5.16.49 METHOD FOR OBTAINING AND TESTING DRILLED CORES
(Kansas Test Method KT-49)

a. SCOPE

a.1. This method covers obtaining, preparing, and testing cores drilled from concrete for length or compressive strength determinations. This test method provides standardized procedures for obtaining and testing specimens to determine the compressive strength of in-place concrete. 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 structure will allow.

a.2. *This standard does not purport to address safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

b. REFERENCED DOCUMENTS

b.1. AASHTO T 231; Capping Cylindrical Concrete Specimens

c. SIGNIFICANCE AND USE

c.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 structure. 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.

d. APPARATUS

d.1. Testing Machine - 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.

d.2. Core Drill - For obtaining cylindrical core specimens, a diamond drill shall be used.

d.3. Caliper and a 12 in (300 mm) steel rule graduated in 0.01 in (0.25 mm).

d.4. Core Length Measuring Apparatus.

d.4.a. The apparatus shall consist of a calipering device that will measure the length of axial elements of the core. While the details of the mechanical design are not prescribed, the apparatus shall conform to the requirements below.

d.4.b. The apparatus shall be so designed that the specimen will be held with its axis in a vertical position by three symmetrically placed supports bearing against the lower end. These supports shall be short posts or studs of hardened steel, and the ends that bear against the surface of the specimen shall be rounded to a radius of not less than $^1/_4$ in (6.4 mm) and not more than $^1/_2$ in (12.7 mm).

d.4.c. The apparatus shall provide for the accommodation of specimens of different nominal lengths over a range of at least 4 to 10 in (100 to 250 mm).

d.4.d. The calipering device shall be so designed that it will be possible to make a length measurement at the center of the upper end of the specimen, and at eight additional points spaced at equal intervals along the circumference of a circle whose center points coincides with that of the end area of the specimen and whose radius is not less than one-half nor more than three-fourths of the radius of the specimen.

d.4.e. The measuring rod or other device that makes contact with the end surface of the specimen for measurement shall be rounded to a radius of $^1/_8$ in (3.2 mm). The scale on which the length readings are made shall be marked with clear, definite, accurately spaced graduations. The spacing of the graduations shall be 0.10 in (2.5 mm) during all normal measuring operations.

e. SAMPLING

e.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 **a:** 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.

f. DETERMINING LENGTH OF DRILLED CORE SPECIMENS

f.1. A core specimen for the determination of length shall have a minimum diameter of 3.75 in (95 mm).

f.2. Determining Length of Core using Calipers.

f.2.a. 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.

f.3. Determining Length of Core using Measuring Apparatus.

f.3.a Before any measurements of the core length are made, calibrate the apparatus with suitable gages so that errors caused by mechanical imperfections in the apparatus are known. When these errors exceed 0.01 in (0.25 mm), apply suitable corrections to the core length measurements.

f.3.b. Place the specimen in the measuring apparatus with the smooth end of the core, this is, the end that represents the upper surface of the pavement slab or a formed surface in the case of other structures, placed down so as to bear against the three hardened-steel supports. So place the specimen on the

supports that the central measuring position of the measuring apparatus in directly over the midpoint of the upper end of the specimen.

f.2.b.1. Make nine measurement of the length on each specimen, one at the central position and one each at eight additional positions spaced at equal intervals along the circumference of the circle of measurement. Read each of these nine measurements directly to tenths of an inch and either directly or by estimation to five-hundredths of an inch.

f.2.b.2. 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 nine 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.

g. SPECIMENS

g.1. Test Specimens - The nominal diameter of core specimens for the determination of compressive strength shall be at least 3.75 in (95 mm). For concrete with nominal maximum aggregate size greater than $1^1/_2$ in (37.5 mm), the nominal 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. Follow the specifications for length to diameter (L/D) determinations.

g.2. End Preparation - The ends of core 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. Neither end of compressive test specimens when tested shall depart from perpendicularity to the axis by more than 0.5 degrees (approximately equivalent to 0.12 inches in 12 inches (3 mm in 300 mm)). The ends of compression test specimens that are not plane within 0.002 in (0.050 mm) shall be sawed, ground, or capped in accordance with T 231 to meet that tolerance. The diameter used for calculating the cross-sectional area of the test specimen shall be determined to the nearest 0.01 in (0.25 mm) by averaging two diameters measured at right angles to each other at about mid-height of the specimen. If necessary, saw or tool the ends of the specimens prior to capping until the following requirements are met.

g.3. 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.

g.3.a. 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 1 hour after drilling, place cores in separate plastic bags or nonabsorbent containers and seal to prevent moisture loss. Maintain cores at ambient temperature, and protect cores from exposure to direct sunlight. Transport the cores to the testing laboratory as soon as practicable. Keep cores in the sealed plastic bags or nonabsorbent containers at all times except during end preparation and for a maximum time of 2 hours to permit capping before testing.

g.3.b. 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.

g.3.c. When direction is given to test cores in a moisture condition other than achieved by conditioning according to Sections **g.3.a.** and **g.3.b.**, report the alternative procedure.

g.4. Capping - Before making the compression test, saw or grind the ends of the specimens in accordance with the tolerance requirements of Section **g.2.** or cap the ends of the specimens in conformance with the procedure prescribed in the applicable section of T 231. The capped surfaces of the specimens shall conform to the planeness requirements of T 231.

NOTE **b:** 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.

g.5. Measurement - Prior to testing, measure the length of the capped specimen to the nearest 0.01 in (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 in (0.25 mm). Do not test cores if differences between the largest and smallest diameter exceed 5 percent of their average.

g.6. Testing - Test the specimens for the 28th day compression strength within seven days after coring, unless specified otherwise.

g.6.a. Compression tests of moist-cured specimens shall be made as soon as practicable after removal from moist storage.

g.6.b. Test specimens shall be kept moist by any convenient method during the period between removal from moist storage and testing. They shall be tested in the moist condition.

g.6.c. All test specimens shall be broken within 28 days ± 20 hours.

g.6.d. 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.

g.6.d.1. 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[c]. 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 **c:** 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.

g.6.e. Rate of Loading - Apply the load continuously and without shock.

g.6.e.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)[d]. The designated rate of movement shall be maintained at least during the latter half of the anticipated loading phase.

NOTE **d:** 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.

g.6.e.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.

g.6.e.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.

g.6.f. 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 percent of the peak load. When testing with unbonded caps, a corner fracture may occur before the ultimate capacity of the specimen has been attained. Continue compressing the specimen until the user is certain that the ultimate capacity has been attained. 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 **g.2.**

g.7. Calculations - Calculate the compressive strength of each specimen using the computed cross-sectional area based on the average diameter of the specimen.

g.8. Length - Determine the length as stated within this test procedure.

h. REPORT

h.1. Report the results as required by the Contract Document with the addition of the following information:

h.1.a. Identification number;

h.1.b. Diameter and length, in (mm);

h.1.c. Cross-sectional area, in^2 (cm^2);

h.1.d. Maximum load, lbf (kN);

h.1.e. Compressive strength calculated to the nearest 10 psi (0.1 MPa);

h.1.f. Type of fracture, if other than the usual cone. (See Figure 1.)

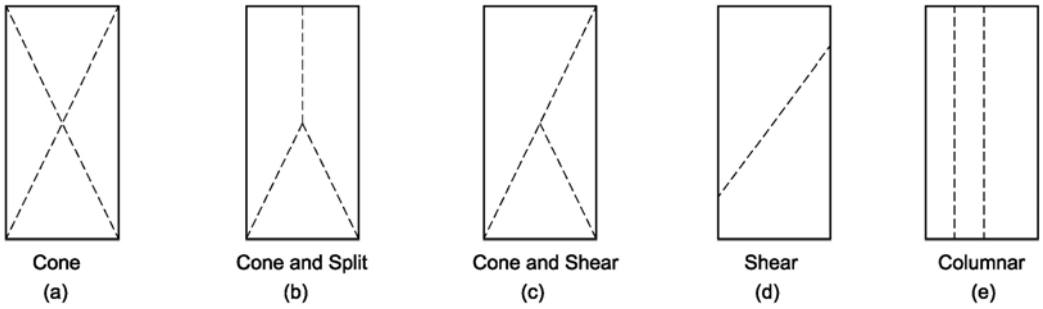

Figure 1 - Sketches of Types of Fracture

h.1.g. Defects in either specimen or caps;

h.1.h. Age of specimen;

h.1.i. Length of core as drilled to the nearest 0.01 in (0.25 mm);

h.1.j. Length of test specimen before and after capping or end grinding to the nearest 0.01 in (0.25 mm), and average diameter of core to the nearest 0.01 in (0.25 mm);

h.1.k. Direction of application of the load on the specimen with respect to the horizontal plane of the concrete as placed;

h.1.l. The moisture conditioning history:

h.1.l.1. The date and the time core was obtained and first placed in sealed bag or nonabsorbent container;

h.1.l.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;

h.1.m. The date and time when tested;

h.1.n. If determined, the density;

h.1.o. If applicable, description of defects in cores that could not be tested; and

h.1.p. If any deviation from this test method was required, describe the deviation and explain why it was necessary.

i. PRECISION AND BIAS

i.1. The single-operator coefficient of variation on cores has been found to be 3.2 percent for a range of compressive strength between 4,500 psi (32.0 MPa) and 7,000 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.

i.2. The multi-laboratory coefficient of variation on cores has been found to be 4.7 percent for range of compressive strength between 4,500 psi (32.0 MPa) and 7,000 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.

i.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.