1. SCOPE

1.1. Description of Test

The Force Ductility test is a measure of the tensile properties of the polymer modified asphalt cement residue of a polymer modified emulsified asphalt.

1.2. Unit of Measure

The force ductility is measured by determining the load/time relationship for a test specimen, then evaluating this relationship to determine the force required to maintain a specific elongation rate of a test sample, at a certain elongation, at a specific temperature.

2. APPARATUS AND MATERIALS

2.1. Equipment

A water bath and thermometers conforming to the specifications described in ASTM Designation D113-86.

Molds for the test specimen conforming to the specifications described in ASTM Designation D113-86 except that it is necessary to use molds with straight sides to produce a test specimen of constant cross section.

A testing machine as described in ASTM Designation D113-86 including force cells that are to be placed in direct line with the test specimen such that the load applied to the test specimen will be transmitted directly to the load cells. Minimum load cell resolution shall not be greater than 1% of maximum specimen load.

A data acquisition apparatus to continuously record load output from the load cell as the test proceeds. A real time analog chart recorder can be used or more sophisticated data acquisition systems which convert analog signals to digital for later processing by micro-computer.

3. PROCEDURE

3.1. Sample Preparation

The sample shall consist of the asphalt cement residue obtained from the distillation of a polymer modified emulsified asphalt.

3.2. Equipment Preparation

Assemble the mold on a flat and level brass or glass plate thoroughly coat the surface of the plate and the inside surfaces of the middle brass spacers with a thin layer of a mixture off glycerin and talc to prevent the test material from sticking.

Strain the melted sample through a 300 mm sieve.

3.3. Testing Procedure

After a thorough stirring pour the sample in the mold. In filling the mold, take care to pour the material in a stream back and forth from end to end until the mold is more than level full. Take care not to disarrange the parts and thus distort the specimen.

Allow the test specimen to cool to room temperature for 15 minutes and then place in a water bath at 4^{o} C for 15 minutes.

Remove the test specimen from the water bath and cut off excess bitumen with a hot, straight edged putty knife or spatula to make the mold just level full.

Place the trimmed specimen and mold back in the water bath at 4^{o} C for 30 minutes prior to testing.

Remove the test specimen from the plate by a shearing action between the specimen and plate, avoiding any bending of the test specimen. Detach the side pieces and attach the specimen to the pins.

Position the crosslead and ensure that the load cells are attached to the specimen.

Set the elongation rate for 5 cm/min.

Start the strip chart recorder and engage the drive when the recorder pen reaches a major division. This records the relationship between load and time.

Elongate the specimen for 100 cm or until the test specimen ruptures.

While the test is being made, the water in the tank of the testing machine shall cover the specimen both above and below by at least 2.5 cm and shall be kept continuously at the temperature of 4^{o} C $\pm$ $.5^{o}$ C.

Refer to the relationship between load and time and determine the load in kg at 800% elongation at the elongation rate 5 cm/minute at a test temperature of 4^{o} C. Report this value.

3.4. Additional Testing

The relationship between time of test and strain shall be evaluated prior to testing using a sample of the test material. This may be accomplished by measuring the rate at which two gage marks on the surface of the specimen diverge during testing. Gage marks should be located on the surface of the specimen by centering within the confines of the side pieces to provide a gage length of 3 cm. Strain rate shall be determined for each material evaluated. This information is used in determining the Engineering Stress-Strain relationship.

From this additional testing other information may be obtained from the original test. The following is a summary.

Engineering Stress-Strain: convert the load-time curve to an engineering stress-strain curve. Engineering stress is calculated by dividing load at any point during the test by the original specimen cross-section of 1 sq. cm. Engineering strain is obtained by multiplying the deformation rate by the time at any moment during the test. Plot engineering stress as a function of engineering strain. Evaluate maximum engineering stress and strain.

True Stress-Strain: convert the engineering stress-strain curve to a true stress-strain curve. True stress is calculated as the ratio of load to the specimen cross-sectional area at any given time. True strain is the sum of all the engineering strains, which can be calculated by taking the logarithm of (1 + engineering strain). Plot true stress as function of true strain. Evaluate maximum true stress and strain.

Asphalt Modulus: determine the slope of the stress-strain curves in the linear portion after initial loading and prior to initial load decline.

Asphalt-Modifier Modulus: determine the slope of the true stress-strain curve in the linear portion after initial load decline and during secondary loading, prior to secondary load decline.

Area Under Stress-Strain Curve: calculate the area under either stress-strain curve described above. Record this area as the work required to fail the test specimen in tension, or that required to elongate the test specimen the full length of 100 cm.

4. ADDITIONAL INFORMATION

4.1. Precautions

Change in readings may be noticed when immersing the test specimen into the water bath which is at a lower temperature than room temperature. This change should not be excessive and the zero adjustment maybe used to compensate for this change.

Do not immerse the FD-4 beyond the marking on the base. A one inch safety margin is allowed to protect the LVDT.

If a maximum pull of 66.7 Newtons is exceeded, the elastic limit of the springs may be exceeded and permanent deformation may result.

4.2. References

ASTM Designation D113-86, Standard Test Method for Ductility of Bituminous Materials, Volume 4.03

ASTM Proposed Designation, Force-Ductility of Bituminous Materials

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