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COMPARISION BETWEEN THE WATER CONTENT DETERMINATION METHOD FROM OVEN DRY AND SENSOR METHOD

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ABSTRACT

For centuries the amount of moisture in soil has been of interest in Civil Engineering as well as in agriculture. The subject of soil moisture is also of great importance to the hydrologist, forester and soil engineer. Many equipments and methods have been developed to measure soil moisture under field and laboratory conditions. Oven dry method is one of the best and accurate method till now but this method have its own drawbacks which can be overcome by the new method such as Geophysical methods (Soil moisture sensors),Satellite remote sensing method.In this present paper different research work's result is been reviewed to analyze and the comparision have done with limitation and drawbacks of method.

Keywords: geophysical method, moisture, oven dry method, sensor, water content

I. INTRODUCTION

For centuries the amount of moisture in soil has been of interest in agriculture. The subject of soil moisture is also of great importance to the hydrologist, forester and soil engineer. Much equipment and many method have been developed to measure soil moisture under field conditions. Knowing the water content of the soil we can know the various properties of soil like strength properties, bearing capacity, etc. for construction purpose.The gravimetric method is concluded to be the most satisfactory method for most problems requiring one time water content data. It is concluded that all method have some limitations and that the ideal method for measurement of water content under field conditions has yet to be perfected.Water content or moisture content is the quantity of water contained in a material, such as soil (called soil moisture), rock, ceramics, crops, or wood. Water content is used in a wide range of scientific and technical areas, and is expressed as a ratio, which can range from 0 (completely dry) to the value of the materials' porosity at saturation. It can be given on a volumetric or mass (gravimetric) basis.Water contained in soil is called soil moisture. The water is held within the soil pores. Soil water is the major component of the soil in relation to plant growth. If the moisture content of a soil is optimum for plant growth, plants can readily absorb soil water. Not all the water, held in soil, is available to plants. Much of water remains in the soil as a thin film. Soil water dissolves salts and makes up the soil solution, which is important as medium for supply of nutrients to growing plants.Water held in a soil is described by the term water content. Water content can be quantified on both a **gravimetric** (g water/g soil) and **volumetric** (ml water/ml soil) basis. The volumetric expression of water content is used most often. Since 1 gram of water is equal to 1 milliliter of water, we can easily determine the weight of water and immediately know its volume.

II. TYPES OF WATER

The four types of water available in the soil are:

(2.1) Gravitational Water or Ground Water

(2.2) Capillary Water

(2.3) Hygroscopic Water and

(2.4) Chemically Combined Water.

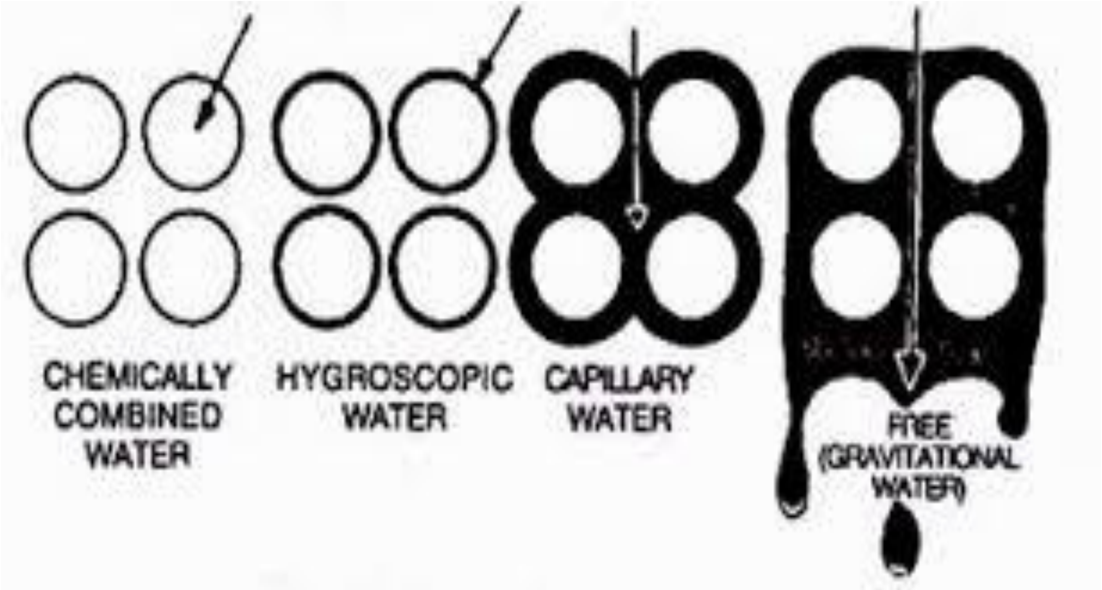

Fig. 1. Types of water

2.1 Gravitational Water or Ground Water:

After a heavy rain or on application of irrigation water, the surface layer of a soil is temporarily saturated. This water obeys the laws of gravity and thus descends rapidly through the dry layers, leaving a moist zone in its path.If there is sufficient water this wet layer penetrates deeply. The rate of this down-ward percolation of this gravitational water is determined by the number, size and con-tinuity of non-capillary or larger pores.

The gravitational water is available to plants only when rain showers follow one another in rapid succession; otherwise it percolates below the reach of the roots within a few days and thus remains unavailable.

2.2 Capillary Water:

As ground water drains out of the upper layer of the soil, it leaves behind considerable moisture in the form of films, coating smaller soil particles and as droplets suspended in the angles of larger pores or completely filling the smaller pores.

This water is retained by the forces of surface tension and this capillary water does not respond to the gravitational pull. The forces are, however, small—seldom more than a fraction of an atmosphere depending on the diameter of the capillaries. This is capillary water. It is primarily this capillary water which is readily available to the plant and this is the source of practically all the water a plant extracts from the soil.

2.3. Hygroscopic Water:

Owing to evaporation from the soil surface and absorption by roots, the capillary water held by the soil is gradually depleted. As depletion pro-gresses, the forces of molecular attraction or adsorption between the soil particles and the thin films of water held against their surfaces increase until finally the remaining water passes into a state where it is no longer in the liquid condition and thus ceases- to be chemically or biologically active.

The forces of molecular attraction increase rapidly as the water film surrounding soil particle grows thinner until a point is reached when the films are only a few molecules thick and the forces of attraction may reach values as high as 1000 atm. Evidently plants can absorb only a relatively small amount of this hygroscopic water. The hygroscopic water cannot be entirely evaporated from a soil under ordinary atmospheric conditions, but it can be done by heating soil to a constant weight in an oven at approximately 150°C. The above three types of soil are not sharply defined but form a continuous series from water which is not retained by the soil, to water which is held with great force.

2.4. Chemically Combined Water:

The water chemically combined in the structure of soil minerals is known as combined water. After the elimination of hygroscopic water by heating soil to about 150°C., the only water that remains is in the hydrated oxides of aluminum, iron, silicon, etc. This water is absolutely unavailable to the plants and can only be driven off from the soil by resorting to very high temperature but not before bringing about irreversible changes in the physical and chemical composition of the soil itself.

III. IMPORTANCE OF SOIL WATER

1. Soil water serves as a solvent and carrier of food nutrients for plant growth.
2. Yield of crop is more often determined by the amount of water available rather than the deficiency of other food nutrients.
3. Soil water acts as a nutrient itself.
4. Soil water regulates soil temperature.
5. Soil forming processes and weathering depend on water.
6. Microorganisms require water for their metabolic activities.
7. Soil water helps in chemical and biological activities of soil.
8. It is a principal constituent of the growing plant.
9. Water is essential for photosynthesis.

IV. DEFINITIONS

1. Volumetric water content, w is defined mathematically as:

$$W = \frac{Vw}{Vwet}$$

Where;

Vw is the volume of water and Vwet= Vs + Vw + Va is equal to the volume of the wet material, i.e. of the sum of the volume of solid material (eg. Soil particles, vegetation) Vs of water Vw and of air Va.

2. Gravimetric water content , is expressed by mass (weight)as follows:

$$U= \frac{Mw}{M}$$

Where;

3. Mw is the mass of water and M is the mass of substance. Normally the latter is taken before drying.

$$U'=\frac{Mw}{Mwet}$$

4. Except for woodworking, geotechnical and soil science applications where oven-dried material is used instead

$$U''= \frac{Mw}{Mdry}$$

5. To convert gravimetric water content to volumetric water content, multiply the gravimetric water content by the bulk specific gravity SG of the material

$$w=U*SG$$

V.OVEN DRY METHOD

For many soils the water content maybe an extremely important index used for establishing the relationship between the way a soil behave and its properties . The consistency of a fine grain soil largely depends on its water content.The water content is used in expressing the phase relationship of air water and solid particles in a given volume of soil.

Soil mass is generally a three phase system. It consists of solid particles liquid and gas. For all partical purposes the liquid maybe considered to be water and the gas as air. The phase system maybe expressed in SI units either in terms of mass volume or weight volume relationships. The inter relationship of different phases are important since they help to define the condition or the physical makeup of soil.the temperature between 105C to 115C is maintain.

IS:2720(Part II)- 1973, Method of test for soil : part II is used.

Fig. 2. Electric oven

Advantages:

Precise; Relatively cheap; Easy to use; Officially sanctioned for many applications; Many samples can be analyzed simultaneously

Disadvantages:

Destructive; Time consuming

Precautions

The drying rate of test samples will be affected by the moisture conditions and number of samples in the drying device. When wet samples are placed in the drying device with nearly dry samples, completion of the drying may be restarted.

Safety and health

Soils and aggregates may contain bacteria and/or organisms which can be harmful to one's health. Wearing dust masks and protective gloves when handling materials is advised. The use of heat resistant gloves/mitts or pot holders to remove samples from the ovens is recommended. Prior to handling, testing or disposing of any waste materials, testers are required to read: Part A (Section 5.0), Part B (Sections: 5.0, 6.0, 10.0 and 12.0) and Part C (Section 1.0) of Caltrans Laboratory Safety Manual. Users of this method do so at their own risk.

VI. GEOPHYSICAL METHODS (SOIL MOISTURE SENSORS)

Determining water content of soil take time and also various methods which give the approximate value, no method is their which is fast as well as give accurate result. In order to overcome such drawbacks electronic method is used which is modern method and which gives faster result and almost accurate. Idea behind this is to get result in seconds. or min. so that speed of work can be increased. Electronic method is fast and various kind of microprocessor and microcontroller are used so that data are displayed in digital form and in smaller time. In this microcontroller is used which is cheaper than other as well as handy. This can be used in field as well as laboratory.

Soil moisture sensors measure the volumetric water content in soil. Since the direct gravimetric measurement of free soil moisture requires removing, drying, and weighting of a sample, soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. The relation between the measured property and soil moisture must be calibrated and may vary depending on environmental factors such as soil type, temperature, or electric conductivity. Reflected microwave radiation is affected by the soil moisture and is used for remote sensing in hydrology and agriculture. Portable probe instruments can be used by farmers or gardeners.

Soil moisture sensors typically refer to sensors that estimate volumetric water content. Another class of sensors measure another property of moisture in soils called water potential; these sensors are usually referred to as soil water potential sensors and include tensiometers and gypsum blocks. The object is to find out the water content or moisture content of soil using electrical method.

6.1 Technology

Technologies commonly used to indirectly measure volumetric water content (soil moisture)

A. **Frequency Domain Reflectometry (FDR)**: The dielectric constant of a certain volume element around the sensor is obtained by measuring the operating frequency of an oscillating circuit.

B. **Time Domain Transmission (TDT) and Time Domain Reflectometry (TD**R**):** The dielectric constant of a certain volume element around the sensor is obtained by measuring the speed of propagation along a buried transmission line.

C. **Neutron moisture gauges**: The moderator properties of water for neutrons are utilized to estimate soil moisture content between a source and detector probe.

D. **Soil resistivity**: Measuring how strongly the soil resists the flow of electricity between two electrodes can be used to determine the soil moisture content.

E. **Galvanic cell**: The amount of water present can be determined based on the voltage the soil produces because water acts as an electrolyte and produces electricity. The technology behind this concept is the galvanic cell.

6.2 SENSOR

There are many different types of soil water content sensors available, choosing the best one for application may seem difficult or even confusing. To help selection, it’s important to understand what soil water content sensors actually measure, what makes a good soil water content sensor, and how to make sense of the manufacturer specifications.

6.3 Soil water content sensors measure

There are no commercially available soil water content sensors that measure water directly. Instead, what the sensors do is detect changes in some other soil property that is related to water content in a predictable way.

Common soil properties that change with water content and are easy to measure include dielectric permittivity, thermal conductivity, and density of neutron flux. This article focuses on sensors that measure dielectric permittivity.

Dielectric permittivity sensors are the most common type of soil water content sensor on the market. These sensors use different technologies to measure the permittivity of the surrounding soil, including the following:

- Time domain reflectometry
- Time domain transmissivity
- Frequency domain reflectometry
- Time of charge capacitance
- Transmission line oscillation
- Coaxial impedance dielectric reflectometry
- Coaxial differential amplitude reflectometry

Regardless of the technology, the same principle is used: the bulk dielectric permittivity of soil changes with volumetric water content. The simplest way to think of permittivity is as stored electrical energy. The sensor generates an electric field in the soil and, because the water molecule is polar, unbound water molecules in the soil rotate to line up with the electric field lines. That rotation of unbound water molecules requires energy, which is stored as potential energy in the aligned water molecules. The more water there is in the soil, the more energy gets stored, and the higher the bulk permittivity of the soil. The other constituents of soil—mineral and organic solids, and air—store electrical energy too, but water can store more than ten times as much as the other parts of soil. Because of that, water movement in and out of the sensor's measurement volume is the major contributor to changes in permittivity.

The soil water content sensor is designed to have an electrical signal that changes with permittivity and, therefore, with water content. Some sensors determine permittivity and then convert that to water content, while others convert the sensor's electrical output to volumetric water content in a single step. No matter which method is used, the water in the soil affects the bulk dielectric permittivity, which affects the sensor's electrical output. This is important to remember when you are comparing accuracy specifications.

6.4 GOOD SOIL WATER CONTENT SENSOR

An ideal high-performance soil water content sensor has all of the following properties:

1. It meets your requirements for accuracy and resolution.
2. It lasts as long as you need it to.
3. It requires minimal calibration and does not require recalibration.
4. It meets your budget requirements.
5. It is easy for you to install and measure.

As you might imagine, these properties can be in competition with one another. For example, a durable, high-accuracy sensor may be more expensive when compared with a less durable sensor with lower accuracy. Sensor manufacturers try to find the right balance between these competing factors. To decide which sensor is best for your application, determine which of these factors are most important to you, and then look for the sensor that best matches your highest priorities.

VII. CONCLUSION

Moisture content determination accuracy for substance samples identifying a larger bulk volume will be as precise as the representative sample quality. When choosing material samples from a batch, the area of sample selection is crucial. For reproducible test results, a test sample must be truly representative of the entire homogenous batch being tested. For example, a bulk powder mixing process must be thoroughly blended before extracting a representative sample. In the bulk mixing process a common condition occurs where as a greater concentration of moisture exists away from the surface and edges of the material. A test sample gathered from the top will not be a true representation of the batch.

The key for successful moisture determination, efficient productivity, and superior product quality is fast test determination without lengthy pauses in production processes. Successful moisture analysis means testing at the point of processing, and making adjustments before product integrity is effected.

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