ADDIS ABABA UNIVERSITY

ADDIS ABABA INISTITUTION OF TECNOLOGY

SCHOOL OF CIVIL AND ENVIROMENTAL ENGINEERING

EVALUATION OF ONE POINT LIQUID LIMIT TEST FOR EXPANSIVE CLAY SOILS OF ETHIOPIA

By

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A THESIS SUBMITTED TO SCHOOL OF GRAGUATED STUDIES OF ADDIS ABABA UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF ENGINEERING IN CIVIL ENGINEERING (GEOTECNICAL ENGINEERING)

By

NARDOS BELETE

ADVISOR

PROF. ALEMAYEHU TEFERRA

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Approved by board of examiners:

Prof. Alemayehu Teferra	____________	____________
Advisor	Signature	Date
Dr.Ing. Samuel Tadesse	____________	____________
Examiner	Signature	Date
____________	____________	____________
Chairman	Signature	Date

DECLARATION

I, the undersigned, declare that this research work titled "EVALUATION OF ONE POINT LIQUID LIMIT TEST FOR EXPANSIVE CLAY SOILS OF ETHIOPIA**"** is my original work performed under the supervision of my research advisor Prof. Alemayehu Teferra and has not been presented for a degree in any other university. All Sources of materials used for this thesis have been duly acknowledged/ referred.

Name: Nardos Belete

Signature ________________________

Place: Addis Ababa institute of technology,

School of civil and Environmental Engineering,

Addis Ababa University,

Addis Ababa

Date: November, 2015

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List of Symbols

ASTM –American Society for Testing and Material

AASHTO-American Association of Highway and Transportation Officials

AAU-Addis Ababa University

CEC- Cation Exchange Capacity

USCS-Unified Soil Classification System

LL-Liquid Limit

PI-Plastic Index

PL-Plastic Limit

N-No of blows

Wn-Water content

tanβ- Slope of the flow line on semi log plot

Abstract

The clay mineral composition is one of the factors that affect the physical properties of soil, and knowledge of it is required to promote a fuller understanding of the origin of these properties. The relation between the clay content and plastic and liquid limits of natural montmorillonitic and kaolitic soils and of artificial mixtures have been examine and compared. Clay soil, expansive soil has a special mineralogical characteristic which leads to swelling when expose to moisture change. This behavior is due to the presence of considerable amount of montmorillonite clay mineral.

The liquid limit is by one point method is the water content, experience in percent, at which the soil change from a liquid state to plastic state and principally it is defined as the water content at which the soil pat cut using standard groove closes for about a distance of 13cm (1/2 in) at certain blows, for a good determination N should be between 20 and 31 blows and with a range of 15 to 41 blows allowable for classification purposes, of the liquid limit machine (casagrande Apparatus).The liquid limit of a soil highly depends upon the clay mineral present.

Thus, this paper is mainly investigating the Evaluation of one point liquid limit test for expansive clay soils of Ethiopia. According, several data was taken from different thesis that was done before on different local places. The relation obtained from statistical analysis relationship has an R^2 *of 0.787 and it shown below.*

$$LL=Wn(N/25)^{0.104}$$

The results of the statistical analysis show that good correlation does exist between the between liquid limit and moisture content of local clay expansive soil.

1. Introduction

Potentially expansive soils find wide distribution in Ethiopia. Expansive soils which are clay those are commonly black and gray in colure with highly plastic properties. The commonly knowing characteristic is swelling when it gen water, shrink when it lost water.

Investigate the engineering properties of the soils is necessary since expansive soils are causing greater damage to those civil engineering structures most of structural damages due to expansive soils result from the differential rather than the total movement of the foundation soil as a result of swell. Damage can occur within a few months following construction, may develop slowly with in a years, or May not appear for many years until some activity occur to disturb the soil moisture equilibrium.

Liquid limit is the percentage of water contain at which the soil has such small shear strength that is flows to close a grove standard width when jarred in a specified manner. At the moisture content of LL the distance between particle is such that the force of interaction between particle in sufficiently weak to allow easy movement of particles relatively to each other. It is dependent on the amount and type clay. one point liquid limit which used the data one trail at one water content multiple by a correction factor to determine the liquid limit.

In this research, the intention of examining is investigating the Evaluation of one point liquid limit test for expansive clay soils of Ethiopia based on the data was taken from different thesis that was done before on different local places.

Therefore the main objective of this research is to investigating the Evaluation of one point liquid limit test for expansive clay soils of Ethiopia.Because of the great potential for to determine the liquid limit easily by taking a single trail at any blows corresponding to water content.

2. Objectives and methodology

2.1 Objectives

In Ethiopia, one point liquid limit method has determined by using ASTM Test Designation D-4318 (LL= Wn (N/25)$^{\tan\beta}$ where tanβ =0.12) ,which is driven from for soil of other locality (outside Ethiopia).

The main objective of this project is to investigating the Evaluation of one point liquid limit test for expansive clay soils of Ethiopia, depending on ASTM Test Designation D-4318 formula; by determine tanβ (slopes of the flow line on a semi log plot) for expansive soil of Ethiopia.

2.2 Methodology

In order to achieve the objective of this project, related researches which were done before are reviewed. In addition the data was selected from researches accomplished on index properties of local soil. A set of 124 different data were selected.

Thus, by used statically regression analysis method analysis was performing by two independent methods (Average value method and linear regression method) by using the X^2 test for each data and then correlated the collected data. Finally, conclusion and recommendation are made.

3. Literature review

3.1 Genera characteristics of swelling soil

Swelling soils, which are clayey soils, are also called expansive soils. When these soils are partially saturated, they increase in volume with the addition of water. They shrink greatly on drying and develop cracks on the surface. These soils possess a high plasticity index. The color varies from dark grey to black. It is easy to recognize these soils in the field during either dry or wet seasons. Shrinkage cracks are visible on the ground surface during dry seasons. The maximum width of these cracks may be up to 20 mm or more and they travel deep into the ground. A lump of dry black cotton soil requires a hammer to break. During rainy seasons, these soils become very sticky and very difficult to traverse.

Expansive soils are residual soils which are the result of weathering of the parent rock. The depths of these soils in some regions may be up to 6 m or more. Normally the water table is met at great depths in these regions. As such the soils become wet only during rainy seasons and are dry or partially saturated during the dry seasons. In regions which have well-defined, alternately wet and dry seasons, these soils swell and shrink in regular cycles. Since moisture change in the soils bring about severe movements of the mass, any structure built on such soils experiences recurring cracking and progressive damage (1).

In Ethiopia expansive soils are observed in area such as central Ethiopia, following the major trunk road like Addis Ambo, Addis Weliso, Addis Debere berehan, Addis Gohatsion, Addis Mojo.(15).Also the cover the area like mekele,Gsmbela and the most Southern ,South-west and south- east part of the capital Addis ababa area in which the most major recent construction are being carried out. the distribution are shown in figure 1.1(15).

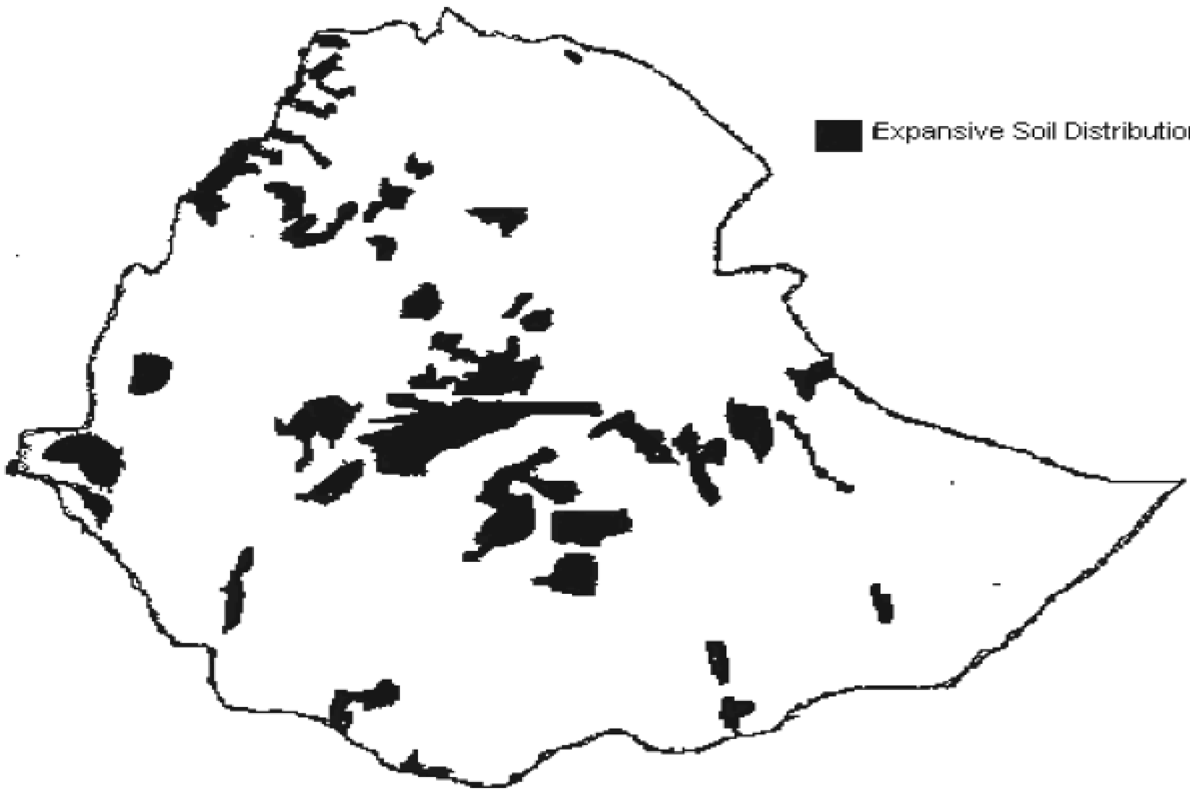

Figure 1.1 Distribution of expansive soil Ethiopia.

3.2 CLAY MINERALOGY AND MECHANISM OF SWELLING

Clays can be divided into three general groups on the basis of their crystalline arrangement. They are:

1. Kaolinite group
2. Montmorillonite group (also called the smectite group)
3. Illite group.

The kaolinite groups of minerals are the most stable of the groups of minerals. The kaolinite mineral is formed by the stacking of the crystalline layers of about 7 A thick one above the other with the base of the silica sheet bonding to hydroxyls of the gibbsite sheet by hydrogen bonds. Since hydrogen bonds are comparatively strong, the kaolinite crystals consists of many sheet stackings that are difficult to dislodge. The mineral is, therefore, stable and water cannot enter between the sheets to expand the unit cells [(1).]

The structural arrangement of the montmorillonite mineral is composed of units made of two silica tetrahedral sheets with a central alumina-octahedral sheet. The silica and gibbsite sheets are combined in such a way that the tips of the tetrahedrons of each silica sheet and one of the hydroxyl layers of the octahedral sheet form a common layer. The atoms common to both the silica and gibbsite layers are oxygen instead of hydroxyls. The thickness of the silica-gibbsite-silica unit is about 10 A. In stacking of these combined units one above the other, oxygen layers of each unit are adjacent to oxygen of the neighboring units, with a consequence that there is a weak bond and excellent cleavage between them. Water can enter between the sheets causing them to expand significantly and thus the structure can break into 10 A thick structural units. The soils containing a considerable amount of montmorillonite minerals will exhibit high swelling and shrinkage characteristics.

The illite group of minerals has the same structural arrangement as the montmorillonite group. The presence of potassium as the bonding materials between units makes the illite minerals swell less [(1).]

3.3 CLAY PARTICLES-WATER RELATIONS

The behavior of a soil mass depends upon the behavior of the discrete particles composing the mass and the pattern of particle arrangement. In all these cases water plays an important part. The

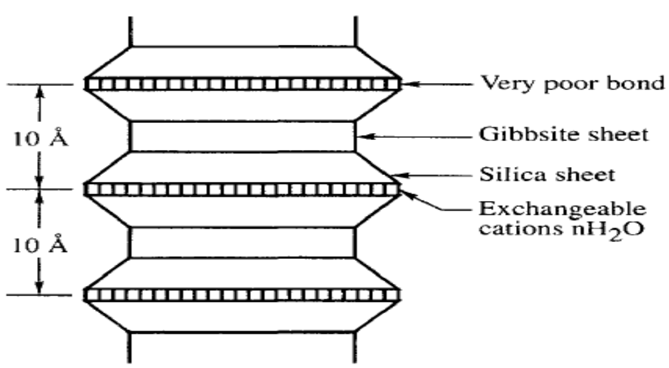

Fig 2.1 structure of montmorilonite layer

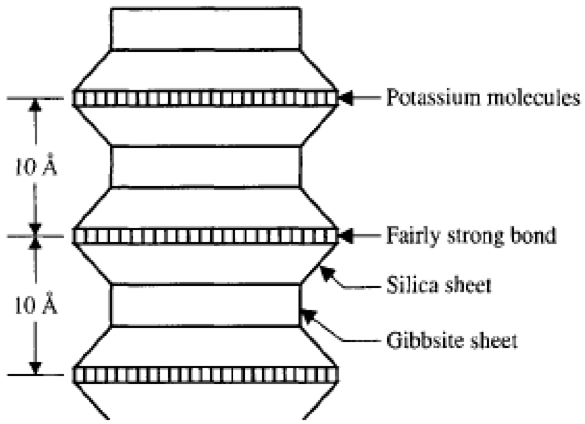

Fig 2.2 structure of ilite layer

behavior of the soil mass is profoundly influenced by the inter-particle-water relationships, the ability of the soil particles to adsorb exchangeable cations and the amount of water present[(1).]

Adsorbed Water

The clay particles carry a net negative charge on their surface. This is the result of both isomorphous substitution and of a break in the continuity of the structure at its edges. The intensity of the charge depends to a considerable extent on the mineralogical character of the particle. The physical and chemical manifestations of the surface charge constitute the surface activity of the mineral. Minerals are said to have high or low surface activity, depending on the intensity of the surface charge. As pointed out earlier, the surface activity depends not only on the specific surface but also on the chemical and mineralogical composition of the solid particle. The surface activity of sand, therefore, will not acquire all the properties of true clay, even if it is ground to a fine powder. The presence of water does not alter its properties of coarser fractions considerably excepting changing its unit weight. However, the behavior of a saturated soil mass consisting of fine sand might change under dynamic loadings. This aspect of the problem is not considered here. This article deals only with clay particle-water relations [(1).]

In nature every soil particle is surrounded by water. Since the centers of positive and negative charges of water molecules do not coincide, the molecules behave like dipoles. The negative charge on the surface of the soil particle, therefore, attracts the positive (hydrogen) end of the water molecules. The water molecules are arranged in a definite pattern in the immediate vicinity of the boundary between solid and water. More than one layer of water molecules sticks on the surface with considerable force and this attractive force decreases with the increase in the distance of the water molecule from the surface. The electrically attracted water that surrounds the clay particle is known as the diffused double-layer of water. The water located within the zone of influence is known as the adsorbed layer as shown in Fig. 2.3. Within the zone of influence the physical properties of the water are very different from those of free or normal water at the same temperature. Near the surface of the particle the water has the property of a solid. At the middle of the layer it resembles a very viscous liquid and beyond the zone of influence, the properties of the water become normal. The adsorbed water affects the behavior of clay particles when subjected to external stresses, since it comes between the particle surfaces. To drive off the adsorbed water, the clay particle must be heated to more than 200 °C, which would indicate that the bond between the water molecules and the surface is considerably greater than that between normal water molecules (1).

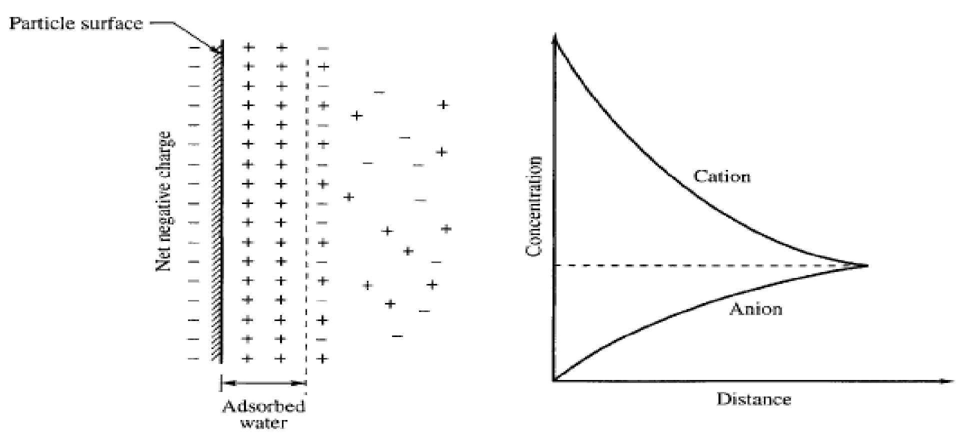

Fig 2.3 adsorbed water layer surrounding a soil particle

The adsorbed film of water on coarse particles is thin in comparison with the diameter of the particles. In fine grained soils, however, this layer of adsorbed water is relatively much thicker and might even exceed the size of the grain. The forces associated with the adsorbed layers therefore play an important part in determining the physical properties of the very fine-grained soils, but have little effect on the coarser soils [(1).]

Soils in which the adsorbed film is thick compared to the grain size have properties quite different from other soils having the same grain sizes but smaller adsorbed films. The most pronounced characteristic of the former is their ability to deform plastically without cracking when mixed with varying amounts of water. This is due to the grains moving across one another supported by the viscous interlayer of the films. Such soils are called cohesive soils, for they do not disintegrate with pressure but can be rolled into threads with ease. Here the cohesion is not due to direct molecular interaction between soil particles at the points of contact but to the shearing strength of the adsorbed layers that separate the grains at these points [(1).]

Base Exchange

Electrolytes dissociate when dissolved in water into positively charged cations and negatively charged anions. Acids break up into cations of hydrogen and anions such as Cl or SO4. Salts and bases split into metallic cations such as Na, K or Mg, and nonmetallic anions. Even water itself is an electrolyte, because a very small fraction of its molecules always dissociates into hydrogen ions H+ and hydroxyl ions OH". These positively charged H+ ions migrate to the surface of the negatively charged particles and form what is known as the adsorbed layer. These H+ ions can be replaced by other cations such as Na, K or Mg. These cations enter the adsorbed layers and constitute what is termed as an adsorption complex. The process of replacing cations of one kind by those of another in an adsorption complex is known as base exchange. By Base Exchange is meant the capacity of

table 2.1 Exchange capacity of some clay minerals

Mineral group	Exchange capacity (meq per 100 g)
Kaolinite	3.8
Illite	40
Montmorillonite	80

Table 2.2 Cations arranged in the order of decreasing shear strength of clay

$NH_4^+ > H^+ > K^+ > Fe^{+++} > A1^{+++} > Mg^+ > Ba^{++} > Ca^{++} > Na^+ > Li^+$

Colloidal particles to change the cations adsorbed on their surface. Thus a hydrogen clay (colloid with adsorbed H cations) can be changed to sodium clay (colloid with adsorbed Na cations) by a constant percolation of water containing dissolved Na salts. Such changes can be used to decrease the permeability of a soil. Not all adsorbed cations are exchangeable. The quantity of exchangeable cations in a soil is termed exchange capacity.

The base exchange capacity is generally defined in terms of the mass of a cation which may be held on the surface of 100 gm dry mass of mineral. It is generally more convenient to employ a definition of base exchange capacity in milli-equivalents (meq) per 100 gm dry soil. One meq is one milligram of hydrogen or the portion of any ion which will combine with or displace

1 milligram of hydrogen. The relative exchange capacity of some of the clay minerals is given in Table 2.1

If one element, such as H, Ca, or Na prevails over the other in the adsorption complex of a clay, the clay is sometimes given the name of this element, for example H-clay or Ca-clay. The thickness and the physical properties of the adsorbed film surrounding a given particle, depend to a large extent on the character of the adsorption complex. These films are relatively thick in the case of strongly water-adsorbent cations such as Li+ and Na+ cations but very thin for H+. The films of other cations have intermediate values. Soils with adsorbed Li+ and Na+ cations are relatively more plastic at low water contents and possess smaller shear strength because the particles are separated by a thicker viscous film. The cations in Table 2.5 are arranged in the order of decreasing shear strength of clay.

Sodium clays in nature are a product either of the deposition of clays in sea water or of their saturation by saltwater flooding or capillary action. Calcium clays are formed essentially by fresh water sediments. Hydrogen clays are a result of prolonged leaching of a clay by pure or acidic water, with the resulting removal of all other exchangeable bases [(1).]

3.4 Classification Methods

Parameters determined from expansive soil identification tests have been combined in number of different classification schemes the classification system used for expansive soils are based on indirect and direct prediction of swell potential as well as combinations to arrive at a rating.

- Classification Using General Methods

Soils are classified in the general schemes: Unified Soil Classification System (USCS) and the American Association of State High way and Transportation Officials (AASHTO) method according to index properties. Soils rated CL or CH by the USCS, and A-6 or A-7 by AASHTO, can be considered potentially expansive (Nelson, 1992)

- Cation Exchange Capacity (CEC)

The CEC is the quantity of exchangeable cations required to balance the negative charge on the surface of the clay particles. CEC is expressed in milli-equivalents per 100 grams of dry clay. CEC is related to clay mineralogy. High CEC values indicate a high surface activity. In general, swell potential increases as the CEC increases. Typical values of CEC for the three basic clay minerals are given in Table 2-3.

Table 2-3 Typical CEC values of basic clay minerals after Mitchell, 1976 (Nelson, 1992)

Clay Mineral	CEC (meq/100 gm)
Kaolinite	3-15
Illite	10-40
Montmorillonite	80-150

- Classification Using Soil Index Properties

Prediction of swelling potential using Atterberg limits is the most popular approach. Many of the procedures also include clay content.

Method of Chen

Chen (1988) presented a single index method for identifying expansive soils using only plasticity index (Table 2-4).

Table 2-4 Expansive soil classification based on plasticity index (Chen, 1988)

Swelling Potential	Plasticity Index (%)
Low	0-15
Medium	10-35
High	20-55
Very High	35 and above

3.5 CONSISTENCY OF CLAY SOIL

Consistency is a term used to indicate the degree of firmness of cohesive soils. The consistency of natural cohesive soil deposits is expressed qualitatively by such terms as very soft, soft, stiff, very stiff and hard. The physical properties of clays greatly differ at different water contents. A soil which is very soft at a higher percentage of water content becomes very hard with a decrease in water content. However, it has been found that at the same water content, two samples of clay of different origins may possess different consistency. One clay may be relatively soft while the other may be hard. Further, a decrease in water content may have little effect on one sample of clay but may transform the other sample from almost a liquid to a very firm condition. Water content alone, therefore, is not an adequate index of consistency for engineering and many other purposes. Consistency of a soil can be expressed in terms of [1]

1. Atterberg limits of soils
2. Unconfmed compressive strengths of soils.

3.5.1 Determination of Atterberg limits

The liquid limit, plastic limit and shrinkage limit are all Attreberg limits. However,for classification purpose, the term Atterberg limits generally referes to the liquid and plastic limits only. the liquid limit (LL) is the moisture content of soil at the boundary between the liquid and plastic states.the plastic limit(PL) is the moisture content at the boundary between the plastic and semi-solid state.the plasticity index (PI) is the difference between LL and PL.(soil and foundation) [16].

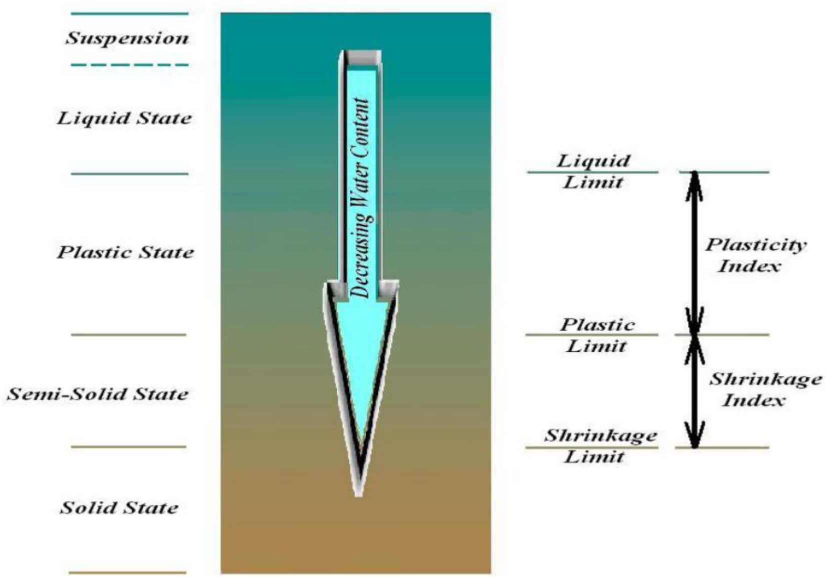

Fig 2.4 Atterberge limits and indices

Liquid limit

The apparatus shown in Fig. 2.5 is the Casagrande Liquid Limit Device used for determining the liquid limits of soils. Figure 2.6 shows a hand-operated liquid limit device. The device contains a brass cup which can be raised and allowed to fall on a hard rubber base by turning the handle. The cup is raised by one cm. The limits are determined on that portion of soil finer than a No. 40 sieve (ASTM Test Designation D-4318). About 100 g of soil is mixed thoroughly with distilled water into a uniform paste. A portion of the paste is placed in the cup and leveled to a maximum depth of 10 mm. a symmetrical axis of the cup [1].

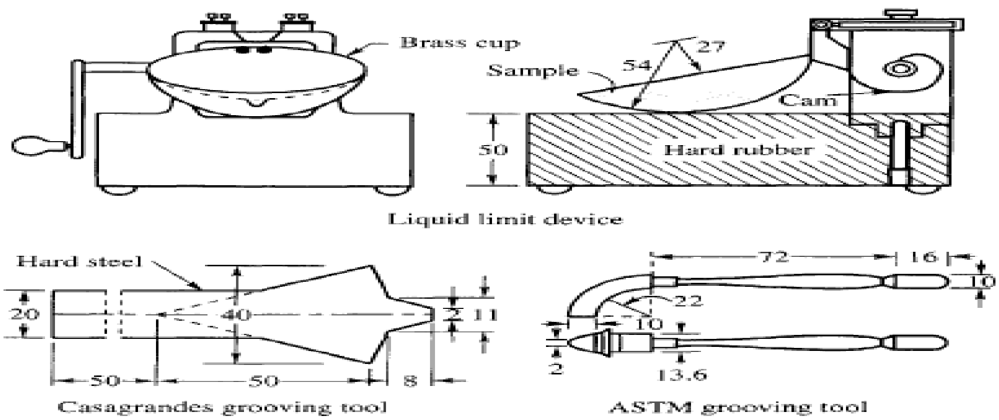

Fig 2.5 Casagrande's liquid limit apparatus

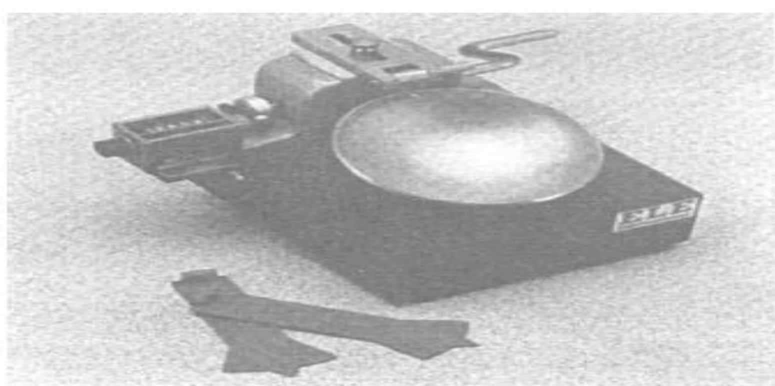

Fig 2.6 Hand-operated liquid limit device

The grooving tool should always be held normal to the cup at the point of contact. The handle is turned at a rate of about two revolutions per second and the number of blows necessary to close the groove along the bottom for a distance of 12.5 mm is counted. The groove should be closed by a flow of the soil and not by slippage between the soil and the cup [1]. There are two methods to determine the liquid limit of soil.

A. multiple point liquid limit

The water content of the soil in the cup is altered and the tests repeated. At least four tests should be carried out by adjusting the water contents in such a way that the number of blows required to close the groove may fall within the range of 5 to 40. Plot the water content against the semi log of blows, within the range of 5 to 40 blows, the plotted points lie almost on a straight line. The curve so obtained is known as a 'flow curve'. The water content corresponding to 25 blows is termed the liquid limit. The equation of the flow curve can be written as [1].

$$W= -I_f \log N+C$$

Where,

W=water content

I_f= slope of the flow curve, termed as flow index

N= number of blows

C= a constant.

B. Liquid limit by one point method

Three principle objectives for correlating a new method to Atterberg's are simplicity of operation, speed, and obtaining results that can be reproduced within narrow tolerances. In regard to one-point methods, there is no question regarding the simplicity of operation because the equipment and general procedure are not changed.

The idea of speed has considerable merit theoretically, because the method should be faster by a factor of 2 or 3 however is necessary for the result, "N", to be within a certain range. For a good determination N should be between 20 and 31 blows, with a range of 15 to 41 blows allowable for classification purposes [14].The time saving factor depends on "N" being on the acceptable ranges without many trials. The one point method can be only as accurate as the regular determination and is obviously going to be somewhat less accurate, because the method has all of the source of error inherent in the standard method plus an additional source [14].

Most one point methods follow early work by the Corps of Engineers, Waterways Experiment Station. The method is based on the hypothesis suggested by Casagrande that plotting both water content and number of blows to a logarithmic scale, might have a constant slope for soils of the same geologic origin. In general, flow lines of higher liquid limit values have steeper slopes than those of lower liquid limit values [14].

On the other hand a log-log plot reduces the slopes of the higher liquid limit slopes more than it does the lower ones; it tends to equalize the slopes. Now, if it can be shown that the slope of the flow lines for soils in the same geologic formation is essentially a constant on a logarithmic plot, then the liquid limit can be determined from one test point for each soil. The flow line can be drawn through the point at the constant slope, and the 25 blow point interpolated as usual. A flow line is determined in the usual manner and its slope is determined [(14)].

The statistic analysis was perform by two independent method by using the X^2 test, that the liquid limit for the set under consideration was random variable that follows the low of normal distribution. In that case the statistical analysis was performed by analyzing and comparing the average value of the corresponding set and the sets used to prove stochastic similarity. Then the equating of the flow curve is as follows:-

$$LL = Wn\,(N/25)^{\tan\beta}$$

where:

LL -liquid limit

Wn = water content at N blows of the liquid limit device

tan β= slope of the flow line on a semi log plot (mean value for a given soil)

4. Result and discussion

4.1General

The primary task of this project gathers the data from different thesis that was done before on different place of Ethiopia (Mekele, Dukem, Ambo, Arbaminche and Addis Ababa) .

Table 4.1 the data that was gather from different thesis.

Title of the project	Author	year
Study on index properties and swelling pressure of expansive soil found in **Duken**	Ashenafi Tamrat	Augest,2013
Examining Atterberg limit for expansive soils.	Habetamu Kassahun	December,2006
Correlation between index property and swelling pressure of expansive soil in **mekele.**	Rigat G/her	Augest,20014
Relation between shrinkage index and swelling pressure for expansive soil found in **A.A**	Jemal Yasin	December ,2011
Investigation in to index property and swelling characteristic of expansive soil of **Ambo.**	Getaneh Berru	November,2005
The unsaturated shear strength and swelling characteristic of expansive soil of **Arbaminch.**	Bantayehu Uba	June,2011
Prediction of California bearing ratio (CBR) value from index property of soil.	Zelalem Worku	March,2010
Stabilization potentially expansive soils using an industry product RBC grade 81 chemical	Getenete	Feberuary,2008
Unsaturated shear strength characteristic and stress strain behavior of expansive soil **Addis Abeba.**	Habtom Gebre	Augest,2010
Appropriate solution for impervious core of embankment Dam to be constructed using Highly plastic soils.(in the case of **Tendaho** dam)	Wuletaw Adane	October,2007
Correlation of CBR value with soil index property for **Addis Abeba** sub grade soil.	Yared Leliso	December.2013

Prediction of characteristic curve based on GSD and PI for red clay and Expansive soil found in **Addis Abeba**.	Nuru Ismail	Augest,2013

4.2 Regression Analysis

Regression analysis is a statistical technique for modeling and investigating the relationship between two or more variables. Many problems in engineering and science involve exploring and making use of the relationships between two or more variables. Regression analysis may take the form linear, parabolic, logarithmic etc depending on the trend that may exist between the dependent and independent variables.

Regression analysis divided into either simple regression or multiple regression analysis pertinent to the number of variables involved in the system. A regression model that contains more than one regressor variable is called multiple regression models. Alternatively, a regression model containing one independent variable or regressor is termed as simple regression model.

A variable whose value is predicted is called dependent variable or response. A variable(s) used to predict the value of dependent variable is termed independent or regressor variable (s).

The development and subsequent Fitting of a regression model requires several assumptions. Estimation of the model parameters requires the assumption that, the residuals (actual values less estimated values) corresponding to different observations are uncorrelated random variables with zero mean and constant variance. Tests of hypotheses and interval estimation require that the errors be normally distributed. In addition, we assume that the order of the model is correct; that is, if we fit a simple linear regression model, we are assuming that the phenomenon actually behaves in a linear or first order manner. This is indeed fundamental assumption of any tests of hypothesis and interval estimation. [17].

4.3 Regression Analysis of the flow curve

The statistical analysis was performing by two independent methods namely:-

1. Average value method
2. Linear regression method

4.3.1 Average value method

4.3.1.1 Average value method for Ethiopia expansive clay soils

In this approach it was necessary to compute the value of exponent tanβ for each 124 curve, which was subsequently subjected to additional statistic analysis.

The equation of the flow curve is:-

$$LL=a*N^{\tan\beta}$$

- **Scatter Plot**

For the purpose of this project, the LL value is the dependent variable where as N is the regressor variable. in carrying out the whole statistical analysis by using in carrying out the whole statistical analysis by using Microsoft office Excel and statistical soft ware program called SPSS.

Using 124 set of data results, to make the relationship between LL and water content. In order to study the relationship existing between the two variables, first a diagram called scatter diagram is applied for each 124 set data. It can be defined as a visual method used to display the relationship between two variables.

As an example of the scatter plot of the dependent variable (Wn) and the regressor variable (N) are shown in Figure 4.1 below.

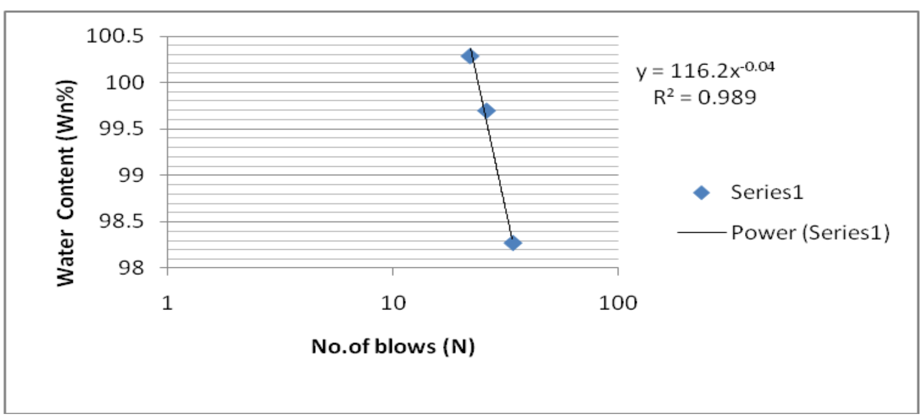

Fig 4.1 scatter plot of number of blows Vs water content

Develop 126 scatter diagrams for each set of data to make the relationship existing between the two variables. The scatter diagram is a graph on which each dependent variable (Wn) and the regressor variable (N) is represented as a point plotted in a two-dimensional coordinate system. The above scatter diagram was produced by making use of the excel spreadsheet, by selecting an option that shows dot diagrams of the (N) and (wn) making it easy to see the distributions of the individual variables. Inspection of the above scatter diagrams indicate that, although no simple curve will pass exactly through all the points, there is a reasonable indication that the points are randomly scattered in exponential pattern.

Thus, from the above scatter plot, it can be construed that a linear correlation does not exist between the dependent and the independent variable. For this project, the relationship between the dependent and independent variables, based on the above discussions and results of past studies is approximated by power regression models of the following form in each set of 124 data.

$$LL = a * N^{\tan\beta}$$

Table 4.2 tanβ value from power regression model for 124 set of data.

Sr.No	tanβ	Sr.No	tanβ	Sr.No	tanβ	Sr.No	tanβ	Sr.No	tanβ
1	0.06	16	0.10	31	0.05	46	0.11	61	0.07
2	0.05	17	0.98	32	0.16	47	0.09	62	0.14
3	0.12	18	0.25	33	0.06	48	0.07	63	0.06
4	0.04	19	0.11	34	0.16	49	0.04	64	0.12
5	0.07	20	0.13	35	0.09	50	0.11	65	0.17
6	0.10	21	0.03	36	0.04	51	0.07	66	0.09
7	0.11	22	0.22	37	0.06	52	0.09	67	0.15
8	0.15	23	0.07	38	0.06	53	0.05	68	0.04
9	0.17	24	0.06	39	0.04	54	0.06	69	0.06
10	0.13	25	0.02	40	0.16	55	0.10	70	0.19
11	0.16	26	0.09	41	0.08	56	0.16	71	0.14
12	0.11	27	0.09	42	0.12	57	0.06	72	0.10
13	0.11	28	0.06	43	0.07	58	0.02	73	0.05
14	0.17	29	0.05	44	0.06	59	0.09	74	0.19
15	0.07	30	0.09	45	0.09	60	0.09	75	0.08

Sr.No	tanβ	Sr.No	tanβ	Sr.No	tanβ	Sr.No	tanβ	Sr.No	tanβ
76	0.09	86	0.06	96	0.17	106	0.13	116	0.07
77	0.08	87	0.04	97	0.15	107	0.11	117	0.04
78	0.11	88	0.02	98	0.12	108	0.16	118	0.12
79	0.06	89	0.12	99	0.21	109	0.17	119	0.10
80	0.04	90	0.10	100	0.07	110	0.10	120	0.08
81	0.12	91	0.11	101	0.08	111	0.14	121	0.06
82	0.07	92	0.04	102	0.08	112	0.05	122	0.07
83	0.08	93	0.13	103	0.25	113	0.16	123	0.14
84	0.11	94	0.15	104	0.12	114	0.08	124	0.13
85	0.04	95	0.14	105	0.08	115	0.20		

Table 4.3 and fig 4.2 shows the statistical analysis of the collected values of tanβ.

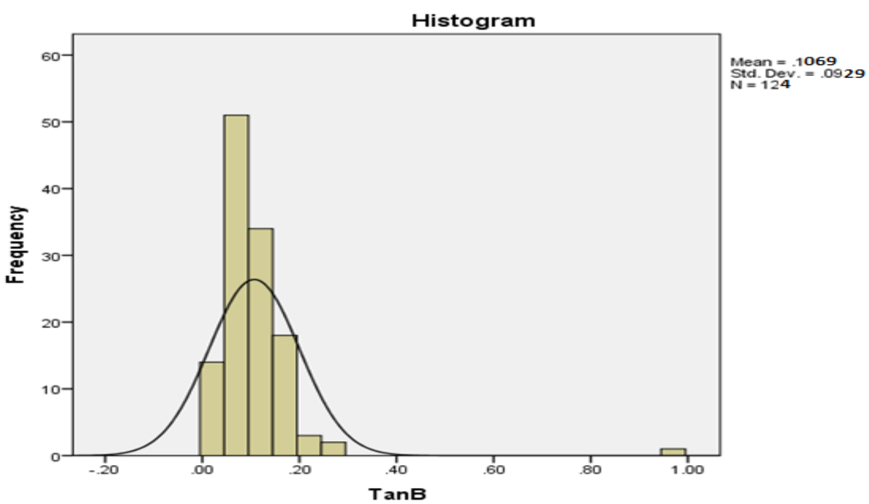

Fig 4.2 the distribution curve of tanβ

Table 4.3 the result of the statistical analysis

Sample size of tanβ	124
Average value of tanβ	0.1069
Std. Error of mean	0.00838
Median of tanβ	0.900
Mode of tanβ	0.06

Standard deviation value of tanβ	0.09294
Variance of tanβ	0.009
Maximum value of tanβ	0.98
Minimum value of tanβ	0.02

- **Therefore the value of tanβ is 0.1069 , hence**

$$LL = a*N^{\tan\beta}$$

Where:-

$a = Wn/(25^{\tan\beta})$

N = Nomber of belows

tanβ = slope of the flow line on a semi log plot

$$LL = Wn*(N/25)^{0.1069}$$

4.3.1.2 Average value method for Addis Ababa expansive clay soils

All of the approaches and the procedures that are used the same as at section 4.3.1.1 but there is only different at the data are used, it was used to compute the value of exponent tanβ is 68 set of data, which was subsequently subjected to additional statistic analysis.

The equation of the flow curve is:-

$$LL = a*N^{\tan\beta}$$

Table 4.4 tanβ value from power regression model for 68 set of data.

Sr.No	tanβ	Sr.No	tanβ	Sr.No	tanβ	Sr.No	tanβ	Sr.No	tanβ
1	0.25	8	0.12	15	0.04	22	0.02	29	0.17
2	0.11	9	0.07	16	0.07	23	0.09	30	0.09
3	0.13	10	0.06	17	0.09	24	0.09	31	0.15
4	0.03	11	0.09	18	0.05	25	0.07	32	0.04
5	0.16	12	0.11	19	0.06	26	0.14	33	0.06
6	0.16	13	0.09	20	0.1	27	0.06	34	0.04
7	0.08	14	0.07	21	0.06	28	0.12	35	0.06

Sr.No	tanβ	Sr.No	tanβ	Sr.No	tanβ	Sr.No	tanβ	Sr.No	tanβ
36	0.04	43	0.21	50	0.16	57	0.07	64	0.14
37	0.12	44	0.07	51	0.17	58	0.04	65	0.13
38	0.15	45	0.08	52	0.1	59	0.12	66	0.14
39	0.14	46	0.25	53	0.14	60	0.1	67	0.14
40	0.17	47	0.12	54	0.05	61	0.08	68	0.13
41	0.15	48	0.13	55	0.16	62	0.06		
42	0.12	49	0.11	56	0.08	63	0.07		

Table 4.5 and fig 4.3 shows the statistical analysis of the collected values of tanβ.

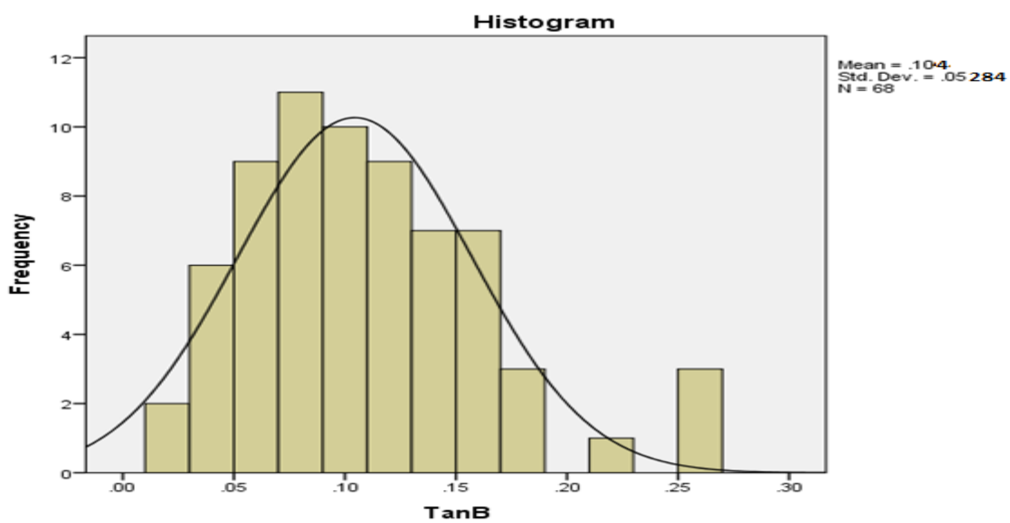

Fig 4.3 the distribution curve of tanβ

Table 4.5 the result of the statistical analysis

Sample size of tanβ	68
Average value of tanβ	0.104
Std. Error of mean	0.00641

Median of tanβ	0.0950
Mode of tanβ	0.06
Standard deviation value of tanβ	0.05284
Variance of tanβ	0.003
Maximum value of tanβ	0.25
Minimum value of tanβ	0.02

- **Therefore the value of tanβ is 0.1044 , hence**

$$LL=a*N^{\tan\beta}$$

Where:-

$a=Wn/(25^{\tan\beta})$

N = Nomber of belows

tanβ = slope of the flow line on a semi log plot

$$LL=Wn*(N/25)^{0.1044}$$

4.3.2 Linear regression method

4.3.2.1 Linear regression method for Ethiopia expansive clay soils

This method used a set of 124 data 456 points are use,In order to consider the set unambiguously. Considering parameter tanβ, it was necessary to standardize the flow curve .The equation of the flow curve is:-

$$LL=a*N^{\tan\beta}$$

- **Scatter Plot**

  For the purpose of this project, this was performed by dividing respective moisture at the liquid limit (LL) by each moisture (Wn) value from each curve (LL/Wn) is the dependent variable where as dividing number of blows (N) by 25(N/25) is the regressor variable. in carrying out the whole statistical analysis by using Microsoft office Excel and statistical soft ware program called SPSS.

Using from a set of 124 data 456 points are use to make the relationship existing between LL/Wn and N/25. table 4.4 shows 456points.

Table 4.6 456 points of LL/Wn and N/25 data

Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25
1	1.01	1.20	26	0.95	0.68	51	1.05	1.44
2	0.98	0.76	27	1.09	1.60	52	1.02	1.24
3	1.00	1.04	28	1.06	1.36	53	0.99	1.08
4	0.99	0.76	29	1.02	1.04	54	0.98	0.68
5	1.01	1.08	30	0.95	0.68	55	1.04	1.32
6	1.01	1.24	31	1.05	1.32	56	1.01	1.08
7	0.95	0.64	32	0.99	1.04	57	0.96	0.64
8	1.00	0.96	33	0.99	0.84	58	0.93	0.48
9	1.04	1.28	34	0.97	0.72	59	1.06	1.56
10	1.02	1.40	35	1.05	1.40	60	1.04	1.44
11	1.01	1.04	36	1.00	1.04	61	1.02	1.08
12	0.97	0.48	37	0.97	0.68	62	0.95	0.64
13	1.02	1.24	38	0.95	0.60	63	1.10	1.40
14	0.98	0.72	39	1.07	1.44	64	1.04	1.20
15	0.99	0.88	40	1.07	1.36	65	0.97	0.88
16	1.00	0.96	41	1.01	1.08	66	0.91	0.44
17	1.02	1.20	42	0.96	0.76	67	1.04	1.28
18	0.95	0.60	43	0.95	0.68	68	1.01	1.16
19	1.07	1.64	44	1.09	1.60	69	1.01	1.04
20	1.06	1.40	45	1.06	1.36	70	0.97	0.72
21	1.00	1.08	46	1.02	1.04	71	1.04	1.24
22	0.97	0.68	47	0.95	0.68	72	1.03	1.16
23	1.07	1.36	48	1.05	1.32	73	0.98	0.88
24	1.01	1.12	49	0.99	1.04	74	0.91	0.44
25	1.00	0.96	50	0.99	0.84	75	1.01	1.36

Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25
76	1.01	1.12	105	0.98	0.84	134	0.95	0.76
77	1.00	0.88	106	0.96	0.64	135	1.04	1.36
78	0.98	0.64	107	1.03	1.36	136	1.01	1.16
79	1.10	1.36	108	1.00	1.12	137	1.00	0.96
80	1.02	1.12	109	1.00	0.88	138	0.97	0.68
81	0.97	0.88	110	0.98	0.72	139	1.01	1.36
82	0.93	0.64	111	1.02	1.32	140	1.01	1.12
83	1.04	1.36	112	1.00	1.12	141	1.00	0.92
84	1.01	1.16	113	0.99	0.96	142	0.98	0.64
85	0.99	0.96	114	0.99	0.68	143	1.04	1.36
86	0.98	0.68	115	1.03	1.36	144	1.02	1.16
87	1.01	1.32	116	1.02	1.12	145	0.99	0.96
88	1.01	1.16	117	1.00	0.92	146	0.97	0.76
89	1.01	0.92	118	0.96	0.68	147	0.98	0.72
90	0.97	0.64	119	1.02	1.32	148	1.00	0.84
91	1.01	1.32	120	1.00	1.04	149	1.00	1.08
92	1.00	1.16	121	0.99	0.88	150	1.02	1.32
93	1.00	0.88	122	0.99	0.72	151	0.99	0.76
94	0.99	0.76	123	1.07	1.36	152	1.00	0.96
95	1.03	1.32	124	1.01	1.16	153	1.01	1.20
96	1.01	1.08	125	1.00	0.96	154	1.01	1.36
97	0.99	0.88	126	0.96	0.76	155	1.10	1.48
98	0.97	0.68	127	1.03	1.36	156	0.99	1.08
99	1.03	1.32	128	1.01	1.16	157	0.97	0.84
100	1.01	1.08	129	0.99	0.96	158	0.94	0.60
101	0.98	0.88	130	0.99	0.72	159	1.03	1.40
102	0.97	0.68	131	1.04	1.36	160	1.02	1.16
103	1.03	1.40	132	1.04	1.12	161	0.99	0.92
104	1.02	1.12	133	1.00	0.92	162	0.96	0.64

Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25
163	1.05	1.36	192	1.00	1.08	221	0.97	0.84
164	1.01	1.08	193	0.99	0.88	222	0.96	0.68
165	0.99	0.88	194	0.98	0.56	223	1.02	1.32
166	0.96	0.64	195	1.05	1.52	224	1.01	1.16
167	1.03	1.48	196	1.04	0.96	225	0.99	0.88
168	1.01	1.12	197	0.97	0.92	226	0.97	0.64
169	1.00	0.88	198	0.95	0.64	227	1.01	1.60
170	0.97	0.68	199	1.07	1.48	228	1.01	1.12
171	1.03	1.52	200	1.04	1.24	229	1.00	0.92
172	1.02	1.20	201	1.00	0.88	230	0.99	0.76
173	0.99	0.88	202	0.99	0.56	231	1.05	1.52
174	0.98	0.64	203	1.06	1.64	232	1.02	1.20
175	1.05	1.60	204	1.01	1.16	233	1.00	1.00
176	1.03	1.16	205	0.99	0.92	234	0.96	0.60
177	0.99	0.88	206	0.98	0.68	235	1.05	1.52
178	0.96	0.56	207	1.02	1.60	236	1.02	1.20
179	1.05	1.52	208	1.02	1.16	237	1.00	1.00
180	1.01	1.08	209	1.00	0.88	238	0.96	0.60
181	1.00	0.96	210	0.97	0.72	239	1.03	1.44
182	0.97	0.76	211	1.04	1.52	240	1.01	1.16
183	1.02	1.24	212	1.01	1.24	241	0.99	0.80
184	1.01	1.08	213	0.98	0.88	242	0.96	0.56
185	0.99	0.84	214	0.98	0.60	243	1.07	1.44
186	0.95	0.60	215	1.06	1.56	244	1.04	1.16
187	1.04	1.52	216	1.01	1.04	245	0.98	0.84
188	1.01	1.08	217	1.00	0.92	246	0.93	0.56
189	0.98	0.84	218	0.95	0.60	247	1.03	1.40
190	0.98	0.68	219	1.08	1.40	248	1.01	1.12
191	1.02	1.32	220	1.00	1.04	249	0.99	0.84

Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25
250	0.98	0.64	279	0.98	0.88	308	1.03	0.64
251	1.06	1.48	280	0.98	0.88	309	1.03	1.56
252	1.02	1.16	281	1.04	1.40	310	1.01	1.12
253	0.99	0.88	282	1.02	1.16	311	0.98	0.76
254	0.96	0.64	283	0.99	0.88	312	1.02	1.40
255	1.07	1.44	284	0.96	0.64	313	1.00	1.08
256	1.03	1.08	285	1.03	1.44	314	0.98	0.64
257	0.97	0.84	286	1.01	1.20	315	1.01	1.48
258	0.93	0.60	287	0.99	0.88	316	1.00	1.08
259	1.03	1.32	288	0.98	0.56	317	0.99	0.64
260	1.01	1.04	289	1.10	1.44	318	1.06	1.56
261	0.98	0.84	290	1.02	1.16	319	1.02	1.08
262	0.96	0.60	291	1.00	0.92	320	0.96	0.68
263	0.95	0.60	292	0.94	0.68	321	1.04	1.40
264	0.98	0.84	293	1.02	1.36	322	1.01	1.04
265	1.00	1.08	294	1.00	1.00	323	0.95	0.60
266	1.11	1.56	295	1.02	0.80	324	1.06	1.52
267	1.02	1.36	296	0.94	0.56	325	1.02	1.16
268	1.00	1.04	297	1.04	1.56	326	0.96	0.68
269	0.99	0.88	298	1.02	1.16	327	1.02	1.32
270	1.02	1.32	299	0.98	0.72	328	1.00	1.04
271	1.01	1.12	300	1.05	1.56	329	0.98	0.72
272	0.99	0.76	301	1.02	1.12	330	1.01	1.28
273	0.99	0.92	302	0.97	0.68	331	1.00	0.92
274	1.01	1.08	303	1.05	1.48	332	0.98	0.64
275	1.05	1.24	304	1.02	1.08	333	1.05	1.40
276	1.06	1.36	305	0.96	0.64	334	1.01	1.04
277	1.07	1.52	306	1.06	1.40	335	0.95	0.64
278	1.03	1.20	307	1.05	1.08	336	1.05	1.56

Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25
337	1.01	1.08	366	1.03	1.12	395	0.94	0.60
338	0.98	0.72	367	0.97	0.88	396	1.00	1.12
339	1.04	1.48	368	0.94	0.72	397	1.05	1.44
340	1.01	1.12	369	1.01	1.12	398	0.95	0.56
341	0.98	0.72	370	0.99	0.92	399	0.99	0.96
342	1.06	1.56	371	0.98	0.72	400	1.04	1.16
343	1.01	1.08	372	1.03	1.32	401	1.09	1.48
344	0.97	0.72	373	1.01	1.12	402	0.97	0.88
345	1.01	1.20	374	0.98	0.72	403	1.03	1.24
346	1.00	1.00	375	1.03	1.36	404	0.94	0.56
347	0.99	0.72	376	0.99	0.88	405	1.02	1.52
348	1.06	1.40	377	0.97	0.68	406	1.02	1.20
349	1.00	1.04	378	1.11	1.36	407	1.00	0.84
350	0.95	0.64	379	1.01	1.08	408	0.98	0.72
351	1.05	1.28	380	0.93	0.72	409	0.93	0.60
352	0.99	1.00	381	1.06	1.40	410	0.99	0.92
353	0.95	0.68	382	1.00	1.04	411	1.07	1.44
354	1.05	1.28	383	0.97	0.68	412	1.05	1.16
355	0.99	1.00	384	1.04	1.20	413	1.05	1.52
356	0.95	0.68	385	1.00	1.04	414	1.01	1.20
357	1.07	1.36	386	0.94	0.60	415	0.98	0.76
358	1.01	1.04	387	1.03	1.24	416	1.00	0.96
359	0.94	0.68	388	1.01	1.08	417	0.92	0.64
360	1.05	1.28	389	0.97	0.72	418	0.97	0.84
361	0.98	0.92	390	1.03	1.12	419	1.08	1.16
362	0.94	0.64	391	0.98	0.92	420	1.08	1.52
363	1.04	1.36	392	0.94	0.68	421	1.04	1.40
364	1.02	1.16	393	0.98	0.88	422	0.99	0.72
365	0.98	0.88	394	1.11	1.48	423	1.00	1.16

Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25
424	0.99	0.96	435	1.00	1.04	446	1.04	1.32
425	1.02	1.48	436	1.04	1.36	447	0.99	0.92
426	0.99	0.80	437	1.03	1.56	448	0.96	0.52
427	1.00	1.08	438	0.97	0.72	449	1.06	1.32
428	0.97	0.48	439	0.99	0.92	450	1.01	1.12
429	1.05	1.52	440	1.02	1.04	451	0.99	0.92
430	1.03	1.04	441	1.01	1.12	452	0.95	0.68
431	0.99	0.84	442	1.02	1.28	453	1.05	1.28
432	0.94	0.64	443	0.98	0.72	454	1.02	1.12
433	0.97	0.68	444	0.99	0.96	455	0.98	0.88
434	0.98	0.84	445	1.01	1.08	456	0.94	0.60

Based on the above data a scatter diagram is generated by applying the Excel Spreadsheet. In order to study the relationships develop between the dependent variable (LL/Wn) and the regressor variable (N/25) so as to determine the model that best suit the data. The scatter plot of the dependent variable (LL/Wn) and the regressor variable (N/25) are shown in Figure 4.4 below.

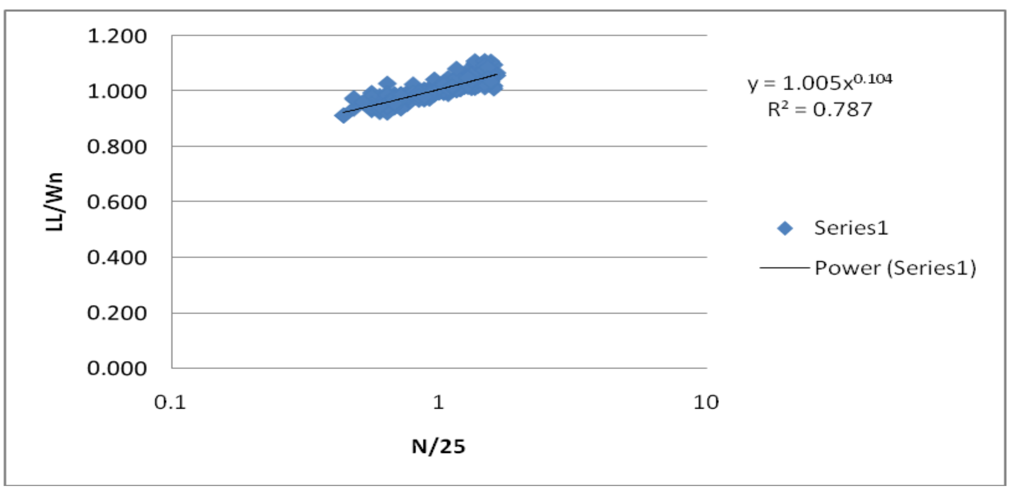

Fig 4.4 scatter plot of N/25 Vs LL/Wn

The above scatter diagram provides visual method of displaying a relationship between variable as plotted in a two-dimensional coordinate system. The above scatter diagram was produced by making use of the excel spreadsheet, by selecting an option that shows dot diagrams of the (N/25) and (LL/Wn) making it easy to see the distributions of the individual variables. Inspection of the above scatter diagrams indicate that, although no simple curve will pass exactly through all the points, there is a reasonable indication that the points are randomly scattered in exponential pattern.

Thus, from the above scatter plot, it can be construed that a linear correlation does not exist between the dependent and the independent variable. For this project, the relationship between the dependent and independent variables, based on the above discussions and results of past studies is approximated by power regression models of the following form.

$$Y=a*X^{\tan\beta}$$

- **Regression analysis**

As discussed in section 4.3.2, the statistical software called SPSS is employed to the study the relation between the regressor variable and the response to be predicted and the analysis is presented in section. Accordingly, the following result is observed.

- **the value of tanβ is 0.104 , hence**

$$Y=a*X^{\tan\beta}$$

$$Y= a*X^{0.104}$$

The details of the output of SPSS soft ware analysis have also been shown in the table below.

Table 4.7 Results of regression analysis between LL and moisture content

Model Summary

Mode l	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.890[a]	.793	.792	.01618

Through the power regression models of the following result is observed

$$Y=1.005*X^{0.104} \quad (N=456)$$

Where Y=LL/Wn AND X=N/25

1.005≈1

$$LL/Wn=1(N/25)^{0.104}$$

$$LL=Wn*(N/25)^{0.104}$$

4.3.2.2 Linear regression method for Addis Ababa expansive clay soils

All of the approaches and the procedure that are used the same as at section 4.3.2.1 but there is only different at the data are used ,it was used a set of 68 data 233 points are use, In order to consider the set unambiguously. Considering parameter tanβ, it was necessary to standardize the flow curve .The equation of the flow curve is:-

$$LL=a*N^{\tan\beta}$$

Table 4.8 233 points of LL/Wn and N/25 data

Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25
1	1.01	1.36	14	0.99	0.92	27	0.98	0.64
2	1.01	1.12	15	0.96	0.64	28	1.05	1.60
3	1.00	0.88	16	1.05	1.36	29	1.03	1.16
4	0.98	0.64	17	1.01	1.08	30	0.99	0.88
5	1.02	1.12	18	0.99	0.88	31	0.96	0.56
6	0.97	0.88	19	0.96	0.64	32	1.05	1.52
7	0.93	0.64	20	1.03	1.48	33	1.01	1.08
8	1.10	1.48	21	1.01	1.12	34	1.00	0.96
9	0.99	1.08	22	1.00	0.88	35	0.97	0.76
10	0.97	0.84	23	0.97	0.68	36	1.02	1.24
11	0.94	0.60	24	1.03	1.52	37	1.01	1.08
12	1.03	1.40	25	1.02	1.20	38	0.99	0.84
13	1.02	1.16	26	0.99	0.88	39	0.95	0.60

Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25
40	1.04	1.52	69	1.00	0.92	98	1.03	1.40
41	1.01	1.08	70	0.95	0.60	99	1.01	1.12
42	0.98	0.84	71	1.00	1.04	100	0.99	0.84
43	0.98	0.68	72	0.97	0.84	101	0.98	0.64
44	1.02	1.32	73	0.96	0.68	102	1.06	1.48
45	1.00	1.08	74	1.02	1.32	103	1.02	1.16
46	0.99	0.88	75	1.01	1.16	104	0.99	0.88
47	0.98	0.56	76	0.99	0.88	105	0.96	0.64
48	1.05	1.52	77	0.97	0.64	106	1.07	1.44
49	0.97	0.92	78	1.01	1.60	107	1.03	1.08
50	0.95	0.64	79	1.01	1.12	108	0.97	0.84
51	1.07	1.48	80	1.00	0.92	109	0.93	0.60
52	1.04	1.24	81	0.99	0.76	110	1.03	1.32
53	1.00	0.88	82	1.05	1.52	111	1.01	1.04
54	0.99	0.56	83	1.02	1.20	112	0.98	0.84
55	1.06	1.64	84	1.00	1.00	113	0.96	0.60
56	1.01	1.16	85	0.96	0.60	114	0.95	0.60
57	0.99	0.92	86	1.05	1.52	115	0.98	0.84
58	0.98	0.68	87	1.02	1.20	116	1.00	1.08
59	1.02	1.60	88	1.00	1.00	117	1.11	1.56
60	1.02	1.16	89	0.96	0.60	118	1.02	1.36
61	1.00	0.88	90	1.03	1.44	119	1.00	1.04
62	0.97	0.72	91	1.01	1.16	120	0.99	0.88
63	1.04	1.52	92	0.99	0.80	121	1.02	1.32
64	1.01	1.24	93	0.96	0.56	122	1.01	1.12
65	0.98	0.88	94	1.07	1.44	123	0.99	0.76
66	0.98	0.60	95	1.04	1.16	124	1.01	1.20
67	1.06	1.56	96	0.98	0.84	125	1.00	1.00
68	1.01	1.04	97	0.93	0.56	126	0.99	0.72

Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25
127	1.06	1.40	156	0.97	0.68	185	1.00	0.84
128	1.00	1.04	157	1.01	1.08	186	0.98	0.72
129	0.95	0.64	158	0.93	0.72	187	0.93	0.60
130	1.05	1.28	159	1.06	1.40	188	0.99	0.92
131	0.99	1.00	160	1.00	1.04	189	1.07	1.44
132	0.95	0.68	161	0.97	0.68	190	1.05	1.16
133	1.05	1.28	162	1.04	1.20	191	1.05	1.52
134	0.99	1.00	163	1.00	1.04	192	1.01	1.20
135	0.95	0.68	164	0.94	0.60	193	0.98	0.76
136	1.07	1.36	165	1.03	1.24	194	1.00	0.96
137	1.01	1.04	166	1.01	1.08	195	0.92	0.64
138	0.94	0.68	167	0.97	0.72	196	0.97	0.84
139	1.05	1.28	168	1.03	1.12	197	1.08	1.52
140	0.98	0.92	169	0.98	0.92	198	1.04	1.40
141	0.94	0.64	170	0.94	0.68	199	0.99	0.72
142	1.04	1.36	171	0.98	0.88	200	1.00	1.16
143	1.02	1.16	172	1.11	1.48	201	0.99	0.96
144	0.98	0.88	173	0.94	0.60	202	1.02	1.48
145	1.03	1.12	174	1.00	1.12	203	0.99	0.80
146	0.97	0.88	175	1.05	1.44	204	1.00	1.08
147	0.94	0.72	176	0.95	0.56	205	0.97	0.48
148	1.01	1.12	177	0.99	0.96	206	1.05	1.52
149	0.99	0.92	178	1.04	1.16	207	1.03	1.04
150	0.98	0.72	179	1.09	1.48	208	0.99	0.84
151	1.03	1.32	180	0.97	0.88	209	0.94	0.64
152	1.01	1.12	181	1.03	1.24	210	0.97	0.68
153	0.98	0.72	182	0.94	0.56	211	0.98	0.84
154	1.03	1.36	183	1.02	1.52	212	1.00	1.04
155	0.99	0.88	184	1.02	1.20	213	1.04	1.36

Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25	Sr.No	LL/Wn	N/25
214	1.03	1.56	221	0.99	0.96	228	0.99	0.92
215	0.97	0.72	222	1.01	1.08	229	0.95	0.68
216	0.99	0.92	223	1.04	1.32	230	1.05	1.28
217	1.02	1.04	224	0.99	0.92	231	1.02	1.12
218	1.01	1.12	225	0.96	0.52	232	0.98	0.88
219	1.02	1.28	226	1.06	1.32	233	0.94	0.60
220	0.98	0.72	227	1.01	1.12			

Based on the above data a scatter diagram is generated by applying the Excel Spreadsheet. In order to study the relationships develop between the dependent variable (LL/Wn) and the regressor variable (N/25) so as to determine the model that best suit the data. The scatter plot of the dependent variable (LL/Wn) and the regressor variable (N/25) are shown in Figure 4.3 below.

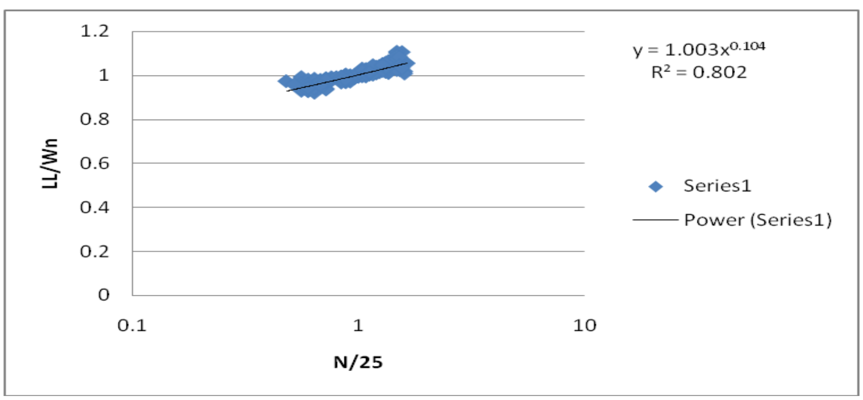

Fig 4.5 scatter plot of N/25 Vs LL/Wn

The above scatter diagram provides visual method of displaying a relationship between variable as plotted in a two-dimensional coordinate system. The above scatter diagram was produced by making use of the excel spreadsheet, by selecting an option that shows dot diagrams of the (N/25) and (LL/Wn) making it easy to see the distributions of the individual variables. Inspection of the above scatter diagrams indicate that, although no simple curve will pass exactly through all the points, there is a reasonable indication that the points are randomly scattered in exponential pattern.

Thus, from the above scatter plot, it can be construed that a linear correlation does not exist between the dependent and the independent variable. For this project, the relationship between the dependent and independent variables, based on the above discussions and results of past studies is approximated by power regression models of the following form.

$$Y=a*X^{\tan\beta}$$

- **the value of tanβ is 0.104 , hence**

$$Y=a*X^{\tan\beta}$$

$$Y= a*X^{0.104}$$

The details of the output of SPSS soft ware analysis have also been shown in the table below.

Table 4.9 Results of regression analysis between LL and moisture content

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.895[a]	.802	.803	.01718

Through the power regression models of the following result is observed

$$Y=1.003*X^{0.104} \quad (N=456)$$

Where Y=LL/Wn AND X=N/25

1.003≈1

$$LL/Wn=1(N/25)^{0.104}$$

$$LL=Wn*(N/25)^{0.104}$$

If we compare the value of the required exponent **tanβ** obtained from **Average value method** And **linear regression method**, the different is 0.0029 for Ethiopia expansive clay soils and 0.00 for Ababa expansive clay soils it is to be insignificant. Hence, the value of **tanβ** will be for Ethiopia and Addis Ababa expansive clay soils are **0.104.**

5. Conclusion and Recommendation

5.1 Conclusion

Based on the experimental results, Evaluation of one point liquid limit test for expansive clay soils of Ethiopia, it may be expressed by its following equation:-

$$LL=Wn(N/25)^{0.104}$$

With R^2 =0.787 and n=124 set (a set of 456 points)

Based on the experimental results, Evaluation of one point liquid limit test for expansive clay soils of Addis Ababa, it may be expressed by its following equation:-

$$LL=Wn(N/25)^{0.104}$$

With R^2 =0.802 and n=68 set (a set of 233 points)

5.2 Recommendation

To make the proposed equation accurate, it is recommended to increase the number of test points from different location within the country.

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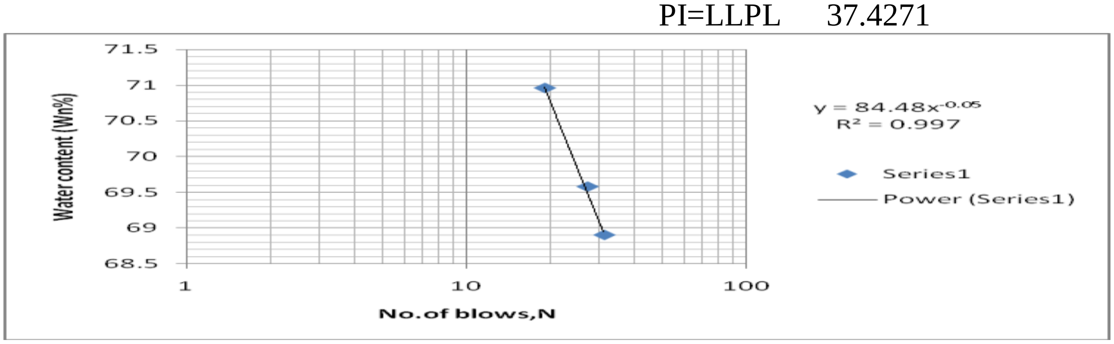
APPENDIX

DUKEM						
	L.L			P.L		
trial no	1	2	3	1	2	3
can no .g	A-19	12	79	D-24	59	D-5
mass of can.g	15.5704	15.8537	15.5022	15.4115	15.2951	15.7065
mass of can+wet soil .g	4.2575	42.3608	37.8311	21.685	20.4227	22.8613
mass of can+dry soil .g	28.5261	29.5599	27.1625	19.8404	18.9934	20.8277
mass weter .g	11.7314	12.8009	10.6686	1.8446	1.4293	2.0336
mass of dry soil.g	12.9557	13.7062	11.6603	4.4249	3.6983	5.1212
water content%	90.5501	93.39486	91.49507	41.68868	38.64749	39.70944
number of blows	30	19	26			
result	91.81			40.0146		

PI=LL-PL 51.7954

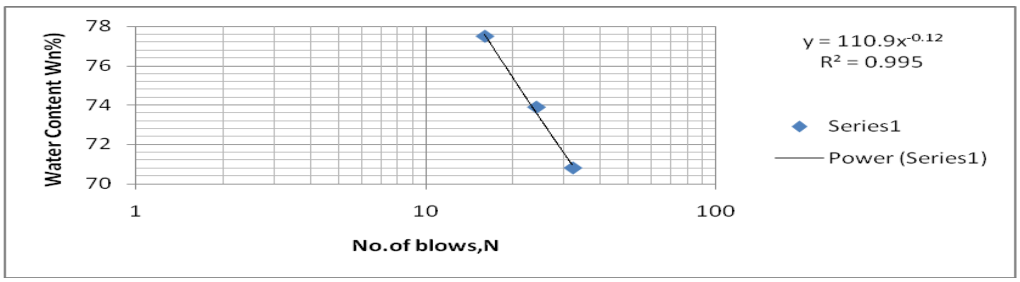
DUKEM						
	L.L			P.L		
trial no	1	2	3	1	2	3
can no .g	D-5	31	47	A-1	33	81
mass of can.g	15.6657	15.4269	15.6712	15.5928	14.0961	15.667
mass of can+wet soil .g	47.8381	46.8019	47.642	24.0197	23.4057	24.3343
mass of can+dry soil .g	34.4969	33.9284	34.5994	21.882	21.1288	22.2753
mass weter .g	13.3415	12.8735	13.0426	2.1377	2.2769	2.059
mass of dry soil.g	18.8012	18.5015	18.9282	6.2892	7.0327	6.6083
water content%	70.9593	69.58084	68.90565	33.99001	323759	31.15779
number of blows	19	27	31			
result	69.935			32.5079		

PI=LLPL 37.4271



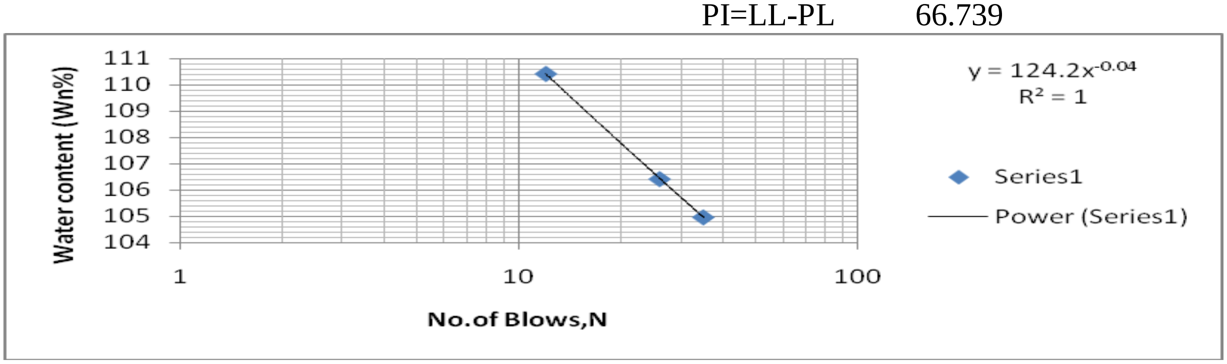
DUKEM						
	L.L			P.L		
trial no	1	2	3	1	2	3
can no .g	33	D-24	70	c-8	D-25	15
mass of can.g	14.0617	15.408	15.716	13.6893	15.8717	15.4814
mass of can+wet soil .g	37.3056	38..1925	40.7276	19.7013	22.3553	22.095
mass of can+dry soil .g	27.1573	28.5098	30.3576	18.3366	20.848	20.5913
mass weter .g	10.1483	9.6827	10.37	1.3647	1.5073	4.5037
mass of dry soil.g	13.0956	13.1018	14.6416	4.6473	4.9763	5.1099
water content%	77.4939	73.9035	70.8255	29.365	30.2895	29.4271
number of blows	16	24	32			
result	73.67			29.6941		

PI=LL-PL 43.9759



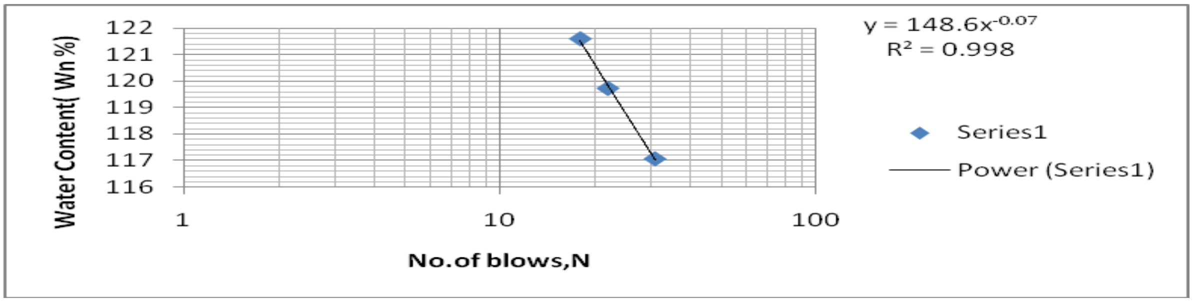
DUKEM						
	L.L			P.L		
trial no	1	2	3	1	2	3
can no .g	74	72	51	54	h-3	24
mass of can.g	15.849	15.6861	15.827	15.842	15.0743	15.6566
mass of can+wet soil .g	35.7974	33.1026	35.336	21.6241	21.1424	22.5168
mass of can+dry soil .g	25.5828	24.1244	25.0978	19.9645	19.408	20.534
mass weter .g	10.2146	8.9782	10.2358	1.6596	1.7344	1.9828
mass of dry soil.g	9.7338	8.4383	9.2706	4.1223	4.3337	4.8774
water content%	104.9395	106.3982	110.4114	40.259	40.0212	40.6528
number of blows	35	26	12			
result	107.05			40.311		

PI=LL-PL 66.739



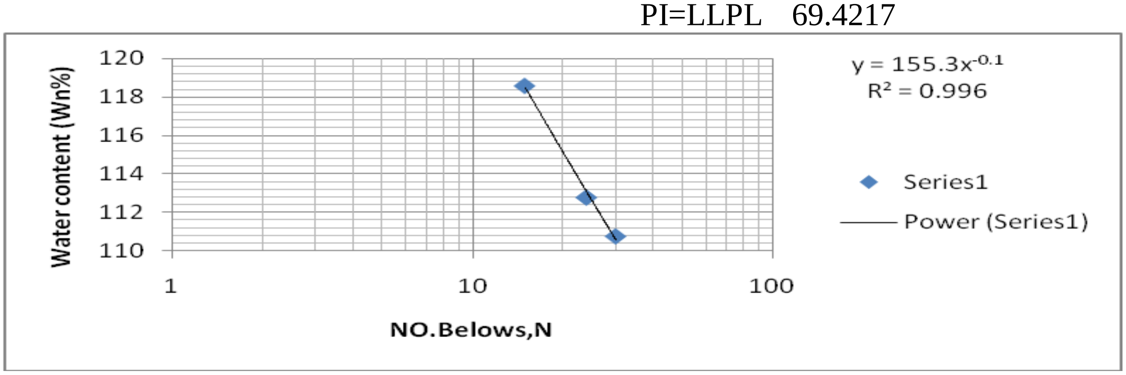
DUKEM						
	L.L			P.L		
trial no	1	2	3	1	2	3
can no .g	100	2	26	47	A-1	85
mass of can.g	15.4412	15.626	15.6972	15.6792	15.7725	15.837
mass of can+wet soil .g	37.17	37.3496	42.8262	21.4345	20.0074	20.2854
mass of can+dry soil .g	25.9123	25.4288	28.0438	19.6841	18.7018	18.9131
mass weter .g	12.2577	11.9208	14.7824	1.7504	1.3056	1.3723
mass of dry soil.g	10.4711	9.8028	12.3466	4.0049	2.9293	3.0761
water content%	117.0622	121.6061	119.7285	43.7064	44.5703	44.616
number of blows	31	18	22			
result	119			44.2962		

PI=LLPL 74.7038



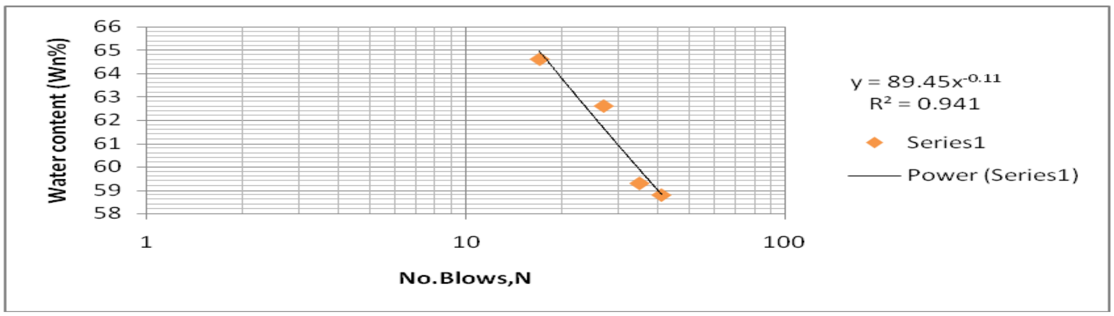
DUKEM						
	L.L			P.L		
trial no	1	2	3	1	2	3
can no .g	A-200	2	85	74	A-22	101
mass of can.g	15.6094	15.6226	15.8285	15.8525	15.547	11.609
mass of can+wet soil .g	41.6201	40.5417	38.9277	22.1313	21.6883	17.3554
mass of can+dry soil .g	27.8338	27.4464	26.3959	20.2116	19.8115	15.6357
mass weter .g	13.7863	13.0953	12.5318	1.9197	1.8768	1.7197
mass of dry soil.g	12.2244	11.8238	10.5674	4.3591	4.2968	4.0258
water content%	112.7769	110.7537	118.5892	44.0389	43.679	42.7169
number of blows	24	30	15			
result	112.9			43.4783		

PI=LLPL 69.4217



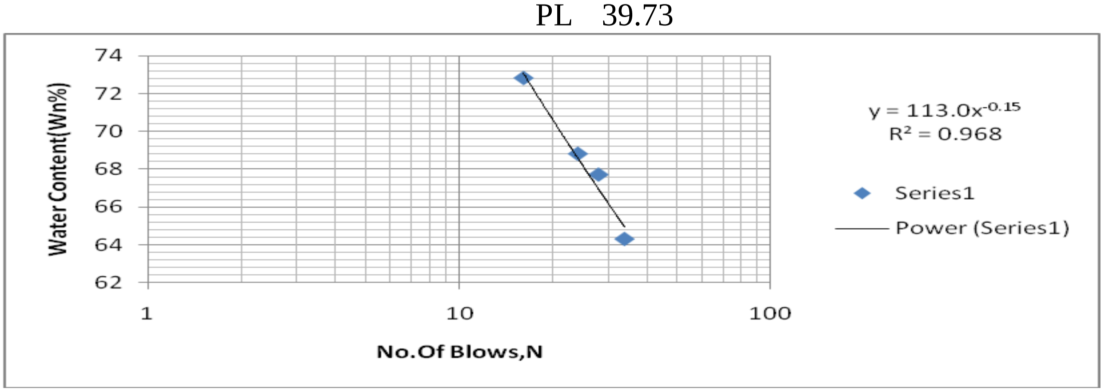
Mekele						
	L.L				P.L	
trial no	1	2	3	4	1	2
number of blows	41	35	27	17		
can no .g	10	58	41	36	57	49
mass of can+wet soil .g	42.5	45.4	49.4	46.6	35.4	32.6
mass of can+dry soil .g	33.8	37.1	39.2	37.1	33.2	31
mass of can.g	19	23.1	22.9	22.4	24	24.4
mass weter .g	8.7	8.3	10.2	9.5	2.2	1.6
mass of dry soil.g	14.8	14	16.3	14.7	9.2	6.6
water content%	58.8	59.3	62.6	64.6	23.91	24.21
result	62.23				23.96	

PI=LLPL 38.27



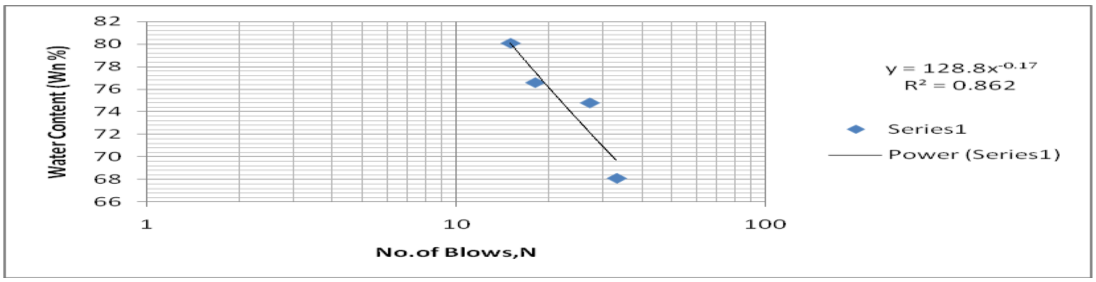
Mekele						
	L.L				P.L	
trial no	1	2	3	4	1	2
number of blows	34	28	24	16		
can no .g	4	57	55	42	4	45
mass of can+wet soil .g	43.2	40.9	33.9	45.5	35.6	30.4
mass of can+dry soil .g	34.9	34.2	29.5	34.5	32.9	28.9
mass of can.g	22	24.3	23.1	19.4	23	24
mass weter .g	8.3	6.7	4.4	11	2	1.5
mass of dry soil.g	12.9	9.9	6.4	15.1	9.9	4.9
water content%	64.3	67.7	68.8	72.8	27.27	30.61
result	68.63				28.9	

PI=LL-
PL 39.73



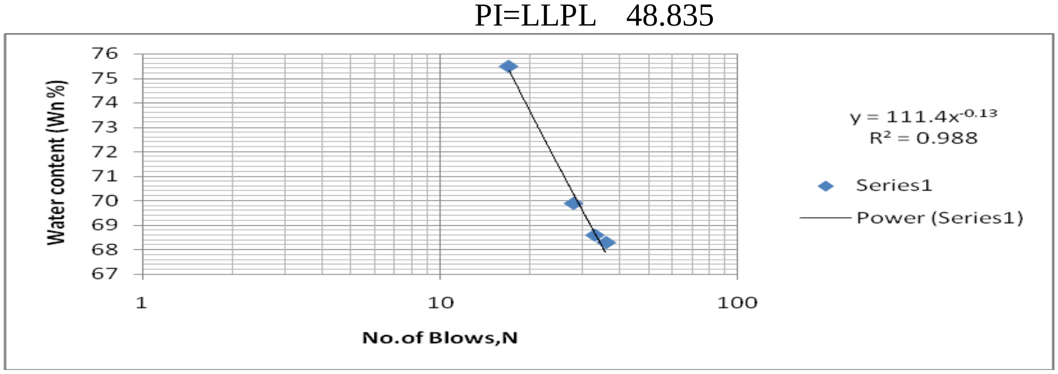
Mekele						
	L.L				P.L	
trial no	1	2	3	4	1	2
number of blows	33	27	18	15		
can no .g	63	41	67	10	4	65
mass of can+wet soil .g	42.2	48.7	48.3	47.1	29.5	30.35
mass of can+dry soil .g	34.1	37.7	37.8	34.6	28	28.9
mass of can.g	22.2	23	24.1	19	23.1	23.95
mass weter .g	8.1	11	10.5	12.5	1.53	1.45
mass of dry soil.g	11.9	14.7	13.7	15.6	4.9	5
water content%	68.1	74.8	76.6	80.1	31.4	29.3
result	73.3				30.4	

PI=LL-
PL 42.9



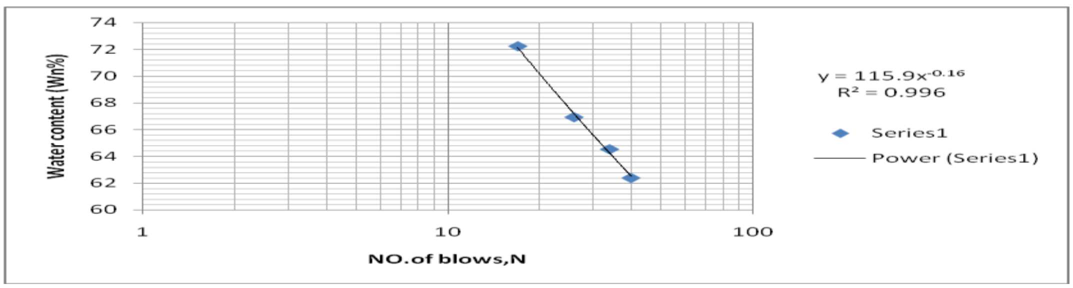
Mekele						
	L.L				P.L	
trial no	1	2	3	4	1	2
number of blows	36	33	28	17		
can no .g	36	40	57	41	58	49
mass of can+wet soil .g	43.3	39.2	40.2	39.4	36	29
mass of can+dry soil .g	34.9	32.2	33.7	32.3	33.6	27.9
mass of can.g	22.6	22	24.4	22.9	23.1	23.2
mass weter .g	8.4	7	6.5	7.1	2.4	1.1
mass of dry soil.g	12.3	10.2	9.3	9.4	10.5	4.7
water content%	68.3	68.6	69.9	75.5	22.9	23.4
result	71.965				23.13	

PI=LLPL 48.835



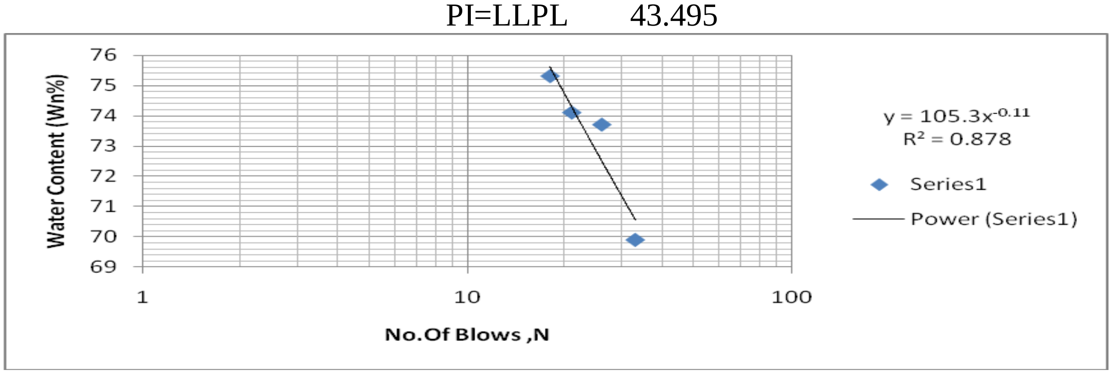
Mekele						
	L.L				P.L	
trial no	1	2	3	4	1	2
number of blows	40	34	26	17		
can no .g	4	15	45	51	59	53
mass of can+wet soil .g	43.7	46.4	44.9	49.1	26.9	30
mass of can+dry soil .g	35.4	37.3	36.4	38.7	26.2	28.7
mass of can.g	22.1	23.2	23.7	24.3	23.2	23.5
mass weter .g	8.3	9.1	8.5	10.4	0.7	1.3
mass of dry soil.g	13.3	14.1	12.7	14.4	3	5.2
water content%	62.4	64.54	66.93	72.22	23.33	25
result	68.315				24	

PI=LL-
PL 44.315



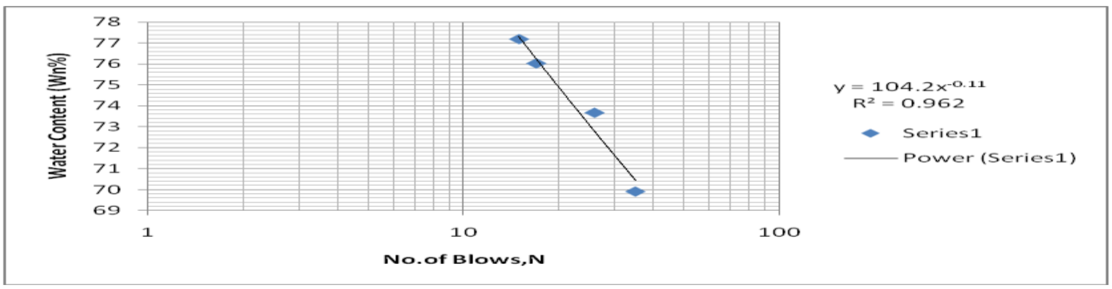
Mekele						
	L.L				P.L	
trial no	1	2	3	4	1	2
number of blows	33	26	21	18		
can no .g	61	63	10	55	32	35
mass of can+wet soil .g	42.7	40.7	39.5	40.7	28.1	30.4
mass of can+dry soil .g	34.8	33.7	30.9	33.5	27	28.9
mass of can.g	23.5	24.2	19.3	23.9	23.1	23.9
mass weter .g	7.9	7	8.6	7.23	1.13	1.5
mass of dry soil.g	11.3	9.5	11.6	9.6	3.9	5
water content%	69.9	73.7	74.1	75.3	29.2	30
result	73.095				29.6	

PI=LLPL 43.495



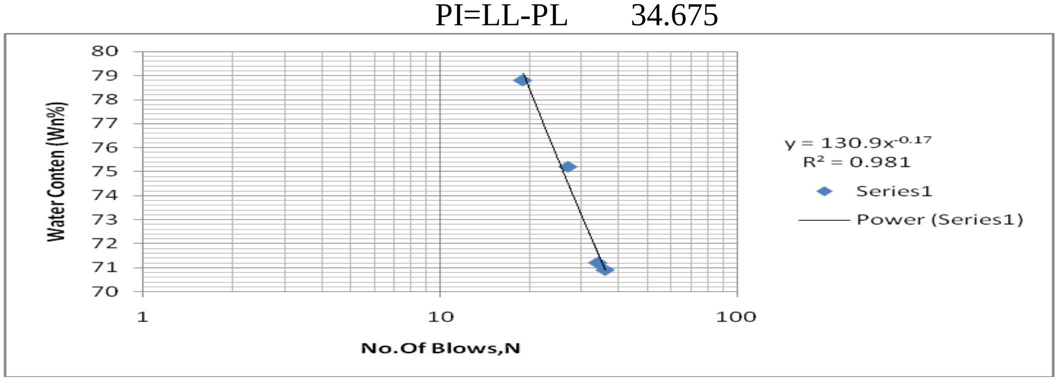
Mekele						
	L.L				P.L	
trial no	1	2	3	4	1	2
number of blows	35	26	17	15		
can no .g	61	63	55	57	60	5
mass of can+wet soil .g	42.7	40.7	40.8	40	38.7	33
mass of can+dry soil .g	34.8	33.7	33.5	32.9	35.3	29.9
mass of can.g	23.5	24.2	23.9	23.7	23.1	19.5
mass weter .g	7.9	7	7.3	7.1	3.4	3.1
mass of dry soil.g	11.3	9.5	9.6	9.2	12.2	10.4
water content%	69.91	73.68	76.04	77.2	27.87	29.8
result	73.61				28.8	

PI=LL-PL 44.81



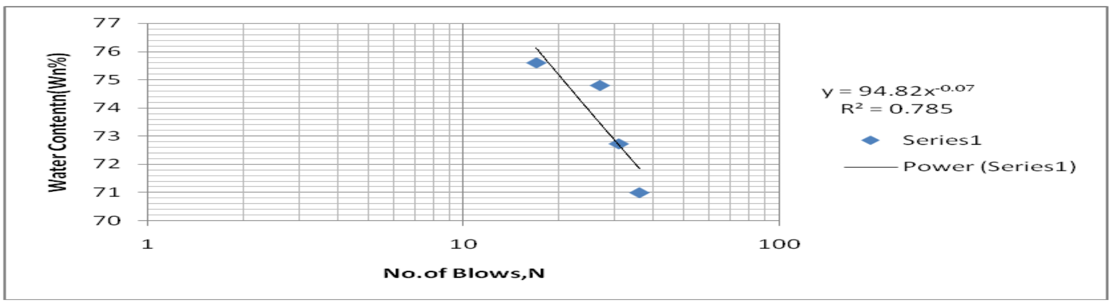
Mekele						
	L.L				P.L	
trial no	1	2	3	4	1	2
number of blows	36	34	27	19		
can no .g	55	54	14	51	57	13
mass of can+wet soil .g	36.6	44.2	40.2	39.4	40.1	35.8
mass of can+dry soil .g	31	35.8	31.4	32.7	35.5	30.9
mass of can.g	23.1	24	19.7	24.2	24.3	19.1
mass weter .g	5.6	8.4	8.8	6.7	4.6	4.9
mass of dry soil.g	7.9	11.8	11.7	8.5	11.2	11.8
water content%	70.9	71.2	75.2	78.8	41.07	41.53
result	75.975				41.3	

PI=LL-PL 34.675



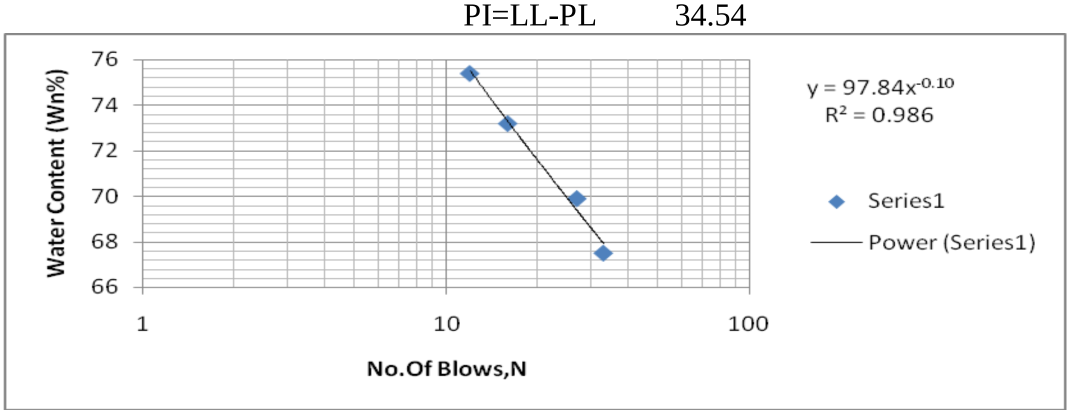
Mekele						
	L.L				P.L	
trial no	1	2	3	4	1	2
number of blows	36	31	27	17		
can no .g	50	57	2	12	59	32
mass of can+wet soil .g	46.5	39.6	47.2	42.4	39	42.6
mass of can+dry soil .g	37.2	33.2	36.8	32.5	34.7	37.4
mass of can.g	24.1	24.4	22.9	19.4	23.3	23.1
mass weter .g	9.3	6.4	10.4	9.9	4.3	5.2
mass of dry soil.g	13.1	8.8	13.9	13.1	11.4	14.3
water content%	71	72.73	74.8	75.6	37.72	36.36
result	74.205				37.04	

PI=LL-PL 37.165



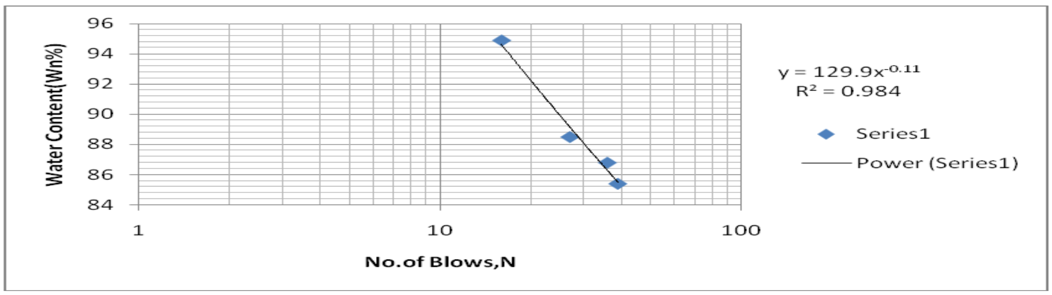
trial no	1	2	3	4	1	2
number of blows	33	27	16	12		
can no .g	7	52	58	35	55	45
mass of can+wet soil .g	43.1	42.9	45.1	44.6	27.7	28.7
mass of can+dry soil .g	35.4	35	35.8	35.7	26.7	27.4
mass of can.g	24	23.7	23.1	23.9	23.9	23.6
mass weter .g	7.7	7.9	9.3	8.9	1.14	1.3
mass of dry soil.g	11.4	11.3	12.7	11.8	2.76	3.8
water content%	67.5	69.9	73.2	75.4	37.68	34.21
result	70.44				35.9	

PI=LL-PL 34.54



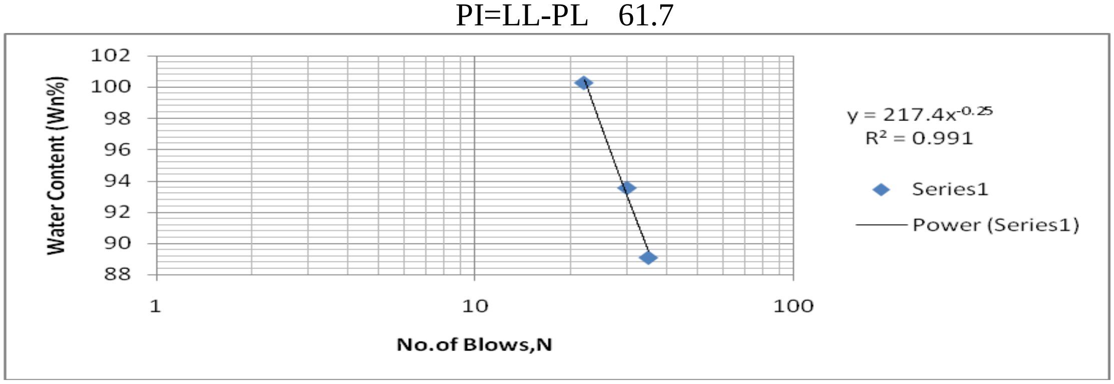
Mekele						
	L.L				P.L	
trial no	1	2	3	4	1	2
number of blows	39	36	27	16		
can no .g	40	11	57	35	3	7
mass of can+wet soil .g	39.5	39.6	48.3	42.9	36.9	37.1
mass of can+dry soil .g	32	30.4	36.8	33.6	32.9	33
mass of can.g	23.22	19.8	23.8	23.8	24	23.8
mass weter .g	7.5	9.2	11.5	9.3	4	4.28
mass of dry soil.g	8.78	10.6	13	9.8	8.9	9.2
water content%	85.4	86.8	88.5	94.9	44.9	44.8
result	90.625				44.8	

PI=LL-PL 45.825



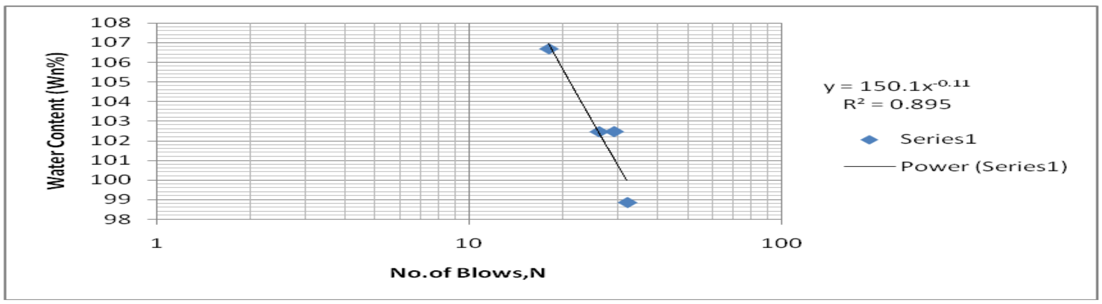
A.A(bole)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	B2	A12	89	A33	26	A22
mass of can.g	21.51	20.48	21.97	22.01	22.17	21.98
mass of can+wet soil .g	35.42	33.43	36.21	36.59	27.2	26.58
mass of can+dry soil .g	28.86	27.17	29.08	29.04	25.9	25.31
mass weter .g	6.55	6.26	7.13	7.55	1.3	1.27
mass of dry soil.g	7.35	6.69	7.11	7.03	3.73	3.33
water content%	89.12	93.57	100.28	107.4	34.85	38.84
number of blows	35	30	22	11		
result	97.7				36	

PI=LL-PL 61.7



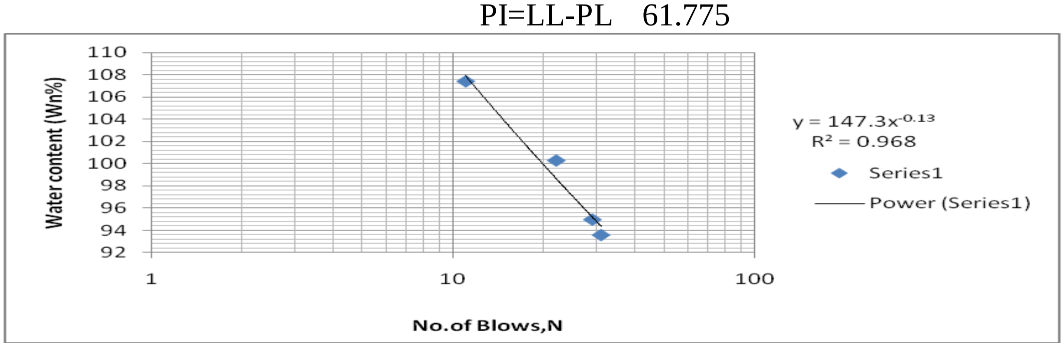
A.A(bole)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	D35	D37	42	51	108	59
mass of can.g	15.5	15.57	42	15.82	15.62	15.3
mass of can+wet soil .g	34.69	37.62	15.39	58.97	17.42	17.08
mass of can+dry soil .g	25.15	26.46	39.2	27.02	16.97	16.63
mass weter .g	9.54	11.16	27.15	11.95	0.45	0.45
mass of dry soil.g	9.65	10.89	12.05	11.2	1.35	1.33
water content%	98.86	102.48	102.47	106.7	33.33	33.83
number of blows	32	29	26	18		
result	103.23				34	

PI=LL-PL 69.23



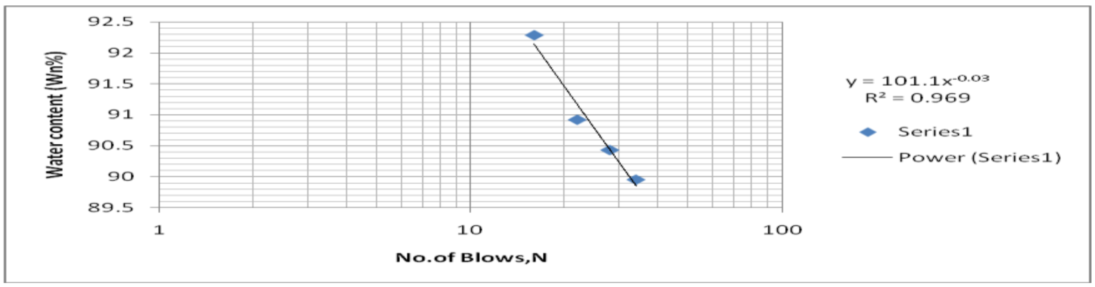
A.A(bole)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	A12	B10	89	A33	26	A22
mass of can.g	20.48	21.51	21.97	22.01	22.17	21.98
mass of can+wet soil .g	33.43	35.43	36.21	36.39	27.2	26.38
mass of can+dry soil .g	27.17	28.65	29.08	29.04	25.9	25.31
mass weter .g	6.26	6.78	7.11	7.55	1.3	1.27
mass of dry soil.g	6.69	7.4	7.11	7.03	3.71	3.33
water content%	93.57	94.96	100.28	107.4	34.85	38.44
number of blows	31	29	22	11		
result	97.775				36	

PI=LL-PL 61.775



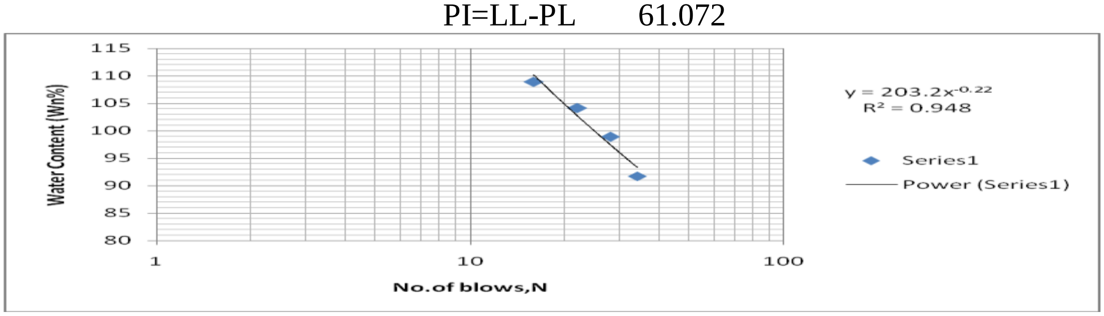
A.A						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	66	92	16	C	M12	P5
number of blows	34	28	22	16		
mass of can+wet soil .g	36.72	36.98	32.58	32.2	39.34	39.21
mass of can+dry soil .g	27.05	27.17	24.87	21.31	33.11	33.03
mass weter .g	9.67	9.83	7.71	10.89	6.23	6.18
mass of can.g	16.3	16.28	16.39	9.51	16.33	16.33
mass of dry soil.g	10.75	10.87	8.48	11.8	16.78	16.7
water content%	89.95	90.43	90.92	92.29	37.33	37.01
result	90.895				37.07	

PI=LL-PL 53.825



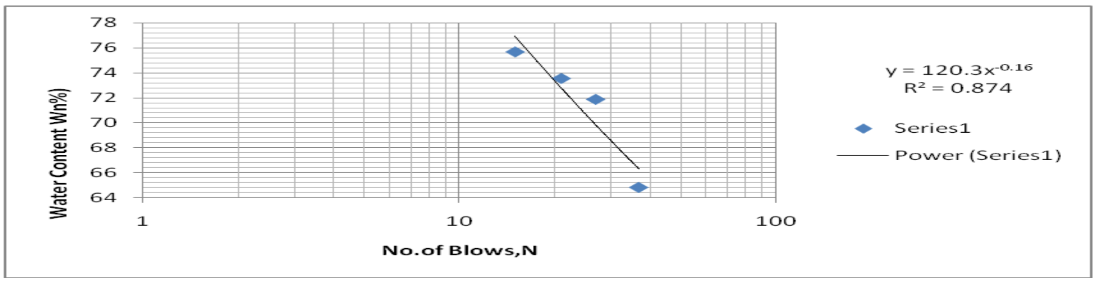
A.A						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	F11	11	F16	14	129	L
number of blows	34	28	22	16		
mass of can+wet soil .g	35.64	41.52	37.42	39.15	30.94	29.36
mass of can+dry soil .g	26.43	29.21	26.78	27.17	26.89	25.71
mass weter .g	9.21	12.31	10.64	11.98	4.05	3.65
mass of can.g	16.39	16.76	16.56	16.17	16.8	16.45
mass of dry soil.g	10.04	12.45	10.22	11	10.09	9.26
water content%	91.73	98.88	104.11	108.91	40.139	39.417
result	100.85				39.778	

PI=LL-PL 61.072



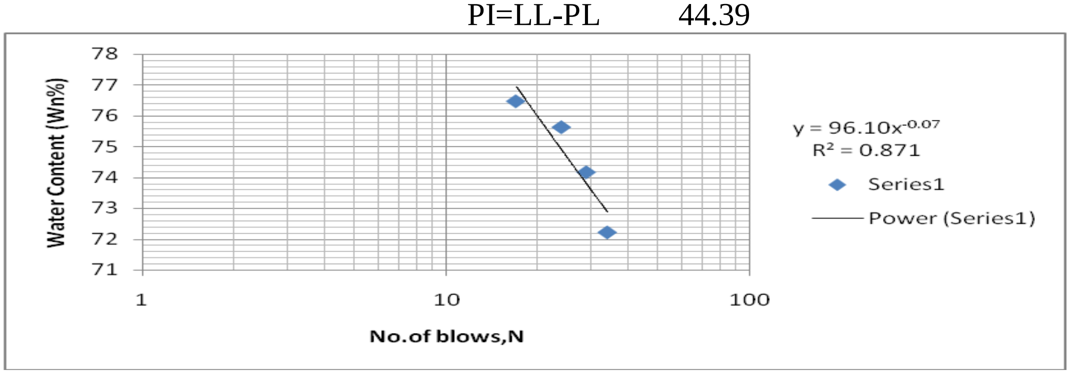
A.A						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	C18	C15	98	24	76	D34
mass of can.g	13.54	13.9	15.35	15.83	15.53	15.36
mass of can+wet soil .g	32.66	35.93	33.6	33.33	19.64	19.21
mass of can+dry soil .g	25.14	27.31	28.83	26.83	13.64	13.26
mass weter .g	7.52	9.64	9.77	8.43	1.02	0.96
mass of dry soil.g	11.6	13.41	13.28	11.2	3.02	2.94
water content%	64.83	71.89	73.57	75.7	33.22	32.65
number of blows	37	27	21	15		
result	71.51				33	

PI=LL-PL 38.51



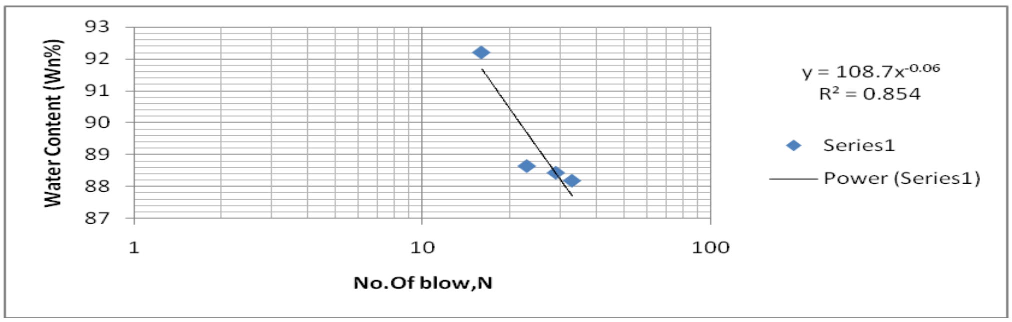
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	2	A22	T9	72	P9	CA
mass of can.g	15.3	15.6	15.5	15.7	15.6	29.9
mass of can+wet soil .g	37	36.5	36.4	33.7	22.5	36.7
mass of can+dry soil .g	27.9	27.6	27.4	25.9	20.9	35.1
mass weter .g	9.1	8.9	9	7.8	1.6	1.6
mass of dry soil.g	12.6	12	11.9	10.2	5.3	5.2
water content%	72.22	74.17	75.63	76.47	30.19	30.77
number of blows	34	29	24	17		
result	74.87				30.48	

PI=LL-PL 44.39



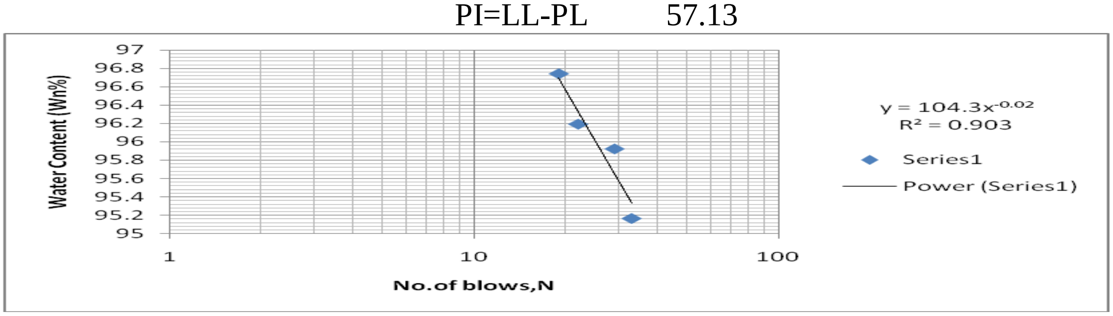
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	3M	AL4	AT8	54	E5	A98
mass of can.g	10.5	15.5	15.5	15.7	15.7	15.2
mass of can+wet soil .g	31.2	38.3	32.1	30.5	22.7	23.1
mass of can+dry soil .g	21.5	27.6	24.3	23.4	20.8	20.9
mass weter .g	9.7	10.7	7.8	7.1	1.9	2.2
mass of dry soil.g	11	12.1	8.8	7.7	5.1	5.7
water content%	88.18	88.43	88.64	92.21	37.25	38.6
number of blows	33	29	23	16		
result	89.44				37.93	

PI=LL-PL 51.51



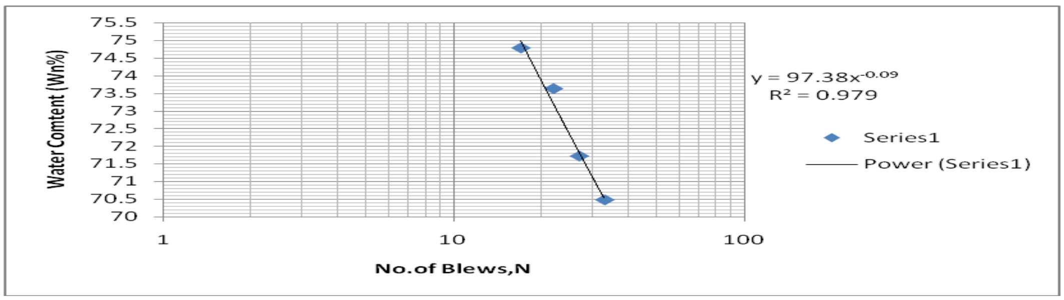
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	DC2	N29	N4	BBC	E2	DA5
mass of can.g	15.5	15.7	15.4	11	15.6	15.5
mass of can+wet soil .g	27.6	34.9	36	29.1	22.2	22.25
mass of can+dry soil .g	21.7	25.5	25.9	20.2	20.35	20.25
mass weter .g	5.9	9.4	10.1	8.9	1.85	1.85
mass of dry soil.g	6.2	9.8	10.5	9.2	4.75	4.75
water content%	95.16	95.92	96.19	96.74	38.95	38.95
number of blows	33	29	22	19		
result	96.08				38.95	

PI=LL-PL 57.13



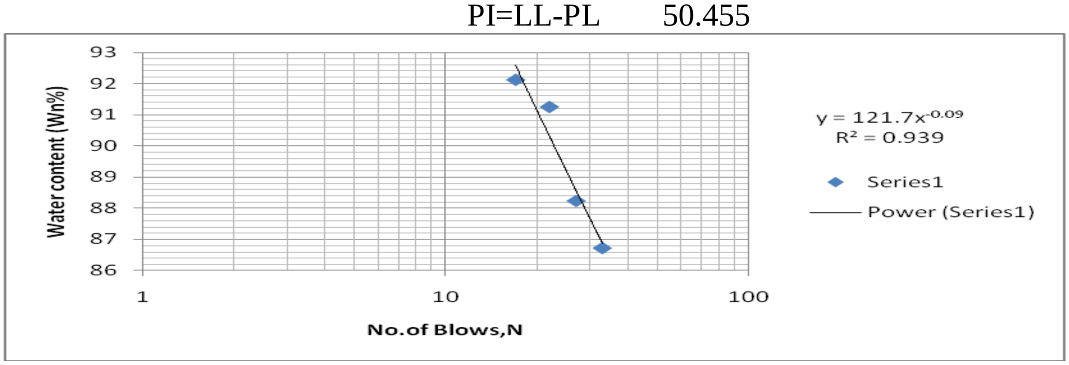
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	24A	TB6	D1	T15	27A	BL
mass of can.g	15.3	15.8	15.5	15.6	15.8	15.6
mass of can+wet soil .g	33.2	32.5	31.3	35.7	22.1	22.6
mass of can+dry soil .g	25.8	25.7	24.6	27.1	20.66	20.95
mass weter .g	7.4	7.1	6.7	8.6	10.5	1.65
mass of dry soil.g	10.5	9.9	9.1	11.5	4.8	5.35
water content%	70.48	71.72	73.63	74.78	31.25	30.84
number of blows	33	27	22	17		
result	72.59				31.05	

PI=LL-PL 41.54



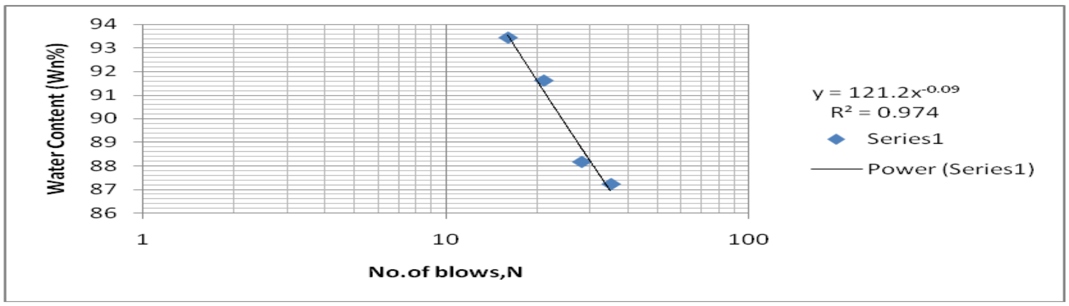
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	T13	47	DAB	G8	LL6	TL3
mass of can.g	15.3	15.4	15.5	20.8	15.6	15.7
mass of can+wet soil .g	33.6	31.4	30.8	40.3	22.6	23.3
mass of can+dry soil .g	25.1	23.9	23.5	30.95	20.65	21.15
mass weter .g	8.5	7.5	7.3	9.35	1.95	2.15
mass of dry soil.g	9.8	8.5	8	10.15	5.05	5.45
water content%	86.73	88.24	91.25	92.12	38.61	39.45
number of blows	33	27	22	17		
result	89.485				39.03	

PI=LL-PL 50.455



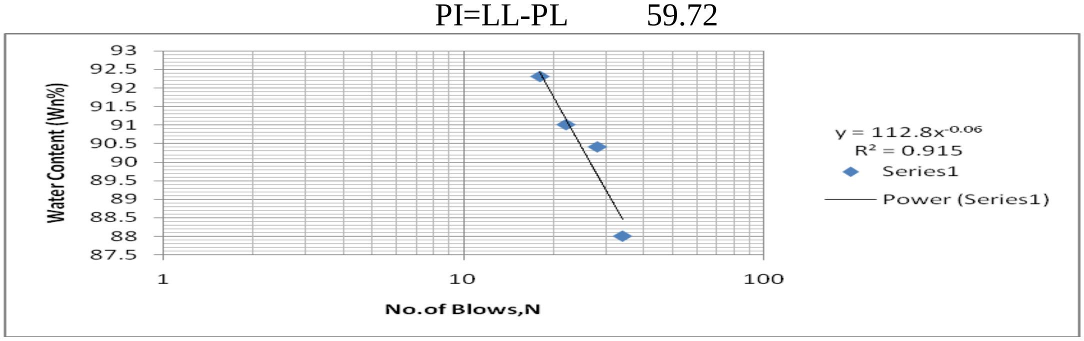
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	DA	At8	D31	72	60	P2
mass of can.g	15.7	15.5	15.5	15.8	15.5	15.3
mass of can+wet soil .g	33.3	33	31.5	33.5	21.8	21.7
mass of can+dry soil .g	25.1	24.8	23.85	24.95	20.2	20.05
mass weter .g	8.2	8.2	7.65	8.55	1.6	1.45
mass of dry soil.g	9.4	9.3	8.35	9.15	4.7	4.75
water content%	87.23	88.17	91.62	93.44	34.04	34.74
number of blows	35	28	21	16		
result	90.13				34.39	

PI=LL-PL 55.74



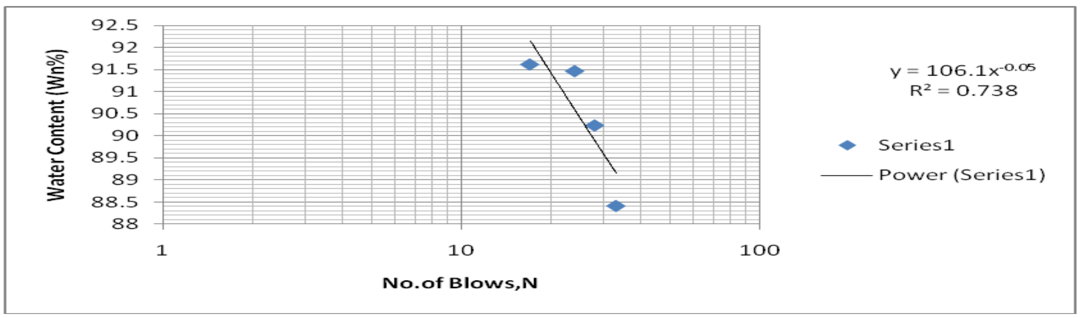
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	2	H7	DC2	P21	2DA	A14
mass of can.g	15.2	15.6	15.5	15.9	15.7	11.4
mass of can+wet soil .g	29.3	29.5	32.5	30.9	21.9	17.5
mass of can+dry soil .g	22.7	22.9	24.4	23.7	20.4	16.1
mass weter .g	6.6	6.6	8.1	7.2	1.5	1.4
mass of dry soil.g	7.5	7.3	8.9	7.8	4.7	4.7
water content%	88	90.41	91.01	92.31	31.91	29.79
number of blows	34	28	22	18		
result	90.57				30.85	

PI=LL-PL 59.72



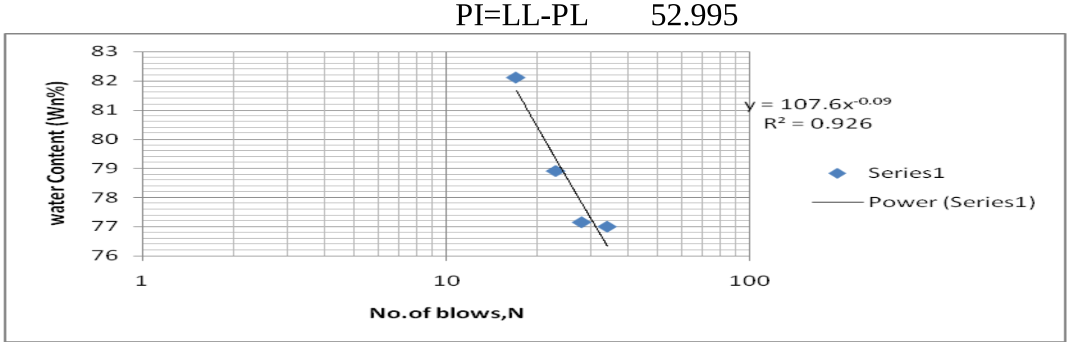
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	117	B1	70	100	C44	TM
mass of can.g	10.9	15.7	15.5	15.5	15.7	15.6
mass of can+wet soil .g	28.8	35.2	35.7	33.8	22.6	22.1
mass of can+dry soil .g	20.4	25.95	26.05	25.05	20.8	20.4
mass weter .g	8.4	9.252	9.65	8.75	1.8	1.7
mass of dry soil.g	9.5	10.25	10.33	9.35	5.1	4.8
water content%	88.42	90.24	91.47	91.62	35.29	35.42
number of blows	33	28	24	17		
result	90.55				35.36	

PI=LL-PL 55.19



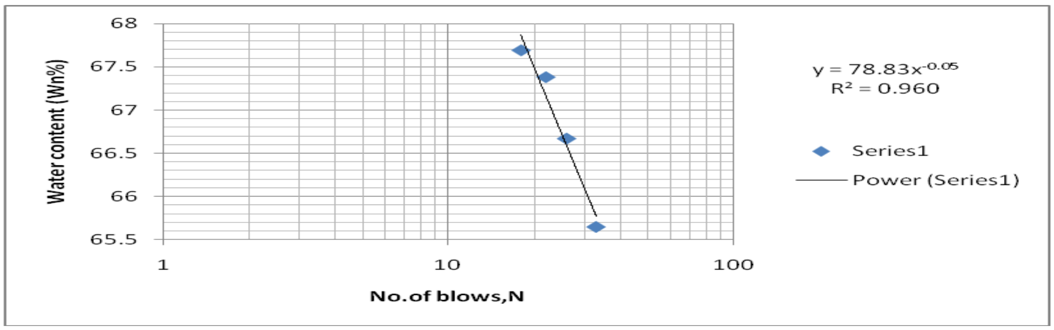
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	M20	T15	SIM	C1	ES	T-8
mass of can.g	15.7	15.6	15.3	10.9	15.7	15.6
mass of can+wet soil .g	35.7	34.2	34.8	33.3	22.2	22.7
mass of can+dry soil .g	27	26.1	26.2	23.2	20.85	21.25
mass weter .g	8.7	8.1	8.6	10.1	1.35	1.45
mass of dry soil.g	11.3	10.5	10.9	12.3	5.15	5.65
water content%	76.99	77.14	78.9	82.11	26.21	25.66
number of blows	34	28	23	17		
result	78.935				25.94	

PI=LL-PL 52.995



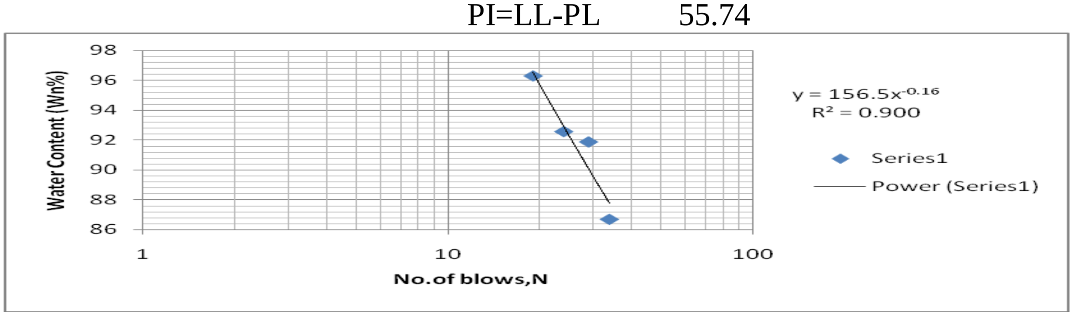
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	CNN	H25	14	57	3M	LL6
mass of can.g	15.5	15	15.3	15.8	10.5	15.68
mass of can+wet soil .g	37.2	35	38.9	37.6	17	23
mass of can+dry soil .g	28.6	27	29.4	28.8	15.7	21.5
mass weter .g	8.6	8	9.5	8.8	1.3	1.5
mass of dry soil.g	13.1	12	14.1	13	520	5.9
water content%	65.65	66.67	67.38	67.69	25	25.52
number of blows	33	26	22	18		
result	66.82				25.21	

PI=LL-PL 41.61



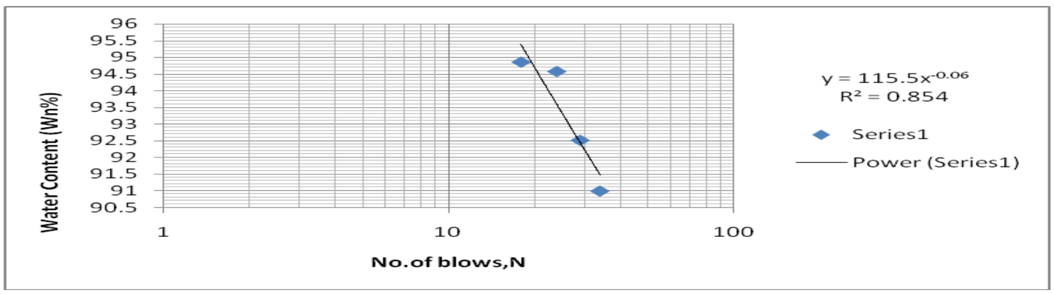
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	6	M20	C44	LL6	117	5IM
mass of can.g	15.6	15.6	15.7	15.5	10.9	15.3
mass of can+wet soil .g	32.4	32.1	33.8	33.95	17.47	22.65
mass of can+dry soil .g	24.6	24.2	25.1	24.9	15.85	20.65
mass weter .g	7.8	7.9	8.7	9.05	1.85	1.95
mass of dry soil.g	9	8.6	9.4	9.4	4.95	5.35
water content%	86.67	91.86	92.55	96.28	37.37	36.45
number of blows	34	29	24	19		
result	92.65				36.91	

PI=LL-PL 55.74



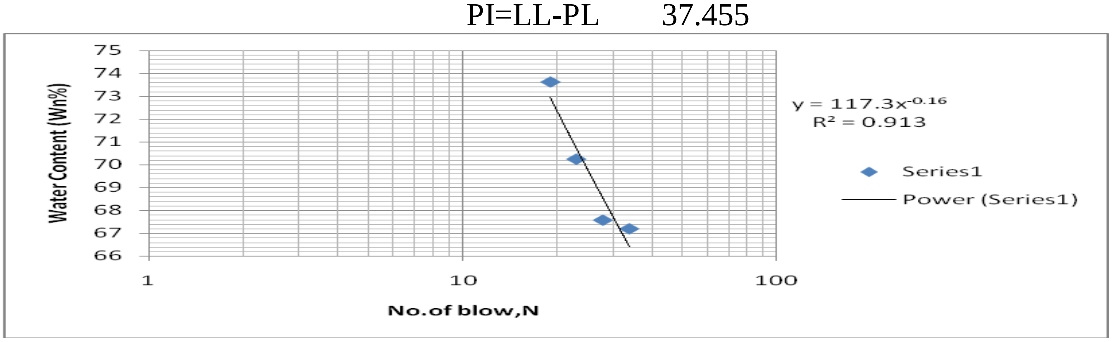
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	CNN	52	Crs	T15	SIM	C44
mass of can.g	15.5	15.1	15.8	15.6	15.3	15.7
mass of can+wet soil .g	36.7	33.1	33.7	34.5	22.3	23.3
mass of can+dry soil .g	26.6	24.45	25	25.3	20.35	21.15
mass weter .g	10.1	8.65	8.7	9.2	1.95	2.15
mass of dry soil.g	11.1	9.35	9.2	9.7	5.05	5.45
water content%	90.99	92.51	94.57	94.85	38.61	39.45
number of blows	34	29	24	18		
result	93.565				39.03	

PI=LL-PL 54.535



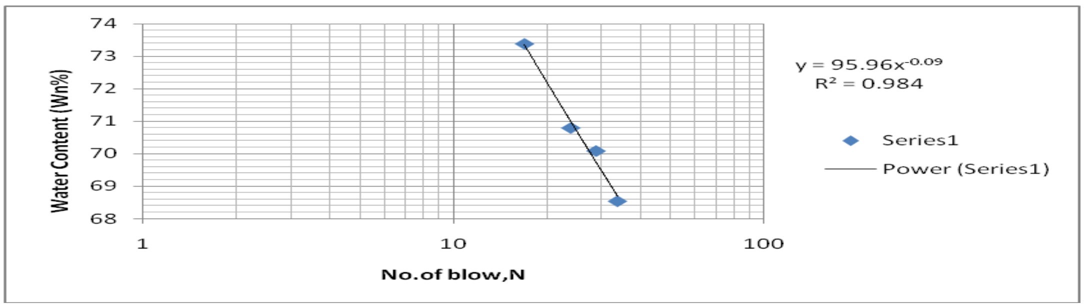
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	F101	B6	3M	M20	B4	117
mass of can.g	15.5	15.6	10.5	15.7	15.7	10.9
mass of can+wet soil .g	36.9	34.2	31.1	38.1	22	17.2
mass of can+dry soil .g	28.3	26.7	22.6	28.6	20.45	15.65
mass weter .g	8.6	7.5	8.5	9.5	1.55	1.55
mass of dry soil.g	12.8	11.1	12.1	12.9	4.75	4.75
water content%	67.19	67.57	70.25	73.64	32.63	32.63
number of blows	34	28	23	19		
result	70.085				32.63	

PI=LL-PL 37.455



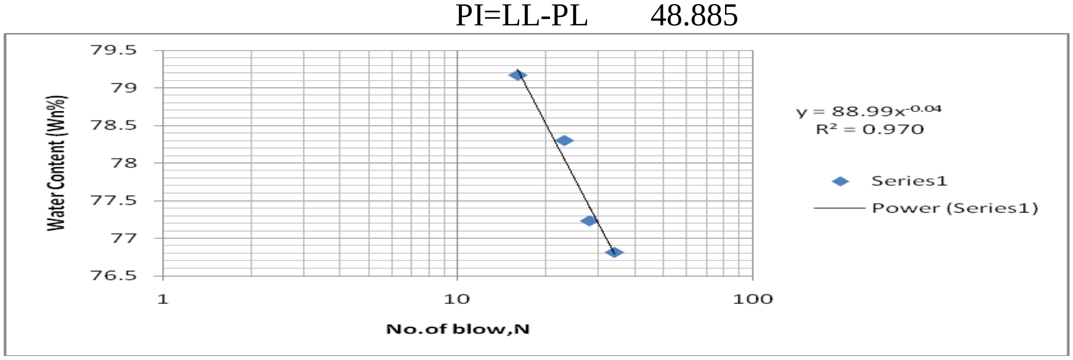
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	T15	52	C1	115	100	E5
mass of can.g	15.6	15.2	10.9	15.5	15.6	15.6
mass of can+wet soil .g	30.6	35.1	30.2	37	24	22.9
mass of can+dry soil .g	24.5	26.9	22.2	27	21.9	21.05
mass weter .g	6.1	8.2	8	9.1	2.1	1.85
mass of dry soil.g	8.9	11.7	11.3	12.4	6.3	5.45
water content%	68.54	70.09	70.8	73.39	33.33	33.94
number of blows	34	29	24	17		
result	70.985				33.64	

PI=LL-PL 37.345



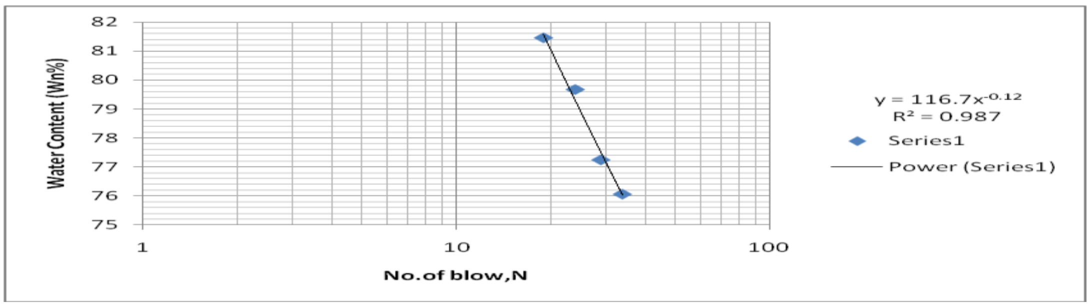
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	CRS	52	140	T15	C44	D31
mass of can.g	15.8	15.1	15.5	15.6	15.7	15.4
mass of can+wet soil .g	34.1	33	34.4	41.4	22	22
mass of can+dry soil .g	26.15	25.2	26.1	30	20.55	20.55
mass weter .g	7.95	7.8	8.3	11.4	1.45	1.45
mass of dry soil.g	10.35	10.1	10.6	14.4	4.85	5.15
water content%	76.81	77.23	78.3	79.17	29.9	28.16
number of blows	34	28	23	16		
result	77.915				29.03	

PI=LL-PL 48.885



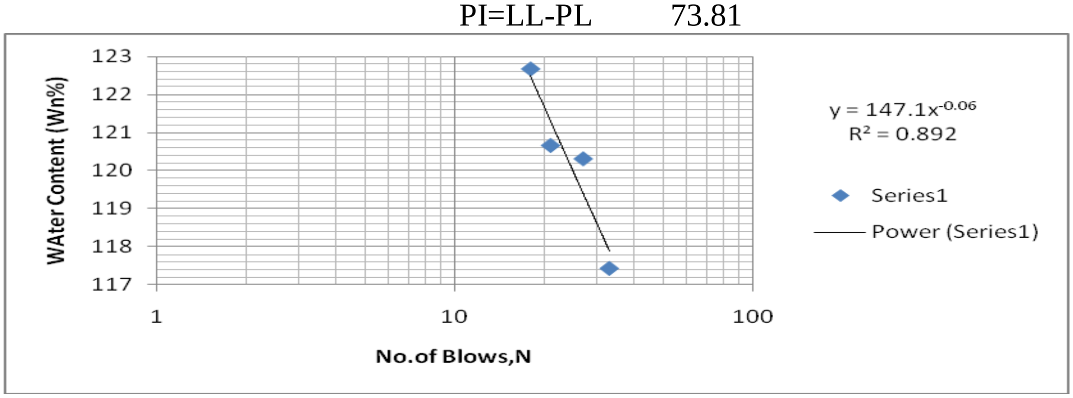
Ambo						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	T13	6	H25	3M	CNN	sLM
mass of can.g	15.2	15.6	15	10.4	15.5	15.3
mass of can+wet soil .g	35.8	38.2	37.1	32.9	22.1	22.8
mass of can+dry soil .g	26.9	28.35	27.3	22.8	20.4	20.8
mass weter .g	8.9	9.8	9.8	10.1	1.7	2
mass of dry soil.g	11.7	12.75	12.3	12.4	4.9	5.5
water content%	76.07	77.25	79.67	81.45	34.69	36.36
number of blows	34	29	24	19		
result	79.165				35.53	

PI=LL-PL 43.635



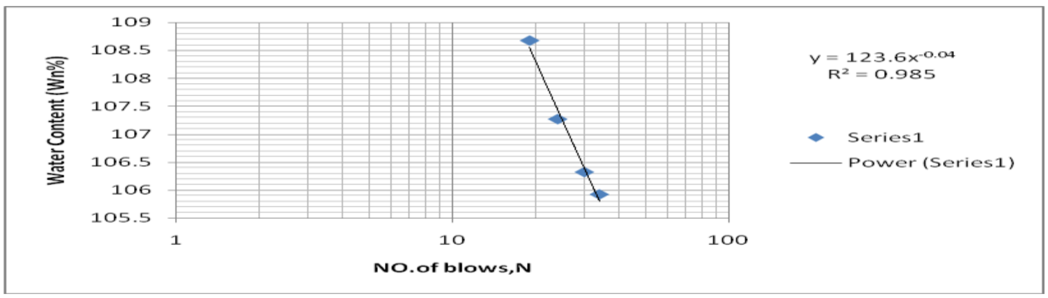
Arebamench						
	L.L				P.L	
trial no	1	2	3	4	1	2
number of blows	18	21	27	33		
can no .g	47	D16	DEF	D8	33	A17
mass of can.g	15.39	15.56	15.62	15.5	14.06	15.79
mass of can+wet soil .g	35.92	.36.17	38.75	35.33	16.88	18.87
mass of can+dry soil .g	24.61	24.9	26.119	24.62	15.99	17.89
mass weter .g	11.31	11.27	12.631	10.71	0.89	0.98
mass of dry soil.g	9.22	9.34	10.499	9.12	1.93	2.1
water content%	122.67	120.66	120.31	117.43	46.11	46.7
result	120.2				46.39	

PI=LL-PL 73.81



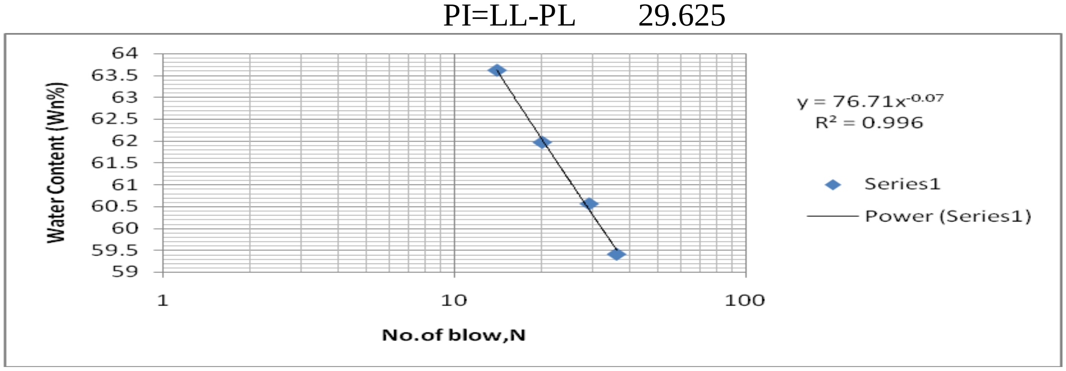
Arebamench						
	L.L				P.L	
trial no	1	2	3	4	1	2
number of blows	19	24	30	34		
can no .g	9	61	72	101	A76	A1
mass of can.g	15.68	15.52	15.69	15.55	15.56	11.5
mass of can+wet soil .g	42.71	39.17	50.27	40.96	19.57	15.81
mass of can+dry soil .g	28.633	26.93	32.45	27.89	18.25	14.39
mass weter .g	14.077	12.24	17.82	13.07	1.32	1.42
mass of dry soil.g	12.953	11.41	16.76	12.34	2.69	2.89
water content%	108.68	107.27	106.32	105.92	49.07	49.13
result	107.35				49.1	

PI=LL-PL 58.25



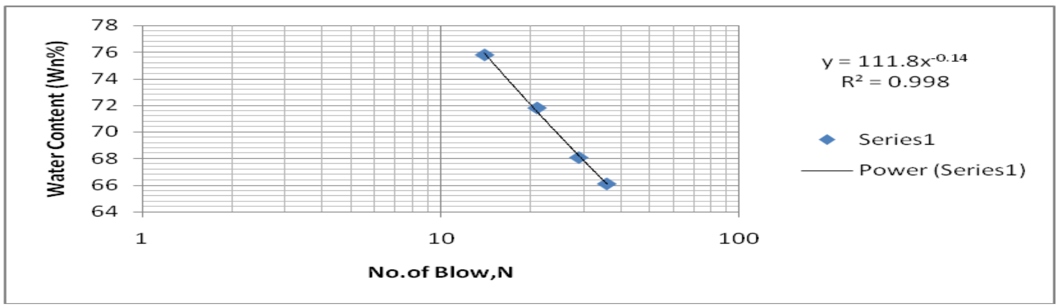
A.A						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	C20	75	A31	D29	C21	
mass of can+wet soil .g	31.22	32.24	34.98	37.31	16.32	18.03
mass of can+dry soil .g	24.72	29.1	27.63	28.81	15.8	17.49
mass of can.g	13.78	15.66	15.77	15.45	14.16	15.79
mass of dry soil.g	10.94	13.44	11.86	13.36	1.64	1.7
mass weter .g	6.5	8.14	7.35	8.5	0.52	0.54
water content%	59.41	60.5655	61.973	63.6228	31.71	31.76
number of blows	36	29	20	14		
result	61.365				31.74	

PI=LL-PL 29.625



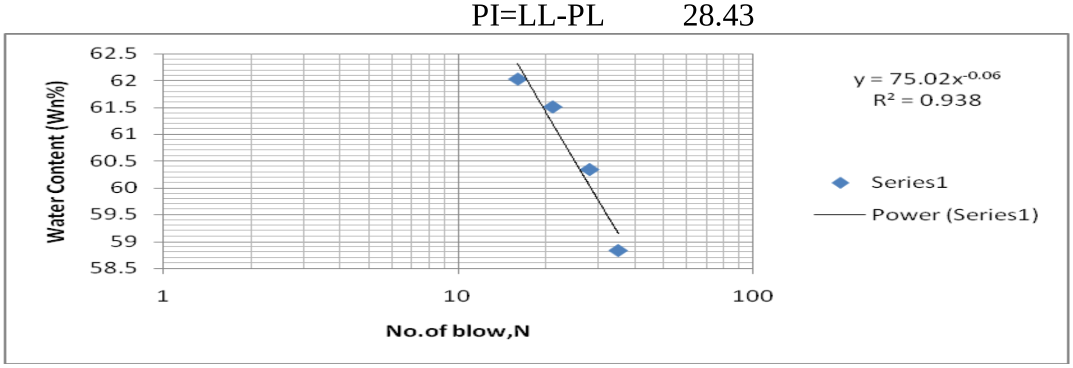
A.A						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	D20	69	95	47	56	D35
mass of can+wet soil .g	32.05	29.56	31.07	32.46	18.25	18.01
mass of can+dry soil .g	25.46	23.93	24.6	25.1	17.5	17.26
mass of can.g	15.49	15.66	15.59	15.39	15.77	15.49
mass of dry soil.g	9.97	8.27	9.01	9.71	1.73	1.77
mass weter .g	6.59	5.63	6.47	7.36	0.75	0.78
water content%	66.09	68.07	71.8	75.79	43.35	44.06
number of blows	36	29	21	14		
result	70.455				43.7	

PI=LL-PL 26.755



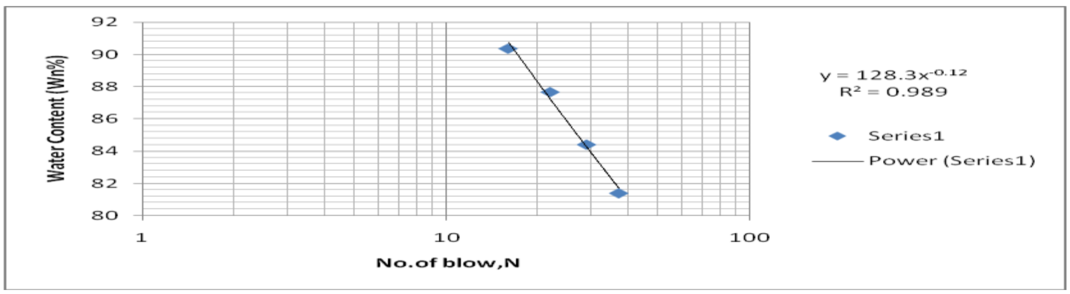
A.A						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	47	D361	76	35	36	8
mass of can+wet soil .g	41.37	36.95	37.72	36.76	15.95	17.63
mass of can+dry soil .g	31.84	28.9	29.28	28.71	15.44	17.15
mass of can.g	15.64	15.56	15.56	15.7	13.87	15.65
mass of dry soil.g	16.2	13.34	13.72	13.01	1.57	1.5
mass weter .g	9.53	8.05	8.44	8.07	0.51	0.48
water content%	58.827	60.34	61.51	62.029	32.48	32
number of blows	35	28	21	16		
result	60.67				32.24	

PI=LL-PL 28.43



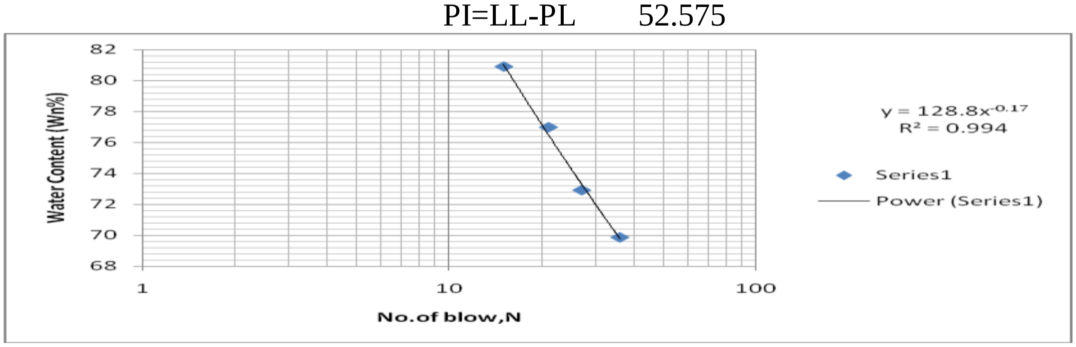
A.A						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	97	A10	75	A14	20	70
mass of can+wet soil .g	32.23	31.28	31.65	33.24	17.92	17.66
mass of can+dry soil .g	24.88	24.08	24.19	24.89	17.32	17.18
mass of can.g	15.85	15.55	15.68	15.65	15.6	15.74
mass of dry soil.g	9.02	8.53	8.51	9.24	1.72	1.44
mass weter .g	7.35	7.2	7.49	8.34	0.6	0.48
water content%	81.394	84.41	87.667	90.36	34.88	33.33
number of blows	37	29	22	16		
result	86.405				34.11	

PI=LL-PL 52.295



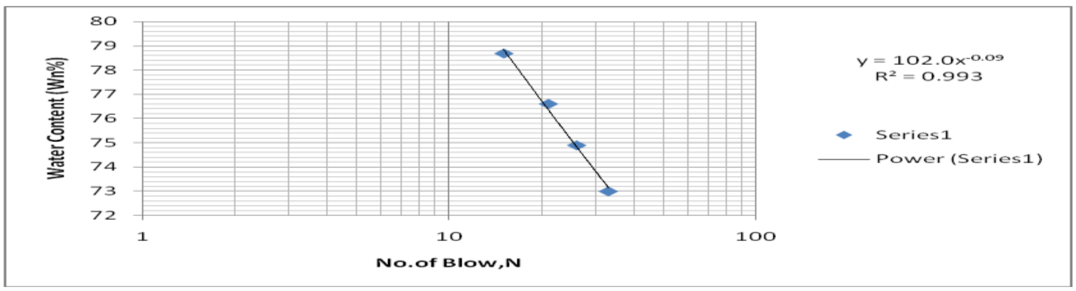
A.A						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	C13	85	C19	C20	36	D20
mass of can+wet soil .g	31.15	35.26	30.97	31.8	16.54	17.43
mass of can+dry soil .g	24.22	27.08	23.58	23.75	16.05	17.08
mass of can.g	14.3	15.86	13.98	13.8	13.87	15.52
mass of dry soil.g	9.92	11.22	9.6	9.95	2.18	1.56
mass weter .g	6.93	8.18	7.39	8.05	0.49	0.35
water content%	69.86	72.91	76.98	80.9	22.48	22.4
number of blows	36	27	21	15		
result	75.035				22.46	

PI=LL-PL 52.575



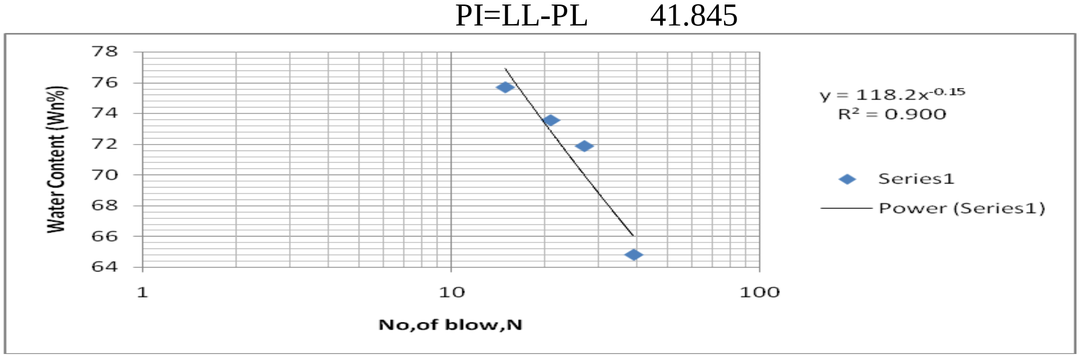
A.A						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	45	24	97	57	33	80
mass of can+wet soil .g	33.3	36.23	32.45	33.38	15.57	17.74
mass of can+dry soil .g	25.76	27.4	25.25	25.41	15.17	17.19
mass of can.g	15.43	15.61	15.85	15.28	14.07	15.7
mass of dry soil.g	10.33	11.79	9.4	10.13	1.1	1.49
mass weter .g	7.54	8.83	7.2	7.97	0.4	0.55
water content%	72.99	74.89	76.6	78.68	36.368	36.91
number of blows	33	26	21	15		
result	75.395				36.64	

PI=LL-PL 38.755



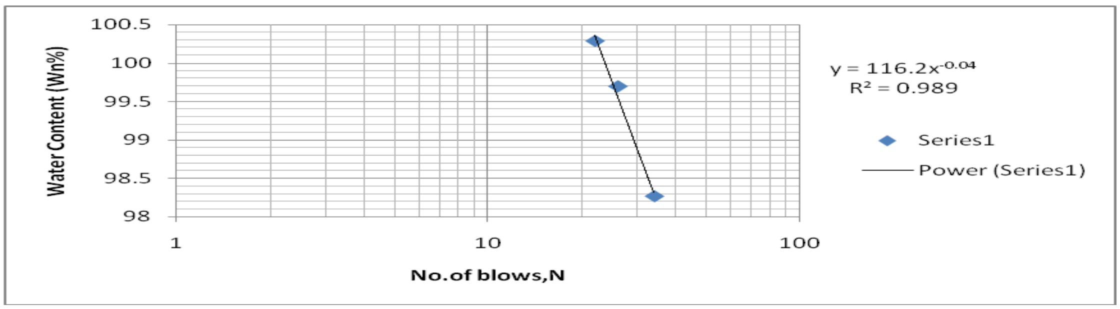
A.A						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	24	98	C15	C18	76	D34
mass of can+wet soil .g	35.31	38.6	36.95	32.66	19.64	19.21
mass of can+dry soil .g	26.83	28.83	27.31	25.14	18.62	18.26
mass of can.g	15.63	15.55	13.9	13.54	15.55	15.35
mass of dry soil.g	11.2	13.28	13.41	11.6	3.07	2.91
mass weter .g	8.48	9.77	9.64	7.52	1.02	0.95
water content%	75.71	73.57	71.89	64.83	33.22	32.65
number of blows	15	21	27	39		
result	74.745				32.9	

PI=LL-PL 41.845



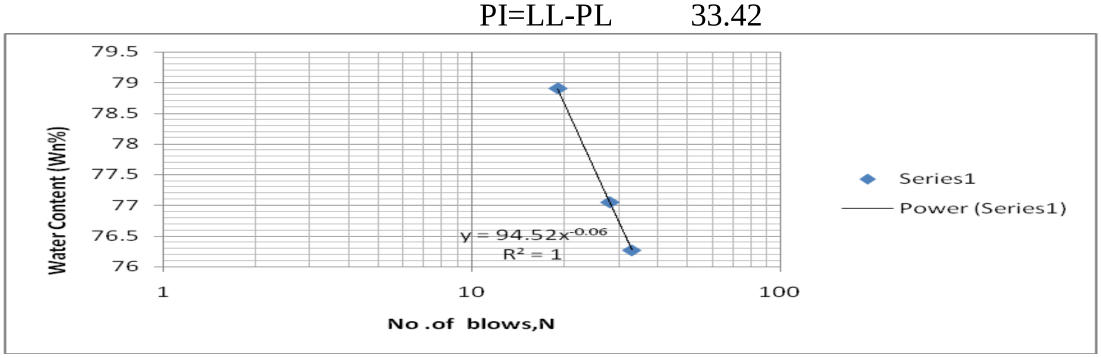
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	A18	A29	C35	65	D34
mass of can+wet soil .g	23.52	23.37	23.41	12.47	12.98
mass of can+dry soil .g	48.76	49.59	50.93	22.15	22.6
mass of can.g	36.25	36.5	37.15	19.21	19.66
mass of dry soil.g	12.51	13.09	13.78	2.94	2.94
mass weter .g	12.73	13.13	13.74	6.74	6.68
water content%	98.27	99.7	100.29	43.62	44.01
number of blows	34	26	22		
result	99.75			43.82	

PI=LL=PL 55.93



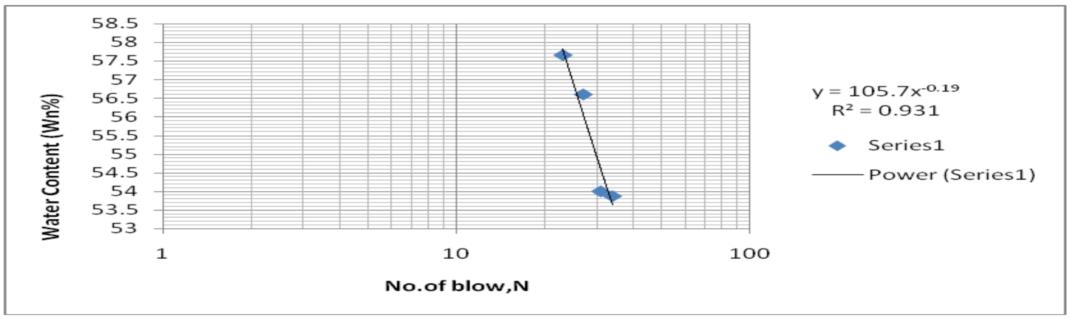
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	A13	C15	98	76	D34
mass of can+wet soil .g	23.37	23.39	23.01	12.73	12.78
mass of can+dry soil .g	51.45	50.16	44.46	19.56	19.96
mass of can.g	39.3	38.51	35	17.47	17.75
mass of dry soil.g	12.15	11.65	9.46	2.09	2.21
mass weter .g	15.93	15.12	11.99	4.74	4.91
water content%	76.27	77.05	78.9	44.09	44.47
number of blows	33	28	19		
result	77.72			44.3	

PI=LL-PL 33.42



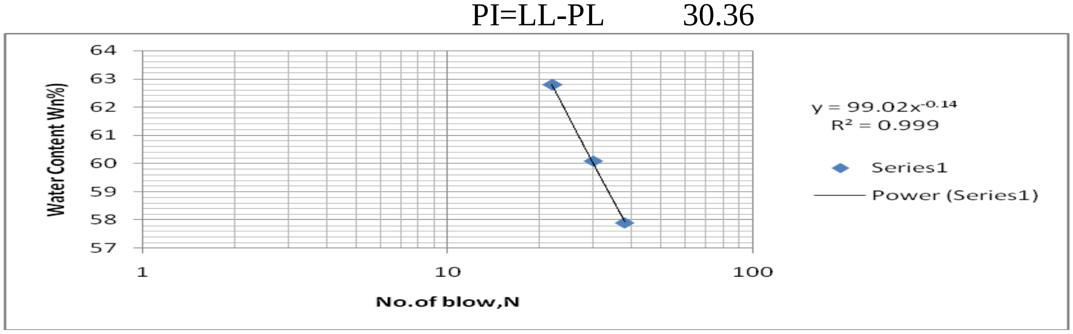
Tendaho						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	72	D36	C2	A14	63	14
number of blows	23	27	31	34	20.489	20.533
mass of can+wet soil .g	49.76	64.7	60.295	55.503	19.647	19.396
mass of can+dry soil .g	37.29	46.938	44.654	41.543	0.842	1.137
mass weter .g	12.47	17.76	15.641	13.96	15.607	15.631
mass of can.g	15.65	15.55	15.69	15.63	4.04	3.765
mass of dry soil.g	21.638	31.38	28.964	25.913	20.842	30.199
water content%	57.653	56.6	54.002	53.873		
result	56.9				25.52	

PI=LL-PL 31.38



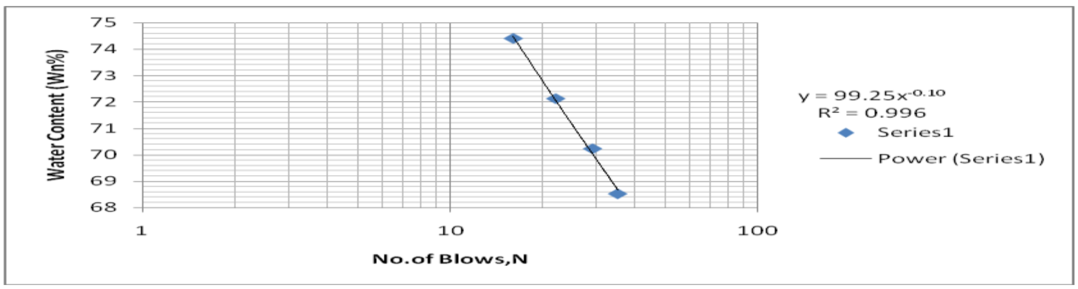
Tendaho						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	30	50	38	38	135	144
number of blows	38	30	22	22	29.2	28.4
mass of can+wet soil .g	52.56	58	57.3	57.3	27.6	26.9
mass of can+dry soil .g	41.5	44.9	43.3	43.8	1.6	1.5
mass weter .g	11.06	13.1	13.5	13.5	22.3	22.2
mass of can.g	22.4	23.1	22.3	22.3	5.3	4.7
mass of dry soil.g	19.1	21.8	21.5	21.5	30.189	31.915
water content%	57.906	60.092	62.791	62.791		
result	61.41				31.05	

PI=LL-PL 30.36



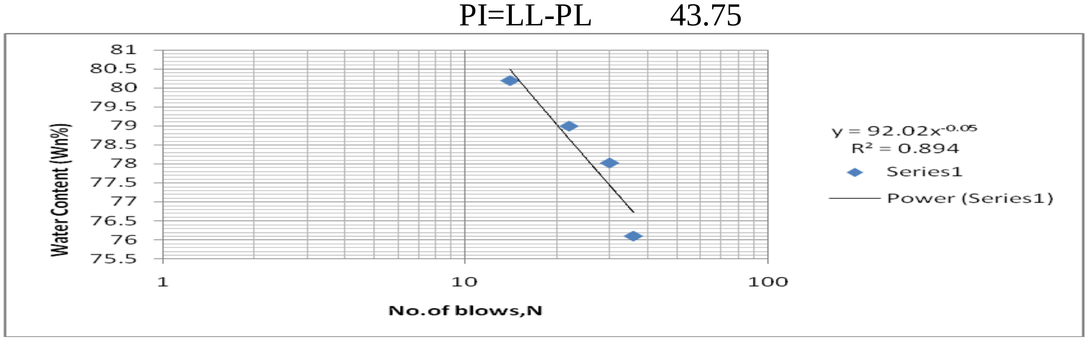
Tendaho						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	170	144	37	151	165	171
number of blows	35	29	22	16	29.8	29.7
mass of can+wet soil .g	40	52.5	50.66	44.2	27.7	27.7
mass of can+dry soil .g	32.6	40	38.7	34.9	2.1	2
mass weter .g	7.4	12.5	11.9	9.3	21.4	21.4
mass of can.g	21.8	22.2	22.2	22.4	6.3	6.3
mass of dry soil.g	10.8	17.8	16.5	12.5	33.33	31.746
water content%	68.519	70.225	72.121	74.4		
result	71				32.54	

PI=LL-PL 38.46



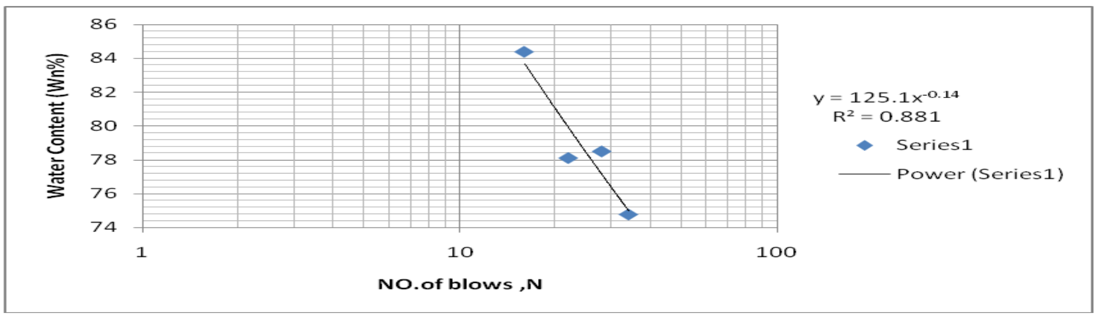
Tendaho						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	39	19	38	36	49	171
number of blows	36	30	22	14	32	32.5
mass of can+wet soil .g	46.7	45.7	41.99	39.8	29.3	30
mass of can+dry soil .g	36.4	35.4	33.3	31.7	2.7	2.5
mass weter .g	10.35	10.3	8.69	8.1	21.9	22.3
mass of can.g	22.8	22.2	22.3	21.6	7.4	7.7
mass of dry soil.g	13.6	13.2	11	10.1	36.486	32.468
water content%	76.103	78.03	79	80.198		
result	78.2				34.45	

PI=LL-PL 43.75



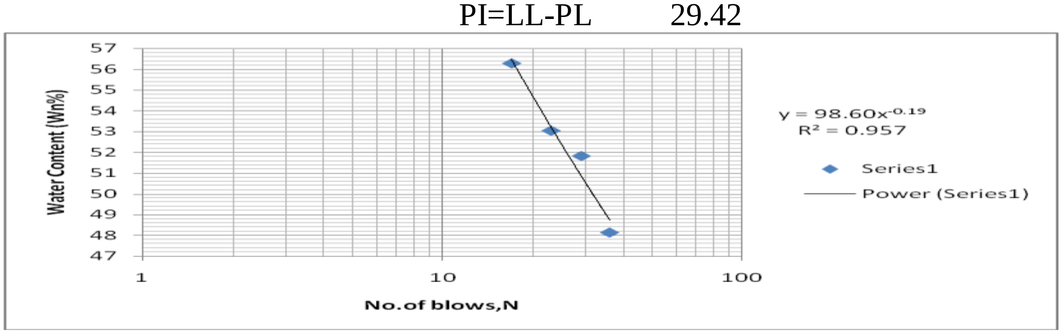
Tendaho						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	158	165	155	190	154	170
number of blows	34	28	22	16	29.45	30.1
mass of can+wet soil .g	39.8	40.07	41.1	44.98	27.5	28.1
mass of can+dry soil .g	32.4	32.3	32.9	34.6	1.95	2
mass weter .g	7.4	7.77	8.2	10.38	21.8	22.1
mass of can.g	22.5	22.4	22.4	22.3	5.7	6
mass of dry soil.g	9.9	9.9	10.5	12.3	34.211	33.33
water content%	74.747	78.485	78.095	84.39		
result	78.6				33.77	

PI=LL-PL 59.204



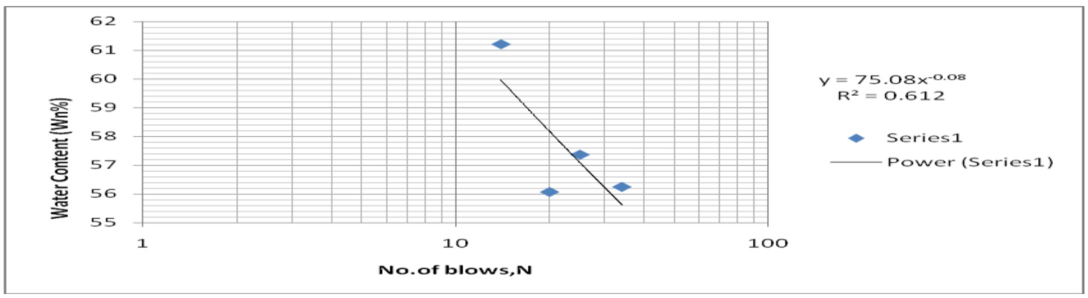
Tendaho						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	167	44	27	39	134	32
number of blows	36	29	23	17	31.8	31.8
mass of can+wet soil .g	46.8	51.7	47.9	46.3	30	30
mass of can+dry soil .g	39	41.8	39.2	37.8	1.8	1.8
mass weter .g	7.8	9.9	8.7	8.5	22.2	22.2
mass of can.g	22.8	22.7	22.8	22.7	7.8	7.8
mass of dry soil.g	16.2	19.1	16.4	15.1	23.077	23.077
water content%	48.148	51.832	53.049	56.291		
result	52.5				23.08	

PI=LL-PL 29.42



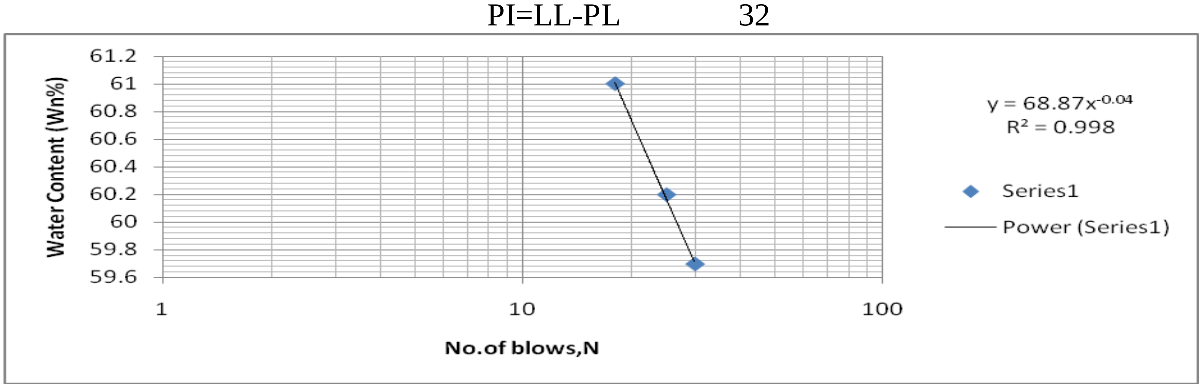
Tendaho						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	56	190	48	155	5	4
number of blows	34	25	20	14	34.44	33.51
mass of can+wet soil .g	53.9	54.25	51.81	50.9	33.2	32.3
mass of can+dry soil .g	42.2	42.6	41.1	40.09	1.24	1.21
mass weter .g	11.7	11.6	10.71	10.82	27.2	26.7
mass of can.g	21.4	22.3	22	22.4	27.2	5.6
mass of dry soil.g	20.8	20.3	19.1	17.68	6	5.6
water content%	56.25	57.369	56.073	61.199	20.667	21.6
result	57.1				21.14	

PI=LL-PL 35.96



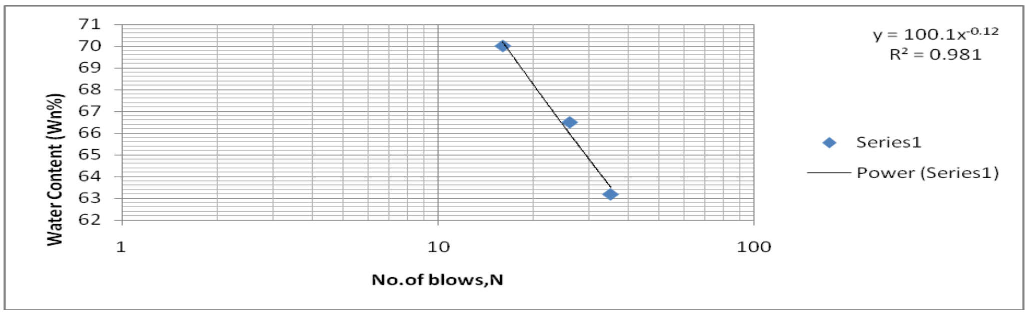
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	C2	T5	D5		
number of blows	30	25	18		
mass of can+wet soil .g	54.2	55.6	56.3	13.1	13.1
mass of can+dry soil .g	38.2	39	39.3	12.7	12.7
mass of can.g	11.5	11.4	11.5	11.4	11.4
mass weter .g	16	16.6	17	0.4	0.1
mass of dry soil.g	26.8	27.6	27.9	1.3	1.3
water content%	59.7	60.2	61	27.8	28.8
result	60			28	

PI=LL-PL 32



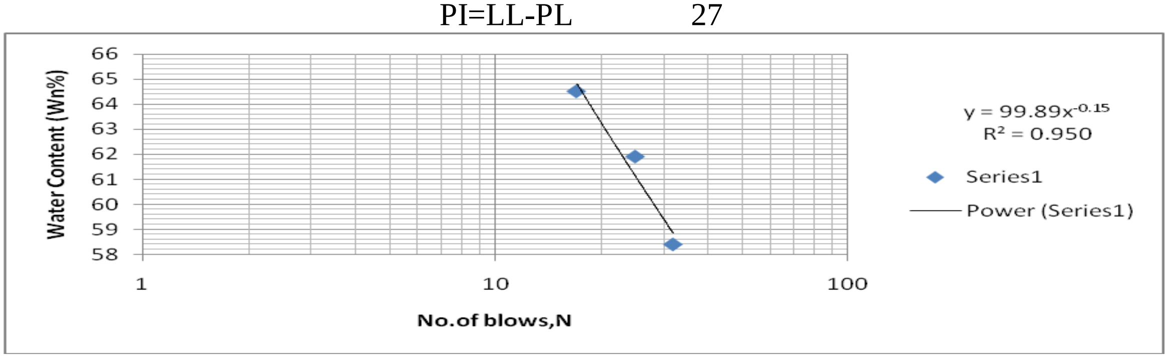
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	C14	C9	C8	C7	C1
number of blows	35	26	16	0	0
mass of can+wet soil .g	47.3	46.7	47	24.91	23.98
mass of can+dry soil .g	35.4	34.7	34.4	22.76	22.04
mass of can.g	16.5	16.6	16.4	16.56	16.57
mass weter .g	11.9	12	12.6	2.2	1.9
mass of dry soil.g	18.9	18.1	18	6.2	5.5
water content%	63.2	66.5	70	34.7	35.5
result	66			35	

PI=LL-PL 31



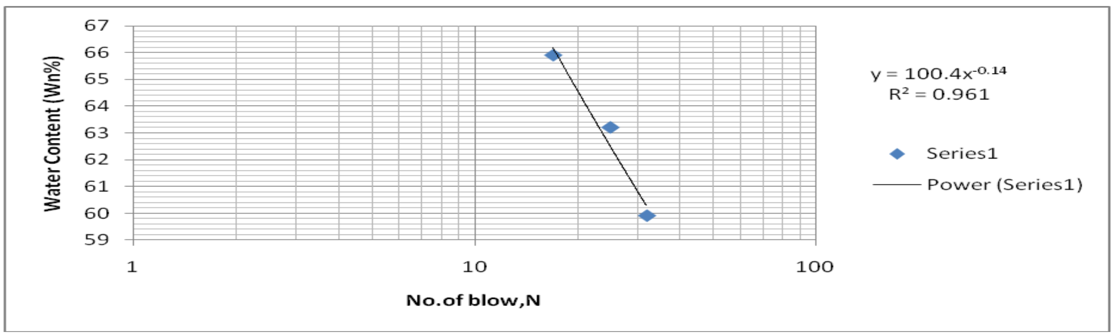
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	C11	C16	C19	A6	E
number of blows	32	25	17	0	0
mass of can+wet soil .g	47.9	47.5	50.6	26.81	21.69
mass of can+dry soil .g	36.3	35.7	37.3	25.3	20.39
mass of can.g	16.5	16.6	16.7	20.91	16.57
mass weter .g	11.6	11.8	13.3	1.5	1.3
mass of dry soil.g	19.8	19.1	20.6	4.4	3.8
water content%	58.4	61.9	64.5	34.4	34
result	61			34	

PI=LL-PL 27



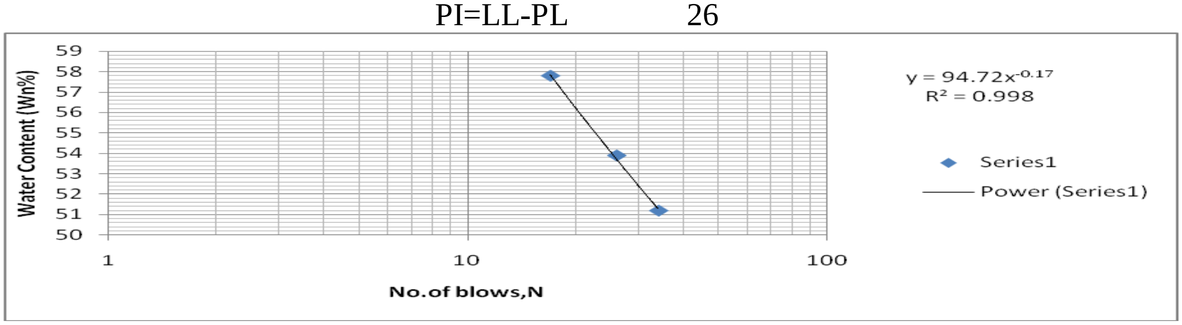
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	G	C11	C12		
number of blows	32	25	17		
mass of can+wet soil .g	43.9	45.5	48	28.3	28.24
mass of can+dry soil .g	33.7	34.2	35.6	26.49	26.29
mass of can.g	16.6	16.5	16.7	21.08	20.49
mass weter .g	10.2	11.2	12.4	1.8	2
mass of dry soil.g	17.1	17.8	18.9	5.4	5.8
water content%	59.9	63.2	65.9	33.5	33.6
result	63			34	

PI=LL-PL 29



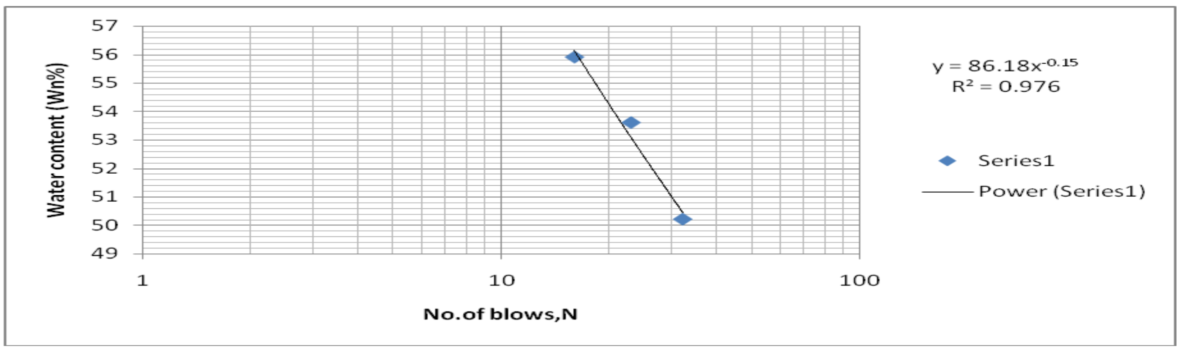
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	C6	C10	C13	C18	C2
number of blows	34	26	17		
mass of can+wet soil .g	43.5	47.2	48.9	27.42	27.42
mass of can+dry soil .g	34.4	36.5	37	25.1	25.06
mass of can.g	16.5	16.6	16.6	16.68	16.56
mass weter .g	9.1	10.7	11.8	2.32	2.36
mass of dry soil.g	17.8	19.9	20.5	8.42	8.5
water content%	51.2	53.9	57.8	27.55	27.76
result	54			28	

PI=LL-PL 26



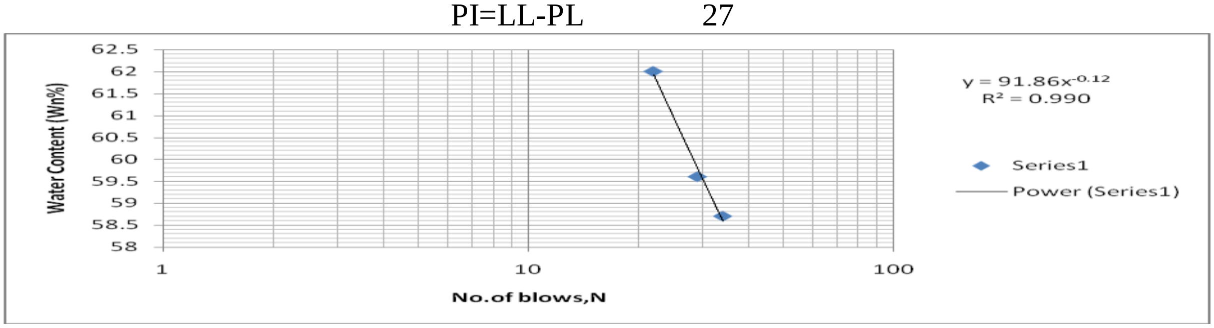
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	C6	C7	C10	A3	A5
number of blows	32	23	16		
mass of can+wet soil .g	47	50.5	48.5	27.47	27.32
mass of can+dry soil .g	36.8	38.7	37.1	25.87	55.69
mass of can.g	16.5	16.6	16.6	21.08	20.71
mass weter .g	10.2	11.8	11.4	1.6	1.63
mass of dry soil.g	20.3	22.1	20.5	4.79	4.98
water content%	50.2	53.6	55.9	33.4	32.73
result	52			33	

PI=LL-PL 19



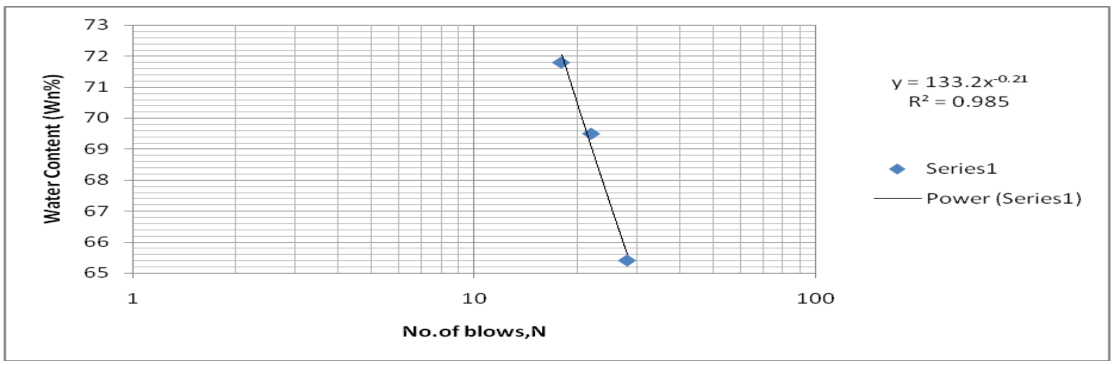
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	D1	D2	D3	C5	F9
number of blows	34	29	22		
mass of can+wet soil .g	81.7	76.9	81.1	62.32	67.08
mass of can+dry soil .g	72	67.3	70.5	58.1	63.27
mass of can.g	55.4	51.2	53.3	45.68	52.05
mass weter .g	9.7	9.6	10.6	4.2	3.81
mass of dry soil.g	16.5	16.1	17.2	12.42	11.22
water content%	58.7	59.6	62	33.98	33.96
result	61			34	

PI=LL-PL 27



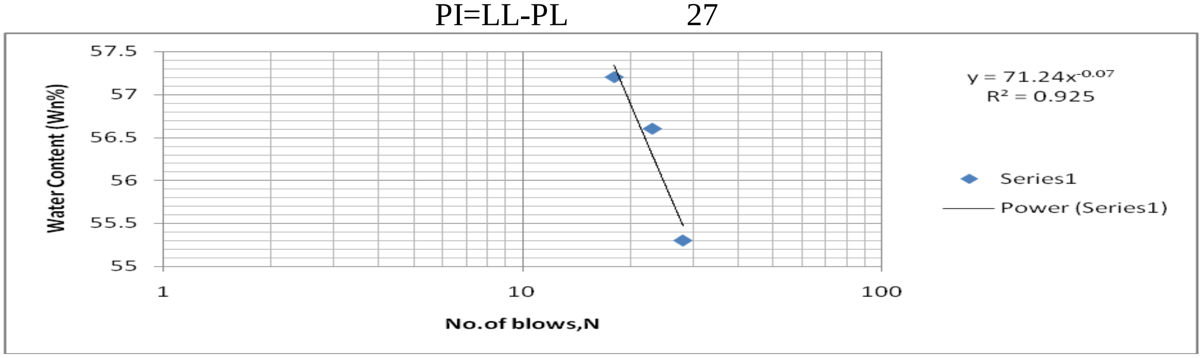
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	G5	B11	G3	D4	C2
number of blows	28	22	18		
mass of can+wet soil .g	82.3	83.3	86.3	73.64	74.45
mass of can+dry soil .g	71	71	73.4	68.25	69.05
mass of can.g	53.7	53.4	55.5	51.32	52.02
mass weter .g	11.3	12.3	12.8	5.39	5.4
mass of dry soil.g	17.3	17.6	17.9	16.93	17.03
water content%	65.4	69.5	71.8	31.84	31.71
result	70			32	

PI=LL-PL 38



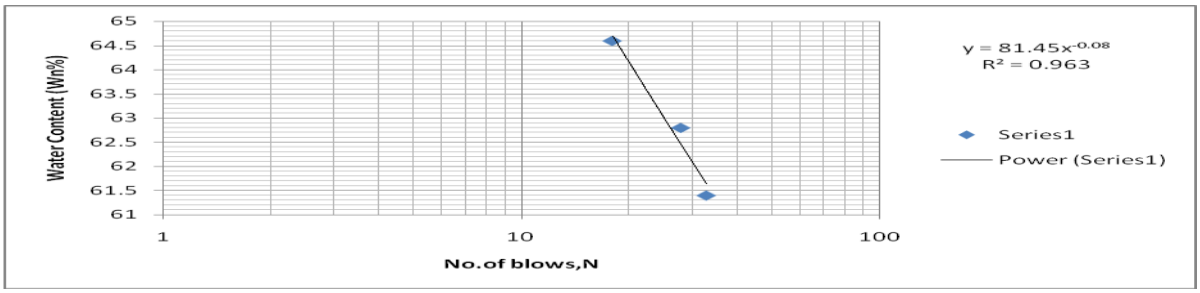
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	H12	E6	G7	F4	F10
number of blows	28	23	18		
mass of can+wet soil .g	75.8	81.7	70.2	71.2	73.25
mass of can+dry soil .g	68.1	71.7	61.3	66.93	68.84
mass of can.g	54.1	54	45.7	52	53.77
mass weter .g	7.7	10	8.9	4.27	4.41
mass of dry soil.g	14	17.7	15.6	14.93	15.07
water content%	55.3	56.6	57.2	28.6	29.26
result	56			29	

PI=LL-PL 27



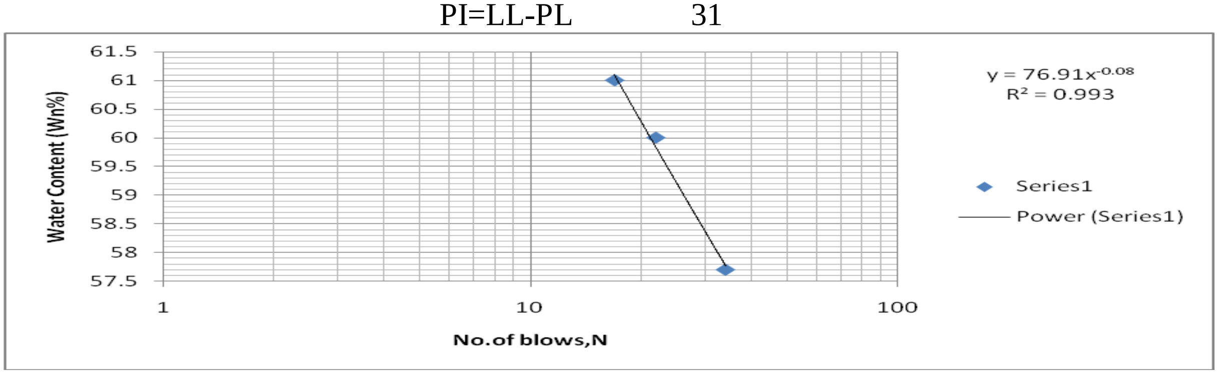
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	D12	G2	G6	F4	H3
number of blows	33	28	18		
mass of can+wet soil .g	76.4	75.7	76.7	122.98	128.23
mass of can+dry soil .g	67	67.2	67	119.19	124.44
mass of can.g	51.7	53.7	52.1	107.66	113.05
mass weter .g	9.4	8.5	9.7	3.79	3.79
mass of dry soil.g	15.3	13.5	15	11.53	11.39
water content%	61.4	62.8	64.6	32.87	33.27
result	63			33	

PI=LL-PL 30



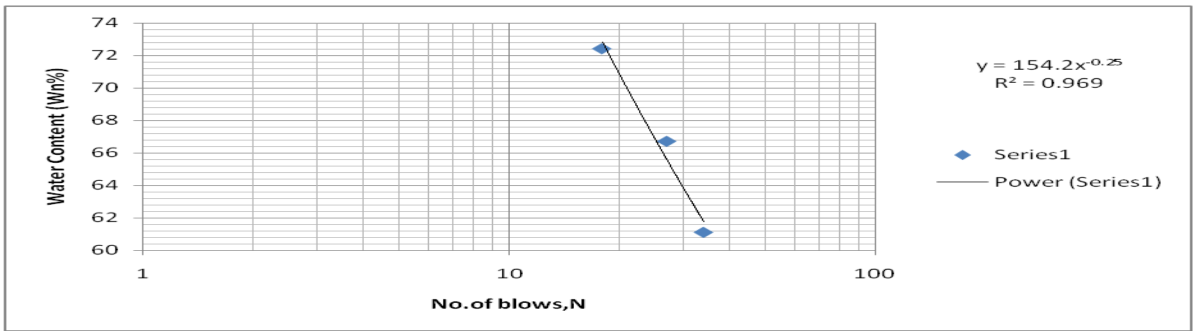
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	G10	N6	B2	G4	F1
number of blows	34	22	17		
mass of can+wet soil .g	72.3	63.4	68.5	57.11	52.26
mass of can+dry soil .g	65.6	56.8	62.1	55.7	50.92
mass of can.g	54.1	45.7	51.7	50.59	46.14
mass weter .g	6.7	6.6	6.4	1.41	1.34
mass of dry soil.g	11.6	11.1	10.5	5.11	4.78
water content%	57.7	60	61	27.59	28.03
result	59			28	

PI=LL-PL 31



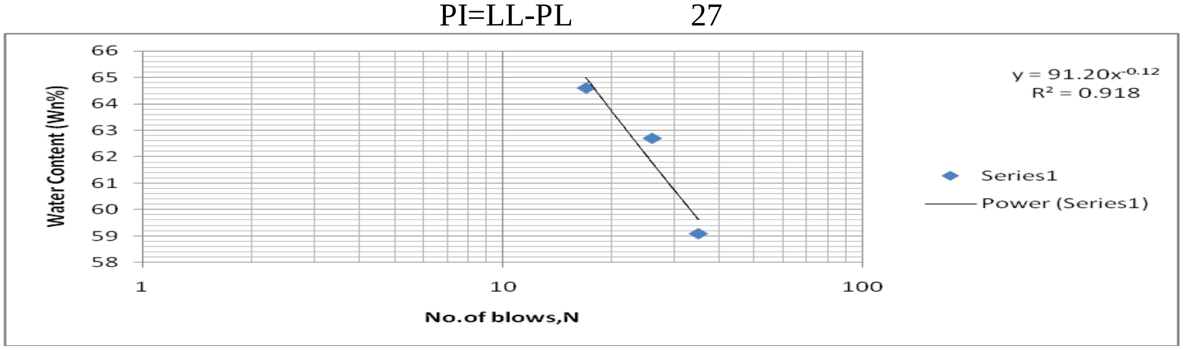
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	C1	C4	C11	C17	C18
number of blows	34	27	18		
mass of can+wet soil .g	48.5	57.6	56.9	24.1	24.8
mass of can+dry soil .g	36.4	41.2	39.9	22	22.6
mass of can.g	16.6	16.7	16.5	16.5	16.7
mass weter .g	12.1	16.4	17	2.07	2.22
mass of dry soil.g	19.8	24.5	23.4	5.52	5.89
water content%	61.1	66.7	72.4	37.5	37.69
result	67			38	

PI=LL-PL 29



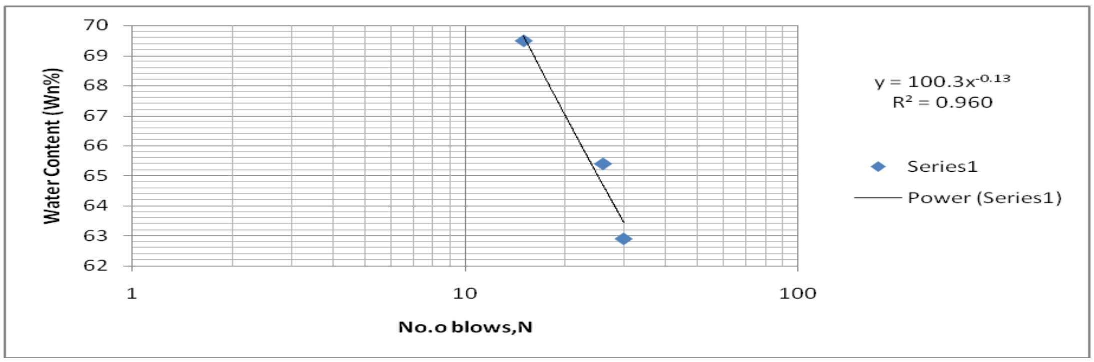
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	P1	C7	C15	C19	A5
number of blows	35	26	17		
mass of can+wet soil .g	57.7	52.4	58.2	29	34
mass of can+dry soil .g	42.5	38.6	41.9	25.9	30.5
mass of can.g	16.7	16.6	16.7	16.7	20.7
mass weter .g	15.3	13.8	16.3	3.15	3.43
mass of dry soil.g	25.8	22	25.2	9.22	9.81
water content%	59.1	62.7	64.6	34.16	34.96
result	62			35	

PI=LL-PL 27



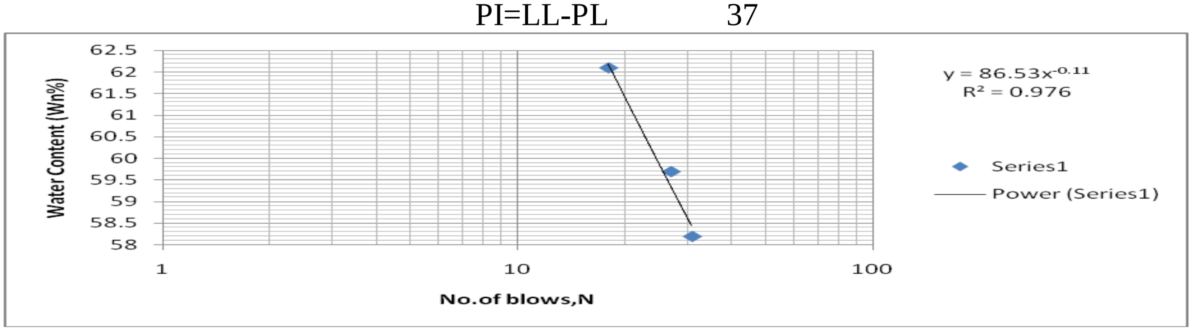
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	A7	A33	G4	X22	K11
number of blows	30	26	15		
mass of can+wet soil .g	44.65	41.7	36.19	24.35	24.01
mass of can+dry soil .g	33.6	31.6	27.8	22.5	22.2
mass of can.g	16	16.1	15.8	16.4	16.3
mass weter .g	11.1	10.1	8.4	1.89	1.82
mass of dry soil.g	17.6	15.5	12	6.09	5.86
water content%	62.9	65.4	69.5	31.03	31.06
result	65			31	

PI=LL-PL 34



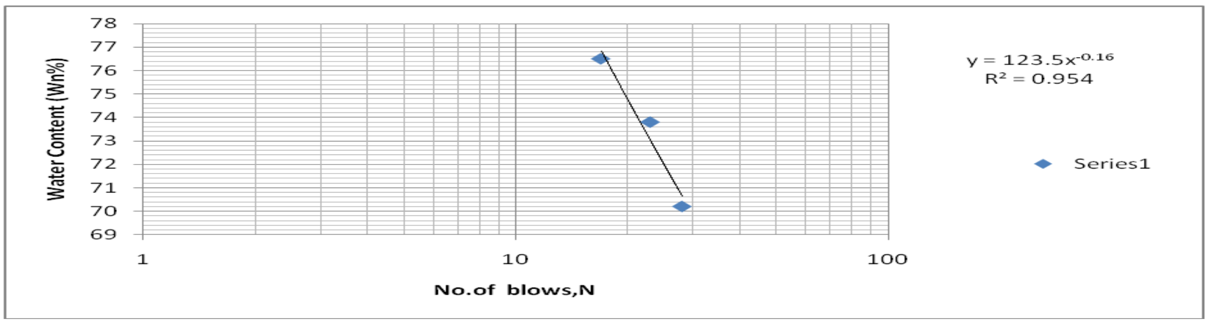
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	B2	T3	A7	C5	A2
number of blows	31	27	18		
mass of can+wet soil .g	52	58	59.6	13.78	13.81
mass of can+dry soil .g	37	40.6	41.1	13.29	13.32
mass of can.g	11.3	11.4	11.2	11.35	11.36
mass weter .g	15	17.4	18.5	0.49	0.49
mass of dry soil.g	25.7	29.2	29.8	1.94	1.96
water content%	58.2	59.7	62.1	25.26	25
result	60			23	

PI=LL-PL 37



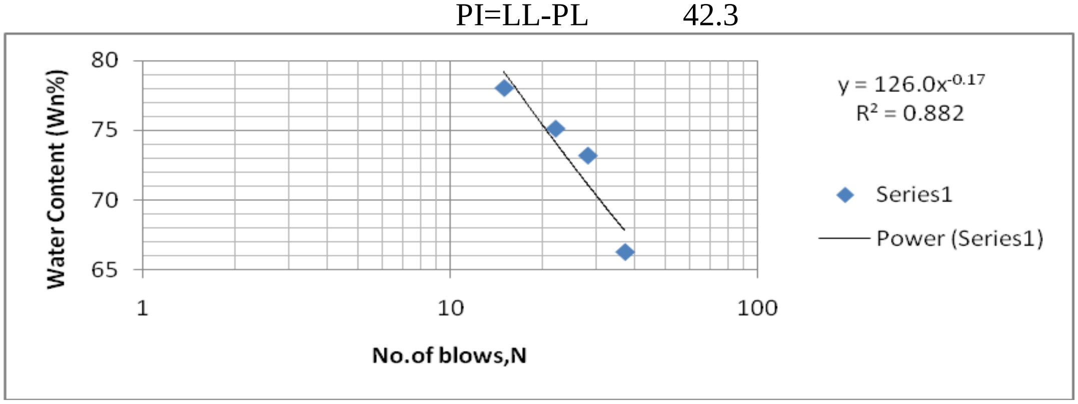
A.A					
	L.L			P.L	
trial no	1	2	3	1	2
can no .g	A5	A4	A1	A5	A4
number of blows	28	23	17	28	23
mass of can+wet soil .g	50.11	52.8	53.1	50.1	52.8
mass of can+dry soil .g	34.1	35.2	35.1	34.1	35.2
mass of can.g	11.4	11.4	11.5	11.4	11.4
mass weter .g	16	17.6	18.1	16	17.6
mass of dry soil.g	22.8	23.8	23.6	22.8	23.8
water content%	70.2	73.8	76.5	70.2	73.8
result	72			20	

PI=LL-PL 52



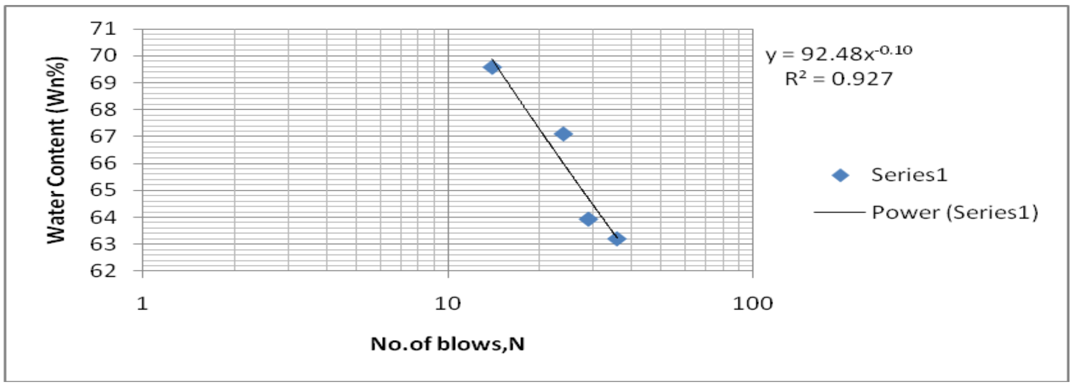
A.A (Kolfe)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	26	D361	C35	1A	H4	107
mass of can.g	14.15	15.75	13.94	15.32	15.77	15.84
mass of can+wet soil .g	20.33	23.52	21.02	22.19	21.42	23.83
mass of can+dry soil .g	17.68	20.42	17.91	19.29	20.05	21.99
number of blows	22	37	15	28		
water content%	75.11	66.26	78.03	73.18	32.2	30.06
result	73.43				31.13	

PI=LL-PL 42.3



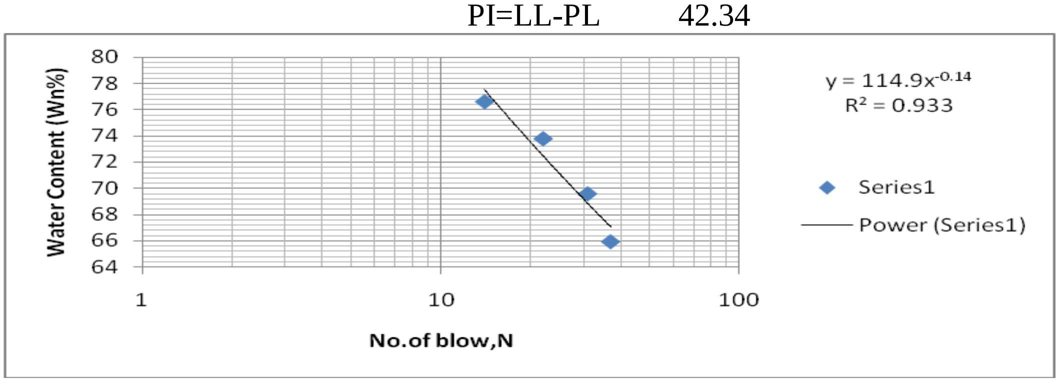
A.A(Kolfe)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	A10	98	53	21	A16	9
mass of can.g	15.56	15.59	15.56	15.56	15.78	15.7
mass of can+wet soil .g	21.57	24.06	23.8	21.93	21.26	21.22
mass of can+dry soil .g	19.25	20.58	20.49	19.45	19.99	19.9
number of blows	36	14	24	29		
water content%	63.21	69.59	67.11	63.94	30.15	29.21
result	66.21				29.68	

PI=LL-PL 36.53



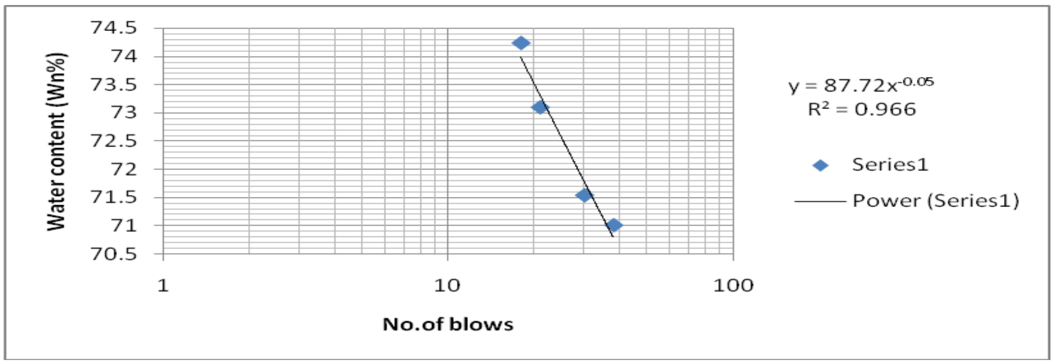
A.A(Adisu gebeya)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	D5	D21	107	A29	C16	C8
mass of can.g	15.7	15.63	15.82	15.34	14.2	13.71
mass of can+wet soil .g	23.07	23.3	22.88	22.74	18.57	18.31
mass of can+dry soil .g	20.14	20.04	19.98	19.53	17.58	17.25
number of blows	37	22	31	14		
water content%	65.9	73.78	69.57	76.61	29.2	30.03
result	71.95				29.61	

PI=LL-PL 42.34



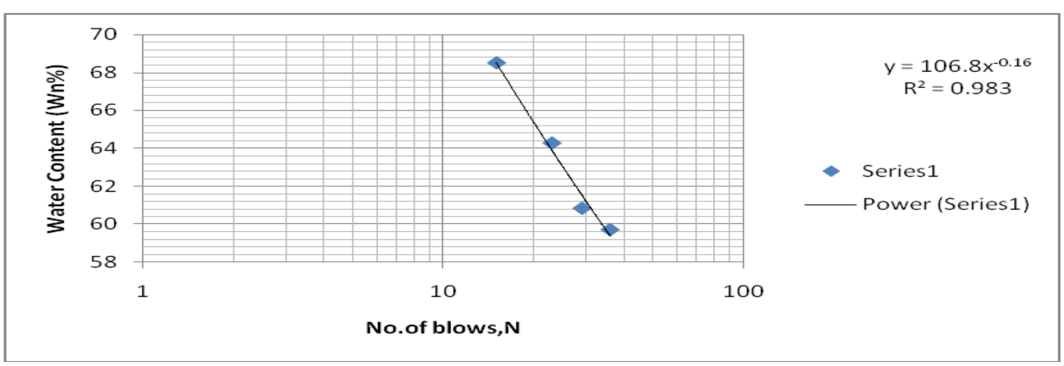
A.A (Adoisu gebeya)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	98	14.05	35	47	A1	26
mass of can.g	15.57	22.05	15.63	15.69	11.5	14.16
mass of can+wet soil .g	26.3	22.55	25.4	22.95	15.23	17.89
mass of can+dry soil .g	21.85	19	21.28	19.86	14.32	16.96
number of blows	38	30	21	18		
water content%	71.01	71.54	73.1	74.24	32.64	33.18
result	72.75				32.91	

PI=LL-PL 39.84



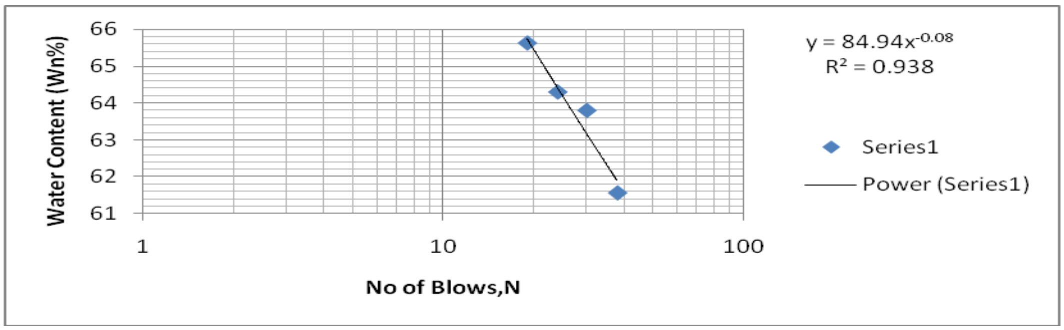
A.A(Aweliya)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	45	79	GHI	59	10	D23
mass of can.g	15.44	15.51	15.6	15.33	15.68	15.38
mass of can+wet soil .g	22.82	21.86	21.83	21.37	18.53	18.86
mass of can+dry soil .g	19.82	19.38	19.5	19.08	17.86	18.05
number of blows	15	23	36	29		
water content%	68.52	64.28	59.7	60.83	30.88	30.52
result	63.67				30.7	

PI=LL-PL 32.97



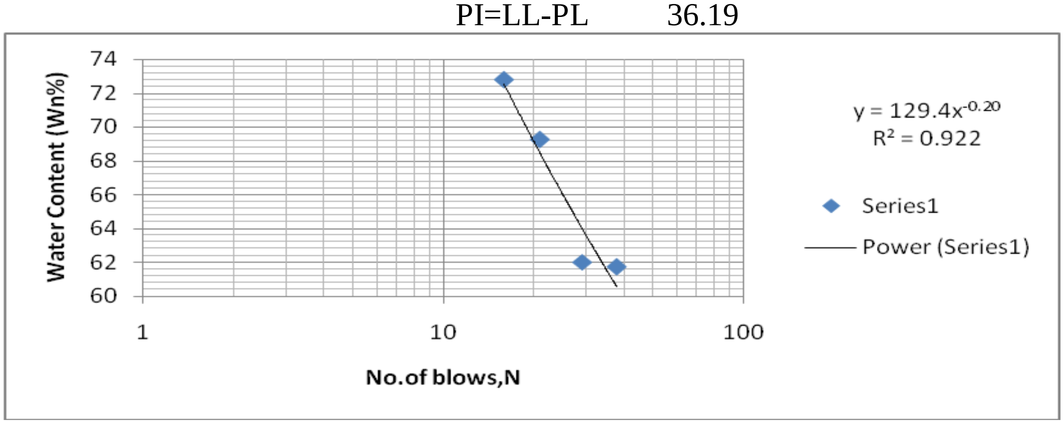
A.A(Aweliya)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	D25	C31	35	40	A25	D5
mass of can.g	15.87	14.05	15.62	15.32	15.78	15.7
mass of can+wet soil .g	22.53	21.86	23.61	22.39	19.11	19.89
mass of can+dry soil .g	19.99	18.81	20.44	19.62	18.31	18.92
number of blows	38	30	19	24		
water content%	61.55	63.79	65.62	64.29	31.4	30.11
result	64.38				30.75	

PI=LL-PL 33.63



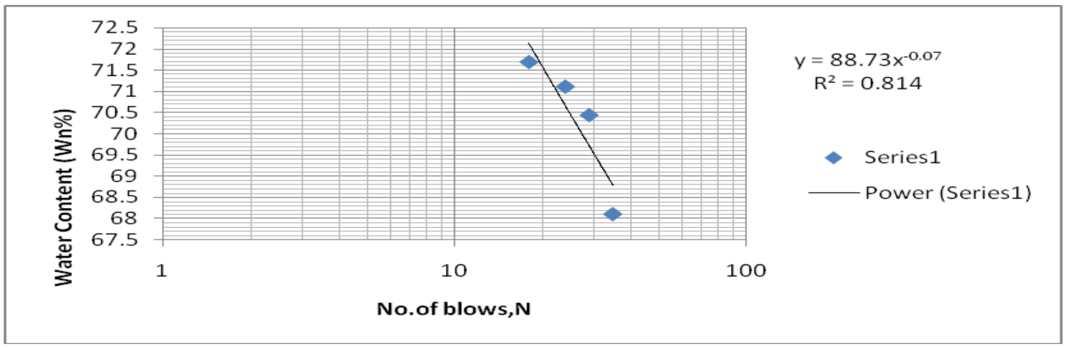
A.A(Shegol)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	D31	100	45	40	A16	H3
mass of can.g	15.46	15.45	15.46	15.33	14.54	15.09
mass of can+wet soil .g	27.8	26.73	29.05	25.78	17.19	17.52
mass of can+dry soil .g	22.6	22.11	23.85	21.79	16.58	16.93
number of blows	16	21	29	38		
water content%	72.78	69.26	62.01	61.74	29.74	31.86
result	66.99				30.8	

PI=LL-PL 36.19



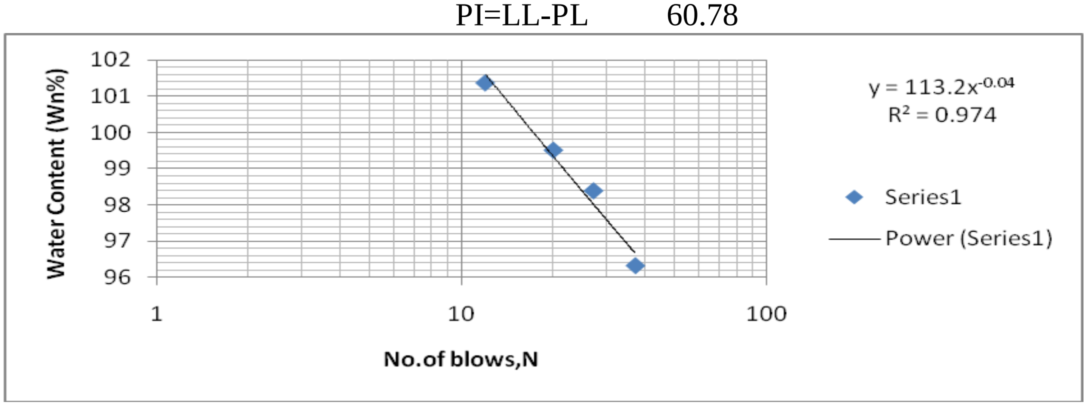
A.A(Shegol)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	1A	C31	D4	107	A1	31
mass of can.g	15.29	14.08	15.95	15.84	15.56	15.44
mass of can+wet soil .g	28.82	28.24	30.13	29.18	17.62	17.63
mass of can+dry soil .g	23.34	22.33	24.27	23.63	17.15	17.09
number of blows	35	18	29	24		
water content%	68.11	71.69	70.44	71.11	29.86	32.34
result	70.66				31.1	

PI=LL-PL 39.56



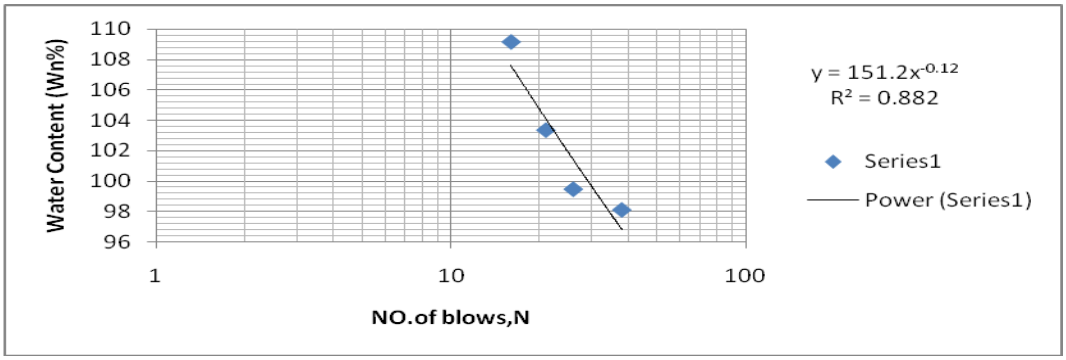
A.A(Bole)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	D25	D22	15	C8	47	H3
mass of can.g	15.88	15.76	15.5	13.7	15.68	14.06
mass of can+wet soil .g	23.11	25.4	25.13	26.22	16.94	15.67
mass of can+dry soil .g	19.56	20.59	20.35	19.91	16.59	15.23
number of blows	37	20	27	12		
water content%	96.34	99.52	98.4	101.37	38.28	37.51
result	98.68				37.9	

PI=LL-PL 60.78



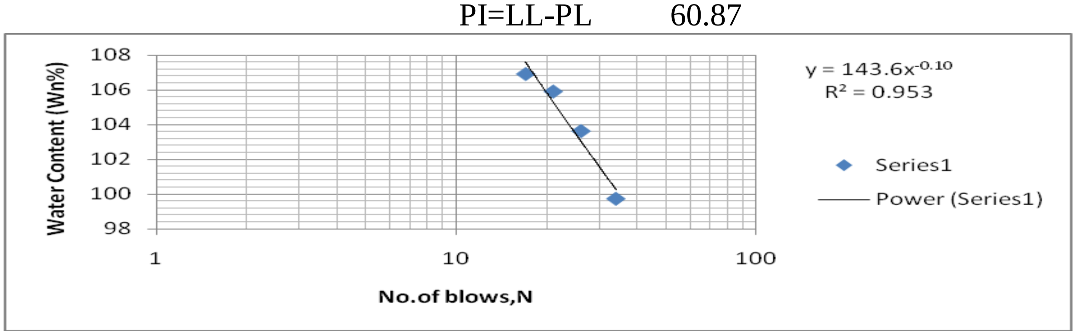
A.A(Bole)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	D4	D31	H2	69	D15	85
mass of can.g	15.96	15.46	15.7	15.74	15.62	15.84
mass of can+wet soil .g	24.3	25.58	25.23	25.89	17.81	17.64
mass of can+dry soil .g	20.17	20.53	20.39	20.59	17.18	17.13
number of blows	38	26	21	16		
water content%	98.11	99.47	103.35	109.13	40.44	40.37
result	102.58				40.4	

PI=LL-PL 62.18



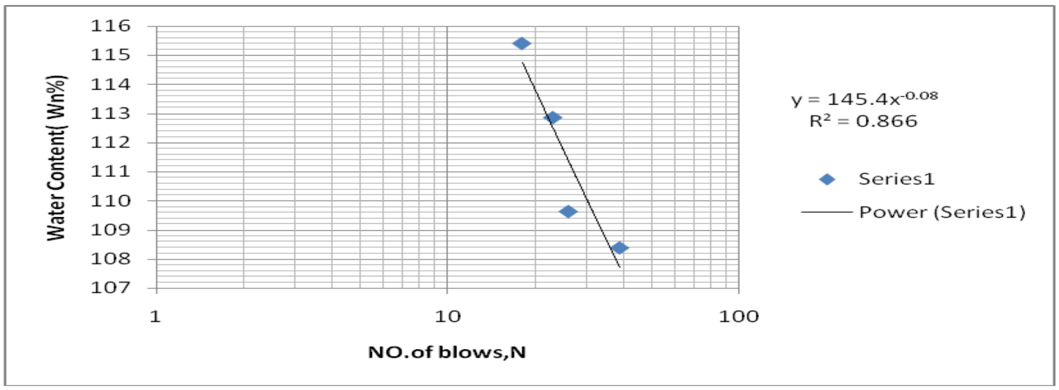
A.A (Cmc)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	98	77	B01	85	101	8
mass of can.g	15.58	15.47	15.57	15.84	11.62	15.7
mass of can+wet soil .g	21.12	24.99	27.17	25.14	13.45	17.68
mass of can+dry soil .g	18.26	20.09	21.27	20.5	12.9	17.09
number of blows	17	21	26	34		
water content%	106.93	105.92	103.64	99.73	43.06	42.76
result	103.78				42.91	

PI=LL-PL 60.87



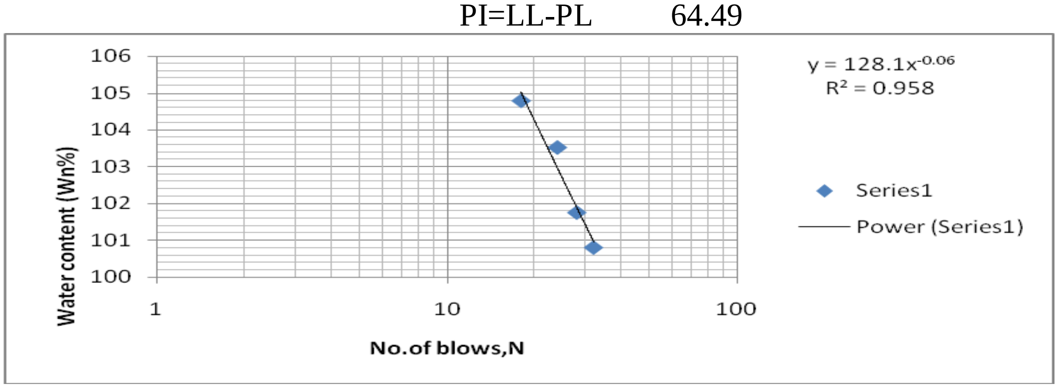
A.A (Cmc)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	A1	100	1A	31	D4	D31
mass of can.g	15.59	15.45	15.29	15.44	15.95	15.46
mass of can+wet soil .g	22.65	25.04	26.41	26.76	18.72	17.54
mass of can+dry soil .g	18.98	19.9	20.52	20.84	17.9	16.92
number of blows	39	18	23	26		
water content%	108.38	115.41	112.86	109.63	42.13	41.63
result	112.03				41.88	

PI=LL-PL 70.15



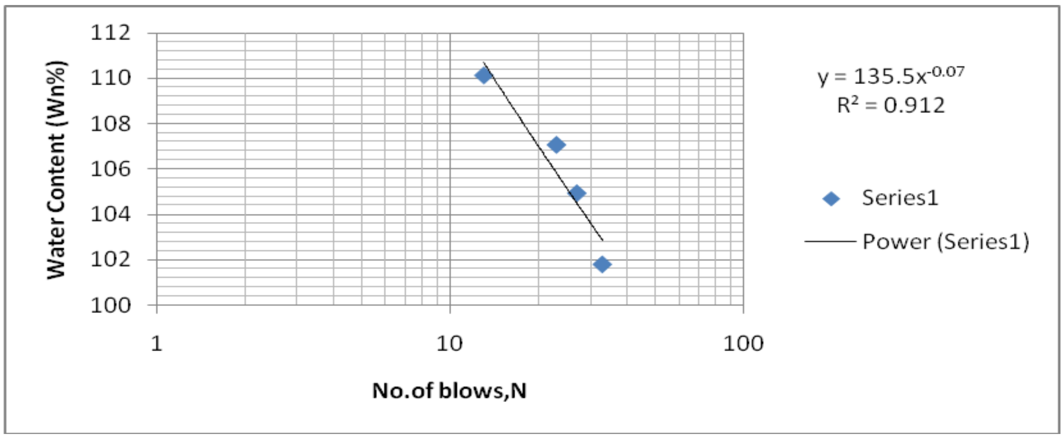
A.A(Emperial)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	45	56	D22	40	54	A16
mass of can.g	15.46	15.82	15.75	15.32	15.85	14.54
mass of can+wet soil .g	25.54	23.9	24.03	28.6	19.34	17.97
mass of can+dry soil .g	20.46	19.85	19.8	21.84	18.37	17.02
number of blows	28	32	18	24		
water content%	101.75	100.8	104.79	103.52	38.45	38.16
result	102.8				38.31	

PI=LL-PL 64.49



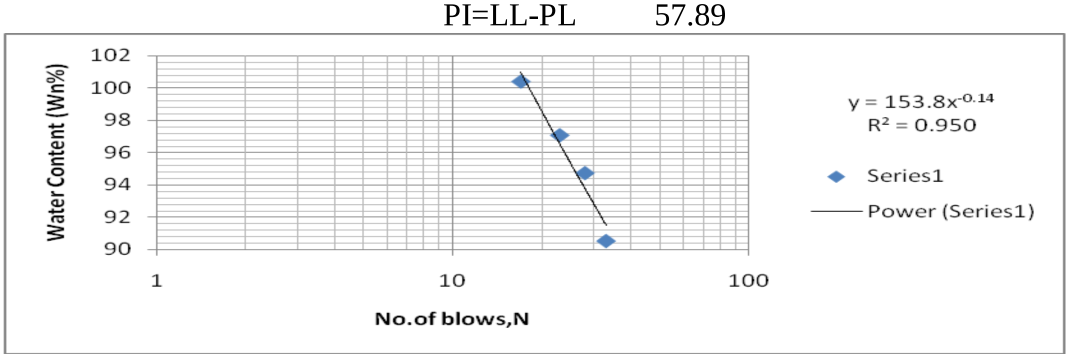
A.A(Emperial)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	C21	D5	D15	H3	D24	A2
mass of can.g	14.2	15.7	15.78	15.1	15.48	11.42
mass of can+wet soil .g	24.09	25.12	26.15	29.16	19.13	15.5
mass of can+dry soil .g	19.03	20.36	20.78	21.79	18.08	14.38
number of blows	27	33	23	13		
water content%	104.95	101.82	107.08	110.13	40.49	38.7
result	105.53				39.59	

PI=LL-PL 65.94



A.A (Hayahulet)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	19	D21	D19	A4	H4	107
mass of can.g	15.62	14.29	15.48	15.61	15.69	15.6
mass of can+wet soil .g	27.07	31.9	33.89	32.04	20.8	23.66
mass of can+dry soil .g	21.63	23.33	24.82	23.81	19.38	21.46
number of blows	33	28	23	17		
water content%	90.55	94.75	97.09	100.41	38.33	37.48
result	95.8				37.91	

PI=LL-PL 57.89



A.A(Hayahulet)						
	L.L				P.L	
trial no	1	2	3	4	1	2
can no .g	D15	100	D12	D31	D4	A29
mass of can.g	15.77	15.45	15.7	15.45	15.95	15.35
mass of can+wet soil .g	30.11	29.66	30.62	30.21	26.52	27.27
mass of can+dry soil .g	23.35	22.86	23.34	22.87	23.59	24.04
number of blows	32	28	22	15		
water content%	89.08	91.82	95.2	98.91	38.15	36.97
result	93.3				37.56	

PI=LL-PL 55.74