Appendix A

(AASHTO T87-86), (ASTM D- 421)

Dry Preparation of Soil Samples

Definitions

This practice covers the dry preparation of soil samples as received from the field for particle-size analysis, the determination of the plasticity tests, Compaction Test and California Bearing Test.

Apparatus

1- Balance, sensitive to 0.1 g.

2- Mortar and Rubber-Covered Pestle, suitable for breaking up the aggregations of soil particles.

3- Sieves-a series of sieves, of square mesh woven wire cloth (No. 4 (4.75-mm), No. 10 (2.00-mm) and No. 40 (425-μm)

4- Sampler—A riffle sampler or sample splitter, for quartering the samples

Procedure

Expose the soil sample as received from the field to the air at room temperature until dried thoroughly. Break up the aggregations thoroughly in the mortar with a rubber-covered pestle. Select a representative sample of the amount required to perform the desired tests by the method of quartering or by the use of a sampler to obtain the amounts of material required to perform the individual tests

Appendix B

(AASHTO T255), (ASTM D- 2216)

Determination of Water (Moisture) Content Test Procedure

Definitions

This test method covers the laboratory determination of the water (moisture) content by mass of soil, rock, and similar materials where the reduction in mass by drying is due to loss of water, the word “material” hereinafter also refers to either soil or rock, whichever is most applicable

Apparatus

1- Balance, sensitive to 0.1 g.

2-Drying Oven thermostatically controlled

3-Water Content Containers

Procedure

A test specimen is dried in an oven at a temperature of110° +or - 5°C to a constant mass. The loss of mass due to drying is considered to be water. The water content is calculated using the mass of water and the mass of the dry specimen.

Calculate the water content of the material as follows:

$$W = ((M_{cws} - M_{cs}) / (M_{cs} - M_c)) * 100 = \frac{M_w}{M_s} * 100$$

Where:

w = water content, %,

M_{cws} = mass of container and wet specimen, g,

M_{cs} = mass of container and oven dry specimen, g,

M_c = mass of container, g,

M_w = mass of water ($M_w = M_{cws} - M_{cds}$), g, and

M_s =mass of solid particles ($M_s = M_{cds} - M_c$), g.

Appendix C

Grain Size distribution Test Procedure

(AASHTO T88-86), (ASTM D- 422)

Definitions

This test method covers the quantitative determination of the distribution of particle sizes in soils. The distribution of particle sizes larger than 75 µm (retained on the No. 200 sieve) is determined by sieving.

Apparatus

1- Sensitive Balances (readability of 0.1g).

2-Sample, for quartering the sample

3- Sieves "Opening Size of Commonly Used Sieves" (37.5, 25, 19, 12.5, 4.75, 2.0, 0.425, 0.150, 0.075 Millimeters)

4-Sieve Shaker /or Manual

5-Drying Oven thermostatically controlled

6- Containers

Procedure

1-Split the sample as mentioned in (Appendix B), and put it in the oven for 24 hours**.**

2-Weight the sample and record the total weight.

3-Separate the portion retained on the No. 10 (2.00-mm) Sieve to divide it into fine & coarse to ease it for washing.

4- Wash the sample through No 200 (0.075 mm) Sieve.

5-Put it in an oven for 24 hours /or dry it by heater prevent local overheating.

6-A nest of sieves is prepared by stacking sieves one above the other with the largest opening at the top followed by sieves of successively smaller

Openings and a catch pan at the bottom. Opening sizes of commonly used sieves are mentioned above.

7- A sample of dry soil is poured onto the top nest is covered, and it is then shaken by hand or mechanical shaker until each particle has dropped to a sieve with openings too small to pass, and for that sieve size recorded the retained weigh either individually /or accumatively .

8- To determine the total percentage retain for each sieve, divide the total mass retain on each sieve by the total mass of sample and multiply the result by 100.

9- And this value is subtracted from 100% to obtain the percent passing that sieve size

10- Results are displayed by plotting the percent passing (on a linear scale) against the sieve opening size (on a log scale) and connecting the plotted points with a smooth curve referred to as a **grain-size distribution curve**.

Appendix D

Atter Berg Limits Test Procedure

(AASHTO T89-86, T90-86), (ASTM D- 4318)

Definitions

These test methods cover the determination of the liquid limit, plastic limit, and the plasticity index of soils .The methods described herein are performed only on that portion of a soil that passes the 425-μm (No. 40) sieve. Therefore, the relative contribution of this portion of the soil to the properties of the sample as a whole must be considered when using these tests to evaluate properties of a soil.

Apparatus

1-Mixing and Storage Container A porcelain, glass, or plastic dish

2- Spatula (75mm) or pill knife having

3-Liquid Limit Device—a mechanical device consisting of a brass cup suspended from a carriage designed to control its drop onto a hard rubber base. Fig (2.5), the device may be operated by either a hand crank or electric motor

4- Flat Grooving Tool—a tool made of plastic or no corroding-metal having the dimensions.

5- Gage—a metal gage block for adjusting the height-of drop of the cup

6- Water Content Containers—Small corrosion-resistant containers with snug-fitting lids for water content specimens Aluminum or stainless steel cans 2.5 cm (1 in.) high by 5 cm (2 in.) in diameter are appropriate.

7- Sensitive Balances, (readability of 0.01 g).

8- Ground Glass Plate

9- Drying Oven thermostatically controlled

Procedure

Liquid Limit (L.L)

1- The specimen is processed to remove any material retained on a 425-μm (No. 40) sieve.

2- Add sufficient water mixing and leave at a night.

3-Thoroughly remix the specimen (soil) in its mixing cup, and, if necessary, adjust its water content until the constancy requires about 25 to 35 blows of the liquid limit device to close the groove

4- Using a spatula, place a portion(s) of the prepared soil in the cup of the liquid limit device at the point where the cup rests on the base, squeeze it down, and spread it into the cup to a depth of about 10 mm at its deepest point, tapering to form an approximately horizontal surface.

5- Form a groove in the soil pat by drawing the tool, beveled edge forward, through the soil on a line joining the highest point to the lowest point on the rim of the cup. When cutting the groove, hold the grooving tool against the surface of the cup and draw in an arc, maintaining the tool perpendicular to the surface of the cup throughout its movement. In soils where a groove cannot be made in one stroke without tearing the soil, cut the groove with several strokes of the grooving tool. Alternatively, cut the groove to slightly less than required dimensions with a spatula and use the grooving tool to bring the groove to final dimensions.

6- Verify that no crumbs of soil are present on the base or the underside of the cup. Lift and drop the cup by turning the crank at a rate of 1.9 to 2.1 drops per second until the two halves of the soil pat come in contact at the bottom of the groove along a distance of 13 mm (1⁄2 in.).

7- Verify that an air bubble has not caused premature closing of the groove by observing that both sides of the groove have flowed together with approximately the same shape. If a bubble has caused premature closing of the groove, reform the soil in the cup, adding a small amount of soil to make up for that lost in the grooving operation and repeat 3-6. If the soil slides on the surface of the cup, repeat 3-6. At higher water content. If, after several trials at successively higher water contents, the soil pat continues to slide in the cup or if the number of blows required closing the groove is always less than 25, record that the liquid limit could not be determined, and report the soil as nonplastic without performing the plastic limit test

8- Record the number of drops, N, required to close the groove. Remove a slice of soil approximately the width of the spatula, extending from edge to edge of the soil cake at right angles to the groove and including that portion of the groove in which the soil flowed together, place in a container of known mass, and cover

9- Return the soil remaining in the cup to the dish. Wash and dry the cup and grooving tool and reattach the cup to the carriage in preparation for the next trial.

10- Remix the entire soil specimen in the dish adding distilled water to increase the water content of the soil and decrease the number of blows required to close the groove. Repeat 3-9 for at least two additional trials producing successively lower numbers of blows to close the groove. One of the trials shall be for a closure requiring 25 to 35 blows, one for closure between 20 and 30 blows, and one trial for a closure requiring 15 to 25 blows.

11- Determine the water content, Wn, of the soil specimen from each trial in accordance with Test Method D 2216

12- Determination of initial masses (container plus moist soil) should be performed immediately after completion of the test. If the test is to be interrupted for more than about 15 minutes, determine the mass of the water content specimens already obtained at the time of the interruption.

13- Plot the relationship between the water content, Wn, and the corresponding number of drops, N, of the cup on a semilogarithmic graph with the water content as ordinates on the arithmetical scale, and the number of drops as abscissas on a logarithmic scale. Draw the best straight line through the three or more plotted points.

14- Take the water content corresponding to the intersection of the line with the 25-drop abscissa as the liquid limit of the soil and round to the nearest whole number. Computational methods may be substituted for the graphical method for fitting a straight line to the data and determining the liquid limit.

Plastic Limit (PL)

1-Select a 20-g or more portion of soil from the material prepared for the liquid limit test; either, after the second mixing before the test, or from the soil remaining after completion of the liquid limit test. Reduce the water content of the soil to a consistency at which it can be rolled without sticking to the hands by spreading or mixing continuously on the glass plate or in the mixing/storage dish.

2- From this plastic-limit specimen, select a 1.5 to 2.0 g portion. Form the selected portion into an ellipsoidal mass.

3- Roll the mass between the palms or fingers and the ground-glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length. The thread shall be further deformed on each stroke so that its diameter reaches 3.2 mm (1⁄8 in.), taking no more than 2. The amount of hand or finger pressure required will vary greatly according to the soil being tested, that is, the required pressure typically increases with increasing plasticity. Fragile soils of low plasticity are best rolled under the outer edge of the palm or at the base of the thumb.

4- When the diameter of the thread becomes 3.2 mm, break the thread into several pieces. Squeeze the pieces together.

5- Gather the portions of the crumbled thread together and place in a container of known mass. Immediately cover the container.

6- Select another 1.5 to 2.0-g portion of soil from the plastic–limit specimen and repeat the operations described in 2 and 3 until the container have at least 6 g of soil.

7- Repeat 2-6 to make another container holding at least 6 g of soil. Determine the water content of the soil contained in the containers in accordance with Test Method D 2216. Fig (2.6)

8-Compute the average of the two water contents (trial plastic limits) and round to the nearest whole number. This value is the plastic limit, PL.

Plasticity Index (PI)

The plasticity index is calculated as the difference between the liquid limit and the plastic limit.

Plasticity Index (PI) = Liquid Limit (L.L) - Plastic Limit (PL)

Where:

LL = liquid limit (whole number), and

PL = plastic limit (whole number).

Both LL and PL are whole numbers. If either the liquid limit or plastic limit could not be determined, or if the plastic limit is equal to or greater than the liquid limit, report the soil as non plastic, NP.

Appendix E

Compaction Test Procedure

(AASHTO T180-86), (ASTM D-1557)

Definitions

These test methods cover laboratory compaction methods used to determine the relationship between water content and dry unit weight of soils (compaction curve) compacted in a 4- or 6-in. (101.6 or 152.4 mm) diameter mold with a 10-lbf. (44.5-N) rammer dropped from a height of 18 in. (457 mm) producing a compactive effort of 56,000 ft-lbf/ft3 (2,700 kN-m/m3).

Apparatus

1- Mold Assembly—The molds shall be cylindrical in shape, made of rigid metal and be within the capacity and dimensions(Mold, 4 in average inside diameter, a height of 4.584 in and a volume of 0.0333 ft^3 and Mold, 6 in average inside diameter, a height of 4.584 in and a volume of 0.075 ft^3. Each mold shall have a base plate and an extension collar assembly

2- Rammer: fall freely through a distance of 18 in. from the surface of the specimen the mass of the rammer shall be 10 6 0.02 lbm.

3- Sample Extruder (optional)—A jack, frame.

4- Balance—a balance of 1-g readability.

5- Drying Oven—thermostatically controlled, maintaining a uniform temperature of 230 6 9°F (110 6 5°C) throughout the drying chamber.

6- Straightedge—A stiff metal straightedge of any convenient length but not less than 10 in.

7- Sieves—3⁄4 in. (19.0 mm), 3⁄8in. (9.5 mm), and No. 44.75 mm

8- Mixing Tools—Miscellaneous tools such as mixing pan, spoon, trowel, spatula, spray bottle, etc

Procedure

1-Three alternative methods are provided. The method used shall be as indicated in the specification for the material being tested. If no method is specified, the choice should be based on the material gradation. We will use method C

Method C: (Mold—6-in. (152.4-mm) diameter, Material—Passing 3⁄4-in. (19.0-mm) sieve, Layers—Five Blows per layer—56)

2- If the sample is too damp to be friable, reduce the water content by air drying until the material is friable

.3- Pass the material through the appropriate sieve: No. 3⁄4 in. (19.0–mm).

4- Prepare at least four (preferably five) specimens having water contents such that they bracket the estimated optimum water content. A specimen having water content close to optimum should be prepared first by trial additions of water and mixing. Select water contents for the rest of the specimens to provide at least two specimens wet and two specimens dry of optimum, and water contents varying by about 2 %.At least two water contents are necessary on the wet and dry side of optimum to accurately define the dry unit weight compaction curve. Some soils with very high optimum water content or a relatively flat compaction curve may require larger water content increments to obtain a well defined maximum dry unit weight. Water content increments should not exceed 4 %.

5- Use approximately 13 lbm (5.9 kg) add the required amounts of water to bring the water contents of the specimens to the values Selected in 4, Follow the specimen preparation procedure specified in 2 for drying the soil or adding water into the soil and curing each test specimen.

6- Compaction—after curing, if required, each specimen shall be compacted as follows:

6.1 - Determine and record the mass of the mold or mold and base plate.

6.2- Assemble and secure the mold and collar to the base plate. The mold shall rest on a uniform rigid foundation, such as provided by a cylinder or cube of concrete with a mass of not less than 200 lbm (91 kg). Secure the base plate to the rigid foundation. The method of attachment to the rigid foundation shall allow easy removal of the assembled mold, collar and base plate after compaction is completed.

6.3- Compact the specimen in five layers. After compaction, each layer should be approximately equal in thickness prior to compaction, place the loose soil into the mold and spread into a layer of uniform thickness. Lightly tamp the soil prior to compaction until it is not in a fluffy or loose state, using either the manual compaction rammer or a 2 in. (5 mm) diameter cylinder. Following compaction of each of the first four layers, any soil adjacent to the mold walls that has not been compacted or extends above the compacted surface shall be trimmed. The trimmed soil may be included with the additional soil for the next layer. A knife or other suitable device may be used. The total amount of soil used shall be such that the fifth compacted layer slightly extends into the collar, but does not exceed 1⁄4 in. (6 mm) above the top of the mold. If the fifth layer does extend above the top of the mold by more than 1⁄4 in. (6 mm), the specimen shall be discarded. The specimen shall be discarded when the last blow on the rammer for the fifth layer results in the bottom of the rammer extending below the top of the compaction mold

6.4 -Compact each layer with 56 blows for the 6 in. (152.4 mm) mold.

6.5- In operating the manual rammer, take care to avoid lifting the guide sleeve during the rammer upstroke. Hold the guide sleeve steady and within 5° of vertical. Apply the blows at a uniform rate of approximately 25 blows/min and in such a manner as to provide complete, uniform coverage of the specimen surface.

6.6-Following compaction of the last layer, remove the collar and base plate from the mold, except as noted in 6.7 A knife may be used to trim the soil adjacent to the collar to loosen the soil from the collar before removal to avoid disrupting the soil below the top of the mold..

6.7- Carefully trim the compacted specimen even with the top and bottom of the mold by means of the straightedge scraped across the top and bottom of the mold to form a plane surface even with the top and bottom of the mold. Initial trimming of the specimen above the top of the mold with a knife may prevent tearing out soil below the top of the mold. Fill any holes in either surface with unused or trimmed soil from the specimen, press in with the fingers, and again scrape the straightedge across the top and bottom of the mold. Repeat the appropriate preceding operations on the bottom of the specimen when the mold volume was determined without the base plate. For very wet or dry soils, soil or water may be lost if the base plate is removed. For these situations, leave the base plate attached to the mold. When the base plate is left attached, the volume of the mold must be calibrated with the base plate attached to the mold .

6.8- Determine and record the mass of the specimen and mold to the nearest gram. When the base plate is left attached, determine and record the mass of the specimen, mold and base plate to the nearest gram.

6.9- Remove the material from the mold. Obtain a specimen for water content by using either the whole specimen (preferred method) or a representative portion. When the entire specimen is used, break it up to facilitate drying. Otherwise, obtain a portion by slicing the compacted specimen axially through the center and removing about 500 g of material from the cut faces. Obtain the water content in accordance with Test Method D 2216.

7- Following compaction of the last specimen, compare the wet unit weights to ensure that a desired pattern of obtaining data on each side of the optimum water content will be attained for the dry unit weight compaction curve. Plotting specimen can be an aid in making the above evaluation. If the desired pattern is not obtained, additional compacted specimens will be required. Generally, one water content value wet of the water content defining the maximum wet unit weight is sufficient to ensure data on the wet side of optimum water content for the maximum dry unit weight.

8- Calculate the dry unit weight and water content of each compacted specimen as explained in 11.3 and 11.4. Plot the values and draw the compaction curve as a smooth curve through the points. Plot dry unit weight to the nearest 0.1 lbf/ft3 (0.2 kN/m3) and water content to the nearest 0.1 %. From the compaction curve, determine the optimum water content and maximum dry unit weight.

9- Water Content, w—Calculate in accordance with Test Method D 2216.

10-Dry Unit Weights—calculate the moist density (Eq 1), the dry density (Eq 2), and then the dry unit weight (Eq 3) as follows:

$$p_q = \frac{(M_t - M_{md})}{1000\ V}$$

Where:
p_q = moist density of compacted specimen, Mg/m3,
M_t = mass of moist specimen and mold, kg,
M_{md} = mass of compaction mold, kg, and
V = volume of compaction mold, m3

$$p_d = \frac{p_m}{1 + \frac{w}{100}}$$

Where:

d_d = dry density of compacted specimen, Mg/m3, and

w = water content, %.

Appendix F

CBR Test Procedure

(AASHTO T193-81), (D-1883)

Definitions

This test method covers the determination of the CBR (California Bearing Ratio) of pavement sub grade, sub base, and base/course materials from laboratory compacted specimens.

Apparatus

1-Loading Machine—The loading machine shall be equipped with a movable head or base that travels at a uniform (not pulsating) rate of 0.05 in. (1.27 mm)/min for use in forcing the penetration piston into the specimen. The machine shall be equipped with a load-indicating device that can be read to 10 lbf (44 N) or less. The minimum capacity of the loading machine shall be based on the requirements indicated in Table

2- Mold—the mold shall be a rigid metal cylinder with an inside diameter of 6 6 height of 7 6 0.018 in. (177.8 6 0.46 mm). It shall be provided 0.026 in. (152.4 6 0.66 mm) and a with a metal extension collar at least 2.0 in. (50.8 mm) in height and a metal base plate having at least twenty eight1⁄16-in. (1.59-mm) diameter holes uniformly spaced over the plate within the inside circumference of the mold. When assembled with spacer disc in place in the bottom of the mold, the mold shall have an internal volume (excluding extension collar) of 0.075 6 0.0009 ft (2124 6 25 cm). Fig. 1 shows a satisfactory mold design. A calibration procedure should be used to confirm the actual volume of the mold with the spacer disk inserted. Suitable calibrations are contained in Test Methods D 698 and D 1557.

3- Spacer Disk—A circular metal spacer disc (see Fig. 1) having a minimum outside diameter of 515⁄16 in. (150.8 mm) but no greater than will allow the spacer to easily slip into the mold. The spacer disc shall be 2.4166 0.005 in. (61.37 60.127 mm) in height.

4- Rammer—Rammer as specified in either Test Methods D 698 or D 1557

5- Expansion-Measuring Apparatus—an adjustable metal stem and perforated metal plate

6- Weights—one or two annular metal weights having a total mass of 4.54 kg and slotted metal weights each having masses of 2.27 kg.

7- Penetration Piston—A metal piston 1.954 6 0.005 in. (49.63 6 0.13 mm) in diameter and not less than 4 in. (101.6 mm) long

8- Gages—two dial gages reading to 0.001 in. (0.025 mm) with a range of 0.200 minimum.

9- Miscellaneous Apparatus—Other general apparatus such as a mixing bowl, straightedge, scales, soaking tank or pan, oven, fast filtering high wet strength filter paper, dishes and 2-in., 3⁄4-in. and No. 4 sieves.

Procedure

1- The sample shall be handled and specimen(s) for compaction shall be prepared in accordance with the procedures shall be prepared in accordance with the procedures for compaction in a 6-in. (152.4-mm) mold except as follows:

1.1- If all material passes a 3⁄4-in. (19-mm) sieve, the entire gradation shall be used for preparing specimens for compaction without modification. If there is material retained on the 3⁄4-in. (19-mm) sieve, the material retained on the 3⁄4-in. (19-mm) sieve shall be removed and replaced by an equal amount of material passing the 3⁄4-in. (19-mm) sieve and retained on the No. 4 sieve obtained by separation from portions of the sample not otherwise used for testing.

1.2- The CBR is desired at optimum water content and some percentage of maximum dry unit weight, compact three specimens from soil prepared to within 60.5 percentage point of optimum water content and using the specified compaction but using a different number of blows per layer for each specimen.

The number of blows per layer shall be varied as necessary to prepare specimens having unit weights above and below the desired value. Typically, if the CBR for soil at 95 % of maximum dry unit is desired, specimens compacted using 65, 30, and 10 blows per layer is satisfactory. Penetration shall be performed on each of these specimens

1.3- Bearing Ratio for a Range of Water Content—Prepare specimens in a manner similar to that described in 1.1 except that each specimen used to develop the compaction curve shall be penetrated. In addition, the complete water content-unit weight relation for the 65-30-blow and 10-blow per layer compactions shall be developed and each test specimen compacted shall be penetrated. Perform all compaction in the CBR mold.

1.4- If the sample is to be soaked, take a representative sample of the material, for the determination of moisture, at the beginning of compaction and another sample of the remaining material after compaction. Use Test Method D 2216 to determine the moisture content.

1.5- Clamp the mold (with extension collar attached) to the base plate with the hole for the extraction handle facing down. Insert the spacer disk over the base plate and place a disk of filter paper on top of the spacer disk. Compact the soil-water mixture into the mold.

1.6- Remove the extension collar and carefully trim the compacted soil even with the top of the mold by means of a straightedge. Patch with smaller size material any holes that may have developed in the surface by the removal of coarse material. Remove the perforated base plate and spacer disk, weigh, and record the mass of the mold plus compacted soil. Place a disk of coarse filter paper on the perforated base plate, invert the mold and compacted soil, and clamp the perforated base plate to the mold with compacted soil in contact with the filter paper.

1.7- Place the surcharge weights on the perforated plate and adjustable stem assembly and carefully lower onto the compacted soil specimen in the mold. Apply a surcharge equal to the weight of the base material and pavement within 2.27 kg5 lb), but in no case shall the total weight used be less than (4.54 kg (10 lb). If no pavement weight is specified, use 4.54 kg. Immerse the mold and weights in water allowing free access of water to the top and bottom of the specimen. Take initial measurements for swell and allow the specimen to soak for 96 h. maintain a constant water level during this period. A shorter immersion period is permissible for fine grained soils or granular soils that take up moisture readily, if tests show that the shorter period does not affect the results. At the end of 96 h, take final swell measurements and calculate the swell as a percentage of the initial height of the specimen.

1.8- Remove the free water and allow the specimen to drain downward for 15 min. Take care not to disturb the surface of the specimen during the removal of the water. It may be necessary to tilt the specimen in order to remove the surface water. Remove the weights, perforated plate, and filter paper, and determine and record the mass.

2- Place a surcharge of weights on the specimen sufficient to produce an intensity of loading equal to the weight of the base material. If no pavement weight is specified, use 4.54 kg mass. If the specimen has been soaked previously, the surcharge shall be equal to that used during the soaking period. To prevent upheaval of soil into the hole of the surcharge weights, place the 2.27 kg annular weight on the soil surface prior to seating the penetration piston, after which place the remainder of the surcharge weights.

3- Seat the penetration piston with the smallest possible load, but in no case in excess of 10 lbf (44 N). Set both the stress and penetration gages to zero. This initial load is required to ensure satisfactory seating of the piston and shall be considered as the zero loads when determining the load penetration relation.

Anchor the strain gage to the load measuring device, if possible; in no case attach it to the testing machines support bars (legs).

4- Apply the load on the penetration piston so that the rate of penetration is approximately 0.05 in. (1.27 mm)/min. Record the load readings at penetrations of 0.025 in. (0.64 mm), 0.050 in. (1.27 mm), 0.075 in. (1.91 mm), 0.100 in. (2.54 mm), 0.125 in. (3.18 mm), 0.150 in. (3.81 mm), 0.175 in. (4.45 mm), 0.200 in. (5.08 mm), 0.300 in. (7.62 mm), 0.400 in. (10.16 mm) and 0.500 in. (12.70 mm). Note the maximum load and penetration if it occurs for a penetration of less than 0.500 in. (12.70 mm). With manually operated loading devices, it may be necessary to take load readings at closer intervals to control the rate of penetration. Measure the depth of piston penetration into the soil by putting a ruler into the indentation and measuring the difference from the top of the soil to the bottom of the indentation. If the depth does not closely match the depth of penetration gage, determine the cause and test a new sample.

5- Remove the soil from the mold and determine the moisture content of the top 1-in. (25.4-mm) layer. Take a moisture content sample in accordance with Test Methods D 698 or D 1557 if the average moisture content is desired. Each moisture content sample shall weigh not less than 100 g for fine-grained soils or less than 500 g for granular soils.

6- Calculate the penetration stress in pounds per square inch or megapascals and plot the stress-penetration curve. In some instances, the stresspenetration curve may be concave upward initially, because of surface

Irregularities or other causes, and in such cases the zero point shall be adjusted

7- Bearing Ratio—Using corrected stress values taken from the stress penetration curve for 0.100 in. (2.54 mm) and0.200 in. (5.08 mm) penetrations, calculate the bearing ratios for each by dividing the corrected stresses by the standard stresses of 1000 psi (6.9 MPa) and 1500 psi (10.3 MPa) respectively, and multiplying by 100. Also, calculate the bearing ratios for the maximum stress, if the penetration is less than 0.200 in. (5.08 mm) interpolating the standard stress. The bearing ratio reported for the soil is normally the one at 0.100 in. (2.54 mm) penetration. When the ratio at 0.200 in. (5.08 mm) penetration is greater, rerun the test. If the check test gives a similar result, use the bearing ratio at 0.200 in. (5.08 mm) penetration.

8- Design CBR for One Water Content Only—using the data obtained from the three specimens, plot the CBR versus molded dry unit weight relation and Determine the design CBR at the percentage of the maximum dry unit weight requested.

9- Design CBR for Water Content Range— Plot the data from the tests at the three comp active efforts.The data plotted as shown represents the response of the soil over the range of water content specified. Select the CBR for reporting as the lowest CBR within the specified water content range having a dry unit weight between the specified minimum and the dry unit weight produced by compaction within the water content range.

Appendix G

(AASHTO T91-86), (ASTM D- 1556)

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Field Density Test Procedure

Definitions

This test method may be used to determine the in-place density and unit weight of soils using a sand cone apparatus.

Apparatus

1- An attachable jar or other sand container

2- A detachable appliance consisting of a cylindrical valve with an orifice approximately 1⁄2in. (13 mm) in diameter, attached to a metal funnel and sand container on one end, and a large metal funnel (sand-cone) on the other end. The valve will have stops to prevent rotating past the completely open or completely closed positions. The appliance will be constructed of metal sufficiently rigid to prevent distortion or volume changes in the cone. The walls of the cone will form an angle of approximately 60° with the base to allow uniform filling with sand.

3- A metal base plate or template with a flanged center hole cast or machined to receive the large funnel (cone) of the appliance described in 6.1.2. The base plate may be round or square and will be a minimum of 3 in. (75 mm) larger than the funnel (sand-cone). The plate will be flat on the bottom and have sufficient thickness or stiffness to be rigid. Plates with raised edges, ridges, ribs, or other stiffners of approximately 3⁄8 to 1⁄2 in. (10 to 13 mm) high may be used.

4- The mass of the sand required to fill the apparatus and base plate will be determined.

5- Sand—Sand must be clean, dry, uniform in density and grading, uncemented, durable, and free-flowing. Any gradation may be used that has a uniformity coefficient ($C_u = D_{60}/D_{10}$) less than 2.0, a maximum particle size smaller than 2.0 mm (No. 10 sieve), and less than 3 % by weight passing 250 μm (No. 60 sieve).

6 - Balances, scale having a minimum capacity of 20 kg and 5.0-g readability

7-Miscellaneous Equipment—Knife, small pick, chisel, small trowel, screwdriver, or spoons for digging test holes, large nails or spikes for securing the base plate; buckets with lids, plastic-lined cloth sacks, or other suitable containers for retaining the density samples, moisture sample, and density sand respectively; small paint brush, calculator, notebook or test forms, etc.

Procedure

1- Select a location/elevation that is representative of the area to be tested.

2- Inspect the cone apparatus for damage, free rotation of the valve, and properly matched base plate. Fill the cone container with conditioned sand for which the bulk-density has been determined and determine the total mass.

3- Prepare the surface of the location to be tested so that it is a level plane. The base plate may be used as a tool for striking off the surface to a smooth level plane

4- Seat the base plate on the plane surface, making sure there is contact with the ground surface around the edge of the flanged center hole. Mark the outline of the base plate to check for movement during the test, and if needed, secure the plate against movement using nails pushed into the soil adjacent to the edge of the plate, or by other means, without disturbing the soil to be tested.

5- In soils where leveling is not successful, or surface voids remain, the volume horizontally bounded by the funnel, plate and ground surface must be determined by a preliminary test. Fill the space with sand from the apparatus, determine the mass of sand used to fill the space, refill the apparatus, and determine a new initial mass of apparatus and sand before proceeding with the test. After this measurement is completed, carefully brush the sand from the prepared surface .

6- The test whole volume will depend on the anticipated maximum particle size in the soil to be tested. Test hole volumes are to be as large as practical to minimize the errors and shall not be less than the volumes indicated in Table 1. A hole depth should be selected that will provide a representative sample of the soil. For construction control, the depth of the hole should approximate the thickness of one, or more, compacted lift(s). The procedure for calibrating the sand must reflect this whole depth.

7- Dig the test hole through the center hole in the base plate, being careful to avoid disturbing or deforming the soil that will bound the hole. The sides of the hole should slope slightly inward and the bottom should be reasonably flat or concave. The hole should be kept as free as possible of pockets, overhangs, and sharp obtrusions since these affect the accuracy of the test. Soils that are essentially granular require extreme care and may require digging a conical-shaped test hole. Place all excavated soil, and any soil loosened during digging, in a moisture tight container that is marked to identify the test number. Take care to avoid losing any materials. Protect this material from any loss of moisture until the mass has been determined and a specimen has been obtained for a water content determination.

8- Clean the flange of the base plate hole, invert the sand-cone apparatus and seat the sand-cone funnel into the flanged hole at the same position as marked during calibration. Eliminate or minimize vibrations in the test area due to personnel or equipment. Open the valve and allow the sand to fill the hole, funnel, and base plate. Take care to avoid jarring or vibrating the apparatus while the sand is running. When the sand stops flowing, close the valve.

9- Determine the mass of the apparatus with the remaining sand, record, and calculate the mass of sand used.

10- Determine and record the mass of the moist material that was removed from the test hole. When oversized material corrections are required, determine the mass of the oversized material on the appropriate sieve and record, taking care to avoid moisture losses

11- Mix the material thoroughly, and either obtains a representative specimen for water content determination, or use the entire sample.

12- Determine the water content in accordance with Test Method D 221

13- Water content specimens must be large enough and selected in such a way that they represent all the material obtained from the test hole. The minimum mass of the water content specimens is that required to provide water content values accurate to 1.0 %.

14- Calculate the volume of the test hole as follows:

$$V = M_1 - M_2 / P_1$$

Where:

V = volume of the test hole, cm3,

M_1 = mass of the sand used to fill the test hole, funnel and base plate, g

M_2 = mass of the sand used to fill the funnel and base plate g, and

P_1 = bulk density of the sand (known), g/cm3.

15- Calculate the dry mass of material removed from the test hole as follows

$$M_4 = M_3 / 100(W + 100)$$

Where:

W =water content of the material removed from test Hole, %,

M_3 = moist mass of the material from test hole, g, and

M_4 = dry mass of material from test hole, g, or multiply by0.002205 for lb.

16- Calculate the in-place wet and dry density of the material tested as follows:

$$P_m = M_3 / V$$
$$P_d = M_4 / V$$

Where

V = volume of the test hole, cm3 .

M_3 = moist mass of the material from the test hole, g,

M_4 = dry mass of the material from the test hole, g,

Pm = wet density of the tested material g/cm3

Apparatus

1- An attachable jar or other sand container

2- A detachable appliance consisting of a cylindrical valve with an orifice approximately 1⁄2in. (13 mm) in diameter, attached to a metal funnel and sand container on one end, and a large metal funnel (sand-cone) on the other end. The valve will have stops to prevent rotating past the completely open or completely closed positions. The appliance will be constructed of metal sufficiently rigid to prevent distortion or volume changes in the cone. The walls of the cone will form an angle of approximately 60° with the base to allow uniform filling with sand.

3- A metal base plate or template with a flanged center hole cast or machined to receive the large funnel (cone) of the appliance described in 6.1.2. The base plate may be round or square and will be a minimum of 3 in. (75 mm) larger than the funnel (sand-cone). The plate will be flat on the bottom and have sufficient thickness or stiffness to be rigid. Plates with raised edges, ridges, ribs, or other stiffners of approximately 3⁄8 to 1⁄2 in. (10 to 13 mm) high may be used.

4- The mass of the sand required to fill the apparatus and base plate will be determined.

5- Sand—Sand must be clean, dry, uniform in density and grading, uncemented, durable, and free-flowing. Any gradation may be used that has a uniformity coefficient (Cu = D60/D10) less than 2.0, a maximum particle size smaller than 2.0 mm(No. 10 sieve), and less than 3 % by weight passing 250 μm(No. 60 sieve).

6- Balances, scale having a minimum capacity of 20 kg and 5.0-g readability
7- Miscellaneous Equipment—Knife, small pick, chisel, small trowel, screwdriver, or spoons for digging test holes, large nails or spikes for securing the base plate; buckets with lids, plastic-lined cloth sacks, or other suitable containers for retaining the density samples, moisture sample, and density sand respectively; small paint brush, calculator, notebook or test forms, etc.

Procedure

1- Select a location/elevation that is representative of the area to be tested.
2- Inspect the cone apparatus for damage, free rotation of the valve, and properly matched base plate. Fill the cone container with conditioned sand for which the bulk-density has been determined and determine the total mass.
3- Prepare the surface of the location to be tested so that it is a level plane. The base plate may be used as a tool for striking off the surface to a smooth level plane
4- Seat the base plate on the plane surface, making sure there is contact with the ground surface around the edge of the flanged center hole. Mark the outline of the base plate to check for movement during the test, and if needed, secure the plate against movement using nails pushed into the soil adjacent to the edge of the plate, or by other means, without disturbing the soil to be tested.
5- In soils where leveling is not successful, or surface voids remain, the volume horizontally bounded by the funnel, plate and ground surface must be determined by a preliminary test. Fill the space with sand from the apparatus, determine the mass of sand used to fill the space, refill the apparatus, and determine a new initial mass of apparatus and sand before proceeding with the test. After this measurement is completed, carefully brush the sand from the prepared surface .
6- The test whole volume will depend on the anticipated maximum particle size in the soil to be tested. Test hole volumes are to be as large as practical to minimize the errors and shall not be less than the volumes indicated in Table 1.

A hole depth should be selected that will provide a representative sample of the soil. For construction control, the depth of the hole should approximate the thickness of one, or more, compacted lift(s). The procedure for calibrating the sand must reflect this whole depth.

7- Dig the test hole through the center hole in the base plate, being careful to avoid disturbing or deforming the soil that will bound the hole. The sides of the hole should slope slightly inward and the bottom should be reasonably flat or concave. The hole should be kept as free as possible of pockets, overhangs, and sharp obtrusions since these affect the accuracy of the test. Soils that are essentially granular require extreme care and may require digging a conical-shaped test hole. Place all excavated soil, and any soil loosened during digging, in a moisture tight container that is marked to identify the test number. Take care to avoid losing any materials. Protect this material from any loss of moisture until the mass has been determined and a specimen has been obtained for a water content determination.

8- Clean the flange of the base plate hole, invert the sand-cone apparatus and seat the sand-cone funnel into the flanged hole at the same position as marked during calibration. Eliminate or minimize vibrations in the test area due to personnel or equipment. Open the valve and allow the sand to fill the hole, funnel, and base plate. Take care to avoid jarring or vibrating the apparatus while the sand is running. When the sand stops flowing, close the valve.

9- Determine the mass of the apparatus with the remaining sand, record, and calculate the mass of sand used.

10- Determine and record the mass of the moist material that was removed from the test hole. When oversized material corrections are required, determine the mass of the oversized material on the appropriate sieve and record, taking care to avoid moisture losses

11- Mix the material thoroughly, and either obtain a representative specimen for water content determination, or use the entire sample.

12- Determine the water content in accordance with Test Method D 221

13- Water content specimens must be large enough and selected in such a way that they represent all the material obtained from the test hole. The minimum mass of the water content specimens is that required to provide water content values accurate to 1.0 %.

14- Calculate the volume of the test hole as follows:

$$V = M_1 - M_2 / P_1$$

Where:

V = volume of the test hole, cm3,

M_1 = mass of the sand used to fill the test hole, funnel and base plate, g

M_2 = mass of the sand used to fill the funnel and base plate g, and

P_1 = bulk density of the sand (known g/cm3.

15- Calculate the dry mass of material removed from the test hole as follows

$$M_4 = M_3 / 100(W+100)$$

Where:

W =water content of the material removed from test Hole, %,

M_3 = moist mass of the material from test hole, g, and

M_4 = dry mass of material from test hole, g, or multiply by0.002205 for lb.

16- Calculate the in-place wet and dry density of the material tested as follows:

$$P_m = M_3 / V$$
$$P_d = M_4 / V$$

Where

V = volume of the test hole, cm3.

M_3 = moist mass of the material from the test hole, g,

M_4 = dry mass of the material from the test hole, g,

Pm = wet density of the tested material g/cm3

Pd =dry density of the tested material, g/cm3

17- It may be desired to express the in-place density as a percentage of some other density, for example, the laboratory densities determined in accordance with Test Method D 698 D 1557, D 4253, or D 4254. This relation can be determined by dividing the in-place density by the laboratory density and multiplying by 100. Calculations for determining relative density are provided in Test Method D 4254. Corrections for oversize material, if required, should be performed in accordance with Practice D 4718.

TABLE (1) Minimum Test Hole Volumes Based on Maximum Size Of Included Particle

Maximum Particle Size		**Minimum Test Hole Volumes**	
in.	**(mm)**	**cm3**	**ft3**
1⁄2	(12.7)	1415	0.05
1	(25)	2125	0.075
11⁄2	(37.5)	2830	0.1

2-Sand Cone and Speedy Moisture Tester

The Speedy Moisture Tester is a portable device used to measure in-situ moisture content of aggregate base and fine grain soils (Plate E2). It takes approximately 1 to 3 minutes to get the results once the test is prepared. The total testing time is approximately 10 minutes.

- **Speed Moisture Testing Kit**

The Speedy Moisture Testing Kit comprises a pressure chamber with a dial gauge, scale, cleaning brushes; cloth and measuring scoop packed in a case Plate (E2).

(a)

(b)

Plate (E2): Speedy Moisture Testing Kit

3- Speed Moisture Test Procedure

Determine the moisture content as percent water of most soils in about 3 minutes. The measured sample is placed in the pressure chamber with calcium carbide reagent. The water in the soil and the reagent react to produce acetylene gas. The gauge reads the percent water content from 0-20% based on weight with an accuracy of 0.5%.It is available in two sizes, 6 gram for fine grained materials and powders and 20 gram for sand, aggregates and lumpy materials

Appendix H

Operational Procedure for TRL DCP

The TRL DCP uses an 8 kg hammer dropping through a height of 575mm and a 60° cone having a maximum diameter of 20mm. The instrument is assembled as shown in plate (F1). It is supplied with two spanners and a Tommy bar to ensure that the screwed joints are kept tight at all times. To assist in this the following joints should be secured with a non-hardening. Thread locking compound prior to use:

- Handle/hammer shaft
- Coupling/hammer shaft
- Standard shaft/cone

The instrument is usually split at the joint between the standard shaft and the coupling for carriage and storage and therefore it is not usual to use locking compound at this joint. However it is important that this joint is checked regularly during use to ensure that it does not become loose.

Operating the DCP with any loose joints will significantly reduce the life of the instrument.

DCP Operation

After assembly, the first task is to record the zero reading of the instrument.

The DCP needs three operators, one to hold the instrument, one to raise and drop the weight and a technician to record the readings. The instrument is held vertical and the weight rose to the handle. Care should be taken to ensure that the weight is touching the handle, but not lifting the instrument before it is allowed to drop. The operator must let it fall freely and not partially lower it with his hands. It is recommended that a reading should be taken at increments of penetration of about l0mm. However it is usually easier to take a reading after a set number of blows. It is therefore necessary to change the number of blows between readings, according to the strength of the layer being penetrated.

Recommended DCP test frequency of readings

- One for every two blows with readings from 10-20 mm (Sub grade)
- One for every five blows with readings from 5-9 mm (Sub base)

- One for every ten blows with readings from 2-4 mm (base)
- Penetration depth less than 1 mm and exceeding 20 blows is considered as refusal.

The DCP can be driven through surface dressings but it is recommended that thick bituminous surfacing is cored prior to testing the lower layers.

Materials Required for DCP Test

Sufficient cold mix to replace the core extracted on pavement sections

Sample Preparation for DCP Test

No preparation is necessary if the test is to start from surface.

TRL DCP Components

Plate (F1): TRL DCP Components

DCP Correlations Chart

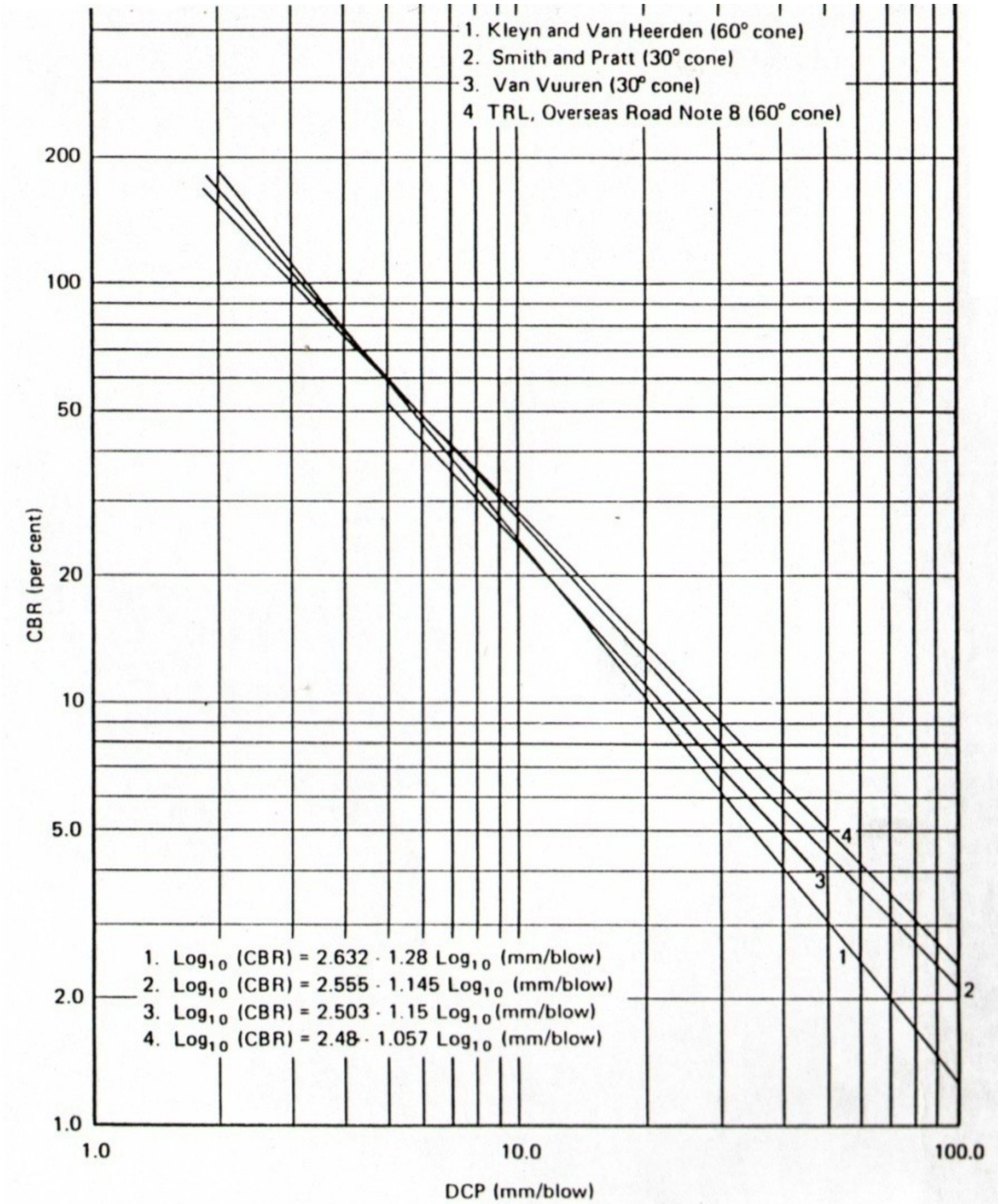

Figure (C1): DCP-CBR Relationship

Appendix I

DCP Penetration Tests Data

UK DCP V3.1

DCP Penetration Data Report

Project Name: AlGiraffe

Chainage (km):	0.850	Surface Type:	Unpaved
Direction:	west	Thickness (mm):	0
Location/Offset:	Lane 2/5.00m	Base Type:	
Cone Angle:	60 degrees	Thickness (mm):	
Zero Error (mm):	115	Surface Moisture:	Unknown
Test Date:	18/02/2009	Moisture adjustment factor:	Not adjusted

No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)	No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)
1	0	0	132	0.00					
2	2	2	157	12.50					
3	2	4	183	13.00					
4	2	6	207	12.00					
5	2	8	234	13.50					
6	2	10	265	15.50					
7	2	12	300	17.50					
8	2	14	339	19.50					
9	2	16	380	20.50					
10	2	18	429	24.50					
11	2	20	482	26.50					
12	2	22	540	29.00					
13	2	24	600	30.00					
14	2	26	660	30.00					
15	2	28	715	27.50					
16	2	30	775	30.00					
17	2	32	833	29.00					
18	2	34	889	28.00					
19	2	36	939	25.00					

UK DCP V3.1

Penetration Data Report

Project Name: Bahri AlMoulead

Chainage (km):	0.200	Surface Type:	Unpaved
Direction:	North	Thickness (mm):	0
Location/Offset:	Lane 2/15.00m	Base Type:	

Cone Angle:	60 degrees	Thickness (mm):	
Zero Error (mm):	102	Surface Moisture:	Unknown
Test Date:	17/02/2009	Moisture adjustment factor:	Not adjusted

No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)	No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)
1	0	0	115	0.00	26	1	49	952	27.00
2	2	2	142	13.50					
3	2	4	161	9.50					
4	2	6	179	9.00					
5	2	8	195	8.00					
6	2	10	210	7.50					
7	2	12	223	6.50					
8	2	14	238	7.50					
9	2	16	251	6.50					
10	2	18	264	6.50					
11	2	20	275	5.50					
12	2	22	296	10.50					
13	2	24	316	10.00					
14	2	26	340	12.00					
15	2	28	375	17.50					
16	2	30	426	25.50					
17	2	32	493	33.50					
18	2	34	551	29.00					
19	2	36	610	29.50					
20	2	38	664	27.00					
21	2	40	705	20.50					
22	2	42	752	23.50					
23	2	44	813	30.50					
24	2	46	868	27.50					
25	2	48	925	28.50					

UK DCP V3.1

Penetration Data Report

Project Name: Bahri Alshabia

Chainage (km):	0.800	Surface Type:	Unpaved
Direction:	North	Thickness (mm):	0
Location/Offset:	Lane 2/12.00m	Base Type:	
Cone Angle:	60 degrees	Thickness (mm):	
Zero Error (mm):	112	Surface Moisture:	Unknown

Test Date: 17/02/2009 Moisture adjustment factor: Not adjusted

No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)	No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)
1	0	0	143	0.00					
2	2	2	186	21.50					
3	2	4	211	12.50					
4	2	6	226	7.50					
5	2	8	243	8.50					
6	2	10	260	8.50					
7	2	12	275	7.50					
8	5	17	305	6.00					
9	5	22	332	5.40					
10	5	27	355	4.60					
11	5	32	380	5.00					
12	10	42	446	6.60					
13	10	52	515	6.90					
14	10	62	570	5.50					
15	10	72	655	8.50					
16	10	82	720	6.50					
17	10	92	783	6.30					
18	10	102	850	6.70					
19	10	112	914	6.40					

UK DCP V3.1

Penetration Data Report

Project Name: Marabee Alsharif

Chainage (km):	0.800	Surface Type:	Unpaved
Direction:	south	Thickness (mm):	0
Location/Offset:	Lane 2/8.00m	Base Type:	
Cone Angle:	60 degrees	Thickness (mm):	
Zero Error (mm):	105	Surface Moisture:	Unknown
Test Date:	18/02/2009	Moisture adjustment factor:	Not adjusted

No.	Blows	Cumulative	Penetration	Penetration	No.	Blows	Cumulative	Penetration	Penetration

		Blows	Depth (mm)	Rate (mm/blow)			Blows	Depth (mm)	Rate (mm/blow)
1	0	0	123	0.00	26	2	50	715	15.00
2	2	2	147	12.00	27	2	52	738	11.50
3	2	4	165	9.00	28	2	54	760	11.00
4	2	6	185	10.00	29	2	56	782	11.00
5	2	8	204	9.50	30	2	58	805	11.50
6	2	10	220	8.00	31	2	60	829	12.00
7	2	12	240	10.00	32	2	62	854	12.50
8	2	14	262	11.00	33	2	64	879	12.50
9	2	16	285	11.50	34	2	66	903	12.00
10	2	18	309	12.00	35	2	68	925	11.00
11	2	20	334	12.50					
12	2	22	368	17.00					
13	2	24	402	17.00					
14	2	26	432	15.00					
15	2	28	461	14.50					
16	2	30	495	17.00					
17	2	32	527	16.00					
18	2	34	558	15.50					
19	2	36	582	12.00					
20	2	38	602	10.00					
21	2	40	620	9.00					
22	2	42	639	9.50					
23	2	44	659	10.00					
24	2	46	677	9.00					
25	2	48	685	4.00					

UK DCP V3.1

Penetration Data Report

Project Name: Marabee Alsharif

Chainage (km):	1.450	Surface Type:	Unpaved
Direction:	west	Thickness (mm):	0
Location/Offset:	Lane 2/8.00m	Base Type:	
Cone Angle:	60 degrees	Thickness (mm):	
Zero Error (mm):	109	Surface Moisture:	Unknown
Test Date:	18/02/2009	Moisture adjustment factor:	Not adjusted

No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate	No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate

				(mm/blow)					(mm/blow)
1	0	0	122	0.00	26	2	50	570	7.50
2	2	2	142	10.00	27	2	52	622	26.00
3	2	4	155	6.50	28	2	54	652	15.00
4	2	6	166	5.50	29	2	56	679	13.50
5	2	8	175	4.50	30	2	58	705	13.00
6	2	10	185	5.00	31	2	60	735	15.00
7	2	12	195	5.00	32	2	62	763	14.00
8	2	14	205	5.00	33	2	64	786	11.50
9	2	16	215	5.00	34	2	66	809	11.50
10	2	18	225	5.00	35	2	68	825	8.00
11	2	20	236	5.50	36	2	70	845	10.00
12	2	22	250	7.00	37	2	72	864	9.50
13	2	24	264	7.00	38	2	74	880	8.00
14	2	26	277	6.50	39	2	76	896	8.00
15	2	28	293	8.00	40	2	78	912	8.00
16	2	30	312	9.50					
17	2	32	330	9.00					
18	2	34	350	10.00					
19	2	36	372	11.00					
20	2	38	395	11.50					
21	2	40	423	14.00					
22	2	42	450	13.50					
23	2	44	482	16.00					
24	2	46	516	17.00					
25	2	48	555	19.50					

UK DCP V3.1

Penetration Data Report

Project Name: Marabee Alsharif

Chainage (km):	1.451	Surface Type:	Unpaved
Direction:	South	Thickness (mm):	0
Location/Offset:	Lane 2/12.00m	Base Type:	
Cone Angle:	60 degrees	Thickness (mm):	
Zero Error (mm):	100	Surface Moisture:	Unknown
Test Date:	17/02/2009	Moisture adjustment factor:	Not adjusted

No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)	No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)

1	0	0	109	0.00	26	2	50	754	15.50
2	2	2	129	10.00	27	2	52	795	20.50
3	2	4	143	7.00	28	2	54	835	20.00
4	2	6	155	6.00	29	2	56	873	19.00
5	2	8	166	5.50	30	2	58	905	16.00
6	2	10	179	6.50	31	2	60	935	15.00
7	2	12	190	5.50					
8	2	14	203	6.50					
9	2	16	215	6.00					
10	2	18	220	2.50					
11	2	20	246	13.00					
12	2	22	265	9.50					
13	2	24	289	12.00					
14	2	26	313	12.00					
15	2	28	342	14.50					
16	2	30	374	16.00					
17	2	32	410	18.00					
18	2	34	449	19.50					
19	2	36	480	15.50					
20	2	38	535	27.50					
21	2	40	580	22.50					
22	2	42	616	18.00					
23	2	44	653	18.50					
24	2	46	688	17.50					
25	2	48	723	17.50					

UK DCP V3.1

Penetration Data Report

Project Name: Zaim Alazhary

Chainage (km):	0.500	Surface Type:	Unpaved
Direction:	Staad Altahrear	Thickness (mm):	0
Location/Offset:	Lane 2/10.00m	Base Type:	
Cone Angle:	60 degrees	Thickness (mm):	
Zero Error (mm):	110	Surface Moisture:	Unknown
Test Date:	17/02/2009	Moisture adjustment factor:	Not adjusted

No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)	No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)
1	0	0	130	0.00	26	5	56	706	7.60

mm

2	2	2	170	20.00	27	5	61	743	7.40
3	2	4	192	11.00	28	5	66	774	6.20
4	2	6	210	9.00	29	5	71	804	6.00
5	2	8	227	8.50	30	5	76	830	5.20
6	2	10	242	7.50					
7	2	12	255	6.50					
8	2	14	271	8.00					
9	2	16	286	7.50					
10	2	18	301	7.50					
11	2	20	317	8.00					
12	2	22	335	9.00					
13	2	24	354	9.50					
14	2	26	375	10.50					
15	2	28	397	11.00					
16	2	30	420	11.50					
17	2	32	446	13.00					
18	2	34	473	13.50					
19	2	36	500	13.50					
20	2	38	528	14.00					
21	2	40	555	13.50					
22	2	42	573	9.00					
23	2	44	600	13.50					
24	2	46	622	11.00					
25	5	51	668	9.20					

UK DCP V3.1

Penetration Data Report

Project Name: AlSook Shabi R1

Chainage (km):	0.200	Surface Type:	Unpaved
Direction:	LH	Thickness (mm):	0
Location/Offset:	Lane 2/15.00m	Base Type:	
Cone Angle:	60 degrees	Thickness (mm):	
Zero Error (mm):	105	Surface Moisture:	Unknown
Test Date:	17/02/2009	Moisture adjustment factor:	Not adjusted

No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)	No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)
1	0	0	110	0.00	26	10	121	491	2.20
2	2	2	120	5.00					
3	2	4	133	6.50					
4	2	6	146	6.50					
5	2	8	153	3.50					

6	2	10	177	12.00					
7	2	12	192	7.50					
8	2	14	206	7.00					
9	2	16	219	6.50					
10	5	21	237	3.60					
11	5	26	247	2.00					
12	5	31	254	1.40					
13	5	36	261	1.40					
14	5	41	272	2.20					
15	5	46	282	2.00					
16	5	51	292	2.00					
17	5	56	305	2.60					
18	5	61	317	2.40					
19	5	66	329	2.40					
20	5	71	342	2.60					
21	5	76	357	3.00					
22	5	81	374	3.40					
23	10	91	409	3.50					
24	10	101	442	3.30					
25	10	111	469	2.70					

UK DCP V3.1

Penetration Data Report

Project Name: Alsook Alshabi R3

Chainage (km):	0.100	Surface Type:	Unpaved
Direction:	CL	Thickness (mm):	0
Location/Offset:	Lane 2/1.00m	Base Type:	
Cone Angle:	60 degrees	Thickness (mm):	
Zero Error (mm):	119	Surface Moisture:	Unknown
Test Date:	17/02/2009	Moisture adjustment factor:	Not adjusted

No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)	No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)
1	0	0	127	0.00					
2	2	2	141	7.00					
3	2	4	152	5.50					
4	2	6	162	5.00					
5	2	8	169	3.50					
6	5	13	185	3.20					
7	5	18	199	2.80					

8	5	23	212	2.60					
9	5	28	220	1.60					
10	10	38	237	1.70					
11	10	48	260	2.30					

UK DCP V3.1

Penetration Data Report

Project Name: Alsook Alshabi R3

Chainage (km):	0.200	Surface Type:	Unpaved
Direction:	CL	Thickness (mm):	0
Location/Offset:	Lane 2	Base Type:	
Cone Angle:	60 degrees	Thickness (mm):	
Zero Error (mm):	125	Surface Moisture:	Unknown
Test Date:	17/02/2009	Moisture adjustment factor:	Not adjusted

No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)	No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)
1	0	0	160	0.00					
2	2	2	235	37.50					
3	2	4	286	25.50					
4	2	6	329	21.50					
5	2	8	343	7.00					
6	2	10	355	6.00					
7	5	15	400	9.00					
8	5	20	440	8.00					

9	5	25	459	3.80					
10	5	30	470	2.20					
11	5	35	480	2.00					
12	5	40	489	1.80					
13	5	45	495	1.20					

UK DCP V3.1

Penetration Data Report

Project Name: Alsook Alshabi R3

Chainage (km):	0.201	Surface Type:	Unpaved
Direction:	RHS	Thickness (mm):	0
Location/Offset:	Lane 2/8.00m	Base Type:	
Cone Angle:	60 degrees	Thickness (mm):	
Zero Error (mm):	120	Surface Moisture:	Unknown
Test Date:	17/02/2009	Moisture adjustment factor:	Not adjusted

No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)	No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)
1	0	0	128	0.00					
2	2	2	140	6.00					
3	2	4	152	6.00					
4	2	6	162	5.00					
5	2	8	172	5.00					
6	5	13	197	5.00					
7	5	18	225	5.60					
8	5	23	263	7.60					

9	5	28	305	8.40					
10	5	33	342	7.40					
11	5	38	375	6.60					
12	5	43	405	6.00					
13	5	48	434	5.80					
14	5	53	464	6.00					
15	5	58	493	5.80					
16	5	63	523	6.00					
17	5	68	555	6.40					
18	5	73	585	6.00					
19	5	78	615	6.00					
20	5	83	643	5.60					
21	5	88	672	5.80					
22	10	98	713	4.10					
23	10	108	765	5.20					
24	10	118	790	2.50					

UK DCP V3.1

Penetration Data Report

Project Name: Alsook Alshabi R3

Chainage (km):	0.202	Surface Type:	Unpaved
Direction:	LHS	Thickness (mm):	0
Location/Offset:	Lane 2/8.00m	Base Type:	
Cone Angle:	60 degrees	Thickness (mm):	
Zero Error (mm):	108	Surface Moisture:	Unknown
Test Date:	17/02/2009	Moisture adjustment factor:	Not adjusted

No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)	No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)
1	0	0	115	0.00					
2	2	2	131	8.00					
3	2	4	148	8.50					
4	2	6	158	5.00					
5	2	8	165	3.50					
6	2	10	170	2.50					
7	2	12	172	1.00					
8	2	14	175	1.50					
9	5	19	185	2.00					

10	5	24	198	2.60					
11	5	29	208	2.00					
12	5	34	218	2.00					
13	5	39	228	2.00					
14	5	44	230	0.40					
15	10	54	244	1.40					
16	10	64	256	1.20					

UK DCP V3.1

Penetration Data Report

Project Name: Alsook Alshabi R3

Chainage (km):	0.400	Surface Type:	Unpaved
Direction:	CL	Thickness (mm):	0
Location/Offset:	Lane 2	Base Type:	
Cone Angle:	60 degrees	Thickness (mm):	
Zero Error (mm):	95	Surface Moisture:	Unknown
Test Date:	17/02/2009	Moisture adjustment factor:	Not adjusted

No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)	No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)
1	0	0	100	0.00					
2	2	2	110	5.00					
3	2	4	120	5.00					
4	5	9	124	0.80					
5	5	14	140	3.20					
6	5	19	151	2.20					
7	10	29	163	1.20					
8	10	39	168	0.50					
9	10	49	175	0.70					
10	10	59	183	0.80					

UK DCP V3.1

Penetration Data Report

Project Name: Alsook Alshabi R3

Chainage (km):	0.500	Surface Type:	Unpaved
Direction:	CL	Thickness (mm):	0
Location/Offset:	Lane 2	Base Type:	
Cone Angle:	60 degrees	Thickness (mm):	
Zero Error (mm):	103	Surface Moisture:	Unknown
Test Date:	17/02/2009	Moisture adjustment factor:	Not adjusted

No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)	No.	Blows	Cumulative Blows	Penetration Depth (mm)	Penetration Rate (mm/blow)
1	0	0	120	0.00					
2	2	2	135	7.50					
3	2	4	146	5.50					
4	2	6	159	6.50					
5	2	8	169	5.00					
6	10	18	206	3.70					
7	10	28	247	4.10					
8	10	38	289	4.20					
9	10	48	365	7.60					
10	10	58	396	3.10					
11	5	63	410	2.80					
12	5	68	429	3.80					

Appendix J

Consolid 444 chemical liquid Stabilizer

Application purpose:

Soil stabilization, soil improvement and soil impermeability

Chemical Characteristic:

Aqueous solution of a mixture of molecular interfacial active substance, solvents, emulgator and catalysts

Amoniu Content: Xi :R 38-41 2.5-10%

Form : Liguid

Colour : milky white to yellow brown

Odour : IPA

Physical and safety- technical data

Change in physical state	<10 ºC
Density	(20 ºC) 0.980g/cm3
Vapour Pressure	(20 ºC) Like Water

Viscosity	(50 ºC) Like Water
Solubility in Water	(40 ºC) dsipersable /mixable %100
Ph-value	(20 ºC'de) ca.8
Flash point	None
Ignition temperature	None
Explosion Limits	None Exposive
Solubility in Water	Completely Mixable
Burning Point	>100 ºC
Melting Point	0 ºC

Information on toxicology

Inhalation may cause irritation in the respiratory tract .

Slow penetration without immediately visible signs of cauterization .

Caution with splashes into the ; they might cause daages.

Hazard of cauterization by inhalation .

Information on ecology

The product does not cause damages to the environment and is biologically decomposable.