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Nature of Soil-Water Characteristics Curves (SWCC) for Soils from Anbar Governorate

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Abstract.

Determinations of unsaturated soil parameters using experimental procedures are time consuming and difficult. In recent years, the soil–water characteristic curve (SWCC) has become an important tool in the interpretation of the engineering behavior of unsaturated soils. Difficulties associated with determining such parameters have justified the use of indirect determination. This paper presents the general nature of the SWCC for soils with different plasticity limits, index and gradation, in terms of gravimetric water content and degree of saturation versus soil matric suction from Anbar governorate. In order to investigate possible relationships between the plasticity limits, index, percent passing no.200 and SWCC, 7 type of soils were tested to find its SWCC experimentally and compared the result with the curves obtained from different model presented in the literature. The objectives of the paper were to check the validity of these models with the experimental results. The results shows a good agreement and to present a simple method for inferring the SWCC for soils, taking into account the liquid limit, plastic limit, plasticity index and percent of fines passing sieve no.200.

Keywords: **Unsaturated soil, soil suction, Liquid Limit, degree saturation, metric suction.**

1. Introduction.

Unsaturated Soil Mechanics is a branch of soil mechanics that takes into account the affects of the pore air phase when quantifying values such as shear strength, permeability and volume change. Unlike tests in soil mechanics, tests that directly measure unsaturated soil properties are not as easily accessible and are often extremely labor intensive. One tool that has made the analysis of unsaturated soil data simpler and more practical is the soil water characteristic curve. This plot of gravimetric water content, volumetric water content, or degree of saturation versus suction (matric or total) indirectly allows for the determination of unsaturated soil properties that can be used to determine the shear strength, permeability, and volume change of material. There are several methods available to determine the unsaturated soil properties of material. Methods include the direct determination of soil properties through experimental procedures, matching material properties to those available in databases, and through the use of the soil water characteristic curve, [1].

The soil water characteristic curve, originally developed in the agriculture science field, is a plot that represents the water storage capacity of a specific material [2]. The majority of soil water characteristic curve data generated using volumetric pressure plate extractors has been developed for material in its natural state, or compacted near the optimum moisture content.

The objective of this study is to perform and present the findings of an experimental program used to generate the soil water characteristic curves for drying condition using pressure plate testing apparatus for 7 soils in Anbar governorate to compare experimental data to estimated curves developed by mathematical models along with the SOIL VISION database program and using correlations developed by (Fredlund and Xing (1994), Van Genuchten(1980) and Fredlund et al.(1993)) and to develop a simple relationship to achieve the SWCC for these soils.[2,3,4]

2. Soil Suction.

Soil suction, commonly expressed in terms of relative humidity, is defined as the free energy of the soil water [2]. It represents the thermodynamic potential of pore water relative to free water, where free water is defined as water with no dissolved solutes [5].

The total suction (free energy) of soil is divided into two components. First the osmotic component, that represents the suction that originates from dissolved solutes in the pore water [5]. “In suction terms, it is the equivalent suction derived from the measurement of the partial pressure of the water vapor in equilibrium with a solution identical in composition with the soil water, relative to the partial pressure of water vapor in equilibrium with free pure water”[2]. The second component of soil suction is the matric suction (sometimes referred to as matrix suction). The matric suction component of soil suction results from the combined effects of capillary tension (explanation below) and short-range adsorption forces [5]. “In suction terms, it is the equivalent suction derived from the measurement of the partial pressure of the water vapor in equilibrium with the soil water, relative to the partial pressure of the water vapor in equilibrium with a solution identical in composition with the soil water” [2]. In unsaturated soil mechanics it is most notably defined as the difference between the pore air pressure and pore water pressure (ua-uw).

As stated previously, matric suction results from a combination of short-term adsorption forces and capillary tension that exists between individual particles.

3. Suction Measurement Techniques.

Several measurement techniques are available to measure the suction of a soil sample. The method selected should depend upon the suction desired. Different methods are used to determine the total suction and matric suction respectively. The following measurement techniques, and their applicable range of suction measurements will be described:

Tensiometers, Conductivity Sensors, Pressure Plate Extractors, Pyschrometers, and Filter Paper Method. In this study Pressure Plate Extractor is used for suction measurement techniques.

4. Pressure Plates Extractors.

The axis translation technique [6], involves using some variation of a pressurized chamber to apply air pressure to a material while keeping the water pressure at a constant value (usually zero). A soil sample is placed within the chamber onto a saturated high air entry disk that will only allow for the flow of water through the saturated pore spaces but prevents air up to a rated value (air entry value) of matric suction. The air pressure inside of the chamber is elevated to a desired value while keeping the pore water pressure at a constant value (normally atmospheric pressure). The difference between the applied air pressure and the constant pore water pressure is the matric suction (ua-uw) at the existing water content or degree of Saturation. As the pore air pressure is elevated, water is expelled from the soil sample through the saturated high air entry disk, and volume outflow measurements are able to be determined. A typical pressure plate device is shown in **fig.(1)**.

5. Soil Water Characteristic Curve.

The soil water characteristic curve is a graphical representation of the mathematical relationship between the matric suction of a soil (defined as the difference between the pore air pressure (u_a) and the pore water pressure (u_w)) and either its water content (gravimetric or volumetric) or degree of saturation (S) [2]. Originally developed by soil and agricultural science, it has gained popularly within the geotechnical engineering community through the research of Fredlund, Vanapalli and others. It represents the water storage (capacity) ability of a given material and allows for the determination of changes in matric suction with respect to changes in water content or degree of saturation. The soil water characteristic curve can be used to describe both the air pressure increase necessary to cause water to be expelled from the sample (desorption), and the pressure reduction needed for water to be imbibed into the soil (sorption). **Fig.(2)** shows a typical soil water characteristic curve for both desorption and sorption phases.

One parameter of interest on the SWCC is the air entry value. The air entry value represents the matric suction value needed to cause water to be drawn from the largest pore space within the soil [8]. In addition to the air entry value both the saturated volumetric water content and residual water content will be defined. The saturated volumetric water content is defined as the water content measured when the applied matric suction value is equal to zero, while the residual water content corresponds to highest value of matric suction that produces no additional water expulsion.

6. Soil Water Characteristic Curves Techniques.

This section describes commons methods used to determine the soil water characteristic curve. It is separated into several different subsections, each of which addresses different available methods. A summary of two of the most common mathematical models [3,5] used to model the soil water characteristic curve is initially presented. The next subsection describes techniques available to estimate the soil water characteristic curve. Techniques include estimations from the grain size distribution curve and the pore size distribution for a specific material. Finally, a synthesis of the experimental methods available for determining the soil water characteristic curve is provided.

6.1 Mathematical Models.

This section describes the mathematical models used to describe the soil water characteristic curve. These models are introduced to software SOILVISION database V.4 along with large data base to define the SWCC according to the soil properties and compare the results with the experimental tests.

6.1.1 Van Genuchten (1980) [4].

Based on Mualem’s theory, van Genuchten developed an equation for the soil water content-pressure head curve that when fit to experimental data resulted in three independent parameters that could be used to determine the hydraulic conductivity based on models proposed by Burdine and Mualem. Mualem’s model, given below, showed that the permeability could be determined based on information obtained from the soil water characteristic curve.

$$K_r = \Theta^{1/2}\left[\int_0^{\Theta}\frac{1}{h(x)}dx \Big/ \int_0^{1}\frac{1}{h(x)}dx\right]^2 \tag{1}$$

Where h is the pressure head, that's a function of the dimensionless water content, Θ.

$$\Theta = \frac{\theta - \theta_r}{\theta_s - \theta_r} \tag{2}$$

r and s represent the residual and saturated water contents, respectively.
Van Genucten used the following relationship to relate the dimensionless water content to the soil water retention curve.

$$\Theta = \left[\frac{1}{1+(\alpha h)^n}\right]^m \tag{3}$$

where α, m, and n are parameters determined from the soil water retention curve.
Combining equations (2) and (3), the following model was proposed.

$$\theta = \theta_r + \frac{(\theta_s - \theta_r)}{\left[1+(\alpha h)^n\right]^m} \tag{4}$$

Four independent parameters (α, n, θs, and θr) were estimated from the soil water retention curve. Values of saturated water content (θs) were obtained by determining the water content of soil specimens in their saturated conditions. Residual water contents (θr) were either determined from the soil water retention curve or determined by measuring the water content of dry soil samples. A parameter S that was evaluated at the midway point of the curve (Θ = ½) was selected and used to describe the slope of the moisture retention curve. The subscript P, in Equation 5 was used to denote the halfway location on moisture retention curve and the location in which each equation was evaluated. The parameter m was determined from evaluating Sp using the following.

$$m = 1 - e^{(-.8S_P)} \qquad (0 < S_P \le 1) \tag{5}$$

$$m = 1 - \frac{.5755}{S_P} + \frac{.1}{S_P^2} + \frac{.025}{S_P^3} \quad (S_P > 1)$$

(6)

The parameters n and α were determined from the following two relationships.

$$m = 1 - \frac{1}{n} \tag{7}$$

And,

$$\alpha = \frac{1}{h}\left(\theta^{-1/m} - 1\right)^{1/n} \tag{8}$$

6.1.2 Fredlund and Xing (1994) [3].

Fredlund and Xing proposed a new model for estimating the soil water characteristic curve based on the shape of the soil water characteristic curve being a function of the material's pore size distribution. They initially started with an integrated form a frequency distribution (Equation 9) with the ability of modeling the soil water characteristic curve over the entire suction range (0 to 106 kPa).

$$\theta(\psi) = \int_{\psi}^{\infty} f(h)\, dh \tag{9}$$

where f(h) represents the pore size distribution of the material as a function of suction. The researchers determined that this particular form of the model produced non-symmetrical S- shaped curves. Several different frequency distributions (Normal, Gamma, Beta) were selected to test the accuracy of the previous mentioned model.

Fredlund and Xing modified the van Genuchten 1980 (Equation 3) model to account for the pore size distribution of the material (Equation 10).

$$f(\psi) = \frac{mnp(p\psi)^{n-1}}{\left[1 + (p\psi)^n\right]^{m+1}} \tag{10}$$

where m, n, and p are independent curve fitting parameters.

The researchers determined that the modified model decreased to zero over a small range of suction and deemed it inappropriate for use over the entire suction range. A new model was proposed that could be used to fit experimental data over the entire suction range (Equation 11).

$$f(\psi) = \frac{mnp(\psi / a)^{n-1}}{a\left[e + (\psi / a)^n\right]\left\{\log\left[e + (\psi / a)^n\right]\right\}^{m+1}} \tag{11}$$

where a=1/p,n, m are independent parameters The researchers fit the previous equation to several experimental curves and determined that there existed a good relationship between experimental and estimated data.

6.1.3. Curves Fitting Process.

Fredlund et al. (1993) defined the soil water characteristic curve as "the variation of water storage capacity within the macro and micro pores of a soil with respect to suction ".

This relationship is generally plotted as the variation of volumetric water content or degree of saturation against the soil matric suction and is described by Equation 12 and 13 [2].

$$\theta_v = C(h).\frac{\theta_s}{\left[\ln\left[\exp(1)+\left(\frac{h}{a_f}\right)^{b_f}\right]\right]^{c_f}} \tag{12}$$

$$\text{C(h)=}\left[1-\frac{\ln\left(1+\frac{h}{h_r}\right)}{\ln\left(1+\frac{10^6}{h_r}\right)}\right] \tag{13}$$

Where θv is the volumetric water content; θs is the saturated volumetric water content or porosity of the soil; h is thematic suction [kPa]; C(h) is an adjustment factor which forces the SWCC through zero water content at a suction of 106 kpa; hrf, af, bf, cf are fitting parameters. Note that $\frac{\theta_v}{\theta_s}$ is degree of saturation, S, expressed a decimal.

6.2 Correlation Equations for Plastic Soils (wPI > 0) [5].

Zapata (1999) and Zapata et al. (2000) developed an experimental correlation to allocate the SWCC for plastic soils, these correlations as follows[9,10]:-

$$a_f = 32.835\ln(wPI) + 32.438 \tag{14}$$

$$b_f = 1.421(wPI)^{-0.3185} \tag{15}$$

$$c_f = -0.2154\ln(wPI) + 0.7145 \tag{16}$$

$$h_r = 500 \tag{17}$$

$$wPI = \frac{PI * P_{200}}{100} \tag{18}$$

Where PI is the plasticity index [%], and P200 is the percent of soil passing US standard sieve #200 [%].

7. Experimental Program.

The primary objective of the experimental program was to determine soil water characteristic curve (drying) of seven natural soils using a volumetric pressure plate apparatus. In order to achieve the stated objectives of the experimental program, one volumetric pressure plate extractors was built to produce the soil water characteristic curves for this study. The following section provides a detailed outline of the materials used through out the experimental program along with detailed information regarding how the material was obtained.

7.1 Materials Tested.

The materials investigated in this study were obtained from different areas in Anbar governorate.Commencement of the experimental program included index testing to determine the material properties of the soils used throughout the experimental process. Tests included Specific Gravity (ASTM D 792), Grain Size Distribution (ASTM D 422-02), and Atterberg Limit testing (ASTM D 854). Material classifications were made in accordance to the Unified Soils Classification System (USCS).The results of these tests are shown in **Table 1**.

7.2. Pressure-Plate Testing Procedure.

One pressure plate extractor designed to handle air pressure to 500 kPa used in testing. **Fig.(3)** shows a schematic of a typical pore water extraction testing setup using a pressure plate apparatus. The primary components of the system are a steel pressure vessel and a saturated HAE ceramic plate. Ceramic plates are designated by air-entry pressure 1 bar.

Approximately 2.5 kg of several natural soils were sieved through the No. 10 sieve; moisture conditioned and allowed to equilibrate for 24-hours in a sealed plastic container. Natural soils were taken from the container and placed into an oven for 24-hours to determine the moisture content. As the result of various trials, it was determined that in order to obtain accurate values of dry density. One ring should be used for each soil specimen.

Prepare a specimen by placing a known mass of the moistened sub-sample into the retaining ring. Trim the upper surface of the specimen so that it is level with the top of the retaining ring. Soil specimens are placed on top of the HAE plate such that the pore water is in equilibrium with the water reservoir at atmospheric pressure for 24 hours **fig.(4)**. Specimens are initially saturated, typically by applying a partial vacuum to the air chamber and allowing the specimens to imbibe water from the underlying reservoir through the ceramic disk.

After saturation, specimens were transferred to the pressure plate chambers. Suction application was applied in accordance with ASTM D 6836-02 Method C [11]. Suction values of 35, 50, 75, 100, and 200 kPa were used for the drying portion of the test.

Table 2 shows the soil properties at the beginning of the laboratory tests and at fully saturation (S=100%) to determine the soil-water characteristic curves. The soils are allowed to wet and swell to under Effective stress and soil suction is 0 kPa.

8. Results and Discussion.

8.1 Applying mathematical models.

Figs (5-11) shows set of SWCC were obtained for the soils used in the test program after they introduced to SOILVISION database applying Fredlund and Xing model and Van Genuchten model, **Table 3 and Table 4** respectively. A good agreement has been obtained.

8.2 Applying Correlation Equations for Plastic Soils (PI > 0).

Figs (12-18) shows set of SWCC obtained for the soils used in the test program using correlation equations described in art.5.2 for plastic soils developed by Zapata (1999) and Zapata et al. (2000)[9,10]. A good agreement with the experimental results was also observed.

Fig.(19) shows a family of curves obtained in **Figs.(12-18**) it is obvious that the plasticity index has a great effect on the obtained curves

9. Analysis of Results.

Multiple linear regression applied on the experimental results using software (Statistica). An equation was obtained relating degree of saturation (S) to liquid limit (LL %), plastic limit

(P.L%), plasticity index(PI%), percent passing no. 200 (F_{200}%) and matric suction (SU kPa). The equation is

$$S = 1.04 + 0.05LL - 0.048PL - 0.048PI - 0.002F_{200} - 0.001SU \qquad (19)$$

A comparison between measured and predicted values of degree of saturation was plotted in **fig.(20)** which shows that the equation has a good agreement with R2 =0.76

This equation was used to build SWCC for the soils explored in this paper, **fig.(21)**.

10. Conclusion.

1. Mathematical models analyzed by Fredlund and Xing (1994) [3], Van Genuchten(1980) [4] and Fredlund et al.(1993) [2], give good agreement with experimental results.
2. Empirical correlation developed by Zapata (1999) and Zapata et al. (2000) [10,11] give a good agreement with experimental results that plasticity properties have a great influence on the obtained SWCC.
3. A new model was build using multiple linear regression to relate degree of saturation (S) to liquid limit (LL %), plastic limit (P.L%), plasticity index(PI%), percent passing no. 200 (F_{200}%) and metric suction (SU kPa). An equation was developed which give a good agreement with experimental results.

11. References.

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12. Nomenclature.

C(h)	An adjustment factor which forces the SWCC through zero water content at a suction of 106 kpa.
e	Void Ratio.
F_{200}	Percent passing no. 200 (%)
f(h)	Pore size distribution of the material as a function of suction.
Gs	Specific Gravity.
h	Thematic suction [kPa]
hrf, af, bf, cf	Fitting parameters
LL	Liquid limit (%)
m, n, p	Independent curve fitting parameters.
m, n, α	Parameters determined from the soil water retention curve.
r	The residual water contents.
S	Degree of saturation
s	saturated water contents.
S_P	The slope of the moisture retention curve.
SWCC	The soil–water characteristic curve.
PL	Plastic limit (%)
PI	The plasticity index [%].
u_a-u_w	The difference between the pore air pressure and pore water pressure.
θr	Residual water contents.
θs	Volumetric water content or porosity of the soil.
θ_v	The volumetric water content
Θ	Function of the dimensionless water content.

Table 1: Material Index Properties.

Type of Soil	**Location**	**Specific Gravity, Gs**	**Liquid Limit, LL (%)**	**Plastic Limit, PL (%)**	**Plasticity Index, PI (%)**	**Particle Size Distribution & Hydrometer Analysis**			**USCS System**	**Description of Soil**
						Fine(passing Sieve no.200) %	**Sand %**	**Gravel %**		
Soil 1	East Ramadi City	2.67	79	45	34	99.86	0.14	0.0	MH	Elastic Silt High Plasticity
Soil 2	West Ramadi City	2.65	60	28	31	80.56	19.44	0.0	CH	Fat Clay with Sand
Soil 2	West Rawa City (1)	2.7	30	22	8	60.1	39.9	0.0	CL	Sandy Lean Clay
Soil 4	South Ramadi City	2.6	35	21	14	76.0	24.0	0.0	CL	Lean Clay with Sand
Soil 5	West Rawa City (2)	2.69	24	22	2	46.66	53.34	0.0	SM	Silty Sand
Soil 6	Rawa City-mining (2)	2.65	32	20	12	57.86	40.12	2.02	CL	Sandy Lean Clay
Soil 7	Rawa City-mining (1)	2.65	29	16	13	58.78	40.6	0.62	CL	Sandy Lean Clay

Table 2: Soil properties at the beginning of the laboratory tests and fully saturation (S=100%).

Types of Soil	**Volumetric Water Content**	**Void Ratio, e**	**Water content %**	**Specific Gravity G_s**	**Dry Unit Weight kN/m^3**
1	0.58	1.388	52.00	2.67	10.97
2	0.63	1.722	65.00	2.65	9.55
3	0.58	1.400	51.85	2.7	11.04
4	0.55	1.224	47.08	2.6	11.47
5	0.59	1.463	54.38	2.69	10.7
6	0.56	1.260	47.54	2.65	11.5
7	0.61	1.590	60.00	2.65	10.04

Table 3: Fredlund and Xing Model results.

Types of Soil	**a_f kPa**	**n_f**	**m_f**	**hr kPa**	**Fredlund Error R^^{2}**	**Fredlund Residual WC%**	**Fredlund AEV kPa**	**Fredlund Max. slope**
1	74.986	19.999	0.0443	14149.22	0.8566	30	67.72	0.4502
2	59.58186	3.221896	0.1792834	9204.2	0.9537	30	44.72	0.3583
3	11.44201	0.451671	0.63892	128227	0.9354	6.1	872.13	0.3235
4	45.88135	17.88624	0.083301	1803.4	0.9893	30	42.02	0.730
5	45.01009	4.843369	0.0675153	501274	0.885	5.0	175259.5	0.8702
6	41.72628	5.661495	0.094978	3779.8	0.9547	30	35.77	0.3568
7	55.53177	3.102558	0.12401	333162	0.9789	7.5	38676.5	0.6988

Table 4: Van Genuchten Model results.

Types of Soil	**Avg (Alpha) 1/kPa**	**nvg**	**mvg**	**Genuchten Error R^^{2}**	**Genuchten AEV kPa**	**Genuchten Max. slope**
1	0.000123243	1.261779	0.9209978	0.6986	171.66	0.6300
2	0.0182894	3	0.07302188	0.9502	44.88	0.3454
3	0.001243878	0.3220797	0.9106997	0.9303	2.72	0.1620
4	0.02869456	3	0.06855602	0.8543	28.9	0.3292
5	0.001988851	1.035959	0.4807467	0.7615	120.11	0.4047
6	0.02781153	3	0.05054834	0.9087	30.5	0.2542
7	0.001971138	1.266859	0.7541897	0.9498	120.74	0.5885

Figure (1): Conventional 5 Bar Pressure Plate Extractor.

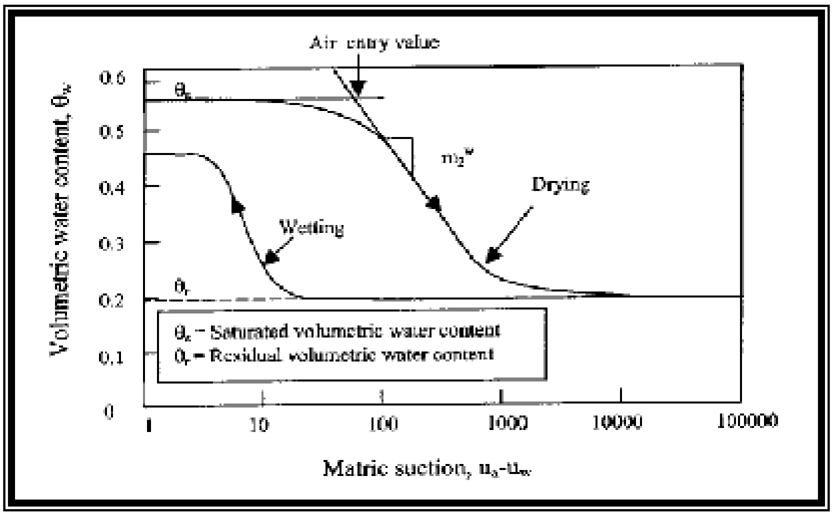


Figure (2): Typical Soil Water Characteristic Curve [7].

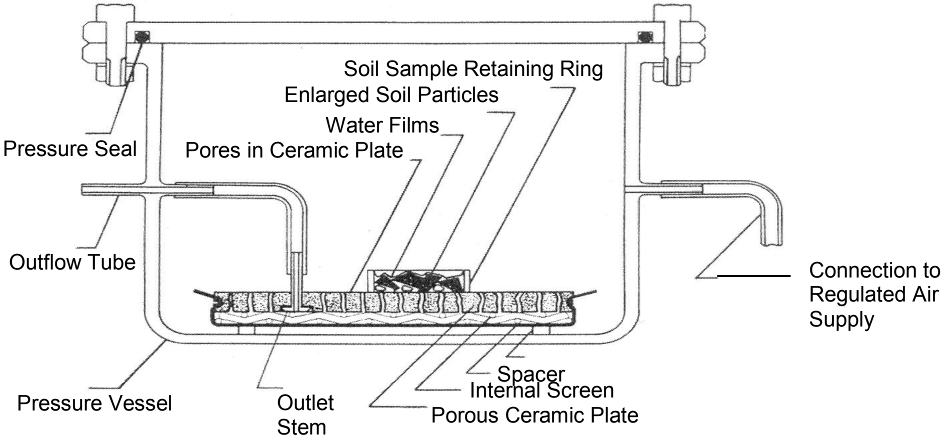
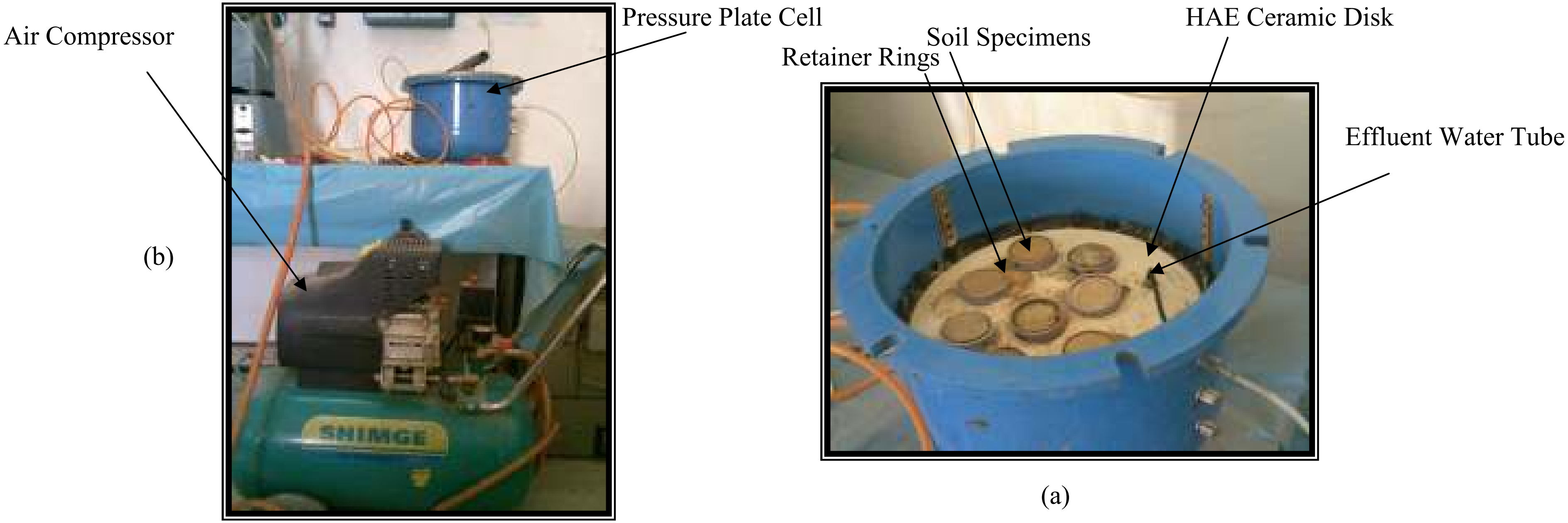


Figure (3): Schematic drawing of pressure plate axis translation apparatus.



(b)

(a)

Figure (4): Photographs of pressure plate testing in progress: (*a*) initial setup of soil specimens on a 1-bar ceramic plate inside pressure vessel and (*b*) closed pressure vessel with air pressure applied.

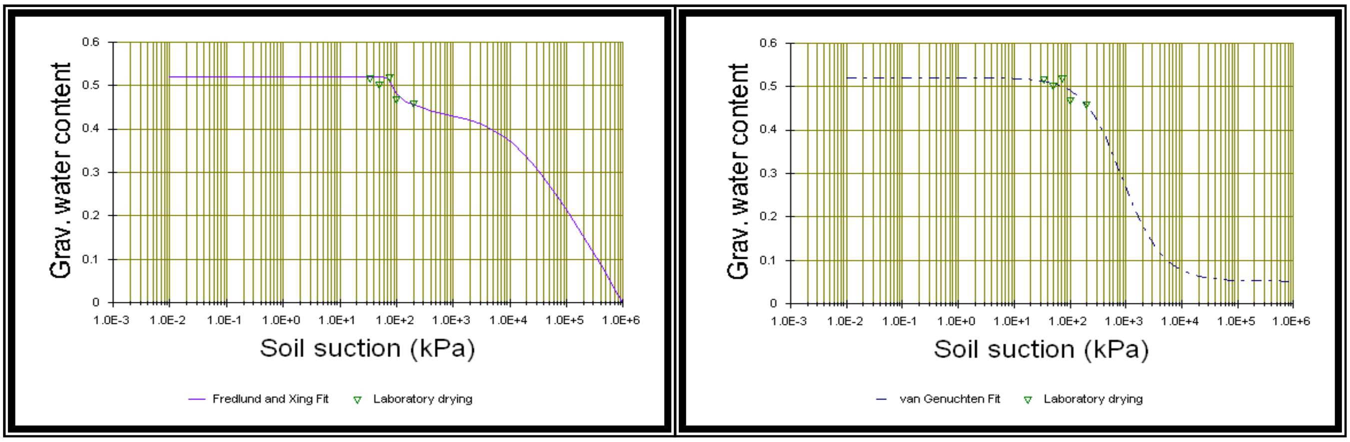


Figure (5): Dry Soil-Water Characteristic Curve for soil 1.

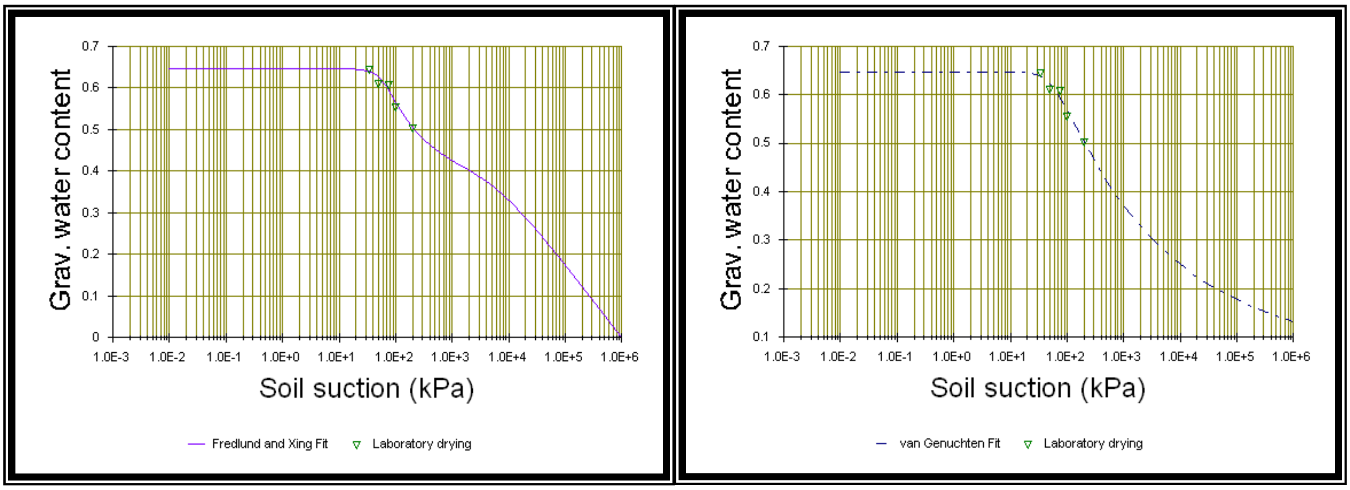


Figure (6): Dry Soil-Water Characteristic Curve for soil 2.

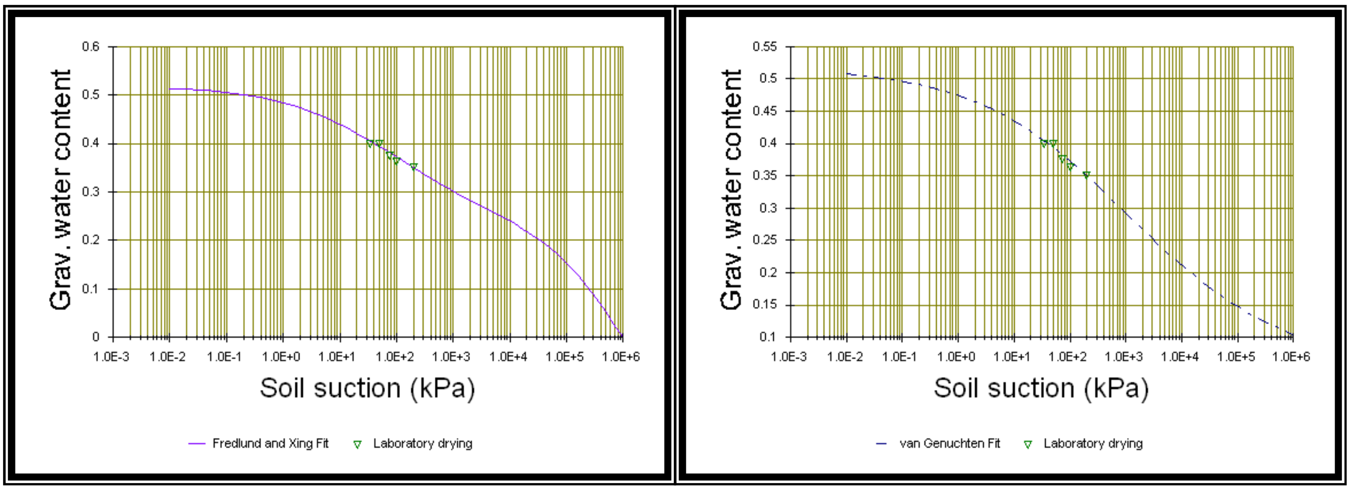


Figure (7): Dry Soil-Water Characteristic Curve for soil 3.

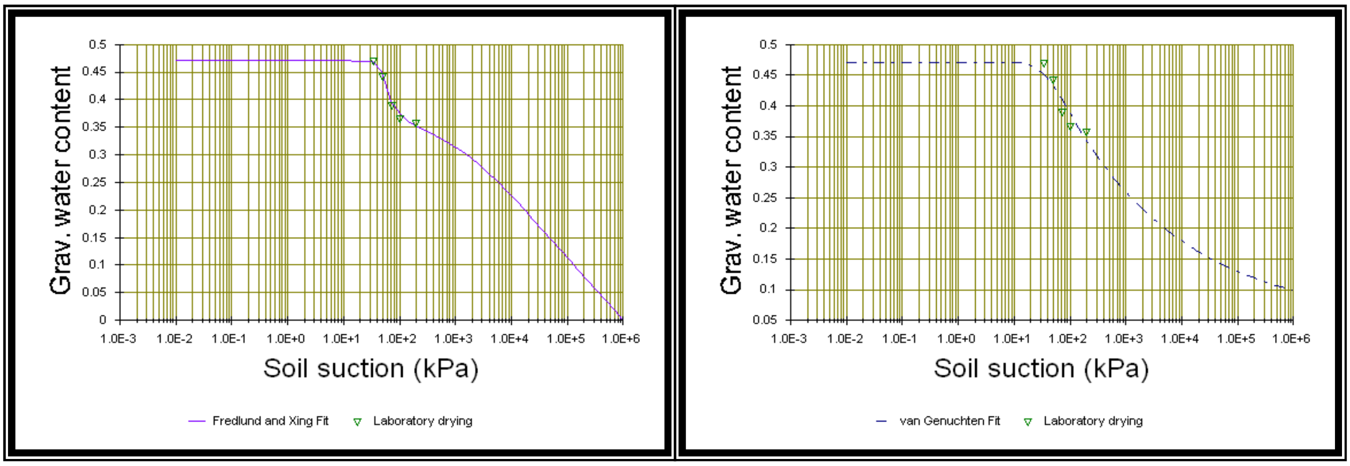


Figure (8): Dry Soil-Water Characteristic Curve for soil 4.

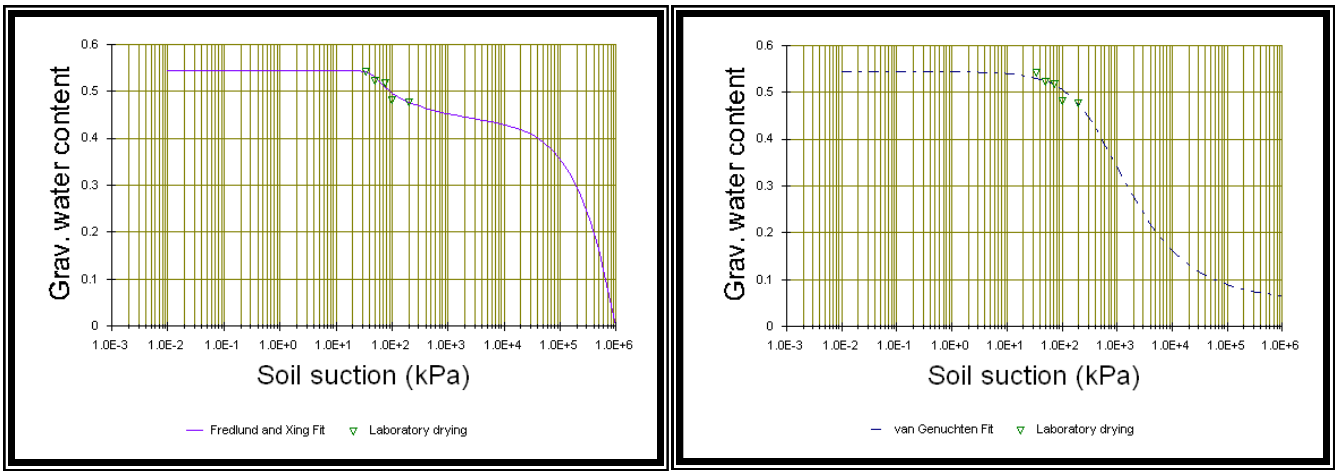


Figure (9): Dry Soil-Water Characteristic Curve for soil 5.

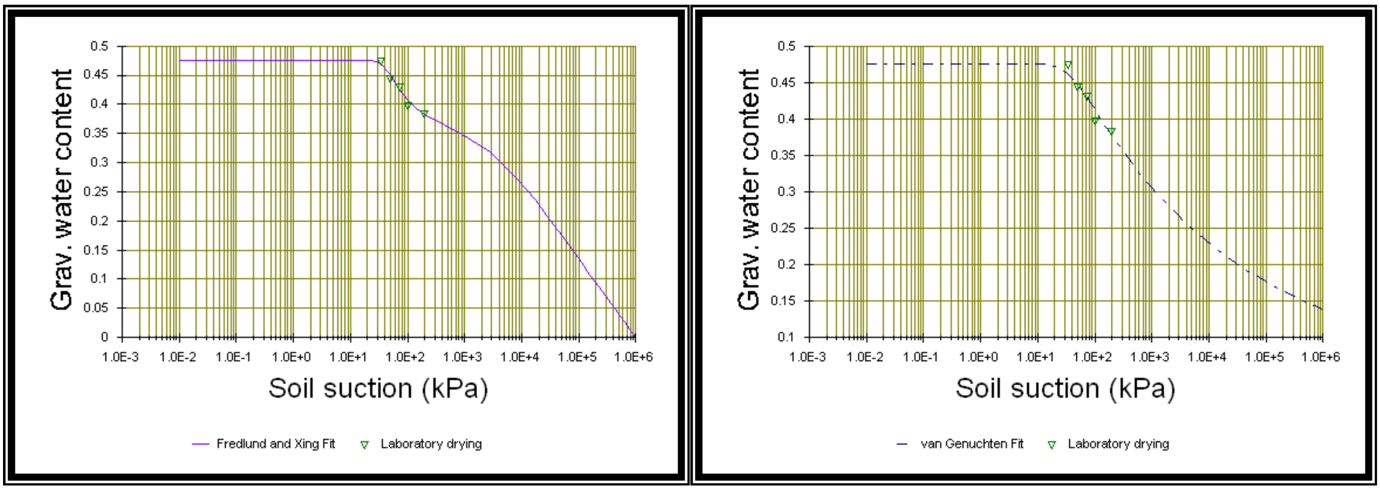


Figure (10): Dry Soil-Water Characteristic Curve for soil 6.

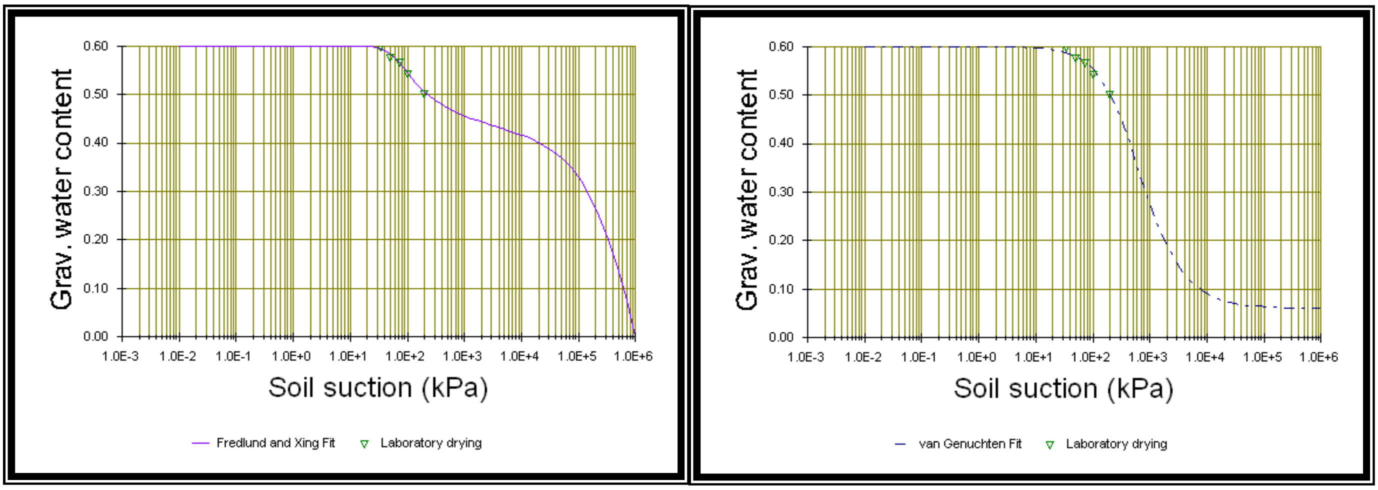


Figure (11): Dry Soil-Water Characteristic Curve for soil 7.

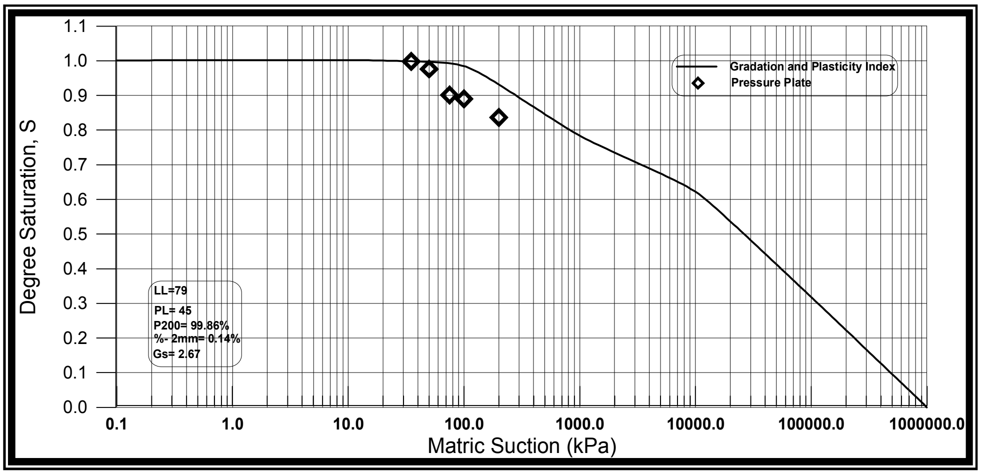


Figure (1)2: SWCC by correlation equations ; Soil1.

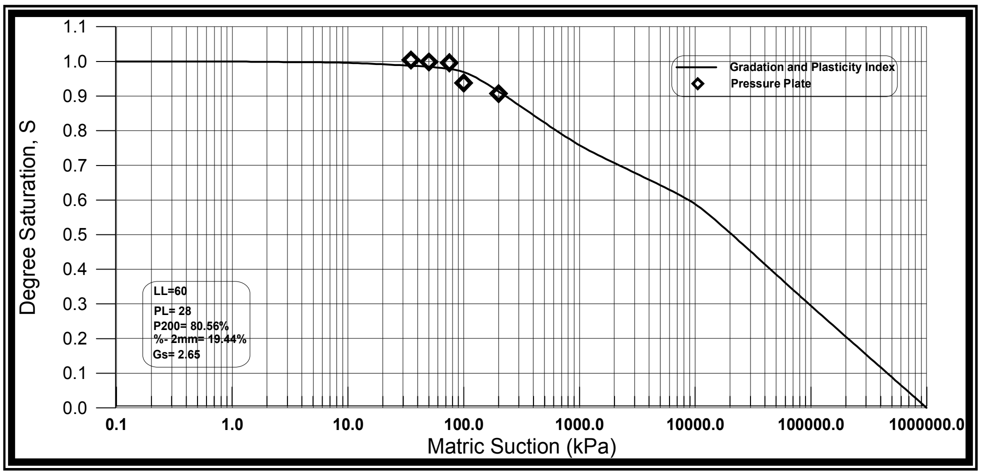


Figure (13): SWCC by correlation equations; Soil2.

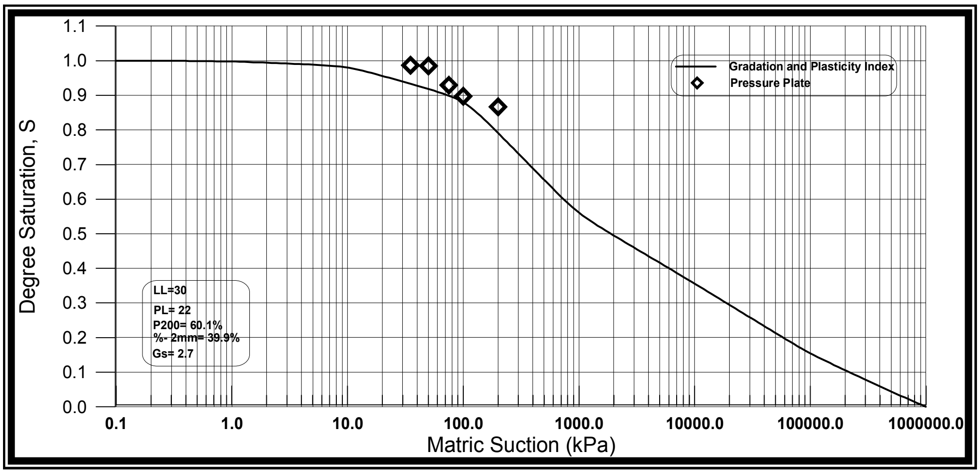


Figure (14): SWCC by correlation equations; Soil3.

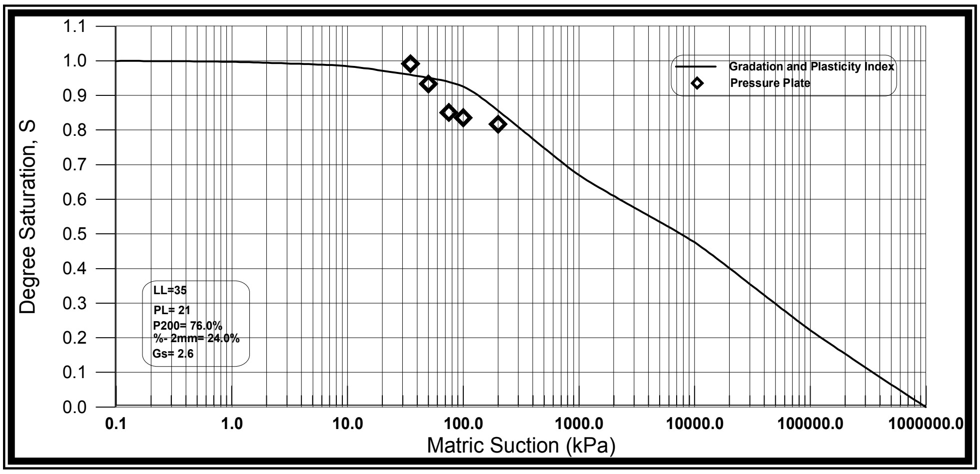


Figure (15): SWCC by correlation equations; Soil4.

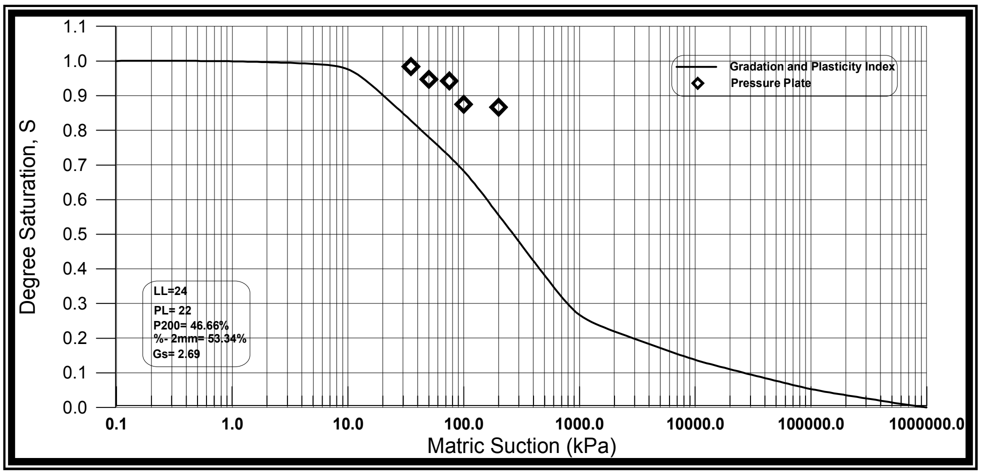


Figure (16): SWCC by correlation equations; Soil5.

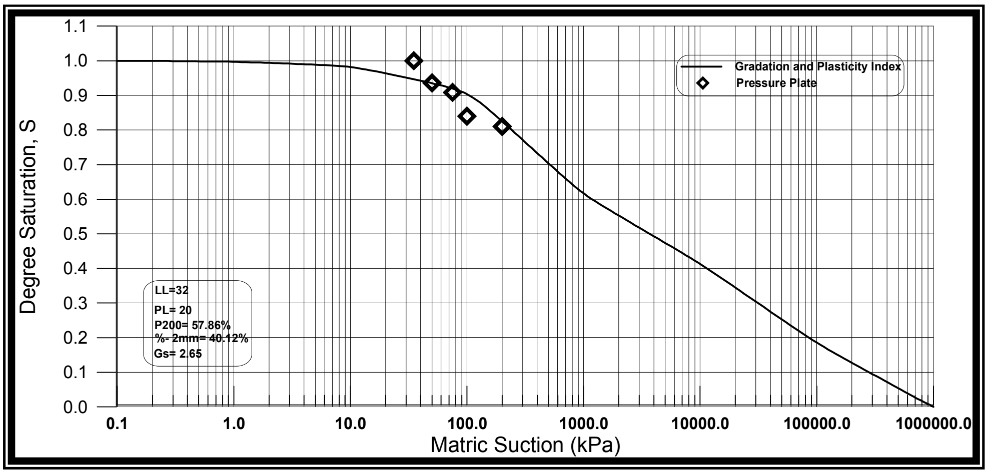


Figure (17): SWCC by correlation equations; Soil6.

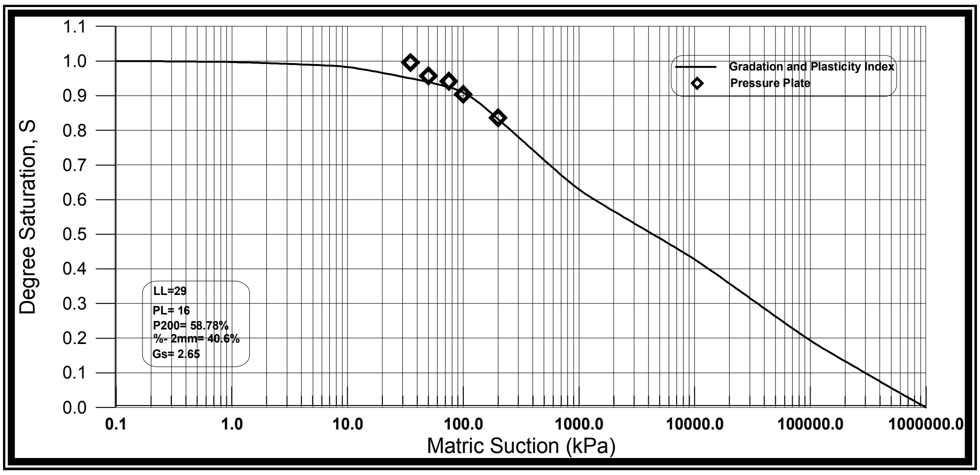


Figure (18): SWCC by correlation equations; Soil7

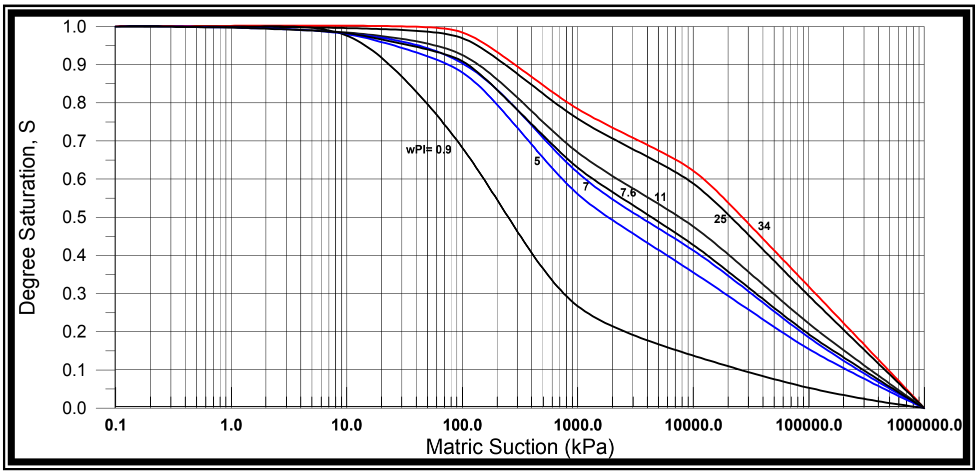


Figure (19): Family of drying SWCC of soils in Anbar district.

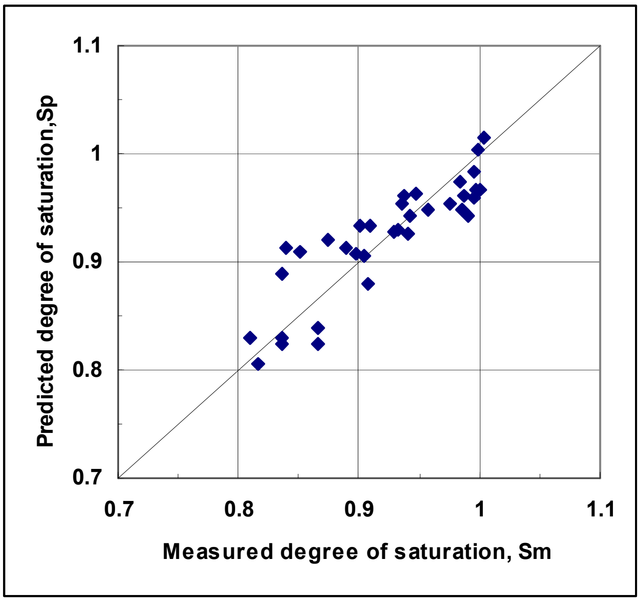


Figure (20): A comparison between measured and predicted value of degree of saturation by the equation.

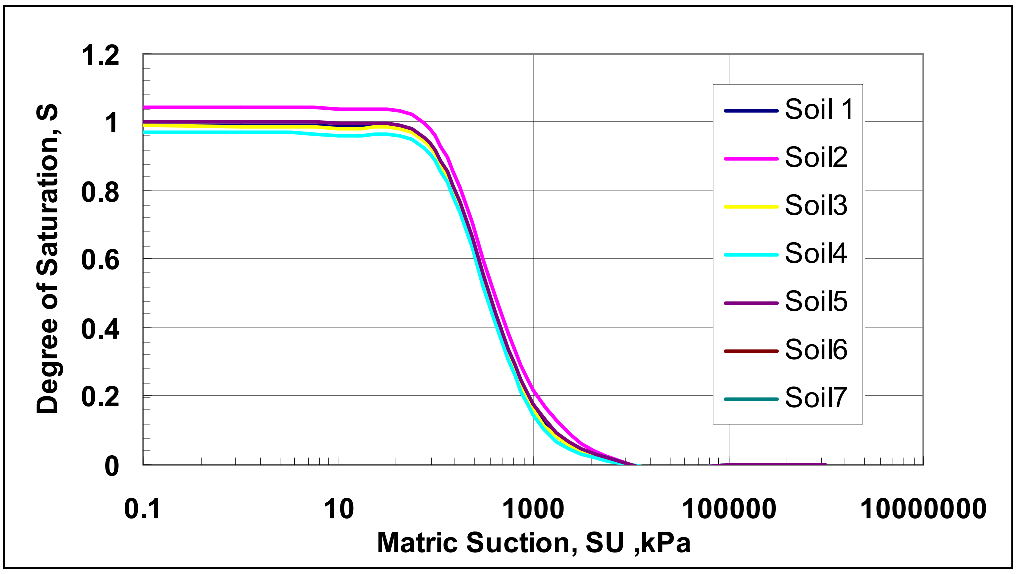


Figure (21): SWCC for soils from Anbar district using the derived equation.

طبيعة منحنيات خصائص التربة – الماء لترب من محافظة الانبار

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الخلاصة.

ان حساب معاملات الترب الغير مشبعة باستخدام الطرق التجريبية يستعمل لغرض اختصار الزمن والصعوبات. وفي السنوات الحديثة ، فان منحني خصائص التربة– الماء اصبح وسيلة مهمة في تمثيل التصرف الهندسي للترب غير مشبعة. الصعوبات المصاحبة لحساب مثل هذه المعاملات يتم فقط باستخدام الحسابات غير مباشرة. هذا البحث يمثل ايجاد الطبيعة العامة لـ SWCC لترب لها حد اللدونة، معامل اللدونة، والتدرج تحت مصطلحات المحتوى الرطوبي الجاذبي ودرجة التشبع متغيرةً مع قوة الامتصاص لانواع مختلفة من الترب في محافظة الانبار. لغرض التحري عن العلاقات المحتملة بين حد اللدونة ، معامل اللدونة ، المار من منخل رقم 200 ، وSWCC هناك سبع انواع من الترب استخدمت في الفحوصات لايجاد SWCC مختبريا ومقارنتها مع نتائج المنحنيات التي تم الحصول عليها من موديلات مختلفة موضحة في البحث.

الهدف من البحث هو تدقيق مدى ملائمة الموديلات المستخدمة مع النتائج المختبرية المستحصلة التي اظهرت نتائجها ان هناك توافق جيد وكذلك اوجدت طريقة بسيطة لحساب SWCC لانواع الترب مع الاخذ بنظر الاعتبار حساب حد السيولة ، حد اللدونة ، معامل اللدونة ، ونسبة المار من منخل رقم 200 .