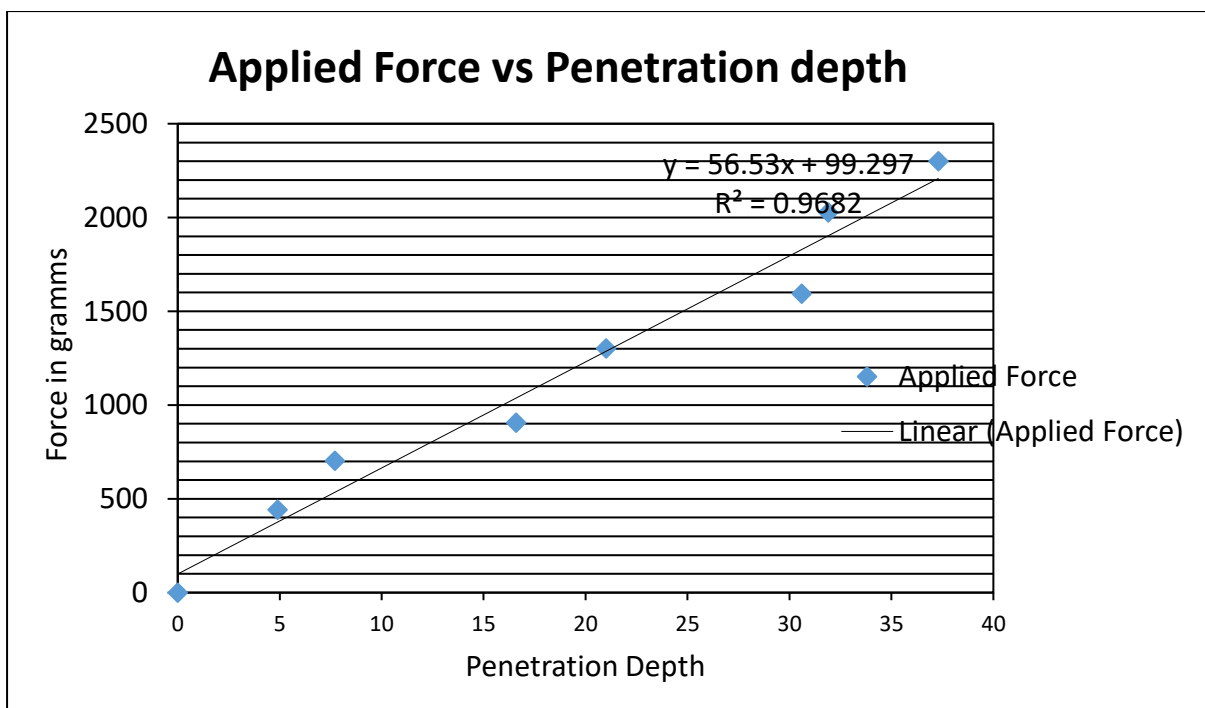
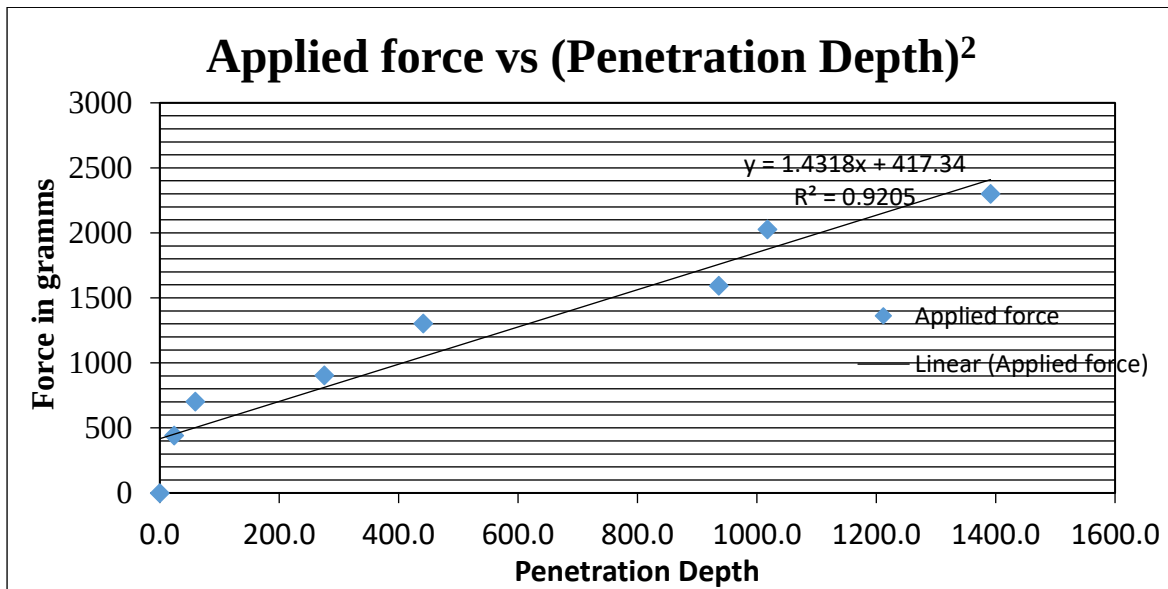


Table of results for soil sample K2 at moisture content 46.8%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.6	247.58	0	0.0	0
51.1	288.67	5.5	30.3	41.09
60.7	295.36	15.1	228.0	47.78
66.2	310.93	20.6	424.4	63.35
72.9	333.4	27.3	745.3	85.82
74.6	345.46	29	841.0	97.88
78.1	365.67	32.5	1056.3	118.09

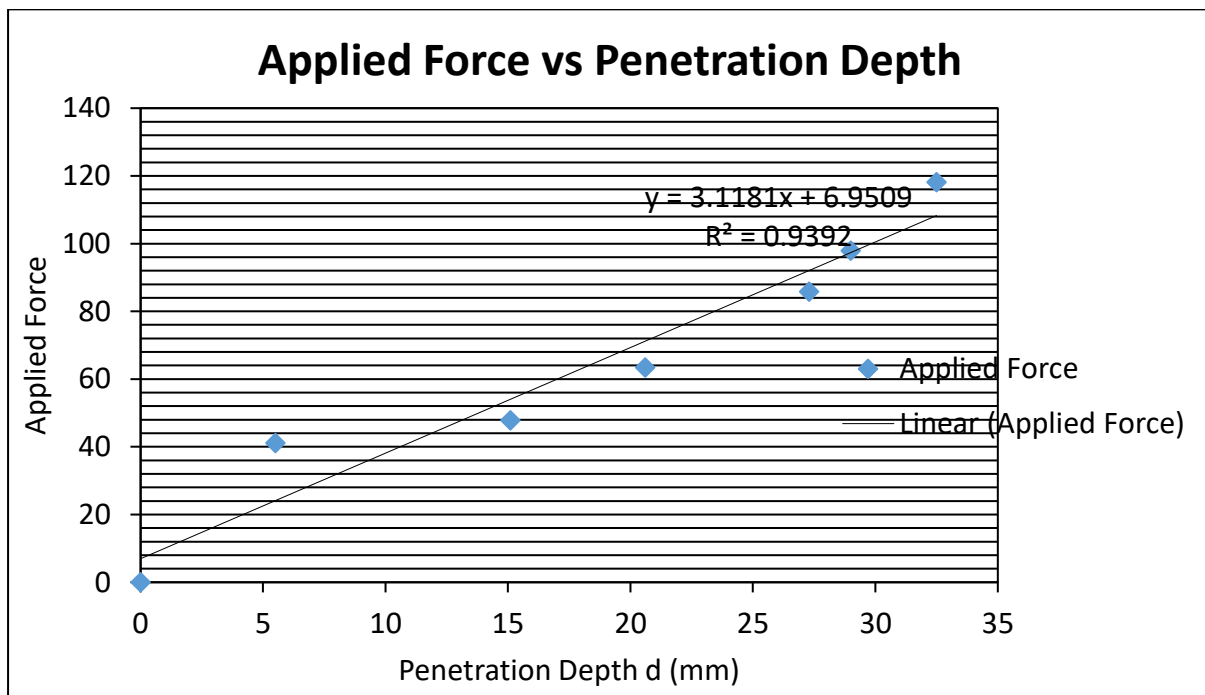
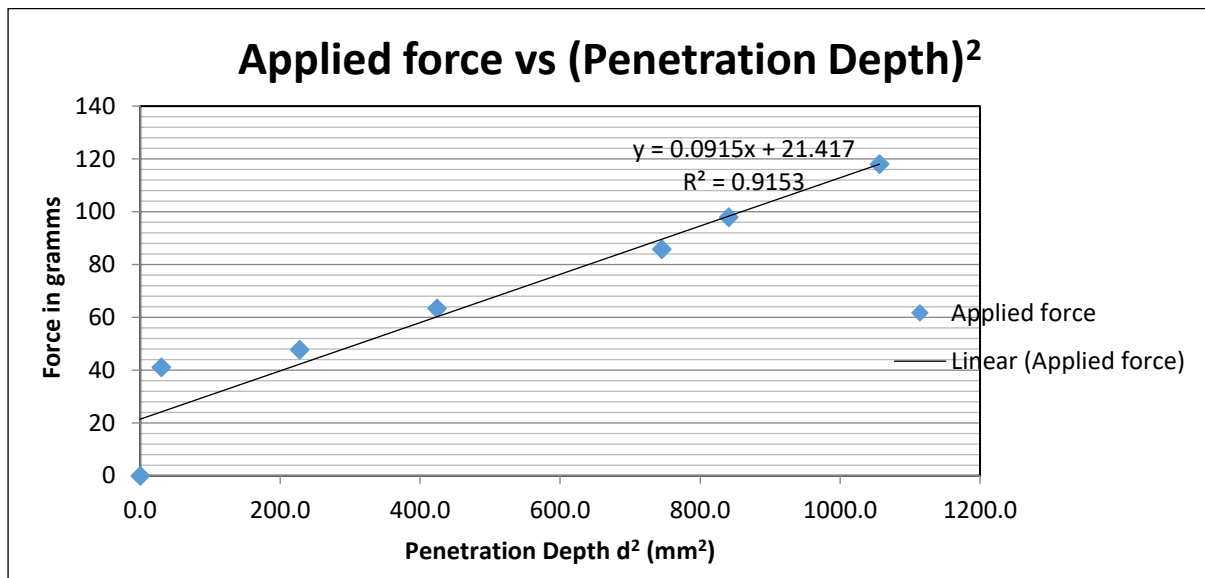


Table of results for soil sample K5 at moisture content 19%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
38.6	316.85	0	0.0	0
45.2	533.69	6.6	43.6	216.84
47.7	831.54	9.1	82.8	514.69
49.4	999.49	10.8	116.6	682.64
56.6	1247.87	18	324.0	931.02
56.8	1715.45	18.2	331.2	1398.6
61.88	2067.29	23.28	542.0	1750.44
73.5	2260.84	34.9	1218.0	1943.99

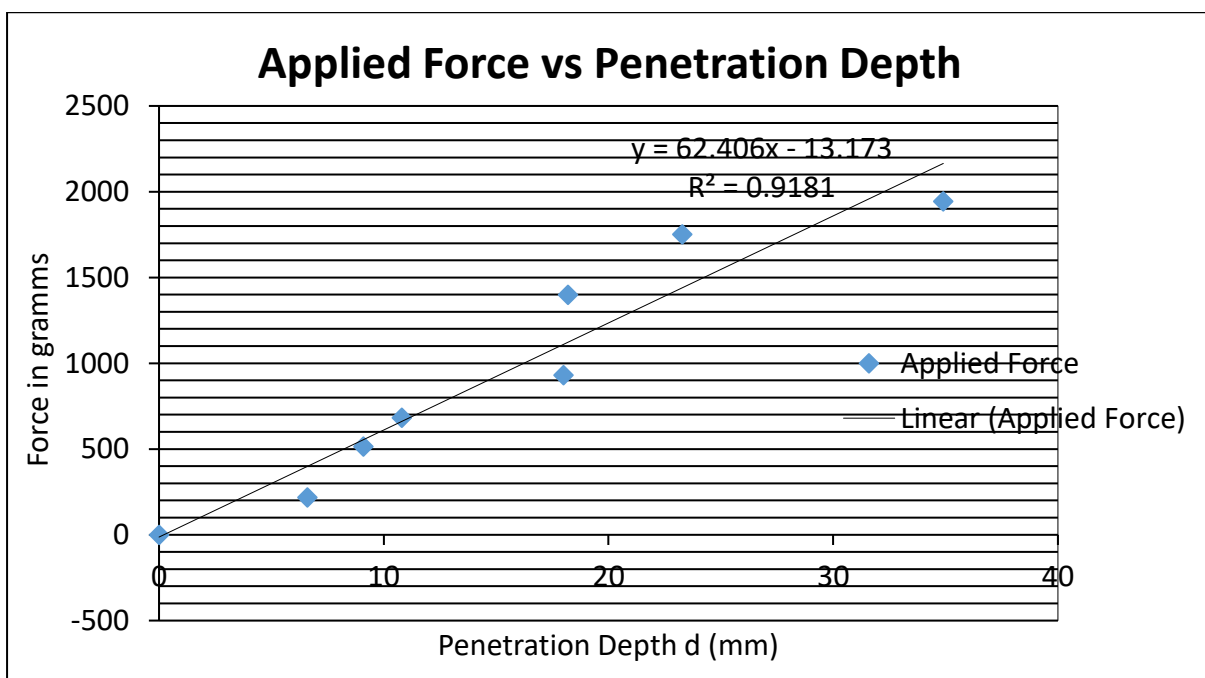
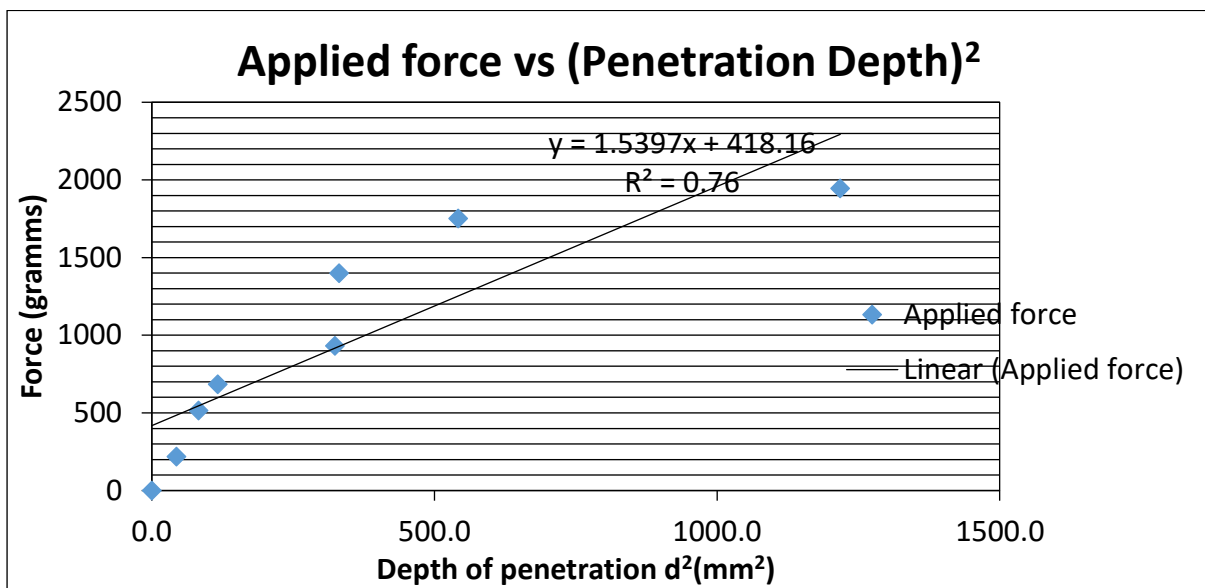


Table of results for soil sample K5 at moisture content 38.5%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
38.5	269.58	0	0.0	0
45.2	288.67	6.7	44.9	19.09
47.7	295.36	9.2	84.6	25.78
49.4	316.93	10.9	118.8	47.35
56.6	323.4	18.1	327.6	53.82
56.8	350.46	18.3	334.9	80.88
61.8	367.67	23.3	542.9	98.09
73.5	380.84	35	1225.0	111.26

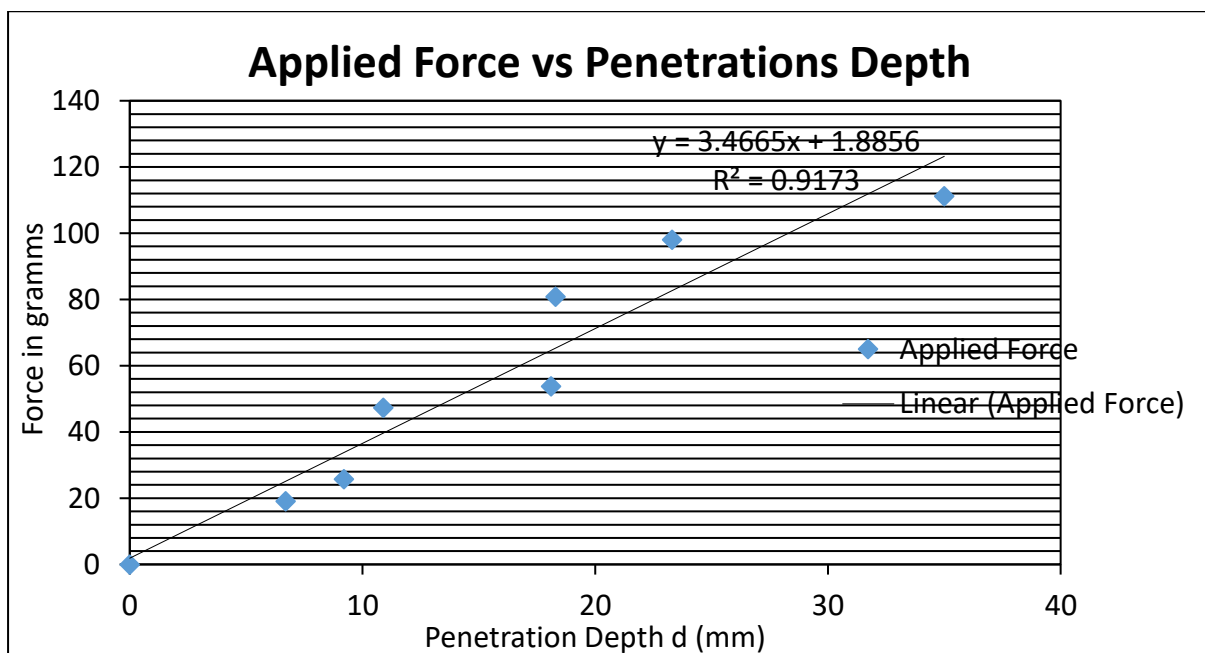
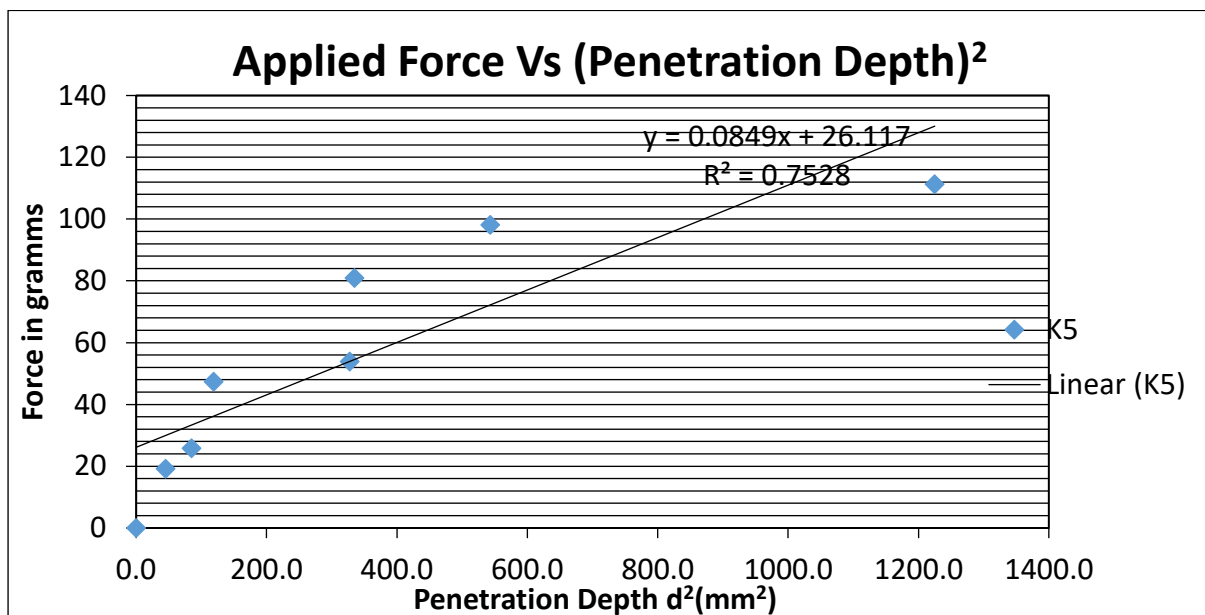


Table of results for soil sample K6 at moisture content 20.5%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
38.6	316.85	0	0.0	0
45.2	533.69	6.6	43.6	216.84
47.7	831.54	9.1	82.8	514.69
49.4	999.49	10.8	116.6	682.64
54.6	1247.87	16	256.0	931.02
58.8	1715.45	20.2	408.0	1398.6
63.8	2167.29	25.2	635.0	1850.44
75.5	2621.84	36.9	1361.6	2304.99

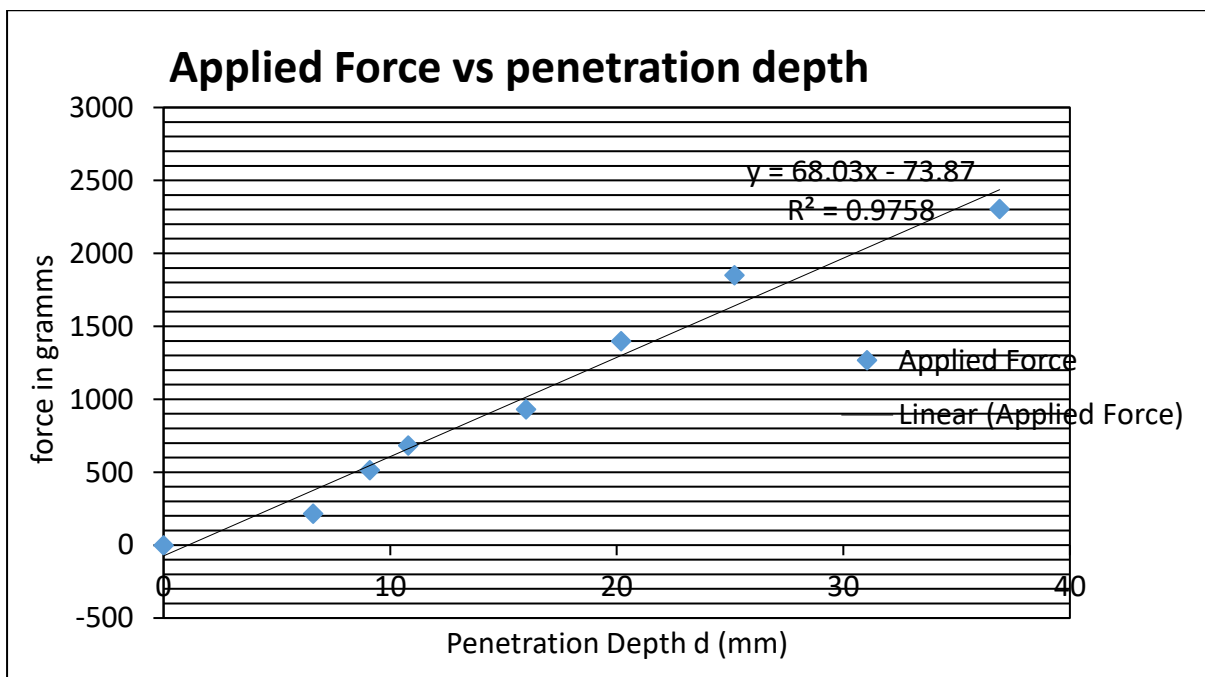
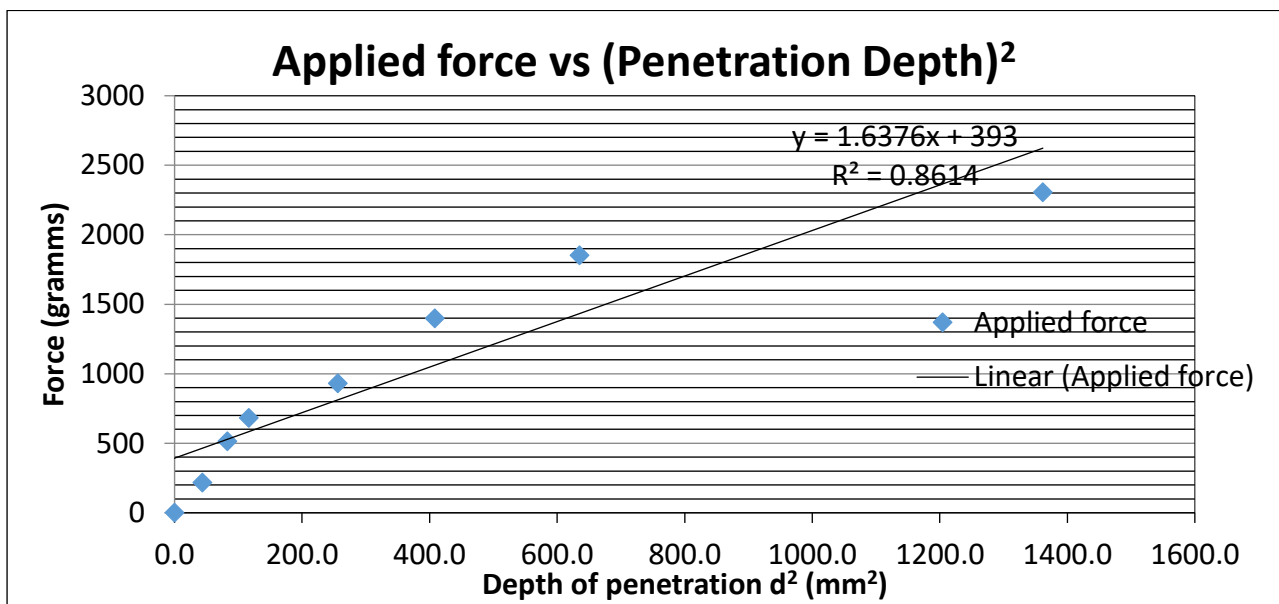
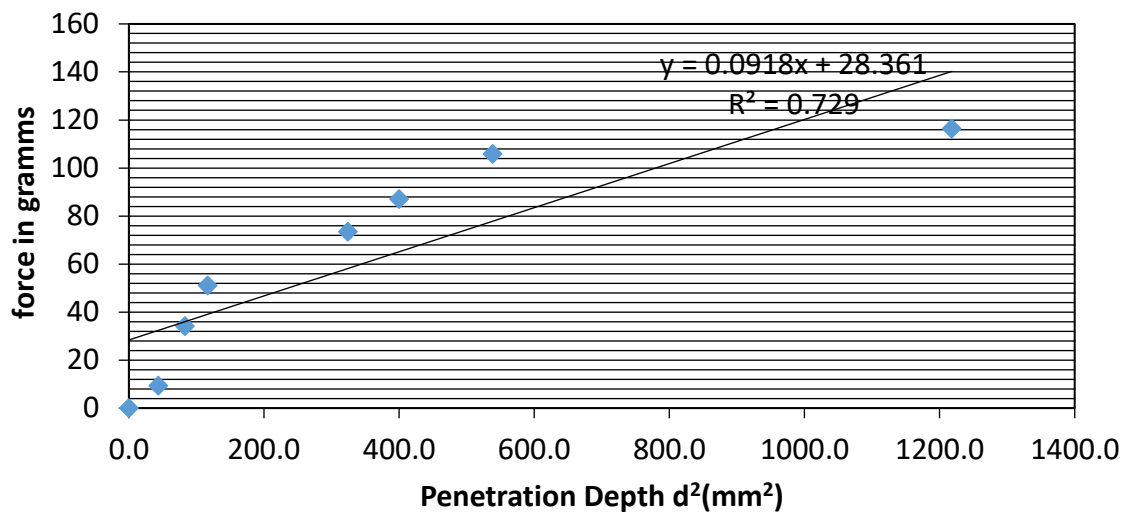


Table of results for soil sample K6 at moisture content 37.4%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
38.6	254.45	0	0.0	0
45.2	263.69	6.6	43.6	9.24
47.7	288.54	9.1	82.8	34.09
49.4	305.49	10.8	116.6	51.04
56.6	327.87	18	324.0	73.42
58.6	341.45	20	400.0	87
61.8	360.29	23.2	538.2	105.84
73.5	370.84	34.9	1218.0	116.39

Applied force vs (Penetration depth)²



Applied Force vs penetration depth

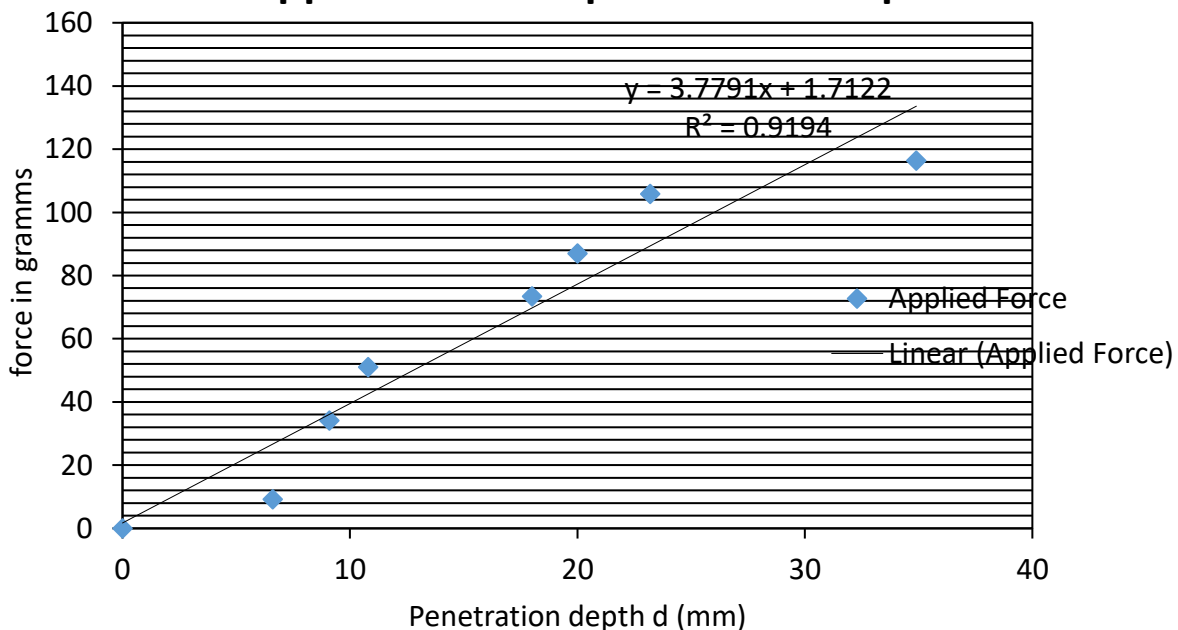


Table of results for soil sample C7 at moisture content 19%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
38.6	316.85	0	0.0	0
45.2	533.69	6.6	43.6	216.84
47.7	831.54	9.1	82.8	514.69
49.4	999.49	10.8	116.6	682.64
56.6	1247.87	18	324.0	931.02
59.2	1715.45	20.6	424.4	1398.6
64.3	2267.29	25.7	660.5	1950.44
75.5	2665.84	36.9	1361.6	2348.99

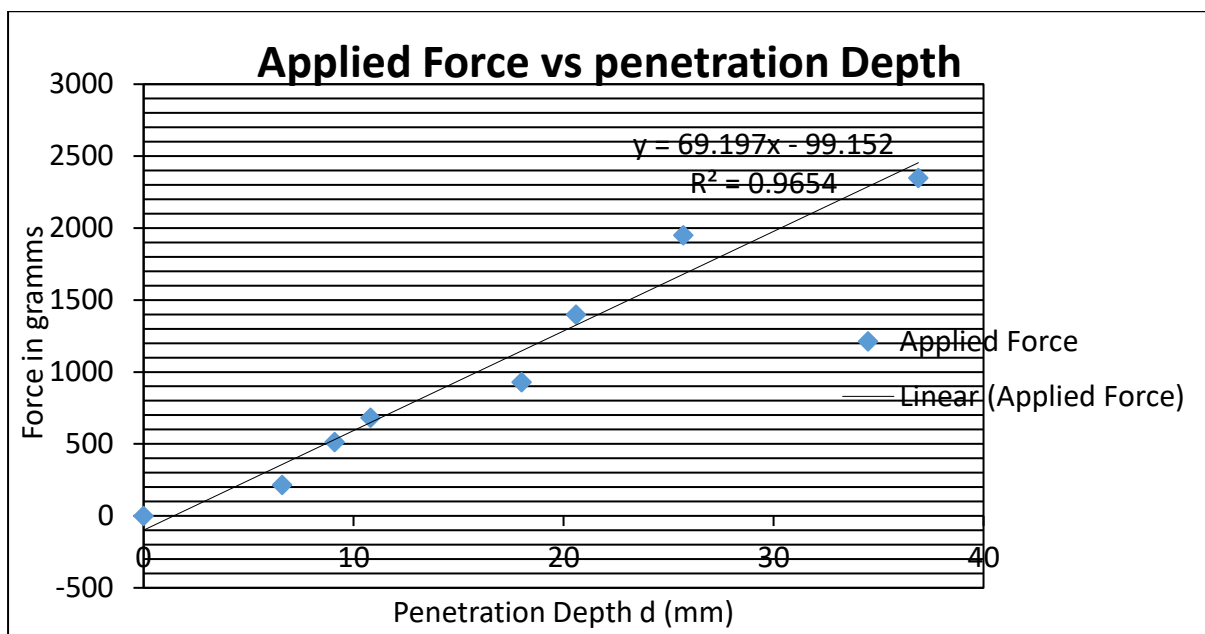
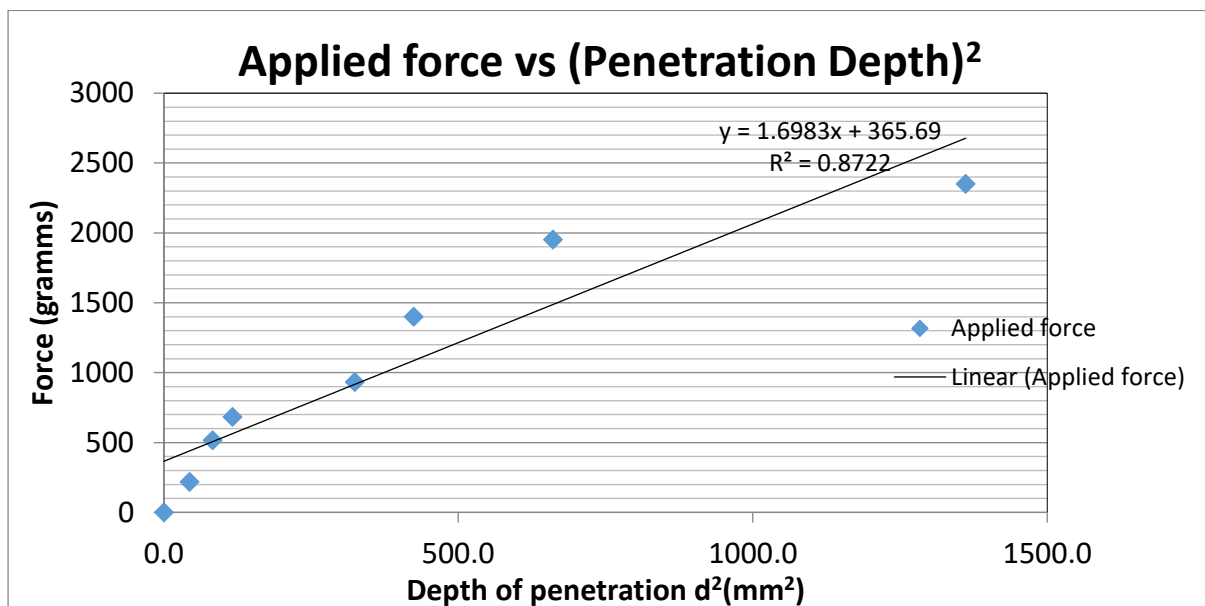
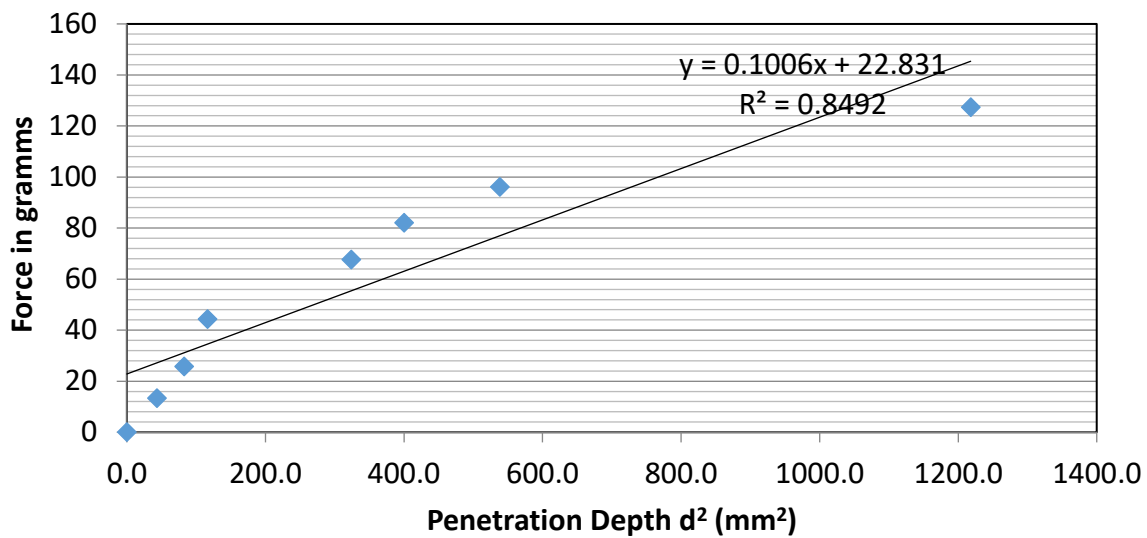


Table of results for soil sample C7 at moisture content 38.3%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
38.6	246.01	0	0.0	0
45.2	259.37	6.6	43.6	13.36
47.7	271.77	9.1	82.8	25.76
49.4	290.36	10.8	116.6	44.35
56.6	313.62	18	324.0	67.61
58.6	328.08	20	400.0	82.07
61.8	342.12	23.2	538.2	96.11
73.5	373.37	34.9	1218.0	127.36

Applied Force vs (Penetration Depth)²



Applied Force vs penetration depth

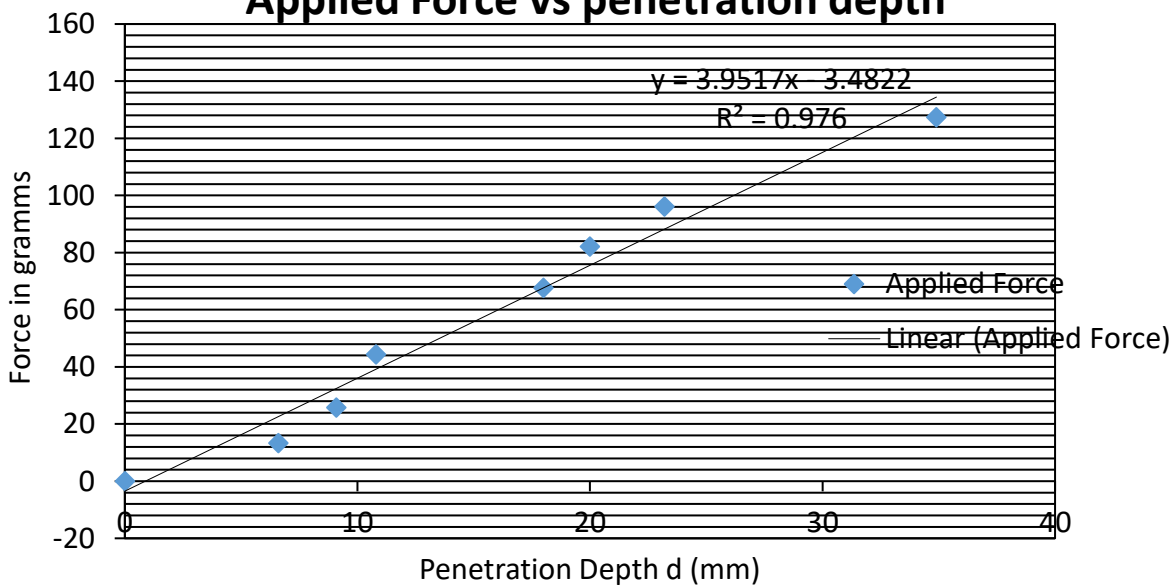


Table of results for soil sample C8 at moisture content 17.4%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
38.6	316.85	0	0.0	0
45.2	533.69	6.6	43.6	216.84
47.7	831.54	9.1	82.8	514.69
49.4	999.49	10.8	116.6	682.64
56.6	1247.87	18	324.0	931.02
58.5	1715.45	19.9	396.0	1398.6
61.8	2067.29	23.2	538.2	1750.44
75.5	2613.84	36.9	1361.6	2296.99

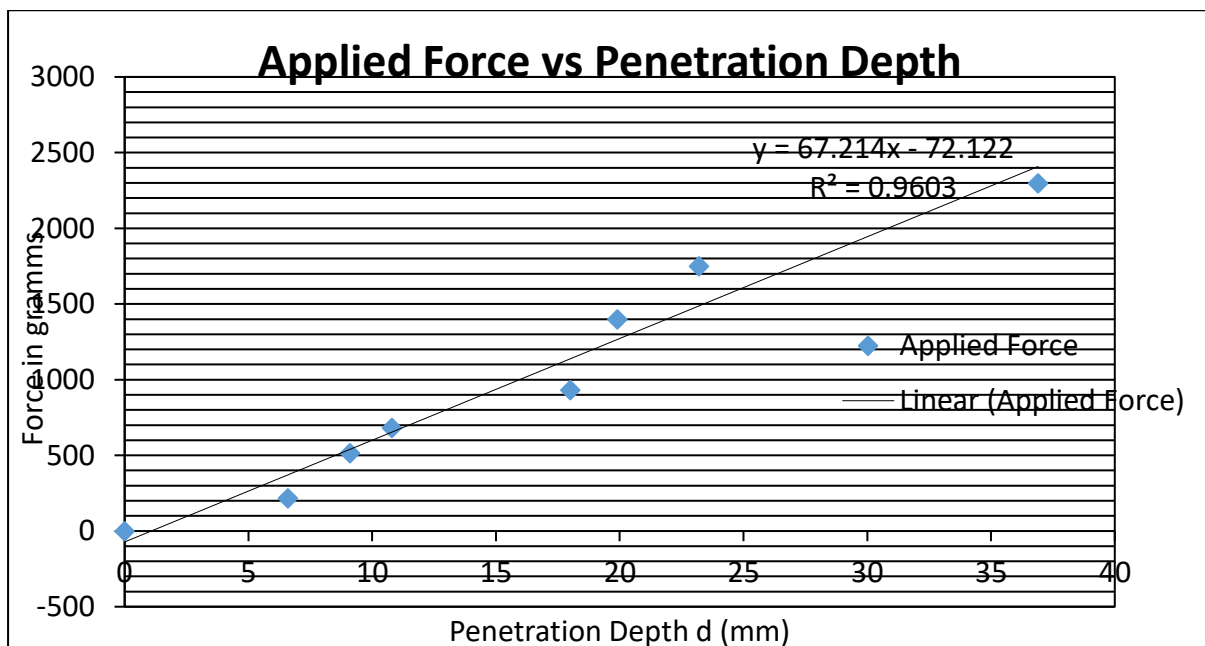
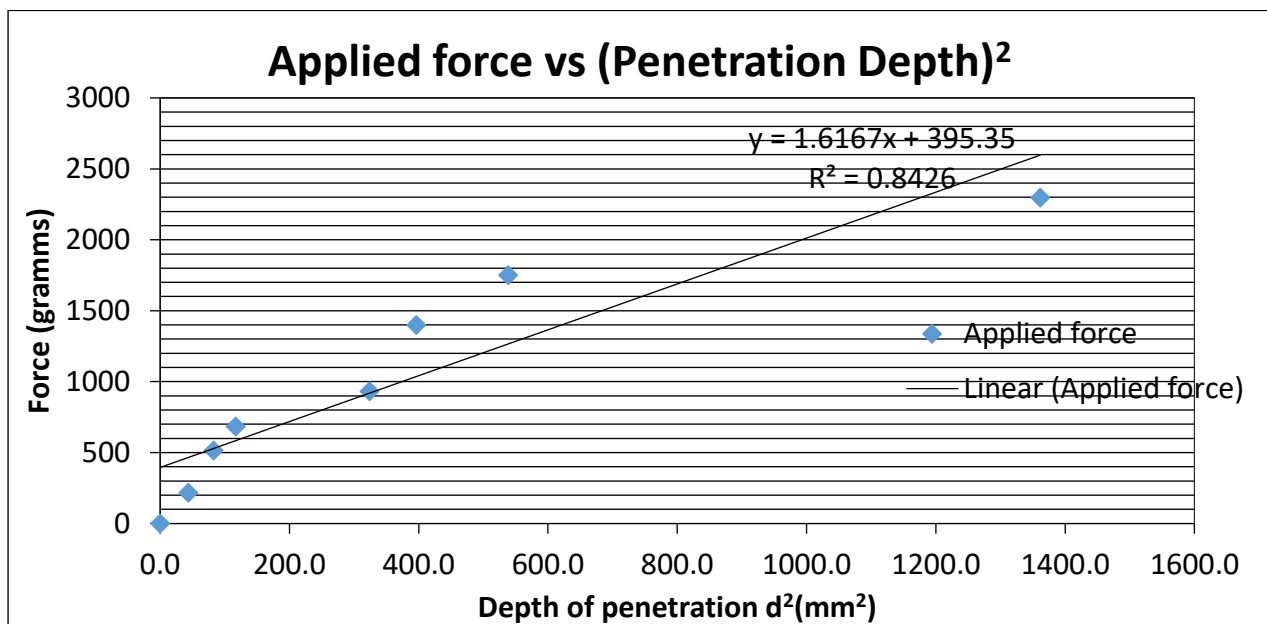


Table of results for soil sample c8 at moisture content 33%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
38.6	259.58	0	0.0	0
45.2	288.67	6.6	43.6	29.09
47.7	295.36	9.1	82.8	35.78
49.4	316.93	10.8	116.6	57.35
54.6	323.4	16	256.0	63.82
58.8	340.46	20.2	408.0	80.88
63.8	357.67	25.2	635.0	98.09
76.5	375.84	37.9	1436.4	116.26

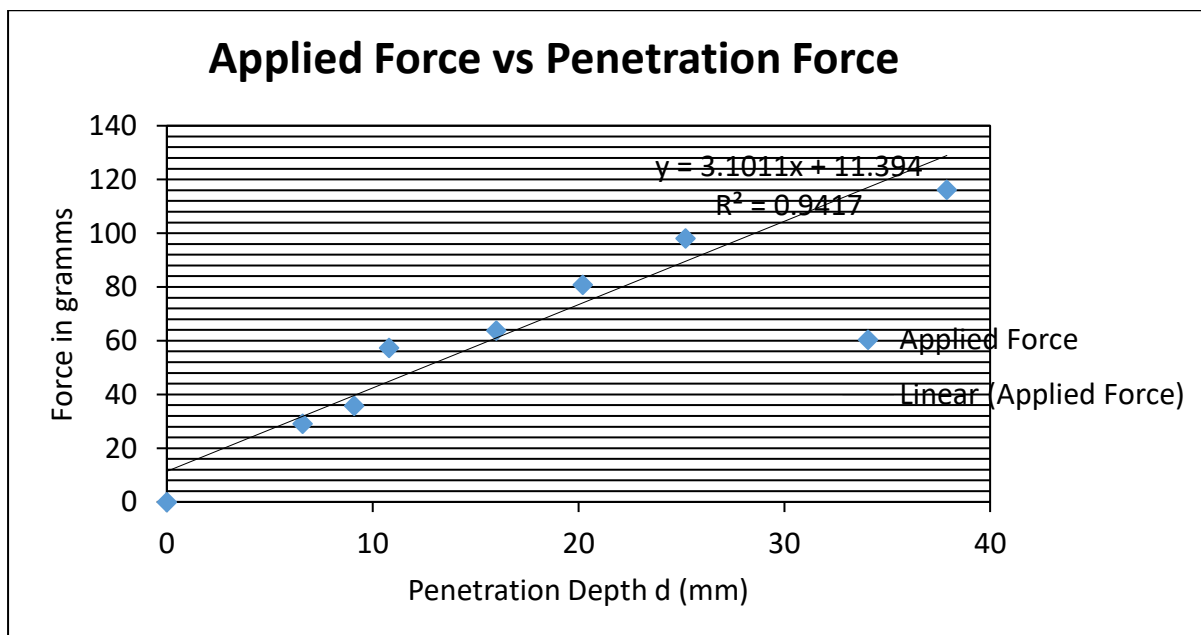
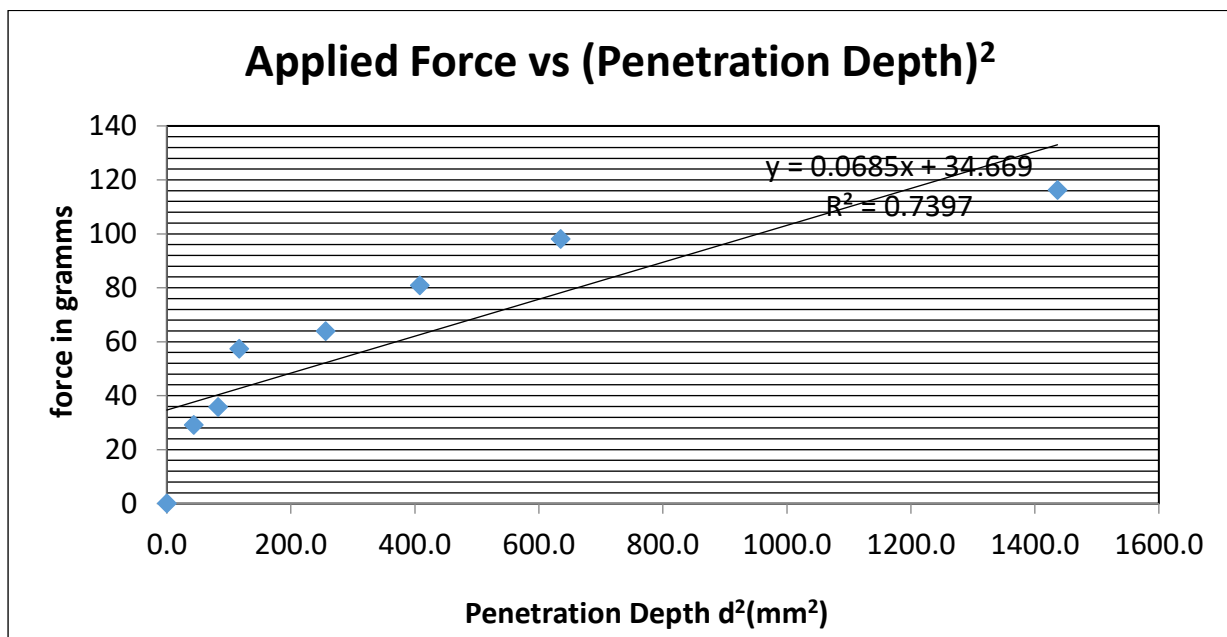


Table of results for soil sample K9 at moisture content 23.3%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
43	216.85	0	0.0	0
50.9	733.69	7.9	62.4	516.84
55.5	831.54	12.5	156.3	614.69
60.8	1099.49	17.8	316.8	882.64
67.4	1247.87	24.4	595.4	1031.02
71.6	1715.45	28.6	818.0	1498.6
72.3	2567.29	29.3	858.5	2350.44
79	3613.84	36	1296.0	3396.99

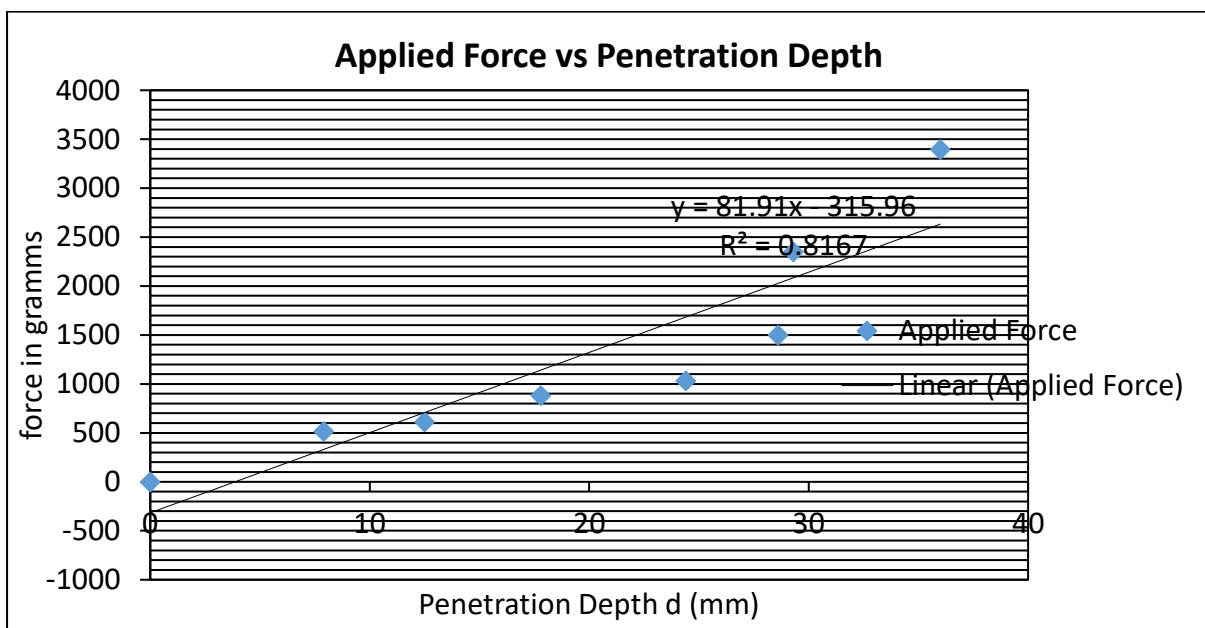
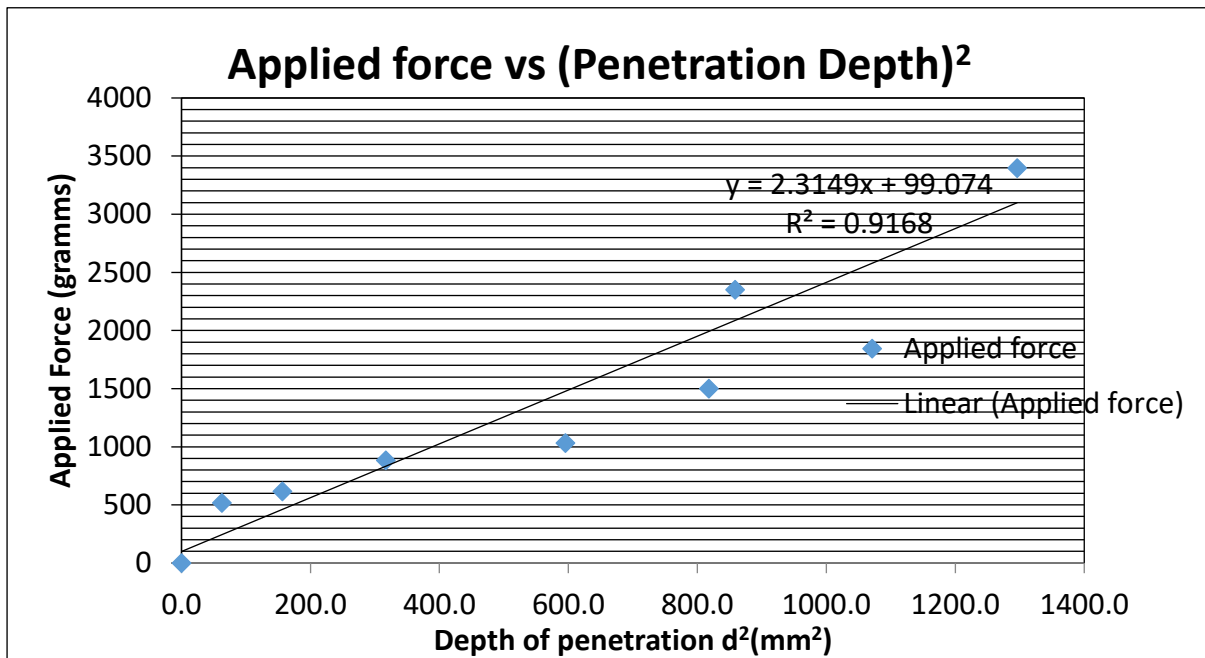


Table of results for soil sample K9 at moisture content 45.2%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
47.9	239.61	0	0.0	0
53.4	259.37	5.5	30.3	19.76
59.9	271.77	12	144.0	32.16
62.8	290.36	14.9	222.0	50.75
65.4	313.62	17.5	306.3	74.01
72	328.08	24.1	580.8	88.47
75	342.12	27.1	734.4	102.51
84.2	373.37	36.3	1317.7	133.76

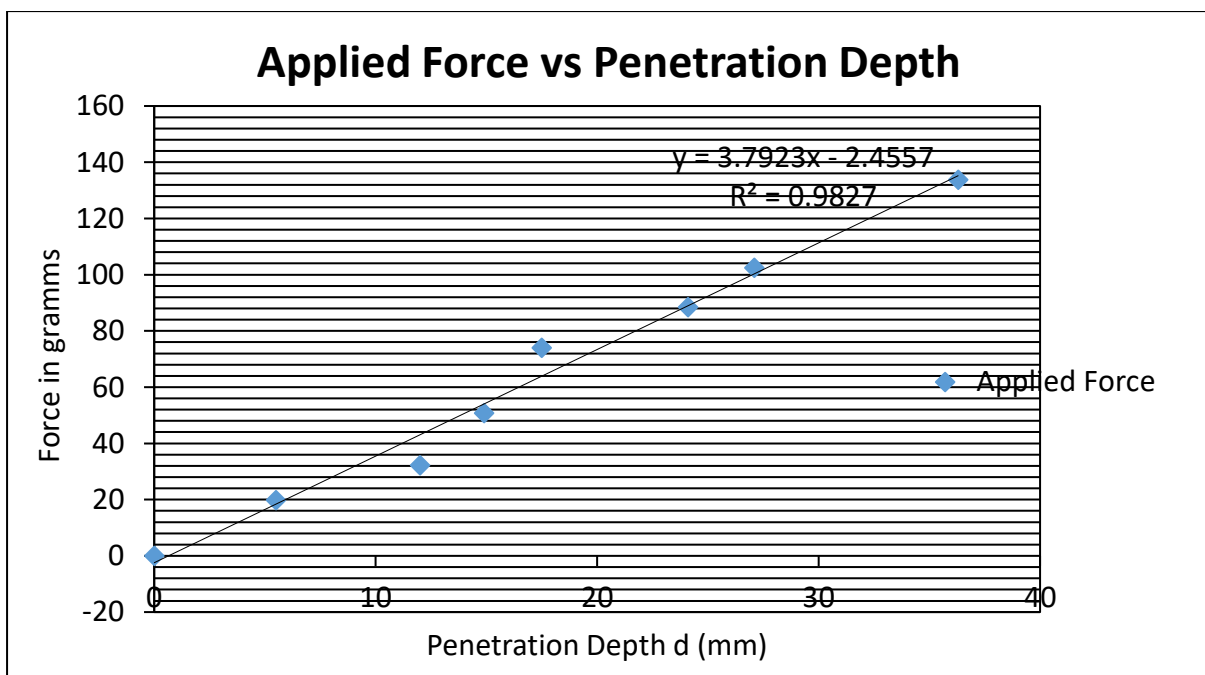
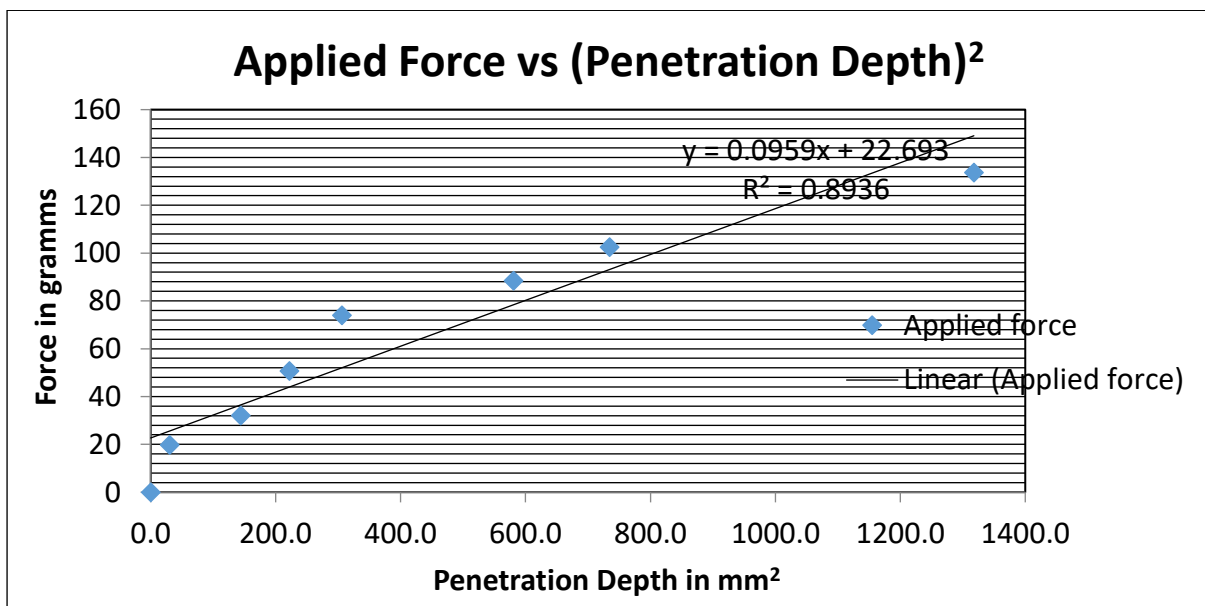


Table of results for soil sample N1 at moisture content 20.3%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
43.5	226.51	0	0.0	0
51.4	678.03	7.9	62.4	451.52
56	880.5	12.5	156.3	653.99
61.3	1174.33	17.8	316.8	947.82
67.9	1685.26	24.4	595.4	1458.75
72.1	2031.23	28.6	818.0	1804.72
75.2	2496.74	31.7	1004.9	2270.23
79.5	2929.9	36	1296.0	2703.39

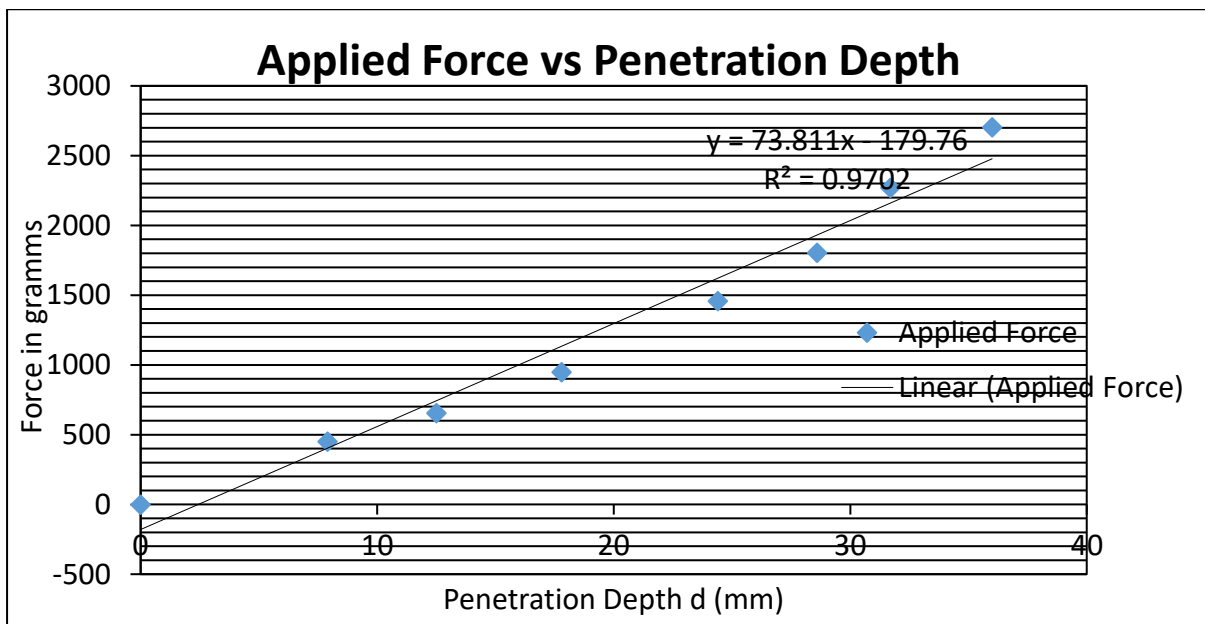
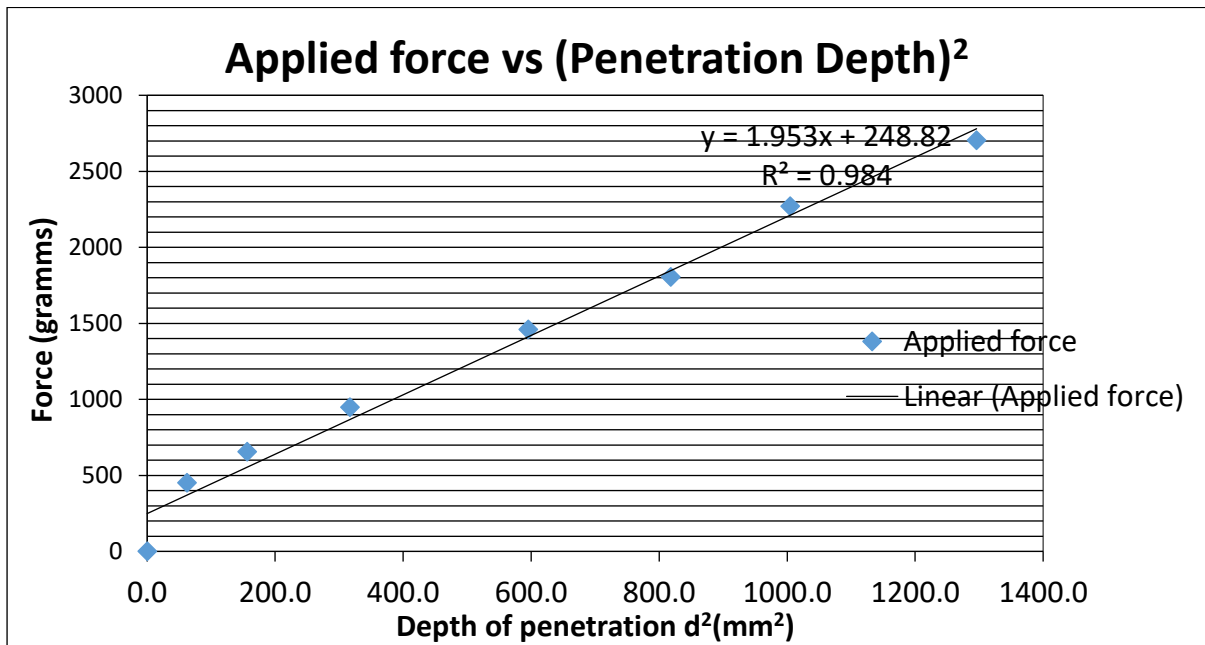


Table of results for soil sample N1 at moisture content 41.2%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
47.9	253.28	0	0.0	0
53.9	288.67	6	36.0	35.39
59.9	295.36	12	144.0	42.08
63.8	316.93	15.9	252.8	63.65
65.9	323.4	18	324.0	70.12
72.5	340.46	24.6	605.2	87.18
75.5	357.67	27.6	761.8	104.39
84.6	385.84	36.7	1346.9	132.56

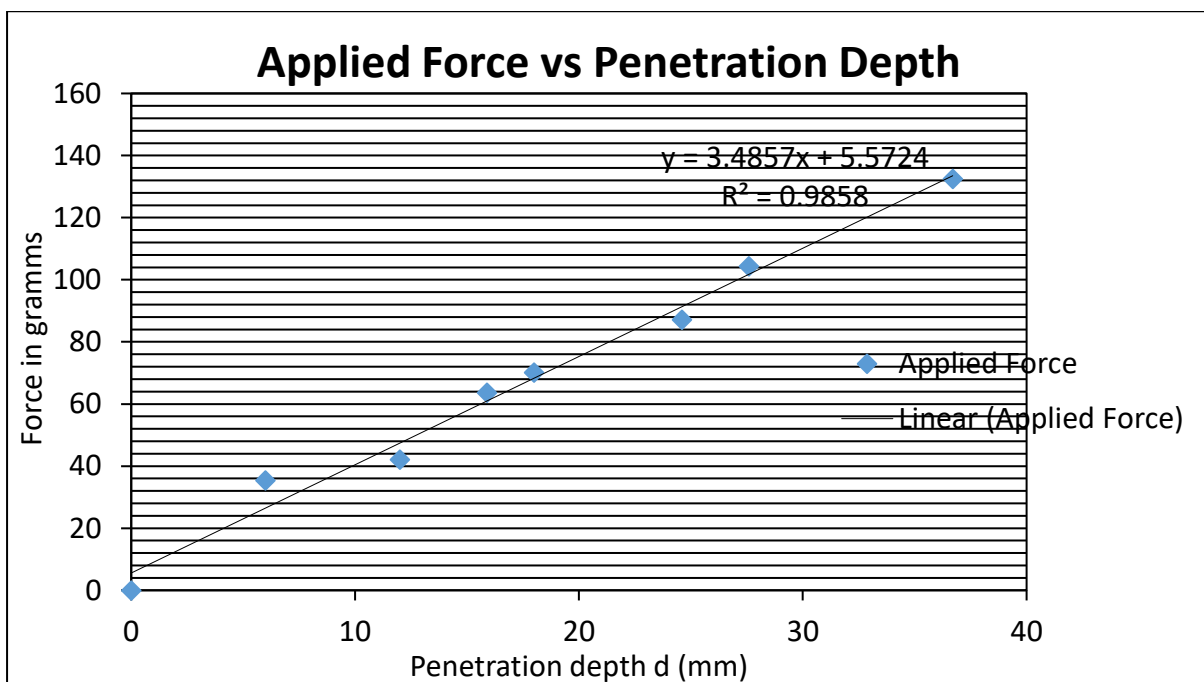
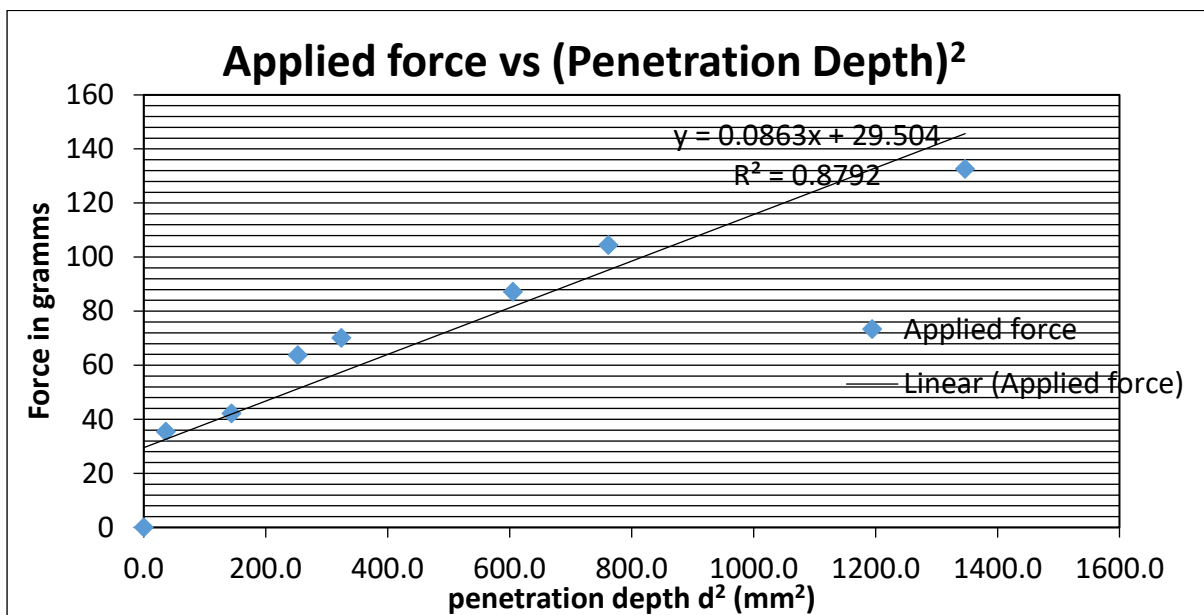


Table of results for soil sample N2 at moisture content 21.5%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42.5	216.85	0	0.0	0
52.4	733.69	9.9	98.0	516.84
56.5	831.54	14	196.0	614.69
61.5	1199.49	19	361.0	982.64
68.9	1811.87	26.4	697.0	1595.02
72.5	2115.45	30	900.0	1898.6
73.6	2367.29	31.1	967.2	2150.44
79.5	3613.84	37	1369.0	3396.99

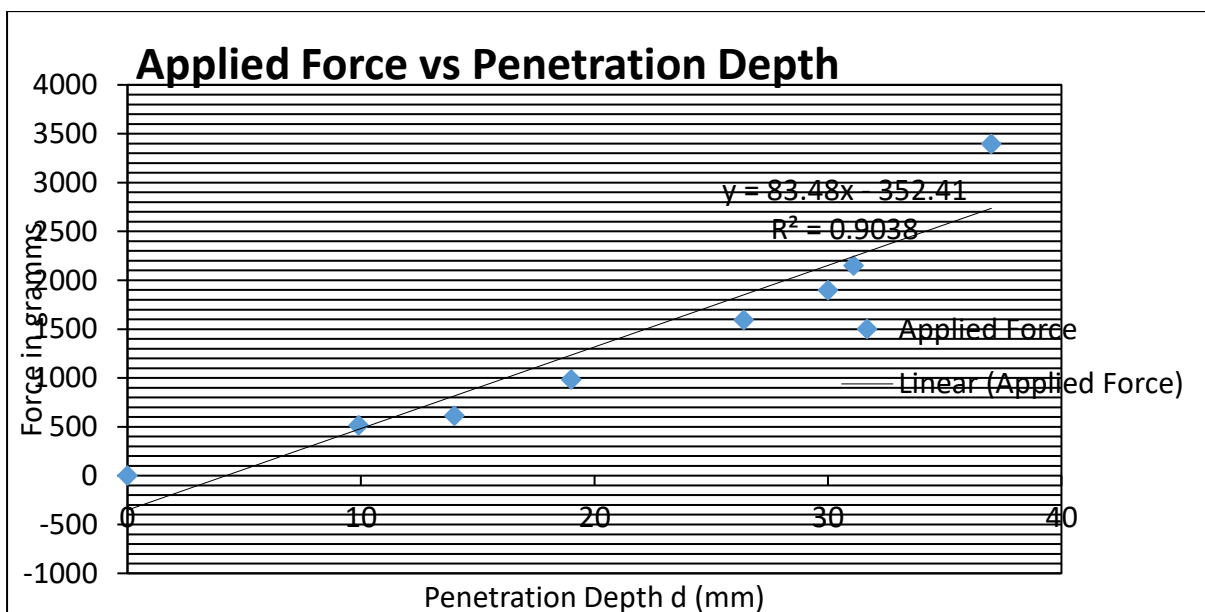
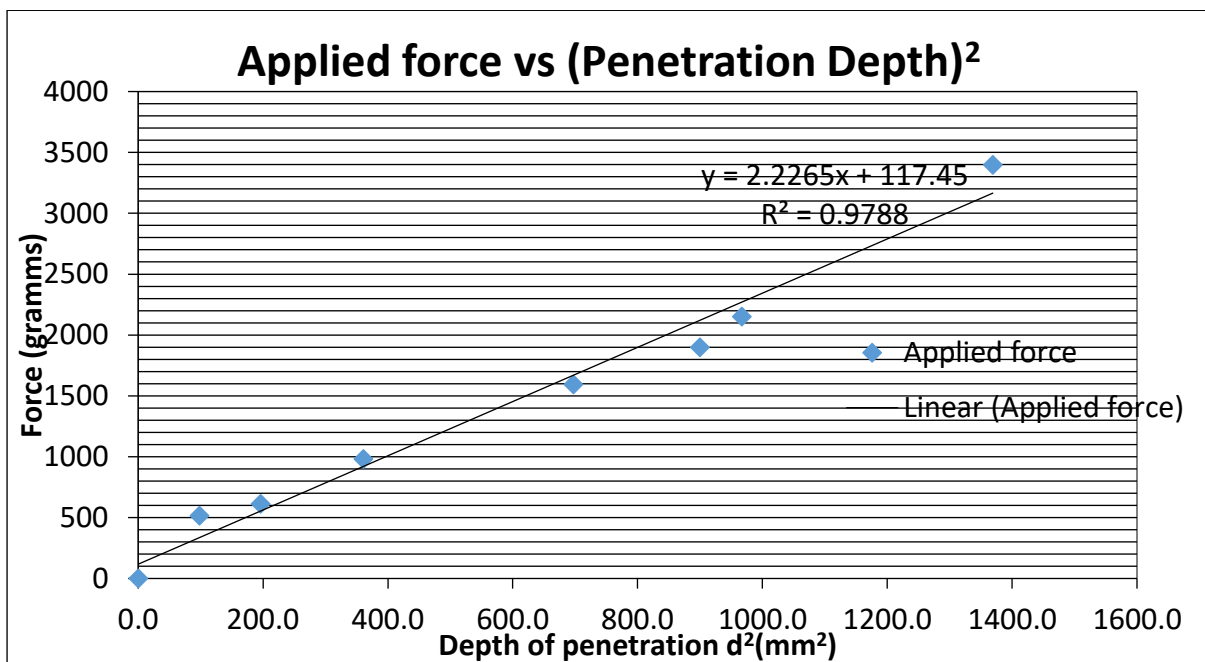


Table of results for soil sample N2 at moisture content 40.4%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
48.9	231.25	0	0.0	0
54.9	248.45	6	36.0	17.2
59.9	254.34	11	121.0	23.09
64.8	278.37	15.9	252.8	47.12
66.9	298.01	18	324.0	66.76
73.5	319.23	24.6	605.2	87.98
76.5	366.15	27.6	761.8	134.9
85.6	387.9	36.7	1346.9	156.65

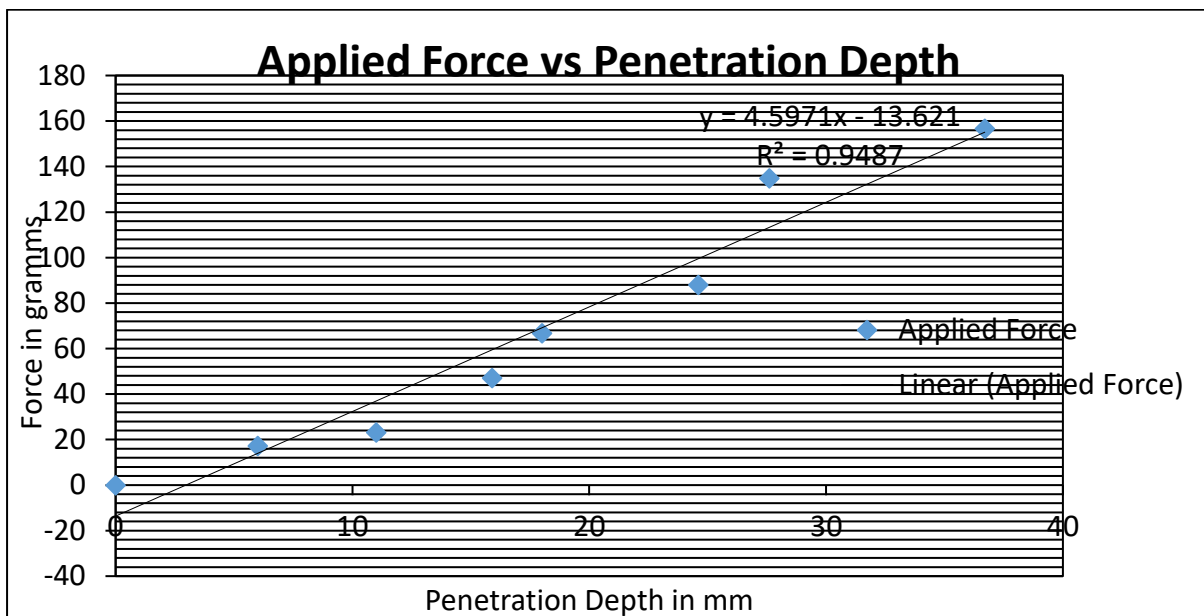
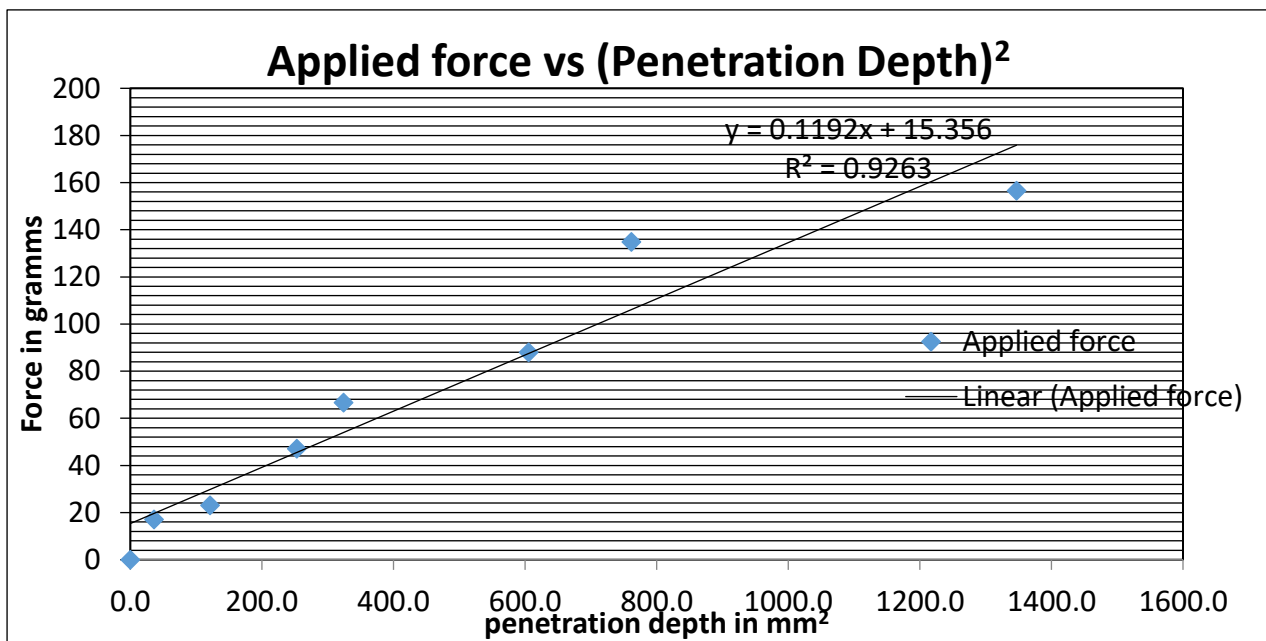


Table of results for soil sample N3 at moisture content 20.8%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
43.5	216.85	0	0.0	0
52.9	733.69	9.4	88.4	516.84
56.9	831.54	13.4	179.6	614.69
61.9	1099.49	18.4	338.6	882.64
69.9	1547.87	26.4	697.0	1331.02
73.5	1915.45	30	900.0	1698.6
74.5	2703.29	31	961.0	2486.44
78.4	3813.84	34.9	1218.0	3596.99

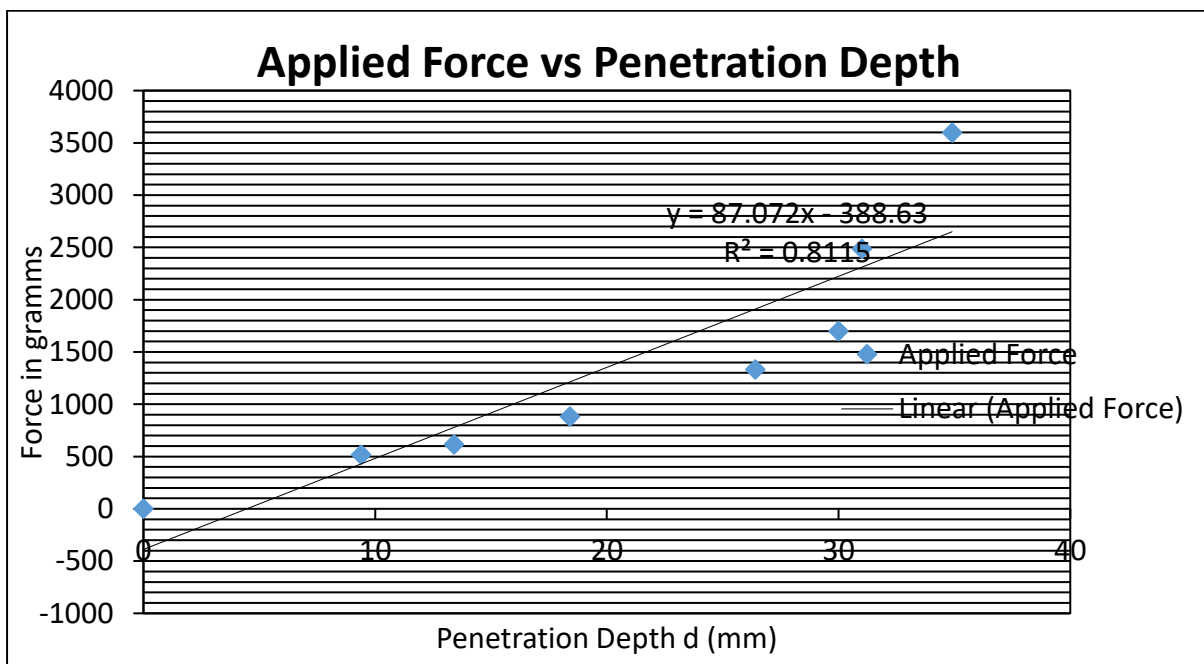
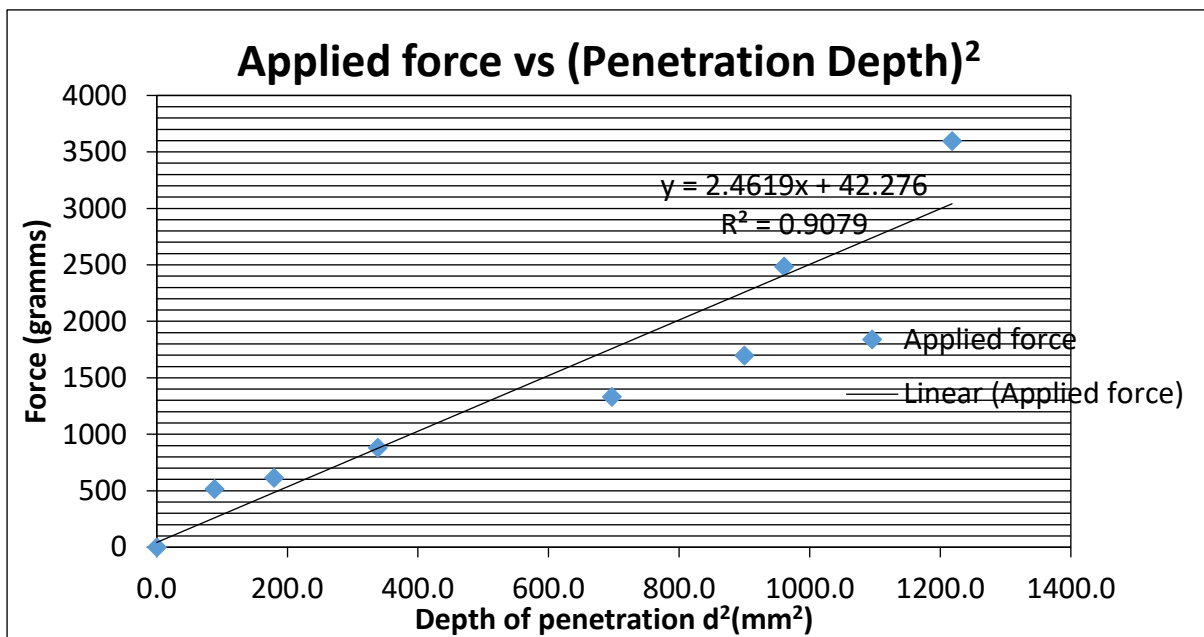


Table of results for soil sample N3 at moisture content 38.5%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
47.9	259.58	0	0.0	0
53.9	288.67	6	36.0	29.09
58.9	295.36	11	121.0	35.78
63.8	316.93	15.9	252.8	57.35
65.9	328.4	18	324.0	68.82
72.5	350.46	24.6	605.2	90.88
75.5	377.67	27.6	761.8	118.09
84.6	395.84	36.7	1346.9	136.26

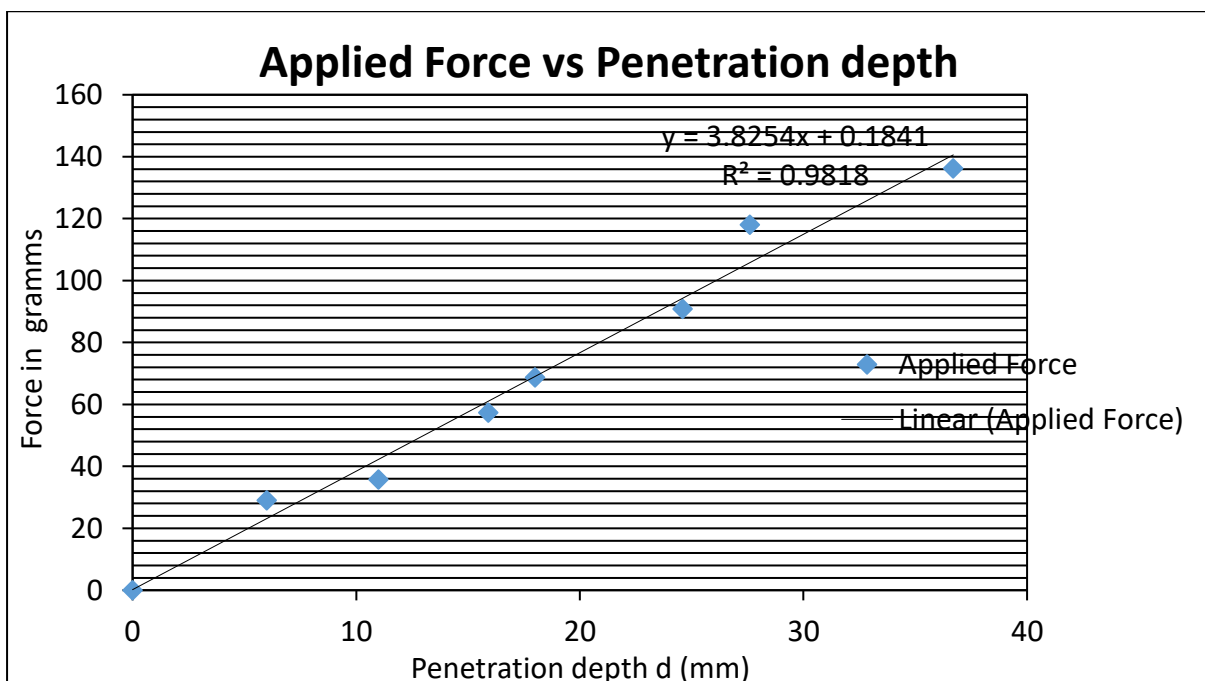
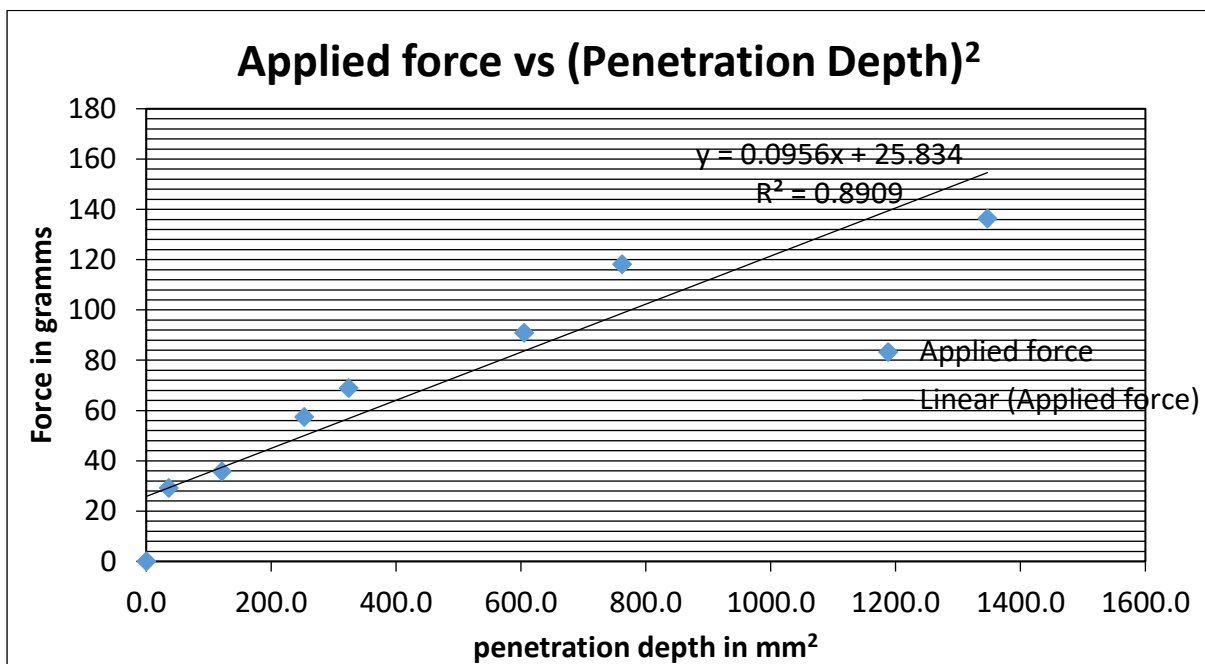


Table of results for soil sample k11 at moisture content 17.4%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
48.9	254.45	0	0.0	0
56.1	533.69	7.2	51.8	279.24
57.5	831.54	8.6	74.0	577.09
62.3	1099.49	13.4	179.6	845.04
66	1247.87	17.1	292.4	993.42
71.7	1415.45	22.8	519.8	1161
75.8	1735.29	26.9	723.6	1480.84
78.5	2151.44	29.6	876.2	1896.99

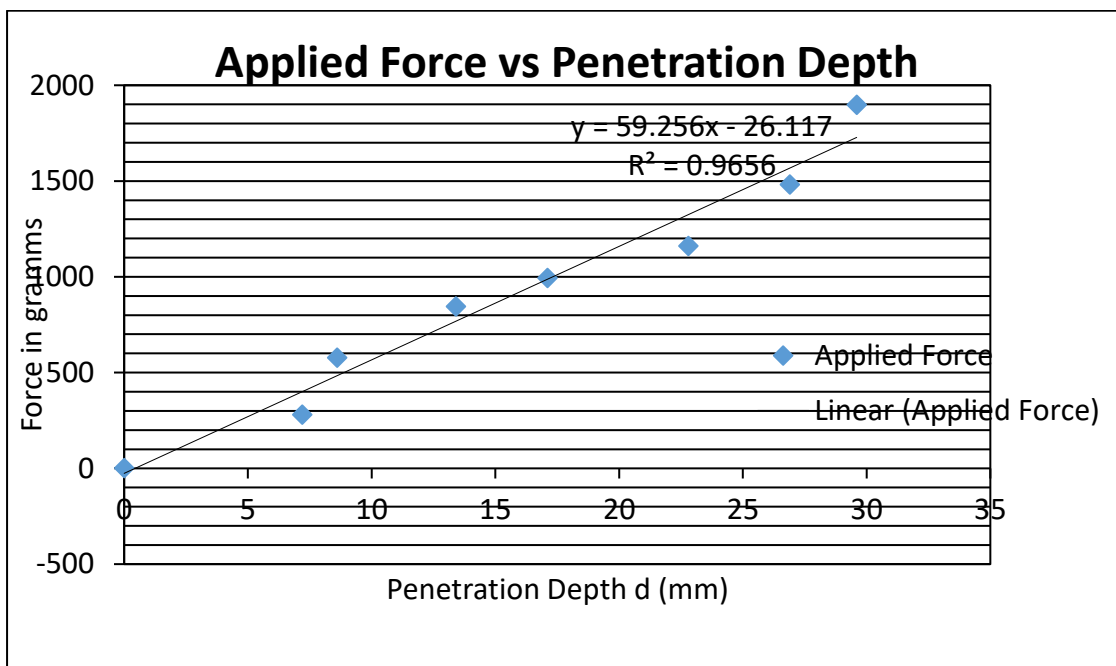
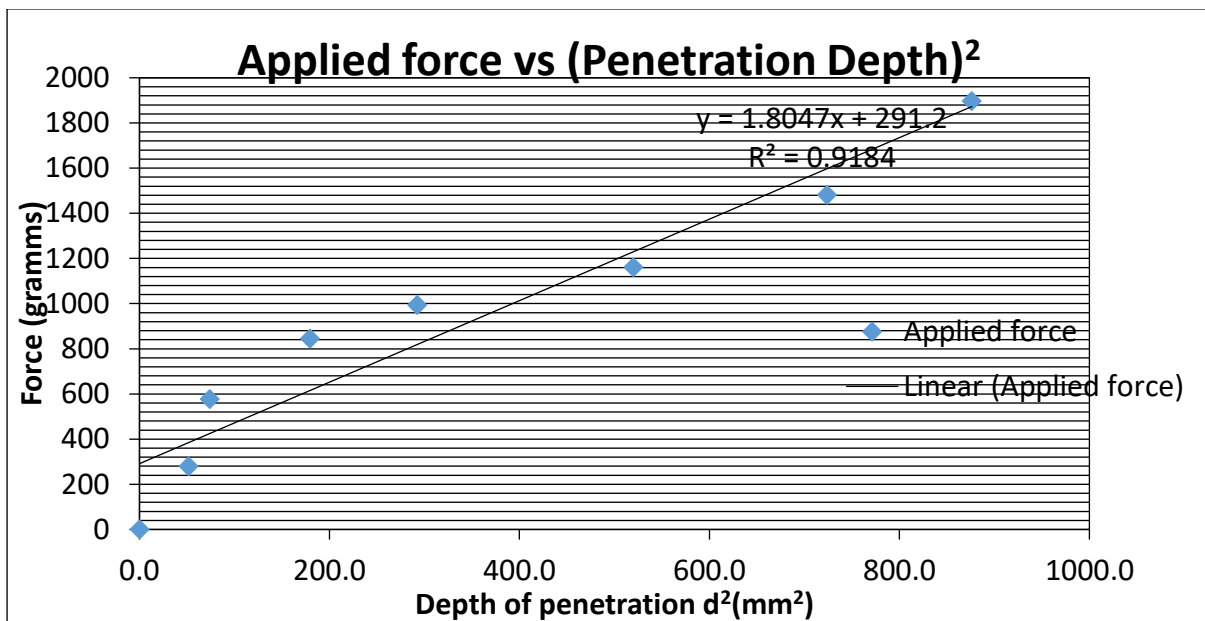


Table of results for soil sample k11 at moisture content 41.6%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
46.3	229.61	0	0.0	0
51.1	259.37	4.8	23.0	29.76
56.3	271.77	10	100.0	42.16
61.4	290.36	15.1	228.0	60.75
69.5	313.62	23.2	538.2	84.01
74.3	328.08	28	784.0	98.47
82.5	362.12	36.2	1310.4	132.51
85.2	393.37	38.9	1513.2	134

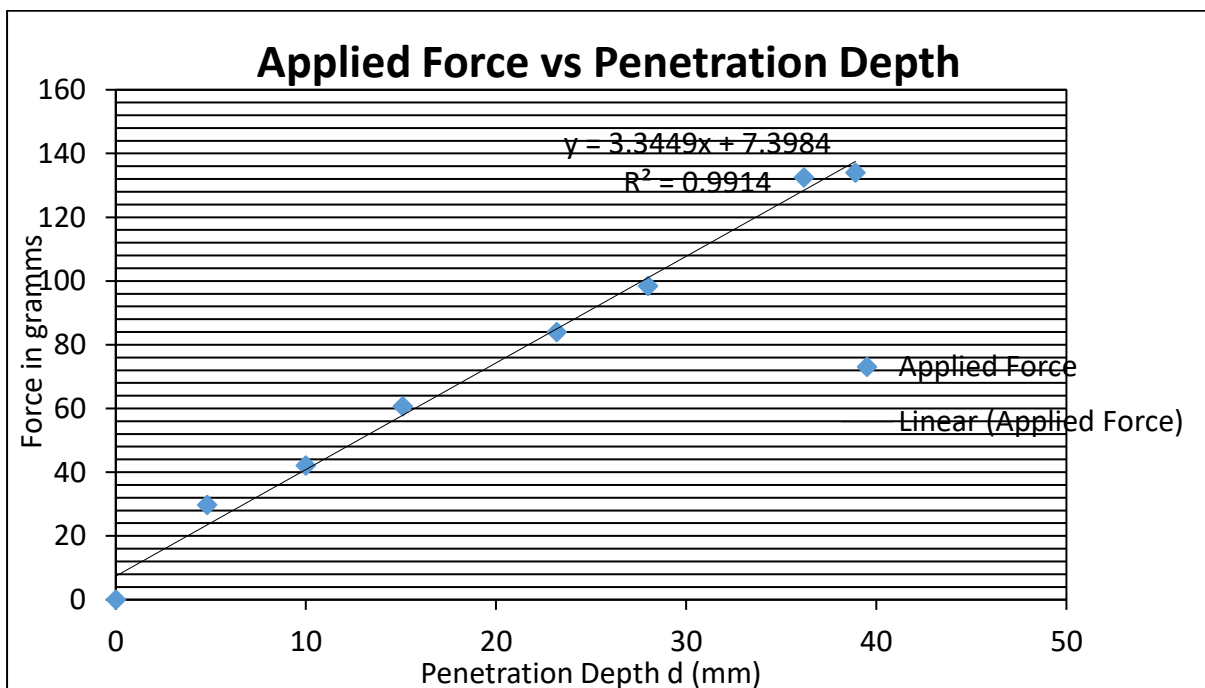
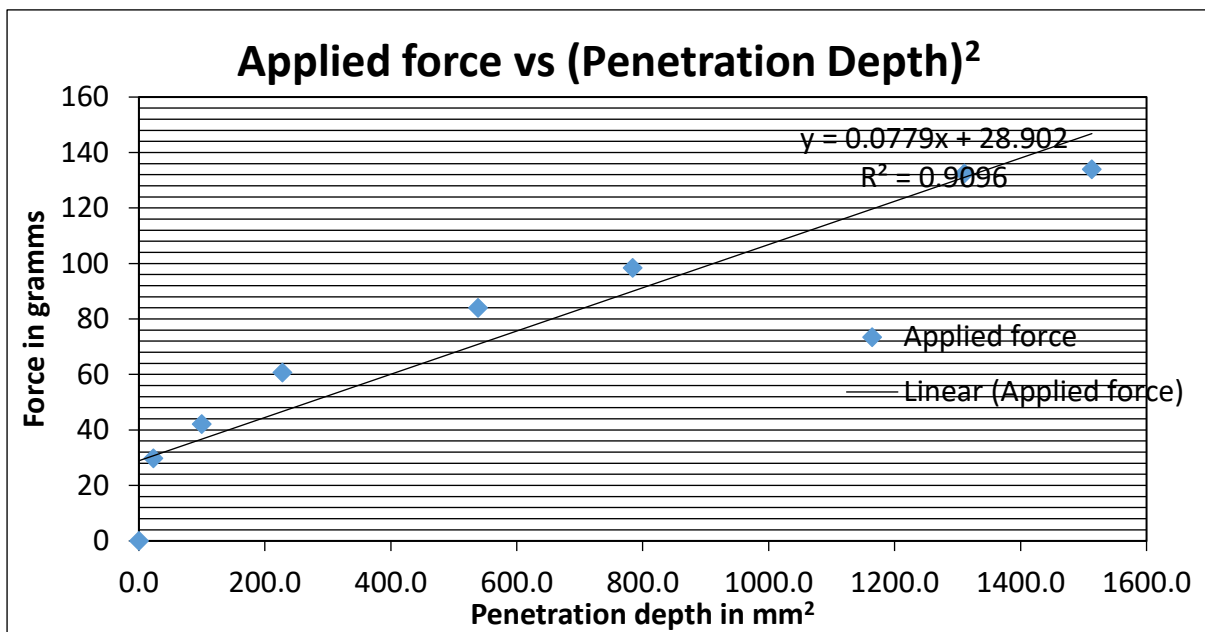


Table of results for soil sample k12 at moisture content 28%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
43.5	216.85	0	0.0	0
51.4	533.69	7.9	62.4	316.84
56	831.54	12.5	156.3	614.69
61.3	999.49	17.8	316.8	782.64
67.9	1247.87	24.4	595.4	1031.02
72.1	1915.45	28.6	818.0	1698.6
75.2	2410.79	31.7	1004.9	2193.94
79.5	3621.84	36	1296.0	3404.99

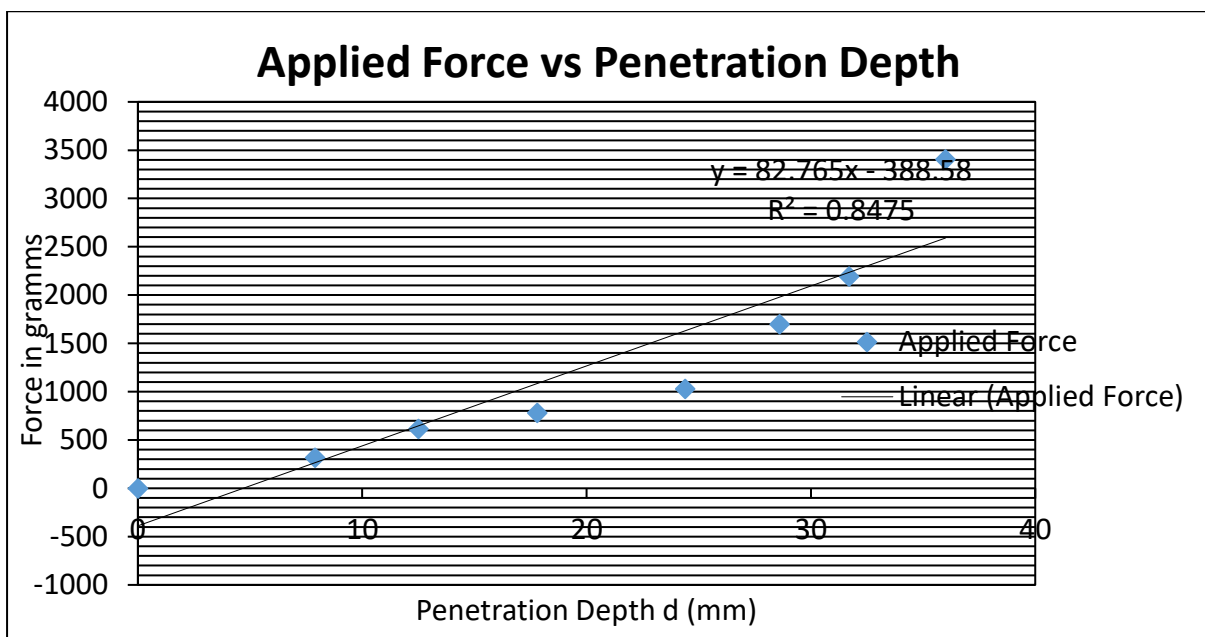
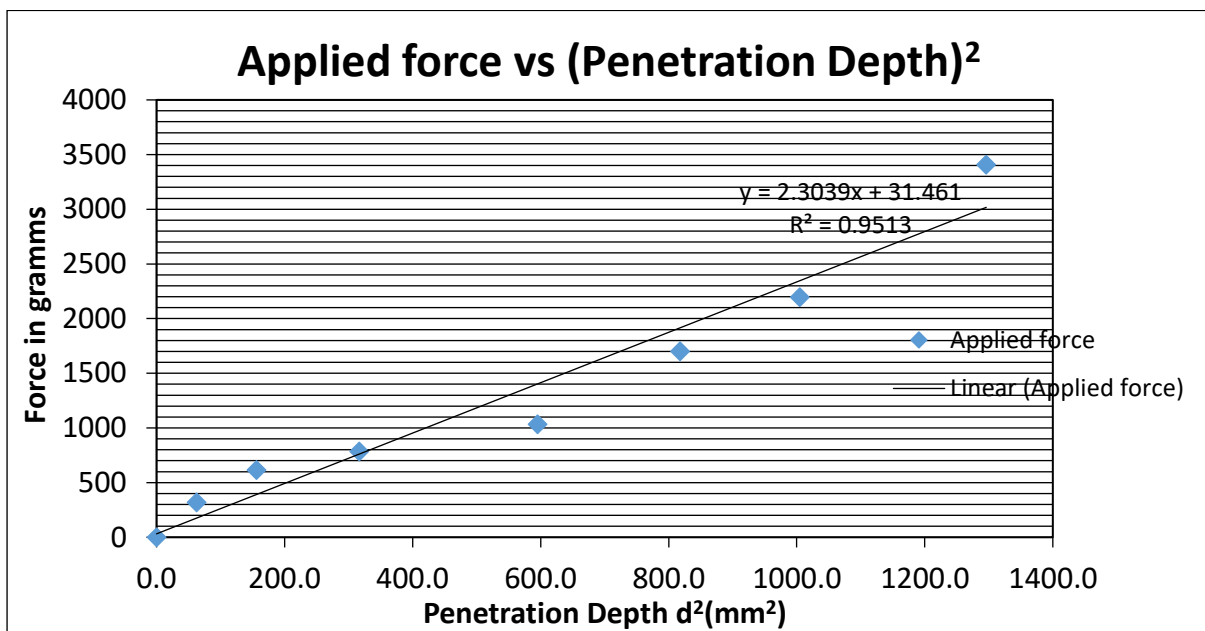


Table of results for soil sample K12 at moisture content 44%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
47.9	254.45	0	0.0	0
53.4	263.69	5.5	30.3	9.24
59.9	288.54	12	144.0	34.09
62.8	305.49	14.9	222.0	51.04
65.4	327.87	17.5	306.3	73.42
72	331.15	24.1	580.8	76.7
75	346.09	27.1	734.4	91.64
84.2	370.24	36.3	1317.7	115.79

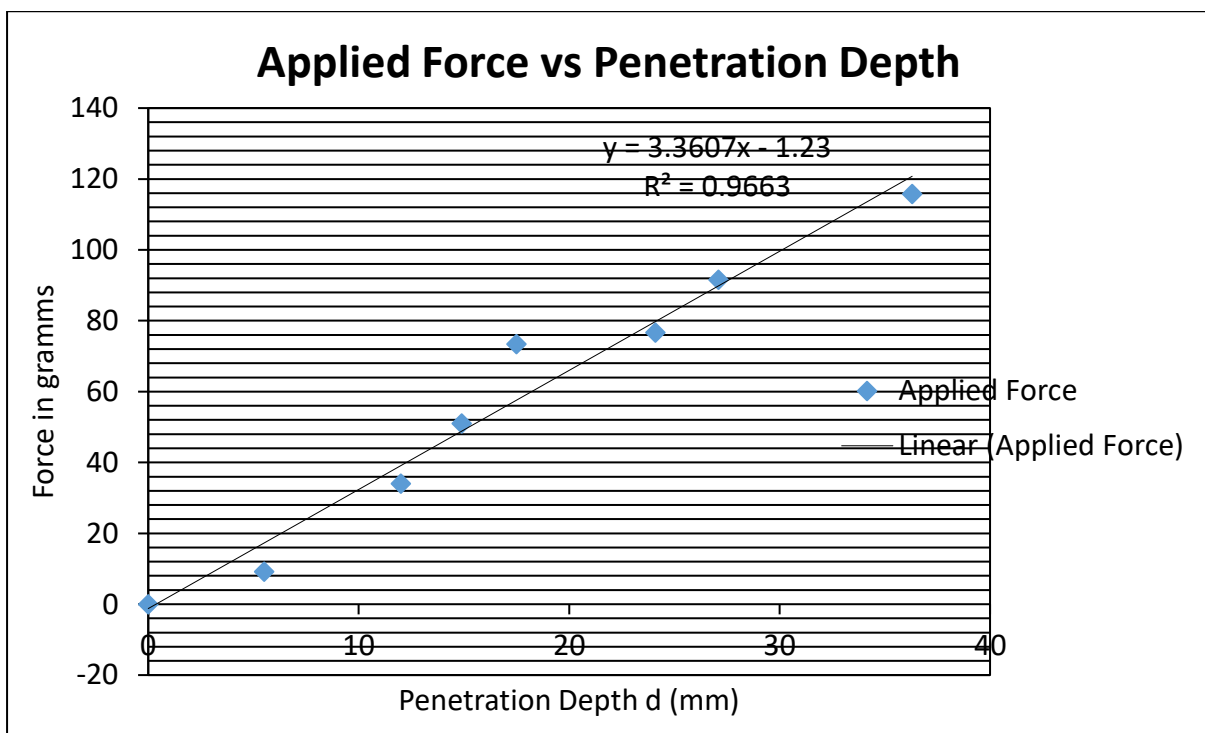
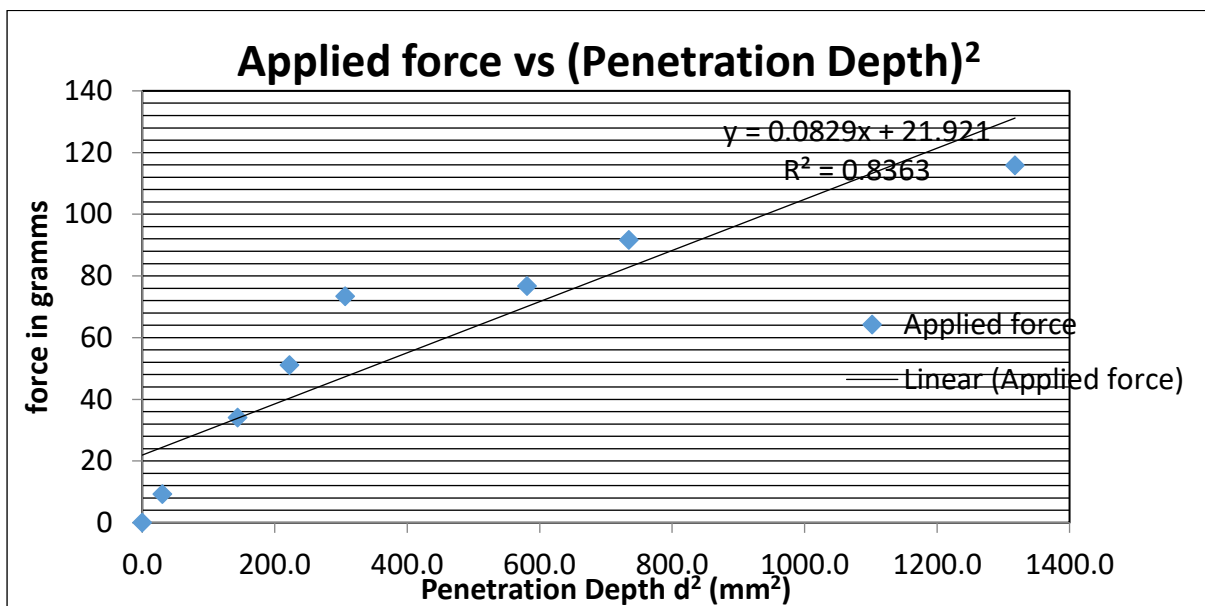


Table of results for soil sample MK 1 at moisture content 17.9

Reading (mm)	length	Reading (g)	Force	Depth of penetration(d) mm	d ²	Applied force
	45.8		216.85	0	0.0	0
	52.5		533.69	6.7	44.9	316.84
	54.2		831.54	8.4	70.6	614.69
	57.1		999.49	11.3	127.7	782.64
	69.3		1247.87	23.5	552.3	1031.02
	73.6		1815.45	27.8	772.8	1598.6
	80.4		2667.29	34.6	1197.2	2450.44
	82.5		3506.84	36.7	1346.9	3289.99

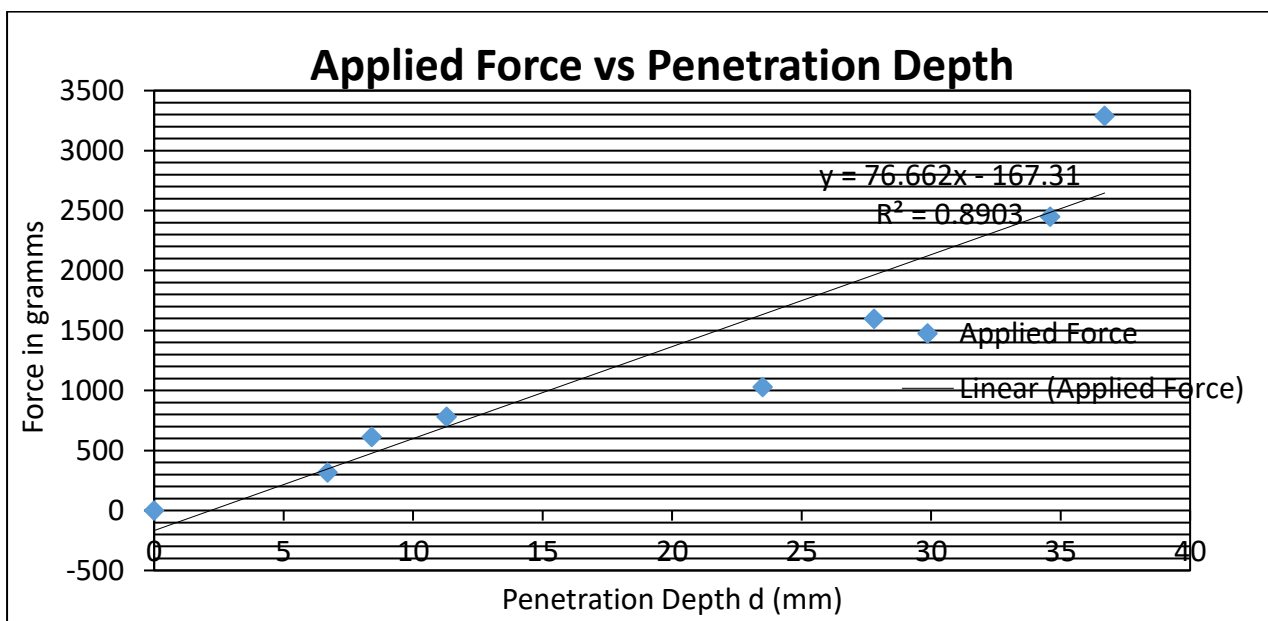
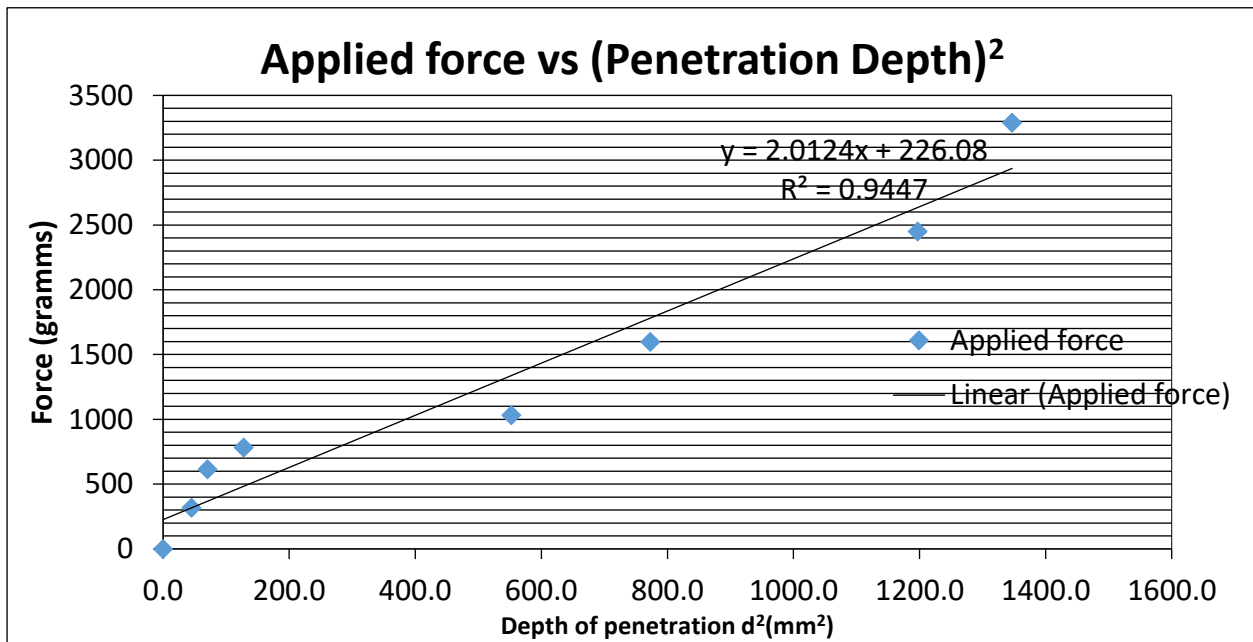


Table of results for soil sample MK1 at moisture content 30%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
44.1	263.28	0	0.0	0
48.4	288.67	4.3	18.5	25.39
49	295.36	4.9	24.0	32.08
53.9	316.93	9.8	96.0	53.65
56.8	323.4	12.7	161.3	60.12
61.4	340.46	17.3	299.3	77.18
69.8	357.67	25.7	660.5	94.39
79.4	379.64	35.3	1246.1	116.36

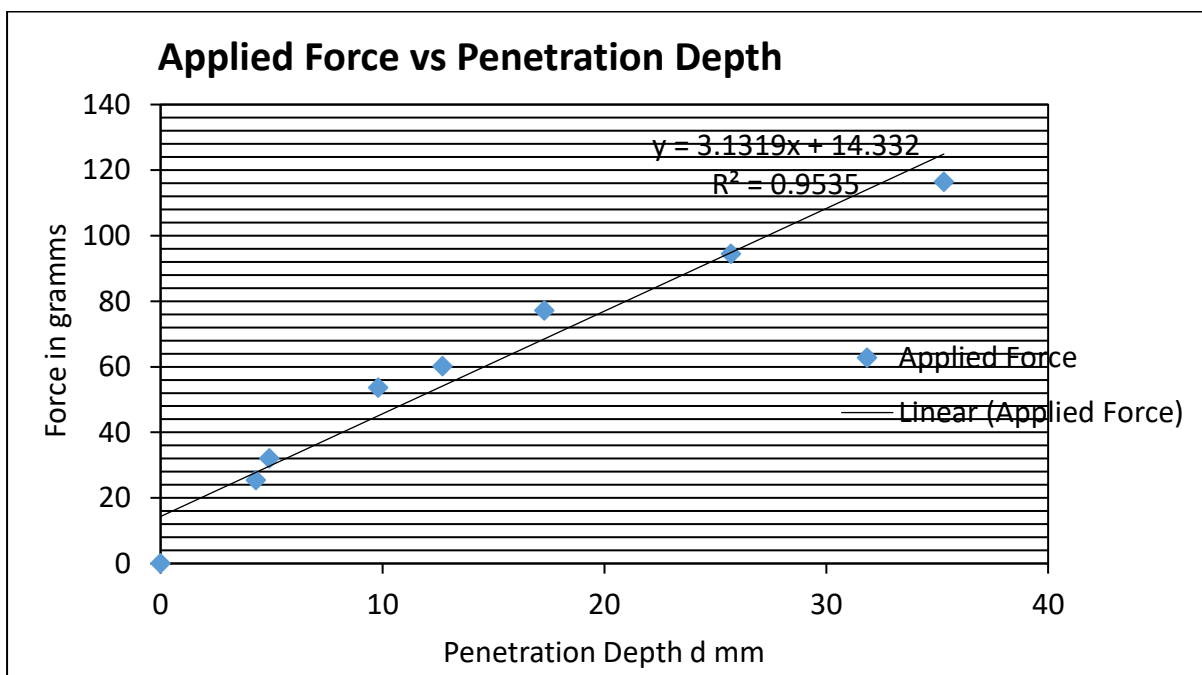
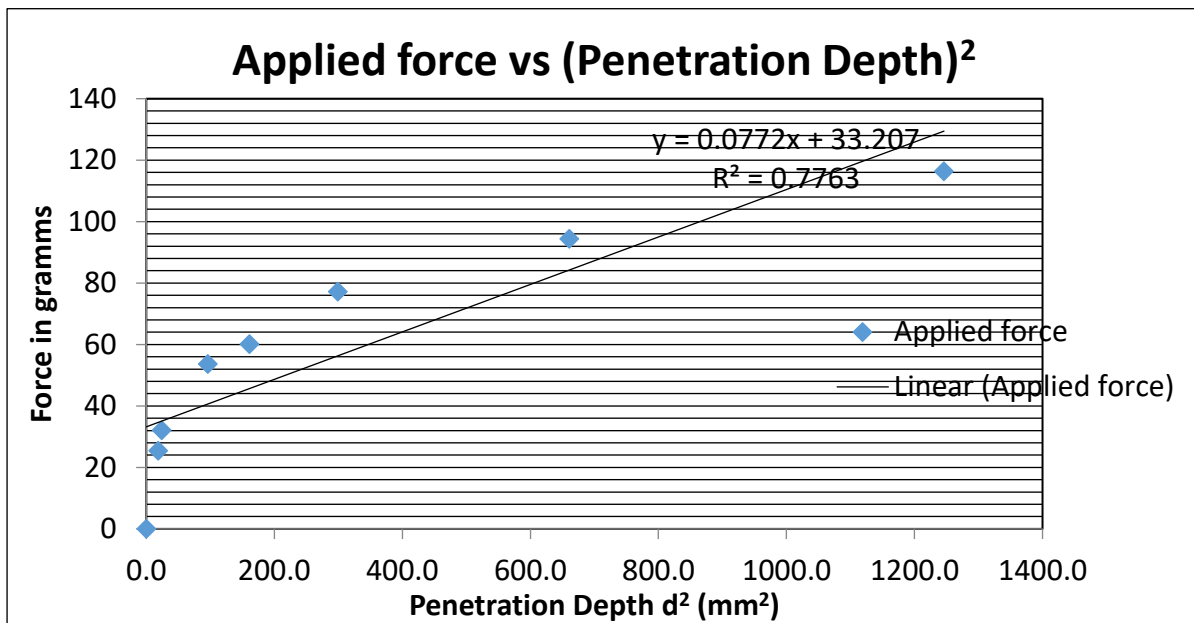


Table of results for soil sample MK 2 at moisture content 16.9

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
44.8	230.56	0	0.0	0
52.5	453.27	7.7	59.3	222.71
55.2	915.25	10.4	108.2	684.69
57.1	1311.4	12.3	151.3	1080.84
69.3	1614.35	24.5	600.3	1383.79
74.6	1951.26	29.8	888.0	1720.7
80.6	2739.71	35.8	1281.6	2509.15
82.5	3178.7	37.7	1421.3	2948.14

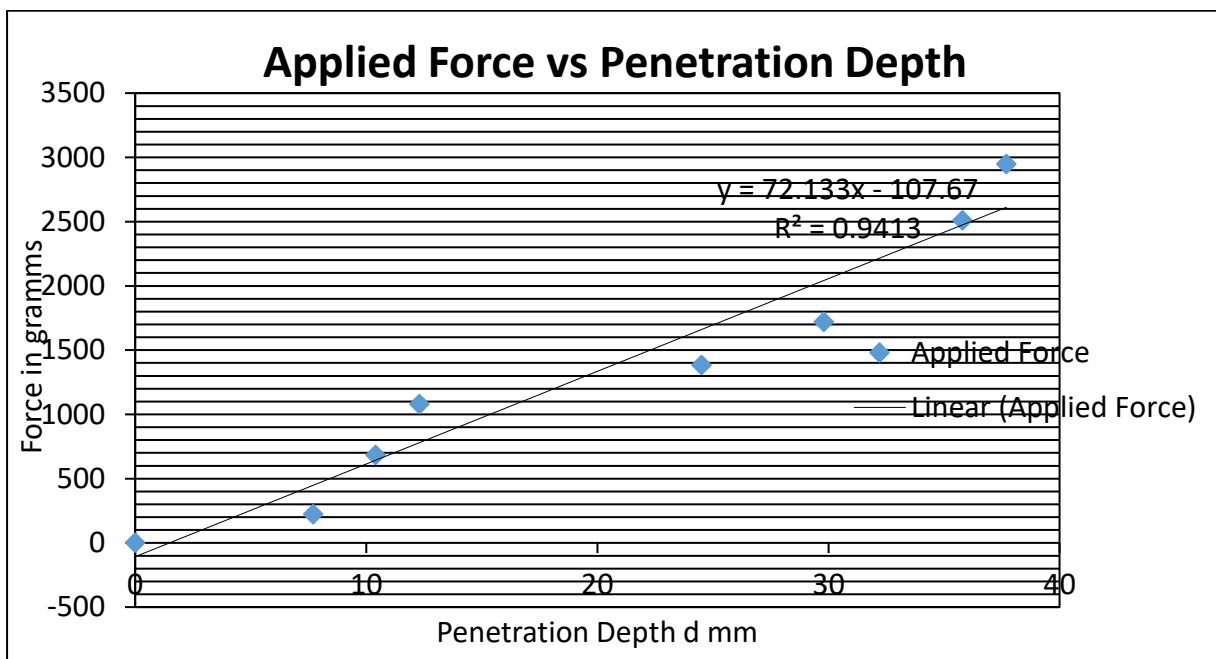
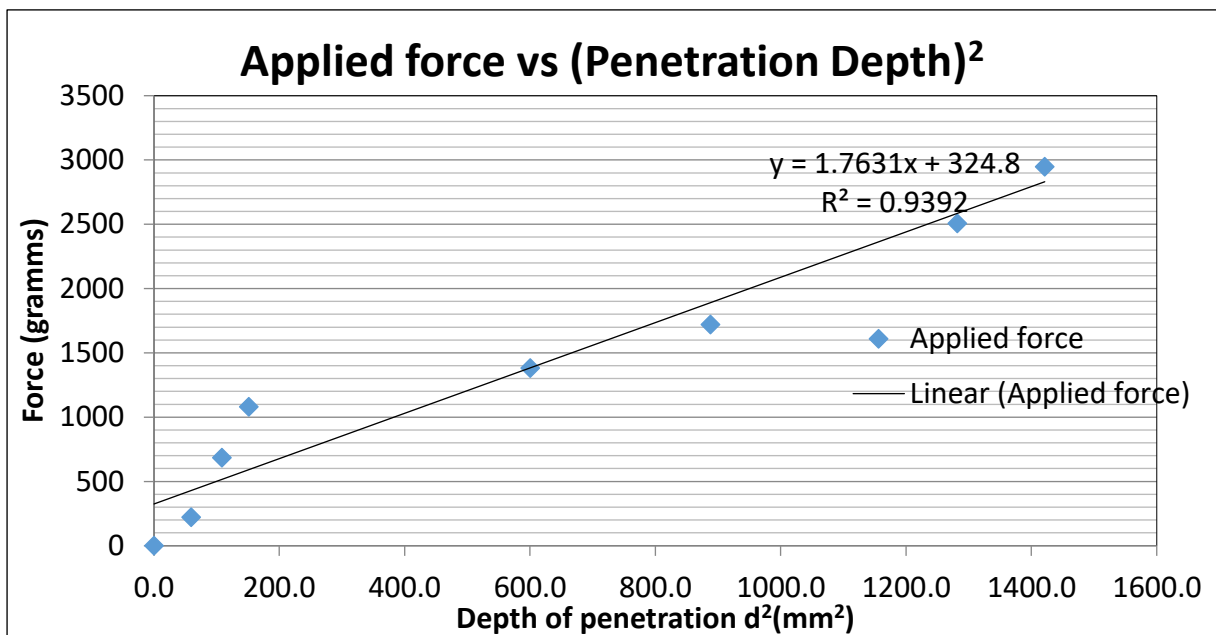


Table of results for soil sample MK2 at moisture content 28.5

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
44.2	247.81	0	0.0	0
48.5	259.37	4.3	18.5	11.56
49	271.77	4.8	23.0	23.96
53.9	290.36	9.7	94.1	42.55
56.8	313.62	12.6	158.8	65.81
61.4	328.08	17.2	295.8	80.27
69.8	352.12	25.6	655.4	104.31
79.4	373.37	35.2	1239.0	125.56

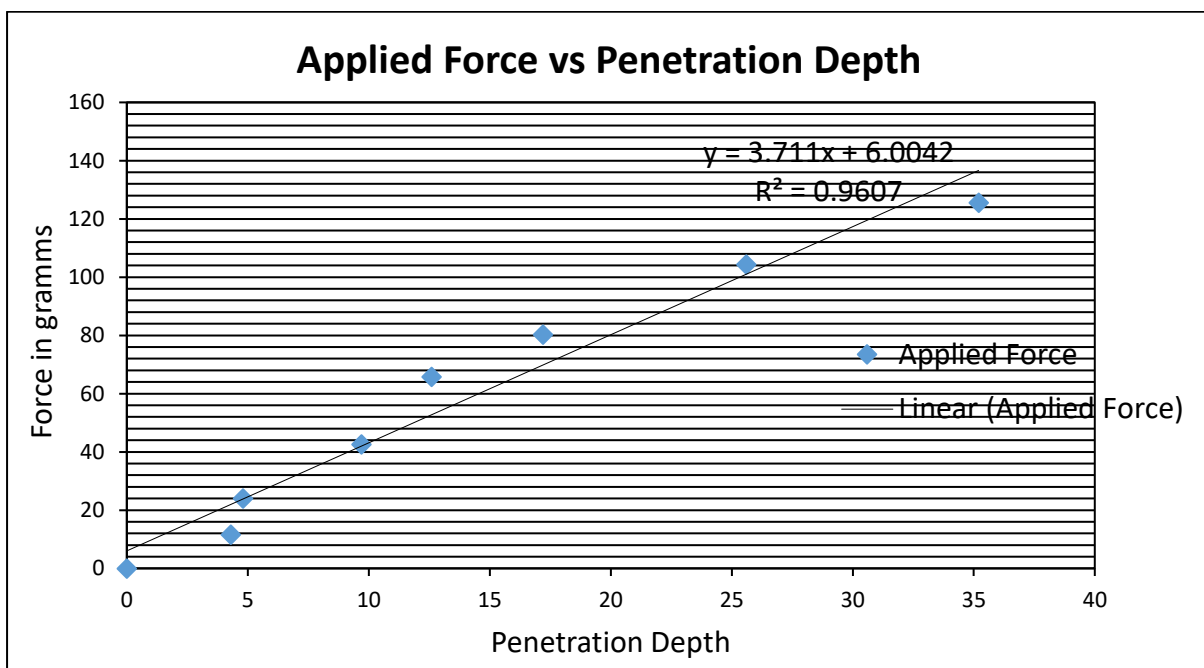
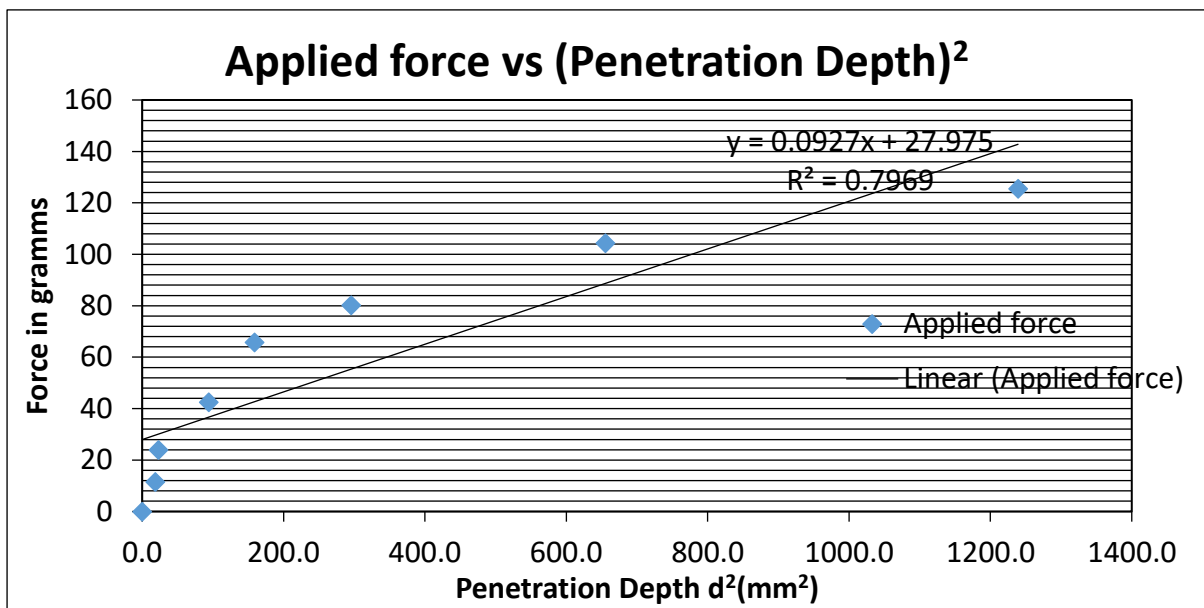


Table of results for soil sample MK 3 at moisture content 15.5

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.8	216.85	0	0.0	0
53.5	733.69	7.7	59.3	516.84
55.2	831.54	9.4	88.4	614.69
57.1	1099.49	11.3	127.7	882.64
69.3	1547.87	23.5	552.3	1331.02
74.6	1915.45	28.8	829.4	1698.6
80.4	2503.29	34.6	1197.2	2286.44
82.5	2724.84	36.7	1346.9	2507.99

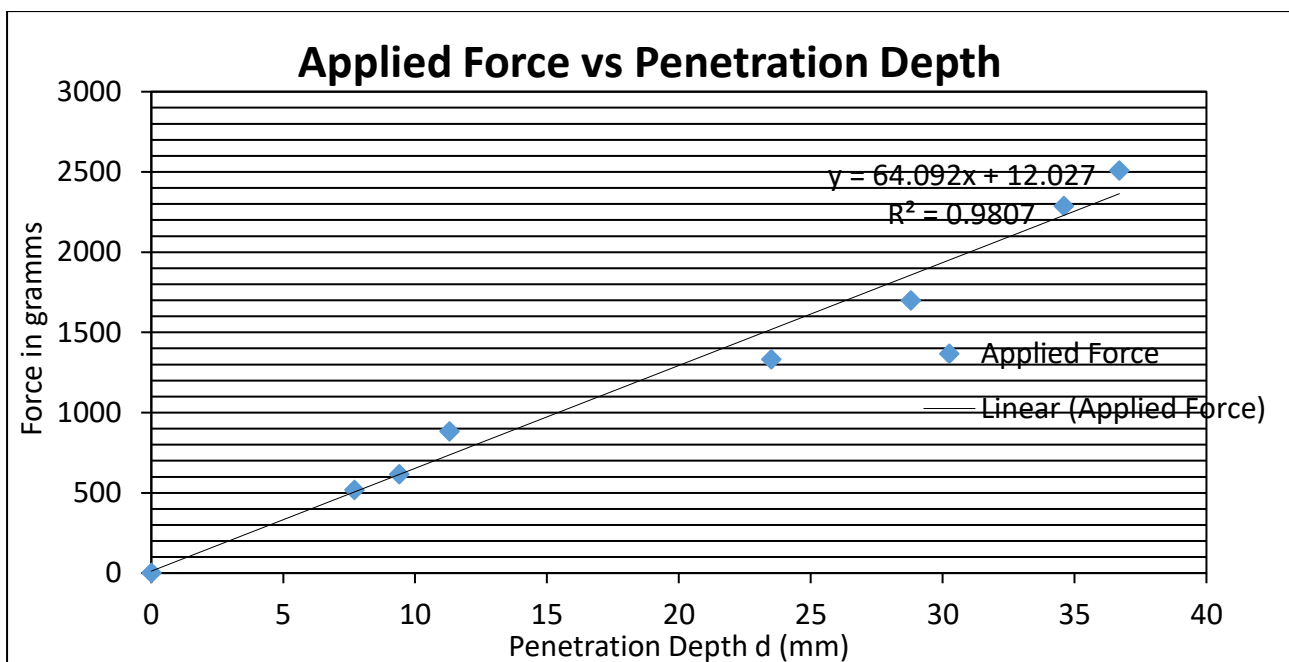
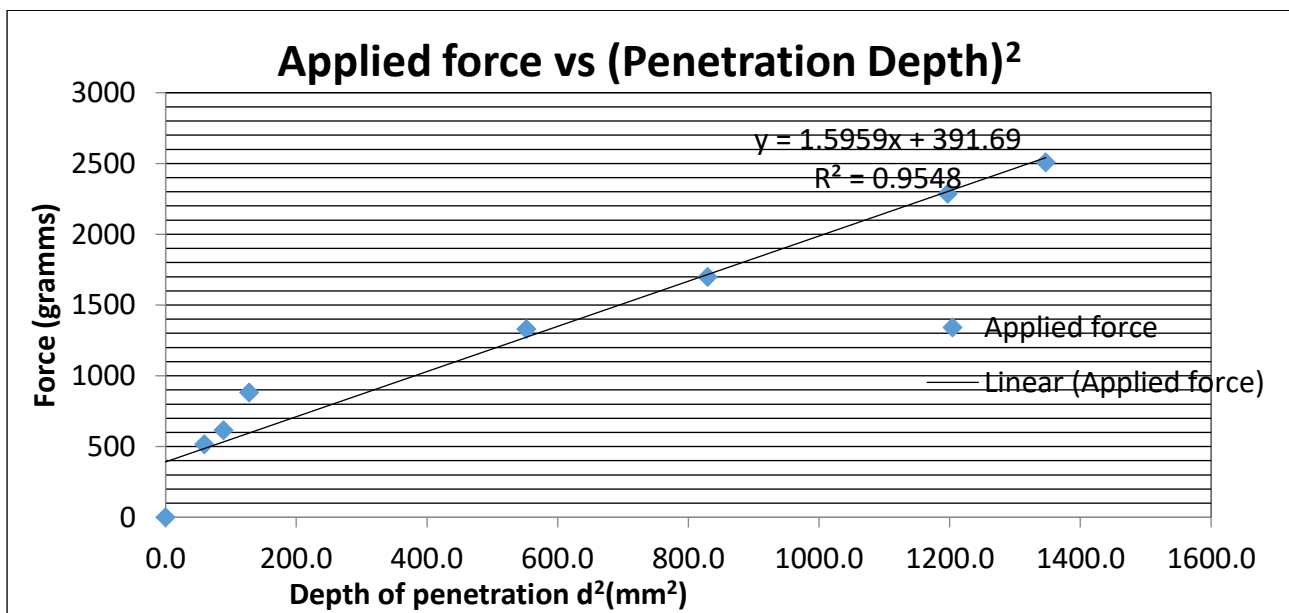


Table of results for soil sample MK3 at moisture content 25.5%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
44.2	244.81	0	0.0	0
48.5	259.37	4.3	18.5	14.56
49.5	271.77	5.3	28.1	26.96
53.9	290.36	9.7	94.1	45.55
56.8	313.62	12.6	158.8	68.81
62.4	328.08	18.2	331.2	83.27
69.8	342.12	25.6	655.4	97.31
79.4	363.37	35.2	1239.0	118.56

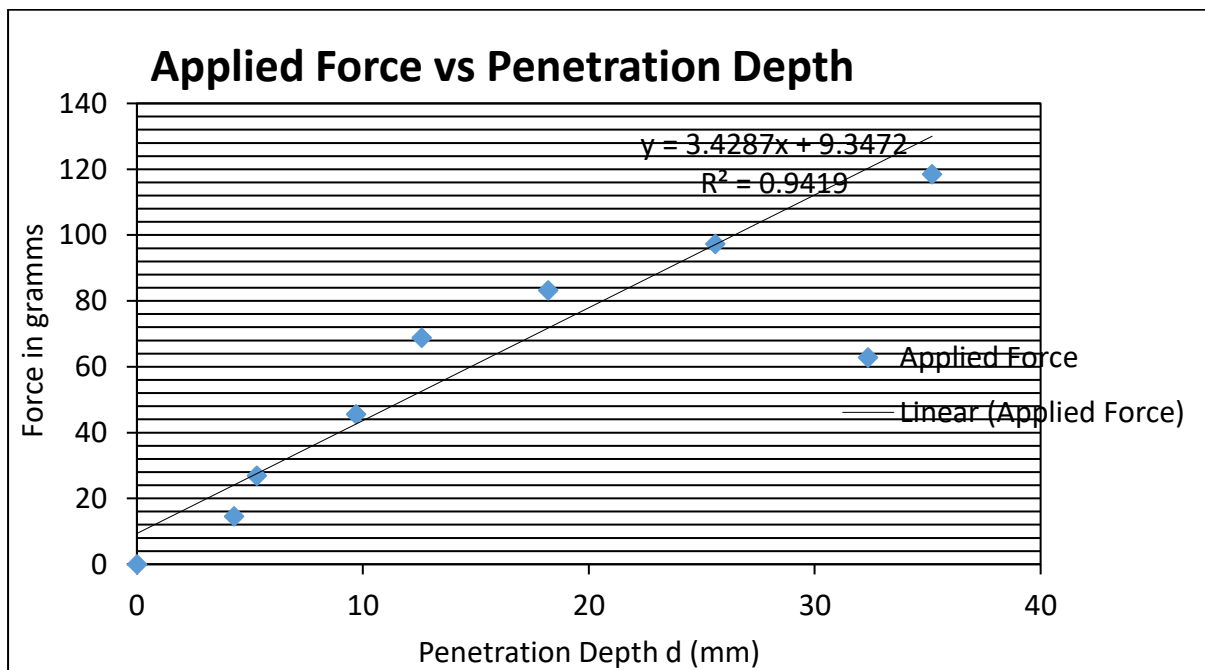
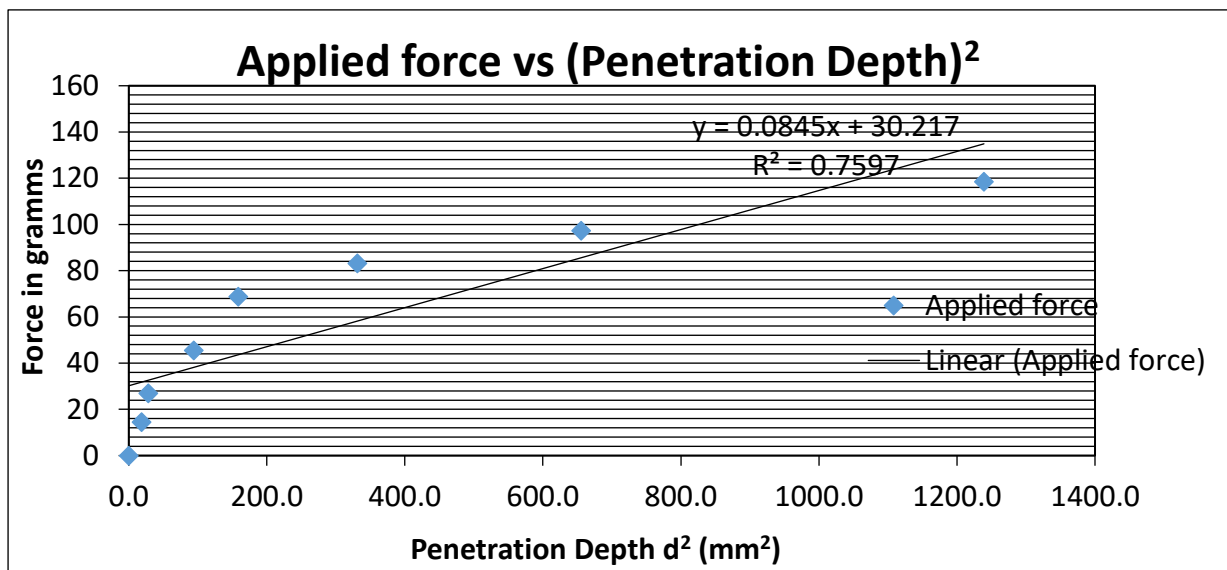


Table of results for soil sample MK 4 at moisture content 14.5%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.8	224.45	0	0.0	0
53.5	533.69	7.7	59.3	309.24
55.2	831.54	9.4	88.4	607.09
57.1	1099.49	11.3	127.7	875.04
69.3	1247.87	23.5	552.3	1023.42
74.6	2215.45	28.8	829.4	1991
80.4	2735.29	34.6	1197.2	2510.84
82.5	3092.14	36.7	1346.9	2867.69

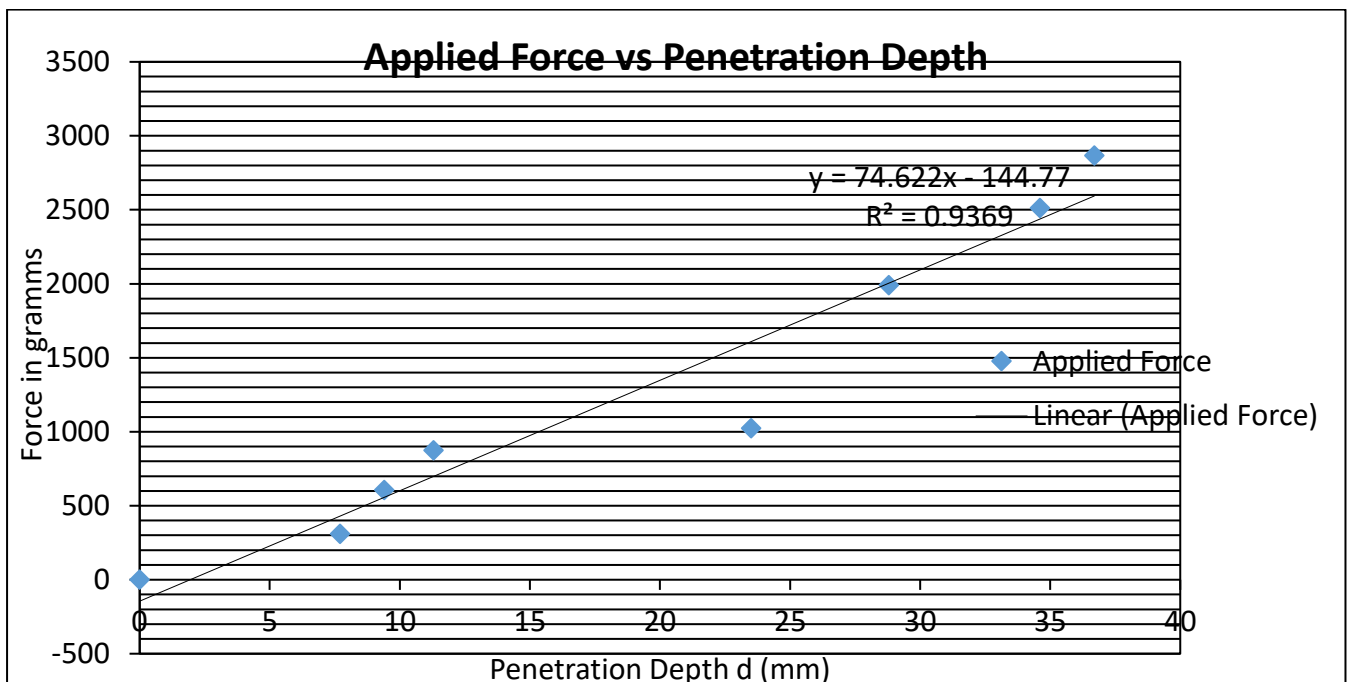
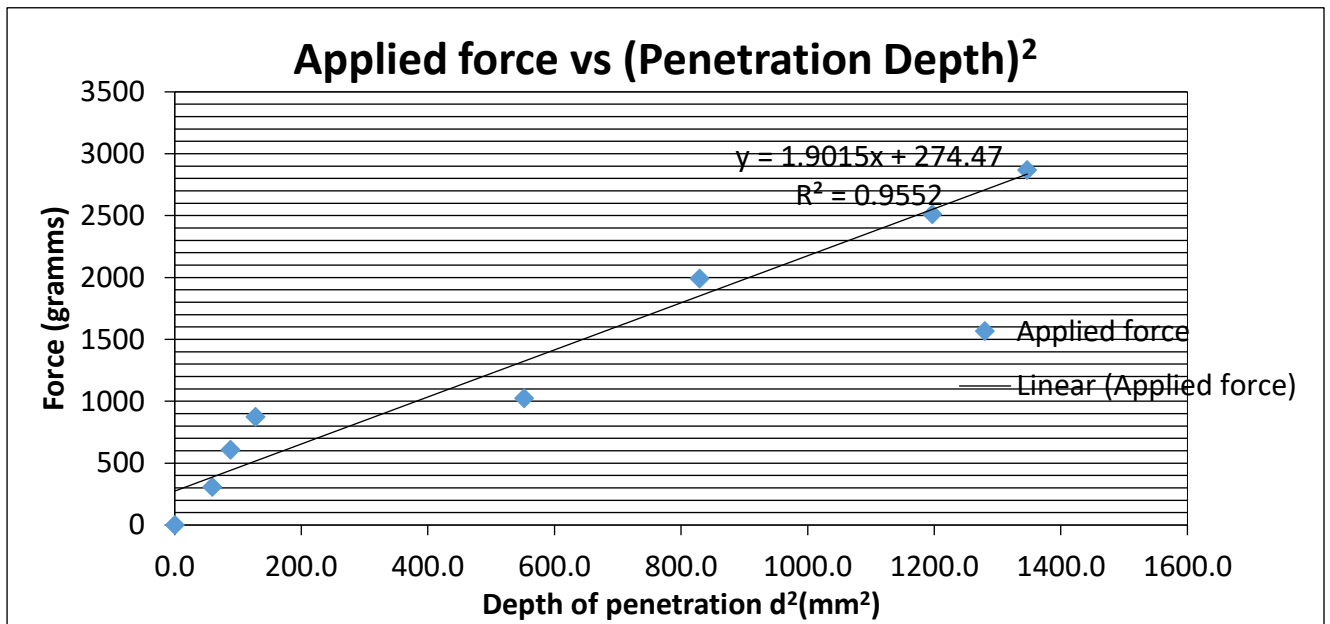


Table of results for soil sample MK4 at moisture content 26.5%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
44.6	263.28	0	0.0	0
48.5	288.67	3.9	15.2	25.39
49.5	295.36	4.9	24.0	32.08
53.9	316.93	9.3	86.5	53.65
56.8	323.4	12.2	148.8	60.12
62.4	340.46	17.8	316.8	77.18
69.8	357.67	25.2	635.0	94.39
79.4	364.34	34.8	1211.0	101.06

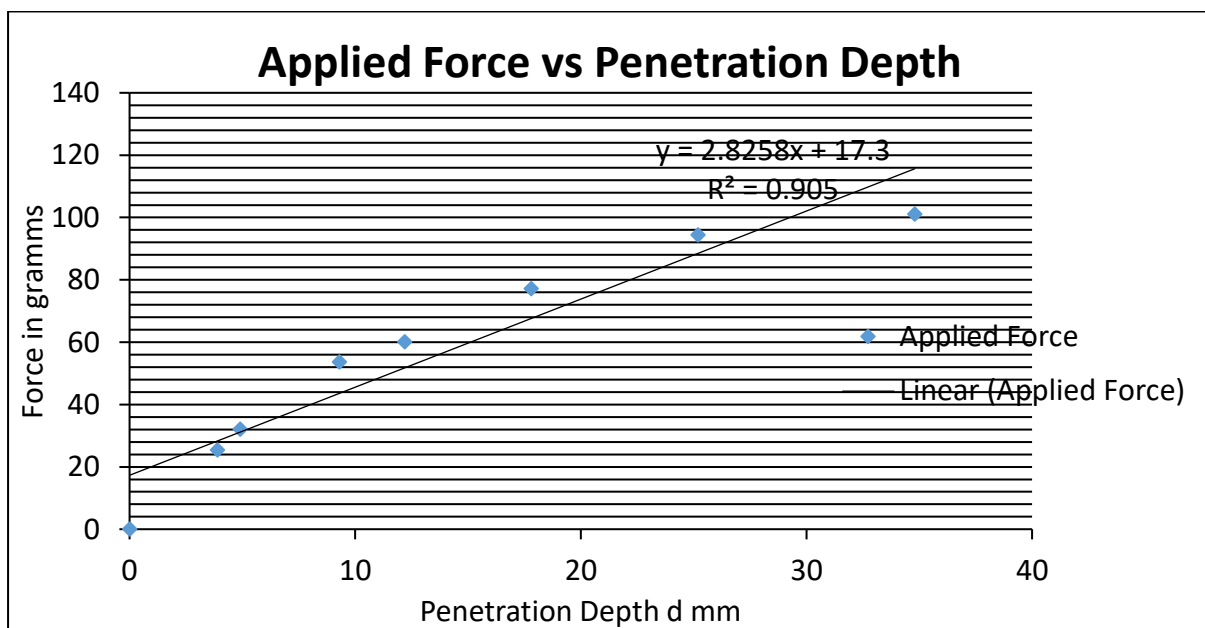
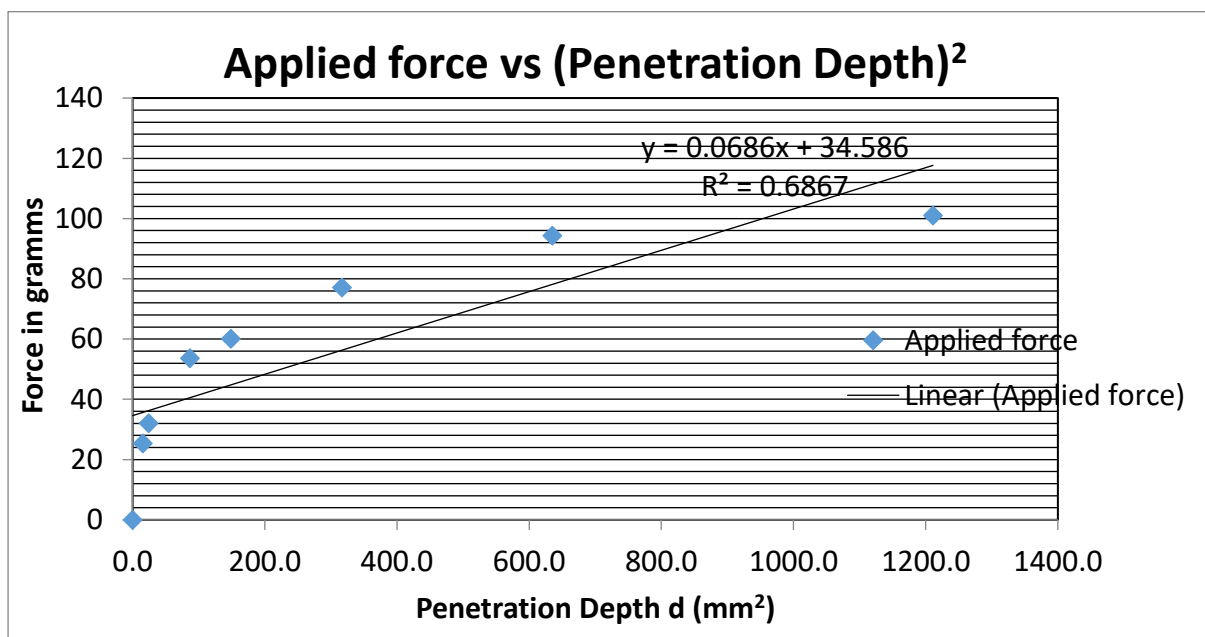


Table of results for soil sample R2 at moisture content 23.3%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
45.8	216.85	0	0.0	0
52.8	733.69	7	49.0	516.84
58.8	831.54	13	169.0	614.69
64.4	1099.49	18.6	346.0	882.64
71.1	1547.87	25.3	640.1	1331.02
76.8	2115.45	31	961.0	1898.6
79.8	3087.52	34	1156.0	2870.67
82.5	4013.84	36.7	1346.9	3280.15

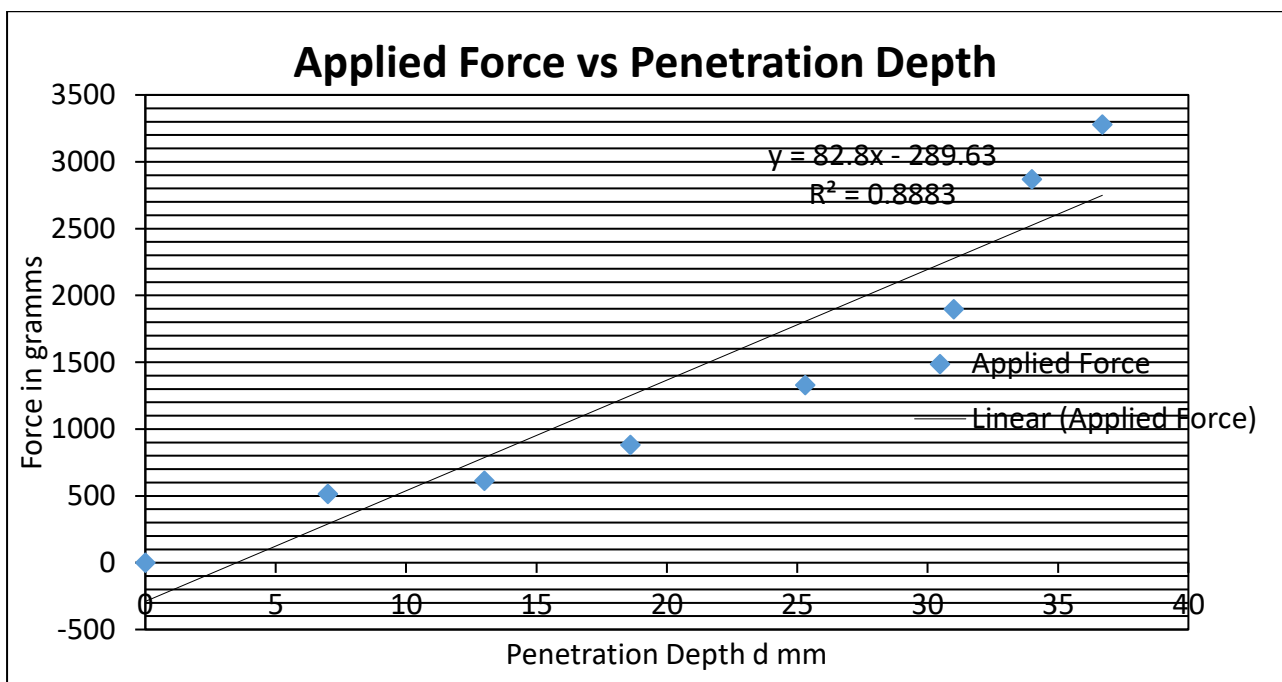
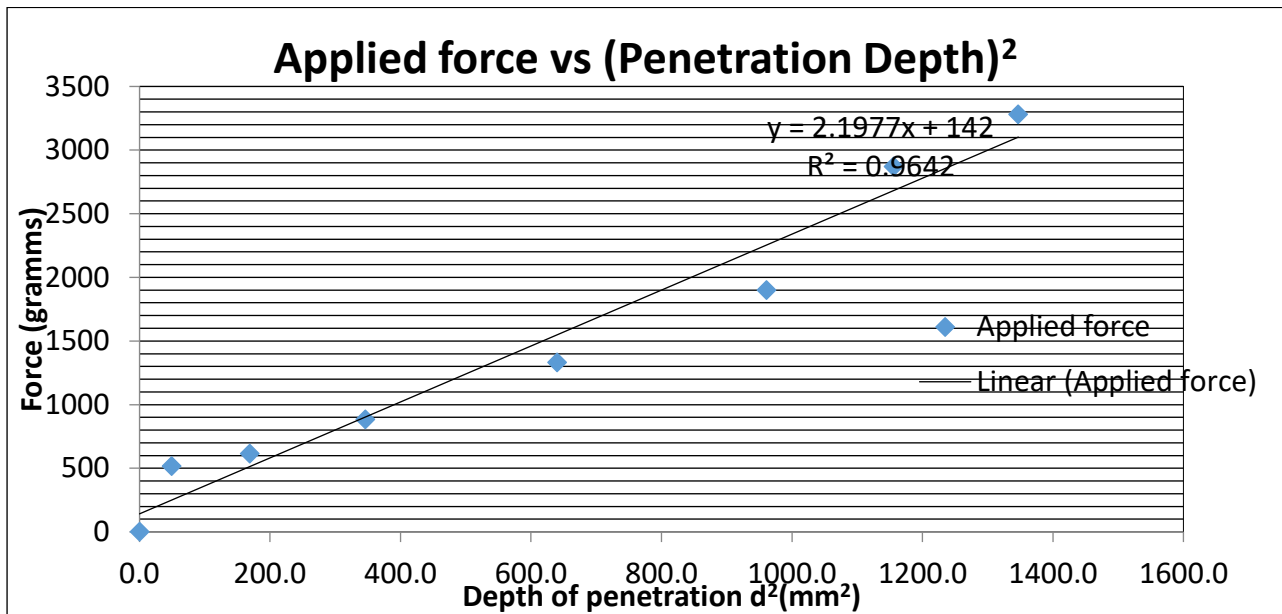


Table of results for soil sample R2 at moisture content 39%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
43.1	251.11	0	0.0	0
52.5	288.67	9.4	88.4	37.56
54.2	295.36	11.1	123.2	44.25
57.5	316.93	14.4	207.4	65.82
69.6	328.4	26.5	702.3	77.29
70.1	350.46	27	729.0	99.35
76.3	377.67	33.2	1102.2	126.56
82.8	395.84	39.7	1576.1	144.73

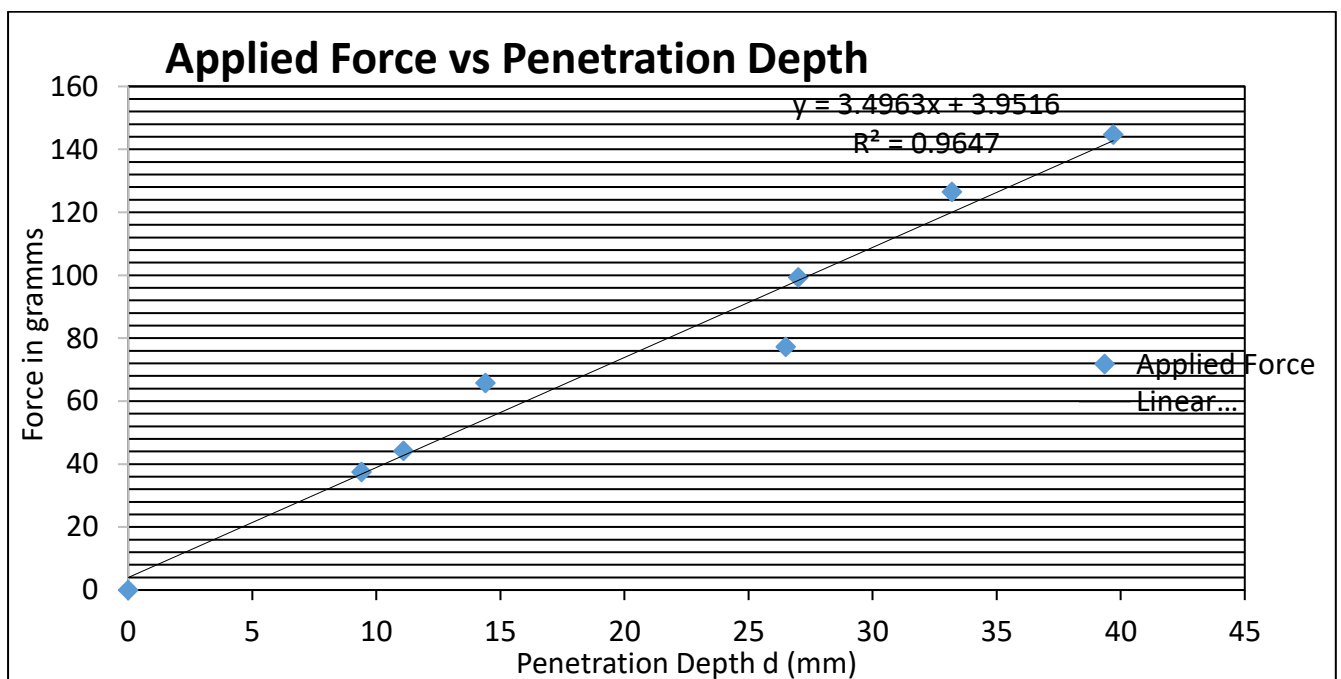
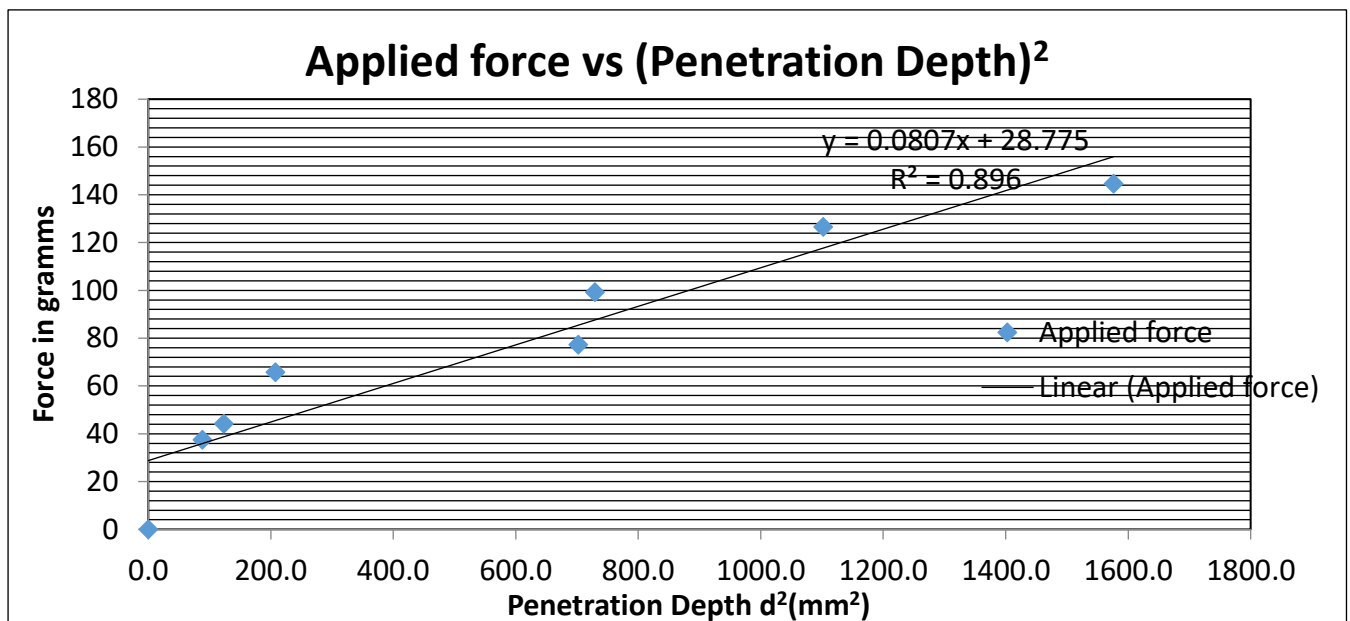


Table of results for soil sample k22 at moisture content 24.6%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
43.1	226.51	0	0.0	0
52.5	678.03	9.4	88.4	451.52
54.2	880.5	11.1	123.2	653.99
57.5	1174.33	14.4	207.4	947.82
69.6	1685.26	26.5	702.3	1458.75
70.1	2031.23	27	729.0	1804.72
76.3	2396.74	33.2	1102.2	2170.23
83.8	3082.49	40.7	1656.5	2855.98

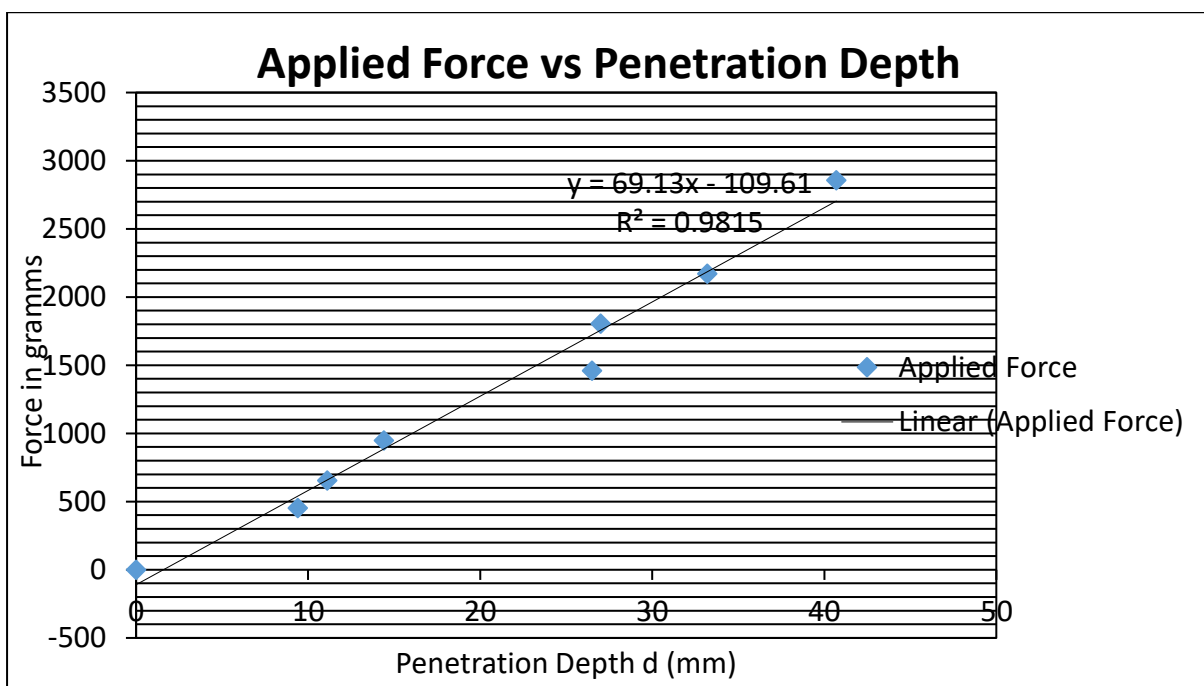
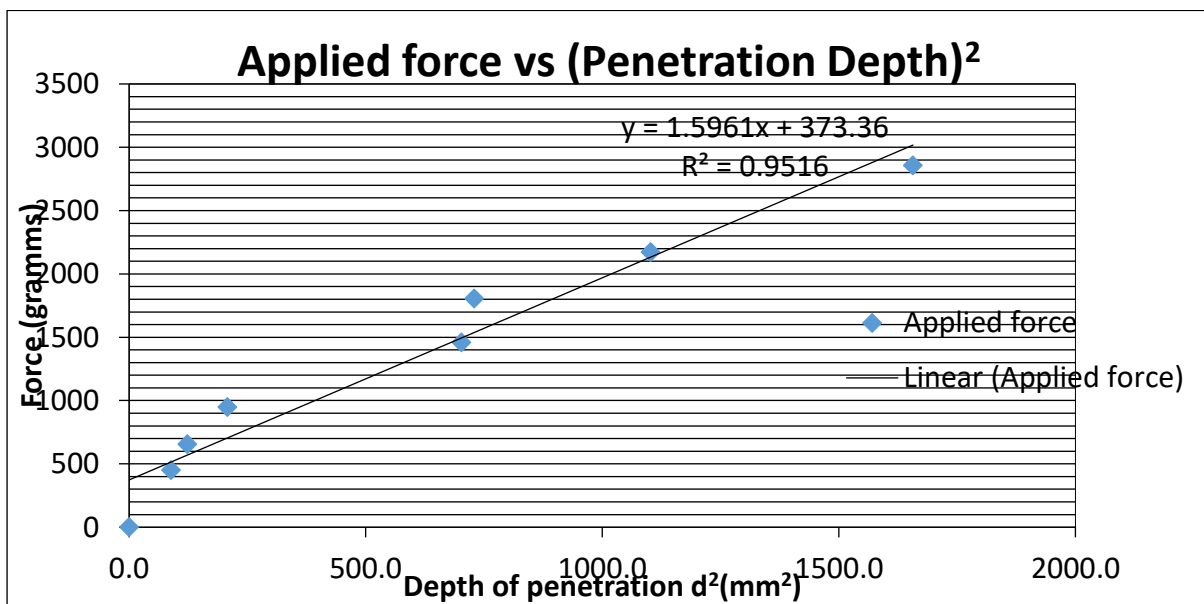


Table of results for soil sample k22 at moisture content 36%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
43.1	228.31	0	0.0	0
52.5	259.37	9.4	88.4	31.06
54.5	271.77	11.4	130.0	43.46
58.5	290.36	15.4	237.2	62.05
69.6	313.62	26.5	702.3	85.31
70.1	328.08	27	729.0	99.77
76.3	362.12	33.2	1102.2	133.81
80.8	393.37	37.7	1421.3	165.06

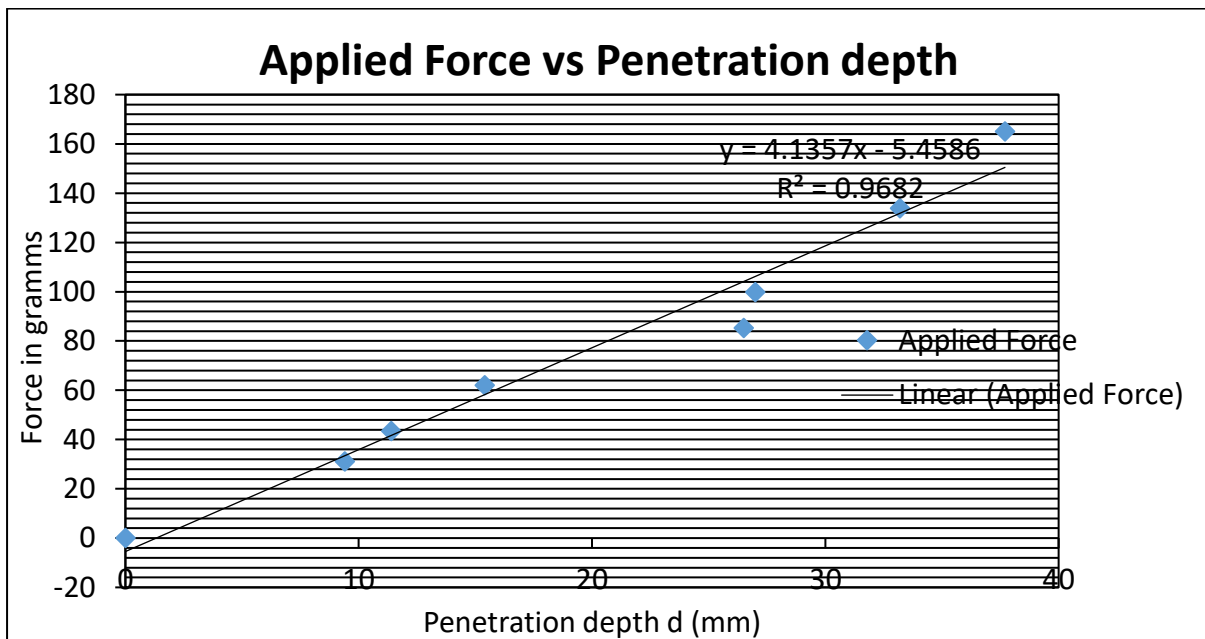
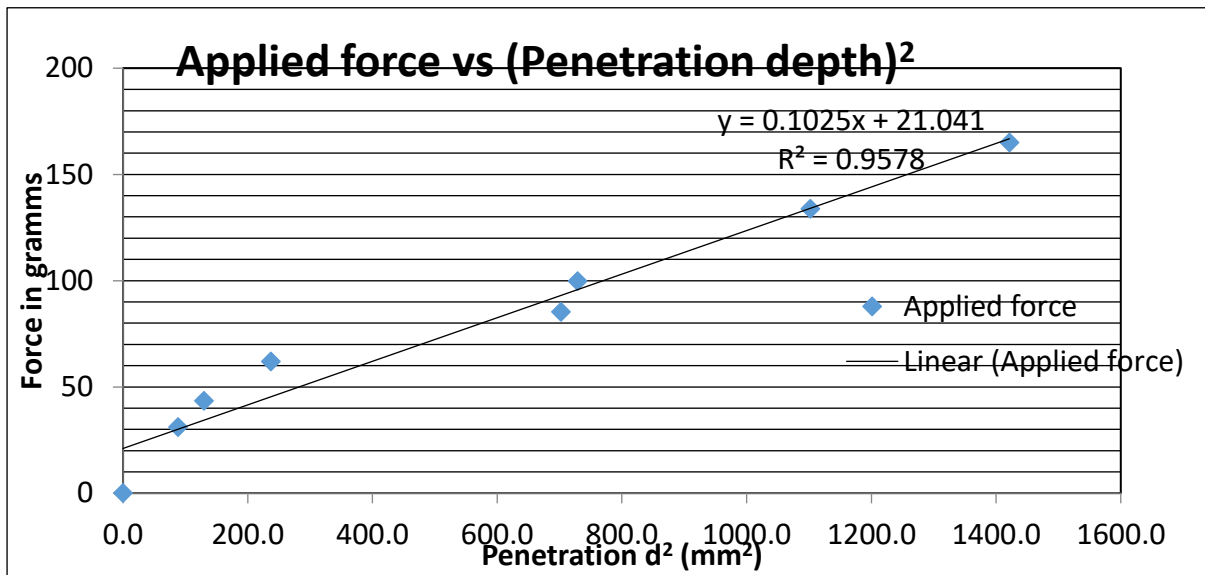


Table of results for soil sample k23 at moisture content 21.6%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
42.8	274	0	0.0	0
53.8	438.38	11	121.0	164.38
58.8	928.5	16	256.0	654.5
61	1273.35	18.2	331.2	999.35
67.7	1910.07	24.9	620.0	1636.07
72.7	2543	29.9	894.0	2269
76.4	3104	33.6	1129.0	2830

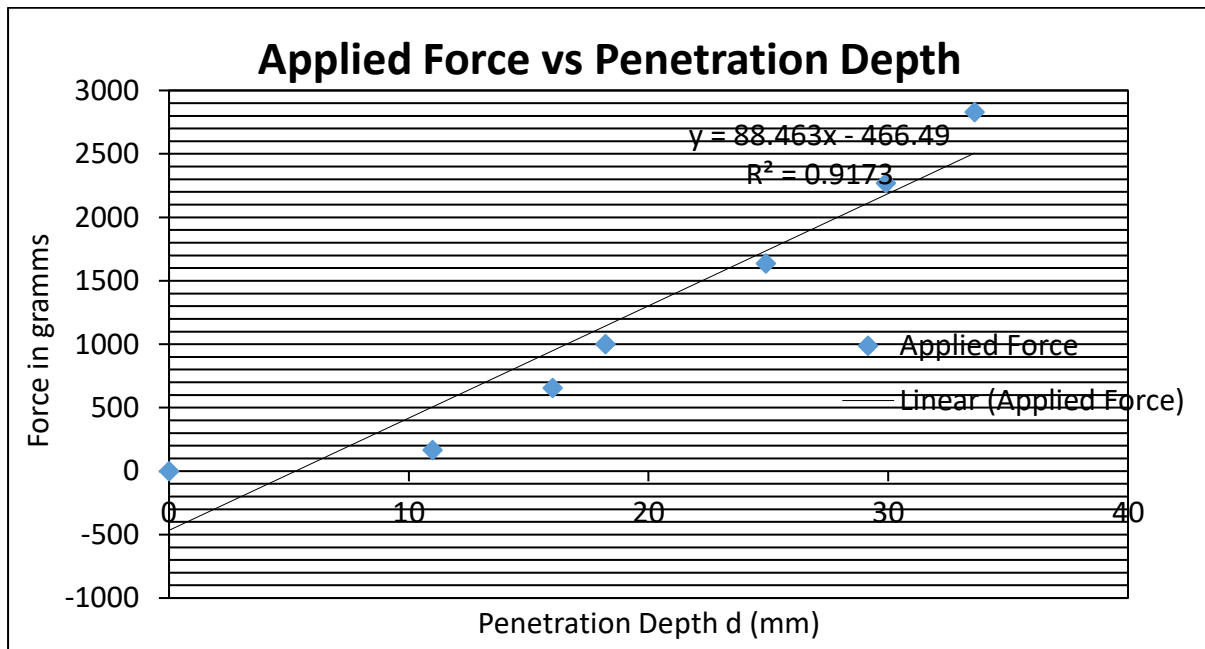
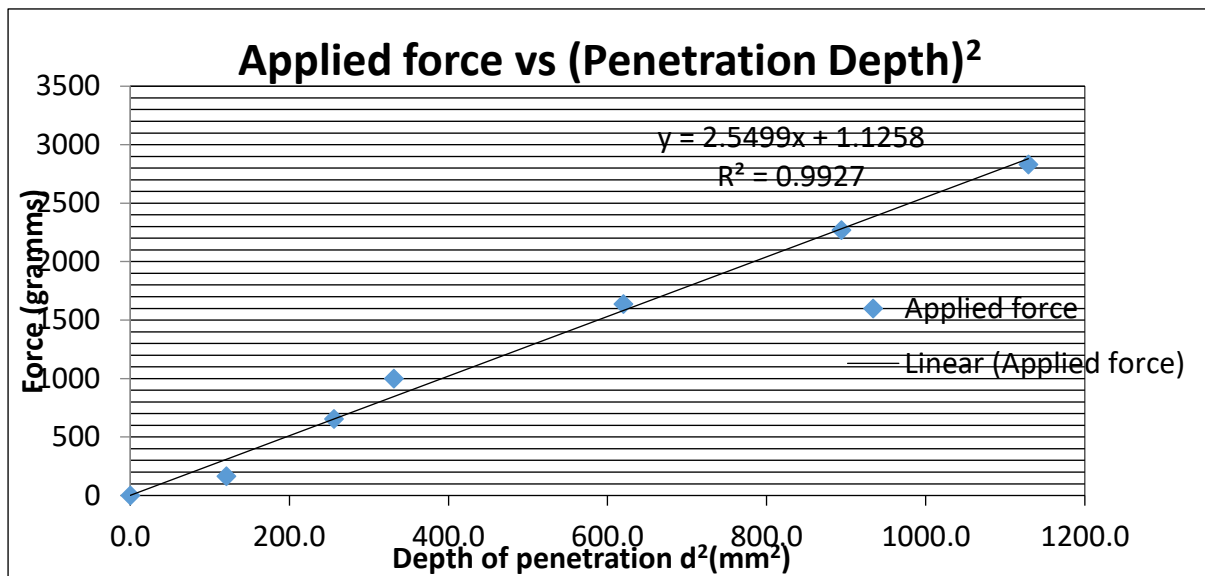
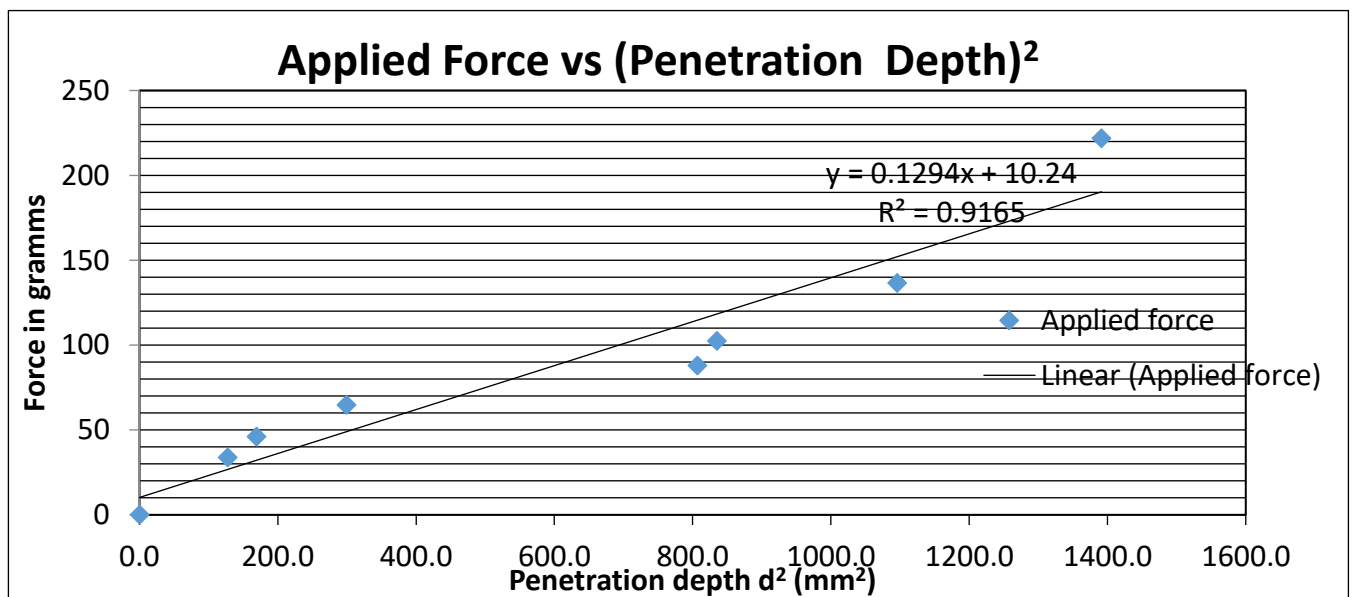
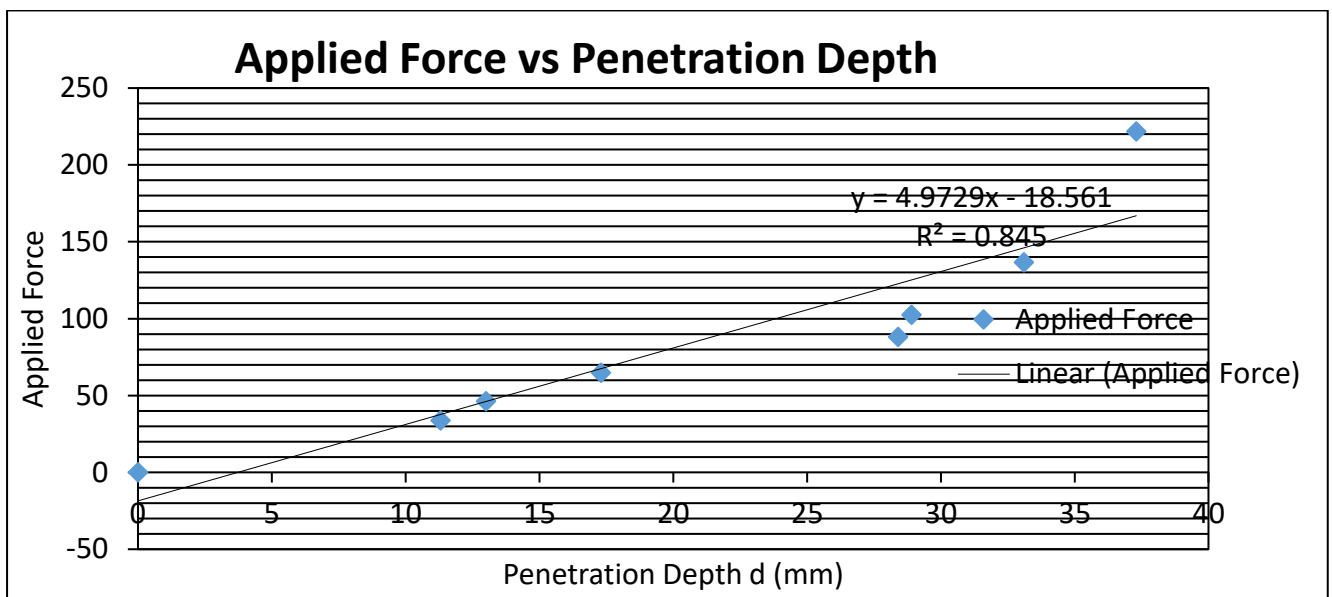


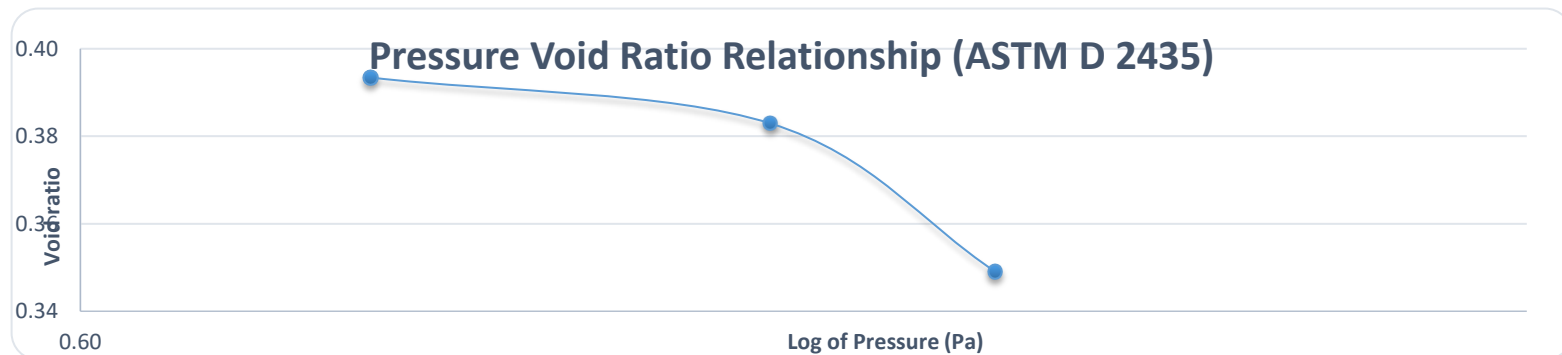
Table of results for soil sample k23 at moisture content 41.3%

Reading length (mm)	Reading Force (g)	Depth of penetration(d) mm	d ²	Applied force
41.2	225.61	0	0.0	0
52.5	259.37	11.3	127.7	33.76
54.2	271.77	13	169.0	46.16
58.5	290.36	17.3	299.3	64.75
69.6	313.62	28.4	806.6	88.01
70.1	328.08	28.9	835.2	102.47
74.3	362.12	33.1	1095.6	136.51
78.5	447.37	37.3	1391.3	221.76

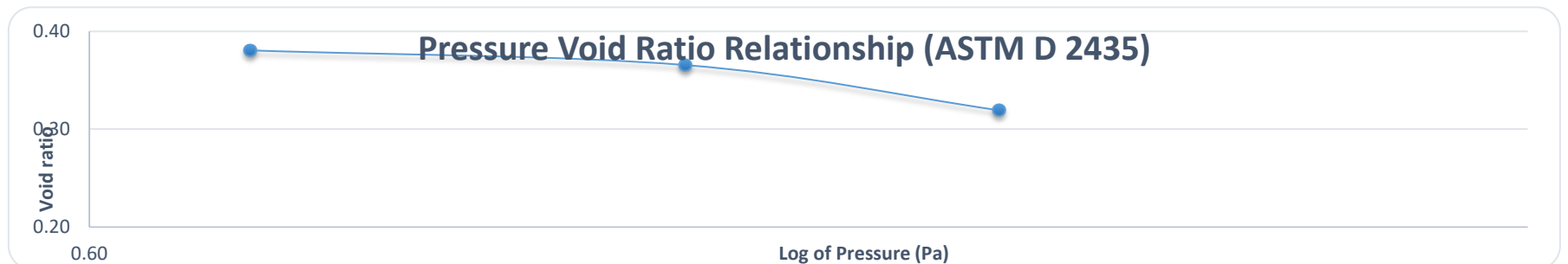


APPENDICES B: Results for Consolidation Test for all the samples

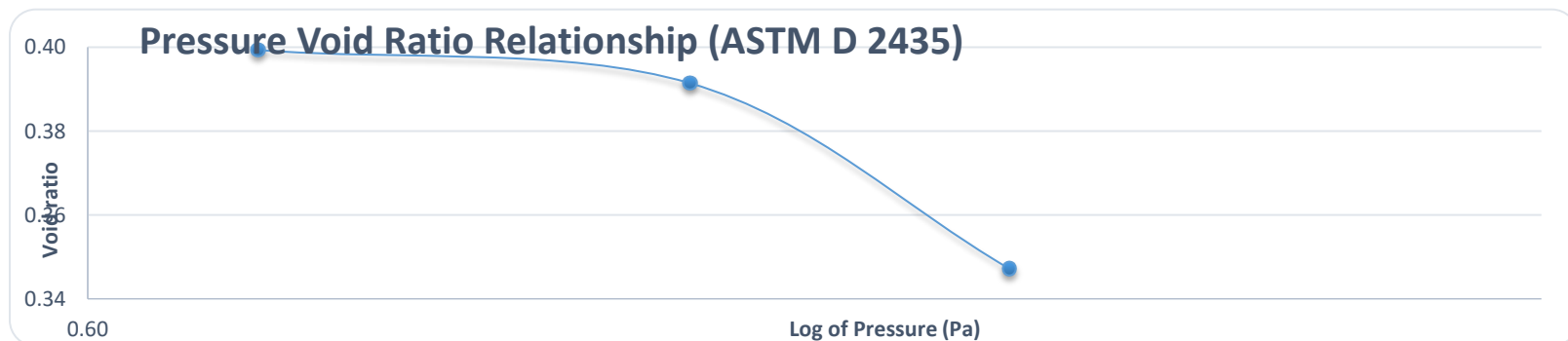
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				CONSOLIDATION TEST ANALYSIS				
Project:								
Client:								
Sampling Date:					Sample No.			
Testing Date:					Checked By:			
	Inside diameter of the ring		7.2	cm	Moisture Content, (final)	16.40%		
	Height of specimen		2.00	cm	Specific Gravity G _s =	2.392	0.000	
Increment No.		Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change Height(dH) In	Change in void ratio(de)	Void ratio
0		0	0	0	20	0.236	0.016625175	0
1		5.81	0.7642	10.00	19.78000	0.016	0.001127131	0.39342
2		11.63	1.0656	7.50	19.63130	-0.133	-0.009348139	0.38294
3		19.28	1.2851	4.90	19.15000	-0.614	-0.043253634	0.34903
UNLOADING		0	0.0000	0.00	19.76400	0	0	0.39229
		M _v				C _c		
1		0.048595315						
2		0.00156293				0.416768253		
3		0.005097083						



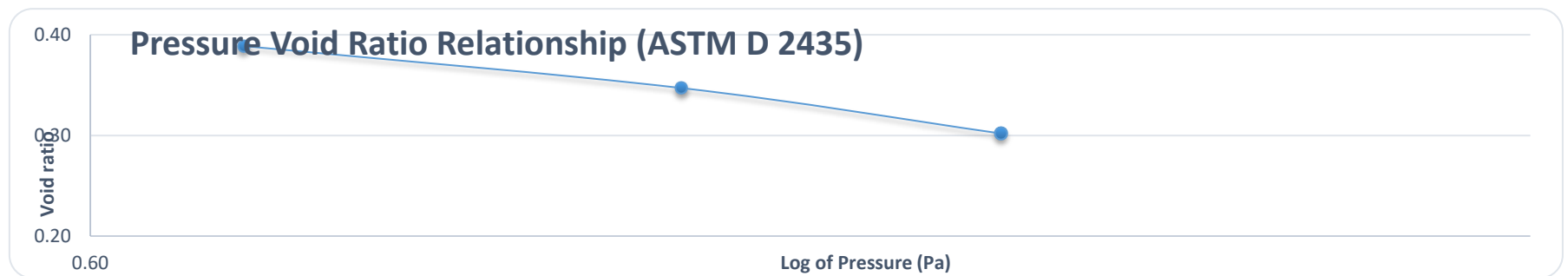
				WORKING SHEET NO: SAMPLE A2			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.412	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.238	0.016807266	0
1	4.86	0.6866	6.00	19.55000	-0.212	-0.014971178	0.38060
2	9.73	0.9881	8.00	19.33750	-0.425	-0.029977665	0.36559
3	19.28	1.2851	4.00	18.68200	-1.080	-0.076268264	0.31930
UNLOADING	0	0.0000	0.00	19.76200	0	0	0.39557
	Mv				Cc		
1	0.056723369						
2	0.002259785				0.405585573		
3	0.007047374						



				WORKING SHEET NO: SAMPLE A3			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity G _s =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.250	0.017623899	0
1	4.91	0.6911	8.00	19.85000	0.100	0.007049559	0.39934
2	9.73	0.9881	9.00	19.73780	-0.012	-0.000860046	0.39143
3	19.38	1.2874	5.40	19.11000	-0.640	-0.045117181	0.34717
UNLOADING	0	0.0000	0.00	19.75000	0	0	0.39229
	M _v				C _c		
1	0.058121415						
2	0.001175134				0.385208528	0.3852	
3	0.00661268						



				WORKING SHEET NO: SAMPLE A4			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.310	0.021920228	0
1	4.81	0.6821	2.70	19.64000	-0.050	-0.003535521	0.38875
2	9.63	0.9836	6.00	19.05000	-0.640	-0.045254663	0.34703
3	19.28	1.2851	2.80	18.41120	-1.279	-0.090424474	0.30186
UNLOADING	0	0.0000	0.00	19.69000	0	0	0.39229
	Mv				Cc		
1	0.058197355						
2	0.006245475				0.3890	0.389	
3	0.006971478						

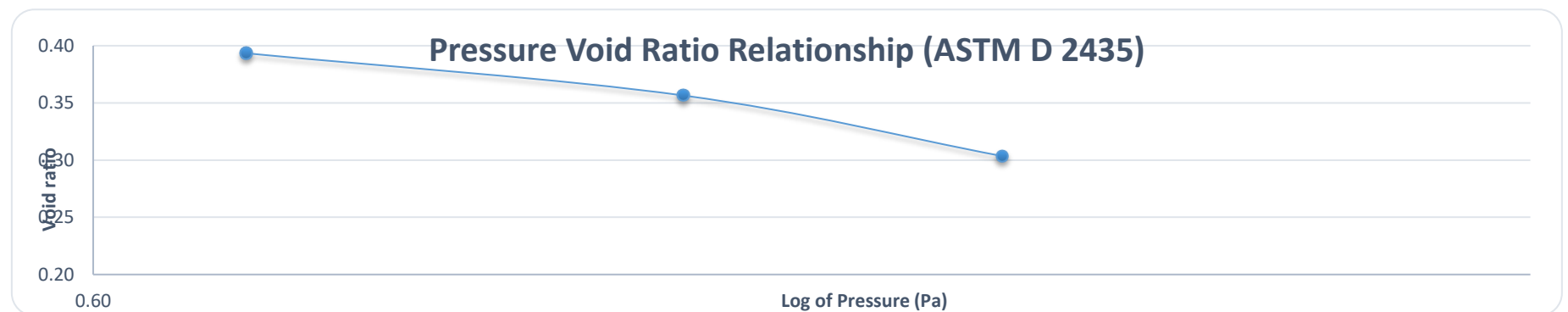


				WORKING SHEET NO: SAMPLE A5			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)		16.40%
Height of specimen			2.00	cm	Specific Gravity Gs =		2.392 0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.310	0.021920228	0
1	4.81	0.6821	2.70	19.64000	-0.050	-0.003535521	0.38875
2	9.63	0.9836	6.00	19.15000	-0.540	-0.038183622	0.35410
3	19.28	1.2851	2.80	18.58250	-1.108	-0.078311781	0.31398
UNLOADING	0	0.0000	0.00	19.69000	0	0	0.39229
	Mv				Cc		
1	0.058197355						
2	0.00518692				0.3456		
3	0.006161011						

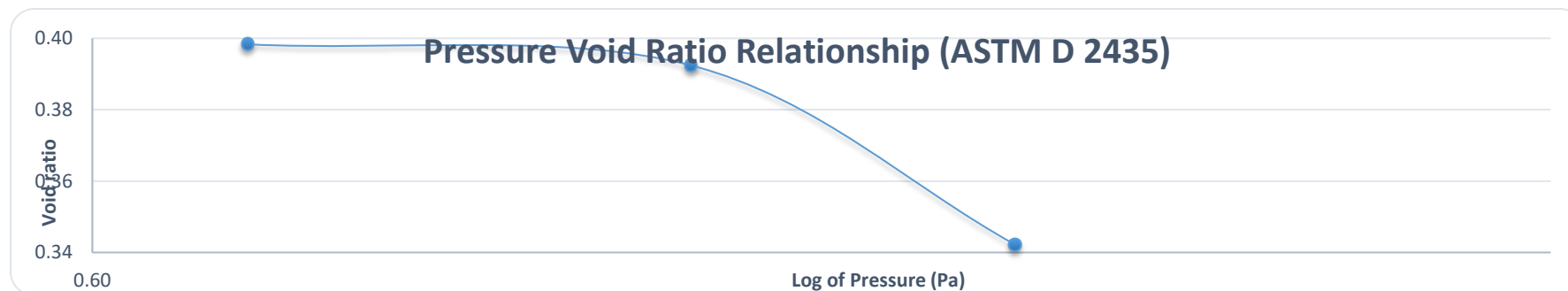
				WORKING SHEET NO: SAMPLE A6			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring		7.2	cm	Moisture Content, (final)	16.40%		
Height of specimen		2.00	cm	Specific Gravity G _s =	2.392	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height, H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.310	0.021920228	0
1	4.81	0.6821	5.50	19.43000	-0.260	-0.018384707	0.37390
2	9.63	0.9836	7.00	19.32000	-0.370	-0.026162852	0.36613
3	19.28	1.2851	5.00	18.66119	-1.029	-0.072747578	0.31954
UNLOADING	0	0.0000	0.00	19.69000	0	0	0.39229
	M _v				C _c		
1	0.056579362						
2	0.001176996				0.4012		
3	0.007089376						

				WORKING SHEET NO: SAMPLE B1			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity G _s =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t₅₀ (mins)	Height, H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	6.50	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	4.30	19.07850	-0.501	-0.035591202	0.35670
3	19.28	1.2851	4.00	18.33100	-1.248	-0.088746893	0.30354
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	M _v				C_c		
1	0.058699432						
2	0.005479993				0.4578		
3	0.008145578						

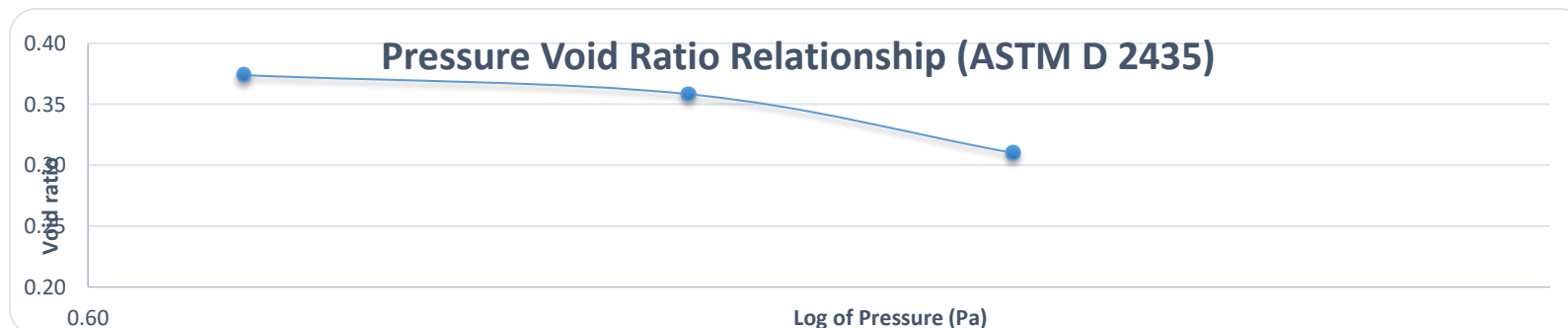
				WORKING SHEET NO: SAMPLE B2			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t50 (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	6.50	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	4.30	19.07601	-0.503	-0.035768482	0.35652
3	19.28	1.2851	4.00	18.33030	-1.249	-0.088796671	0.30349
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	Mv				Cc		
1	0.058699432						
2	0.005506443				0.4567		
3	0.008127101						



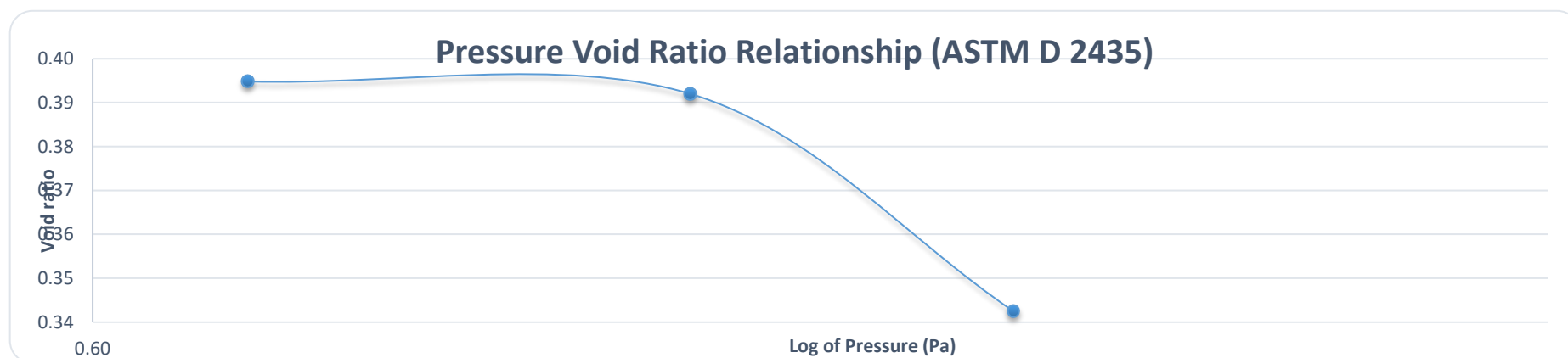
				WORKING SHEET NO: SAMPLE B3			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity G _s =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.136	0.009532379	0
1	4.81	0.6821	10.00	19.95000	0.086	0.006027828	0.39832
2	9.63	0.9836	7.50	19.86580	0.002	0.000126164	0.39241
3	19.28	1.2851	4.90	19.15000	-0.714	-0.050044988	0.34224
UNLOADING	0	0.0000	0.00	19.86400	0	0	0.39229
	M _v				C _c		
1	0.059221201						
2	0.000877454				0.43210		0.43210
3	0.007491013						



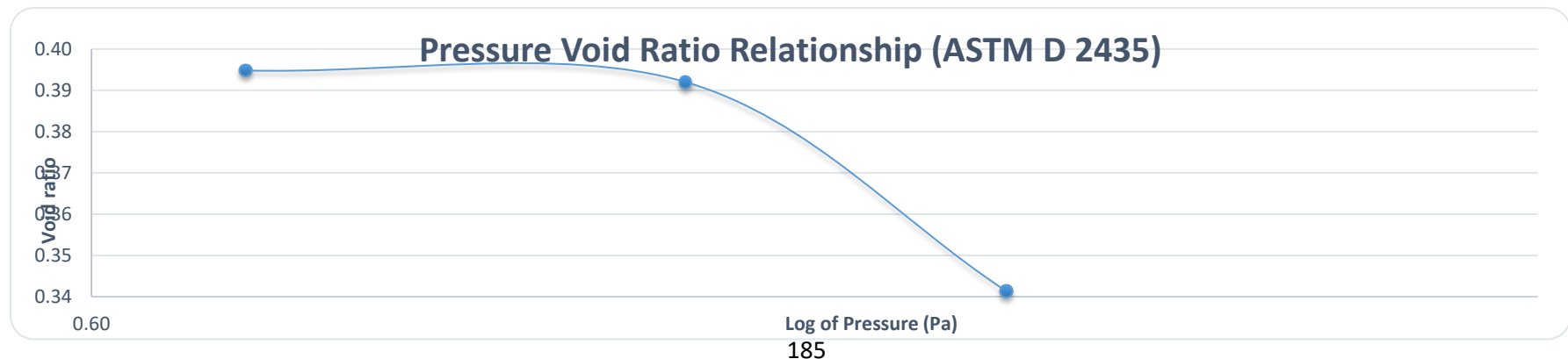
			WORKING SHEET NO: SAMPLE B4				
			CONSOLIDATION TEST ANALYSIS				
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring		7.2	cm	Moisture Content, (final)	16.40%		
Height of specimen		2.00	cm	Specific Gravity Gs =	2.392	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.310	0.021920228	0
1	4.81	0.6821	5.50	19.43000	-0.260	-0.018384707	0.37390
2	9.63	0.9836	7.00	19.21000	-0.480	-0.033940997	0.35835
3	19.28	1.2851	5.00	18.52750	-1.163	-0.082200853	0.31009
UNLOADING	0	0.0000	0.00	19.69000	0	0	0.39229
	Mv				Cc		
1	0.056579362						
2	0.002353991				0.4156	0.4156	
3	0.007386356						

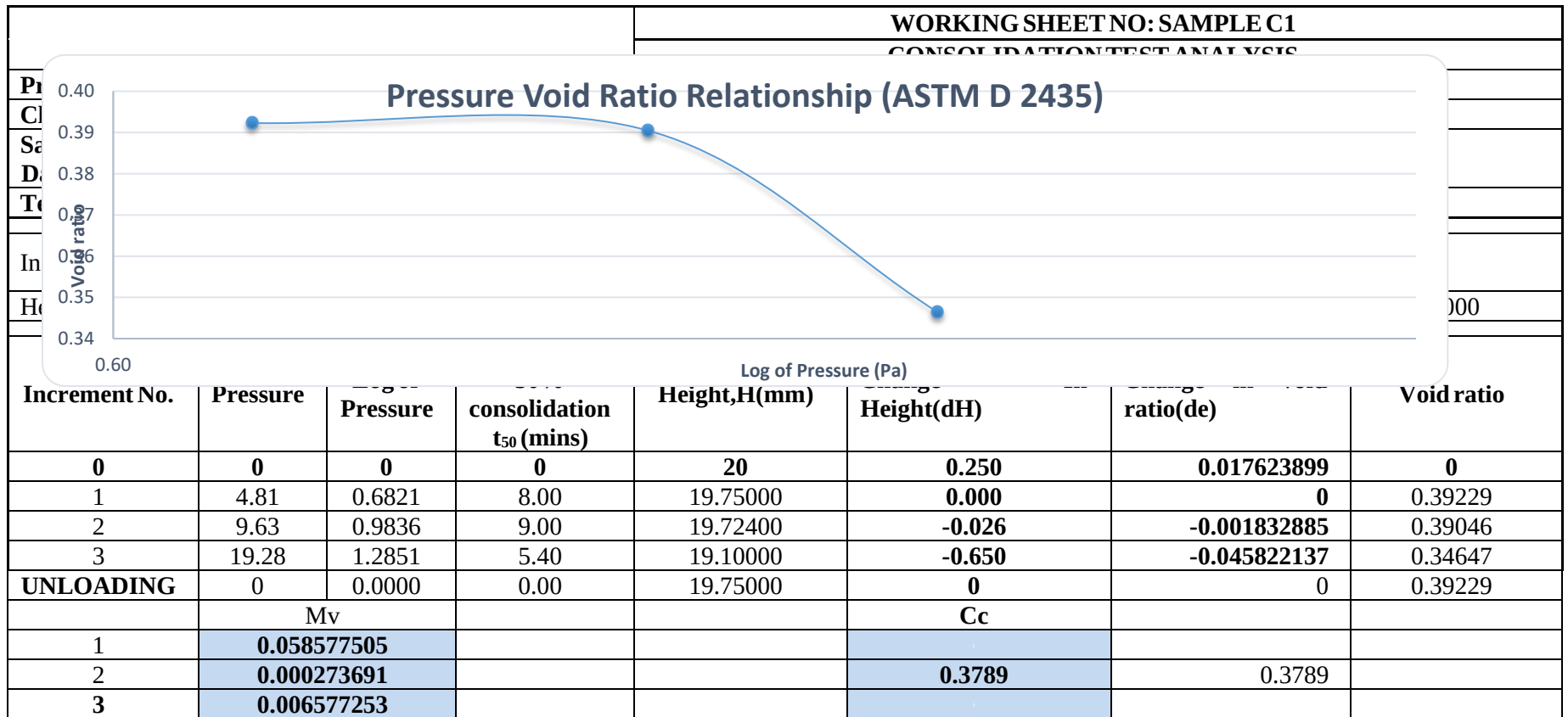


				WORKING SHEET NO: SAMPLE B5			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change Height(dH) In	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.136	0.009532379	0
1	4.81	0.6821	10.00	19.90000	0.036	0.002523277	0.39481
2	9.63	0.9836	7.50	19.86000	-0.004	-0.000280364	0.39201
3	19.28	1.2851	4.90	19.15320	-0.711	-0.049820696	0.34247
UNLOADING	0	0.0000	0.00	19.86400	0	0	0.39229
	Mv				Cc		
1	0.058847636						
2	0.00041789				0.4267	0.4267	
3	0.007398986						

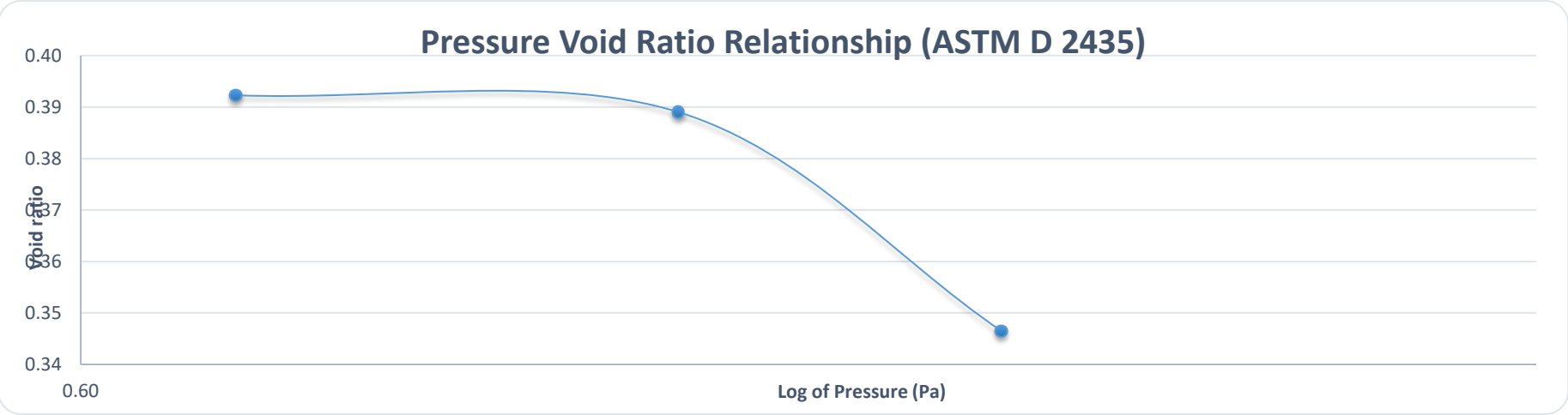


				WORKING SHEET NO: SAMPLE B6			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:					Sample No.		
Testing Date:					Checked By:		
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity G _s =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.136	0.009532379	0
1	4.81	0.6821	10.00	19.90000	0.036	0.002523277	0.39481
2	9.63	0.9836	7.50	19.86000	-0.004	-0.000280364	0.39201
3	19.28	1.2851	4.90	19.13650	-0.727	-0.050991216	0.34130
UNLOADING	0	0.0000	0.00	19.86400	0	0	0.39229
	M _v				C _c		
1	0.058847636						
2	0.00041789				0.4368		
3	0.007573807						

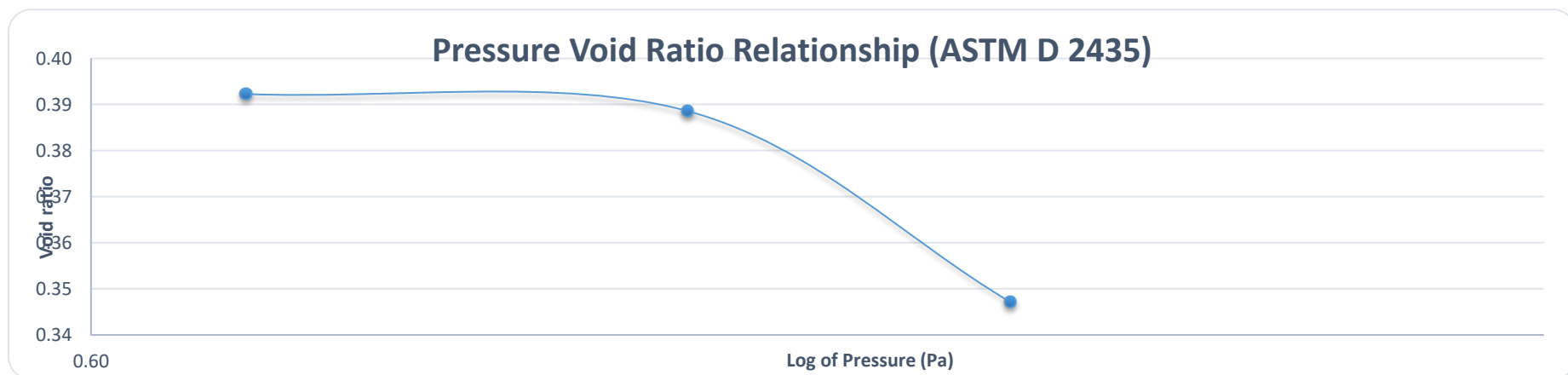




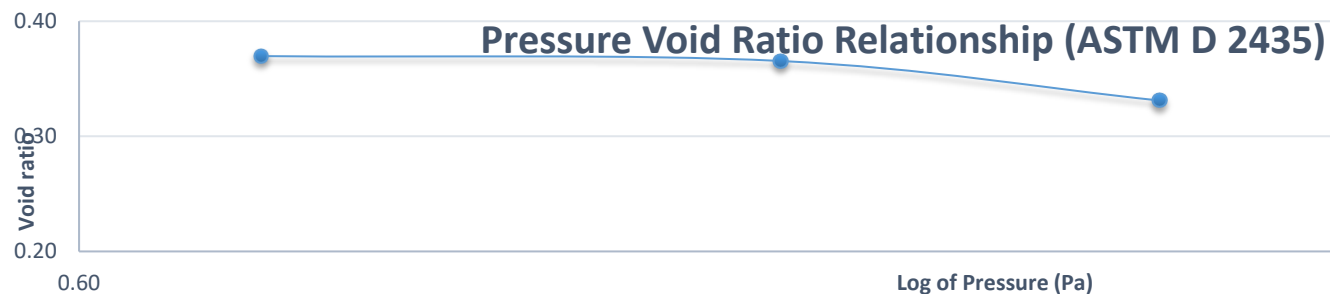
				WORKING SHEET NO: SAMPLE C2			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.250	0.017623899	0
1	4.81	0.6821	8.00	19.75000	0.000	0	0.39229
2	9.63	0.9836	9.00	19.70370	-0.046	-0.003263946	0.38902
3	19.28	1.2851	5.40	19.10000	-0.650	-0.045822137	0.34647
UNLOADING	0	0.0000	0.00	19.75000	0	0	0.39229
	Mv				Cc		
1	0.058577505						
2	0.000487381				0.3665	0.3665	
3	0.006369837						



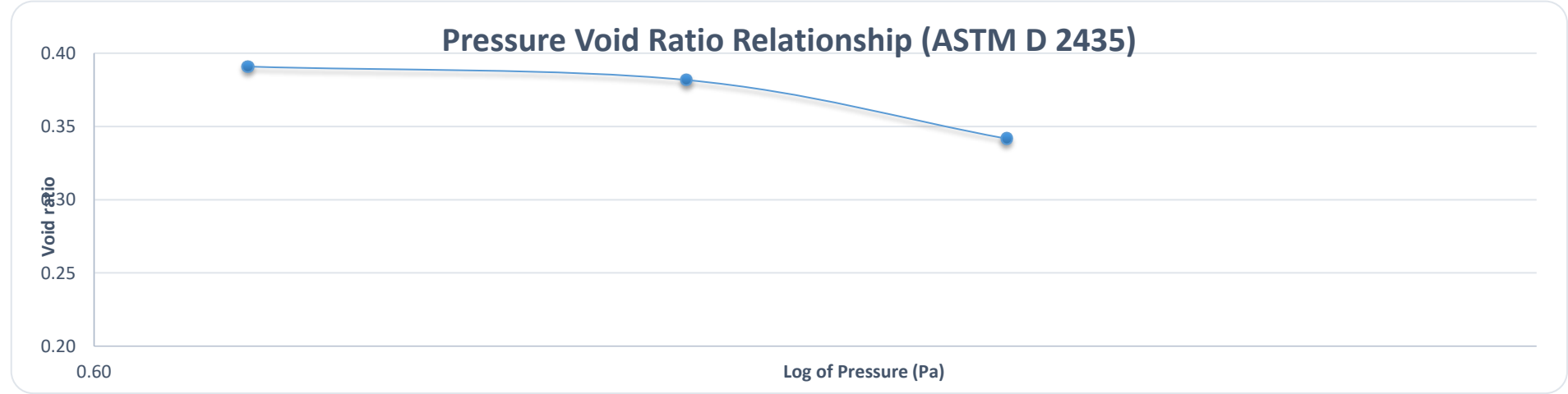
				WORKING SHEET NO: SAMPLE C3			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring		7.2	cm	Moisture Content, (final)	16.40%		
Height of specimen		2.00	cm	Specific Gravity G _s =	2.392	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.250	0.017623899	0
1	4.81	0.6821	8.00	19.75000	0.000	0	0.39229
2	9.63	0.9836	9.00	19.69760	-0.052	-0.003693969	0.38859
3	19.28	1.2851	5.40	19.11000	-0.640	-0.045117181	0.34717
UNLOADING	0	0.0000	0.00	19.75000	0	0	0.39229
	M _v				C _c		
1	0.058577505						
2	0.000551593				0.3568		
3	0.006201881						



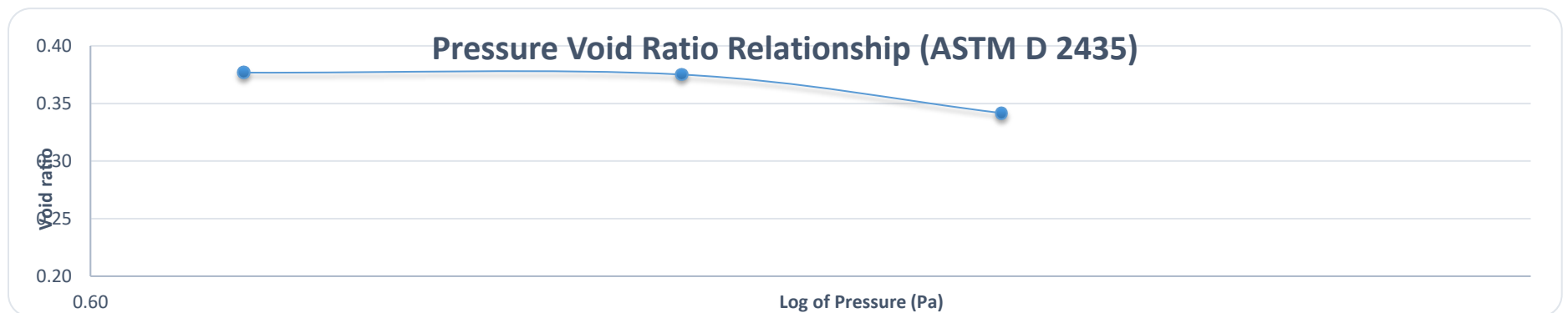
				WORKING SHEET NO: SAMPLE C4			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:						Sample No.	
Testing Date:						Checked By:	
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity G _s =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.260	0.01833814	0
1	4.81	0.6821	4.00	19.42000	-0.320	-0.022570018	0.36972
2	9.63	0.9836	6.00	19.36000	-0.380	-0.026801897	0.36549
3	19.28	1.2851	4.50	18.87250	-0.868	-0.061185909	0.33110
UNLOADING	0	0.0000	0.00	19.74000	0	0	0.39229
	M _v				C _c		
1	0.056116986						
2	0.000642328				0.296	0.296	
3	0.00523509						



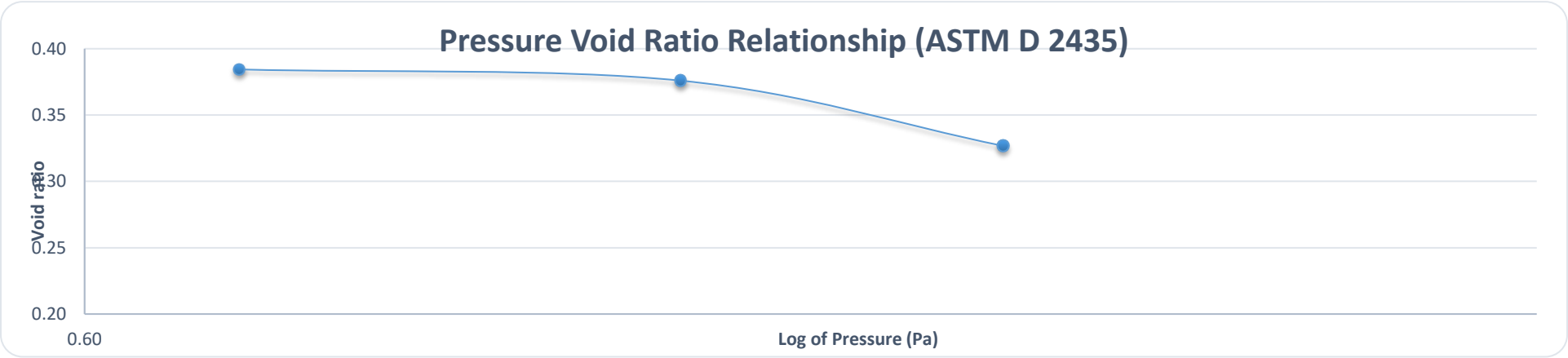
				WORKING SHEET NO: SAMPLE C5			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:						Sample No.	
Testing Date:						Checked By:	
Inside diameter of the ring		7.2	cm	Moisture Content, (final)	16.40%		
Height of specimen		2.00	cm	Specific Gravity Gs =	2.392	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.260	0.01833814	0
1	4.81	0.6821	4.00	19.72000	-0.020	-0.001410626	0.39088
2	9.63	0.9836	6.00	19.59000	-0.150	-0.010579696	0.38171
3	19.28	1.2851	4.50	19.02200	-0.718	-0.050641478	0.34165
UNLOADING	0	0.0000	0.00	19.74000	0	0	0.39229
	Mv				Cc		
1	0.058426062						
2	0.001370539				0.3450	0.345	
3	0.006027939						



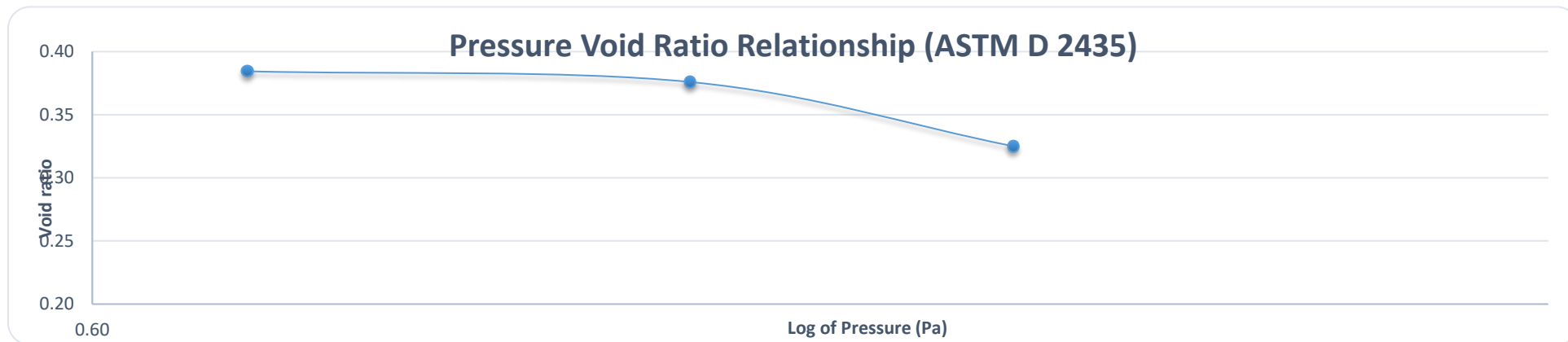
				WORKING SHEET NO: SAMPLE C6			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:					Sample No.		
Testing Date:					Checked By:		
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.260	0.01833814	0
1	4.81	0.6821	4.00	19.52000	-0.220	-0.015516888	0.37677
2	9.63	0.9836	6.00	19.49600	-0.244	-0.017209639	0.37508
3	19.28	1.2851	4.50	19.02200	-0.718	-0.050641478	0.34165
UNLOADING	0	0.0000	0.00	19.74000	0	0	0.39229
	Mv				Cc		
1	0.056894564						
2	0.000255615				0.2879	0.2879	
3	0.005054611						



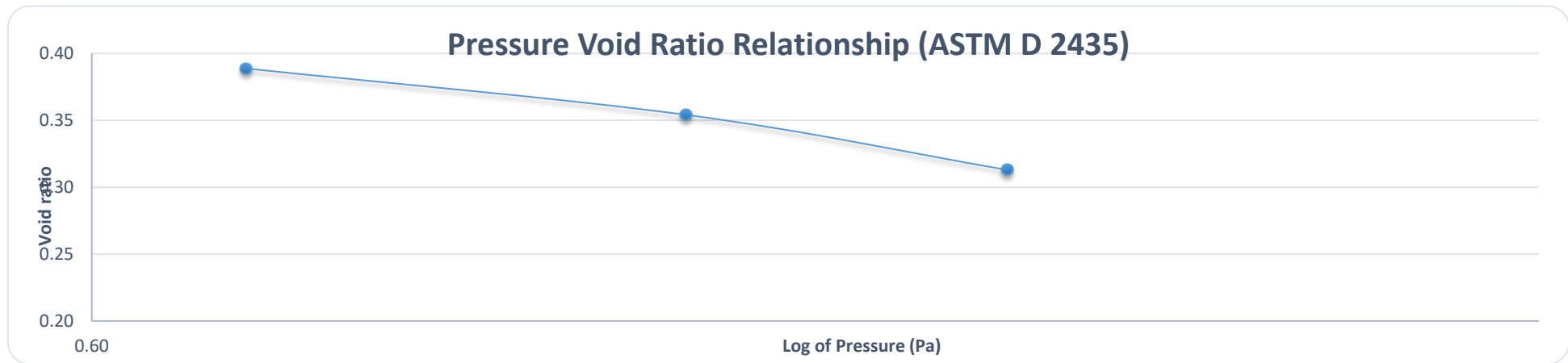
				WORKING SHEET NO: SAMPLE C7			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity G _s =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height, H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.238	0.016767764	0
1	4.81	0.6821	6.00	19.65000	-0.112	-0.007890712	0.38440
2	9.63	0.9836	8.00	19.53000	-0.232	-0.016345047	0.37594
3	19.28	1.2851	4.00	18.83170	-0.930	-0.065542229	0.32675
UNLOADING	0	0.0000	0.00	19.76200	0	0	0.39229
	M _v				C _c		
1	0.057726403						
2	0.00126962				0.4237	0.4237	
3	0.007433524						



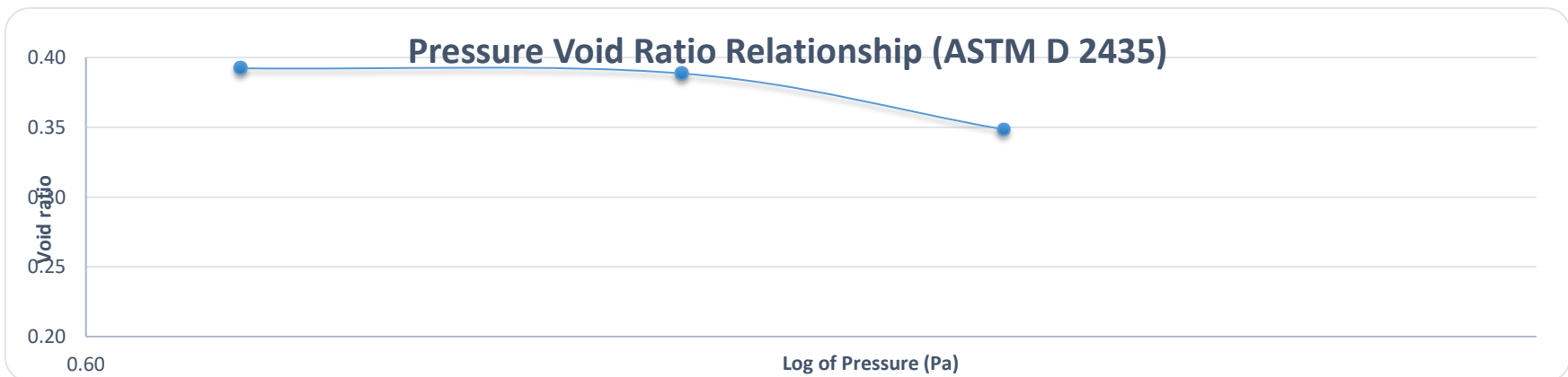
			CONSOLIDATION TEST ANALYSIS				
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.238	0.016767764	0
1	4.81	0.6821	6.00	19.65000	-0.112	-0.007890712	0.38440
2	9.63	0.9836	8.00	19.53000	-0.232	-0.016345047	0.37594
3	19.28	1.2851	4.00	18.80758	-0.954	-0.06724155	0.32505
UNLOADING	0	0.0000	0.00	19.76200	0	0	0.39229
	Mv				Cc		
1	0.057726403						
2	0.00126962				0.4384	0.4384	
3	0.007690285						



				WORKING SHEET NO: SAMPLE K1			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.310	0.021920228	0
1	4.81	0.6821	2.70	19.64000	-0.050	-0.003535521	0.38875
2	9.63	0.9836	6.00	19.15000	-0.540	-0.038183622	0.35410
3	19.28	1.2851	2.80	18.56790	-1.122	-0.079344153	0.31294
UNLOADING	0	0.0000	0.00	19.69000	0	0	0.39229
	Mv				Cc		
1	0.058197355						
2	0.00518692				0.3545	0.3545	
3	0.006319515						

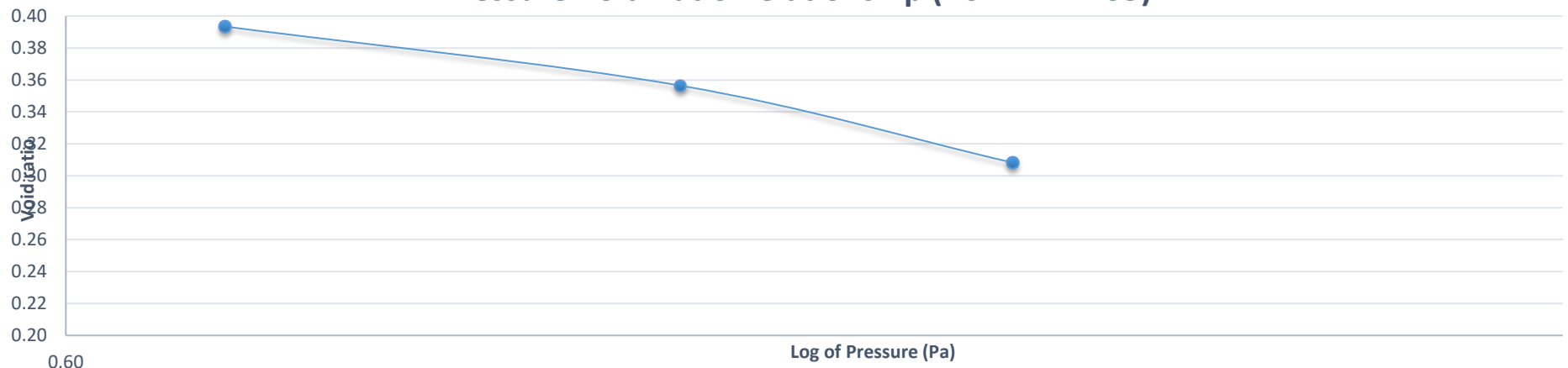


				WORKING SHEET NO: SAMPLE K2			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:					Sample No.		
Testing Date:					Checked By:		
Inside diameter of the ring		7.2	cm	Moisture Content, (final)	16.40%		
Height of specimen		2.00	cm	Specific Gravity G _s =	2.392	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.250	0.017623899	0
1	4.81	0.6821	4.00	19.75000	0.000	0	0.39229
2	9.63	0.9836	6.00	19.69760	-0.052	-0.003693969	0.38859
3	19.28	1.2851	4.50	19.12840	-0.622	-0.043820062	0.34847
UNLOADING	0	0.0000	0.00	19.75000	0	0	0.39229
	M _v				C _c		
1	0.058577505						
2	0.000551593				0.3456	0.3456	
3	0.006007676						

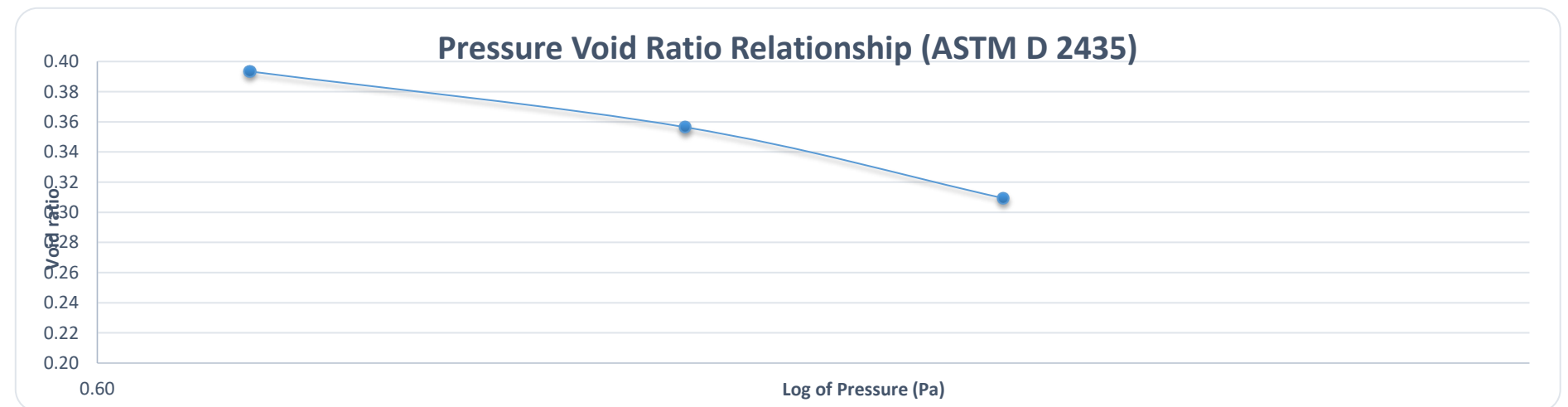


				WORKING SHEET NO: SAMPLE K3			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	6.50	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	4.30	19.07500	-0.504	-0.035840092	0.35645
3	19.28	1.2851	4.00	18.39640	-1.183	-0.084096215	0.30819
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	Mv				Cc		
1	0.058699432						
2	0.005517127				0.4156	0.4156	
3	0.007396125						

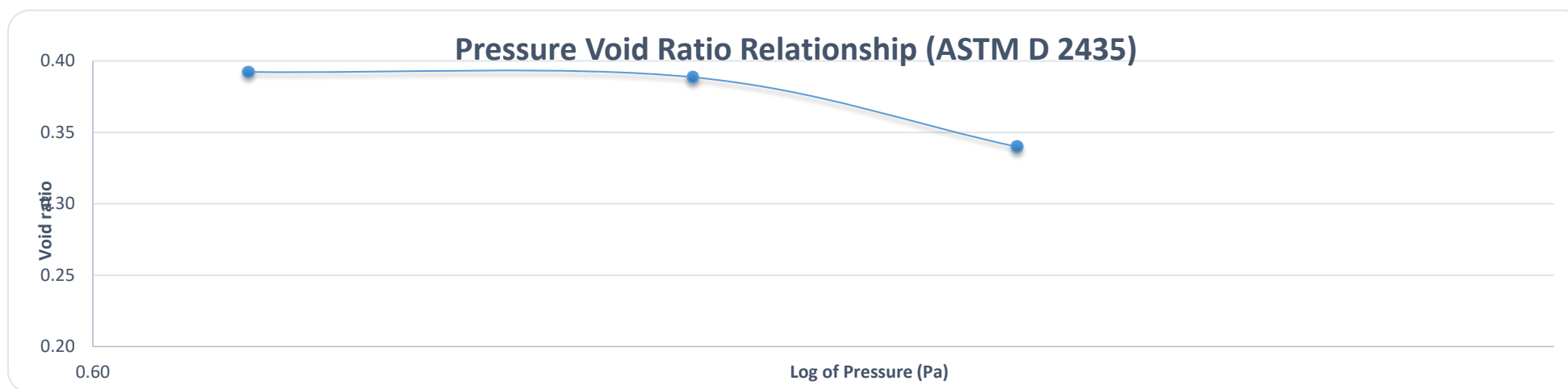
Pressure Void Ratio Relationship (ASTM D 2435)



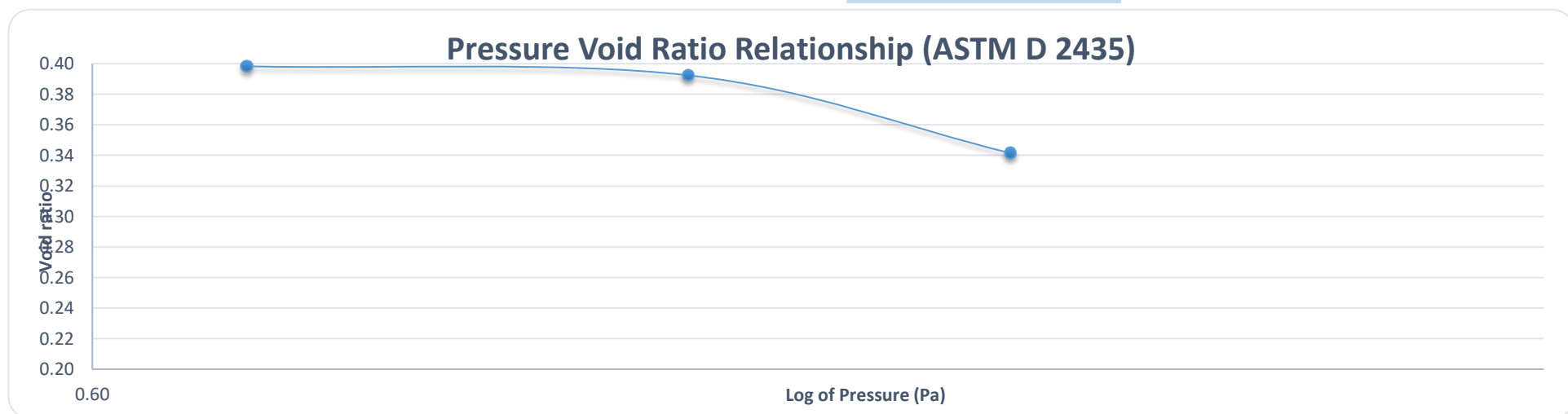
				WORKING SHEET NO: SAMPLE K4			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring		7.2	cm	Moisture Content, (final)	16.40%		
Height of specimen		2.00	cm	Specific Gravity Gs =	2.392	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	6.50	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	4.30	19.07500	-0.504	-0.035840092	0.35645
3	19.28	1.2851	4.00	18.41260	-1.166	-0.082944212	0.30934
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	Mv				Cc		
1	0.058699432						
2	0.005517127				0.4057	0.4057	
3	0.00721956						



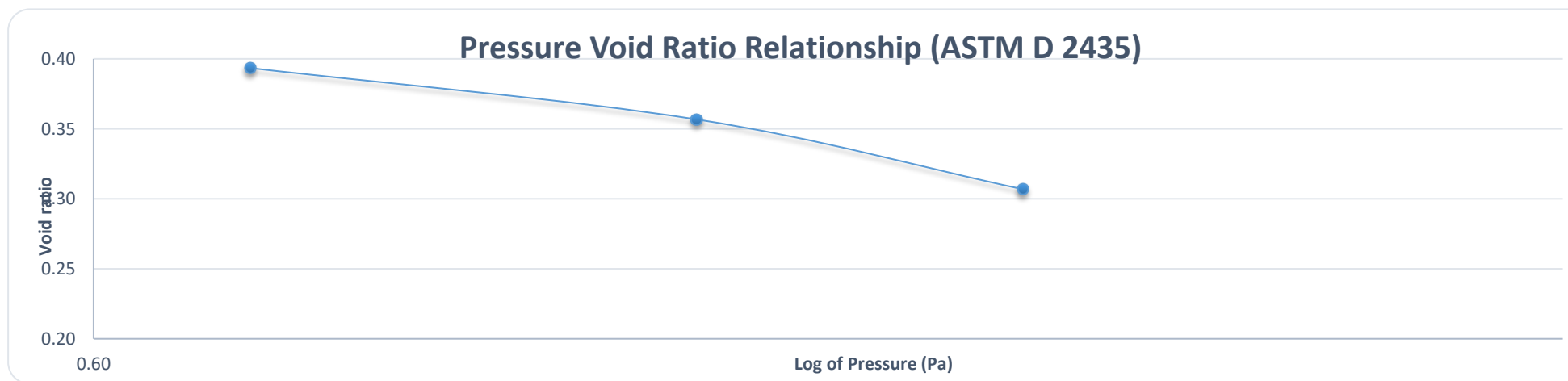
				WORKING SHEET NO: SAMPLE K5			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.250	0.017623899	0
1	4.81	0.6821	6.00	19.75000	0.000	0	0.39229
2	9.63	0.9836	8.00	19.69760	-0.052	-0.003693969	0.38859
3	19.28	1.2851	4.00	19.00610	-0.744	-0.052441673	0.33985
UNLOADING	0	0.0000	0.00	19.75000	0	0	0.39229
	Mv				Cc		
1	0.058577505						
2	0.000551593				0.4198	0.4198	
3	0.007298503						



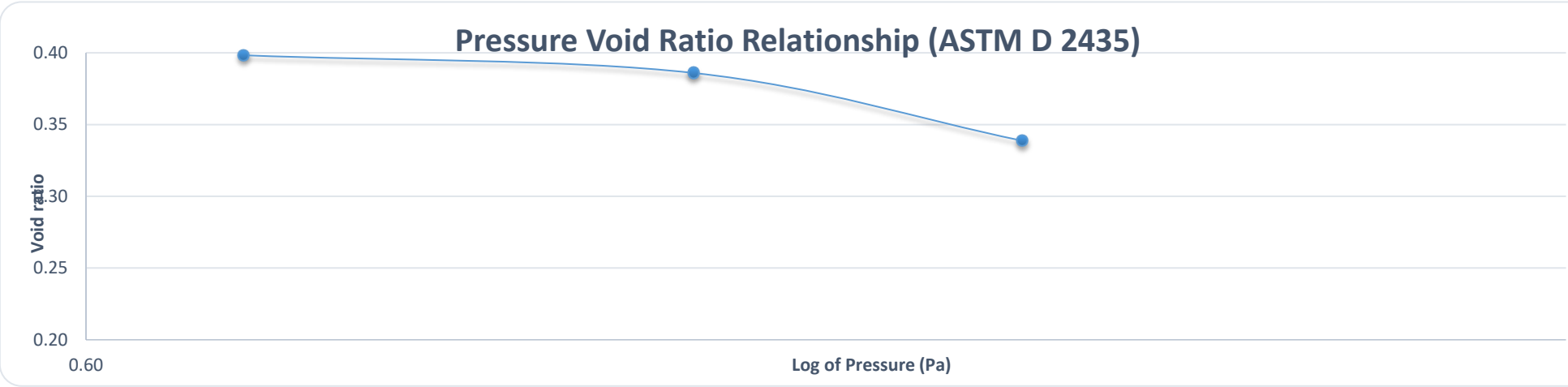
				WORKING SHEET NO: SAMPLE K6			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392 0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.136	0.009532379	0
1	4.81	0.6821	6.00	19.95000	0.086	0.006027828	0.39832
2	9.63	0.9836	8.00	19.86580	0.002	0.000126164	0.39241
3	19.28	1.2851	4.00	19.13900	-0.725	-0.050815989	0.34147
UNLOADING	0	0.0000	0.00	19.86400	0	0	0.39229
	Mv				Cc		
1	0.059221201						
2	0.000877454				0.4387	0.4387	
3	0.007606131						



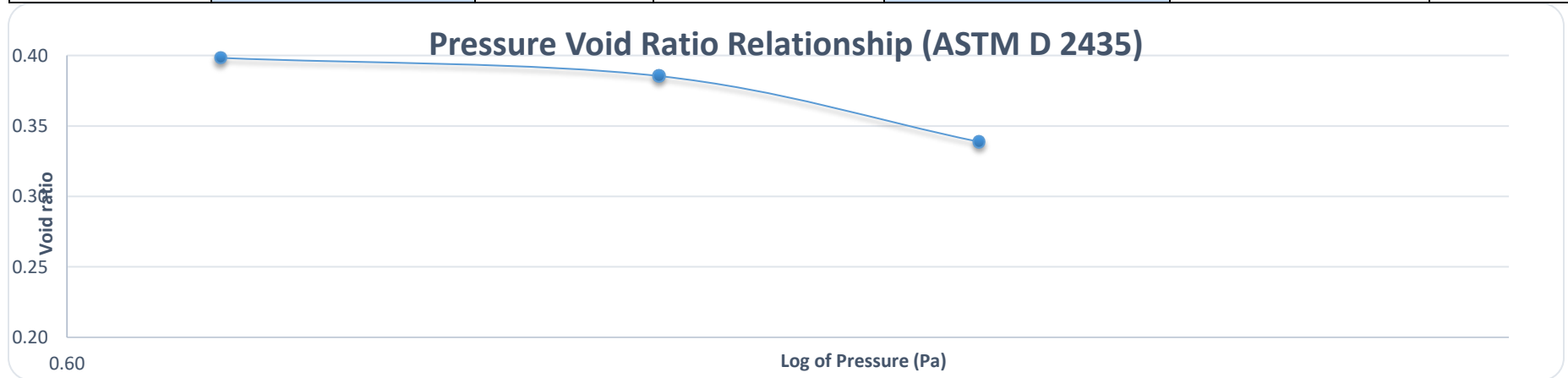
				WORKING SHEET NO: SAMPLE K7			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	6.00	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	8.00	19.07850	-0.501	-0.035591202	0.35670
3	19.28	1.2851	4.00	18.37688	-1.202	-0.085484307	0.30680
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	Mv				Cc		
1	0.058699432						
2	0.005479993				0.4297	0.4297	
3	0.007645619						



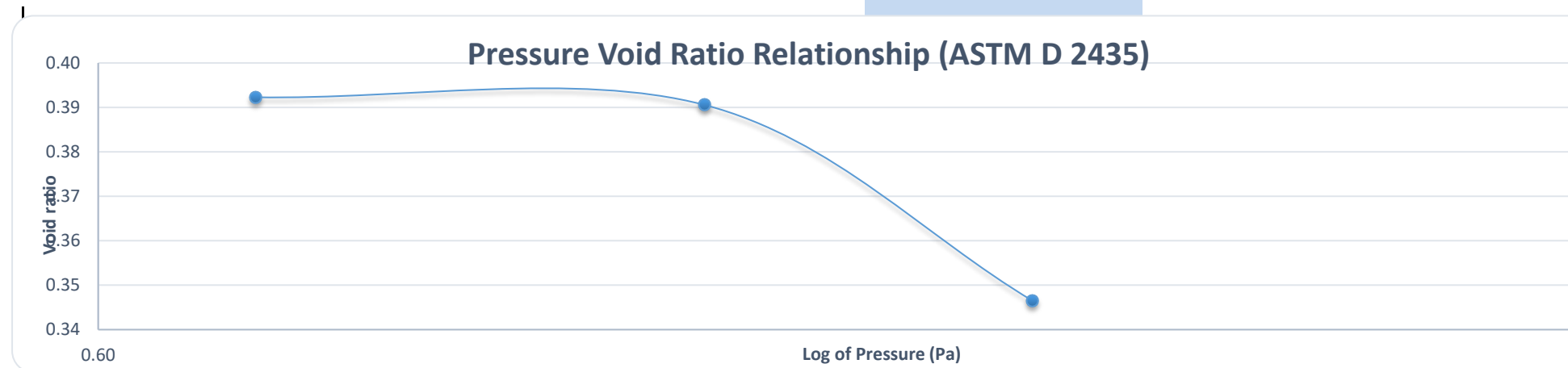
				WORKING SHEET NO: SAMPLE K8			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	
						0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.136	0.009532379	0
1	4.81	0.6821	6.00	19.95000	0.086	0.006027828	0.39832
2	9.63	0.9836	8.00	19.77378	-0.090	-0.006323612	0.38596
3	19.28	1.2851	4.00	19.10000	-0.764	-0.053549538	0.33874
UNLOADING	0	0.0000	0.00	19.86400	0	0	0.39229
	Mv				Cc		
1	0.059221201						
2	0.0018364				0.4067	0.4067	
3	0.007084078						



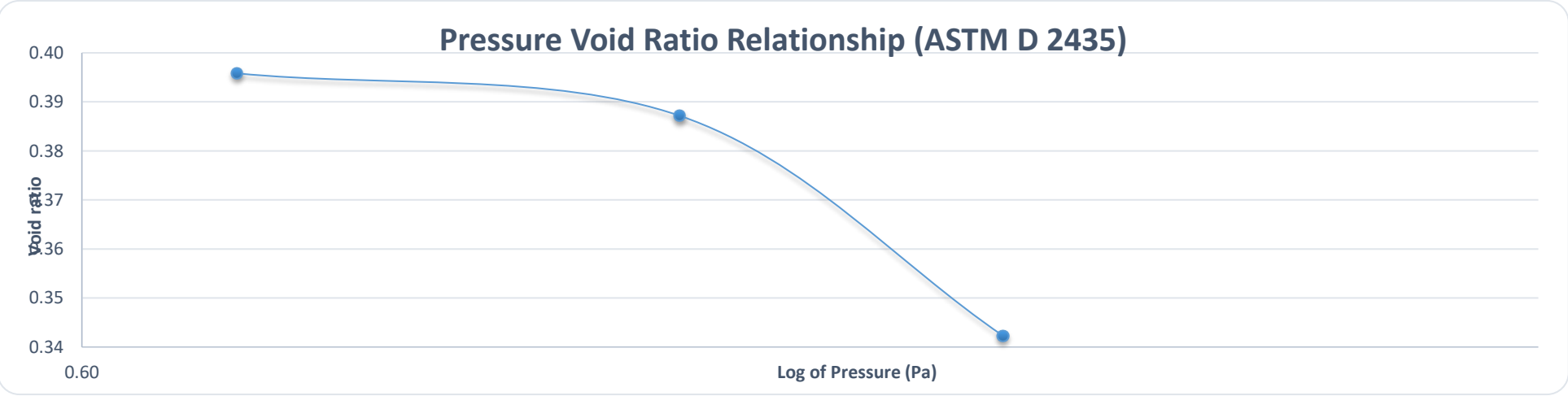
				WORKING SHEET NO: SAMPLE K9			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring		7.2	cm	Moisture Content, (final)	16.40%		
Height of specimen		2.00	cm	Specific Gravity Gs =	2.392	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.136	0.009532379	0
1	4.81	0.6821	6.00	19.95000	0.086	0.006027828	0.39832
2	9.63	0.9836	8.00	19.76615	-0.098	-0.006858406	0.38543
3	19.28	1.2851	4.00	19.10000	-0.764	-0.053549538	0.33874
UNLOADING	0	0.0000	0.00	19.86400	0	0	0.39229
	Mv				Cc		
1	0.059221201						
2	0.001915912				0.4021	0.4021	
3	0.00700656						



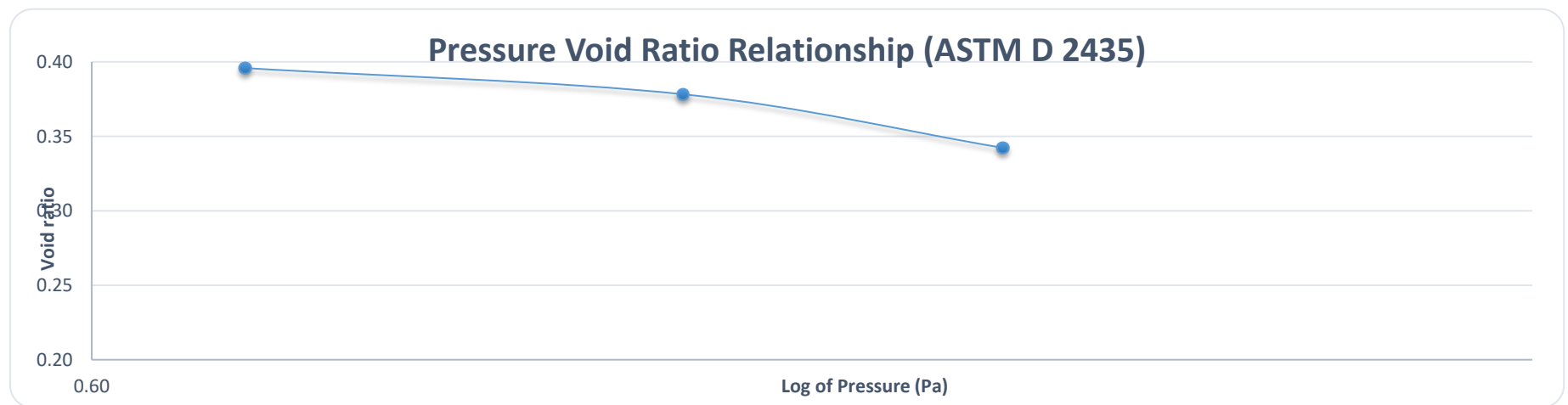
				WORKING SHEET NO: SAMPLE K10			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.250	0.017623899	0
1	4.81	0.6821	8.00	19.75000	0.000	0	0.39229
2	9.63	0.9836	9.00	19.72540	-0.025	-0.001734192	0.39055
3	19.28	1.2851	5.40	19.10000	-0.650	-0.045822137	0.34647
UNLOADING	0	0.0000	0.00	19.75000	0	0	0.39229
	Mv				Cc		
1	0.058577505						
2	0.000258954				0.3797	0.3797	
3	0.006591541						



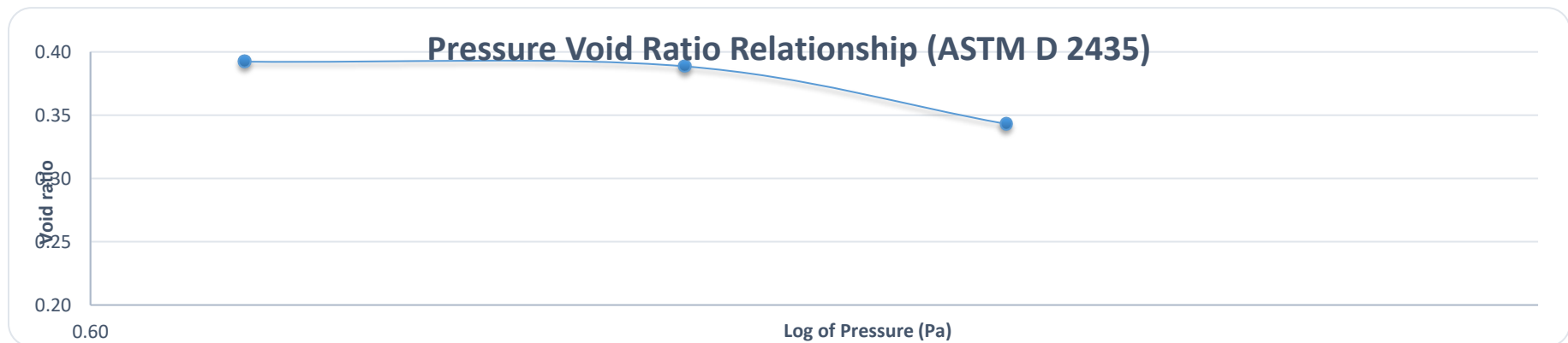
				WORKING SHEET NO: SAMPLE K11			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.310	0.021920228	0
1	4.81	0.6821	8.00	19.74000	0.050	0.003535521	0.39582
2	9.63	0.9836	9.00	19.61750	-0.073	-0.005126505	0.38716
3	19.28	1.2851	5.40	18.98250	-0.708	-0.050027616	0.34226
UNLOADING	0	0.0000	0.00	19.69000	0	0	0.39229
	Mv				Cc		
1	0.058955728						
2	0.001290161				0.3867	0.3867	
3	0.006729534						



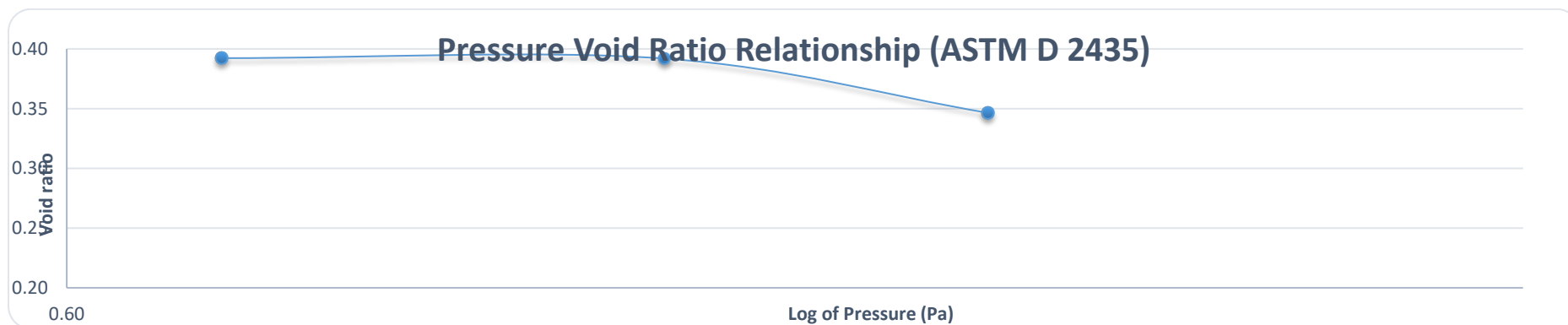
				WORKING SHEET NO: SAMPLE K12			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:					Sample No.		
Testing Date:					Checked By:		
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity G _s =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.310	0.021920228	0
1	4.81	0.6821	4.00	19.74000	0.050	0.003535521	0.39582
2	9.63	0.9836	6.00	19.49120	-0.199	-0.01405723	0.37823
3	19.28	1.2851	4.50	18.98250	-0.708	-0.050027616	0.34226
UNLOADING	0	0.0000	0.00	19.69000	0	0	0.39229
	M _v				C _c		
1	0.058955728						
2	0.002620343				0.3098	0.3098	
3	0.005425979						



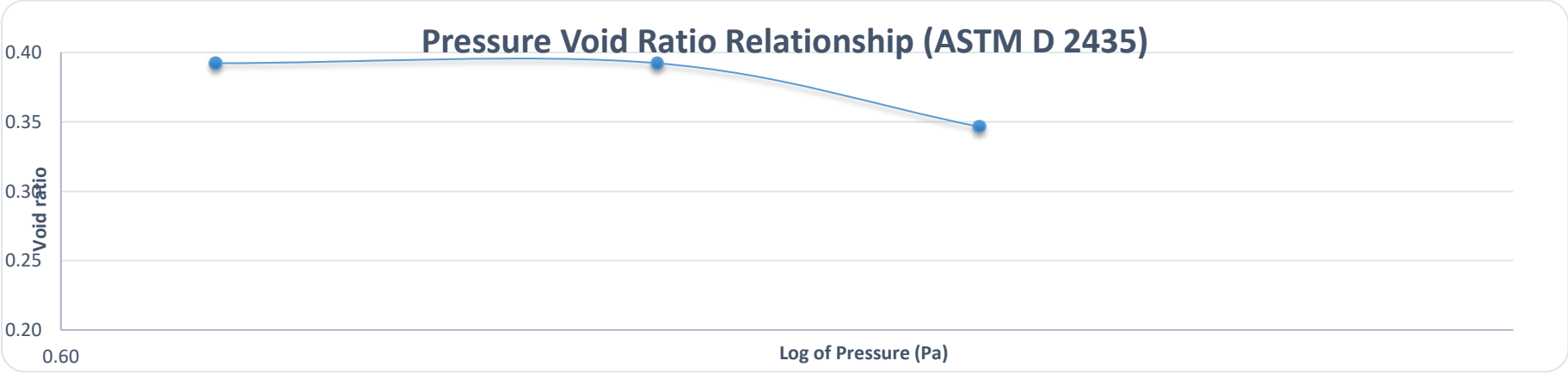
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				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392 0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.250	0.017623899	0
1	4.81	0.6821	5.50	19.75000	0.000	0	0.39229
2	9.63	0.9836	7.00	19.69760	-0.052	-0.003693969	0.38859
3	19.28	1.2851	5.00	19.05180	-0.698	-0.049220024	0.34307
UNLOADING	0	0.0000	0.00	19.75000	0	0	0.39229
	Mv				Cc		
1	0.058577505						
2	0.000551593				0.3921	0.3921	
3	0.006816158						



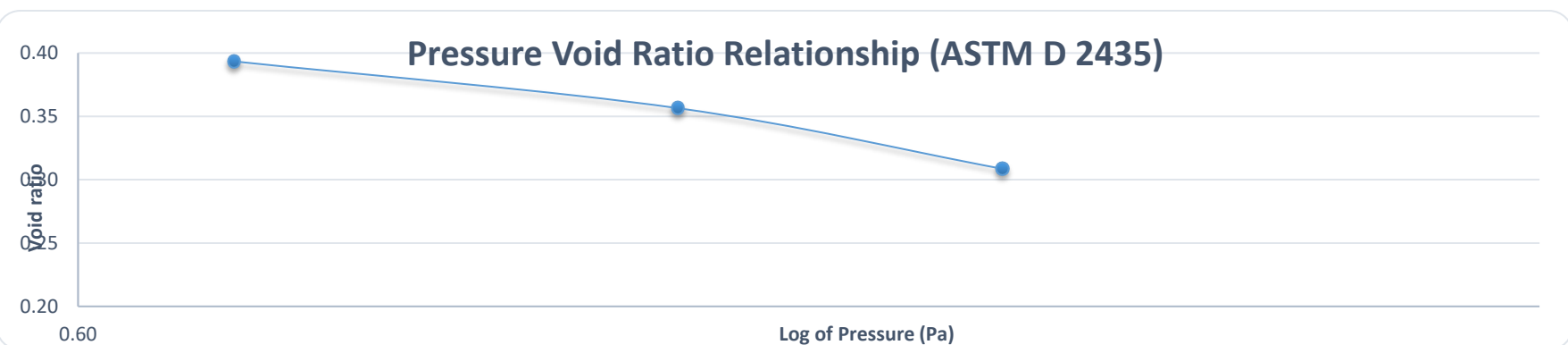
				WORKING SHEET NO: SAMPLE K22			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.250	0.017623899	0
1	4.81	0.6821	5.50	19.75000	0.000	0	0.39229
2	9.63	0.9836	7.00	19.74483	-0.005	-0.000364462	0.39192
3	19.28	1.2851	5.00	19.10000	-0.650	-0.045822137	0.34647
UNLOADING	0	0.0000	0.00	19.75000	0	0	0.39229
	Mv				Cc		
1	0.058577505						
2	5.44225E-05				0.3915	0.3915	
3	0.00678964						



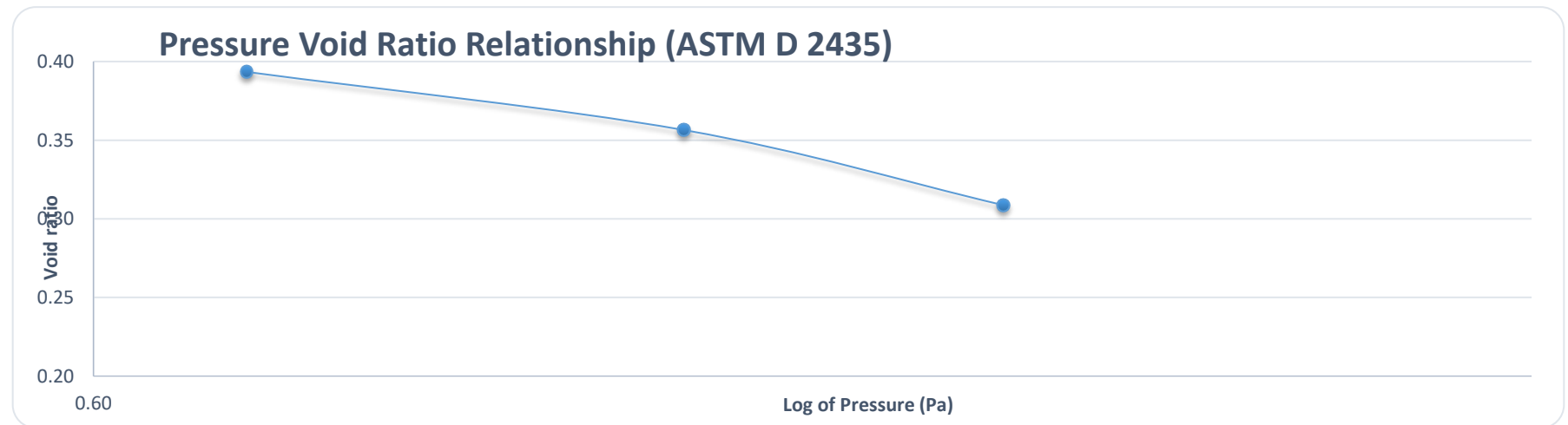
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				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring		7.2	cm	Moisture Content, (final)	16.40%		
Height of specimen		2.00	cm	Specific Gravity Gs =	2.392	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.250	0.017623899	0
1	4.81	0.6821	5.50	19.75000	0.000	0	0.39229
2	9.63	0.9836	7.00	19.74983	0.000	-1.19843E-05	0.39228
3	19.28	1.2851	5.00	19.10000	-0.650	-0.045822137	0.34647
UNLOADING	0	0.0000	0.00	19.75000	0	0	0.39229
	Mv				Cc		
1	0.058577505						
2	1.78952E-06				0.3945	0.3945	
3	0.006840555						



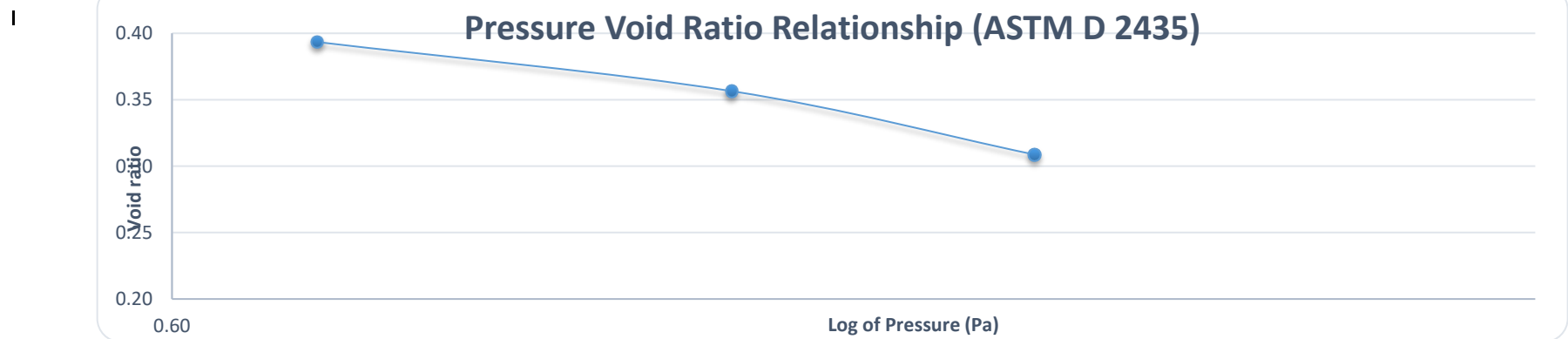
				WORKING SHEET NO: SAMPLE MK1			
CONSOLIDATION TEST ANALYSIS							
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity G _s =	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	6.50	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	4.30	19.07500	-0.504	-0.035840092	0.35645
3	19.28	1.2851	4.00	18.40148	-1.178	-0.083734969	0.30855
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	M _v				C _c		
1	0.058699432						
2	0.005517127				0.4125	0.4125	
3	0.007340757						



Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring		7.2	cm	Moisture Content, (final)	16.40%		
Height of specimen		2.00	cm	Specific Gravity G _s =	2.392	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	6.50	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	4.30	19.07500	-0.504	-0.035840092	0.35645
3	19.28	1.2851	4.00	18.40361	-1.175	-0.083583502	0.30870
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	M _v				C _c		
1	0.058699432						
2	0.005517127				0.4112		
3	0.007317542						

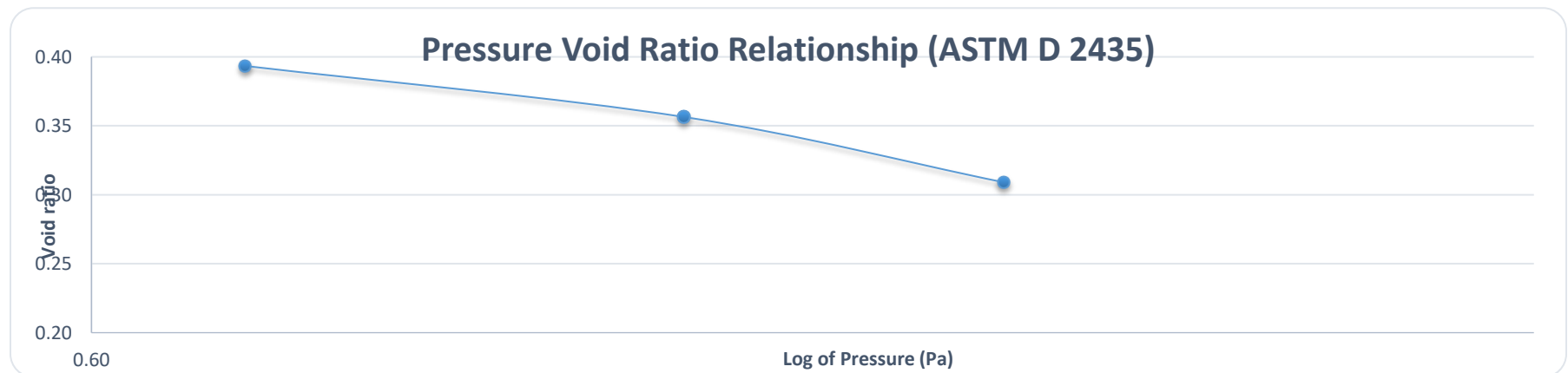


				WORKING SHEET NO: SAMPLE MK3			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity G _s =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	6.50	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	4.30	19.07500	-0.504	-0.035840092	0.35645
3	19.28	1.2851	4.00	18.40381	-1.175	-0.08356928	0.30872
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	M _v				C _c		
1	0.058699432						
2	0.005517127				0.4111	0.4111	
3	0.007315363						

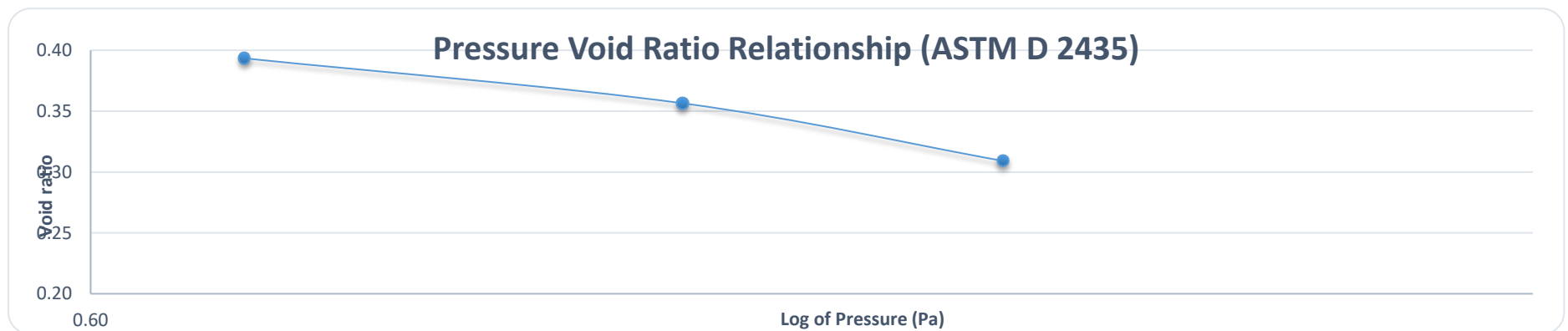


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CONSOLIDATION TEST ANALYSIS							
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring		7.2	cm	Moisture Content, (final)	16.40%		
Height of specimen		2.00	cm	Specific Gravity G _s =	2.392	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	6.50	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	4.30	19.07500	-0.504	-0.035840092	0.35645
3	19.28	1.2851	4.00	18.39140	-1.188	-0.084451771	0.30784
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	M _v				C _c		
1	0.058699432						
2	0.005517127				0.4187	0.4187	
3	0.00745062						

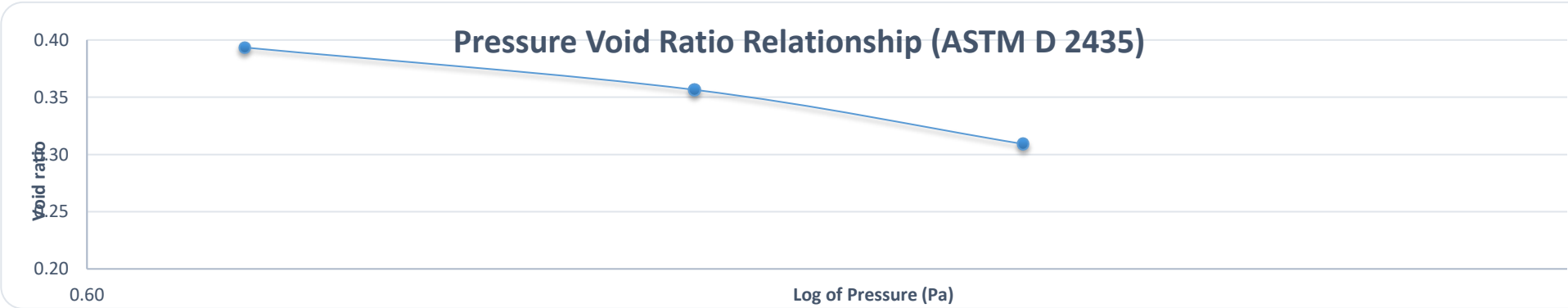
				WORKING SHEET NO: SAMPLE N1			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring		7.2	cm	Moisture Content, (final)	16.40%		
Height of specimen		2.00	cm	Specific Gravity Gs =	2.392	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	6.00	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	8.00	19.07500	-0.504	-0.035840092	0.35645
3	19.28	1.2851	4.00	18.40781	-1.171	-0.083284835	0.30900
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	Mv				Cc		
1	0.058699432						
2	0.005517127				0.4086	0.4086	
3	0.007271766						



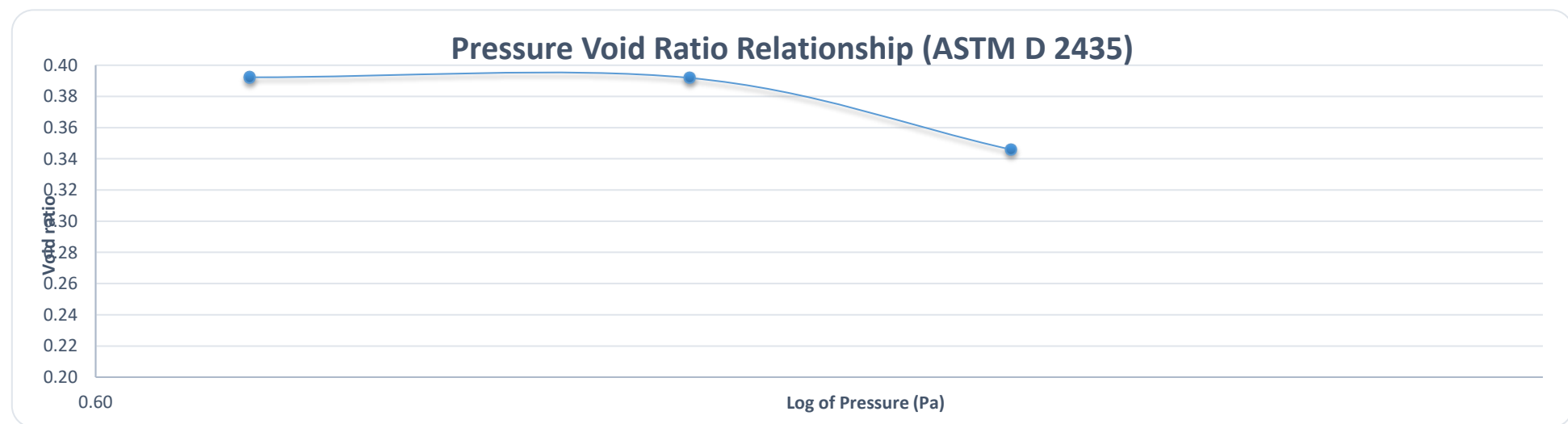
				WORKING SHEET NO: SAMPLE N2			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	6.00	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	8.00	19.07500	-0.504	-0.035840092	0.35645
3	19.28	1.2851	4.00	18.40950	-1.170	-0.083164657	0.30912
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	Mv				Cc		
1	0.058699432						
2	0.005517127				0.4076	0.4076	
3	0.007253347						



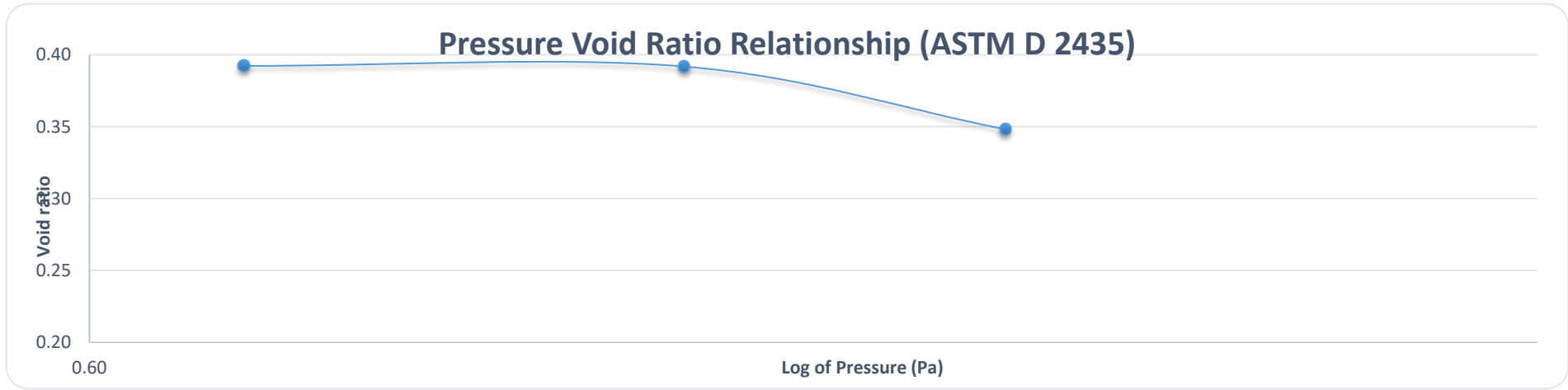
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				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	6.00	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	8.00	19.07500	-0.504	-0.035840092	0.35645
3	19.28	1.2851	4.00	18.40900	-1.170	-0.083200212	0.30909
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	M _v				C _c		
1	0.058699432						
2	0.005517127				0.4079	0.4079	
3	0.007258796						



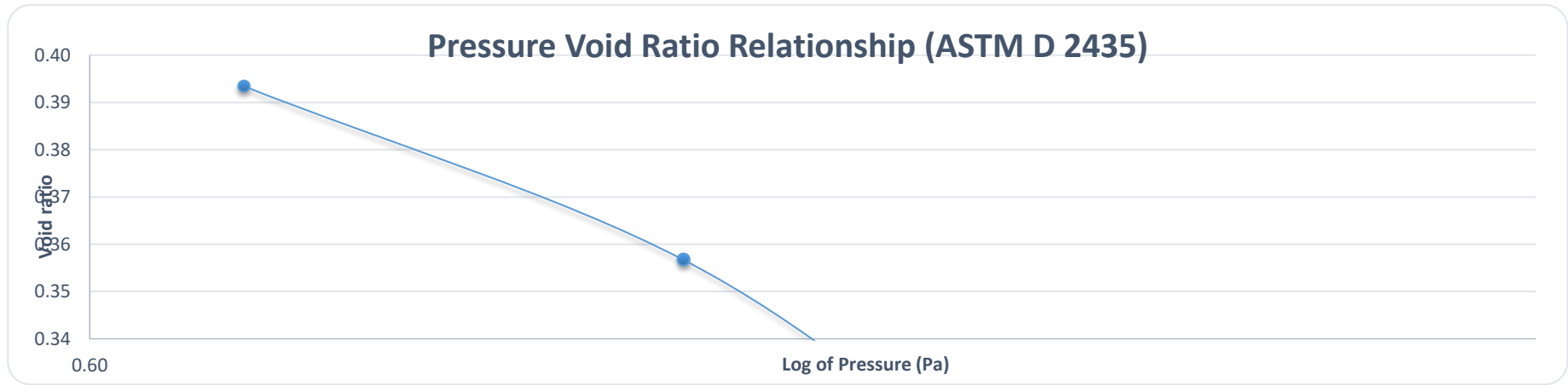
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				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.250	0.017623899	0
1	4.81	0.6821	2.70	19.75000	0.000	0	0.39229
2	9.63	0.9836	6.00	19.74400	-0.006	-0.000422974	0.39187
3	19.28	1.2851	2.80	19.09240	-0.658	-0.046357903	0.34593
UNLOADING	0	0.0000	0.00	19.75000	0	0	0.39229
	Mv				Cc		
1	0.058577505						
2	6.31596E-05				0.3956	0.3956	
3	0.006861212						



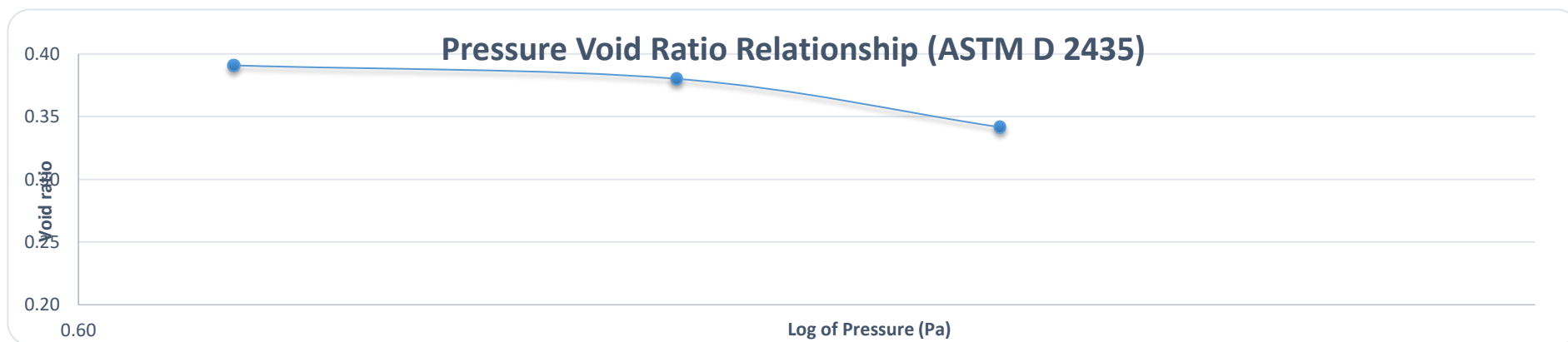
				WORKING SHEET NO: SAMPLE R2			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring		7.2	cm	Moisture Content, (final)	16.40%		
Height of specimen		2.00	cm	Specific Gravity Gs =	2.392	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.250	0.017623899	0
1	4.81	0.6821	5.50	19.75000	0.000	0	0.39229
2	9.63	0.9836	7.00	19.74400	-0.006	-0.000422974	0.39187
3	19.28	1.2851	5.00	19.12440	-0.626	-0.044102044	0.34819
UNLOADING	0	0.0000	0.00	19.75000	0	0	0.39229
	Mv				Cc		
1	0.058577505						
2	6.31596E-05				0.3762	0.3762	
3	0.006524259						



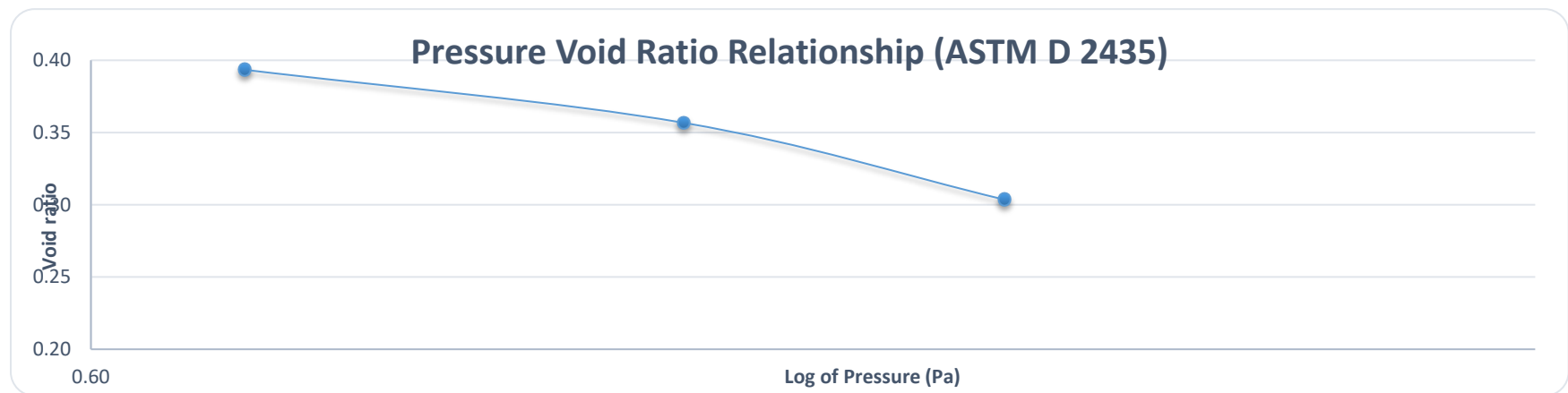
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				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring		7.2	cm	Moisture Content, (final)	16.40%		
Height of specimen		2.00	cm	Specific Gravity Gs =	2.392	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	10.00	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	7.50	19.07850	-0.501	-0.035591202	0.35670
3	19.28	1.2851	4.90	18.42070	-1.158	-0.08236821	0.30992
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	Mv				Cc		
1	0.058699432						
2	0.005479993				0.4029	0.4029	
3	0.007168108						



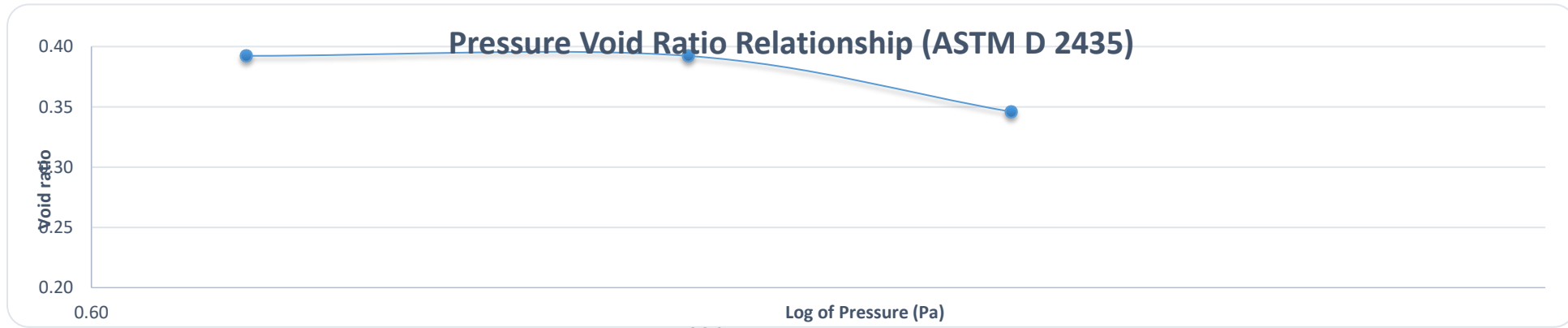
				WORKING SHEET NO: SAMPLE R5			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:					Sample No.		
Testing Date:					Checked By:		
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.260	0.01833814	0
1	4.81	0.6821	4.00	19.72000	-0.020	-0.001410626	0.39088
2	9.63	0.9836	6.00	19.56826	-0.172	-0.012113047	0.38017
3	19.28	1.2851	4.50	19.02100	-0.719	-0.05071201	0.34158
UNLOADING	0	0.0000	0.00	19.74000	0	0	0.39229
	Mv				Cc		
1	0.058426062						
2	0.001599735				0.3324	0.3324	
3	0.005814286						



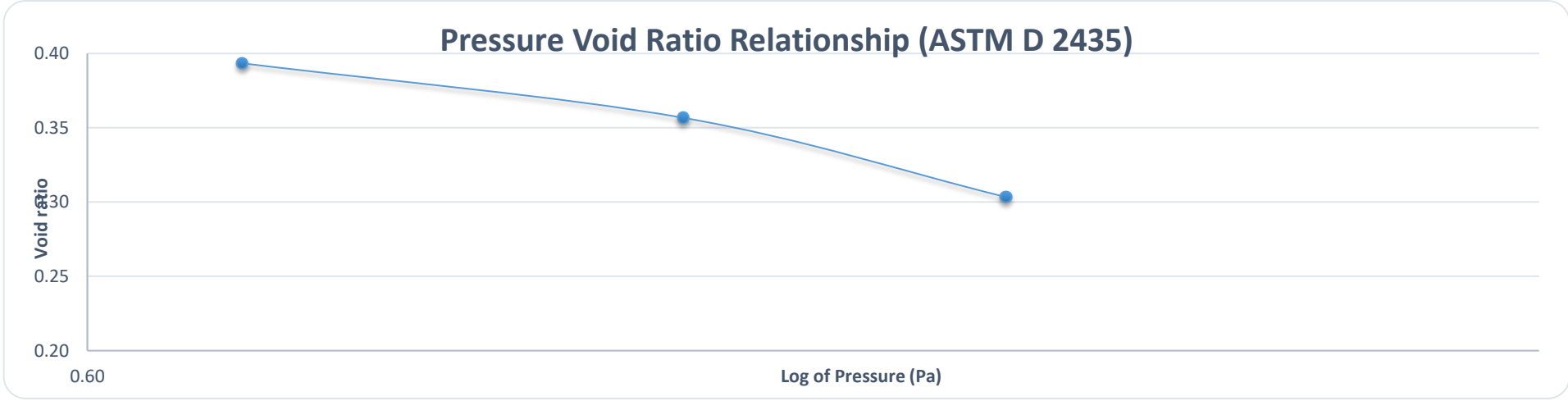
				WORKING SHEET NO: SAMPLE R6			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity G _s =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	6.00	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	8.00	19.07850	-0.501	-0.035591202	0.35670
3	19.28	1.2851	4.00	18.33080	-1.248	-0.088761116	0.30353
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	M _v				C _c		
1	0.058699432						
2	0.005479993				0.4579	0.4579	
3	0.008147757						



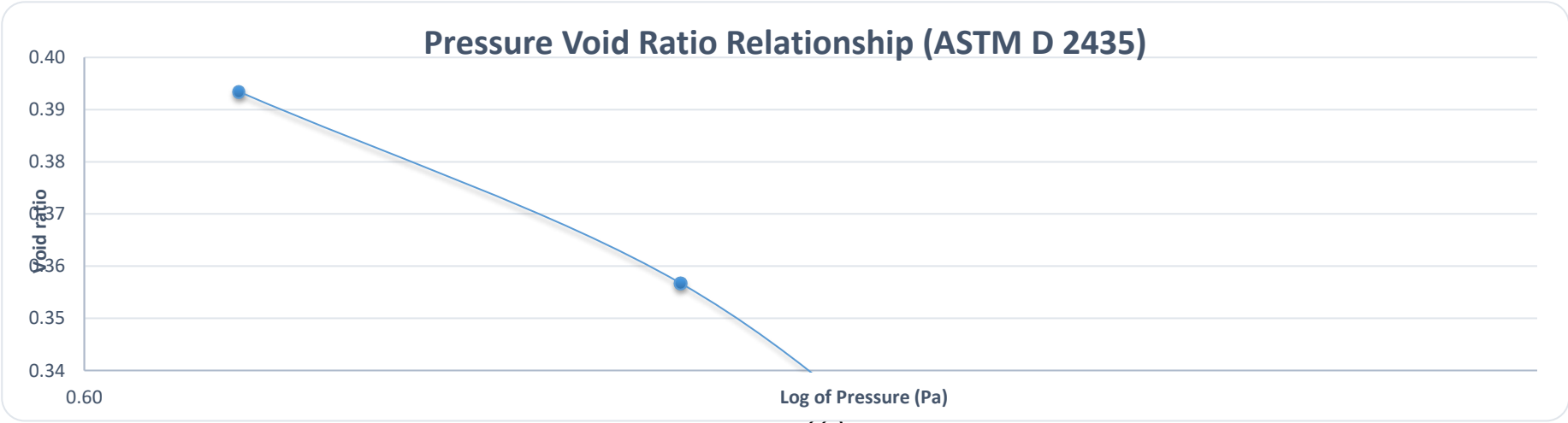
				WORKING SHEET NO: SAMPLE R7			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392 0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.250	0.017623899	0
1	4.81	0.6821	2.70	19.75000	0.000	0	0.39229
2	9.63	0.9836	6.00	19.74905	-0.001	-6.69708E-05	0.39222
3	19.28	1.2851	2.80	19.09240	-0.658	-0.046357903	0.34593
UNLOADING	0	0.0000	0.00	19.75000	0	0	0.39229
	Mv				Cc		
1	0.058577505						
2	1.00003E-05				0.3987	0.3787	
3	0.00691262						



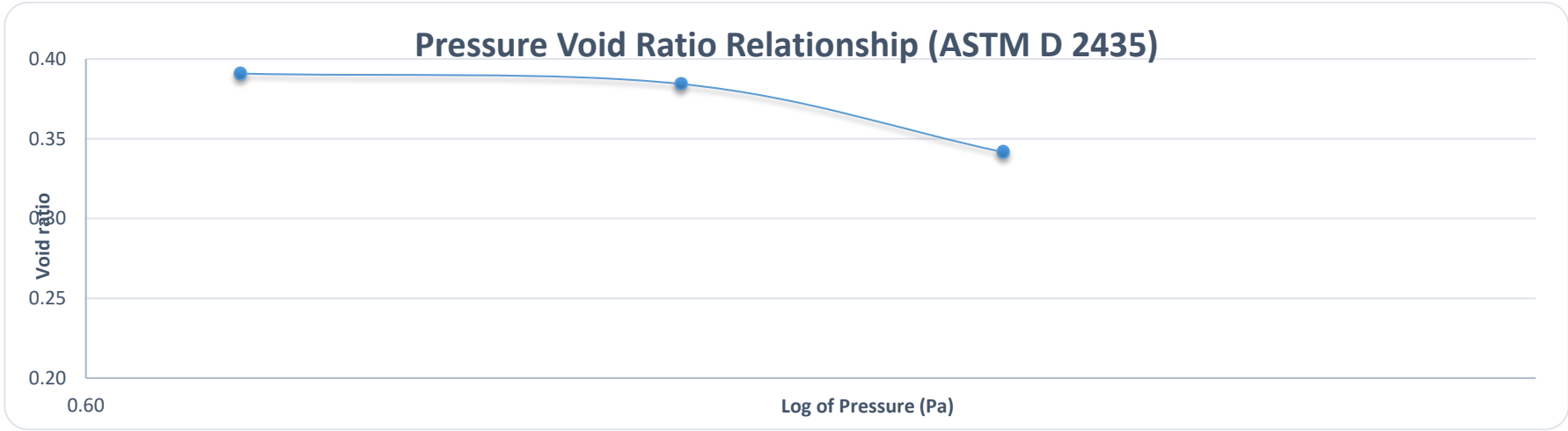
				WORKING SHEET NO: SAMPLE R10			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity G _s =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	6.50	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	4.30	19.07850	-0.501	-0.035591202	0.35670
3	19.28	1.2851	4.00	18.32920	-1.250	-0.088874894	0.30341
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	M _v				C _c		
1	0.058699432						
2	0.005479993				0.4589	0.4589	
3	0.008165193						



				WORKING SHEET NO: SAMPLE 11			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring			7.2	cm	Moisture Content, (final)	16.40%	
Height of specimen			2.00	cm	Specific Gravity Gs =	2.392	0.000
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.421	0.029937854	0
1	4.81	0.6821	10.00	19.59500	0.016	0.001137781	0.39343
2	9.63	0.9836	7.50	19.07850	-0.501	-0.035591202	0.35670
3	19.28	1.2851	4.90	18.41250	-1.167	-0.082951323	0.30934
UNLOADING	0	0.0000	0.00	19.57900	0	0	0.39229
	Mv				Cc		
1	0.058699432						
2	0.005479993				0.4079	0.4079	
3	0.007257465						



				WORKING SHEET NO: SAMPLE S6			
				CONSOLIDATION TEST ANALYSIS			
Project:							
Client:							
Sampling Date:				Sample No.			
Testing Date:				Checked By:			
Inside diameter of the ring		7.2	cm	Moisture Content, (final)	16.40%		
Height of specimen		2.00	cm	Specific Gravity Gs =	2.392	0.000	
Increment No.	Pressure	Log of Pressure	Time for 50% consolidation t ₅₀ (mins)	Height,H(mm)	Change In Height(dH)	Change in void ratio(de)	Void ratio
0	0	0	0	20	0.260	0.01833814	0
1	4.81	0.6821	2.70	19.72000	-0.020	-0.001410626	0.39088
2	9.63	0.9836	6.00	19.62750	-0.112	-0.007934772	0.38435
3	19.28	1.2851	2.80	19.02200	-0.718	-0.050641478	0.34165
UNLOADING	0	0.0000	0.00	19.74000	0	0	0.39229
	Mv				Cc		
1	0.058426062						
2	0.000975191				0.3678	0.3678	
3	0.006413633						



APPENDICES C: results of Atterberg limits and Compression Index from RSV Materials Laboratory