DETERMINING THE STRENGTH OF FIELD SAMPLES

1. SCOPE

This method describes the procedure to be followed to determine the Indirect Tensile Strength (ITS) and Tensile Strength Ratio (TSR) of a field sample of BSM.

2. SAMPLE PREPARATION

- **Taking of field samples**. A ± 50 kg sample of bitumen stabilised material may be taken at any point in the processing cycle (from behind the recycler, from stockpile at the mixing plant, from trucks transporting the mix or from behind the paver) and placed in a sealed plastic container for transport to the laboratory.
- **Sizing the material**. Pass the sample through a 19mm sieve and discard all particles larger than 19mm. Seal the sample in a container and place in an air cabinet at 25°C.
- **Moisture content adjustment**. Determine the moisture content of a small sample and, if necessary, adjust the moisture content of the entire remaining sample by drying back or adding water to achieve a moisture content of 100% of optimum moisture content. Return the sample to the sealed container and place back in an air cabinet at 25°C and delay manufacture specimens for a minimum of 30 minutes.

3. SPECIMEN MANUFACTURE

Use one of the following two procedures to manufacture 100 mm diameter specimens:

3.1. MARSHALL COMPACTION

- Prepare the Marshall compaction equipment by cleaning the mould, collar, base-plate and face of the compaction hammer;
- Place a round plastic or paper disc at the bottom of the mould;
- weigh sufficient material to achieve a compacted height of 63.5 ± 1.5 mm (usually ±1150g) and transfer into the mould avoiding segregation. Poke the mixture with a spatula 15 times around the perimeter of the mould and poke the surface 10 times, leaving the surface slightly rounded;
- Compact the material by applying 75 blows with the Marshall compaction hammer. Care must be taken to ensure that the hammer falls freely;
- Remove the mould and collar from the pedestal, invert (turn over), then replace it on the base plate and press it down firmly ensuring that it rests firmly on the base plate; and
- Compact the other face of the specimen with a further 75 blows.

3.2. VIBRATING HAMMER COMPACTION

- Prepare the compaction equipment by cleaning the mould, collar, base-plate and foot of the vibrating hammer;
- Place a round plastic or paper disc at the bottom of the mould;
- Weigh sufficient material to achieve a compacted height of 63.5 ± 1.5 mm (usually ±1150g) and transfer into the mould avoiding segregation. Poke the mixture with a spatula 15 times around the perimeter of the mould and poke the surface 10 times, leaving the surface slightly rounded;
- Lower the foot of the vibrating hammer on to the material and compact for 20 seconds. Care must be taken to ensure that the vibrating hammer slides freely in the mounting frame;

- Remove the mould and collar from the pedestal, invert (turn over), then replace it on the base plate and press it down firmly ensuring that it rests firmly on the base plate; and
- Compact the other face of the specimen for a further 20 seconds of vibrating hammer.

Following this process, manufacture six (6) specimens from each sample. Determine the moisture content of a small sample remaining after all specimens have been manufactured.

4. CURING

After compaction, remove each mould from the base-plate and, without removing the specimen, place them in an air cabinet at 25°C twenty-four (24) hours.

After 24 hours, carefully extrude the specimens by means of an extrusion jack. Number each specimen.

Carefully place the extruded specimens on a smooth flat tray and cure in a forced-draft oven for a further seventy-two (72) hours at 40°C.

5. DETERMINATION OF THE BULK DENSITY

After curing, leave the specimens overnight in an air cabinet at 25°C before testing. Then, for each specimen:

- Measure the height at four evenly-spaced places around the circumference and calculate the average height, h (cm);
- Measure the diameter, d (cm); and
- Determine the mass by weighing, M (g)

Calculate the bulk density of each specimen using the following formula:

$$BD = \frac{4 \times M}{(\pi \times d^2 \times h)} \times 1000$$

Where BD = bulk density (kg/m³)
h = height of specimen (cm)
M = mass of specimen (g)
d = diameter of specimen (cm)

Exclude from testing any specimen whose bulk density differs from the mean bulk density of the batch (six specimens) by more than 50 kg/m³. If more than one specimen differs from the mean bulk density by more than 50 kg/m³, abandon any further testing and start again with a fresh sample.

6. DETERMINATION OF INDIRECT TENSILE STRENGTH (ITS)

The standard ITS test is used to test the specimens under both dry and soaked conditions. The ITS is determined by measuring the ultimate load to failure of a specimen subjected to a constant deformation rate of 50.8 mm/minute on its diametrical axis. The procedure is as follows:

- After determining the bulk densities, place three of the specimens back in an air cabinet at 25°C;
- Submerge the remaining specimens (three, unless one was discarded after determining the bulk density) in a soaking bath with the water temperature controlled at 25°C for twenty-four (24) hours;
- After 24 hours, remove the specimens from the water bath and place them on a free-draining surface at 25°C for a minimum of two (2) hours.

Determine the load required to break each dry specimen as follows:

- Place the specimen onto the ITS test loading apparatus;
- Position the sample such that the loading strips are parallel and centred on the vertical diametrical plane;
- Place the transfer plate on the top bearing strip and position the assembly centrally under the loading ram of the compression testing device;
- Apply the load to the specimen, without shock, at a rate of advance of 50.8 mm per minute until the maximum load is reached;
- Record this load, P (in kN), accurate to 0.1 kN; and
- Measure the temperature at the centre of the broken face of the specimen.

Surface dry each of the soaked specimens and, in turn, determine the load required to break each specimen following the procedure described above.

Calculate the Indirect Tensile Strength (ITS) for each specimen (to the nearest 1 kPa) using the following formula:

$$ITS = \frac{2 \times P}{(\pi \times d \times h)} \times 10000$$

where ITS = Indirect Tensile Strength (kPa)
P = maximum applied load (kN)
h = average height of the specimen (cm)
d = diameter of the specimen (cm)

Calculate the dry Indirect Tensile Strength (ITS_{DRY}) by calculating the average of the ITS values determined for each of the three dry specimens.

Calculate the soaked Indirect Tensile Strength (ITS_{SOAKED}) by calculating the average of the ITS values determined for each soaked specimen.

7. DETERMINATION OF THE TENSILE STRENGTH RATIO (TSR)

Determine the tensile strength ratio (expressed as a percentage to the nearest 1%) using the following formula:

$$TSR = \frac{ITS_{SOAKED}}{ITS_{DRY}} \times 100$$

8. DETERMINATION OF THE DRY DENSITY

After breaking, determine the moisture content of each of the dry specimens by placing a weighed portion in a forced draft oven at 110°C for twenty-four (24) hours.

Calculate the dry density (to the nearest 1 kg/m³) of each specimen using the following formula:

$$DD = \frac{100}{(m+100)} \times BD$$

Where DD = dry density (kg/m³)
BD = bulk density determined in A5 above (kg/m³)
m = moisture content of sample (%).

9. REPORTING

Use the sheet on the following page to report the test results.

D3.9 INDIRECT TENSILE STRENGTH - REPORT SHEET

Project descrition							
Location of Sample					Date		
Sample Description:					Sample No.		
Maximum dry density (MDD)		kg/m3		Optimum moisture content (OMC)			%

Moisture content of sample			**From field**		**At moulding**
Pan Number					
Mass wet sample + pan	m1	g		g	
Mass dry sample + pan	m2	g		g	
Mass pan	mp	g		g	
Mass moisture	m1 - m2 = Mm	g		g	
Mass dry sample	m2 - Mp = Md	g		g	
Moisture content	Mm/Md x 100 = Mc	%		%	
Percent water to be added to field sample:	Pa = 0.75(OMC - Mc)	%			
Water added to 10 000g field sample:	(10 000/(100+Mc) x Pa) = g				

BRIQUETTE MANUFACTURE, CURING AND TESTING									
Briquette number									
Date manufactured									
Date placed in oven									
Date tested									
Average height	h	cm							
Diameter	d	cm							
Mass after curing	M	g							
Bulk density	BD	kg/m^3							
Average Bulk Density		kg/m^3							
Strength of Briquettes			Dry			Soaked			
Temperature at centre of broken briquette		°C							
Maximum load applied		kN							
Indirect Tensile Strength (ITS) = 2 x Load / (3.1416 x d x h)		kPa							
Average ITS		kPa							
Tensile strength ratio (TSR)		%							

DRY DENSITY OF BRIQUETTES WHEN TESTED									
Briquette number									
Pan number									
Mass wet sample + pan	m1	g							
Mass dry sample + pan	m2	g							
Mass pan	mp	g							
Mass moisture	m1 - m2 = Mm	g							
Mass dry sample	m2 - Mp = Md	g							
Moisture content	Mm/Md x 100 = Mc	%							
Dry Density	DD = BD x 100/(Mc+100)	kg/m^3							

D3.10 INDIRECT TENSILE STRENGTH - REPORT SHEET (EXAMPLE)

N2 - 21 Rehab Kokstad : sample taken behind recycler

Location of Sample	km 24+320	Date	3rd Feb 2009
Sample Description:	250mm full layer thickness	Sample	F 12 / 2/09

Maximum dry density (MDD)	2075	kg/m3	Optimum moisture content (OMC)	6.1	%

Moisture content of sample			From field		At moulding
Pan Number					B56
Mass wet sample + pan	m1	g	577.2	g	462.3
Mass dry sample + pan	m2	g	557.2	g	446.8
Mass pan	mp	g	231.1	g	186.7
Mass moisture	m1 - m2 = Mm	g	26.7	g	15.5
Mass dry sample	m2 - Mp = Md	g	326.0	g	260.1
Moisture content	Mm/Md x 100 = Mc	%	4.80%	%	5.96%

Percent water to be added to field sample:	Pa = 0.75(OMC - Mc)	%	1.3%
Water added to 10 000g field sample:	(10 000/(100+Mc) x Pa) = g		130

BRIQUETTE MANUFACTURE, CURING AND TESTING

Briquette number			B56/1	B56/2	B56/3	B56/4	B56/5	B56/6
Date manufactured			2009/02/03					
Date placed in oven			2009/02/03					
Date tested			2009/02/06			2009/02/07		
Average height	h	cm	58.4	58.5	58.5	59	58.3	58.5
Diameter	d	cm	10.1	10.1	10.1	10.1	10.1	10.1
Mass after curing	M	g	982	979	884	984	989	993
Bulk density	BD	kg/m³	2074	2064	1864	2057	2092	2094
Average Bulk Density		kg/m³		2069	OUT		2081	
Strength of Briquettes				Dry			Soaked	
Temperature at centre of broken briquette		°C		25.2			24.8	
Maximum load applied		kN	3.6	3.4		2.7	2.5	2.8
Indirect Tensile Strength (ITS) = 2 x Load / (3.1416 x d x h)		kPa	386.3	364.2		286.7	268.7	299.9
Average ITS		kPa		375.2			285.1	
Tensile strength ratio (TSR)		%		76				

DRY DENSITY OF BRIQUETTES WHEN TESTED

Briquette number			B56/1	B56/2		B56/4	B56/5	B56/6
Pan number			G23	A17		B02	C12	F11
Mass wet sample + pan	m1	g	358.2	415.4		363.8	394.4	405.3
Mass dry sample + pan	m2	g	356.9	413.9		351.5	380.5	392.1
Mass pan	mp	g	56.8	55.3		52.3	55.2	51.6
Mass moisture	m1 - m2 = Mm	g	1.3	1.5		12.3	13.9	13.2
Mass dry sample	m2 - Mp = Md	g	300.1	358.6		299.2	325.3	340.5
Moisture content	Mm/Md x 100 = Mc	%	0.4	0.4		4.1	4.3	3.9
Dry Density	DD = BD x 100/(Mc+100)	kg/m³	2065	2056		Void		