METHOD OF TEST FOR ASPHALT CEMENT GRADING FOR COLD TEMPERATURE FRACTURE PERFORMANCE USING COMPACT TENSION TEST (CT)

1. SCOPE

1.1 The "Compact Tension Test" (CT), a fracture mechanics based test, grades asphalt cement for the temperature above which transverse thermal cracking may be prevented in pavements containing the asphalt cement.

1.2 This test is to determine the fracture performance in or around the brittle to ductile state. This test is not intended for asphalt cement containing larger particles such as crumb rubber.

1.3 LS-298 has been published as a provisional test method. The test is a working document and continuous refinement to the test method may be expected.

2. RELEVANT DOCUMENTS

2.1	AASHTO PP 1	Standard Practice for Accelerated Aging of Asphalt Cement Using a Pressurized Aging Vessel (PAV)
	AASHTO T 240	Effect of Heat and Air on Rolling Film of Asphalt (Rolling Thin-Film Oven Test)
2.2	ASTM D8	Standard Definitions of Terms Relating to Materials for Roads and Pavements
	ASTM D5045	Plane-Strain Fracture Toughness and Strain Energy Release Rate of Plastic Materials
	ASTM E399	Standard Test Method for Plane-Strain Fracture Toughness of Metallic Materials
	ASTM E616	Terminology Relating to Fracture Testing

3. DEFINITIONS AND ACRONYMS

v_p – displacement at ductile to brittle state, mm

v – displacement in test, mm

P – load, N

T_{grade} – the low temperature grade as determined by CT testing, °C

$T_{d\text{-}b}$ – ductile-to-brittle transition temperature, °C

T_c – conditioning temperature: $T_c = T + 10°C$ where T is the low temperature of the asphalt cement's temperature grading (i.e. T = –YY if PGAC grade is XX–YY). Example, if a PGAC grade of 58-28 is being tested, the conditioning temperature T_c = -18°C = -28 + 10°C

T_{Rn} – testing temperature: T_{Rn} = T + 10ºC + 3(n-1) for n = 1, 2, and 3

T – asphalt cement supplier's low temperature grading of material: (T = -YY for PGAC grade XX-YY), °C

a – notch depth, mm

W – sample height, mm

4. APPARATUS

4.1 MOLD ASSEMBLY: Silicon CT mold with an a/W ratio of 0.4 (see Figure 1).

4.2 CT ADAPTOR: Two appropriately configured adaptors that will permit the testing apparatus to perform CT tests on samples (see Figure 2).

4.3 ALUMINUM END PIECES: Two inserts per specimen built from an aluminum bar to dimensions shown in Figure 3.

4.4 TESTING APPARATUS: A constant rate of displacement device capable of generating rates of displacement varying from 0.001 mm/s to 1.5 mm/s. The displacement rate set shall not fluctuate more than ± 1%. The maximum stroke for the instrument shall be 20 mm. A Direct Tension testing apparatus may be used with a CT adaptor installed as shown in Figure 4.

4.5 LOAD SENSOR: Load sensor mounted on the test apparatus adaptor capable of electronically measuring and recording the load P and displacement v, every 0.3 sec during the test within an accuracy of ± 1%. The load sensor shall have a nominal maximum force of 500 N.

4.6 RTFO: Rolling Thin Film Oven.

4.7 PAV: Pressure aging vessel capable of aging material for 20 h as per AASHTO T 240 and PP 1.

4.8 GLASS STIR: Stick capable of stirring the hot asphalt cement vigorously.

4.9 VACUUM OVEN: Of appropriate size capable of maintaining a uniform temperature of 160 ± 5°C.

4.10 FREEZER: Temperature controlled air-cooled freezer capable of maintaining the T_c to within a temperature tolerance of ± 0.5°C.

4.11 FLUID BATH: Temperature controlled fluid bath capable of maintaining the T_c without fluctuating more than 0.5°C.

4.12 ALUMINUM PLATE: An aluminum plate that can serve as a tray to hold the specimens.

4.13 PLASTIC SHEET: A plastic sheet that can be placed in between the specimens and the aluminum plate to prevent the specimens from sticking to the plate.

5. PREPARATION OF SPECIMEN

5.1 The test specimen (see Figure 5) shall be made with asphalt cement aged by RTFO followed by 20 h in a pressure-aging vessel as per AASHTO T 240 and PP 1, respectively.

5.2 Determine T_{Rn}, which will be the samples' testing temperatures. The temperatures shall cover a range so as to obtain both purely brittle failure (i.e. complete linearity), as well as limited degree of ductility followed by a brittle failure.

5.3 Heat the aged asphalt cement for 1 h at 160 ± 5°C in the vacuum oven. The temperature may be raised to a maximum of 180°C if required to provide a low enough viscosity but shall not be overheated.

5.4 Subsequent to heating, the asphalt cement shall be homogenized by vigorous stirring. Air entrapped during the PAV aging procedure or during stirring shall be removed by a vacuum oven.

5.5 Two aluminum end pieces shall be inserted into the CT mold assembly. Contact surfaces on the aluminum end pieces shall be sand-blasted and free of any greasy substances to provide sufficient adhesion with the asphalt cement.

5.6 Heat the CT mold for 3 min in the oven at a temperature that will not damage the mold.

Note: This is to reduce the temperature difference between the mold and the asphalt cement.

5.7 Pour the hot RTFO and PAV aged asphalt cement into one specimen cavity at a time in the heated mold. The cavity should be overfilled to form a small crown to compensate for shrinkage due to cooling. Repeat this step for the remaining specimen cavities.

5.8 Let samples cool at room temperature for approximately 1 h and then place the specimens with the CT mold into a freezer set at T_c for 1 h. Place plastic-covered aluminum plate in freezer.

Note: This hour shall be counted towards the 24 h conditioning time.

5.9 Take the mold with the specimens out of freezer. Remove all specimens from the CT mold and place them on a plastic sheet covered aluminum plate retrieved from freezer. Return the aluminum plate with specimens to freezer as soon as possible and continue the rest of the conditioning at T_c for an additional 22.5 hrs.

Note: The sample is conditioned to a total of 24 hrs prior to testing.

6. TEST PROCEDURES

6.1 Once the specimen has been conditioned at T_c and just prior to testing, the sample shall be equilibrated at the test temperatures T_{Rn} for 30 min in the fluid bath to be included as part of the conditioning time.

6.2 Load the specimen (see Figure 5) onto the testing apparatus adaptor as shown in Figure 4.

6.3 Fracture tests at a T_{Rn} and a rate of loading of 0.001 mm/s ± 1%, shall be repeated a minimum of 3 times (3 runs, n = 1, 2, 3) to determine the ductile-to-brittle transition temperature. The aged asphalt cement shall be tested after conditioning for 24 h at T_c, and conditioning times shall be within ± 5 min of the specified times.

The loading rate shall be kept constant during and in between tests. The test temperatures T_{Rn} shall not vary by more than ± 0.5°C.

6.4 The v_p is determined by drawing a best straight line tangent through the origin of the load-displacement curve, excluding any start effects, and horizontally shifting this line to intercept with the maximum load point. The horizontal distance between the 2 parallel lines is called v_p (see Figure 6). The v_p shall be measure to an accuracy of ± 0.01 mm. A v_p greater than or equal to 0.25 mm would indicate ductile failure. A v_p less than 0.25 mm in any of the 3 tests would indicate brittle failure and will need an additional run and repeat of steps 6.1 to 6.4. The temperature at which the v_p is either reached or exceeds 0.25 mm in all 3 tests shall be reported as the ductile-to-brittle transition temperature, $T_{d\text{-}b}$.

Note: The number of runs depends on the result of the displacement v_p obtained from each run.

7. CALCULATION

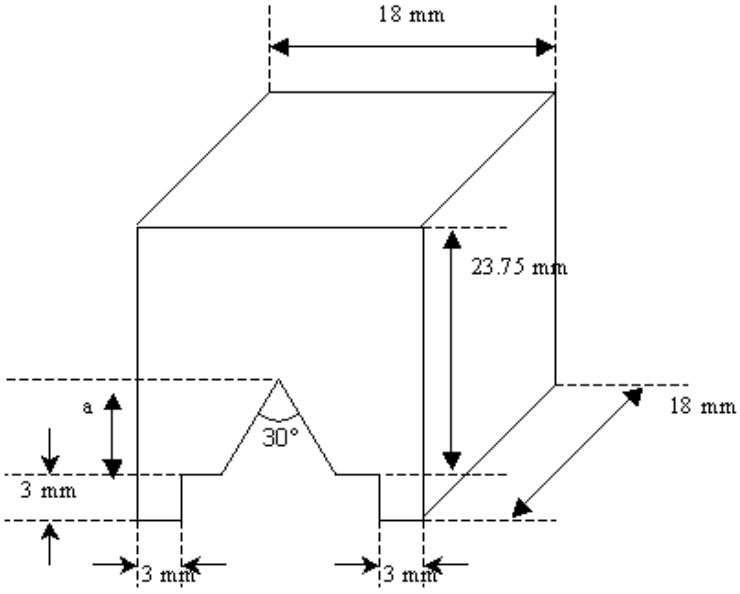
Calculate the minimum permissible in service temperature of the asphalt cement, T_{grade},

Where: $\mathbf{T_{grade} = T_{d\text{-}b} - 10}$

8. REPORTING OF RESULTS

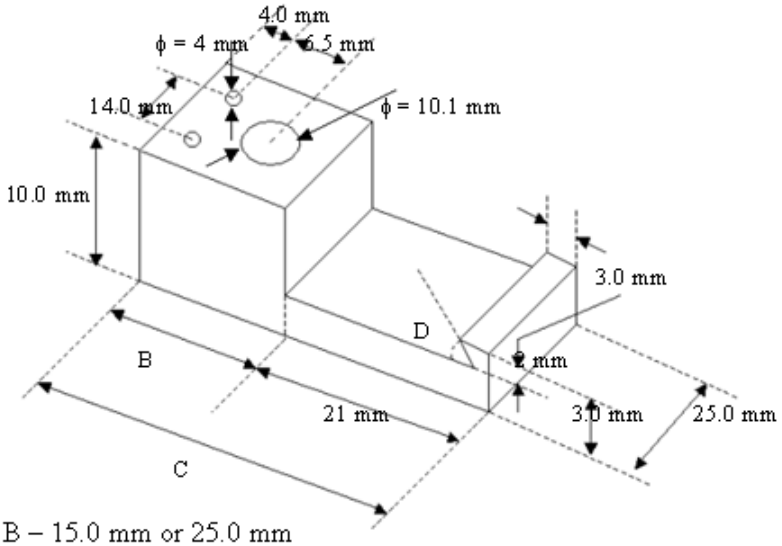
8.1 Report the v_p, $T_{d\text{-}b}$ and T_{grade} for the $v_p \geq 0.25$ and for the 2 v_p values preceding it. Also record the average, minimum, and maximum loads at failure for each test temperature.

8.2 The report should contain information such as: laboratory name, date, PGAC information, sample number, condition times, and temperatures.



Where a = 8.75 mm

Figure 1 – Mold Assembly



Where:

B – 15.0 mm or 25.0 mm
C – 52.5 mm or 46 mm
D – 60°

Figure 2 – Compact Tension Adaptor

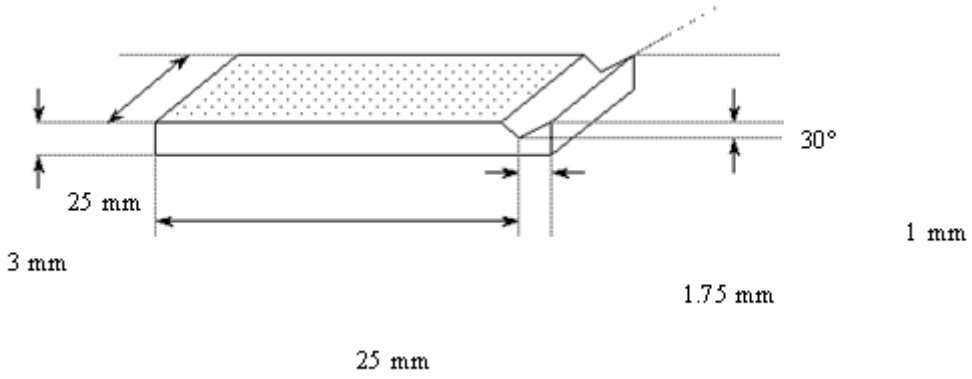


Figure 3 – Aluminum End Pieces

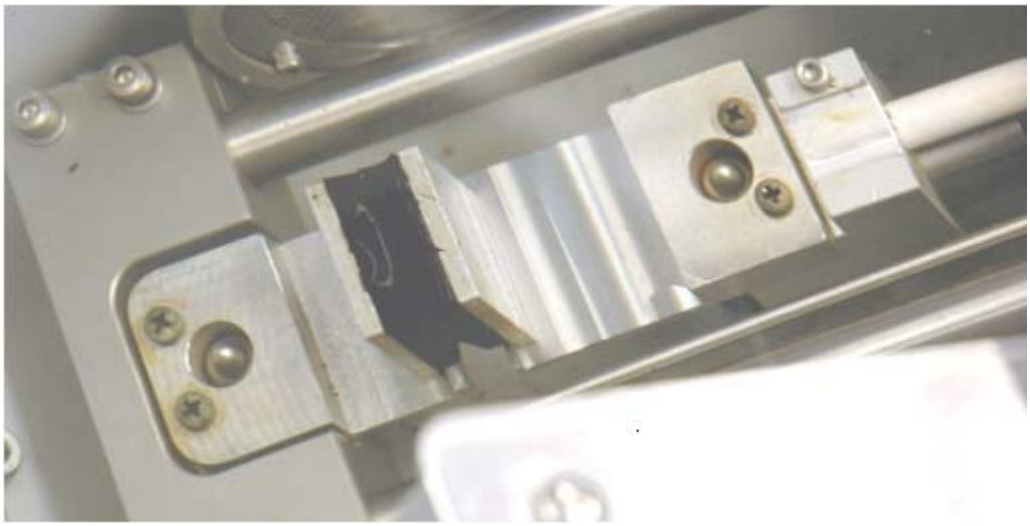


Figure 4 – CT Adaptor with Sample Installed in a Direct Tension Testing Apparatus

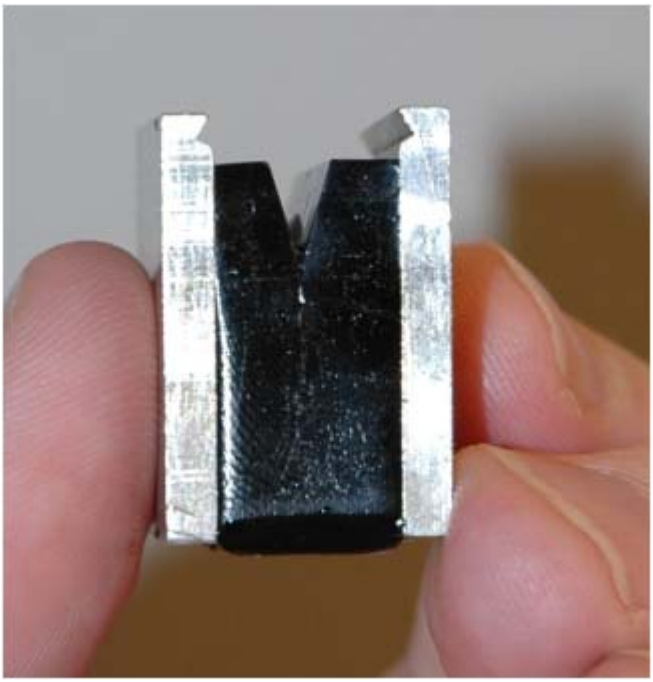


Figure 5 – CT Notched Sample with Aluminum End Pieces

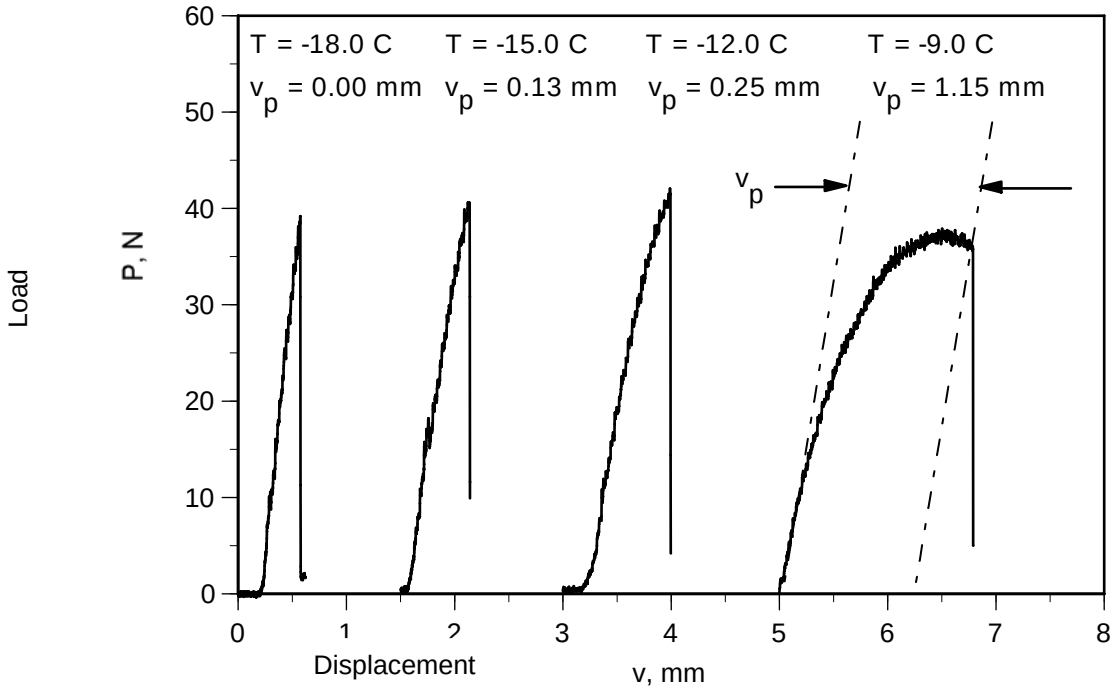


Figure 6 – Typical Load-Displacement Curves in CT Grading Tests