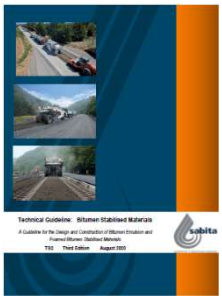
Pavement Rehabilitation by Cold Recycling / Bitumen Stabilisation

TG2, 3rd Edition, August 2020

APPENDIX B. LABORATORY TESTS



APPENDIX B CONTENTS

BSM1. Determining the Foaming Characteristics of Bitumen

BSM2. Laboratory Mix Design of Bitumen Stabilised Material

BSM3. Vibratory Hammer Compaction of Test Specimens

BSM4. Determination of the Indirect Tensile Strength (ITS)

BSM5. Determination of the Shear Properties

SANS 3001-BSM1:20XX, etc.

APPENDIX B Laboratory Tests

All test procedures follow the standard SANS format:

1. Scope
2. References
3. Definitions
4. Apparatus
5. Hazards
6. Principles
7. Preparation
8. Procedure
9. Calculations
10. Test Report

Annexures

APPENDIX B Laboratory Te

BSM2: LABORATORY MIX DESIGN OF BITUMEN STABILISED MATERIAL

1. SCOPE

This test method describes a mix design procedure for laboratory preparation, mixing, compacting, curing and testing of bitumen stabilised material using either foamed bitumen or bitumen emulsion.

2. REFERENCES

The following referenced documents are indispensable for the application of this method. All normative documents are to be used in their latest edition including any applicable amendments. Documents cited are referenced in the text within of this document. Parties to agreements based on this document are encouraged to take steps to ensure the use of the most recent editions of the normative documents indicated below. Information on currently valid national and international standards can be obtained from Standards South Africa.

- SANS 1690, Non-automatic self-indicating, semi-self-indicating and non-self-indicating weighing instruments with demonstrated verification scale intervals.
- SANS 3001-GR1, Civil engineering test methods Part GR1: Wet preparation and particle size analysis.
- SANS 3001-GR10, Civil engineering test methods Part GR1: Determination of the one point liquid limit, plastic limit, plasticity index and linear shrinkage.
- SANS 3001-GR20, Civil engineering test methods Part GR20: Determination of the moisture content by oven-drying.
- SANS 3001-GR30, Civil engineering test methods Part GR30: Determination of the maximum dry density and optimum moisture content.
- TG2, Test Method BSM1, Determination of the foaming characteristics of bitumen.
- TG2, Test Method BSM2, Vibratory hammer compaction for test specimens of bitumen stabilised material.
- TG2, Test Method BSM3, Determination of the indirect tensile strength of bitumen stabilised material.
- TG2, Test Method BSM4, Determination of the shear properties of bitumen stabilised material (Triaxial test)
- TMH 5, Sampling methods for road construction materials.

3. DEFINITIONS

3.1 Bitumen stabilised material (BSM)
Granular, previously cement treated or reclaimed asphalt material bound, stabilised either using bitumen emulsion or foamed bitumen.

3.2 Foamed bitumen
Vaporizing cold water in hot bitumen to create foam.

3.3 Optimum fluid content (OFC)
The percentage (by mass) of the combination of bitumen emulsion and water required to achieve the maximum dry density (MDD) of material treated with bitumen emulsion.

3.4 Raw
Untreated material (gravel, crushed stone or reclaimed asphalt).

4. APPARATUS

4.1 Foamed bitumen laboratory unit
Capable of producing foamed bitumen at a consistent rate of between 50 g/sec and 200 g/sec, equipped with a thermostatically controlled bath of capacity 10 kg of bitumen, operating at a constant temperature

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Table B.2. Mix Design Procedure

Stage	Step	Action by	Description of Action Required	
Preliminary	1	Laboratory	Carry out preliminary tests to determine the moisture content, grading and plasticity of the field sample.	
	2	Designer Input	Approve material or specify material and blending proportions to adjust grading and plasticity.	
	3	Designer Input	Select type of bitumen stabilising agent – foamed bitumen or bitumen emulsion.	
	4	Laboratory	Proportion the material and reduce to minus 20 mm maximum size.	
	5	Laboratory	Test the blended material to determine the MDD and OMC.	
	6	Laboratory	Test the bitumen stabilising agent to determine its properties. Evaluate foamed bitumen characteristics or obtain bitumen emulsion certification.	TEST BSM1
Effect of active filler	7	Laboratory	Mix 3 samples with the same amount of bitumen; one with 1% lime, one with 1% cement and one with no active filler.	
	8	Laboratory	Compact specimens, cure and ITS test to determine the wet and dry values.	TESTS BSM3 & 4
	9	Designer Input	Select the type of active filler.	
Optimum bitumen application rate	10	Laboratory	Mix 3 further samples with the active filler (step 8) and at 3 different bitumen application rates in 0.2% intervals either side of previous mix (step 6) i.e. 2 mixes lower + 1 higher	
	11	Laboratory	Compact specimens, cure and ITS test to determine the wet and dry values.	TESTS BSM3 & 4
	12	Designer Input	Select optimum bitumen application rate.	
Triaxial test	13	Laboratory	Mix samples with the active filler (selected in step 8) and bitumen at the optimum application rate (selected in step 11).	
	14	Laboratory	Compact specimens, cure and perform Triaxial testing to determine the shear properties.	TESTS BSM3 & 5
Outcome	15	Laboratory	Report ITS and Triaxial results for the mix design.	

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BSM3: Vibratory Hammer Compaction of Test Specimens

APPENDIX B Laboratory Tests (BSM3) – Page 148

BSM3: Vibratory Hammer Compaction of Test Specimens

Table B.10. Specimen Requirements

Requirements	ITS test	Triaxial test
Number of specimens per set	6	10
Mass of BSM required per set (kg)	26	150
Specimen height (mm)	95	300
Number of layers	2[1]	5[2]
Layer thickness (mm)	47,5	60

Note. All specimens are compacted to 100% MDD

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Inter-Layer Roughening (ILR) Device

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BSM4: Determination of the Indirect Tensile Strength (ITS)

APPENDIX B Laboratory Tests (BSM4) – Page 156

BSM4: Determination of the Indirect Tensile Strength (ITS)

Notes. Specimens are cured to constant mass at 40°C

Displacement control (50.8mm/min)

Testing temperature is 25°C

Test 3 unsoaked specimens and 3 soaked

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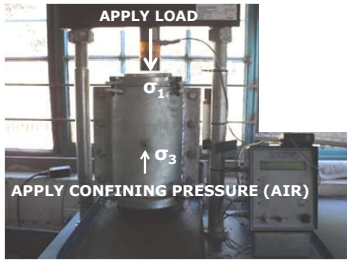
BSM5: Determination of the Shear Properties (Triaxial test)



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BSM5: Determination of the Shear Properties (Triaxial test)

Notes. Specimens are cured to equilibrium moisture content (40°C

Large specimens (150mm φ x 300mm high)

Testing temperature is 25°C

Test pairs of unsoaked specimens at 4 different confining pressures

Test 1 pair of soaked specimens at 100kPa confining pressure

Displacement control (3mm/min)

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APPENDIX D

QUALITY CONTROL

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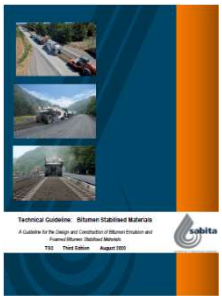

QUALITY CONTROL FOR RECYCLING

- Material (before stabilising)
  - quality (indicators)
  - temperatures
- Layer thickness
- Stabilising agents
  - quality
  - consumption
- Density
- Strength achieved
- Surface shape

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SAMPLING

PER SHIFT:

6 bulk samples
(pre-determined locations)
for
6 x MDD/OMC tests
3 x strength tests

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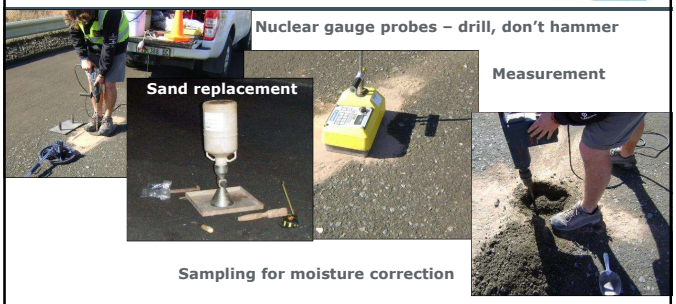
DENSITY TESTING



Nuclear gauge probes – drill, don't hammer

Measurement

Sampling for moisture correction

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LABORATORY TESTING

SAMPLE PREPARATION

(within 4 hours)

Scalp < 19mm

Retain in sealed container

Determine water addition for OMC ?

Manufacture 6 No. 150mm φ x 95mm specimens

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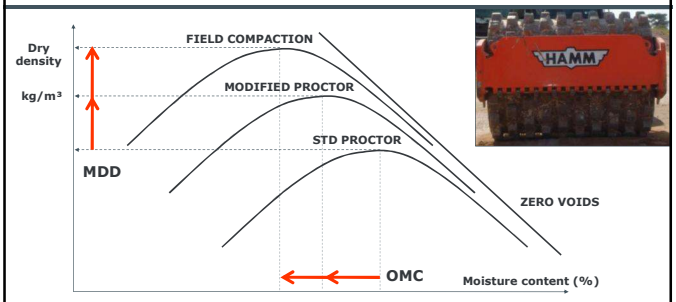
MOISTURE / DENSITY RELATIONSHIP



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SPECIMEN MANUFACTURE

150mm φ x 95mm specimens

100% of mod Proctor density

Use only split moulds

Vibrating hammer compaction

(CoV < 15%)

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CURING THE SPECIMENS

Leave specimens in their moulds for 4 hours

Place in forced-draught oven at 40°C

Dry to constant mass (± 72 hours)

Measure and weigh

Identify outliers

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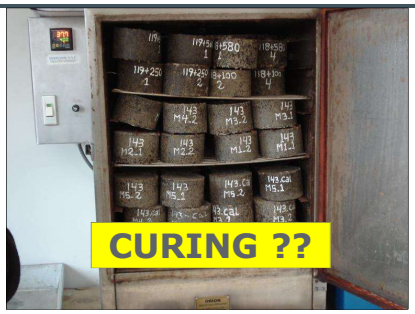

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CURING THE SPECIMENS

Place half the specimens under water and soak for 24 hours at 25°C

Condition the other half of the specimens in a temperature controlled room (25°C)

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INDIRECT TENSILE STRENGTH TEST

Test all soaked and unsoaked specimens

Displacement control: 50.8mm/min

Determine maximum load at failure

Calculate ITS_{DRY} and ITS_{WET} (kPa)

Measure the temperature in the middle

Determine the moisture content

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ITS Report sheet

BRIQUETTE MANUFACTURE, CURING AND TESTING							
Briquette number			B-56/1	B-56/2	B-56/3	B-56/4	B-56/5	B-56/6
Date manufactured			2009/02/05					
Date placed in oven			2009/02/06					
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	582	599	594	594	589	593
Bulk density	BD	kg/m³	2074	2134	2109	2097	2092	2094
Average Bulk Density		kg/m³	2089		2101		2091	
Strength of Briquettes			Dry			Soaked		
Temperature at centre of broken briquette		°C	25.2			24.8		
Maximum load applied		kN	3.6	3.4		2.9	2.5	2.8
Indirect Tensile Strength (ITS) = 2 x Load / (3.1416 x d x h)		kPa	386.3	364.5		306.7	268.9	299.9
Average ITS		kPa	375.2			285.1		
Tensile strength ratio (TSR)		%	76					

DRY DENSITY OF BRIQUETTES WHEN TESTED								
Briquette number			B-56/1	B-56/2		B-56/4	B-56/5	B-56/6
Pan number			A20	A17		B-02	B12	F11
Mass wet sample + pan	m1	g	398.2	415.4		363.8	354.4	408.3
Mass dry sample + pan	m2	g	396.9	413.9		361.3	350.5	392.1
Mass pan	mp	g	56.8	55.3		62.3	55.2	51.6
Mass moisture	m1 - m2 = Mm	g	1.3	1.5		2.5	3.9	15.2
Mass dry sample	m2 - Mp = Md	g	340.1	358.6		299.0	325.3	340.5
Moisture content	Mm/Md x 100 = Mc	%	0.4	0.4		4.1	4.3	3.9
Dry Density	BD = BD x 100/(Mc+100)	kg/m³	2006	2052		Void		

Dealing with ITS failures

Samples abused (delays / drying out)

Specimens abused (taken out of the mould immediately)

Low specimen density (moisture not corrected)

Poor specimens (coarse material)

Incorrect curing (oven overloaded)

Specimens not properly aligned in breaking head

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Extracting core samples

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Testing core specimens

Extracting 150mm φ cores

Allow the material in the layer to cure: BSM-foam – 2 weeks
BSM-emulsion – 4 to 8 weeks

Core gently / minimum water (air is better)

Cut 95mm high specimens from the core

Standard curing procedure

Where possible, determine ITS_{DRY} and ITS_{WET} from same core

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