KT-37 MAKING, CURING AND TESTING CEMENT TREATED AND UNBOUND BASES IN THE LABORATORY (Kansas Central Lab Test KT-37)

a. SCOPE

This method covers the procedure for making and curing compression test specimens of Cement Treated and Unbound Base in the laboratory under accurate control of quantities of materials and test conditions. Bound bases are considered the same as Cement Treated Bases.

b. REFERENCED DOCUMENTS

b.1. KT-FORWARD (5.16.00)

b.2. KT-11 **b**.; Moisture Tests **b.** Constant Mass Method

b.3. KT-12; Standard Compaction Test

b.4. AASHTO M 92; Wire-Cloth Sieves for Testing Purposes

b.5. AASHTO M 231; Balances Used in the Testing of Materials

b.6. AASHTO T 99**;** The Moisture-Density Relations of Soils Using a 5.5 lb (2.5 kg) Rammer and a 12 in (305 mm) Drop

c. APPARATUS:

c.1. Test Specimen Molds. A calibrated cylindrical mold solid or split of predetermined volume approximately 6 in (150 mm) in diameter and 6 in (150 mm) in height and having a volume of approximately 1/10 ft^3 (2.8 L). The mold is equipped with a removable top collar and removable base plate. Example of acceptable mold assembly is the Humbolt compaction mold, model number H-4163, Durham GEO S-328, or a Durham GEO S-319.

> NOTE: The volume of the mold (without the collar) is measured by coating one end with cup grease or vaseline to form a seal and then placing it on a glass plate which should be placed in a level position on a scale. The other end of the mold is coated with cup grease or vaseline and then the mold and two glass plates are weighed. The mold may then be filled with 77 $\pm$ 2°F (25 $\pm$ 1°C) water after which the second glass plate should be placed on top of the mold in such a way as to eliminate air bubbles and excess water. Any excess water thus removed must be carefully wiped off after which the final mass of the mold, water and glass plates may be determined. The volume of the mold may then be calculated using 62.243 lb/ft^3 (997 kg/m^3) as the density of water.

c.2. Rigid steel straight edge meeting standards set forth in AASHTO T 99 **2.6**.

c.3. Standard Proctor Compaction Machine: A mechanically operated metal rammer equipped to control the height of drop to 12 $\pm$ 1/16 in (304.8 $\pm$ 1.524 mm) above the elevation of the material and to distribute the blows uniformly over the material surface. The rammer has a rigid "pie-shaped" (sector) foot. The foot shall

be a sector of a 6 in (150 mm) diameter circle and shall have an area equal to that of a 2 in (50 mm) diameter circle. The nominal mass of the rammer is 5.50 ± 0.02 lb (2.495 ± 0.009 kg).

c.4. Manually Operated Hammer: Metal rammer with a mass of 5.5 ± 0.02 lb (2.495 ± 0.009 kg), and having a flat circular face of 2.000 in. ± 0.01 in (50.80 mm ± 0.25 mm) diameter. The in-service diameter of the flat circular face shall be not less than 1.985 in (50.42 mm). The rammer shall be equipped with a suitable guide-sleeve to control the height of drop to a free fall of 12.00 ± 0.06 in (305 ± 2 mm) above the elevation of the soil. The guide-sleeve shall have at least four vent holes, no smaller than ⅜ in (9.5 mm) diameter spaced approximately 90 degrees apart and approximately ¾ in (19 mm) from each end; and shall provide sufficient clearance so the free fall of the rammer shaft and head is unrestricted.

c.5. Sieves: Meeting requirements set forth under AASHTO M 92 for: 1 in (25.0 mm), 3/4 in (19.0 mm), 1/2 in (12.5 mm), 3/8 in (9.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), and No. 16 (1.18 mm).

c.6. Balances: One-10 kg balance or scale to meet or exceed the requirements set forth under AASHTO M 231 Class G20 (Table 2). One-1 kg balance to meet or exceed the requirements of a Class G2 (Table 2). [See KT-FORWARD for clarification]

c.7. Drying oven: A thermostatically controlled drying oven capable of maintaining a temperature of 230 ± 9°F (110 ± 5°C).

c.8. Specimen Extruder: Frame, jack and circular metal loading plate or other device for removing specimens from the mold.

c.9. Drying Pans

c.10. Trowels, spatulas and other mixing tools or a mechanical mixer that will thoroughly mix the material, cementitious material and water.

c.11. Moist Room or Cabinet (CTB Only): A moist room or cabinet capable of maintaining a temperature of 73.4 ± 2.0°F (23.0 ± 1.1°C) and a relative humidity of not less than 96%.

c.12. Tamping Rod (CTB Only): 5/8 inch (16 mm) diameter and approximately 24 inches (600 mm) in length that is round with at least one end having a hemispherical tip.

d. SAMPLE PREPARATION:

d.1. For mix design, dry the base aggregate to a constant mass at approximately 100°C (230°F).

Separate the base aggregate by dry screening into the desired fractions and compute the percentage retained on each sieve. The following size fractions are recommended as a minimum:

1½ to 1in (37.5 mm to 25 mm)	No.4 to No. 8 (4.75 mm to 2.36 mm)
1in to 3/4in (25 mm to 19 mm)	No. 8 to No.16 (2.36 mm to 1.18 mm)
3/4in to 1/2in (19 mm to 12.5 mm)	No. 16 to No.30 (1.18 mm to 600 µm)
1/2in to 3/8in (12.5 mm to 9.5 mm)	No. 30 to No. 100 (600 µm to 150 µm)
3/8in to No. 4 (9.5 mm to 4.75 mm)	No. 100 to No. 200 (150 µm to 75 µm)

d.2. Make six portions of base aggregate for each percent of cementitious material to be tested. Recombine the aggregate fractions at the percentages determined in **d.1.** Each portion shall weigh 7,000 g minus the amount of cementitious material to be added.

d.3. Thoroughly mix each sample portion of aggregate with the required amount of cementitious material and place the mixture in a separate pan if applicable.

d.4. For production (QC/QA) control, prepare field material in the following manner:

d.4.a. Acquire a random sample of at least 35 lbs (15 kg) of material. Split the material as follows:

d.4.a.1. Place the sample on clean sheet metal and mix thoroughly with a trowel.

d.4.a.2. Divide the pile into two equal halves with a straightedge (trowel or similar metal blade) and completely remove the back half of the sample.

d.4.a.3. If the sample isn't the proper size (approximately 7,000 g), then use the trowel (or metal blade) to remove or add a portion to achieve the proper size.

e. MOISTURE DENSITY RELATIONSHIP TEST PROCEDURE:

e.1. For mix design purposes, add a measured amount (approximately 5 percent) of water and thoroughly mix with one-7000 g portion. After the addition of water and thorough mixing, compact immediately. DO NOT CURE OR AGE THE SPECIMEN AT THIS POINT. For field production obtain a 7,000 g portion of combined material.

e.2. Place the assembled mold on the rigid base and fill approximately 1/2 full of the loose moist material. Compact the layer with 56 blows of the rammer with the blows being distributed uniformly over the surface of the layer. Place three, approximately equal, additional layers of material in the mold and compact each layer in a similar manner.

e.2.a. If the sample has a slump greater than 1 inch (25 mm), then it may be more appropriate to rod the sample in the following manner:

e.2.a.1. Place enough material in the mold to fill half of the mold (not the collar and mold depth). Rod the material 25 times throughout its depth. Distribute the strokes uniformly over the cross section of the mold. After rodding, tap the outsides of the mold lightly 10 to 15 times with a soft rubber mallet, to close any holes left by rodding and to release any large air bubbles that may have been trapped.

e.2.a.2. Repeat this process for the second and third lifts. The second lift should completely fill the mold, while the third lift should come close to filling the mold and collar. While rodding the second and third lifts, be sure to penetrate the lower lifts by about ½ inch (12 mm).

e.3. After the final layer has been compacted, remove the collar and trim excess material level with the top of the mold.

e.4. Remove from the base and weigh the specimen while it is in the mold. Subtract the mass of the mold to determine the wet mass of the compacted specimen. Then remove the specimen from the mold and place it in an individual drying pan.

e.5. (For Laboratory Prepared Material Only): Repeat the compaction procedure using the other 7,000 g increments of the sample to which different measured amounts of water have been added and thoroughly mixed. This procedure will be continued with varying moisture contents until at least three points are obtained on the dry side of "optimum moisture" and at least two points are obtained on the wet side of "optimum moisture". This can usually be accomplished by compacting different specimens at moisture intervals of 2 to 3 percent, starting on the dry side of "optimum moisture" and ending on the wet side.

e.6. Dry each specimen to constant mass or remove a small representative increment from each specimen (at least 500 g) and determine its moisture content in accordance with KT-11 **c**.

f. CALCULATIONS:

f.1. When the entire specimen is dried:

$$\text{Moisture Content } \% = \frac{100(\text{Wet Mass-Dry Mass})}{\text{Dry Mass}}$$

$$\text{Dry Density} = \frac{\text{Dry Mass of Specimen}}{\text{Volume of Mold}}$$

Where:

Dry Density	= lb/ft^3 (kg/m^3)
Dry Mass of Specimen	= lb (kg)
Volume of Mold	= ft^3 (m^3)

f.2. When a small increment of each specimen is dried, compute dry mass of specimen as follows:

$$\text{Dry Mass of Specimen} = \frac{100(\text{Wet Mass of Specimen})}{100 + \%\ \text{Moisture}}$$

Compute dry density of specimen as in **f.1.** above.

g. LABORATORY PREPARED MATERIAL COMPACTION CURVE:

Plot a density/moisture curve on coordinate paper (KDOT Form No. 638) to determine the maximum density and optimum moisture. The dry density values are plotted as ordinates, the corresponding moisture contents are plotted as abscissa and a smooth curve is drawn to best fit the points.

> NOTE: In drawing a curve by this method all of the points will not necessarily be on the curve and the maximum density may be more or less than the highest test point (See KT-12 for examples).

The optimum moisture content is the moisture content at which the maximum density occurs on the curve.

h. COMPRESSION TEST PROCEDURE (FOR CTB ONLY):

h.1. Prepare the molds by lightly oiling the inside of the mold and placing a filter paper disc in the bottom of the mold prior to introducing the material for the first lift. Scratch the surface of each lift after it is compacted to insure bonding between lifts.

h.1.a. For mix designs: Prepare nine essentially identical specimens at the selected mix design parameter by the procedures shown in **d.** through **e.3.** above.

h.2. After compacting, allow specimens to cure for 24 ± 4 hours. If this falls on a non-working day, then adjust as stipulated in i.4. Keep specimens moist either using a moist room or covered with wet burlap or plastic to minimize moisture loss while curing.

h.2.a. For mix designs: After completion of compaction, allow three specimens to cure in the mold for 24 ± 4 hours, three at 48 ± 4 hours, and three at 72 ± 4 hours at room temperature before removing it from the molds.

> NOTE: If a moisture room is not available, then place each of the specimens in a sealable plastic container (plastic bags are not acceptable), drape a damp cotton towel over the specimen and seal the container for the specified time. The object is to achieve and maintain near 100% moisture conditions throughout the curing process.

h.3. Place the specimens in the moist room, but protect them from dripping water for the specified curing period. When the cure is completed; the specimens are removed from the moist room, weighed, measured for height and diameter, capped and broken. If sulfur is used to cap, then allow the caps to cure for a minimum of 2 hours prior to breaking.

h.4. Place the specimen on the table of the compression-testing machine. Make sure the vertical axis of the specimen is aligned with the center of thrust of the load head. Apply the load continuously and without shock. Adjust the loading to a constant rate of 10-12 psi/sec (69-83 kPa/sec) for a hydraulic system. Record the total load at failure to the nearest 10 lbf (50 N).

h.5. After testing, place each specimen in a drying pan and put in a 230°F (100°C) oven for 24 to 48 hours until a constant mass is attained. Determine the mass of the dry specimen.

i. CALCULATIONS:

i.1. Determine the moisture content at the time of testing and the dry density of the specimen using the methods shown in **f.1.** of this test method.

> Note: The moisture and density determined in this section will not be used in the plotting of control charts, but can be used for comparison purposes should other tests results fail to meet criteria.

i.2. Determine the correction factor for the value of the ratio of the length of the specimen to the diameter (L/D) from the following table:

L/D	Correction Factor	L/D	Correction Factor

1.94 - 2.00	1.00	1.23 - 1.28	0.93
1.82 - 1.93	0.99	1.19 - 1.22	0.92
1.69 - 1.81	0.98	1.15 - 1.18	0.91
1.56 - 1.68	0.97	1.11 - 1.14	0.90
1.46 - 1.55	0.96	1.06 - 1.10	0.89
1.38 - 1.45	0.95	1.02 - 1.05	0.88
1.29 - 1.37	0.94	1.00 - 1.01	0.87

i.3. Multiply the failure load by the correction factor determined from the table above and divide by the area of the test specimen to determine the pressure psi (kPa) at failure.

i.4. During the Design phase, develop a time adjustment factor for the 48-hour and 72-hour molded specimens to correlate back to the 24-hour molded specimens in the following manner:

i.4.a. Determine the average corrected compressive strengths for each of the three sets (24, 48, 72-hour) of molded specimens.

i.4.b. Determine the time adjustment factor by dividing the base time (24-hour) by the extended times in the following manner:

$$T_{48} = \frac{P_{24}}{P_{48}} \qquad T_{72} = \frac{P_{24}}{P_{72}}$$

Where:

T_{48}, T_{72} = Time adjustment factor for a given (either 48-hour or 72-hour) molded specimen.

P_{24}, P_{72} = Average compressive strength values for a given (either 48-hour or 72-hour) set of molded specimens.

i.5. During the field production phase, apply the appropriate time adjustment whenever specimens are not removed from the mold in 24 $\pm$ 4 hours in the following manner:

$$C_{adj} = C_{48}T_{48} \quad \text{or} \quad C_{adj} = C_{72}T_{72}$$

j. REPORTING:

j.1. For laboratory prepared material, report the pressure at failure of each specimen in the three-specimen set in addition to the average failure pressure of the three specimens. For field prepared material, report the pressure at failure for each specimen. The report should reference this test procedure.