COMMENTARY TO AG:PT/T124 - TOUGHNESS OF POLYMER MODIFIED BINDERS (ARRB EXTENSIOMETER)

PREFACE

This modified binder test method was prepared by The bituminous Surfacing Research Reference Group on behalf of Austroads. Representatives of Austroads, ARRB Group and the Australian Asphalt Pavement Association have been involved in the development and review of this test method.

FOREWORD

Polymer modified binders (PMBs) exhibit complex rheological behaviour and, consequently, simple testing equipment will not provide a satisfactory measure of their characteristics. Toughness is a property which is considered to be an important PMB performance characteristic and is an indication of the cohesive strength of a PMB under strain and retention of that strength during extension.

SCOPE

This test method sets out the procedures for the determination of toughness of PMBs under specific conditions of deformation using the ARRB Extensiometer.

Further Development

There are no further plans for the development of this test method.

TOUGHNESS OF POLYMER MODIFIED BINDERS (ARRB EXTENSIOMETER)

1 REFERENCED DOCUMENTS

The following documents are referred to in this method:

AUSTROADS

AG:PT/T101	Method of sampling polymer modified binders, polymers and crumb rubber
AG:PT/T102	Protocol for handling polymer modified binders in the laboratory
AG:PT/T121	Elastic recovery, consistency and stiffness of polymer modified binders (ARRB Elastometer)

2 PRINCIPLE

The Extensiometer operates by straining, in tension, a sample of binder between two parallel end plates, at a controlled elongation rate and to a desired preset elongation. The resultant force is monitored along with the actual displacement. The normally specified test temperature is 4°C.

3 APPARATUS

The following apparatus is required:

a. ***ARRB Extensiometer*** – This exists in two versions, manually controlled version, or the PC-controlled version. The Extensiometer is shown in Fig. 1, and described in the Elastometer User Manual (1996).

b. ***Recording device*** -

   i. ***For manually controlled instrument***: 2-pen Chart recorder, such as a Pantos Model U228-2P-500, or alternatively a suitable PC based data acquisition system.

   ii. ***For PC controlled instrument***: A PC with minimum requirements of a 486/33 with 8Mb RAM, 540Mb hard disk and operating under Windows 3.1.

c. ***Constant temperature bath*** - capable of maintaining a temperature of 0°C to 25°C to within ± 0.1°C, such as a LAUDA Model MS 20, or equivalent, coupled with an auxiliary cooling unit, or equivalent device. The water bath must be of suitable dimensions to satisfactorily accommodate the Extensiometer and provide a water depth of 350 mm for immersion of the sample. The bath is fitted with a special overflow vessel to achieve this.

d. ***Sample moulds*** - consisting of a silicone rubber mould for casting a square section specimen, with the dimensions of 9 mm x 9 mm and 25 mm long, integral with two end plates and a mould keeper.

e. ***Forced convection oven*** - conforming to the requirements of AG:PT/T102.

f. ***Thermometer*** - calibrated for measuring the temperature in the overflow vessel of the water bath to ± 0.1°C at the required test temperature.

g. ***Pouring containers*** – 50 mL beakers, or small cans, with a pouring lip (other sizes may be required).

4 CALIBRATION

The operational dimensions and accuracy of the instrument must be checked periodically. The procedure is similar to that for the ARRB elastometer (refer AG:PT/T121), except for the long travel displacement transducer, and is as follows:

4.1 General

a. ***Sample moulds*** - Regularly check the silicone rubber moulds and endplates for damage.

b. ***Balance wheel -*** Check the wheel for free movement after removing the counterweight cable. There should be negligible friction.

c. ***Level -*** Check the level of the instrument regularly to ensure that the pullrod hangs centrally and clears the hole in the load cell.

4.2 Electronics

The instrument control unit, including chart recorder or PC, must be switched on at least half hour before use to allow the electronics to stabilise. The instrument must be operated in a stable temperature environment, as substantial temperature changes can influence the accuracy of the system. The calibration procedures are as follows:

4.2.1 Manually controlled instruments

a. ***Force -*** A 200 N load cell has been fitted to the Extensiometer. The accuracy of the load cell can be checked regularly using the built in calibration function (*cal*). This simulates a load application and provides a calibrated reference output, which has been set to 190.00 N. Firstly, zero the output with the load cell unloaded. Then press the *cal* button and check the output as shown on the meter. If the reading is within 0.1% of the reference output, then the functioning of the load cell can be regarded as correct.

   At six monthly intervals, the load cell accuracy should be checked by applying a known load. This is done by hanging an accurately known mass (5 to 10 kg) from the load cell and checking the output, which should be within 0.1%. It may be convenient to remove the sample holder assembly for this operation.

b. ***Speed -*** This should be checked on a regular basis by analysing the displacement versus time chart during the loading phase. This will also provide a verification of the correct function of the displacement transducer.

c. ***Displacement -*** The calibration of the displacement transducer (LVDT) is checked by measuring the output for a given displacement of about 200 mm. Using the *slow* controls, position the drive unit to the start position and zero the displacement transducer output. Then move the unit up by about 200 mm and accurately measure

the displacement and the corresponding transducer output. The calibration should correspond to a value of 10 V for a displacement of 250 mm. (ie. 0.04 V/mm)

4.2.2 PC controlled instruments

The calibration of Force, Speed and Displacement is fully automated, with minimal actions required by the operator. The procedures are self-contained, with full instructions on the PC screen via the control software.

The calibration routines are selected under *Calibration* in the ARRB PMB Test System main menu. They are carried out quickly, and it is recommended that a check of the calibration be performed at least at the beginning of each day of testing.

5 PREPARATION OF SAMPLES

5.1 General

PMBs are complex mixtures of polymers and a variety of petroleum products. If handled in accordance with the directions of the suppliers, there should be no significant risk. The hazard of burns with PMBs is greater than with standard bitumens, due to the (normally) higher handling temperatures. It is recommended that notices, describing the action to be taken in the event of bitumen or PMB burns, should be displayed in the laboratory in the areas where bitumen and PMBs are handled. A suitable warning could be as follows:

WARNING: HOT BITUMEN & PMBs CAN CAUSE BURNS

The following precautions should be taken when handling bitumen, or PMBs:

a. Eye protection, such as safety glasses and/or face shields, shall be worn when handling hot bitumen or PMBs.

b. Heat-resistant gloves, with close-fitting cuffs, and other suitable protective clothing, shall be worn when handling hot bitumen or PMBs.

c. There shall be no smoking while handling hot bitumen or PMBs.

d. While the material is still cold, loosen the lid of the sample container (invert the can and warm the lid, if necessary), or punch a hole in the lid.

e. Examine the cold sample for the presence of water. If water is thought to be present, drain most of it out, or blow with clean compressed air to evaporate the free water.

5.2 Sample Preparation

Samples for testing shall be provided in accordance with AG:PT/T101 and AG:PT/T102.

5.3 Pouring Containers

These are smaller containers, with a pouring lip to facilitate pouring of the binder into the moulds. Small beakers (50 mL) are recommended. For higher consistency binders, a larger number of smaller containers may be needed. For more fluid binders, a larger container

may be used to fill more moulds, before the material becomes too viscous to pour easily (see Note 1).

6 PROCEDURES

6.1 Chart Recorder Adjustments

a. ***Displacement channel -*** Set the recorder sensitivity to 10 V full scale. This corresponds to a displacement of 250 mm and is used in conjunction with a break point of 250 mm (ie 100% full scale). For other displacements, when selecting a different break point, set the sensitivity accordingly. For example, select 5 V for a 125 mm displacement (and break point).

b. ***Force channel -*** Set the recorder sensitivity to 10 V full scale. This corresponds to a force of 200N (see Note 2) for a full scale chart deflection.

For repeat testing, where the expected force is known, select an appropriate sensitivity for that channel. In other cases, initially use the high setting.

c. ***Zero check -*** Zero both channels by switching to *check* mode and using the position control. Switch back to *measure* mode for testing. Generally, this operation only needs to be done at the start of each day and requires occasional checking during testing.

d. ***Chart speed -*** Select a chart speed of 60 mm/(min). For the standard test speed of 0.7 mm/s and displacement of 250 mm, a recorder trace of about 360 mm will be obtained. Use the *normal* mode if the chart recorder has been modified.

6.2 Extensiometer Adjustments

6.2.1 Manually controlled instruments only

a. ***Mode -*** Switch over to *Extensiometer* mode, and select either *return* or *stop*. In the *return* mode, the drive unit returns slowly to the starting position at the end of the test. This mode is generally more convenient, but the elongated samples can move around and stick to the instrument. In the *stop* mode, the drive unit stops at the end of the test. The sample can then be removed, but the drive unit must be returned manually to the starting position.

b. ***Speed -*** Select a speed of 0.70 mm/s and check the setting accuracy on the meter. Use the low range of the speed dial (0 to 10 mm/s).

c. ***Break Point*** - Select a break point of 10.00 corresponding to 250 mm travel. Check the dial setting accuracy on the meter.

d. ***Zero*** - Adjust the zero controls for both force and displacement until the red indicator lights extinguish and the green light is on. This indicates that the zero is within the acceptable preset limits and can be checked on the meter.

6.2.2 PC controlled instruments only

The system runs under Windows 3.1, and all operating adjustments are made using the PC.

a. Select ARRB PMB Test System from the Program Manager to bring up the operations main menu.

b. Select the *Extensiometer / Run Test* function to bring up the *Extensiometer Run Parameters* window.

c. Enter all relevant details of the experiment as requested. The test cannot progress until all required information has been supplied. The following information will be required:

   i. Run number, Date and Time (automatic).

   ii. Operator.

   iii. Sample mould. Select XA (only one choice at present)

   iv. Temperature.

   v. Speed (or strain rate)

   vi. Break Point (or strain).

   vii. Timer - Select required time delay before test starts after pressing START.

   viii. Mode - Select Return. (Hold is for future development)

   ix. Sample description. Two lines of text available. *

   x. Comments (optional). Three lines of text available. *

* Do not use *Enter* key after the second (or third) line, as this will delete first line of text.

6.3 Preparation of Moulds

a. Assemble the silicone rubber mould with the two end plates in the support keeper.

b. Heat the assembly to 180°C in the sample preparation oven.

c. Using a 50 mL beaker, pour the sample slowly into the mould and avoid trapping air. Overfill to 0.5 mm of the top of the silicone rubber mould.

d. Be careful not to pour binder on the mould surrounds as the sample cannot be satisfactorily trimmed afterwards. If trimming is required, this should be carried out by levelling the sample with a hot blade.

e. Allow the specimens to cool at room temperature for 60 minutes, then place in the water bath for a further 15 minutes before testing. Avoid rapid cooling since rapid contraction can distort the sample and lead to adhesion failure at the face of the end plate(s).

f. Trim the surface of the sample if required.

6.4 Loading the Sample into Extensiometer

a. Maintain the overflow vessel of the waterbath at the test temperature (see Note 3), within ± 0.1°C. Due to thermal losses the waterbath temperature has to be maintained slightly lower than the overflow vessel.

b. Before loading the sample mould into the instrument, ensure that the drive unit is correctly positioned.

Normally the drive unit is automatically positioned correctly after a test run. If this is not the case, then position it as follows:

i. **Manually controlled instrument***:* Switch to *run*, and using the *slow* controls, move the drive unit up about 1 mm and then down until it stops automatically in the correct starting position. Switch back to *standby* until ready to test.

ii. **PC-controlled instrument***:* Using the *up*/*down* switch on the motor controller, move the drive unit up about 1 mm and then down until it automatically stops in the correct starting position, which is indicated by the illumination of the ***ready*** light on the motor controller module.

c. Immediately prior to testing, remove the keeper from the mould.

d. Assemble the sample into the Extensiometer, keeping the silicone rubber mould as support. Fit the sample so that the shaft of the upper plate locates fully in the pullrod, and secure with the two grub screws.

e. Lower the pull rod and sample so that it hangs freely from the load cell, and the shaft of the lower end plate fits loosely into the base plate. Secure the lower end plate with the two grubscrews. The silicone rubber mould can now be removed carefully.

f. Lower the Extensiometer into the overflow vessel.

g. Leave the sample for 15 minutes to achieve temperature equilibrium before starting the test.

6.5 Testing (manually controlled instruments only)

a. Switch to *run* on the motor drive (red flashing light will extinguish).

b. Lower both pens of chart recorder. Select normal for the chart drive (if modified).

c. Recheck zero for force and displacement on the Extensiometer.

d. Press the start button to commence the test. Simultaneously (or just before) switch on the chart drive of the recorder. This will happen automatically if the recorder has been modified. The Extensiometer will begin straining the sample and will automatically stop when the break point is reached.

e. At the end of the test, switch off the chart drive, either directly or using the stop / reset button, if automatic.

f. Raise the Extensiometer out of the waterbath. Inspect the sample for any signs of imperfection in straining, such as uneven cross-section or trapped air bubbles.

g. Record all test conditions on the chart such as:

i. Sample description.

ii. Sample mould.

iii. Temperature.

iv. Speed.

v. Break Point.

vi. Recorder voltage settings and chart speeds used.

vii. Comments.

viii. Operator.

6.6 Testing (PC-controlled instruments only)

The Extensiometer can be started in two modes, either directly, or via a timer delay function. The delay mode has been provided to allow a 15 minute period for temperature equilibration of the sample, after which the test is automatically started. (Other times are available if required).

a. ***Direct mode -*** Set timer for 0 min. in Run parameters. Leave the sample for 15 minutes to achieve temperature equilibrium, then click *START* to start the test.

b. ***Timer mode*** - Set timer for 15 minutes in Run parameters. Click *START* as soon as the run parameters have been entered and the sample has been lowered into the bath. The timer will then count down for 15 minutes and start the test automatically after this period. The test sequence and data acquisition will progress fully automatically. While the test is running progress is displayed on the screen as elapsed displacement.

7 CALCULATIONS

7.1 Manually Controlled Instrument

Measure the first peak force from the chart and record the displacement at which the maximum force occurred. Record the displacement at which the sample failed (characterised by a rapid drop in recorded load) and the load at this point, if it is not the maximum. Record the load at the point of maximum extension, if the sample did not go to failure.

Calculate the area under the force-displacement curve to the specified level of displacement (see Note 4) for both of the duplicate tests. Calculate the toughness as the mean of the two tests.

7.2 PC Controlled Instrument

All calculations are performed within the software with outputs displayed in summary form on the screen and available in hard copy form.

8 REPORT

a. Toughness, in Nm, and the corresponding displacement, in mm.

b. Force, in N, of the first peak, and the corresponding displacement, in mm, at which it occurred.

9 PRECISION

No inter-laboratory testing has been conducted for the range of PMBs currently available.

Notes

1. The temperatures and times for heating and stirring may need to be varied for certain materials in accordance with recommendations from suppliers.

2. For lower forces, other sensitivities may be used, eg select 2 V for a force of 20N.

3. The normally specified test temperature is 4°C.

4. Commonly specified displacement levels are 100 mm, 150 mm and 250 mm.

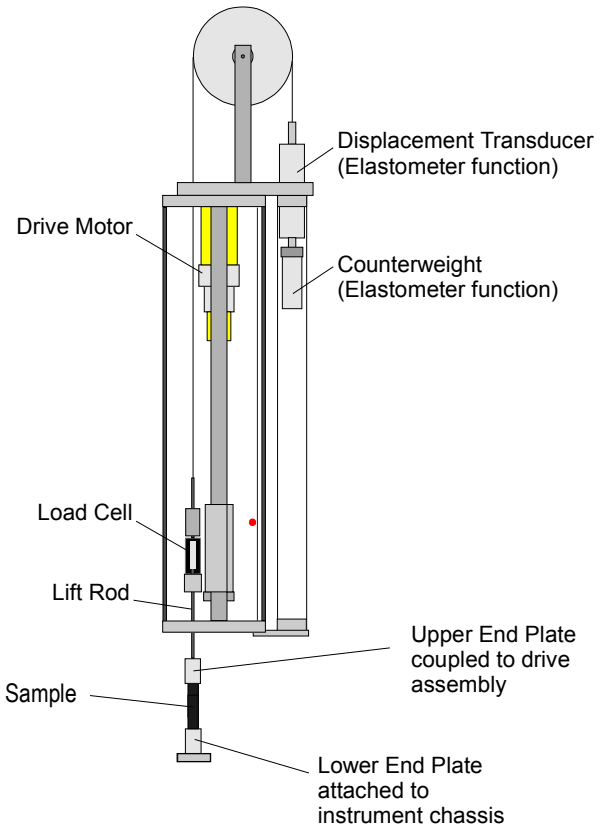

Fig. 1. The Elastometer is shown schematically in Extensiometer mode.

AMENDMENT RECORD

Amendment No.	Clauses amended	Action	Date
1	Commentary Page	New	June 2005
	Footer and header	Format	
	Applied revised test method number	Format	
	Applied new styles	Format	
2	Applied new test method numbers	Substitution	March 2006
	Moved notes to the end of the method	Format	

Key

Format	Change in format
Substitution	Old clause removed and replaced with new clause
New	Insertion of new clause
Removed	Old clauses removed