TEST METHOD **WA 115.1 - 2019**

PARTICLE SIZE DISTRIBUTION: SIEVING AND DECANTATION METHOD

1 SCOPE

This method describes the procedure for the determination of the particle size distribution of soils and granular materials by sieve analysis and decantation.

The required outcome from the performance of this test is the characterisation of the particle size distribution of the test sample; therefore the largest sieve used in the coarse sieving should approximate the largest particle size in the test sample. Thus a test sample containing cobbles and boulders should be tested using either a 125.0 mm or 106.0 mm sieve. It is inappropriate for such a test sample to be tested over a 37.5 mm sieve and to simply report a large percentage mass retained.

2 SAFETY

This method does not attempt to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this method to establish appropriate occupational health and safety practices that meet statutory regulations.

3 REFERENCED METHODS

Australian Standard

AS 1152: Specification for test sieves

Main Roads Western Australia

WA 100.1: Sampling Procedures for Soil and Granular Pavement Materials

WA 105.1: Preparation of Disturbed Soil and Granular Pavement Materials for Testing

WA 110.1: Soil and Granular Pavement Material Moisture Content: Convection Oven Method

WA 110.2: Soil and Granular Pavement Material Moisture Content: Microwave Oven Method

4 DEFINTIONS

(a) **Flocculation** - The clumping together of smaller particles to form larger particles which drop out of suspension quickly during the decantation process.

(b) **Constant mass** - as defined in Test Method WA 110.1

5 APPARATUS

(a) **Sieves** complying with AS 1152.

(b) **Thermostatically controlled oven** with good air ventilation capable of maintaining a temperature within the range of 105°C to 110°C.

(c) **Sieve Brushes**.

(d) A **mortar and rubber pestle** (International Rubber Hardness Degrees 87 approximately).

(e) **Balance** of at least 16 kg capacity, readable to 0.1 g, with a Limit of Performance (F) of not more than 0.5 g.

(f) **Balance** of at least 2 kg capacity, readable to 0.01 g, with a Limit of Performance (F) of not more than 0.05 g.

(g) **Glass or aluminium beaker** approximately 150 mm deep and approximately 1 L capacity.

(h) **Glass stirring rod**.

(i) **Timing device** capable of measuring up to 15 minutes ± 0.5 minutes.

(j) The **dispersing agent** used shall be either 33 g of sodium hexametaphosphate with 7 g of anhydrous sodium carbonate (Na_2CO_3) in 1000 mL of water or 33 g of sodium hexametaphosphate with 18.9 g of hydrated sodium carbonate ($Na_2CO_3.10H_2O$) in 1000 mL of water.

Other dispersing agents such as a 10% ammonia solution may be tried if use of the above solutions does not prevent flocculation from occurring.

(k) **Thermometer**, with range of at least 0°C to 100°C and readable to 1°C.

6 PROCEDURE

(a) Obtain a test sample taken in accordance with Test Method WA 100.1.

(b) Obtain from the test sample a test portion that has been prepared in accordance with Test Method WA 105.1. Record the initial mass ($m_{int.}$) of the test portion to 0.1 of a gram.

6.1 Coarse Sieving

(a) Nest the selected sieves in order of decreasing aperture size from top to bottom. The aperture of the largest sieve selected should approximate the size of the largest particle in the sample being tested.

For particle sizes greater than 19.0 mm appropriate sieves are generally 75.0, 53.0 and 37.5 mm, however other, larger or intermediate sieve sizes should be used as appropriate for the nominal size of the test sample. The smallest sieve used shall be a 2.36 mm sieve. Place a retainer under the 2.36 mm sieve.

NOTE: Sieves are selected in accordance with the specified requirements and such that the largest particles pass through the largest sieve used

(b) Place the test portion in the top sieve.

(c) Agitate the sieves. When sieving by hand, use lateral and vertical motion of each sieve accompanied by a jarring action to keep the particles moving over the surface of the sieve. On sieves of 19 mm and greater particles shall also be hand placed through the apertures to facilitate the passage of particles through the sieve which would otherwise have difficulty passing by the sieving action. However particles shall not be forced through the apertures by hand pressure. Mechanical sieve shakers may be used as an alternative for initial sieving but must be followed by hand sieving.

Break up any aggregations of particles using the mortar and rubber pestle. Take care that no discrete particles are crushed in this operation but ensure that all aggregations of particles are broken down so that only discrete, uncrushed particles are retained on each sieve used. If necessary, brush fines off the particles using a stiff nylon bristle brush.

Complete the sieving by hand using one sieve at a time. If the mass retained on any sieve exceeds that shown in Table 1, divide the material into increments to satisfy Table 1 and sieve separately recording the number of increments on the worksheet. Continue agitation until the mass passing each sieve in twenty to thirty seconds of continuous hand sieving is less than one percent of the mass of material retained on that sieve.

NOTE: Compliance to Table 1 can be visually assessed. If the material on the sieve is evenly spread over the entire surface of the sieve and is more than a single particle thickness deep; then the sieve is probably overloaded.

d) Determine and record the mass, to 0.1 g, of material retained on each sieve including any material cleaned from the mesh or perforated plate. If the sieve portion was divided into test increments, recombine the particles retained from each sieving and consider these as single sieve fractions.

Care shall be taken when cleaning material from the mesh or perforated plate not to damage the sieve apertures. A stiff nylon bristle brush shall be used to clean sieves of 2.36 mm aperture and greater.

(e) Determine and record the mass (m_1), to 0.1 g, of material passing the 2.36 mm sieve that has been collected in the retainer.

TABLE 1
MAXIMUM MASS OF MATERIAL TO BE RETAINED ON EACH SIEVE AT THE COMPLETION OF SIEVING

AS SIEVE (mm)	200 mm Diameter (g)	300 mm Diameter (g)
125.0		5 500
106.0		3 500
75.0	1 000	2 200
53.0	1 000	2 200
37.5	1 000	2 200
26.5	800	1 800
19.0	600	1 200
16.0	500	1 000
13.2	400	900
9.50	250	500
6.70	200	400
4.75	200	400
2.36	150	300
1.18	100	200
0.600	75	-
0.425	60	-
0.300	50	-
0.150	40	-
0.075	25	-

(f) Obtain a representative test increment, of at least 30 g, from the material passing the 2.36 mm sieve and determine the hygroscopic moisture content (w) in accordance with Test Method WA 110.1 or WA 110.2.

NOTE: In the event that the decantation process does not commence on the same day as the coarse sieving then it may be necessary to take a second, hygroscopic moisture content on the day the decantation is commenced. This will be particularly relevant to hydrophilic materials, which absorb moisture.

6.2 Decantation

(a) Tare a clean, dry beaker on the balance.

(b) Obtain a representative test increment, by sample division, of approximately 100 g from the material passing the 2.36 mm sieve. Place the test increment into the tared beaker and record the mass (d_1) to

0.01 g. Add approximately 500 mL of potable water to the beaker.

(c) Boil the mixture for at least 15 minutes allow to cool then add approximately 10 mL of dispersing agent.

(d) Fill the beaker to a mark approximately 130 mm above the base. Stir the mixture with a to-and-fro motion avoiding rotation. Allow the mixture to stand before decantation. The minimum time the mixture shall stand before decantation is dependent on its temperature and shall be in accordance with Table 2.

NOTES:
1. The time the liquid stands before decantation is based upon Stokes' Law and has been calculated such that after the elapsed time only particles finer than 0.0135 mm will be in suspension.

2. In circumstances where the water supply has a temperature in excess of 34°C it will be necessary to cool the water prior to use. Using water at temperatures above 34° C may induce convection currents within the liquid, which may affect the rate of settlement based on Stokes' Law.

TABLE 2
STANDING TIME

Temperature °C	Minimum Standing Time Minutes
9	11
13	10
17	9
21	8
24	7.5
27	7
30	6.5
34	6

(e) Decant the suspension carefully in one continuous motion to a mark approximately 50 mm above the base.

NOTE: The sediment, which has settled, should not be decanted by this operation. For the initial pours it is recommended that the suspension be decanted to a mark approximately 75 mm above the base. As the suspension clears it is possible to see the settled sediment.

(f) Repeat the decantation process in accordance with Procedure 6.2(d) and 6.2(e) until the water poured off after the appropriate time has elapsed is clear. For the last pour the standing times given in Table 2 should be adhered to within plus 0.5 minutes. After the last pour stand the beaker, at an angle of approximately 45 degrees for approximately 15 minutes, then decant off the excess water making sure no sediment is lost.

Dispersing agent shall be added every third or fourth pour but never in the last three pours.

NOTE: The success of the decantation depends on the dispersion of the material finer than 0.0135 mm. Failure to disperse the particles can be detected if the soil flocculates and settles leaving a clear solution above a fluffy band of particles near the bottom of the beaker. In such cases other dispersing agents that may be tried may include 10% ammonia solution, sodium silicate solution or distilled water. If flocculation cannot be prevented, the decantation test is invalid.

(g) Dry the beaker and sediment to constant mass in an oven at a temperature within the range of 105°C to 110°C. Constant mass shall be achieved, when the difference between successive dry mass weighings, after additional oven drying for intervals of not less than 1 hour does not differ by more than 0.1 percent of the corrected, dry mass of the sample increment taken in Procedure 6.2(b).

(h) After constant mass is achieved, cover the beaker and allow the beaker and sediment to cool.

(i) Transfer the sediment to a tared container and record the mass of sediment (d_2) to 0.01 g.

6.3 Fine Sieving

(a) Nest the 1.18 mm to 0.075 mm sieves in order of decreasing size of aperture from top to bottom, with a retainer under the bottom sieve and place the sediment in the top sieve.

NOTE: Unless otherwise directed the following fine sieves should be used for the particle size distributions: 1.18 mm, 0.600 mm, 0.425 mm, 0.300 mm, 0.150 mm and 0.075 mm.

(b) Agitate the sieves. When sieving by hand use a lateral and vertical motion of each sieve accompanied by a jarring action to keep the particles moving on the surface of the sieve. Material shall not be forced through sieves by hand or the use of brushes. Mechanical sieve shakers may be used as an alternative for initial sieving but must be followed by hand sieving.

Complete the sieving by hand using one sieve at a time. If the mass retained on any sieve exceeds that shown in Table 1, divide the material into increments to satisfy Table 1 and sieve separately. Continue agitation until the mass passing each sieve in twenty to thirty seconds of continuous hand sieving is less than one percent of the mass of material retained on that sieve.

NOTE: Refer to Note at 6.1(c)

(c) Determine and record the mass, to 0.01 g, of materials retained on each sieve including any material cleaned from the mesh.

Care shall be taken when cleaning material from the mesh or perforated plate not to damage the sieve apertures. A stencil brush shall be used to clean sieves of apertures 1.18 mm to 0.300 mm inclusive and a camel hair brush used to clean sieves of apertures 0.150 mm and 0.075 mm.

d) Determine the mass, to 0.01 g, of material passing the 0.075 mm sieve that has been collected in the retainer. Record this as the mass that would be retained on a 0.0135 mm sieve.

7 CALCULATONS

7.1 Coarse Sieving

(a) Calculate the dry mass of material passing the 2.36 mm sieve using the formula:

$$m_d = \frac{m_1 \times 100}{w + 100}$$

Where:

m_d = dry mass of material passing the 2.36 mm sieve in grams.

m_1 = mass of material plus hygroscopic moisture passing the 2.36 mm sieve in grams.

w = hygroscopic moisture content as a percentage of the dry soil mass.

(b) Calculate, by addition, the mass of material passing each of the coarse sieves used for the particle size distribution commencing with the dry mass of material passing the 2.36 mm sieve and add the mass of any material which may have been retained on the largest sieve used. Denote this mass as m_4.

The summation of the masses of the material retained on each sieve after sieving plus the wet mass of the material passing the 2.36 mm sieve (m_1) may not equal the initial mass (m_{int}) of the test portion before sieving due to errors such as balance approximations, moisture variation, or particle retention (blinding) on sieves.

If the difference is greater than 0.5% of the initial mass of the test portion recombine the sieved material and re-sieve. If the difference is still greater than 0.5% repeat the coarse sieving procedure using a fresh test portion.

(c) Calculate the percentage mass of material passing each sieve, using the formula:

$$P_P = \frac{m_P}{m_4} \times 100$$

Where:

P_P = percentage mass of material passing the sieve.

m_P = mass of material passing the sieve in grams.

m_4 = total dry mass of test sample.

(d) Calculate the percentage mass of material retained on the 37.5 mm sieve, using the formula:

$$P_{R37.5} = \frac{m_{R37.5}}{m_4} \times 100$$

Where:

$P_{R37.5}$ = percentage mass of material retained on the 37.5 mm sieve.

$m_{R37.5}$ = sum of the mass of material retained on the 37.5 mm sieve and any larger sieves used.

m_4 = total dry mass of test sample.

7.2 Fine Sieving

(a) Calculate the dry mass of the test increment taken for decantation using the formula:

$$d_d = \frac{d_1 \times 100}{w + 100}$$

Where:

d_d = dry mass of the test increment in grams.

d_1 = wet mass of sample in grams.

w = hygroscopic moisture content as a percentage of the dry soil mass.

(b) Calculate the dry mass of material that would pass a 0.0135 mm sieve using the formula:

$$m_{0.0135} = d_d - d_2$$

Where:

$m_{0.0135}$ = dry mass of material that would pass a 0.0135 mm sieve in grams.

d_d = dry mass of test increment in grams.

d_2 = dry mass of sediment in grams.

(c) Calculate, by cumulative addition, the mass of material passing each of the fine sieves used for the particle size distribution commencing with the mass of material that would pass a 0.0135 mm sieve ($m_{0.0135}$). Denote the mass as m_5

The summation of the masses of the sediment after sieving may not equal the mass of the sediment before sieving due to errors such as balance approximations, moisture, or particle retention (blinding) on sieves. If the difference is greater than 0.4 g recombine the sediment material and re-sieve. If the difference is still greater than 0.4 g repeat the decantation and fine sieving procedure using a fresh test increment.

(d) Calculate the percentage mass of material passing the 1.18mm sieve using the formula:

$$P_{1.18} = \frac{m_{1.18}}{m_5} \times P_{2.36}$$

Where:

$P_{1.18}$ = percentage mass of material passing the 1.18mm sieve.

$m_{1.18}$ = mass of material passing the 1.18mm sieve in grams.

$P_{2.36}$ = percentage mass of material passing the 2.36mm sieve.

m_5 = mass of material passing the 2.36mm sieve after fine sieving in grams.

(e) Calculate the percentage mass of material passing each of the other fine sieves used for the particle size distribution including the percentage mass of material that would pass a 0.0135 mm sieve.

8 REPORTING

Report the following to the nearest 1 percent:

(a) The percentage mass passing each sieve.

(b) The percentage mass that would pass a 0.0135 mm sieve, if required.

(c) The percentage mass retained on the 37.5 mm sieve, if required.

9 REVISION STATUS RECORD

Page No.	Section	Revision Description / Reference
2	6.1 (c)	Added requirement to record sieve increments