3
TESTING

TESTING ROAD MATERIALS

PRESENT STATE OF BASIC TESTING

- Mainly Empirical
- Many tests have poor Reproducibility
- Often do not Measure the Required Property

However, Based on Extensive Experience

Don't throw out the Baby with the bathwater!!

SAMPLING (TMH 5)

- G^2 : Garbage IN = Garbage OUT
- Trial Pit : Full depth of each layer from the side wall. Avoid contamination
- Samples : Must be representative
- Stockpiles : Watch out for segregation
  Take enough samples
- Duplicate Samples : Quartering & Riffling
  Follow procedures very carefully
- Labeling : Clear and Unique
  Project/Location/Pit/Layer

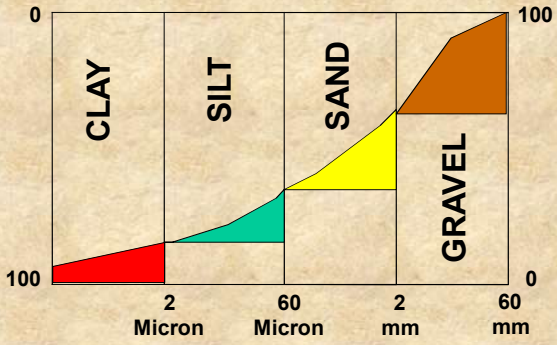
INDICATOR TESTS

GRADING ANALYSIS

Sieve & Hydrometer

Provides general Descriptor

Usually a combination of Particle types

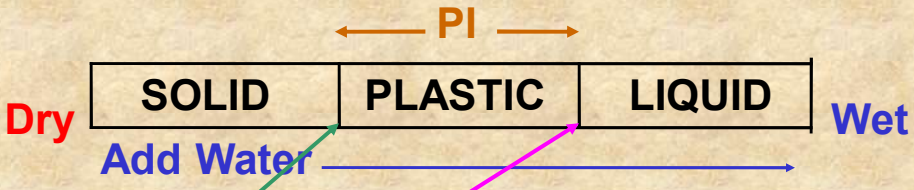


SANS 3001-GR1

INDICATOR TESTS

ATTERBERG LIMITS

[SANS 3001-GR10]



PL = Moisture Content @ the Plastic Limit

LL = Moisture Content @ the Liquid Limit

PI = LL – PL = Plasticity Index

INDICATOR TESTS

LINEAR SHRINKAGE

- LS = Linear Shrinkage of the soil fines from the Liquid Limit test in a metal trough on drying (good for gravel roads)
- Provides a useful check of plasticity and moisture sensitivity

  (2 x LS = roughly PI)

GRADING, PI and LS can with experience and knowledge of the soil type provide a very good preliminary guide to the engineering properties of a soil

DENSITY TESTS

There are a number of density tests used in the field and the laboratory.

In Road Construction the following are the most common:-

Field: Nucleonic Gauge

Sand Replacement

Laboratory: Maximum dry density (MDD) or "Mod"

Apparent (Relative) Density (AD)

Bulk (Relative) Density (BD)

FIELD DENSITIES

- SAND REPLACEMENT SANS 3001-GR35
  - ✓ Hand work using a calibrated sand
  - ✓ Operator dependent

- NUCLEONIC GAUGE SANS 3001-NG1 to NG5
  - ✓ Less operator dependent
  - ✓ Needs (gravimetric) moisture correction

** Beware Iron-rich soils, calcretes & soils H^+

LABORATORY DENSITIES

- Maximum Dry Density Test :

  SANS 3001-GR30

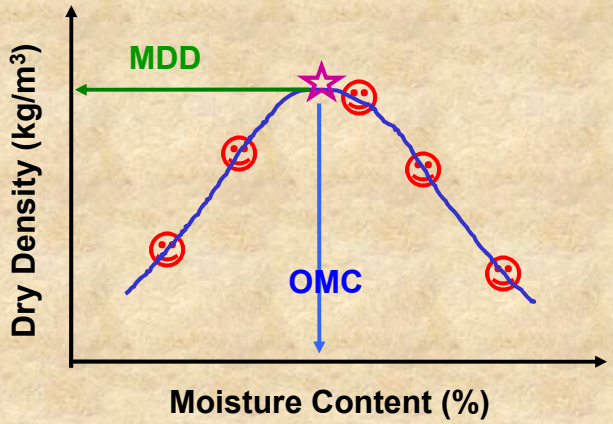
Uses Standard:- Mould, Rammer, Drop, Number of Layers and Blows

to Provide a Standard Compactive Effort

Material – SANS 3001-GR30: Scalped on 37,5 mm sieve. TMH1: Screened on a 20 mm sieve, the oversize material was lightly crushed and mixed back into the sample.

Moulded at a range of moisture contents

MDD TEST



MDD = Maximum Dry Density

OMC = Optimum Moisture Content

BULK & APPARENT DENSITY

SANS 3001-AG20, AG21 & AG22

APPARENT DENSITY

Depends solely on the densities of the individual particles expressed as the density of a solid block without voids. Hence the use of the term "Solid" density

AG22 is the SANRAL test for crushed stone base

BULK (RELATIVE) DENSITY

Similar to AD but takes water absorption of the particles into account

Neither test is affected by the grading

Laboratory Densities

TWO-FOLD PURPOSE:-

- MDD, AD & BD provide a **Standard Density** as a reference for judging field compaction
- MDD provides a **Moisture Content** to aim for when compacting both in the field and the laboratory

NB: The laboratory MDD is not the Ultimate compaction. Field equipment may have different MDD and OMC depending on their compactive effort

RELATIVE COMPACTION

When the actual density obtained is compared to the **Standard Density** the result, in percent, is termed the:-

Relative Compaction

For Example:-

Field Density = 2 545 kg/m^3

MDD = 2 431 kg/m^3

AD = 2 955 kg/m^3

NB Same Packing – Different Standard

Relative Compaction (MDD) = 104,7%

Relative Compaction (AD) = 86,1%

CALIFORNIA BEARING RATIO

SANS 3001-GR40

CRUDE TEST OF (BEARING) STENGTH

- **Samples prepared at MDD / OMC using three compactive efforts which give: 100%, about 96% and 93% Relative Compaction**
- **After soaking (why?), a standard plunger (2 ins or 50 mm diameter) is forced into the sample and the resisting force is measured at 2,5 mm; 5 mm and 7,5 mm penetration**
- **The resisting force is divided by the Standard Force (OJ Porter) to give the CBR**

CBR Continued

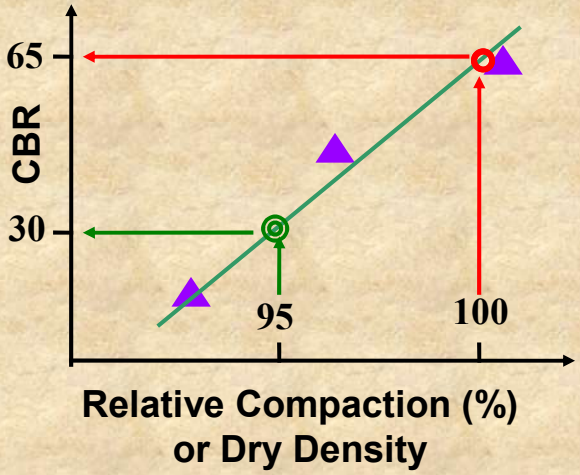
- **Plot CBR @ 2,5mm penetration vs Relative Compaction**
- **Swell is measured during soaking – this gives a good indication of moisture sensitivity**
- **Usually express CBR at the minimum Relative Compaction required for the layer in which the material is used:-**

Subgrade $CBR_{90\%MDD} = 7$

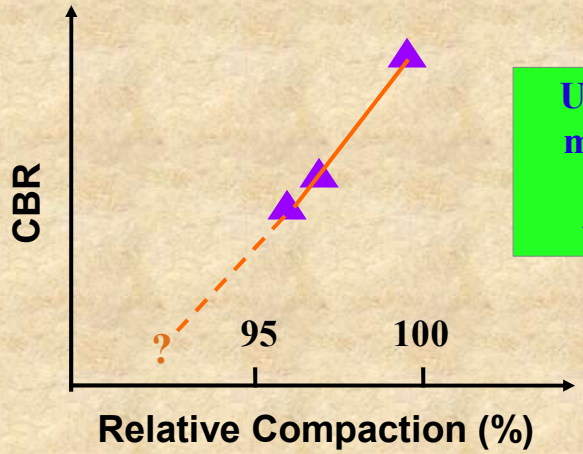
Subbase $CBR_{97\%MDD} = 39$

CBR Continued

Thus CBR at 95% Relative Compaction = 30



CBRs on Sand - Problematic



Use rubber membrane on top of the sand

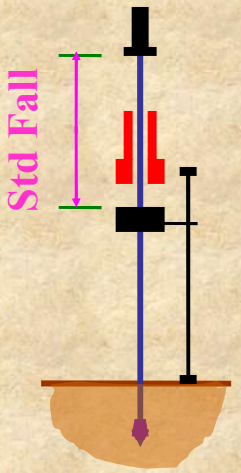
SHORT BREAK

10 Minutes

Dynamic Cone Penetrometer

The "DCP" - Was originally developed as a mini SPT for testing Non-Cohesive fine-grained materials (sands).

Subsequently used in other materials (w/o adaptation) by Kleyn (TPA) and others who developed rough correlations with CBR & UCS



Measures resistance of in situ material to Cone Penetration in mm/blow (DN)

DCP Plot

DCP Continued

DRAW-BACKS

- Moisture Sensitive
- Particle Size affects penetration
- Overburden Pressure
- Sensitive to Plasticity

WARNING

Be careful about correlations with CBR and UCS, and use for pavement design!!

BUT.... It's better than sticking your thumb in it and very useful for relative comparisons

CHEMICAL TREATMENT

SANS 3001-GR31 and GR50 to GR54

MODIFICATION – Reduces PI

STABILIZATION – Provides Strength through cementation

- Strength Tests are used to:-
  - ✓ Check Stabilization
  - ✓ Check Mixing Uniformity & Strength
  - ✓ Check Carbonation
- Chemical Tests to check Stabilizer Content – GR56
- Phenolphthalein to check Carbonation

STABILIZATION

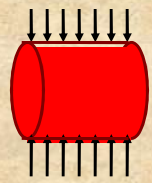
Laboratory Strength tests

❖ Unconfined Compressive Strength (UCS) SANS 3001-GR53

Rapid Cure, 7 Days or long term?

Problems with reproducability

❖ Indirect Tensile Strength (ITS) SANS 3001-GR54



Not easy to correlate between the two tests. Check Client's preference, especially Curing

AGGREGATE STRENGTH

Treton Test - SANS 3001-AG9

Impact Resistance on -20 mm +16 mm stone
(Gravel roads)

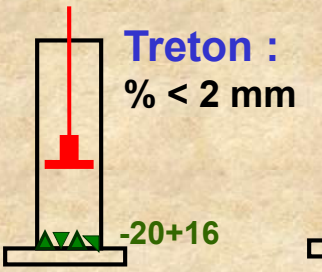
Aggregate Crushing Value (ACV) & 10%FACT
- SANS 3001-AG10

Crushing Resistance (wet and dry)
on -14 mm + 10 mm stone

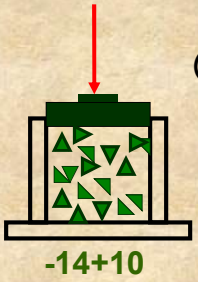
Modified Ball-Mill Test - SANS 3001-AG16

Wet and dry, on whole sample - Resistance to degradation during construction and during pavement life

Aggregate Strength Tests

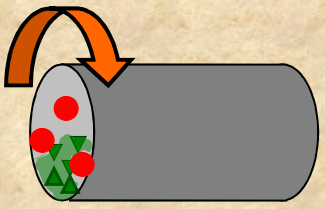


Treton :
% < 2 mm



ACV : % Fines
@ 400kN Load

10%FACT : Load to Generate 10% Fines



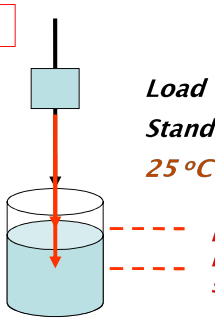
Whole Sample

Modified Ball-Mill
60 rpm for 10 min
B-M Index = P0,425 x PI
using max values

EXISTING BASIC BITUMEN TECHNOLOGY

Penetration grade bitumen

Commonly used grades:
- 40/50 pen
- 60/70 pen
- 80/100 pen



Load 100 g

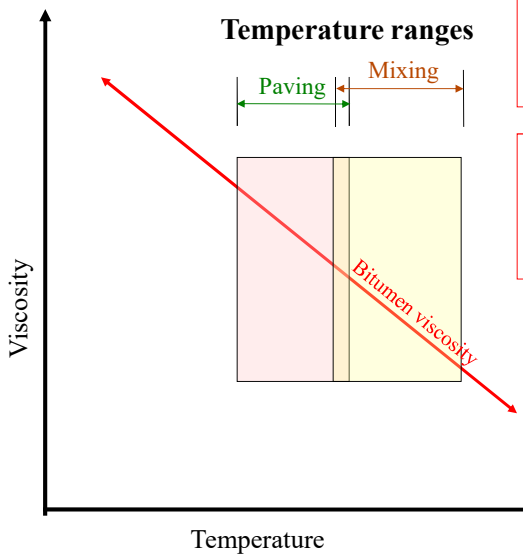
Standard needle

25 °C

Penetration, measured in tenths of mm after 5 seconds

"Pen Bitumen"

Viscosity



Note

If bitumen is heated to too high a temperature it will degrade and its performance with be significantly reduced

Typical mixing temperatures for continuously graded mixes

40/50 pen 140 to 165 °C

60/70 pen 135 to 160 °C

Paving temperatures

Shall not be more than 10°C less than min mixing temperature

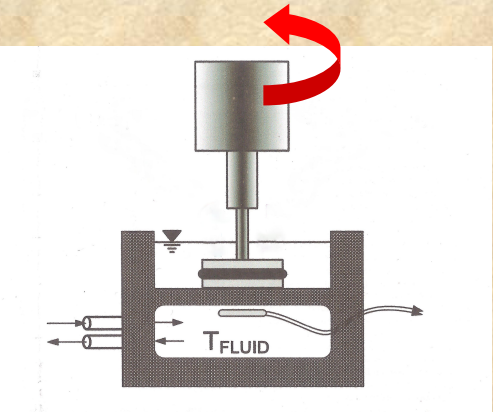
New tests for PG Binders

- **Dynamic Shear Rheometer**
  for the warm to hot range of temperatures

Measure shear stress and strain

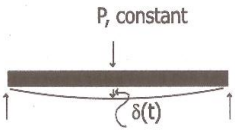
Complex Modulus (G*) = stress/strain

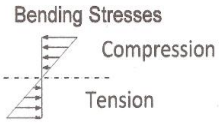
Phase angle (δ)



- **Bending Beam Rheometer**
  for cold conditions

- Simply Supported Beam, 6 x 12 x 200 mm
  - Apply constant load step load at midspan
  - Measure deflection with time
- Assumptions
  - Tensile – compressive stresses/strains vary linearly
  - Tensile and compression modulus are equal
  - Effect of shear stresses on deflection is negligible





Applied Load (σ_1) = 980 mN

Deflection (δ_t) measured versus time up to 240 seconds

Stiffness S(t) = σ_1/δ_t

Plot S(t) versus t The slope of the curve = m

Bitumen Stabilized Material (BSM)

New suite of tests – SANS 3001-BSM

BSM1 : Foaming Characteristics of bitumen

BSM2 : Prep lab mixed specimens of BSM

BSM3 : Vibratory compaction of BSM

BSM4 : ITS testing of BSM

BSM5 : Monotonic triaxial testing of BSM

ASPHALT TESTS

MARSHALL : SANS 3001-AS1, 2 & 10

Similar to gravel MDD - vary binder instead of moisture; load each specimen recording peak strength and deformation

MAXIMUM VOIDLESS DENSITY : SANS 3001-AS11

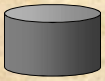
was Max Theoretical Density (Rice's)

OTHER TESTS :

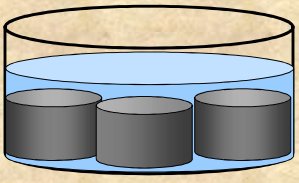
Binder Content, Grading, Core Density,
Dynamic Creep, Resilient Modulus & ITS

MARSHALL Stability & Flow Test SANS 3001-AS1 & AS2

1. Compact briquettes using standard Marshall apparatus

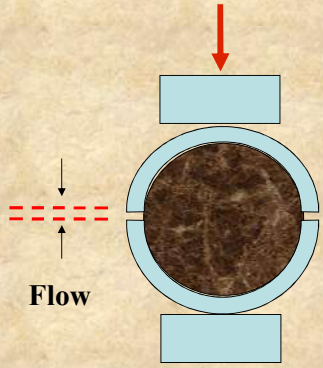


2. Determine bulk densities



3. Soak briquettes in water for 30 minutes at 60 °C

4. Apply load to failure = Marshall Stability

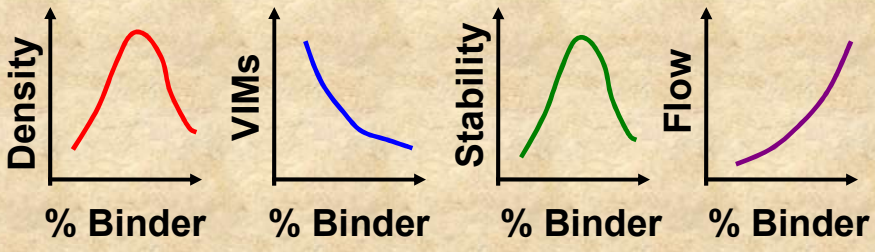


Asphalt Tests Cont.

MARSHALL RESULTS

Plot:- Binder Content versus Density, VIMs, Stability and Flow

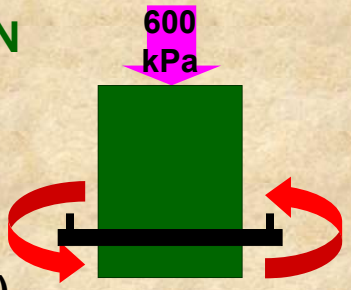
$$VIMs = \frac{\text{Rice's MTD - Marsh D}}{\text{Rice's MTD}} \times 100$$



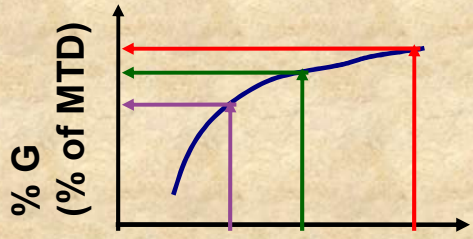
Asphalt Tests Cont.

GYRATORY COMPACTION

150mm Diameter Mould
250mm High
1,25° Tilt x 30 rpm



Material heated to 135°C (visc)



$G_{initial}$
G_{design}
G_{max}