APPENDIX B

DETERMINATION OF FLEXURAL STRENGTH AND MODULUS OF ELASTICITY OF BITUMINOUS CONCRETE

B-1. Purpose. This appendix describes procedures for preparation and testing of bituminous concrete to determine flexural strength and modulus of elasticity. The procedures are an adaptation of tests conducted on portland cement concrete specimens.

B-2. Applicable Standards. The standard applicable to this procedure is ASTM C 78.

B-3. Apparatus. Apparatuses required are a testing machine capable of applying repetitive loadings for compaction of beam specimens 6 by 6 by 21 inches to the design density (an Instron electromechanical testing machine meets this requirement); a steel mold, suitably reinforced to withstand compaction of specimens without distortion; two linear variable differential transformers (LVDT's); a 5,000-pound load cell; an X-Y recorder; and a testing machine for load applications conforming to ASTM C 78 (a Baldwin or Tinius Olsen hydraulic testing machine is suitable for this purpose).

B-4. Materials. Sufficient aggregate and bitumen meeting applicable specifications to produce six 6- by 6- by 21-inch test specimens are required. In the event the proportions of aggregate and bitumen, bitumen content, and density of compacted specimens are not known, additional materials will be required to conduct conventional Marshall tests to develop the needed mix design data.

B-5. Sample Preparation.

a. Prepare in a laboratory mixer four portions of paving mixture for one 6- by 6- by 21-inch beam test specimen consisting of aggregate and bitumen in the proportions indicated for optimum bitumen content. The total quantity of paving mixture should be such that when compacted to a uniform 6- by 6-inch cross section, the density of the beam will be as specified from previous laboratory mix design tests or other sources. The temperature of the paving mixture at the time of mixing should be such that subsequent compaction can be accomplished at 250 $\pm$ 5 degrees Fahrenheit. Place two of the four portions in the 6- by 6- by 21-inch reinforced steel mold and compact to a 3-inch thickness with a 6- by 6-inch foot attached to the repetitive loading machine. Shift the mold between load applications to distribute the compaction effort uniformly. Add the remaining two portions and continue compaction until the paving mixture is compacted to a 6- by 6-inch cross section. After compaction and while the mixture is still hot, place a 6- by 21-inch steel plate on the surface of the paving mixture and apply a leveling load of 2,000 pounds to the plate for 30 minutes. Prepare six beam test specimens in the manner described.

b. After cooling, remove the beams from the molds and rotate 90 degrees so that the smooth, parallel sides will become the top and bottom. Cement and L-shaped metal tab with quick-setting epoxy glue to each 6- by 21-inch side of the beams on the beams' neutral axes at midspan. The tabs should be drilled for attachment of the LVDT's. Cure and condition the beams at 75 $\pm$ 5 degrees Fahrenheit for 4 days prior to testing and record the temperature.

B-6. Test Procedure. Place the specimens in the test machine as described in ASTM C 78. Place thin Teflon strips at the point of contact between the test specimens and the load-applying and load-support blocks. While the beams are being prepared for testing, place an additional support block at midspan to prevent premature sagging of the beams. Remove this support block immediately prior to the initiation of load application. Mount the LVDT's on laboratory stands on each side of the beams, and attach the LVDT's to the L-shaped tabs on the sides of the beams. Connect the LVDT's and load cell to the X-Y recorder. Make final adjustments and checks on specimens and test equipment. Apply loading in accordance with ASTM C 78, omitting the initial 1,000-pound load.

B-7. Calculations.

a. The modulus of rupture R is calculated from the following equation (from ASTM C 78)—

$$R=PL/bd^2 \qquad \text{(eq B-1)}$$

where

R = modulus of rupture, psi
P = maximum applied load, pounds
L = span length, inches (18 inches)
b = average width of beam, inches
d = average depth (height) of beam, inches

b. The modulus of elasticity E is calculated from the following equation:

$$E = \frac{23PL^3}{1296\Delta I} k \qquad \text{(eq B-2)}$$

where

E=static Young's modulus of elasticity, psi
P=applied load, pounds
L=span length, inches (18 inches)
Δ=deflection of neutral axis, inches, under load P
I=moment of inertia inch^4 (=bd^3/12)
k=Pickett's correction for shear (third-point loading).

(Values of E for bituminous beams should be calculated without using Pickett's correction k for shear.)

B-8. Report. The report shall include the following:

a. Gradation of Aggregate.
b. Type and Properties of Bituminous Cement.
c. Bituminous Concrete Mix Design Properties.
d. Bituminous Concrete Beam Properties.
e. Modulus of Rupture.
f. Modulus of Elasticity.