METHOD A10 (b) T

TENTATIVE METHOD FOR DETERMINING THE IN-PLACE DENSITY AND MOISTURE CONTENT OF SOILS AND GRAVELS BY NUCLEAR METHODS

1 SCOPE

This method describes the in-place determination of the density and moisture content of a compacted layer by nuclear methods.

Definition

The in-place dry density of a material is the dry mass per unit volume of the material expressed in kilograms per cubic metre.
The in-place moisture content (m/v) is the mass of water per unit volume of the in-place material expressed in kilograms per cubic metre. (In this method moisture content will refer to this definition.) This moisture content can be converted and expressed as a percentage moisture per mass of dry material (m/m).

2 APPARATUS

2.1 A nuclear system complete with accessories and stored in a suitable transit case as supplied by the manufacturer. A detailed description of each unit and principles of operation should be given in the manual for the nuclear instrument.

2.2 Other equipment needed to do the test, e.g. bedding sand for levelling site if necessary, bedding plate, paint brush, etc.

2.3 Safety

Radiation levels and shielding must com ply with government regulations. The equipment should also have safety features such as an automatic source retraction mechanism. Please note that nuclear apparatus must be registered with the Atomic Energy Board.

3 METHOD

3.1 Standardization of equipment

3.1.1 The following checks shall be made before any instrument is used:

(a) The warm-up time must be in accordance with the manufacturer's specifications.
(b) The power supply must be properly charged (a low power level should be indicated by an audible warning or any other suitable indicator).
(c) The metering or display system must be checked for correct functioning.

3.1.2 Laboratory check

Check the instrument on the reference unit at the preselected reference spot at the

main laboratory before the instrument is taken into the field.
Sufficient readings must be taken on the reference standard as recommended by the manufacturer.
If more than the prescribed number of readings fall outside the calibration limits, a second set of readings should be taken. If more than the prescribed number of these readings fall outside the limits, the instrument should be referred back to the manufacturer.
A permanent record should be kept of the readings taken on the reference unit.

3.1.3 Field check

A reference spot must be selected in the field against which daily checks can be made before and after routine tests. Two readings must be taken and they should fall within the field calibration limits set by the manufacturer. If one reading is outside the limits a second set of readings must be taken. If this second set of readings is not within the limits, another field reference spot must be selected . Care should be taken to ensure that other objects, such as vehicles, walls or other nuclear instruments, are not in the immediate vicinity (at least 10 m away).

3.2 Preparation of test site

3.2.1 Flush backscatter measurements

The gauge must be properly bedded on the surface of the material for all flush count measurements.
A bedding of finely-graded sand (passing the 0,600 mm sieve) should be strewn lightly over the site. The surface gauge should then be bedded on the surface by moving it backwards and forwards over the site. The bedding sand should only serve to fill the surfacevoids. A continuous layer of sand over the material must be avoided.

3.2.2 Direct transmission mode of measurement

The drill rod is placed through the guide in the bedding plate and then driven into the ground at least 50 mm deeper than the desired depth of measurement. Care must be taken not to damage the hole when withdrawing the drill rod.

3.3 Moisture and denslty measurements

Three methods exist for determining the density of a material. These are the:

(A) flush backscatter method;
(B) the air-gap count ratio method; and
(C) the direct transmission method.

The moisture content (m/v) of a material can only be determined by the flush backscatter method.

3.3.1 Method A - Flush backscatter (FBS)

The following procedure should be used to carry out the flush backscatter density and moisture count measurements.

(a) Bed the surface gauge ensuring that it is flush with the surface of the material.
(b) Activate the nuclear instrument (ensure that the source is not in the retracted position).
(c) Read and record moisture and density readings after the counting period has ceased. (Record in 1 and 3 of Form A10(b)T/1 .)
(d) The source must then be retracted and the gauge turned through 180E. Rebed on the same test point. Repeat procedures (b) and (c). (Record in 1 and 3 of Form A10(b)T/1.)

3.3.2 Method B - airgap count ratio method (ACR)

This method is applied for instruments using this facility. The following procedure is followed:

(a) Bed the surface gauge ensuring that it is flush with the surface of the material.
(b) Activate the nuclear instrument (ensuring that the source is not in the retracted position).
(c) Read and record the moisture and density readings after the counting period has ceased. (Record in 1 and 3 of Form A10(b)T/1 .)
(d) The source must then be retracted and the gauge turned through 180E. Rebed on the same test point. Repeat procedures (b) and (c). (Record in 1 and 3 of Form A10(b)T/1.)
(e) After retracting the source of the surface gauge, lift it gently off the test site. Care must be taken so as not to disturb the bedding sand when used.
(f) Carefully place the airgap cradle over the same position as previously occupied by the surface gauge. Lower the surface gauge into the recess in the cradle ensuring that the radio-active source occupies the same position as before. Care should be taken to ensure the sole-plate is free of mud and bedding sand before being placed onto the cradle.
(g) Read and record the density reading after counting has ceased. (Record in 2 of Form A10(b)T/1.)
(h) Retract the source of the gauge.
(i) Without disturbing the airgap cradle, turn the surface gauge through 180E and replace in the recess.
(j) Activate the source and read and record the density reading after counting has ceased. (Record in 2 of Form A10(b)T/1.)

3.3.3 Method C - Direct transmission (DT)

The direct transmission (DT) mode of measurement is used for determining density only.
With some machines moisture count readings may be taken by backscatter simultaneously with the DT density readings.
The procedure for determining the density by DT is as follows:

(a) Place the instrument over the prepared test point with the direct transmission probe directly above the hole.
(b) Lower the probe into the hole to the desired depth of density measurement.
(c) To minimize the airgap between the source and the detector, the gauge must be gently pulled to position the probe against the side of the hole.
(d) After taking density count readings, the probe must first be retracted before attempts to remove the instrument from the test point are made, in order to prevent damage to the probe.
(e) A second density count reading may be taken (by turning the gauge through 180 E and carrying out the procedure (a)- (d)

4 CALCULATIONS

4.1 For Method A - Flush backscatter (FBS)

4.1.1 Wet density. Calculate the average of the flush backscatter density counts for each test point. Read off the correspond ing wet density i n kg/m^3 from the backscatter density calibration curve or tables. The wet density should be read off to the nearest 5 kg/m^3.

4.1.2 Moisture content (m/v). Calculate the average of the moisture counts for each test point. Read off the correspond ing moistu re content in kg/m^3 from the relevant moisture calibration curve or tables. The wet density should be read off to the nearest 5 kg/m^3.

4.2 For Method B - Airgap count ratio (ACR)

4.2.1 Wet density

(a) Calculate the average of the flush backscatter density counts and the average of the airgap density counts.
(b) Divide the average airgap density count by the average backscatter density count to determine the airgap count ratio (ACR). The division shall be carried out to the third decimal place.
(c) Read off the corresponding wet density from the ACR density curve. The wet density shall be read off to the nearest 5 kg/m^3.

4.2.2 Moisture content (m/v). Calculate the average of the moisture counts. Read off the corresponding moisture content in kg/m^3 from the moisture curve. The moisture content shall be read off to the nearest kg/m^3.

4.3 For Method C - Direct transmission (DT)

4.3.1 Wet density. Calculate the average of the direct transmission density counts for each test point. Read off the wet density in kg/m^3 from the calibrated DT density curve. The wet density shall be read off to the nearest 5 kg/m^3.

4.3.2 Moisture content (m/v). Calculate the average of the moisture counts. Read off the corresponding moisture content in kg/m^3 from the moisture curve. The moisture content shall be read off to the nearest kg/m^3.

4.4 Dry density

Calculate the dry density by subtracting the moisture content from the wet density. Round off the result to the nearest 5 kg/m^3.

4.5 Reporting of results

The results should be reported to the nearest 1 0 kg/m^3.

5 NOTES

5.1 The basic count/moisture and count/density backscatter curves and the air-gap count ratio/density curve are supplied by the manufacturer.

5.2 Material type effect

The basic calibration curve of some instruments may require adjustment due to the effect of change in chemical composition of a material as described in 5.3 for the density, and in 5.4 for the moisture calibration curves for all instruments. Techniques such as the airgap count ratio (ACR) method can be employed to compensate for this effect.

5.3 Compensation of back scatter density curve

5.3.1 Carry out ACR wet density measurements as in Method B at six different test points.

(a) Calculate the average FBS density count for each test point.
(b) Calculate the average air-gap density backscatter count for each test Point.
(c) Determine the air-gap count ratio for each test point.
(d) Determine the wet density for each test point from the ACR curve.

5.3.2 Plot the average of these wet densities against the average of the corresponding six flushback scatter count averages on copies of the basic back scatter graph supplied with the equipment.

5.3.3 Through this point plot a line parallel to the basic backscatter curve. This is then the compensated density backscatter for the particular material .

5.4 Compensation of basic moisture curve

5.4.1 Investigations have shown that where moisture measurements are carried out on ferrugenous materials (laterite, iron-stone, ferricrete) or on materials containing chemically bound water (such as clay or soil having a high organic matter content), it is necessary to compensate the basic moisture curve supplied with the instrument. The appropriate moisture calibration curve tor those materials can be established by means of comparative gravi-metrical moisture determinations. The calibrated curve is generally offset by a constant factor from the basic curve. The following procedure should be followed to establish the correct curve:

5.4.2 Determine nuclear moisture and wet density counts at five different test points using Method B.

5.4.3 Immediately after each test, take a sample (approximately 2 kg) at the same test point to a depth of 75 mm. Determine the moisture content (m/m basis) by oven drying.

5.4.4 Determine the wet densities f rom the basic ACR curve.

5.4.5 Convert the moisture content (mass per mass) to a mass per volume basis by means of the following formula:

$$\text{Moisture content (m/v) in kg/m}^3 = \frac{M + Dw}{M + 100}$$

where
Dw = wet density in kg/m^3
M = moisture content (m/m) (per cent)

5.4.6 Establish the correct calibration curve by drawing a line parallel to the basic curve through a plot of the average of the five mean moisture counts against the average of the five moisture contents (m/v) in kg/m^3.

Recording sheet for the determination of the in-place density of soils and gravels by nuclear methods

FORM A10(b)T/1

PLACE/PLEK _____ LAYER/LAAG _____

IN PLACE DENSITY RESULTS
IN SITU-DIGTHEIDRESULTATE

ROAD/PAD _____ DATE/DATUM _____

										STANDARD COUNTS STANDAARDTELLINGS	
CHAINAGE / KETTING										DENSITY DIGTHEID	MOISTURE VOG
THICKNESS / DIKTE											
1 FBS OR DT COUNTS GTS- OF DS- TELLINGS	1										
	2										
	3										
	TOTAL TOTAAL										
	AVERAGE GEMIDDELDE										
2 AIRGAP COUNTS LUGGAPING- TELLINGS	1										
	2										
	3										
	TOTAL TOTAAL										
	AVERAGE GEMIDDELDE										
ACR / LTV											
WET DENSITY (kg/m^3) NAT DIGTHEID (kg/m^3)											
3 MOISTURE COUNTS VOGTELLINGS	1										
	2										
	3										
	TOTAL TOTAAL										
	AVERAGE GEMIDDELDE										
MOISTURE CONTENT VOGINHOUD	kg/m^3 / %										
DRY DENSITY DROË DIGTHEID	(kg/m^3)										
M.D.D./O.M.C. MDD/OVI											
% COMPACTION % VERDIGTING											
SAMPLE NO. MONSTER NR.											