KTMR-34 DETERMINING DYNAMIC MODULUS OF HOT-MIX ASPHALT CONCRETE AND COLD-IN-PLACE RECYCLE MIXTURES (Kansas Test Method KTMR-34)

A. SCOPE

This test method covers procedures for preparing and testing asphalt concrete mixtures to determine the dynamic modulus and phase angle over a range of temperatures and loading frequencies. This test is applicable to laboratory prepared specimens of mixtures with nominal maximum size aggregate less than or equal to 1.48 in. (37.5 mm).

b. REFERENCED DOCUMENTS

b.1. AASHTO R 30; Practice for Mixture Conditioning of Hot-Mix Asphalt (HMA)

b.2. AASHTO T 166; Bulk Specific Gravity of Compacted Hot-Mix Asphalt Mixtures

b.3. AASHTO T 209; Maximum Specific Gravity of Bituminous Paving Mixtures

b.4. AASHTO T 269; Percent Air Voids in Compacted Dense and Open Asphalt Mixtures

b.5. AASHTO T 312; Method for Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

b.6. AASHTO TP 62-07; Determining Dynamic Modulus of Hot-Mix Asphalt Concrete Mixtures

c. SUMMARY OF METHOD

c.1. A sinusoidal (haversine) axial compressive stress is applied to a specimen of asphalt concrete at a given temperature and loading frequency. The applied stress and the resulting recoverable axial strain response of the specimen is measured and used to calculate the dynamic modulus and phase angle.

c.2. Figure 1 presents one schematic of the dynamic modulus test that is in use.

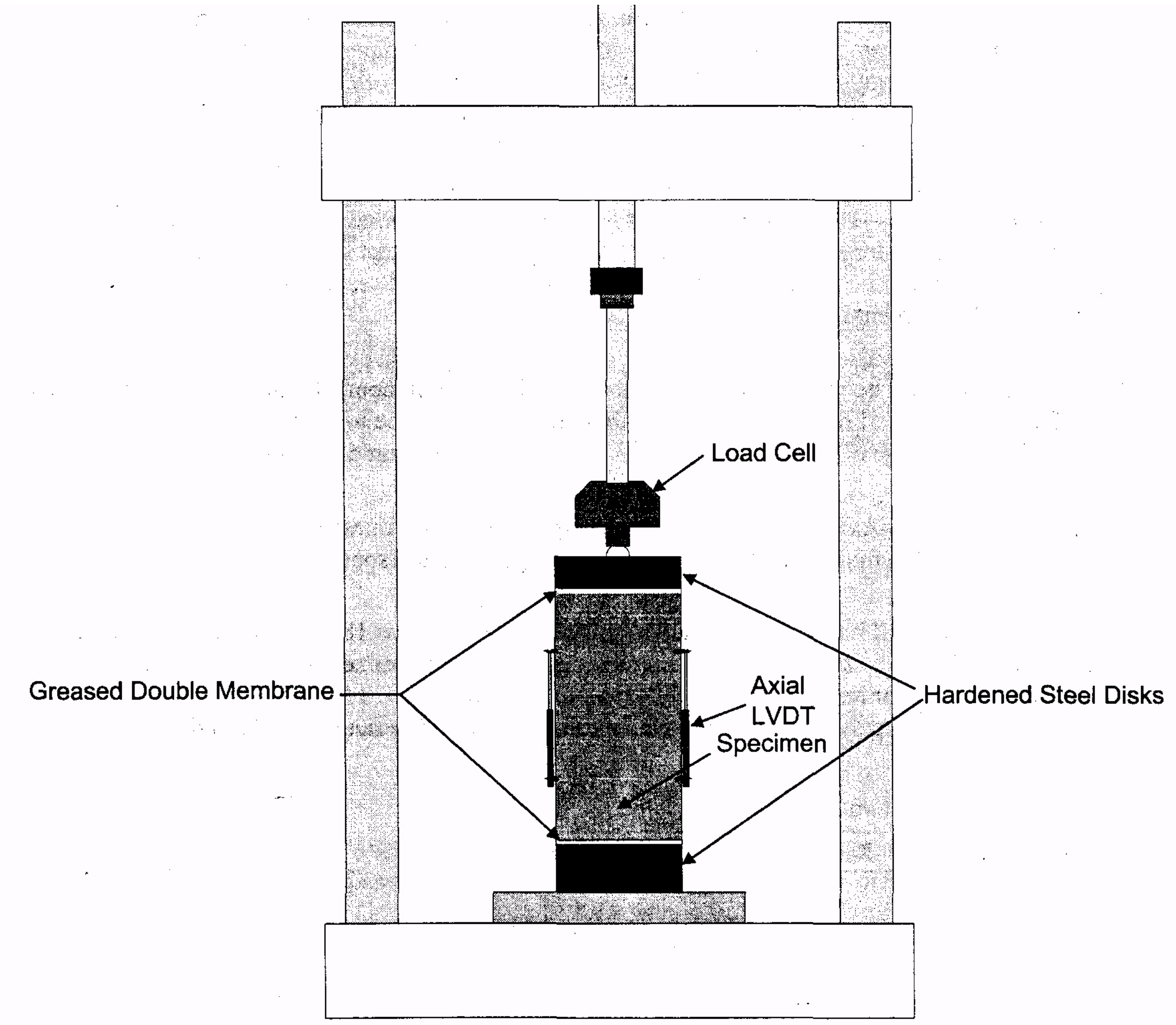

Figure 1 General Schematic of Dynamic Modulus Test

d. APPARATUS

d.1. Dynamic Modulus Test System, a dynamic modulus test system consisting of a testing machine, environmental chamber, and measuring system

d.2. Testing Machine, A servo-hydraulic testing machine capable of producing a controlled haversine compressive loading. The testing machine should have a capability of applying load over a range of frequencies from 0.1 to 25 Hz and stress level up to 400 psi (2800 kPa).

d.3. Environmental Chamber, A chamber for controlling the test specimen at the desired temperature. The environmental chamber shall be capable of controlling the temperature of the specimen over a temperature range from 14 to 140^{o} F (-10 to 60^{o} C) to an accuracy of $\pm 1^{o}$ F (0.5^{o} C). The chamber shall be large enough to accommodate the test specimen and a dummy specimen with thermocouple mounted at the center for temperature verification.

d.4. Measurement system, The system shall be fully computer controlled capable of measuring and recording the time history of the applied load, and the axial deformations. The system shall be capable of measuring the period of the applied sinusoidal load and resulting deformations with a resolution of 0.5%.

d.5. Load, The load shall be measured with an electronic load cell in contact with one of the specimen caps. The load cell shall be calibrated in accordance with AASHTO T-67. The load measuring system shall have a minimum range of 0-5600 lb (0 to 25 kN) with a resolution of 1 lb (5 N).

d.6. Axial Deformations, Axial deformations shall be measured with linear variable differential transformers (LVDT) mounted between gauge points glued to the specimen as show in figure 2. The deformations shall be measured at a minimum of two locations 180 degrees apart; however, three locations located 120 degrees apart is recommended to minimize the number of replicate specimens required for testing. The LVDTs shall have a range of ± 0.02 in (0.5 mm). The deformation measuring system shall have auto zero and selectable ranges as defined in Table 1.

Table 1 Deformation Measuring System Requirements

Range, in. (mm)	Resolution, in. (mm)
±0.01969 (0.5)	0.00039 (0.0100)
±0.00984 (0.25)	0.00020 (0.0050)
±0.00492 (0.125)	0.00010 (0.0025)
±0.00246 (0.0625)	0.00004 (0.0010)

d.7. Loading Platens, sized 104.5 ± 0.5 mm, are required above and below the specimen to transfer the load from the testing machine to the specimen. Generally these platens should be made of hardened or plated steel, or anodized high-strength aluminum. Softer materials will require more frequent replacement. Materials that have linear elastic modulus properties and hardness properties lower than that of 6061-T6 aluminum shall not be used.

d.8. End Treatment, friction reducing end treatments shall be placed between the specimen ends and the loading platens. The end treatments shall consist of two Teflon® sheets or two 0.5 mm (0.02 in.) thick latex membranes separated with silicone grease.

d.9. Superpave Gyratory Compactor, a gyratory compactor and associated equipment for preparing laboratory specimens in accordance with T 312. The compactor shall be capable of compacting 6.7 in. (170 mm) high specimen.

d.10. Saw, A machine for sawing test specimen ends to the appropriate length is required. The saw shall have a diamond cutting edge and shall be capable of cutting specimens to the prescribed dimensions without excessive heating or shock.

d.11. Core Drill, A coring machine with cooling system and a diamond bit for cutting nominal 4.00 in. (101.6 mm) diameter test specimens.

e. TEST SPECIMENS

e.1. Size, Dynamic modulus testing shall be performed on test specimens cored from gyratory 6 in (150 mm) compacted mixtures. The average diameter of the test specimens shall be between 3.94 and 4.1 in. (100 and 104 mm) with a standard deviation of 0.04 in. (1.0 mm). The average height of the test specimen shall be between 5.81 and 6.00 in. (147.5 and 152.5 mm).

e.2. Aging, Laboratory prepared mixtures shall be temperature-conditioned in accordance with the four-hour short-term oven conditioning procedure in R 30. Field mixtures need not be aged prior to testing.

e.3. Gyratory Specimens, Prepare 6.7 in. (170 mm) tall specimens to the required air void content in accordance with T 312.

e.4. Coring, Core the nominal 4.0 in. (101.6 mm) diameter test specimens from the center of the gyratory specimens. Both the core drill and the gyratory specimen should be adequately supported to ensure that the resulting test specimen is cylindrical with side are smooth, parallel, and free from steps, ridges, and grooves.

e.5. Diameter, Measure the diameter of the test specimen at the mid-height and third points along axes that are 90 degrees apart. Record each of the six measurements to the nearest 0.04 in. (1 mm). Calculate the average and the standard deviation of the six measurements. If the standard deviation is greater than 0.10 in. (2.5 mm), discard the specimen. For acceptable specimens, the average diameter reported to the nearest 0.04 in. (1 mm) shall be used in all material property calculations.

e.6. End Preparation, The ends of all test specimens shall be smooth and perpendicular to the axis of the specimen. Prepare the ends of the specimen by sawing with a single or double bladed saw. The prepared specimen end shall meet the tolerances described below. Reject test specimens not meeting these tolerances.

e.6.1. The specimen ends shall have a cut surface waviness height within a tolerance of ±0.002 in. (±0.05 mm) across any diameter. This requirement shall be checked in a minimum of three positions at approximately 120 degree intervals using a straight edge and feeler gauges approximately 0.32 to 0.49 in. (8.1 to 12.5 mm) wide or an optical comparator.

e.6.2. The specimen ends shall not depart from perpendicular to the axis of the specimen by more than on degree, equivalent to 0.11 in. in 6.1 in. (2.7 mm in 152.4 mm). This requirement shall be checked on each specimen using a machinist’s square and feeler gauges.

e.7. Air Void Content, Determine air void content of the final test specimen in accordance with T 269. Reject specimens with air voids that differ by more than 0.5 percent from the target air voids.

e.8. Replicates, The number of test specimens required depends on the number of axial strain measurements made per specimen and the desired accuracy of the average dynamic modulus. Three replicate specimens should be tested to obtain a desired accuracy limit (e.g. less than ±15 percent of the true dynamic modulus). Table 2 summarizes the estimated accuracy associated with the number of specimens.

Table 2 Estimated Accuracy Related to the Number of Specimens

LVDT's per Specimen	Number of Specimens	Estimated Limit of Accuracy
2	2	±18.0 %
2	3	±15.0 %
2	4	±13.4 %
3	2	±13.1 %
3	3	±12.0 %
3	4	±11.5 %

e.9. Sample Storage, If test specimens will not be tested within two days, wrap specimens in polyethylene and store in an environmentally protected storage area at temperatures between 40 and 60ºF (5 and 15 ºC). Specimens shall not be stacked during storage. To eliminate effects of aging on test results, it is recommended that specimens be stored no more than two weeks prior to testing.

f. PROCEDURE FOR HOT MIX ASPHALT (HMA)

f.1. KTMR-34 follows the procedures outlined in AASHTO TP 62-07.

g. PROCEDURE FOR COLD-IN-PLACE RECYCLE MIXTURES (CIR)

g.1. Perform the Dynamic Modulus testing according to AASHTO TP 62-07 with the following exceptions:

g,1.1. Specimens using the medium gradation and optimum design emulsion content shall be 150 mm in diameter and at least 173-180 mm in height after compaction. Cure the test specimens at 140ºF no less than 48 hours and no more than 72 hours. Check specimen weight every 2 hours after 48-hour cure to check with compliance of no more than 0.05% change in weight in 2 hours. After curing, core and cut the specimens to the dimensions required in the test method. Check the air voids of the cored and cut specimen prior to testing and verify that the specimens are within ±1% of the value given at the optimum design emulsion content.

g.1.2. Do not perform the 4-hour short-term oven conditioning procedure on the samples.

g.1.3. The values to be reported from this procedure are those listed in Table 3. The graphical representation of the constructed master curve, or the individual curves, shall also be included in the report.

Table 3 Required input Data

Temperature, ºF	Replicate	Mixture |E*|, psi at Frequency Noted					
		0.1	0.5	1	5	10	25
14	1						
	2						
	3						
	4						
40	1						
	2						
	3						
	4						
70	1						
	2						
	3						
	4						
100	1						
	2						
	3						
	4						
130	1						
	2						
	3						
	4						

NOTE: Reporting Dynamic Modulus of CIR Mixtures

The Dynamic Modulus data is being reported to give an indication of the validity of this test method for cold mix processes and to provide valuable information for input to the AASHTO 2002 Design Guide.