SANS 3001-BSM3:201X
Edition 1

SOUTH AFRICAN NATIONAL STANDARD

Civil engineering test methods

Part BSM3: Vibratory hammer compaction of test specimens of bitumen stabilized material

WARNING
This document references other documents normatively.
Table of changes

<table>
<thead>
<tr>
<th>Change No.</th>
<th>Date</th>
<th>Scope</th>
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Acknowledgement

The SABS Standards Division wishes to acknowledge the valuable assistance of the Committee of Transport Officials (COTO), the Southern African Bitumen Association (SABITA), and the South African National Roads Agency.

Foreword

This South African standard was approved by National Committee SABS/TC 081/SC 08, Construction materials, products and test methods – Bitumen and bituminous products, in accordance with procedures of the SABS Standards Division, in compliance with annex 3 of the WTO/TBT agreement.

This document was approved for publication in xxxx 201X.

SANS 3001 consists of various parts under the general title Civil engineering test methods.

Parts BSM of the SANS 3001 series contain methods for testing bitumen stabilized materials.

Annex A is for information only.

Compliance with this document cannot confer immunity from legal obligations.

Introduction

In this part of SANS 3001 a vibratory hammer is used to compact test specimens of bitumen stabilized material used in a number of tests for the purpose of mixture design. The procedure may be used for the compaction of samples of bitumen stabilized material prepared in the laboratory as well as for samples manufactured using full-scale equipment. The procedure is only suitable for materials having a maximum aggregate size of 20 mm.

Apparatus dimensions that are critical to the outcome of the method or procedure are given with a tolerance. All other dimensions are nominal and should be considered fit for purpose.

This standard forms part of a set of methods used for mixture design of bitumen stabilized material (BSM), and includes the following:

a) determining the foaming characteristics of bitumen (see SANS 3001-BSM1);

b) laboratory mix design of BSM (see SANS 3001-BSM2);

c) vibratory hammer compaction of BSM (SANS 3001-BSM3);

d) determining the indirect tensile strength of BSM (see 3001-BSM4); and

e) determining the shear properties of BSM (see 3001-BSM5).
# Contents

Acknowledgement
Foreword
Introduction

1 Scope ........................................................................................................................ ...........

2 Normative references ...........................................................................................................

3 Definitions ....................................................................................................................... ..........

4 Apparatus ......................................................................................................................... ..........

5 Preparation of the test specimens .......................................................................................

   5.1 Sample preparation
   5.2 Determination of sample size

6 Procedure ......................................................................................................................... ..........

   6.1 Equipment preparation
   6.2 Compaction

7 Test report ......................................................................................................................... ..........

Annex A (informative) Examples of the calculation procedure ...........................................

Bibliography ...........................................................................................................................
Civil engineering test methods

Part BSM3: Vibratory hammer compaction for test specimens of bitumen stabilized material

1 Scope
This part of SANS 3001 describes a method for preparing and compacting test specimens of bitumen stabilized material (BSM) using a vibratory hammer.

2 Normative references
The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. Information on currently valid national and international standards can be obtained from the SABS Standards Division.

SANS 1649, Non-automatic self-indicating, semi-self-indicating and non-self-indicating weighing instruments with denominated verification scale intervals

SANS 3001-BSM2, Civil engineering test methods – Part BSM2: Laboratory mix design of bitumen stabilized samples.

SANS 3001-BSM4, Civil engineering test methods – Part BSM4: Determination of the indirect tensile strength of bitumen stabilized material.

SANS 3001-BSM5, Civil engineering test methods – Part BSM5: Determination of the shear properties of bitumen stabilized material (triaxial test).

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.

TMH5, Sampling methods for roads construction materials.

3 Definitions
For the purpose of this document, the following definitions apply.

3.1 bitumen stabilized material BSM
granular, previously cement treated or reclaimed asphalt material blends, stabilized either using bitumen emulsion or foamed bitumen

3.2 **indirect tensile strength** (ITS) the stress at failure generated by the load required to split a cylindrical specimen of bitumen stabilized material

3.3 **maximum dry density** (MDD) the maximum dry density of the material determined from the peak of the dry density versus moisture content curve obtained as described in SANS 3001-GR30

3.4 **optimum moisture content** (OMC) the moisture content at which the maximum dry density is achieved

4 **Apparatus**

4.1 **Vibratory demolition hammer**, of mass 11.5 kg ± 0.1 kg with rated power input of 1700 W, an impact rate of 900 to 1700 beats per minute and impact energy of 23 J ± 1 J per stroke.

**WARNING** Prolonged exposure to the noise emitted by a demolition hammer can lead to impaired hearing. The operator should always wear ear plugs and, to protect others in the vicinity, the vibratory hammer compaction unit should be housed in a soundproof cabinet. Working beneath the suspended hammer assembly has the potential of causing bodily harm in the event of the locking device malfunctioning. Such locking device requires regular inspection and maintenance to ensure its functionality. In addition, exercise care when lowering the tamping foot into the mould to prevent damaging fingers or hands.

**NOTE** A Bosch Demolition Hammer, GSH 11VC Professional, is an example of a suitable product available commercially. This information is given for the convenience of the users of this standard and does not constitute an endorsement by TC81 SC08 of this product.

4.2 **Compaction shank**, of corrosion resistant steel, with a tamping foot of diameter 145 mm ± 1 mm and 10 mm ± 1 mm in thickness, of combined mass 3.0 kg ± 0.1 kg (see figure 1). The shank is machined with an SDS fitting to enable it to be fitted into the demolition hammer.

4.3 **Compaction block**, of concrete with a strength of approximately 25 MPa, that is at least 1 m x 1 m and 300 mm thick, reinforced with 2 layers of steel mesh (395), one placed 50 mm from the top of the block, the other 50 mm from the bottom. The surface of the block is cast level. The block has attachments such that the mould base plate can be securely and uniformly fixed to the block.

4.4 **Frame**, with vertical slides, complete with mounting head for the vibratory hammer, that allows the vibratory hammer to be suspended above the mould with the tamping foot centred on the mould. The slides are to ensure free downward movement of the hammer as it compacts the material in the mould. The frame is fitted with a system (connected to the top of the frame) for lifting and lowering the vibratory hammer. The base of the frame is bolted to the compaction block.

**NOTE** A Wirtgen WLV1 frame, is an example of a suitable product available commercially. This information is given for the convenience of the users of this standard and does not constitute an endorsement by TC81 SC08 of this product.
4.4 **Split cylindrical moulds**, of corrosion-resistant steel, with two segments
   
a) with inside diameter 152 mm ± 0.5 mm and height of at least 120 mm; and base plate, for ITS test specimens;
   
b) with inside diameter 150 mm ± 0.5 mm and height of at least 320 mm; and base plate, for triaxial test specimens.

NOTE The base plate that fits the 152 mm diameter mould may be used for the 150 mm diameter mould.

4.5 **Interlayer roughening device (IRD)**, of diameter 145 mm ± 1.0 mm, fitted with protruding teeth of length 12 mm ± 2.0 mm for roughening the upper surface of each compacted layer.

4.6 **Carrier plates**, of plywood of thickness approximately 15 mm and diameter approximately 160 mm, one for each compacted specimen.

4.7 **Electronic balances**, fine measurement type that comply with SANS 1649:
   
a) with a capacity of at least 30 kg, and that reads to 1 g;
   
b) with a capacity of at least 10 kg, and that reads to 0.1 g.

4.8 **Drying oven**, that is capable of maintaining a temperature range of 105 °C to 110 °C with continuous draft.

4.9 **Containers**, with lids that retain moisture, of capacity of at least
   
a) 2.5 L for moisture content samples,
   
b) 20 L for the mixed treated material.

4.10 **Suitable basins**, one of diameter approximately 300 mm, and one of diameter at least 500 mm.
4.11 Scoop, of capacity approximately 500 mL.

4.12 Trowel, garden type.

4.13 Timer, capable of reading up to 5 min and reading to 1 s.

4.14 Vernier callipers, measuring to 350 mm ± 1 mm.

4.15 Spatula, with steel blade, of length approximately 350 mm.

4.16 Marking materials, consisting of
   a) marker pen,
   b) oil based white paint for marking compacted specimens,
   c) thin artist's brush.

5 Preparation of the test specimens

5.1 Sample preparation

5.1.1 Preparation of BSM samples mixed in the laboratory
5.1.1.1 Determine the maximum dry density (MDD) and optimum moisture content (OMC) as described for Preliminary tests in SANS 3001-BSM2.

5.1.1.2 Prepare the bulk samples for ITS and Triaxial testing as described in SANS 3001-BSM2.

NOTE The procedure given in SANS 3001-BSM2 requires the mix designer to specify the percentages by mass of active filler and stabilizing agent to be added, and the type of bituminous stabilizing agent.

5.1.2 Preparation of samples from field mixed BSM
5.1.2.1 Sample the BSM in the field as described in TMH 5.

5.1.2.2 Obtain the maximum dry density (MDD) and optimum moisture content (OMC) from routine field control testing.

5.2 Determination of sample size

Use the data from table 1 and the formula in 7.1.2 to determine the amount of BSM required to prepare the test specimens.

<table>
<thead>
<tr>
<th>Requirements</th>
<th>ITS test</th>
<th>Triaxial test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of specimens per set</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Mass of BSM required per set (kg)</td>
<td>26</td>
<td>150</td>
</tr>
<tr>
<td>Specimen height (mm)</td>
<td>95</td>
<td>300</td>
</tr>
</tbody>
</table>
6 Procedure

6.1 Equipment preparation

Ensure that the vibratory hammer frame is securely attached to the concrete support block and is installed vertically. Install the vibratory hammer and surcharge weight into the mounting frame and insert the tamping foot. Using the lifting system, raise and lower the hammer to ensure that there is no resistance to sliding.

Clean the mould and base plate. Lubricate the inside of the mould with a light application of lubricating grease or non-stick spray. Fix the mould and base plate to the concrete block. Check the alignment of the mould and vibratory hammer by lowering the tamping foot into the mould. Check that the lifting system provides sufficient slack for the tamping foot to rest on the base plate.

6.2 Compaction

6.2.1 Lower the vibratory hammer so that the tamping foot rests on the base plate. Using a marking pen, mark the location of the slide on the frame. Raise the vibratory hammer using the lifting system and secure it at least 500 mm above the mould. Using a steel rule, measure upwards from the mark on the frame and accurately mark the distance to the top of the first compacted layer (47.5 mm for ITS specimens and 50 mm for triaxial specimens); and subsequent layers (95 mm for ITS specimens; 100 mm, 150 mm, 200 mm, 250 mm and 300 mm for triaxial specimens).

When the vibratory hammer frame is fitted with an electronic system for controlling the compacted thickness of the layers, carefully follow the set up and operating procedures specified by the manufacturer.

6.2.2 Determine the mass of BSM required for each layer using the formula in 7.1.3.

6.2.3 From the sample prepared as described in SANS 3001 BSM-2 (see 5.1.1.1) or from the field mixed sample (see 5.1.2.1) measure out the mass of the BSM required for the first layer (accurate to ± 1 g) and carefully pour it into the mould without any spillage. Use the spatula to spread the material evenly in the mould avoiding segregation. Retain the remainder of the sample in the sealed container to prevent moisture loss.

6.2.4 Lower the vibratory hammer until the tamping foot rests on the material. Ensure that the lifting system is slack, allowing the hammer to slide downwards as the material compacts. Turn on the vibratory hammer and start the timer. Allow the hammer to run until the mark on the sliding frame for the first layer is reached. Immediately turn the hammer off and stop the timer. Record the time taken to compact the layer. Raise the hammer using the lifting system and secure it at least 500 mm above the mould.

When the compaction time for any layer exceeds 120 s, terminate the manufacturing procedure, increase the number of layers and start the procedure again from 6.2.1. In the unlikely event of the problem persisting with an increased number of layers, terminate the manufacturing procedure and seal all the material in airtight containers. Repeat the moisture / density relationship test on a new
sample of the untreated material to determine the correct values for the MDD and OMC (see 5.1.1.2 or 5.1.2.2). Then start the procedure again using the revised MDD as the target density.

6.2.5 Prepare the surface of the compacted layer inside the mould using the interlayer roughening device (IRD). Place the IRD on top of the compacted material and apply sufficient pressure so that the teeth fully penetrate into the material. Maintaining the applied pressure, turn the IRD through 90° and then back again at least four times to loosen the material at the top of the layer. Lift the IRD out of the mould and inspect the roughened surface. If the material is not sufficiently loose, repeat the procedure described above as many times as necessary. When the surface has been sufficiently roughened, proceed immediately with the next layer.

6.2.6 Compact the second and any subsequent layers as described in 6.2.1 to 6.2.5. All layers are to be compacted in a continuous operation.

6.2.7 After the treated material has been placed in the mould for the second layer, transfer approximately 1 kg of the remaining material in a suitable container for moisture content determination as described in SANS 3001-GR20.

6.2.8 After compaction is complete remove the mould from the base plate, carefully place the mould and specimen on the carrying plate and allow to stand for a minimum of 4 h.

6.2.9 Carefully dismantle and remove the two mould segments, leaving the compacted specimen on the carrying plate. Mark all specimens clearly with white paint with unique identification numbers.

6.2.10 Cure the specimens as described in SANS 3001-BSM4 for ITS or SANS 3001-BSM5 for triaxial testing.

7 Calculations

NOTE an example of the calculation procedure is given in annex A.

7.1 Calculations required in the procedure

7.1.1 Determine the mass of each BSM specimen at OMC to the nearest gram, using the following equation:

\[ M_s = \frac{\pi d^2 h}{4 \times 10^6} \times (M_{DD} \times (1 + \frac{OMC}{100})) \]

where

- \( M_s \) is the mass of BSM specimen at OMC, expressed in grams (g);
- \( d \) is the diameter of the specimen, expressed in millimetres (mm);
- \( h \) is the height of the specimen, expressed in millimetres (mm);
- \( M_{DD} \) is the MDD, expressed in kilograms per cubic metre (kg/m\(^3\));
- \( OMC \) is the OMC, expressed as a percentage (%).
7.1.2 Determine the total mass of BSM required for manufacturing a batch of specimens to the first decimal place, using the following equation:

\[ M_b = \frac{(N_S \times M_S) + 4}{1000} \]

where

- \( M_b \) is the mass of BSM required to manufacture a batch of specimens, expressed in kilograms (kg);
- \( N_S \) is the number of specimens to be manufactured (see table 1).

7.1.3 Determine the mass of material required per compaction layer (of equal thickness) to the nearest gram, using the following equation:

\[ M_L = \frac{M_b}{n} \]

where

- \( M_L \) is the mass of material in each layer, expressed in grams (g);
- \( n \) is the number of layers (of equal thickness) to be compacted (see table 1).

8 Test report

Report the MDD to the nearest kg/m\(^3\) and the OMC and moulding moisture content to the nearest 0.1 %.

The test report shall include the following general information:

a) the mould diameter;

b) details of aggregate and binder used in the mix including mix proportions;

c) the date of manufacture;

and for each specimen:

a) the identification marking;

b) the number of layers and compaction time for each layer to the nearest 1 s.

Annex A

(informative)
Examples of the calculation procedure

A.1 Use the following information given in table A.1 to calculate A.2, A.3 and A.4.

Table A.1 – Data for example calculations

<table>
<thead>
<tr>
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<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property</td>
<td>ITS test</td>
<td>Triaxial test</td>
<td></td>
</tr>
<tr>
<td>d (mm)</td>
<td>152</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>h (mm)</td>
<td>95</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>MDD (kg/m³)</td>
<td>2 145</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OMC (%)</td>
<td>5.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ns</td>
<td>6</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>2</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

A.2 Calculate the mass of each specimen at the OMC (see 7.1.1).

A.2.1 for ITS test

\[
M_s = \frac{(\pi \times d^2) \times h \times (MDD \times (1 + (OMC)))}{4 \times 10^6}
\]

\[
= \frac{(\pi \times 152^2) \times 95 \times (2 \times 145 \times (1 + 5.6))}{4 \times 10^6}
\]

\[
= 3905 \text{ g}
\]

A.2.2 for triaxial test

\[
M_s = \frac{(\pi \times d^2) \times h \times (MDD \times (1 + (OMC)))}{4 \times 10^6}
\]

\[
= \frac{(\pi \times 150^2) \times 300 \times (2 \times 145 \times (1 + 5.6))}{4 \times 10^6}
\]

\[
= 12008 \text{ g}
\]

A.3 Calculate the mass of material required to manufacture a batch of specimens (see 7.1.2).

A.3.1 for ITS test

\[
M_b = \frac{(Ns \times M_s) + 4}{1000}
\]

\[
= \frac{(6 \times 3905) + 4}{1000}
\]
= 27.4 kg

A.3.2 for triaxial test

\[ M_b = \frac{(N_s \times M_s) + 4}{1000} \]

= \frac{(10 \times 12\,008) + 4}{1\,000}

= 124.1 kg

A.4 Calculate the mass of material required per layer (see 7.1.3).

A.4.1 for ITS test

\[ M_l = \frac{M_b}{n} \]

\[ = \frac{3\,905}{2} \]

= 1953 g

A.4.2 for triaxial test

\[ M_l = \frac{M_b}{n} \]

\[ = \frac{12\,008}{6} \]

= 2001 g

Bibliography