5.9.49 METHOD FOR OBTAINING AND TESTING DRILLED CORES FROM PCCP AND PRECAST GIRDERS (Kansas Test Method KT-49)

1. SCOPE

1.1. This test method provides standardized procedures for obtaining and testing specimens to determine the compressive strength of in-place concrete in pavement and precast girders and depth of concrete pavement. Sampling and sample preparation requirements are given to ensure that dimensional requirements are met and that the specimens are made of intact, sound concrete, and are as free of flaws as the particular pavement or precast girder will allow.

2. REFERENCED DOCUMENTS

2.1. AASHTO T 22; Compressive Strength of Cylindrical Concrete Specimens

2.2. AASHTO T 148; Measuring Length of Drilled Concrete Cores

2.3 KT-77; Method for Capping Cylindrical Concrete Specimens

3. SIGNIFICANCE AND USE

3.1. The strength of concrete measured by tests of cores is affected by the amount and distribution of moisture in the specimen at the time of test. There is no standard procedure to condition a specimen that will ensure that, at the time of test, it will be in the identical moisture condition as concrete in the pavement or precast girder. The moisture conditioning procedures in this test method are intended to provide reproducible moisture conditions that minimize within-laboratory and between-laboratory variations and to reduce the effects of moisture introduced during specimen preparation.

4. APPARATUS

4.1. Testing Machine – The testing machine shall comply with requirements set forth in AASHTO T-22. The testing machine shall be of a type having sufficient capacity and capable of providing the rates of loading corresponding to a stress rate on the specimen of 35 ± 7 psi/s (0.25 ± 0.05 MPa/s). The designated rate of movement shall be maintained at least during the latter half of the anticipated loading phase. The testing machine shall be capable of testing cores up to and including 12 in (300 mm) in length.

4.2. Core Drill - For obtaining cylindrical core specimens, a diamond drill shall be used.

4.3. Caliper and a 12 in (300 mm) steel rule graduated in 0.01 in (0.25 mm).

5. SAMPLING

5.1. Core Drilling - A core specimen taken perpendicular to a horizontal surface shall be located, when possible, so that its axis is perpendicular to the bed of the concrete as originally placed and not near formed joints or obvious edges of a unit of deposit. A specimen taken perpendicular to a vertical surface, or perpendicular to a surface with a batter, shall be taken from near the middle of a unit of deposit when possible and not near formed joints or obvious edges of a unit of deposit.

NOTE: All coring for the purpose of determining compressive strength must be performed a minimum of 21 days after the pavement has been placed, and in time to determine the 28-day compressive strengths.
6. DETERMINING LENGTH OF DRILLED CORE SPECIMENS

6.1. A core specimen for the determination of length shall have a minimum diameter as stated in the applicable specification.

6.2. Determining Length of Core using Calipers.

6.2.1. Cores used as specimens for length measurement shall be in every way representative of the concrete in the structure from which they are removed. The specimen shall be drilled with the axis normal to the surface of the structure, and the ends shall be free from all conditions not typical of the surfaces of the structure. Cores that show abnormal defects or that have been damaged appreciably in the drilling operation shall not be used. If a core drilled from a pavement or structure placed on dense-graded aggregate base course includes particles of the aggregate bonded to the bottom surface of the concrete, the bonded particles shall be removed by wedging or by chisel and hammer applied so as to expose the lower surface of the concrete. If the concrete is placed on an open-graded aggregate base course, the mortar in the concrete may penetrate into the base and surround some particles. Use sufficient force with a wedge or chisel and hammer to remove bonded particles but not such force as to fracture particles substantially surrounded by mortar. If during the removal of bonded aggregate the concrete is broken so that the instructions of section 6.2.3 of this test method cannot be followed, the core shall not be used for length measurement.

6.2.2. Take three caliper measurements at 120 degree intervals along the circumference of the circle of measurement to the nearest 0.01 in (0.25 mm), to determine the average length.

6.2.3. If, in the course of the measuring operation, it is discovered that at one or more of the measuring points the surface of the specimen is not representative of the general plane of the core end because of a small projection or depression, the specimen shall be rotated slightly about its axis and a complete set of three measurements made with the specimen in the new position. With cores from pavements placed over open-graded aggregate bases the foregoing provisions frequently cannot be met because of the great number of projections or voids on the bottom surface.

7. SPECIMENS

7.1. Test Specimens – For concrete greater than or equal to 8 inches in thickness the nominal diameter of core specimens for the determination of compressive strength shall be at least 3.75 in (95 mm). Core diameters less than 3.75” are permitted when it is impossible to obtain cores with length-to-diameter (L/D) ratio ≥ 1 for compressive strength evaluations. For concrete with a thickness of less than 8 inches the nominal core diameter should preferably be at least three times the nominal maximum size of the coarse aggregate and must be at least twice the nominal maximum size of the coarse aggregate.

7.2. Moisture Conditioning - Test cores after moisture conditioning as specified in this test method. The moisture conditioning procedures specified in this test method are intended to preserve the moisture of the drilled core and to provide a reproducible moisture condition that minimizes the effects of moisture gradients introduced by wetting during drilling and specimen preparation.

7.2.1. After cores have been drilled, wipe off surface drill water and allow remaining surface moisture to evaporate. When surfaces appear dry, but not later than one hour after drilling, place cores in separate plastic bags or nonabsorbent containers and seal to prevent moisture loss. Maintain cores at ambient

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temperature, and protect cores from exposure to direct sunlight. Transport the cores to the testing laboratory as soon as practical. Keep cores in the sealed plastic bags or nonabsorbent containers at all times except during end preparation and for a maximum time of two hours to permit capping before testing.

7.2.2. If water is used during sawing or grinding of core ends, complete these operations as soon as practicable, but no later than two days after drilling of cores. After completing end preparation, wipe off surface moisture, allow the surfaces to dry, and place the cores in sealed plastic bags or nonabsorbent containers. Minimize the duration of exposure to water during end preparation.

7.2.3. When direction is given to test cores in a moisture condition other than achieved by conditioning according to sections 7.2.1. and 7.2.2. of this test method, report the alternative procedure.

7.3. End Preparation Prior to Capping - The ends of specimens to be tested in compression shall be essentially smooth, perpendicular to the longitudinal axis, and of the same diameter as the body of the specimen. Saw or grind the top of the specimen no more than 0.375 inches (10 mm) to remove surface tining or roughness. Saw or grind the bottom of the specimen only the amount that is required for the specimen to fit into the testing machine. No point on either end of compressive test specimens shall protrude by more than 0.125 inches (3 mm) from a plane perpendicular to the axis of the specimen at the lowest point of the surface prior to capping with sulfur.

NOTE: Prior to capping, the density of a core may be determined by weighing it and dividing it by the volume calculated from the average diameter and length, or by any other standard method for determining density.

8. CAPPING

8.1. Cap the specimen according to the procedures contained in KT-77.

8.2. Measurement - Prior to testing, measure the length of the capped specimen to the nearest 0.01 inch (0.25 mm) and use this length to compute the length-diameter ratio. Determine the average diameter by averaging two measurements taken at right angles to each other about the mid-height of the specimen. Measure core diameters to the nearest 0.01 inch (0.25 mm). Do not test cores if the difference between the largest and smallest diameter exceeds five percent of their average.

9. TESTING

9.1. Test the specimens for the 28th day compression strength within seven days after coring, unless specified otherwise.

9.2. Specimens shall be tested at the age required by the applicable specification within the time tolerances shown in Table 1.
Table 1 Permissible Time Tolerances

<table>
<thead>
<tr>
<th>Test Age</th>
<th>Permissible Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 h</td>
<td>± 0.25 h</td>
</tr>
<tr>
<td>24 h</td>
<td>± 0.5 h</td>
</tr>
<tr>
<td>3 days</td>
<td>± 2 h</td>
</tr>
<tr>
<td>7 days</td>
<td>± 6 h</td>
</tr>
<tr>
<td>28 days</td>
<td>± 20 h</td>
</tr>
<tr>
<td>56 days</td>
<td>± 40 h</td>
</tr>
<tr>
<td>90 days</td>
<td>± 2 days</td>
</tr>
</tbody>
</table>

9.3. Placing the Specimen - Place the plain (lower) bearing block, with its hardened face up, on the table or platen of the testing machine directly under the spherically-seated (upper) bearing block. Wipe clean the bearing faces of the upper- and lower-bearing blocks and of the test specimen and place the test specimen on the lower bearing block.

9.4. Zero Verification and Block Seating - Prior to testing the specimen, verify that the load indicator is set to zero. In cases where the indicator is not properly set to zero, adjust the indicator. As the spherically-seated block is brought to bear on the specimen, rotate its movable portion gently by hand so that uniform seating is obtained.

NOTE: The technique used to verify and adjust load indicator to zero will vary depending on the machine manufacturer. Consult your owner’s manual or compression machine calibrator for the proper technique.

9.5. Rate of Loading - Apply the load continuously and without shock.

9.5.1. The load shall be applied at a rate of movement (platen to crosshead measurement) corresponding to a stress rate on the specimen of 35 ± 7 psi/s (0.25 ± 0.05 MPa/s). The designated rate of movement shall be maintained at least during the latter half of the anticipated loading phase.

NOTE: For a screw driven or displacement-controlled testing machine, preliminary testing will be necessary to establish the required rate of movement to achieve the specified stress rate. The required rate of movement will depend on the size of the test specimen, the elastic modulus of the concrete, and the stiffness of the testing machine.

9.5.2. During application of the first half of the anticipated loading phase, a higher rate of loading shall be permitted. Apply the higher loading rate in a controlled manner so that the specimen is not subjected to shock loading.

9.5.3. Do not adjust the rate of movement (platen to crosshead) as the ultimate load is being approached and the stress rate decreases due to cracking in the specimen.

9.5.4. Apply the compressive load until the load indicator shows that the load is decreasing steadily and the specimen displays a well-defined fracture pattern (See Figure 1). For a testing machine equipped with a specimen break detector, automatic shut-off of the testing machine is prohibited until the load has dropped to a value that is less than 95% of the peak load. A setting of 60% of peak is recommended. Continue compressing the specimen until the user is certain that the ultimate capacity has been attained and a clear fracture pattern is discernable. Record the maximum load carried by the specimen during the
test, and note the type of fracture pattern according to Figure 1. If the fracture pattern is not one of the typical patterns shown in Figure 1, sketch and describe briefly the fracture pattern. If the measured strength is lower than expected, examine the fractured concrete and note the presence of large air voids, evidence of segregation, whether fractures pass predominantly around or through the coarse aggregate particles, and verify end preparations were in accordance with section 8.1 of this test method.

10. CALCULATIONS

10.1. Calculate the compressive strength of each specimen using the computed cross-sectional area based on the average diameter of the specimen as follows:

\[ \text{Compressive strength} = \frac{\text{peak load}}{\text{area}} \]

\[ \text{Area} = \pi r^2 \]

10.2. Determine the length/diameter ratio (LD), and round the result to the nearest hundredth using the following formula:

\[ \text{LD} = \frac{\text{Length}}{\text{Diameter}} \]

Determine a correction factor to the nearest hundredth by using the appropriate formula in TABLE 2. Correct the compressive strength by multiplying the compressive strength determined in 10.1 by the correction factor.

### TABLE 2: COMPRRESSIVE STRENGTH CORRECTION FACTOR FORMULAS

<table>
<thead>
<tr>
<th>LD</th>
<th>Correction Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>LD &lt; 2</td>
<td>( \frac{100}{95 + 0.2 \left( \frac{1}{LD} \right) + 19.5 \left( \frac{1}{LD} \right)^2} )</td>
</tr>
<tr>
<td>LD = 2</td>
<td>1.00</td>
</tr>
<tr>
<td>LD &gt; 2</td>
<td>( \frac{100}{110 - 5(LD)} )</td>
</tr>
</tbody>
</table>

11. REPORT

11.1. Report the results as required by the Contract Document with the addition of the following information:

11.1.1. Identification number.

11.1.2. Diameter and length, inch (mm).

11.1.3. Cross-sectional area, in\(^2\) (cm\(^2\)).

11.1.4. Maximum load, lbf (kN).

11.1.5. Compressive strength (corrected) calculated to the nearest 10 psi (0.1 MPa).

11.1.6. Type of fracture, if other than the usual cone. (See Figure 1)
**Figure 1 - Sketches of Types of Fracture**

11.1.7. Defects in either specimen or caps.

11.1.8. Age of specimen.

11.1.9. Length of core as drilled to the nearest 0.01 inch (0.25 mm).

11.1.10. Length of test specimen before and after capping or end grinding to the nearest 0.01 inch (0.25 mm), and average diameter of core to the nearest 0.01 inch (0.25 mm).

11.1.11. Direction of application of the load on the specimen with respect to the horizontal plane of the concrete as placed.

11.1.12. The moisture conditioning history.

11.1.12.1. The date and the time core was obtained and first placed in sealed bag or nonabsorbent container.

11.1.12.2. If water was used during end preparation, the date and time end preparation was completed and the core placed in sealed bag or nonabsorbent container.

11.1.13. The date and time when tested.

11.1.14. If determined, the density.

11.1.15. If applicable, description of defects in cores that could not be tested.

11.1.16. If any deviation from this test method was required, describe the deviation and explain why it was necessary.

**12. PRECISION AND BIAS**

12.1. The single-operator coefficient of variation on cores has been found to be 3.2% for a range of compressive strength between 4500 psi (32.0 MPa) and 7000 psi (48.3 MPa). Therefore, results of two properly conducted tests of single cores by the same operator on the same sample of material should not differ from each other by more than nine percent of their average.
12.2. The multi-laboratory coefficient of variation on cores has been found to be 4.7\% for range of compressive strength between 4500 psi (32.0 MPa) and 7000 psi (48.3 MPa). Therefore results on two properly conducted tests on cores sampled from the same hardened concrete (where a single test is defined as the average of two observations (cores), each made on separate adjacent drilled 4 in (100 mm) diameter cores), and tested by two different laboratories should not differ from each other by more than 13 percent of their average.

12.3. Since there is no accepted reference material suitable for determining the bias for the procedure in this test method, no statement on bias is being made.