1. **SCOPE**
   The Indirect Tensile Strength (ITS) of a bitumen stabilised material is determined by measuring the resistance to failure of a cylindrical specimen 152mm in diameter and 95mm high when a load is applied to the curved sides of the specimen.

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 3001 Test Method GR 20: Determination of the moisture content by oven-drying.
   - SANS 3001 Test Method GR 30: Determination of the Maximum Dry Density and Optimum Moisture Content (AASHTO T-180 2105 Edition)
   - SABITA publication TG2: Bitumen Stabilised Materials:
     - Procedure for manufacturing test specimens from bitumen stabilised material (BSM) using vibratory hammer compaction

3. **DEFINITIONS**
   For the purpose of this document, the following definitions apply:

   3.1 Acceptable
   Acceptable to the authority administering this standard or to the parties concluding the purchase contract, as relevant.

   3.2 Indirect Tensile Strength (ITS) of a bitumen stabilised material.
   The stress at failure generated by the load required to split a cylindrical specimen of height 95mm and of diameter 152mm at a constant displacement rate of 50.8mm/min.

   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 using the specified compaction effort to manufacture specimens of height 127mm and of diameter 152mm.

   3.4 Optimum Moisture Content (OMC)
   The moisture content at which the maximum dry density is achieved.

4. **APPARATUS**
   4.1 Two loading strips of hardened steel, 19mm x 20mm x 220mm, with the 19mm face ground concave to a radius of 76mm ± 1mm, together with a frame of suitable design to align the loading strips on the test specimen (see picture).

   4.2 A steel load-transfer plate or 19mm diameter steel ball to transfer the load from the compression testing machine to the loading strips without any deformation. Where a load-transfer plate is used, the dimensions should be such that it will be slightly longer than the height of the specimen to be tested.

   4.3 A water bath with perforated bottom, at least 150mm deep, thermostatically controlled so as to maintain a temperature of 25°C ± 1°C.
4.4 A forced-draft drying oven, thermostatically controlled and capable of maintaining the temperature within 1°C of the setting (minimum 240 litres capacity).

4.5 A compression testing machine capable of applying at least 25kN at a constant displacement rate of 50.8mm per minute and capable of measuring the load accurately to 0.05kN and the displacement to 0.1mm.

4.6 Electronic balance (fine measurement type) that complies with SANS 1649 and has the capacity to weigh up to 10kg with an accuracy of 0.1g.

4.7 A digital thermometer capable of measuring between 0°C and 100°C to an accuracy of 1°C.

4.8 Vernier callipers capable of measuring up to 200mm (±1mm).

4.9 Suitable waste receptacle with a minimum capacity of 10 litres for the disposal of specimens after testing.

5. HAZARDS
Compression testing machines that are used to break specimens can apply a force in excess of 20kN on the sample. Samples of BSM tend to deform in a plastic manner under the applied force. However, it is possible for particles to be expelled from the specimen during the test and, for this reason, it is advisable for the operator of the testing machine to wear safety glasses for the duration of the test.

6. PRINCIPLES
The objective is to determine the Indirect Tensile Strength (ITS) of specimens under both dry and soaked conditions.

7. PREPARATION (PREPARING THE SPECIMENS FOR TESTING (CURING))
Six specimens 152mm in diameter and 95mm high are manufactured for each test following the relevant procedure for manufacturing test specimens using vibratory hammer compaction.

7.1 Curing. Once the specimens have been extracted from their respective moulds and marked, they are placed in a forced-draft oven at a temperature of 40°C (±1°C) for a minimum period of 72 hours (3 days).

Note. When placing specimens inside the oven, ensure that there is a minimum air-space of 25mm between all specimens.

After 72 hours, remove the specimens from the oven and weigh each one, recording their individual mass. Return all the specimens to the oven (at 40°C) for a further 4 hours and repeat the weighing exercise. If the mass of any specimen reduces by more than 10g, place all the specimens back in the oven for a further 12 hours. This procedure is repeated as many times as is necessary until the specimens have achieved constant mass.

The specimens are then left to cool to a constant temperature of 25°C (±1°C).

7.2 After cooling, determine the bulk density of each specimen using the following procedure:

- Determine the mass of the specimen.
- Measure the height of the specimen at four evenly-spaced locations around the circumference and calculate the average height of the specimen.
- Measure the diameter of the specimen.
- Calculate the bulk density of the each specimen using the equation in paragraph 9.1.
7.3 Calculate the mean and standard deviation of the bulk density for all six specimens. Using the equation in Paragraph 9.2, determine if any of the specimens are outliers and exclude them from further testing.

**Note.** If more than two specimens are excluded, the test must be abandoned.

7.4 Place half of the specimens under water in the soaking bath for 24 hours at 25°C (± 2°C). (If only one specimen was discarded as an outlier, place 3 specimens in the water bath.)

**Note.** The water must cover the top surface of the specimens by approximately 25mm.

After 24 hours, remove the specimens from the water, surface dry and test immediately.

8. **PROCEDURE FOR DETERMINING THE INDIRECT TENSILE STRENGTH (ITS) OF SPECIMENS**

Ensure that the temperature of the unsoaked specimens is 25°C (± 2°C) by leaving them in a temperature controlled environment for a minimum of 4 hours. (A longer period of 24 hours is recommended, whilst the soaked specimens are in the water bath).

Then, follow the procedure described below:

8.1 Place the specimen on the bottom loading strip. Then place the top loading strip on top of the specimen, diametrically opposite the bottom strip. Ensure that the loading strips are parallel and centred on the vertical diametrical plane.

Place the transfer plate (or steel ball) on the top bearing strip and position the assembly centrally under the loading ram of the compression testing device.

Apply a load of 0.1kN to the specimen to seat the loading strips. Inspect the assembly for symmetry.

8.2 Load the specimen, without shock, at a constant rate of advance of 50.8 mm per minute until the maximum load is reached. Record the maximum load accurate to 0.1kN and the displacement at break to the nearest 0.1mm.

8.3 Unload the compression tester, remove the specimen from the loading strips, break it in half and record the temperature of the specimen at its centre (as shown by the red dot in the picture).

8.4 Break up one of the soaked and one of the unsoaked specimens and determine the moisture content of each following the standard test method for moisture determination (SANS 3001, Test Method GR 20).

8.5 Calculate the ITS value for each specimen (to the nearest 1kPa) using the equation in paragraph 9.3.

8.6 Determine the $\text{ITS}_{\text{DRY}}$ value by calculating the average ITS using the results for all unsoaked specimens. Determine the $\text{ITS}_{\text{WET}}$ value by calculating the average ITS using the results for all soaked specimens.

8.7 Determine the moisture content (as a percentage of the dry mass) for soaked and unsoaked specimens using the equation in paragraph 9.5.

8.8 Determine the dry density for each specimen using the equation in paragraph 9.6 (using the moisture content determined for the unsoaked specimen).
9. **CALCULATIONS**

9.1 **Determine the Bulk Density of a specimen:**

\[ BD_s = \frac{4 \times M_s}{\pi \times d^2 \times h} \times 1 \, 000 \, 000 \]

where:
- \( BD_s \) = bulk density of specimen \([\text{kg/m}^3]\)
- \( M_s \) = mass of specimen \([\text{g}]\)
- \( h \) = average height of specimen \([\text{mm}]\)
- \( d \) = diameter of specimen \([\text{mm}]\)

9.2 **Identify outliers from the bulk density of 6 specimens:**

\[ T_0 = \frac{X_o - \bar{X}}{S_n} \]

where:
- \( T_0 \) = test value
- \( X_o \) = bulk density of specimen \([\text{kg/m}^3]\)
- \( \bar{X} \) = mean of bulk density \([\text{kg/m}^3]\)
- \( S_n \) = std deviation of bulk density \([\text{kg/m}^3]\)
- \( n = 6 \), number of specimens

If the absolute value of \( T_0 \) is greater than 1.82 then the specimen is an outlier.

9.3 **Determine the Indirect Tensile Strength (ITS):**

\[ ITS = \frac{2 \times P}{\pi \times h \times d} \times 1 \, 000 \, 000 \]

where
- \( ITS \) = Indirect Tensile Strength \([\text{kPa}]\)
- \( P \) = maximum applied load \([\text{kN}]\)
- \( h \) = average height of the specimen \([\text{mm}]\)
- \( d \) = diameter of the specimen \([\text{mm}]\)

9.4 **Determine the moisture content of the material:**

\[ W_s = \frac{(M_{CM} - M_{CD})}{(M_{CM} - M_C)} \times 100 \]

where:
- \( W_s \) = moisture content expressed as a percentage of the dry material (%)
- \( M_{CM} \) = mass of container and moist material (g)
- \( M_{CD} \) = mass of container and dry material (g)
- \( M_C \) = mass of container only (g)

9.5 **Determine the Dry Density of a specimen:**

\[ DD_s = BD_s \times \left(1 - \frac{W_s}{100}\right) \]

where:
- \( DD_s \) = dry density of specimen [% by mass]
- \( BD_s \) = bulk density of specimen [g]
- \( W_s \) = moisture content of specimen [g]

10. **TEST REPORT** (see Annexure B)

Report the following:
- Parent material description and stabilisation details
- Specimen ID (marking)
- Date of specimen manufacture
- Date and time specimens placed in oven (start of curing)
- Date and time specimens removed from oven (end of curing)
- Date of testing the specimens
- Specimen size (diameter and average height)
- Bulk Density of each specimen
- Identification of outliers (in terms of bulk density)
- Moisture content (soaked and unsoaked specimens)
- Dry Density of each specimen (using unsoaked moisture content)
- Soaked or unsoaked condition of specimen when tested
- Maximum load applied to each specimen
- ITS value of each specimen
- Temperature measured at centre of each specimen after failure
- Deformation of each specimen at failure
- Average $\text{ITS}_{\text{DRY}}$ value determined for unsoaked specimens
- Average $\text{ITS}_{\text{WET}}$ value determined for soaked specimens
Annexure A (informative). Examples of the calculation procedures.

A.1 Determine the Bulk Density of a specimen:

Equation in paragraph 9.1:

\[
BD_s = \frac{4 \times M_s}{\pi \times d^2 \times h} \times 1000000
\]

where:
- \(BD_s\) = Bulk Density of specimen [kg/m\(^3\)]
- \(M_s\) = mass of specimen [g]
- \(h\) = average height of specimen [mm]
- \(d\) = diameter of specimen [mm]

Calculation:

\[
BD_s (kg/m^3) = \frac{(4 \times 3836) / (\pi \times 152^2 \times 94.2) \times 10^6}{2243 kg/m^3}
\]

A.2 Identify outliers from the Bulk Density of 6 specimens.

Equation in paragraph 9.2:

\[
T_0 = \frac{X_o - \bar{X}}{S_n}
\]

where:
- \(T_0\) = test value
- \(X_o\) = Bulk Density of specimen [kg/m\(^3\)]
- \(\bar{X}\) = mean of Bulk Density [kg/m\(^3\)]
- \(S_n\) = std deviation of Bulk Density [kg/m\(^3\)]
- \(n\) = 6, number of specimens

Calculation:

\[
\begin{align*}
X_0 & = 3822 \\
X_1 & = 3813 \\
X_2 & = 3849 \\
X_3 & = 3796 \\
X_4 & = 3718 \\
X_5 & = 3803 \\
X_6 & = 3800.17
\end{align*}
\]

\[
\begin{align*}
S_n & = 44.28
\end{align*}
\]

If the absolute of \(T_0\) > 1.82 then the specimen is an outlier.

A.3 Determine the Indirect Tensile Strength (ITS).

Equation in paragraph 9.3:

\[
ITS = \frac{2 \times P}{\pi \times h \times d} \times 1000000
\]

where:
- \(ITS\) = Indirect Tensile Strength [kPa]
- \(P\) = maximum applied load [kN]
- \(h\) = average height [mm]
- \(d\) = diameter of the specimen [mm]

Calculation:

\[
\begin{align*}
ITS (kPa) & = \frac{(2 \times 5.2) / (\pi \times 94.2 \times 152) \times 10^6}{231 kPa}
\end{align*}
\]

A.4 Moisture content of the material.

Equation in paragraph 9.4:

\[
W_s = \frac{(M_{CM} - M_{CD})}{(M_{CD} - M_C)} \times 100
\]

where:
- \(W_s\) = moisture content [percentage of the dry material]
- \(M_{CM}\) = mass of container and moist material (g)
- \(M_{CD}\) = mass of container and dry material (g)
- \(M_C\) = mass of container only (g)

Calculation:

\[
\begin{align*}
W_s (%) & = \frac{(1264 \times 1216) / (1216 - 345) \times 100}{48 / 871 \times 100} \\
& = 5.5% 
\end{align*}
\]
A.5 Determine the Dry Density of a specimen.

Equation in paragraph 9.5:

\[
DD_s = \text{BD}_s \times \left(1 - \frac{W_s}{100}\right)
\]

where:
- \(DD_s\) = Dry Density of specimen [% by mass]
- \(\text{BD}_s\) = Bulk Density of specimen [g]
- \(W_s\) = moisture content of specimen [g]

Example

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>(DD_s)</td>
<td>To be calculated</td>
<td></td>
</tr>
<tr>
<td>(\text{BD}_s)</td>
<td>2243</td>
<td></td>
</tr>
<tr>
<td>(W_s)</td>
<td>5.5</td>
<td></td>
</tr>
</tbody>
</table>

Calculation:

\[
DD_s (\text{kg/m}^3) = \frac{2243 \times (1 - (5.5 / 100))}{1} = 2120 \text{ kg/m}^3
\]
**INDIRECT TENSILE STRENGTH (ITS) DETERMINATION (BSM)**

<table>
<thead>
<tr>
<th>Project:</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Sample No:</td>
<td>Report date:</td>
</tr>
<tr>
<td>Material description:</td>
<td></td>
</tr>
</tbody>
</table>

**Moisture / density relationship (treated / untreated material)**

| Maximum dry density (MDD): | Optimum moisture content: |

**TREATMENT (stabilisation)**

<table>
<thead>
<tr>
<th>Bitumen Source:</th>
<th>Bitumen / emulsion type:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active filler type:</td>
<td></td>
</tr>
</tbody>
</table>

**Application rates (% by mass of MDD)**

| (Residual) Bitumen | Active filler: |

**SPECIMEN DETAILS**

<table>
<thead>
<tr>
<th>Date of manufacture</th>
<th>Date placed in oven</th>
<th>Date removed from oven</th>
<th>Date tested</th>
<th>Diameter (mm)</th>
</tr>
</thead>
</table>

**Specimen ID**

<table>
<thead>
<tr>
<th>Height measurements (mm)</th>
<th># 1</th>
<th># 2</th>
<th># 3</th>
<th># 4</th>
<th>Average</th>
</tr>
</thead>
</table>

**Mass after curing (g)**

**Bulk density (kg/m³)**

**Mean and Standard Deviation**

<table>
<thead>
<tr>
<th>Mean X̄</th>
<th>Standard deviation S₀</th>
<th></th>
</tr>
</thead>
</table>

**T₀ value**

<table>
<thead>
<tr>
<th>Outlier (T₀&gt;1.82)</th>
<th></th>
</tr>
</thead>
</table>

**Moisture content (%)**

(Enter the moisture content of unsoaked specimen)

**Dry density (kg/m³)**

**INDIRECT TENSILE STRENGTH**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Unsoaked</th>
<th>Soaked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content (%)</td>
<td></td>
<td>(Moisture content of soaked specimen)</td>
</tr>
<tr>
<td>Displacement (mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature at break (°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum load (kN)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITS (kPa)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average ITS (kPa)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>