****

**TERM PAPER ON SOIL PERMEABILITY AND CAPILLARITY**

**BY**

**Emenyonu clinton**

**17/ENG03/021**

**SUBMITTED TO**

**ENGR. EMEKA**

**AFE BABALOLA UNIVERSITY, ADO-EKITI, EKITI STATE.**

**IN PARTIAL COMPLETION OF THE CONTINUOUS ASSESSMENT (C.A) FOR SOIL MECHANICS (CVE 306) COURSE.**

**April 14th, 2020**

**CERTIFICATION**

This project is to certify that the work was carried out by **EMENYONU CLINTON.** of the Department of civil/ environmental Engineering with Matric number **17/Eng03/021** in partial completion of the continuous assessment (C.A) of the SOIL MECHANICS (CVE306) course under the supervision of Engr. Emeka, Afe Babalola University, Ado Ekiti. Nigeria during the 2019/20 academic session.

Engr. Emeka

Lecturer-in-Charge

**DEDICATION**

This presentation is dedicated to me, family and my lecturers who have imparted the knowledge of this course on me.

**ACKNOWLEDGEMENT**

My gratitude and appreciation goes to God almighty who saw me through this period of time with his grace and kindness, Engr. Emeka the lecturer in charge of the ENG 384 course.

**ABSTRACT**

Reasearch on soil permeability where soil transmit water and air and soil capillarity determining the amount of water held by the soil.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **9. SOIL PERMEABILITY****9.0 Why is it important to determine soil permeability?**

|  |  |  |
| --- | --- | --- |
| Soil permeability is the property of the soil to transmit water and air and is one of the most important qualities to consider for fish culture. |  | http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000169.JPG |

|  |  |  |
| --- | --- | --- |
| A pond built in impermeable soil will lose little water through [seepage](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6705e/x6705e02.htm#84s). |  | http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000170.JPG |
|  |  |  |
| The more permeable the soil, the greater the seepage. Some soil is so permeable and seepage so great that it is not possible to build a pond without special construction techniques. You will [learn about these techniques](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6709e/x6709e03.htm#90) in a later volume in this series. |  | http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000171.JPG |

|  |  |  |
| --- | --- | --- |
| Soils are generally made up of **layers** and soil quality often varies greatly from one layer to another. Before pond construction, it is important to determine the relative position of the permeable and impermeable layers. The design of a pond should be planned to avoid having a permeable layer at the **bottom** to prevent excessive water loss into the subsoil by seepage. |  | http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000172.JPG |

The **dikes**of the pond should be built with soil which will ensure a good water retention. Again, soil quality will have to be checked with this in mind.

|  |  |  |
| --- | --- | --- |
| http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000173.JPG |  | http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000174.JPG |

**9.1 Which factors affect soil permeability?**Many factors affect soil permeability. Sometimes they are extremely localized, such as cracks and holes, and it is difficult to calculate representative values of permeability from actual measurements. A good[study of soil profiles](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e02.htm#16a)provides an essential check on such measurements. Observations on soil texture, structure, consistency, colour/mottling, layering, visible pores and depth to impermeable layers such as bedrock and**claypan\***form the basis for deciding if permeability measurements are likely to be representative.**Note**: you have already learned that soil is made up of a number of horizons, each of them usually having different physical and chemical properties. To determine the permeability of soil as a whole, each horizon should be studied separately.**9.2 Soil permeability relates to soil texture and structure**The size of the soil pores is of great importance with regard to the rate of **infiltration**(movement of water into the soil) and to the rate of **percolation**(movement of water through the soil). Pore size and the number of pores closely relate to soil texture and structure, and also influence soil permeability.***Permeability variation according to soil texture***Usually, the finer the soil texture, the slower the permeability, as shown below:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|

|  |  |  |
| --- | --- | --- |
| **Soil** | **Texture** | **Permeability** |
| Clayey soils | Fine | From very slow to very rapid |
| Loamy soils | Moderately fine |
| Moderately coarse |
| Sandy soils | Coarse |

 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Example** **Average permeability for different soil textures in cm/hour**

|  |  |
| --- | --- |
| ***Sand*** | ***5.0*** |
| ***Sandy loam*** | ***2.5*** |
| ***Loam*** | ***1.3*** |
| ***Clay loam*** | ***0.8*** |
| ***Silty clay*** | ***0.25*** |
| ***Clay*** | ***0.05*** |

 |

***Permeability variation according to***[***soil structure***](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e07.htm)Structure may greatly modify the permeability rates shown above, as follows:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|

|  |  |
| --- | --- |
| **Structure type** | **Permeability1** |
| Platy | - Greatly overlapping | From very slow to very rapid |
| - Slightly overlapping |
| Blocky |
| Prismatic |
| Granular |

1 This may vary according to the degree to which the structure is developed.It is common practice to**alter the soil structure to reduce permeability**, for example, in irrigated agriculture through the [puddling](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6705e/x6705e02.htm#91) of rice fields and in civil engineering through the mechanical **compaction\***of earthen dams. Similar practices may be applied to fish-ponds to reduce water seepage. |

|  |  |  |
| --- | --- | --- |
| **9.3****Soil permeability classes**Permeability is commonly measured in terms of the rate of water flow through the soil in a given period of time. It is usually expressed either as a **permeability rate** in centimetres per hour (cm/h), millimetres per hour (mm/h), or centimetres per day (cm/d), or as a **coefficient of permeability k** in metres per second (m/s) or in centimetres per second (cm/s). |  | **Example** http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000175.JPG |

[**For agriculture and conservation**](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e09.htm#89a)uses, soil permeability classes are based on permeability rates, and [**for civil engineering**](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e09.htm#90a), soil permeability classes are based on the coefficient of permeability (see Tables 15 and 16).For **fish culture**, two methods are generally used to determine soil permeability. They are:* The coefficient of permeability;
* The seepage rate.

For the **siting of ponds**and the**construction of dikes**, the **coefficient of permeability** is generally used to qualify the suitability of a particular soil horizon:* Dikes without any impermeable clay core may be built from soils having a coefficient of permeability less thanK = 1 x 10-4 m/s;
* Pond bottoms may be built into soils having a coefficient of permeability less than K = 5 x 10-6 m/s.

For **pond management**, the **seepage rate** is generally used:* In commercial pond culture, an average seepage rate of 1 to 2 cm/d is considered acceptable, but corrective measures should be taken to reduce soil permeability when higher values exist, particularly when they reach 10 cm/d or more.

**9.4 Measurement of soil permeability in the laboratory**When you take an **undisturbed sample** to a testing laboratory, to measure permeability, a column of soil is placed under specific conditions such as water saturation and constant head of water. The result will be given to you either as a **permeability rate** (see Table 15), or as a**coefficient of permeability** (see Table 16).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **TABLE 15** **Soil permeability classes for agriculture and conservation**

|  |  |
| --- | --- |
| Soil permeability classes | Permeability rates1 |
| cm/hour | cm/day |
| Very slow | Less than 0.13 | Less than 3 |
| Slow | 0.13 - 0.3 | 3 - 12 |
| Moderately slow | 0.5 - 2.0 | 12 - 48 |
| Moderate | 2.0 - 6.3 | 48 - 151 |
| Moderately rapid | 6.3 - 12.7 | 151 - 305 |
| Rapid | 12.7 - 25 | 305 - 600 |
| Very rapid | More than 25 | More than 600 |

**1 Saturated samples under a constant water head of 1.27 cm** |  | **TABLE 16 Soil permeability classes for civil engineering**

|  |  |
| --- | --- |
| Soil permeability classes | Coefficient of permeability (K in m/s) |
| Lower limit | Upper limit |
| Permeable | 2 x 10-7 | 2 x 10-1 |
| Semi-permeable | 1 x 10-11 | 1 x 10-5 |
| Impermeable | 1 x 10-11 | 5 x 10-7 |

 |

**9.5 Measurement of soil permeability in the field**To measure soil permeability in the field, you can use one of the following tests:* The visual evaluation of the permeability rate of soil horizons;
* A simple field test for estimating soil permeability;
* A more precise field test measuring permeability rates.

***The visual evaluation of the permeability rate of soil horizons***The permeability of individual soil horizons may be evaluated by the visual study of particular soil characteristics which have been shown by soil scientists to be closely related to permeability classes. The most significant factor in evaluating permeability is **structure:** its type, grade, and aggregation characteristics, such as the relationship between the length of horizontal and vertical axes of the aggregates and the direction and amount of overlap.Although neither**soil texture** nor **[colour mottling](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e05.htm%22%20%5Cl%20%2213a)**alone are reliable clues, these soil properties may help to estimate permeability when considered **together with the structural characteristics.** To evaluate visually the permeability of soil horizons:* Examine a fresh soil profile in an open pit;
* Determine the soil horizons present;
* Using [**Table 17A**](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e09.htm#77a), evaluate the permeability class to which each horizon belongs, carefully studying the structural characteristics of the soil;
* Confirm your results through the other soil properties shown in [**Table 17B**](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e09.htm#53a)**;**
* Ranges of permeability rates may then be found in[**Table 15**](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e09.htm#94a)**.**

|  |
| --- |
| **TABLE 17A** **Visual indicators of permeability: structural characteristics of soil**http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000237.JPG |

|  |
| --- |
| **TABLE 17 B** **Visual Indicators of permeability: texture, physical behaviour and colour of soil**http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000238.JPG |

***A simple field test for estimating soil permeability***

|  |  |  |
| --- | --- | --- |
| * Dig a hole as deep as your waist;

http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000176.JPG |  | * Early in the morning, fill it with water to the top;

http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000177.JPG |
|  |  |  |
| * By the evening, some of the water will have sunk into the soil;
 |  | http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000178.JPG |

|  |  |  |
| --- | --- | --- |
| * Fill the hole with water to the top again, and cover it with boards or leafy branches;

http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000179.JPG |  | http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000180.JPG |
|  |  |  |
| * If most of the water is still in the hole the next morning, the soil permeability is suitable to build a fish-pond here;
 |  | http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000181.JPG |
|  |  |  |
| * Repeat this test in several other locations as many times as necessary, according to the soil quality.
 |  |  |

***A more precise field test for measuring permeability rates***

|  |  |  |
| --- | --- | --- |
| * Carefully examine the drawings you have made when studying your soil profiles;

**Note**: you could also use the visual method (see [**Tables 17A**](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e09.htm#77a) and [**17B**](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e09.htm#53a)) to estimate permeability. |  | * On the basis of texture and structure, determine which soil horizons seem to have the **slowest permeability**;
 |
|  |  |  |
| * Mark the soil horizons on your drawings which seem to have the slowest permeability. Use a coloured pencil;

**Note**: water seeps into the soil both horizontally and vertically, but you need only be concerned with the vertical water seepage because this is mainly what happens in ponds. |  | http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000182.JPG |

|  |  |  |
| --- | --- | --- |
| * Dig a hole approximately 30 cm in diameter until you reach the uppermost least permeable horizon;

http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000183.JPG |  | * Thoroughly smear the sides of the hole with heavy wet clay or line them with a plastic sheet, if available, to make them waterproof;

http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000184.JPG |
|  |  |  |
| * Pour water into the hole to a level of about 10 cm;
 |  | http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000185.JPG |

* At first, the water will seep down rather quickly, and you will have to refill as it disappears. When the pores of the soil are full of water, seepage will slow down. You are then ready to measure the permeability of the soil horizon at the bottom of the hole;

|  |  |  |
| --- | --- | --- |
| http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000186.JPG |  | http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000187.JPG |
|  |  |  |
| * Make sure that the water in the hole is about 10 cm deep as before. If it is not, add water to reach that level;

http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000188.JPG |  | * Put a measuring stick into the water and record the exact water depth, in millimetres (mm);

http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000189.JPG |
|  |  |  |
| * Check the water level in the hole every hour for several hours. Record the rate of seepage for each hourly period. If the water disappears too rapidly, add water to bring the level up to 10 cm again. Measure the water depth very carefully;
 |  | http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000190.JPG |

|  |  |  |
| --- | --- | --- |
| * When your hourly measurements become nearly the same, the rate of permeability is constant and you may stop measuring;
* If there are great differences in seepage each hour, continue pouring water into the hole to keep the level at 10 cm until the rate of seepage remains nearly the same;

**Note**: a soil horizon with suitable permeability for a pond bottom should also be at least 0.7-1 m thick, unless lower horizons exist with suitable permeability and thickness.* Now compare your results with the following values:
 |  | http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000191.JPG |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|

|  |  |
| --- | --- |
| ***Permeability rate in mm/h*** | ***Suitability of horizon for a pond bottom*** |
| Slower than 2 | Acceptable seepage: soil suitable |
| 2-5 | Fast seepage: soil suitable ONLY if seepage due to soil structure which will disappear when pond is filled |
| 5-20 | Excessive seepage: soil unsuitable unless seepage can be reduced as described below |

 |

**If the permeability rate is faster than 5 mm/h**, this may be owing to a strongly developed structure in the soil. In such cases, you try to reduce the permeability rate by destroying the structure, as follows:

|  |  |  |
| --- | --- | --- |
| * Puddle the bottom soil of the hole as deep as you can;

http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000192.JPG |  | * Repeat the more precise permeability test until you can measure a nearly constant value for seepage.

http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000193.JPG |

* If this new permeability rate does not exceed 4 mm/h, you may consider this soil horizon as suitable for a pond bottom. However, the entire bottom of the pond will have to be puddled before filling it with water;
* If this new permeability rate exceeds 4 mm/h, this may be owing to the presence of a permeable soil horizon under the horizon you have tested. Such a permeable layer is often found between layers of soil which are semi- permeable or even impermeable;

|  |  |  |
| --- | --- | --- |
| * Check this with the following test
* ***Dig a new hole 30 cm in diameter through the uppermost least permeable layer (A) to the top of the next least permeable layer (B);***
* ***Repeat the permeability test until you measure a nearly constant value for seepage;***
* ***If this permeability rate does not exceed 3 mm/h, you may consider this soil horizon as suitable for a pond bottom. However, remember that such slow permeability should be found in a layer at least 0.7-1 rn thick to ensure limited seepage through the pond bottom.***
 |  | http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000194.JPG |

**Note**: when building your pond, you do not necessarily need to remove a shallow permeable layer if there is a deeper layer of soil which is not permeable and will serve to hold the water. You must, however, build the pond dikes down to the deeper non-permeable layer to form an enclosed basin and to avoid horizontal water seepage ([see Section 9.0](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e09.htm#102b)).**9.6 Determining coefficients of permeability**To obtain a more accurate measurement of soil permeability, you can perform the following test in the field which will give you a value for the coefficient of permeability:

|  |  |  |
| --- | --- | --- |
| * Using a bucket auger, drill a hole about 1 m deep in the soil at the location where you wish to determine the coefficient of permeability;

http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000195.JPG |  | * Fill the hole with water to the top;

http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000196.JPG |

|  |  |  |
| --- | --- | --- |
| * Every five minutes, for at least 20 minutes, refill the hole to the top to be sure that the soil is fully saturated;
* Top the water in the hole and start measuring the rate at which the water surface goes down, using a watch to measure time and a centimetre-graduated ruler to measure the distance P between the water surface and the top of the hole. Stop measuring when the rate becomes nearly constant;

**Example Rate becomes constant**http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000198.JPG |  | http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000197.JPG |

* Measure exactly the total depth of the hole (H) and its diameter (D). **Express all measurements in metres** (m): for example

**H = 1.15 m and D = 12 cm or 0.12 m*** For each of the above two consecutive measurements of time/distance, calculate the **coefficient of permeability K**using the following formula:

**K= (D÷2) x In (h1÷ h2) / 2 (t2- t1)*****where (D*÷*2) is the radius of the hole or half its diameter in metres;*In*refers to the* Napierian or natural logarithm; *h1 and h2 are the two consecutive depths of water in metres, h1 at the start and h2 at the end of the time interval; (t2 - t1) expresses the time interval between two consecutive measurements, in seconds;*****Note**: the h-values may be readily calculated as the differences between the total depth of the hole H and the successive P values. Be careful to express all the measurements in metres and seconds so as to obtain K in m/s.* Now compare your K values (in m/s) with those in [Table 16](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e09.htm#103a).

**Example*****If (D ÷ 2) = 0.12 m ÷ 2 = 0.06 m and H = 1.15 m, calculations of the various K values are made progressively according to the formula (see***[***Table 18***](http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e09.htm#104a)***).*****Note**: for obtaining the **natural logarithm**of (h1 ÷ h2), you will have to use either a logarithmic table or a pocket calculator.Remember that 10 - 6 = 0.000001 and 6.8 x 10-6 = 0.0000068, the negative exponent of 10 reflecting the decimal place to be given to the multiplicant.If you wish **to compare a K value (m/s) with permeability rates (cm/day)**, multiply K by 8 640 000 or 864 x 104such as for example:**K = 1 x 10-5 m/s = 86.4 cm/day**

|  |
| --- |
| **TABLE 18** **Successive steps for the calculation of coefficients of permeability on the basis of field measurements****(for a test hole with H = 1.15 m and D = 0.12 m)**http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/GR000199.JPG**NOTE:**The formula for calculating coefficients of permeability is K = [(D ÷ 2) x In (h1 ÷ h2)] / 2 (t2 - t1) or A ÷ B (see Section 9.6). |

 |

Soil water holding capacity

Before we discuss the capacity of soils to hold water, we must understand the concept of capillarity.

Capillarity

* Water molecules behave in two ways:
	+ Cohesion Force: Because of cohesion forces, water molecules are attracted to one another. Cohesion causes water molecules to stick to one another and form water droplets.
	+ Adhesion Force: This force is responsible for the attraction between water and solid surfaces. For example, a drop of water can stick to a glass surface as the result of adhesion.
* Water also exhibits a property of surface tension:
	+ Water surfaces behave in an unusual way because of cohesion. Since water molecules are more attracted to other water molecules as opposed to air particles, water surfaces behave like expandable films. This phenomenon is what makes it possible for certain insects to walk along water surfaces.
* Capillary Action:
	+ Capillary action, also referred to as capillary motion or capillarity, is a combination of cohesion/adhesion and surface tension forces.
	+ Capillary action is demonstrated by the upward movement of water through a narrow [tube](http://en.wikipedia.org/wiki/Tube) against the [force](http://en.wikipedia.org/wiki/Force) of [gravity](http://en.wikipedia.org/wiki/Gravity).
	+ Capillary action occurs when the [adhesive](http://en.wikipedia.org/wiki/Adhesion) [intermolecular forces](http://en.wikipedia.org/wiki/Intermolecular_force) between a [liquid](http://en.wikipedia.org/wiki/Liquid), such as water, and the [solid](http://en.wikipedia.org/wiki/Solid) surface of the tube are stronger than the [cohesive](http://en.wikipedia.org/wiki/Cohesion_%28chemistry%29) intermolecular forces between water molecules.
	+ As the result of capillarity, a [concave](http://en.wikipedia.org/wiki/Concave) [meniscus](http://en.wikipedia.org/wiki/Meniscus) (or curved, U-shaped surface) forms where the liquid is in contact with a vertical surface.
	+ Capillary rise is the height to which the water rises within the tube, and decreases as the width of the tube increases. Thus, the narrower the tube, the water will rise to a greater height.


**Figure 3**. Capillary rise in tubes of varied widths. This picture demonstrates the phenomenon of capillary rise. As you can see, the liquid rises to the greatest height in the narrowest tube (at far right), whereas capillary rise is lowest in the widest tube (at far left). Although easily demonstrated by simple experiments using tubes, capillary action occurs in soils. Smaller pores that exist in finely-textured soils have a greater capacity to hold and retain water than coarser soils with larger pores.

Capillary action is the same effect that causes [porous](http://en.wikipedia.org/wiki/Porous) materials, such as sponges, to soak up liquids.

* Capillarity is the primary force that enables the soil to retain water, as well as to regulate its movement.
	+ The phenomenon of capillarity also occurs in the soil. In the same way that water moves upwards through a tube against the force of gravity; water moves upwards through soil pores, or the spaces between soil particles.
	+ The height to which the water rises is dependent upon pore size. As a result, the smaller the soil pores, the higher the capillary rise.
	+ Finely-textured soils, like in Maui, typically have smaller pores than coarsely-textured soils. Therefore, finely-textured soils have a greater ability to hold and retain water in the soil in the inter-particle spaces. We refer to the pores between small clay particles as micropores. In contrast, the larger pore spacing between lager particles, such as sand, are called macropores.
	+ In addition to water retention, capillarity in soil also enables the upward and horizontal movement of water within the soil profile, as opposed to downward movement caused by gravity. This upward and horizontal movement occurs when lower soil layers have more moisture than the upper soil layers and is important because it may be absorbed by roots.


**Figure 4**. This picture shows how more water may be held between finer particles against the force of gravity, as compared to coarser particles. As a result, finer-textured soils have greater water holding capacities.
Water holding capacity

Since water is held within the pores of the soil, the water holding capacity depends on capillary action and the size of the pores that exist between soil particles. Sandy soils have large particles and large pores. However, large pores do not have a great ability to hold water. As a result, sandy soils drain excessively. On the other hand, clayey soils have small particles and small pores. Since small pores have a greater ability to hold water, clayey soils tend to have high water holding capacity.

REFRENCES

[https://www.ctahr.<http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e09.htm>hawaii.edu/mauisoil/a\_comp03.aspx](https://www.ctahr.hawaii.edu/mauisoil/a_comp03.aspx)