A neutron meter for measuring moisture in soils

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SUBJECT A NEUTRON METER FOR MEASURING MOISTURE IN SOILS

Since the first foil-type neutron moisture meters were developed at Cornell University (USA) and the University of Saskatchewan, Canada, about a decade ago, several developments have contributed to the improvement in this technique of measuring moisture in soils, and to the widespread acceptance of its use as field equipment. After some preliminary experience with an Indium foil unit, the National Research Council of Canada developed a neutron meter employing a scintillation detection unit for use in measuring moisture in soils from a vertical access tube (Burn 1960).

Principle of the Neutron Meter

When neutrons are emitted from a high energy source into a soil medium, their velocities are reduced as they collide with the nuclei of atoms of which the soil is comprised. The resulting physical action is one of elastic collisions with loss of energy inversely proportional to the mass of the nuclei. Because hydrogen atoms have the only nuclei of a mass that is almost equal to that of neutrons, they are almost entirely responsible for the neutrons being reduced to thermal velocities. Since hydrogen atoms occur chiefly in the water of soils the activity of neutrons moderated to thermal velocities is proportional to the quantity of water in the soil. A neutron meter consists essentially of a constant source of high energy neutrons, a detection apparatus for thermal neutrons, and an electronic counting apparatus to measure quantities of neutrons.

Calibration problem

Ultimately the instrument was to be used for studies of moisture migration in natural soils, but because it would be impossible to control the parameters affecting calibration in the field, this was undertaken in the laboratory.

Further, because the principle upon which the neutron moisture meter functions makes it a potentially more accurate method than the usual one of weighing samples before and after drying at 105°C, some consideration was given to the possible use of artificial soil media whose hydrogen contents could be determined more precisely from specific gravities and chemical formulae (Burn 1958).

In the selection of substitute materials certain basic requirements were recognized.

1. Bulk densities characteristic of natural soils should be maintained.

2. Elements of high neutron capture cross-sections must be avoided.

3. Elements with atomic weights lower than those encountered in natural soils should be avoided.

4. Materials should be selected which would facilitate uniform distribution of hydrogen content and bulk density.

Laboratory calibration

Based on the above requirements four artificial mixtures were prepared to cover a wide range of hydrogen densities. In the low hydrogen range mixtures of sand and water and of sand, dextrose and water were used. In the high range mixtures of sand, bentonite and water and solutions of sodium hexametaphosphate were used. The relation between thermal neutron activity referenced to a wax standard and moisture density for these media is shown in Figure 1.

Field calibration

Field calibration of the neutron meter has been carried out in only one type of soil: a marine deposit called Leda clay. In this soil the field calibration curve was found to be consistently displaced from the laboratory curve by an amount corresponding to a moisture density some 6 pounds per cubic foot higher. It appears that some unexpected factors in the natural soil are influencing neutron activity. Research is now being carried out to establish the reasons for this discrepancy.

Use of the Neutron Meter

Experience with the instrument has shown it to be stable and adequately accurate. Since the neutron activity appears to be susceptible to variation in soil type, however, it must either be limited in use to detecting only the changes that occur in moisture density, or be calibrated for each soil type, without which it would be impossible to determine absolute moisture densities to any degree of accuracy.

References

1. Burn, K. N. (1958). Assessment of Possible Materials for Use in the Calibration of a Neutron Moisture Meter. National Research Council, Division of Building Research, Technical Note 269.

2. Burn, K. N. (1960). Design and Calibration of a Neutron Moisture Meter. Presented to the Symposium on Nuclear Methods of Measuring Soil Density and Moisture. Annual Meeting of the A. S. T. M. Atlantic City, June 1960.

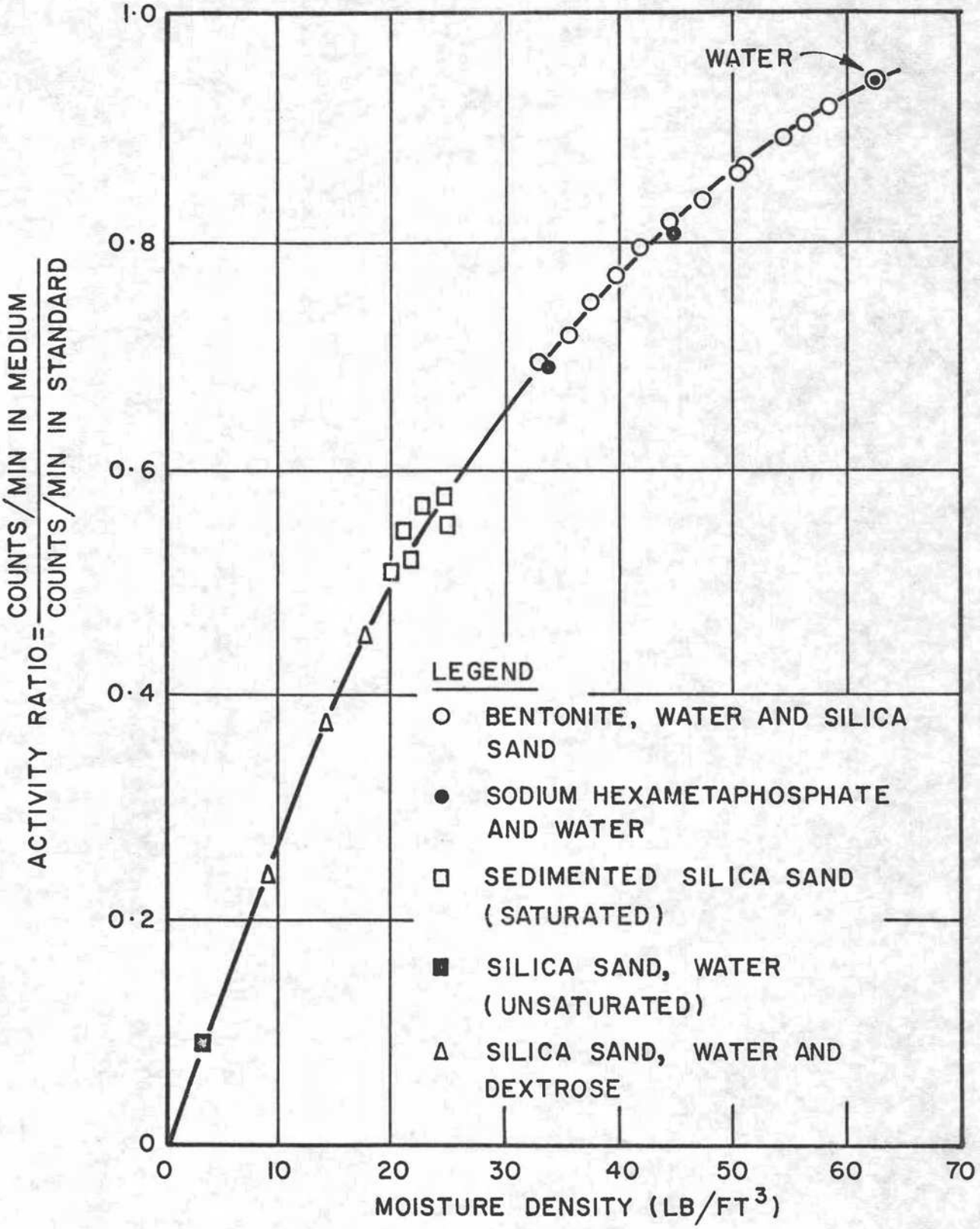

FIGURE 1
CALIBRATION CURVE OF NEUTRON MOISTURE METER

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