WAKA KOTAHI
NZ TRANSPORT AGENCY

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ESTIMATION OF THE DENSITY OF COMPACTED AGGREGATE LAYERS BY DIRECT TRANSMISSION

New Zealand Government

1 SCOPE

This test method provides a procedure for determining the density of modified, bound and unbound granular pavements by using a nuclear densometer in direct transmission mode. This mode allows determination of the average density at various depths and, by calculation, estimating the density of surface and sub-surface layers.

This test method is particularly applicable to modified pavements that have been laid in one layer and in-situ stabilised in accordance with NZTA B05 specification. Other types of granular pavements that can be shown to be vertically uniform throughout the layer may be tested using NZS 4407 Test 4.3 (i.e. using a nuclear density meter in backscatter mode).

This method refers to and should be used in conjunction with NZS 4407 Test 4.2 *The Field Water Content and Field Dry Density of Compacted Materials – Method Using a Nuclear Moisture-Density Gauge – Direct Transmission*. All the requirements of test 4.2 shall be met except as modified by this test method.

This method is not intended as a replacement for routine density testing using the method of NZS 4407 Test 4.3 (i.e. nuclear density meter in backscatter mode) but should be used in parallel to test 4.3 to investigate the vertical uniformity of pavement layers.

1.1 Safety Disclaimer

The use of this test method may involve hazardous materials, operations and equipment. This document does not purport to address all the safety issues associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2 RELATED DOCUMENTS

(a) Standards New Zealand, Methods of Sampling and Testing Road Aggregates, NZS 4407.

3 APPARATUS

The following apparatus is required:

(a) Nuclear density gauge and associated equipment as required by NZS 4407 test 4.2 clause 4.2.3;

(b) Equipment for determining the water content of aggregates as required by NZS 4407 test 3.1 clause 3.1.2.

(c) Optionally, an impact drill and masonry bit suitable for forming a hole in the compacted aggregate layer. A 22mm diameter drill bit has been found to be suitable.

(d) Suitable sealable containers, such as plastic bags or lidded pails for water content samples.

4 PROCEDURE

(a) Follow the procedure of NZS 4407 test 4.2 except as amended below for determining the field water content and field dry density.

(b) Select a test position as required by NZS 4407 clause 4.2.5 (b). Use the guide plate and drive pin, or alternatively a powered masonry drill to form a hole in the compacted aggregate layer. The hole diameter shall be slightly greater than the diameter of the nuclear gauge source rod diameter. If a drill is used to form the hole, use the diameter of the drive pin supplied with the nuclear gauge to select an appropriately sized drill.

Note: For modified and bound materials drilling is preferred to minimise localised disturbance around the hole. Experience has shown that drills with a greater number of cutting edges form cleaner holes with less spalling of the aggregate particles from the side of the hole.

(c) Form the hole to a depth of 350mm or to the base of the pavement layer plus 50mm, whichever is less.

(d) Place the nuclear gauge over the hole and extend the probe to a depth of 300mm or the bottom of the layer being tested, whichever is less. Record the wet density and water content in accordance with

NZS 4407 test 4.2, section 4.2.5, using a count time of at least 60 seconds. Record the probe depth D_1, wet density WD_1 and reported percentage water content M_1.

(e) Retract the probe to approximately half of the depth used in step (d) above (i.e. depth of 150mm for a depth of 300mm in step (d) above). Record the wet density and water content in accordance with NZS 4407 test 4.2 section 4.2.5 using a count time of at least 60 seconds. Record the probe depth D_2, wet density WD_2 and reported percentage water content M_2.

(f) Retract the gauge probe and remove it from the test position. Obtain a sample of the aggregate from the exposed sub-surface material in accordance with NZS 4407 test 4.2 clause 4.2.6 to a depth no greater than the half depth in step (e) above, transfer it to the sealable container and immediately seal it to prevent loss of water. Transfer the sample to a suitable accredited testing laboratory as soon as practically possible and determine the water content of the aggregate, w, using NZS 4407 test 3.1.

For job sites with multiple test positions, the number of aggregate samples taken for water (moisture) correction may be reduced for reasons of practicality provided the material being tested is consistent. Where more than one material is used, then each material shall be treated as a separate job site for the purposes of water correction sampling and testing. See note 7(b).

Where the number of test positions per job site is 5 or less, one sample per test position shall be taken. For locations with greater than 5 test positions, the number of water content samples shall be the greater of:

(i) five samples, or;

(ii) the number of test positions divided by 4, rounded to the nearest whole number.

5 CALCULATIONS

Complete the following calculations:

(a) Determine the average measured water content, percent, M_{av} for each test position:

$$M_{av} = \frac{M1+M2}{2} \quad (\%)$$

(b) Calculate the water correction ratio R, where w is the laboratory oven-dry water content taken as in 4(f) above:

$$R = \frac{w}{M_{av}}$$

Note: where multiple water contents have been determined for a job site (for the same material) then the average of the water (moisture) correction ratios shall be used for correcting the measured water contents.

(c) Calculate the corrected water content, w_{corr} for the average water content for each test position by multiplying the measured water content by the water correction ratio:

$$w_{corr} = R \times M_{av} \quad (\%)$$

(d) Calculate the dry density for each test position, for both of the probe depths D_1 and D_2, from the wet density results, WD_1 and WD_2, where the DD_1 = the dry density measured at the full probe extension, and DD_2 = the dry density measured at approximately half the layer depth:

$$DD_n = WD_n \times \frac{100}{(100+w_{corr})} \quad \text{kg/m}^3$$

Refer to Note (a)

(e) Calculate the inferred dry density DD_{lower} for the depth interval $D_1 - D_2$:

$$DD_{lower} = \frac{(DD_1 \times D_1)-(DD_2 \times D_2)}{(D_1 - D_2)} \quad (\text{kg/m}^3)$$

(f) Calculate the percent variance δ from the mean dry density for each test position as follows:

$$\delta = \frac{200 \times (DD_{upper} - DD_{lower})}{(DD_{upper} + DD_{lower})} \quad (\%)$$

6 REPORTING

Report the following for the job site:

(a) The information required by NZS 4407 test 4.2;

(b) The depth of the aggregate layer (mm).

For each test position, report the following:

(c) The probe depths D_1 and D_2;

(d) The field wet density recorded at the base of the layer (WD_1) and at the midpoint of the layer (WD_2) to the nearest 0.01 T/m³;

(e) The water correction ratio R used for each test position;

(f) The corrected water content W_{corr} for each test position to two significant figures;

(g) The dry density for the aggregate layer between the layer midpoint and the surface, DD_2 to the nearest 0.01 T/m³;

(h) The apparent dry density for the aggregate layer between the lower test position point (i.e. at 300mm depth or the base of the layer) and layer midpoint at depth D_2, DD_{lower} to the nearest 0.01 T/m³;

(i) The absolute value of the variance from the mean, δ, for each test position to two significant figures;

(j) Reference to this test method.

7 NOTES

(a) For the purposes of this test method and practicality it has been assumed that the water content of the aggregate layer under test is uniform. This was done as it was considered onerous, and would significantly reduce testing productivity, if each test position was excavated to a depth greater than the intermediate test depth in order to take additional samples for laboratory water content testing.

This assumption may reduce the accuracy of the apparent dry density of the lower portion (DD_{lower}) of the aggregate layer. Consequently, it is recommended that compacted aggregate pavements should not be rejected on the basis of unsatisfactory DD_{lower} results or high variances (δ), but that further investigation should be completed to check vertical uniformity of the compacted aggregate.

(b) On larger projects where many water correction ratios have been determined and can be shown to be consistent, an assumed water correction ratio may be used, based on historical results. This assumed value shall be confirmed regularly, at a frequency no less than every 5th visit to the site.

(c) The Contractor is responsible for repair and reinstatement of the test positions. These will need to be repaired prior to the placement of any surfacing materials.