TEST METHOD T150

DRY DENSITY - MOISTURE RELATIONS FOR MIXTURES OF ROAD MATERIALS AND BITUMINOUS MATERIALS

REVISION SUMMARY

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TEST METHOD T150

DRY DENSITY - MOISTURE RELATIONS FOR MIXTURES OF ROAD MATERIALS AND BITUMINOUS MATERIALS

1. Scope

This test method sets out the procedures for the determination of the relationship between dry density and moisture content for mixtures of soil, gravel or crushed rock material and bitumen, cut back bitumen, bitumen emulsion, or tar, using standard compaction or modified compaction. The procedures have been adapted from Tests 3 and 4 of BS 1924

This method is applicable to materials passing a 19.0 mm AS sieve.

2. Apparatus

(a) A cylindrical metal mould having an internal diameter of 105± 0.5 mm and a volume of 1000 ± 10 mL, fitted with a detachable base-plate and a removable collar assembly approximately 60 mm high, both of which can be firmly attached to the mould. A suitable design is shown in AS 1289.

(b)

(i) A metal rammer with a 50 ± 0.5 mm face diameter and a drop mass of 2.7 kg +10 g -25 g, equipped with a suitable device to control the height of drop to a free fall of 300 ± 2 mm.

(ii) A metal rammer with a 50 ± 0.5 mm face diameter and a drop mass of 4.9 kg +10 g -30 g, equipped with a suitable device to control the height of drop to a free fall of 450 ± 2 mm.

Suitable forms of hand apparatus are shown in AS 1289. Mechanical forms of the apparatus may be used provided the essential dimensions are adhered to.

(c) A rigid foundation on which to compact the specimen, e.g. a concrete floor or a cubical concrete block of at least 100 kg mass.

(d) A metal mixing and quartering tray.

(e) Mixing apparatus such as a trowel and palette knife and quartering apparatus such as metal plates approximately 400 mm by 125 mm and 200 mm by 125 mm.

(f) Sample dividers (riffle boxes) of appropriate size openings (Optional).

(g) A thermostatically controlled oven with good air circulation capable of maintaining a temperature within the range of 105°Cto 110°C.

(h) 37.5 mm, 19.0 mm and 4.75 mm AS sieves.

(i) A balance of at least 6000 g capacity accurate and readable to 0.5 g within the operating range.

(j) A balance of at least 500 g capacity, accurate and readable to 0.01 g within the operating range.

(k) A jack, lever and frame or other device suitable for extruding compacted specimens from the mould. A suitable form of apparatus is shown in AS 1289.

(l) A bowl suitable for thoroughly mixing increments of water with the test sample. A mixing machine (11 litre capacity) may be used.

(m) Moisture measurement tins, at least 500 ml capacity, with press-on lids or other suitable seal.

(n) A 100 ml measuring cylinder.

(o) A steel straightedge; a suitable size being about 300 mm long, 25 mm wide and 3 mm thick preferably with a bevelled edge.

(p) A 300 mm rule.

(q) A porcelain mortar, approximately 178 mm diameter, and a rubber pestle.

(r) Metal dishes, approximately 225 mm and 350 mm diameter.

3. Preparation of Sample

3.1. Soil , Gravel or Crushed Rock

(a) Allow the sample to dry sufficiently to enable it to be crumbled. If necessary, dry the sample at a temperature not exceeding 50^{o}C.

(b) Break up any aggregations of particles in such a way as to avoid crushing any discrete particles. All aggregations of particles are to be broken down so that if the sample was screened on a 4.75 mm AS sieve, only discrete uncrushed particles would be retained. A rubber pestle should be used to avoid breaking down sound pieces of mineral matter. Adhering material should be brushed from coarse pieces. When in doubt as to whether lumps are to be broken, place some in water and boil. If slaking occurs, the material should be broken further with the rubber pestle.

(c) Screen the sample on a 37.5 mm AS sieve. Discard material retained.

(d) Screen the remaining sample on 19.0 mm and 4.75 mm AS sieves. Material passing the 37.5 mm AS sieve and retained on the 19.0 mm AS sieve shall be removed and replaced by an equal mass of material passing the 19.0 mm AS sieve and retained on the 4.75 mm AS sieve obtained from another portion of the sample.

(e) Thoroughly remix all material passing the 19.0 mm AS sieve and reduce, as necessary by quartering or riffling, to provide not less than 15000 g of material for determination of density - moisture relationships.

(f) Obtain by quartering or riffling six 2500 g portions of the sample prepared in *Preparation of Sample (e)* .

3.2. Bituminous Materials

(a) Bituminous materials used in laboratory investigations should be of the same type and from the same source of supply or manufacture as the materials proposed for use in the field. Unless otherwise specified or approved the bituminous materials should comply with the requirements of the appropriate Australian Standard (i.e. Bitumen, Cut Back Bitumen, Bitumen Emulsion, or Tar).

(b) Where bitumen emulsion is specified or approved for use in investigations in relation to stabilisation or modification of road materials, the water used in the test should be from the same source as that proposed for use in the field.

3.2.1. Addition of the Bituminous Material

Determination of the Desirable Viscosity and Moisture Content For the Addition of Bitumen of Cut Back Bitumen

(a) Take one of the 2500 g portions of the sample obtained in *Preparation of Sample (e)* and quarter or riffle it to obtain 6 to 8 portions each of 300 g (approximately).

(b) Take one of the 300 g portions of soil, add sufficient water to dampen the soil, mix thoroughly and add a small quantity of bitumen that has been heated as necessary to produce a "pourable" condition. Mix with a trowel in an attempt to produce a uniform mix. If the viscosity is unsuitable for mixing, balls of unmixed bitumen will form. When this happens it is necessary to cut back the bitumen with power kerosene starting from 5 per cent cutter and increasing by 2 per cent increments.

(c) To another 200-300 g portion, add a measured quantity of water (but do not exceed optimum moisture at this stage) and add a small amount of cut back bitumen. Mix thoroughly with a trowel and note ease (or difficulty) of mixing.

(d) Repeat *Addition of the Bituminous Material (b)* and *(c)* with increases in moisture content of the soil and/or the proportion of cutter in the bitumen until conditions for satisfactory mixing are determined.

(e) Record the moisture content of the soil and the cutter content of the bitumen at which satisfactory mixing occurred.

(f) Adopt the soil moisture content and cutter content of the bitumen recorded in *Addition of the Bituminous Material (e)* in the mixture to be tested in accordance with this Test Method.

(g) Add the cut back bitumen to the moist soil in small quantities, mixing thoroughly after each addition, until the required amount of bitumen has been added to the soil.

3.2.2. Determination of Desirable Viscosity and Moisture content for the Addition of Tar

(a) Adopt a similar procedure to that described for bitumen above except that instead of fluxing with kerosene, different grades of tar should be used.

(b) Add the desired grade of tar to the moist soil in small quantities, mixing thoroughly after each addition until the required amount of tar has been incorporated in the soil.

3.2.3. Addition of Bitumen Emulsion

(a) Dampen the test portion to a moisture content of 4% to 5%.

(b) Calculate the additional quantity of water to be added to bring the emulsion - soil mix to the desired moisture content. For this purpose the water content of bitumen emulsion shall be taken as 45 per cent by mass.

(c) Dilute the bitumen emulsion by adding at least half the additional water to the bitumen emulsion. Add the remainder of the additional water to the soil portion.

(d) Add the diluted bitumen emulsion to the soil portion in small quantities mixing thoroughly after each addition until the required amount of bitumen emulsion has been incorporated in the soil.

4. Procedure

(a) Weigh the mould and record the mass (M_2) to the nearest 5 g.

(b) Assemble the mould, collar and base-plate and place the assembly on the rigid foundation.

(c) Take one of the 2500 g portions and determine the mass to the nearest 1 g. Screen on a 4.75 mm AS sieve. All material retained on the 4.75 mm AS sieve shall be soaked for at least one hour and then surface dried.

(d) Bring the soil to the moisture content and add the bituminous material as described in Section 3.2.

(e) Compact the mixture into the mould by the specified compactive effort. Unless otherwise specified, use Standard Compaction.

(i) Standard compaction. Compact the mixture into the mould in three layers, not varying in compacted thickness by more than 5 mm. Subject each layer to 25 uniformly distributed blows of a 2.7 kg rammer falling freely from a height of 300 mm.

(ii) Modified compaction. Compact the mixture into the mould in five layers, not varying in compacted thickness by more than 5 mm. Subject each layer to 25 uniformly distributed blows of a 4.9 kg rammer falling freely from a height of 450 mm.

(f) Use only sufficient material to slightly overfill the mould leaving not more than 5 mm to be struck off after removing the collar. Free the material from around the collar and then carefully remove the collar.

(g) Level the compacted material to the top of the mould by means of the straightedge. Patch with smaller sized material, any holes developed in the surface by removal of coarse material.

(h) Remove the base-plate and weigh the mould plus compacted material and record the mass (M_1) to the nearest 5 g.

(i) Eject the compacted material from the mould and cut into four vertical segments. Shave off not less than 300 g from the full height of the inside of the segments. Place in a tared moisture content tin and weigh immediately. Dry to substantially constant mass at a temperature within the range of 105^{o}C to 110^{o}C. Calculate the moisture content as described in 5(b) below. Discard the remainder of the compacted material.

(j) Repeat *Procedure (c) to (i)* with the other 2500 g portions adding the same amount of binder each time but increasing the quantity of water for each successive portion to provide the following approximate ranges:

(i) Sandy materials: 7 to 15 per cent in steps of 2 per cent.

(ii) Clayey materials: 12 to 24 per cent in steps of 4 per cent.

(k) Repeat the procedure for each of the additive contents.

5. Calculations

(a) Calculate the mass of compacted material (M_3) after each compaction, as follows:

$$M_3 = (M_1 - M_2)\ g$$

Where

M_1 = Mass of the mould plus compacted material 4(h)

M_2 = Mass of mould 4(a)

(b) Calculate the moisture content (w) of the compacted material after each compaction, as follows:

$$w = \frac{A - B}{B - C} \times 100$$

where

w = percentage of moisture in the compacted material.
A = mass of moisture tin + wet sample.
B = mass of moisture tin + oven-dry sample.
C = mass of moisture tin.

(c) Calculate the dry density of the compacted material after each compaction, as follows:

$$\text{Dry Density} = \frac{M_3 \times 0.1}{100 + w}\ t/m^3$$

(d) Plot the dry densities obtained in the series of compactions against the corresponding moisture contents. Draw a smooth curve through the resulting points and determine the maximum dry density and the related optimum moisture content from the peak of the curve, or use the procedure described in the appendix.

(e) If the optimum moisture content has not been straddled, prepare additional test samples and compact these at the appropriate moisture contents as in *Procedure (c) to (i)* above.

6. Reporting

Report the following results for each bitumen content as appropriate:-

(a) Type and source of bituminous material.

(b) Additive content.

(c) Amount of cutter used (if any) and moisture content at which binder was added.

(d) Source of water if bitumen emulsion is used.

(e) Maximum Dry Density in t/m^3 to the nearest 0.01 t/m^3.

(f) Optimum moisture content to the nearest 0.5%.

7. Techniques

(a) The height of each layer should be checked with a gauge or rule to ensure that the layer is about one-third (or one-fifth) of the height of the mould. If the final

layer is more than 5 mm above the top of the mould after removing the collar the test must be rejected.

(b) The range of moisture contents required will vary according to the type of material to which the binder has been added. As a guide, the Plastic Limit gives an indication of the approximate upper limit of the range. In some cases it may be advisable to use increments of 2 per cent or less.

(c) If more than 5% of the total material is retained on the 19.0 mm AS sieve, a 2 litre mould should be used. The method of compaction and apparatus required is described in Test Method T111.

(d) If difficulty is experienced in incorporating bitumen emulsion into the soil, an additive compatible with emulsion may be required.

e.g. Anionic emulsions must be diluted with water of an alkaline nature. This may be achieved by the addition of 0.05 - 0.10% household detergent or phosphate softener (Calgon) to the water before mixing with the emulsion.

Cationic emulsions must be diluted with water of an acidic nature. This may be achieved by the addition of 1% solution of hydrochloric acid (muriatic acid) or 0.05% by weight of amine salt, in a minimal amount just sufficient to acidify the local water.

If such an additive is found necessary, the type and quantity used should be recorded in the test report.

(e) Difficulties may be experienced in the use of cut-back bitumen when mixed with road materials because of the slow rate of evaporation of cutter oil. The amount of cutter added should therefore be kept to a minimum.

Appendix

8. Compaction Test - Parabola Vertex

8.1. Graphical Solution for Vertex of a Parabola with Vertical Axis Given 3 Points (See Fig. 1).

(a) Of the points available choose the 3 points closest to optimum moisture content.

(b) Draw a horizontal base line through the left point, A, and draw vertical lines through points B and C.

(c) Draw a line DE parallel to AB. Point E lies on a vertical line through C.

Project E horizontally to establish point F on a vertical line through Point B.

(d) Draw a line DG parallel to AC, Point G lies on a vertical line through C.

(e) Draw line FG to intersect the base line at H. Bisect base line AH to form the axis of the parabola.

(f) Draw line AB to intersect axis of parabola at J. Project J horizontally to K, which lies on the vertical line through B.

(g) Line KH intersect the axis at 0, the vertex.

8.2. Graphical Solution for Vertex of a Parabola with Vertical Axis when the 3 Points are Equally Spaced Horizontally.

(a) If points A, B and C are equally spaced horizontally Clauses 1(c) and 1(d) above are eliminated. Point F coincides with Point B and Point G is halfway between the baseline and Point C.

(b) Obtain Point H by drawing line BG.

(c) Obtain Point O by clauses 1(e) to 1(g) above

Fig.1. GRAPHICAL SOLUTION FOR PEAK POINT OF PARABOLA