METHOD A10 (a)

THE DETERMINATION OF THE IN-PLACE DRY DENSITY OF SOIL OR GRAVEL BY THE SAND REPLACEMENT METHOD

1 SCOPE

The in-place dry density of compacted soil or gravel, as defined below, is determined by making a hole in a compacted layer and dividing the dry mass of the material removed from the hole by the volume of the hole which is determined by filling the hole with a fine sand of known density.

Definition

The in-place dry density of a material is the dry mass per unit volume of the material and is expressed in kilograms per cubic metre.

2 APPARATUS

2.1 A density device complete with accessories, viz. pouring can, dolly, garden trowel, chisel and three pegs (Figure A10 (a)/l)(see 5.1 and 5.2).

2.2 A balance with scoop to weigh up to 6 kg accurate to 19.

2.3 About 10 kg of specially prepared and calibrated sand (see 5.3 and 5.4).

2.4 A drying oven, thermostatically controlled and capable of maintaining a temperature of 105 to 110 EC.

2.5 A small spade (border spade)

2.6 Paint brushes: a 100mm and a 20 to 30mm brush.

2.7 A road tamper.

2.8 A 2 kg hammer.

2.9 A pan, about 300 mm x 300 mm.

2.10 A tablespoon.

2.11 A 300 mm rule.

2.12 A suitable container such as a tin of about 5 l capacity. (For preparation and calibration of sand:)

2.13 Sieves - A 0,425 mm and a 0,250 mm.

2.14 A basin, about 400 mm in diameter.

2.15 A cylindrical container with an internal diameter and height of 152, 0 +5 mm.

2.16 A 180 mm x 180 mm glass plate, about 7 mm thick.

2.17 Lubricating grease.

2.18 A 5 m~ pipette.

2.19 A thermometer, 0 to 50 EC.

3 METHOD

3.1 Preparatlon

The point at which the density is to be determined is selected and a fairly even surface of about 300 mm by 300 mm is chosen. All loose material is brushed away to leave a clean and firm surface. If the surface is very uneven, it can be levelled by carefully skimming off the irregularities with the small border spade. The ring of the density device is now placed on the surface of the material and the dolly is placed on the ring. The three pegs are hammered in so that they just touch the rim of the ring (see 5.2). By means of light blows with the road tamper on the dolly, the density ring is driven down until the lower surface of the ring makes firm contact with the surface of the material. If coarse aggregate near the surface prevents the penetration of the edge of the ring, the ring should be shifted somewhat. Care should be taken to ensure that the material in the centre of the ring is not loosened unduly. The three pegs are now hammered in the rest of the way to hold the density ring firmly in place. The dolly is removed and the material which may have been loosened in the ring is removed by brushing it lightly into the trowel or spoon.

3.2 Volume of density ring and tunnel

The density funnel is now placed on the density ring so that the lower funnel rests in the recess in the ring. The machined recess should be clean with no soil or grit on the ring. The funneltap is closed. About 2 000 9 of the prepared and calibrated density sand (which should be more than sufficient to fill the lower funnel and the volume of the ring not occupied by the material) is accurately weighed and transferred to the pouring can. It is then poured from the can into the upper funnel. When the sand level comes to within about 25mm of the top of the upper funnel, the tap is opened completely and the sand is allowed to flow into the lower funnel. In the meantime the sand from the can is allowed to run out completely, keeping the sand level in the upper funnel about 25 mm from the top. As soon as the sand in the upper funnel stops flowing, the funnel tap should be closed carefully. On no account should the funnel be jarred (see 5.1).

The density funnel is now removed and inverted over the scale scoop. The tap is opened and the sand confined in the orifice in the tap is also returned to the scale scoop. This sand is weighed and then returned to the bulk supply.

As much of the sand remaining in the density ring as can readily be transferred by means of a trowel or tablespoon should be removed and placed in the square pan. Care should be taken to see that the surface of the material is not touched. When most of

the sand has been removed, the remainder is brushed into the centre of the ring. The sand in the square pan is weighed and then returned to the bulk supply. The remainder is collected with the material later on.

3.3 Removal of material from the density hole

The cold chisel is now used to loosen the material in the density ring and this, including the sand remaining in the ring is removed by means of a trowel and a spoon and placed in the square pan. When possible, only the chisel and the trowel are used to loosen the material, except when the layer of material is extremely hard, in which case a chisel and hammer may have to be used. The edge of the density ring should not be used as a fulcrum when using the chisel. The procedure should be to push or tap the chisel into the soil and then rotate the chisel by means of the cross handles and move the chisel to and fro.

The sides of the density hole must be cut vertically and should extend to the full depth of the layer to be tested, as otherwise a true average density is not obtained. If a stone is removed from the wall of the hole, the cavity should be cut away at the top so that there is o gradual slope down the wall to ensure that the sand, when poured, will fill the hole completely. As far as possible the sides and bottom of the hole should not be loosened, but maintained in their compacted state.

All loose material in the hole should be removed and collected in a container. Any material which may have fallen on the density ring should be collected by means of a brush and spoon. The average depth of the hole is then measured.

3.4 Volume of the density hole

The density funnel is replaced on the density ring which should be perfectly clean. From 5 500 to 6 000 gram of density sand is weighed off accurately and transferred to the pouring can. The density hole, etc., is now filled up in exactly the same manner as was set out when filling the funnel and ring at the commencement of the test. It is possible that the sand may be more than sufficient to fill the upper funnel as well, in which case some sand will be left in the pouring can. The funnel-tap is then closed carefully. The sand in the upper funnel, pouring can and also in the orifice of the tap is returned to the scale scoop and weighed. This sand can then be remixed with the bulk supply. The sand remaining in the hole and on the density ring is removed and placed in the bag containing used sand, which must be prepared before being used again (see 5.5).

3.5 Drying and weighing of material

The material removed from the hole is taken to the laboratory where it is transferred to a square pan and dried to constant mass in an oven at 105 to 110EC. The sand and material should be weighed accurately to the nearest 1 gram.

4 CALCULATIONS

Dry density in kg/m^3

$$D = \frac{Wf}{w}$$

where

D = dry density in kg/m3.
W= mass of dry material from density hole in 9.
w= mass of sand to fill density hole in 9.
F = poured density of sand in kg/m3 (see 5.4)

W and w are obtained from the test data as follow:

X gram = mass of sand taken initially for filling the lower funnel and unoccupied part of ring.

Y gram = mass of sand over after filling lower funnel and part of ring.

X - Y gram = mass of sand in lower funnel and unoccupied part of ring.

M gram = mass of sand removed from ring with trowel and tablespoon.

^ (X - Y) - M gram = mass of residual sand left on surface of material and taken out with density sample.

Z gram = mass of sand taken initially for filling the lower funnel, ring and density hole.

d gram = mass of sand over from this operation.

^ (Z- d) gram = mass of sand in lower funnel, ring and density hole

K gram = mass of dry material and residual sand.

^ K - (X - Y - M) = W. (i.e. mass of dry material) and (Z - d) - (X - Y) = w (i.e. mass of sand).

Finally, substitute the above values for W and w in the formula :

$$D = \frac{\left[K - \left(X - Y - M\right)\right]F}{\left(Z - d\right) - \left(X - y\right)} \quad kg / cubic \;\; metre$$

The calculation should be carried out to the nearest 1 kg/m3 and the dry density reported to the nearest 5 kg/m3 on the A1 0(a)/1 (or a similar form).

5 NOTES

5.1 In windy conditions a density funnel with a metal cylinder welded to the top cone may be used to protect the sand from the wind. The metal cylinder should be 300 mm long and have the same inside diameter as the inside diameter of the top of the funnel. All the sand is poured into the funnel before the top is opened. To eliminate any possible errors it is also advisable to calibrate the density sand with the same funnel.

5.2 In granular material where the material may be disturbed when hammering in the pegs, three metal bars, approximately 100 mm long, 20 mm wide and 5 mm thick with a 12 mm hole drilled through one end may be welded, at an equal spacing, to the side of the density ring. The pegs for holding the ring are then hammered through the holes in the bars.

5.3 Preparation of sand

A large quantity of sand (preferably quartzitic sand) should be washed thoroughly with water and the water decanted from time to time until clear. The sand is then dried and sieved through 0,425 mm and 0,250mm sieves. The fraction passing the 0,425 mm sieve and retained on the 0,250mm sieve is used in the density determination. Other closely graded fine sand may also be used, but it is desirable that not more than one type of sand should be used on one job.

5.4 Calibration of the sand (determination of poured density)

5.4.1 *Mass of sand required to fill funnel*. - The density funnel is placed with the lower funnel resting on the glass plate. The funnel lap is closed. About 17009 of the density sand is accurately weighed and transferred to the pouring can. The sand is then poured into the upper funnel. When the level of the sand comes within about 25 mm of the top of the upper funnel, the funnel tap is opened, and the sand allowed to flow into the lower funnel. The remainder of the sand in the can is poured into the upper funnel, maintaining the level at about 25 mm from the top of the funnel. When the sand stops flowing into the lower funnel, the tap is closed carefully without jarring the funnel. The density funnel is removed and the sand remaining in the upper funnel including the sand contained in the orifice in the tap is transferred to the scale scoop and weighed. This determination should be carried out in triplicate and the average mass of sand required to fill the lower funnel recorded.

5.4.2 *Mass of Sand required to fill 152.4mm container and Funnel* - The density funnel is placed centrally over the 152,4 mm container so that the lower funnel is on top of the container. The funnel tap is closed. About 60009 of the density sand is accurately weighed and transferred to the pouring can. The sand is then poured into the upper funnel. When the level of the sand comes within 25 mm of the top of the upper funnel, the funnel tap is opened, and the sand allowed to flow into the lower funnel and the container. The remainder of the sand from the can is poured into the upper funnel, maintaining the level at about 25 mm from the top of the funnel. When the flow through the tap ceases, the tap is closed carefully without jarring the funnel. The funnel is then removed and the sand in the upperfunnel and tap orifice, as well as any sand that may have remained in the pouring can, is transferred to the scale scoop and weighed. This determination should be carried out in triplicate and the average mass of sand required to fill the funnel and container is recorded.

5.4.3 *Volume of the container*. - A fairly thin film of lubricating grease is applied to the top edge of the 152,4 mm container. The container and the glass plate are weighed. Water is now poured into the container and, when f ull, the glass plate is slid gently over the top of the container. Before the glass plate quite covers the container, the final drops of water are added from a pipette. When the container is covered fully by the glass plate, no air bubbles should be entrapped under the plate. The container with water and glass plate are now weighed. The temperature of the water is measured. This determination should also be carried out in triplicate to obtain an average value for the mass of water in the container.

5.4.4 *Calculations.*

5.4.4.1 $$F = \frac{1000W}{V}$$

where

F = poured density of the sand in kg/m^3
W = mass of sand in g to fill container.
V = volume of container in ml.

5.4.4.2 W is obtained from the test data as follows:

s gram = mass of sand initially taken for filling lower funnel
t gram = mass of sand over after filling lower funnel.
^ s - t gram = mass of sand in lower funnel.

u gram = mass of sand initially taken for filling lower funnel and container.
v gram = mass of sand over after filling funnel and container.
^ u - v gram = mass of sand in funnel and container.

^ (u - v) - (s - t) gram = W (i.e. mass of sand in container only).

5.4.4.3 V is obtained from the test data as follows:

m gram = mass of container and glass plate and water
n gram = mass of container and glass plate.
m - n gram = mass of water.

d = RD of water at the temperature at which the test is carried out (see Method A7 section 5.3)

then : $\frac{m-n}{d} = V$ (i.e. volume of container).

5.4.4.4 Substitute these values for W and V in the above formula

$$F = \frac{\left[(u-v)-(s-t)\right]}{m-n} \; x \; d \; x \; 1000$$

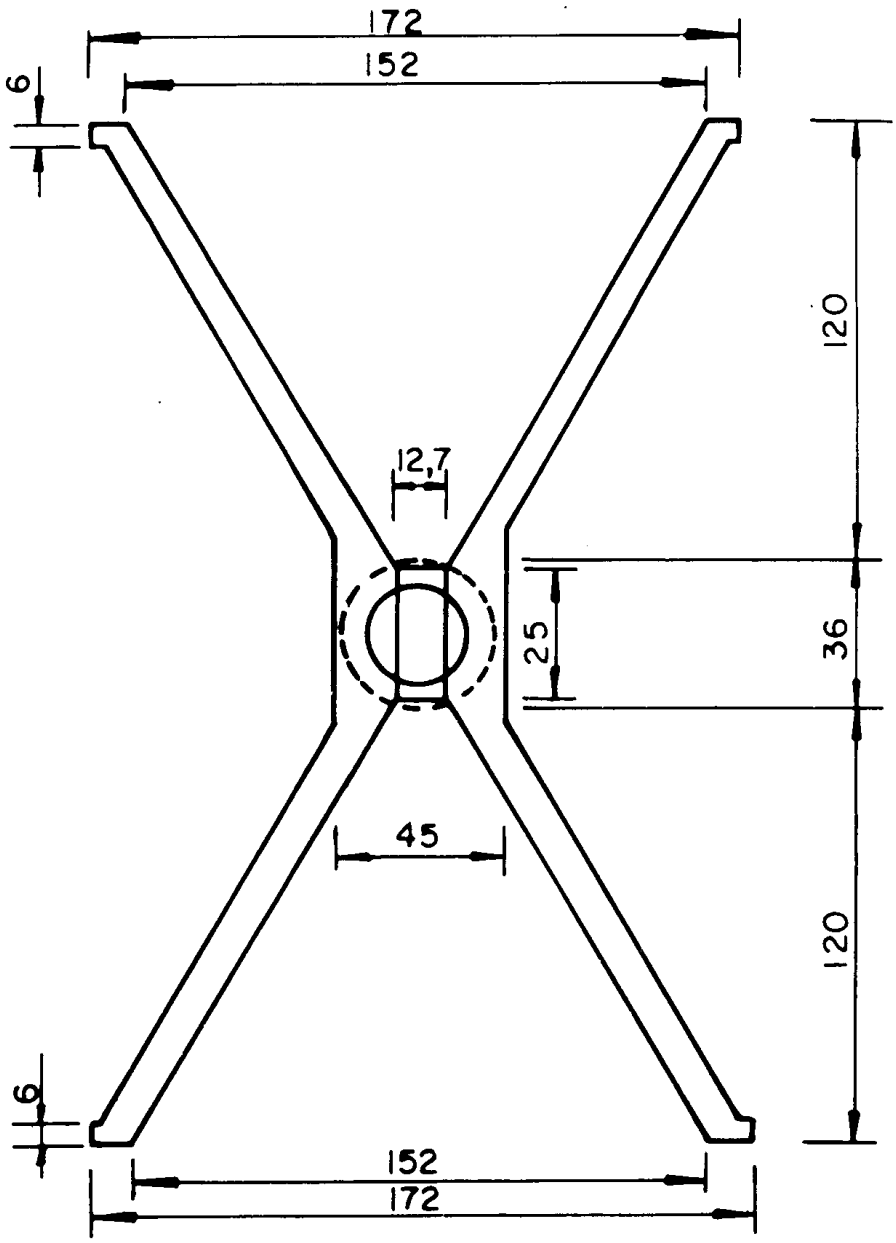
5.5 Once sand has been used for a density determination, it should be resieved. (This, of course, does not apply to clean sand returned to the bulk supply.) After the sand has been used for some time, it tends to become dirty, in which case it should be rewashed as well as resieved and its poured density (or factor) redetermined. Whenever a new batch of sand is prepared, it should be calibrated.

5.6 Layers in the road foundation are normally constructed to a compacted thickness of between 75 and 150 mm and density determinations are normally limited to approximately these minimum and maximum depths. I n any case, a determination to a depth of less than 75 mm is more subject to error and may not be very reliable, whereas a determination to a depth of more than 150 mm creates practical difficulties in the digging of the hole. It should also be remembered that the poured density of the sand is determined in a 152,4 mm deep container. Another consideration is the effect of density gradients, and although the construction of layers considerably thicker than 150 mm may be permissible (or unavoidable in the case of very coarse material), it is considered that the density determinations should be limited to a depth of 150mm.

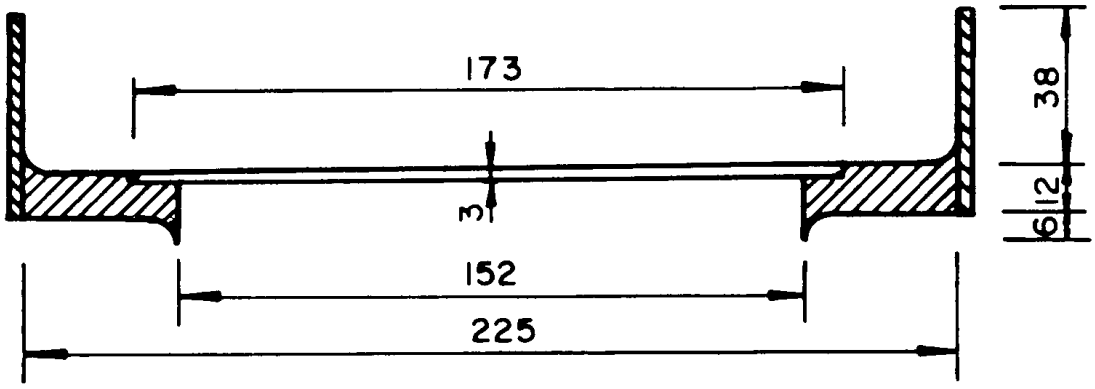
5.7 If a large stone is encountered in the density hole, the determination should not be attempted. Apart from the practical difficulty of removing the stone, the test result will be meaningless. Another spot should then be selected for the determination. If the material contains a large proportion of very coarse aggregate, i.e. aggregate of, say, more than 75 mm in diameter, the density test is hardly considered worthwhile as the results will not be sufficiently reliable.

REFERENCES

AASHTO Designation T191-61
ASTM Designation D1556-64



DENSITY FUNNEL



DENSITY RING

FIGURE A10(a)/I

Sand density apparatus

DISTANCE (km) AFSTAND	PEG NO. PEN NR.	MODIFIED AASHTO DATA GEWYSIGDE AASHTO-DATA		M.C. AT WHICH COMPACTED (%) VOGINHOUD WAARBY VERDIG	FIELD DENSITY RESULTS VELDDIGTHEIDSRESULTATE			COMPACTION (%) VERDIGTING
		MAXIMUM DENSITY MAKSIMUM DIGTHEID	OPTIMUM M.C. OPTIMUM VOGINHOUD		DEPTH DIEPTE	DENSITY DIGTHEID	MOISTURE CONTENT (%) VOGINHOUD	

FORM A10(a)/1

Sheet for field compaction data