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WORKSHOP:
Verification of Specifications for the use of laterite in road pavements:
Chap 3, 4 & 5

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OBJECTIVES

- Raise awareness of the existence of the performance-based specifications that have been developed specifically for the use of laterites in road construction in such countries as Angola, Brazil and Australia.
- Highlight the fact that such specifications are quite different to the more traditional ones that are still used in a number of countries in Africa, as a result of which unnecessary recourse is often made to the relatively expensive stabilization of these local materials for use in low volume roads (LVRs).
- Review existing specifications for the use of laterites in LVR construction based on the most recent/relevant documentation on the subject.

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PROPERTIES AND TESTING

- Properties normally considered most important for laterite specification
  - Particle size distribution
  - Atterberg Limits
  - Aggregate (particle strength)
  - Material strength
- Also the potential for self hardening
  - May contribute to long-term performance
  - *Remember short term loadings*

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PARTICLE SIZE DISTRIBUTION

- Only applicable to more immature materials
  - Plinthite, nodular and soft honeycomb
  - Others need to be broken or crushed
- Affects the particle packing and stability
  - Modified by construction procedures and processes
  - **Also by test methods**
  - LAA (no balls) - 500 revs?
- Need to understand and take account of fundamentals

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PARTICLE SIZE DISTRIBUTION

- Standard sieve analysis uses mass
- This assumes that all the particles have the same relative density
- Not true – iron rich particles may be 3.0 – 3.5 and fine clays and quartz 2.6 to 2.7
- Actual packing during construction is volumetric
  - Mass based calculations are therefore incorrect
- Constructed layer may then be gap graded with a compromised stability
- Need to inspect the material carefully and recalculate “gradings” if differences are suspected

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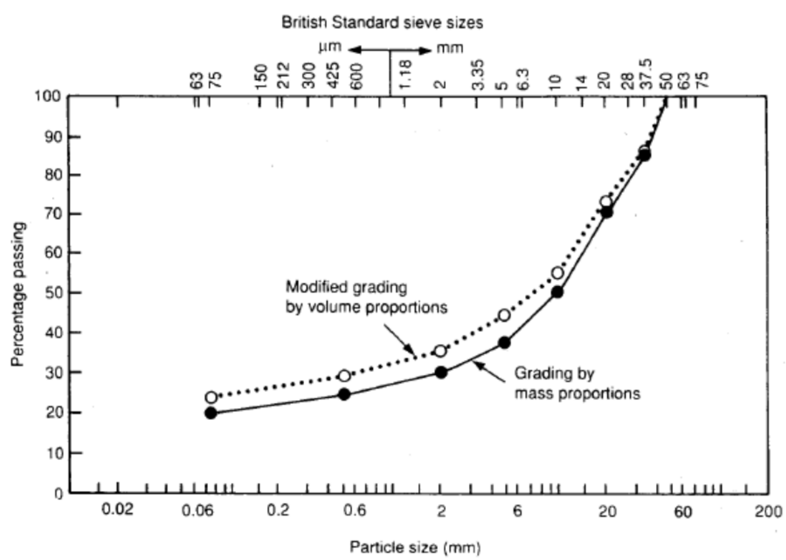

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PARTICLE SIZE DISTRIBUTION

- Laterites often contain materials with a range of particle hardnesses
- Soft particles should not be crushed during preparation and testing
- Fines adhere to particles so washing is necessary

- Hydrometer test
  - Sodium hexametaphosphate appears too be best dispersant

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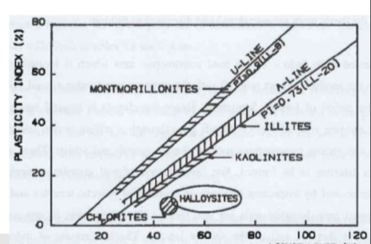
ATTERBERG LIMITS, SHRINKAGE AND SWELLING

- Atterberg's are fundamental to nearly every current specification
- Determination in laterites is fraught with difficulties
  1. Material variability
  2. Preparation of soil fines – working, drying
  3. Oven-drying, air drying, no drying – irreversible changes
  4. Time of mixing – standard 10 minutes – Lyons recommend 5 mins
  5. Apparatus – BS vs ASTM (BS 4% higher)
     1. Rather use bar linear shrinkage ? BS vs SANS (TMH) ?
  6. A – line - plot on both sides – those lower may present problems – halloysite
  7. Swell – low – don't relate to Atterbergs



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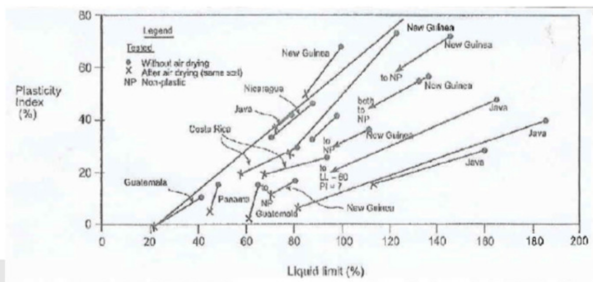
ATTERBERG LIMITS, SHRINKAGE AND SWELLING

- Need to simulate field conditions as closely as possible
- Drying
  - Australia < 50° C
  - Brazil < 60° C
  - SA - 105 -110° C
  - Air
- **Need to standardise**



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SILICA-SESQUIOXIDE RATIO

- Used to classify laterites
- Different ways of determining (ratio or molecular ratios)
- $\frac{S}{R} = \frac{\frac{SiO_2}{60}}{\frac{Al_2O_3}{102} + \frac{Fe_2O_3}{160}}$ or $\frac{S}{R} = \frac{SiO_2}{Al_2O_3 + Fe_2O_3}$
- Which fraction tested – full grading, -2.0 mm, -0.425 mm or -0.002 mm
- Different methods – Brazil – wet chemistry

  Western Australia – XRD, XRF or wet chemistry and ICP

- Probably not useful because of limited testing capabilities of engng labs

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COMPACTION/CBR

- Affected by moisture content and changes – (wet reduces it significantly)
- Cannot reuse material
- Can be extraordinarily high
- Frequently unsoaked – no reference to equilibration
- Can be predicted from classification test results
- **Remember : different test methods**

- Perhaps DN is a better measure – needs to be investigated more fully
- Relevant models ? – standardise !

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HARDENING AND SELF-STABILIZATION)

- Still highly debateable – F Netterberg paper
- Definite evidence observed
- Petrifaction degree and cycled CBR
- CBR should at least double to ensure that it is not due to poor CBR repeatability
- Requires additional investigation

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AGGREGATE STRENGTH/DURABILITY

- Various tests used – mainly LAA internationally
- Not really appropriate for either
- Probably AIV (or APV/AFV) more appropriate

MCT (Miniature Compacted Tropical Soils test)

- Used in Sao Paulo State, Brazil only for *fine grained lateritic soils*
- Suite of many tests defining various properties
- Not appropriate for most gravel laterites

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SPECIFICATIONS

- Traditional specifications are not appropriate
  - Too conservative
  - Based on standard test methods, that are not realistic
- Recognised in many tropical countries who have modified specifications (often traffic related)
- Mostly:
  - PI – up to 21%
  - Grading – looser envelopes
  - CBR – as low as 45% (soaked at 95% Mod AASHTO)
  - “Best” use a combination of Atterberg and grading

    (various parameters described but probably better than a grading alone)
- Summary of many different specifications provided in the document

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SPECIFICATIONS (TRL)

Table 6-10 Guidelines for the selection of lateritic gravel roadbase materials

Subgrade CBR		Design traffic class					
		≯0.01	0.05	0.1	0.3	0.5	1.0
S2	I_P	≯15	≯15	≯12	≯9	≯9	≯6
	PM	≯400	≯250	≯150	≯150	≯120	≯90
	GE	B	B	B	A	A	A
S3	I_P	≯18	≯15	≯15	≯12	≯9	≯6
	PM	≯550	≯320	≯250	≯180	≯120	≯90
	GE	B	B	B	B	A	A
S4	I_P	≯20(1)	≯18	≯15	≯15	≯9	≯9
	PM	≯800	≯450	≯320	≯300	≯200	≯90
	GE	GM 1.6-2.6	B	B	B	B	A
S5	I_P	≯25(1)	≯20	≯18	≯15	≯12	≯9
	PM	n/s	≯550	≯400	≯350	≯250	≯150
	GE	GM 1.6-2.6	B	B	B	B	B
S6	I_P	≯25(1)	≯20	≯20	≯18	≯15	≯12
	PM	n/s	≯650	≯550	≯400	≯300	≯180
	GE	GM 1.6-2.6	B	B	B	B	A

Notes:
(1) Ip maximum = 8 x GM
n/s = not specified
Unsealed shoulders are assumed

Ip = plasticity index
PM = plasticity modulus
GE = grading envelope
GM = grading modulus

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SPECIFICATIONS - Lateritic Gravels Based On Grading Classification Tests (MRWA, 2002)

Type of Material		Lateritic Gravel			Crushed Rock
Designation		Lt6	Lt10	Lt16	NS
Grading	Sieve Size mm	% Passing	% Passing	% Passing	% Passing
	37.5	100	100	100	
	26.5				100
	19.0	71-100	95-100	95-100	95-100
	13.2				70-90
	9.5	50-81	50-100	50-100	60-80
	4.75	36-66	36-81	36-81	40-60
	2.36	25-53	25-66	25-66	30-45
	1.18	18-43	18-53	18-53	20-35
	0.60				13-27
	0.425	11-32	11-39	11-39	11-23
	0.30				8-20
	0.15				5-14
	0.075	4-19	4-23	4-23	5-11
	0.0135	2-9	2-11	2-11	
Dust Ratio		0.3-0.7	0.3-0.7	0.3-0.7	0.35-0.6
Liquid Limit %		≤25	≤30	≤35	≤25
Plasticity Index %		≤6	≤10	≤16	NS
Linear Shrinkage %		≤3	≤5	≤8	0.4-2.0
P0.425 x LS		≤150	≤200	≤250	NS
Expected maximum Dry Compressive Strength kPa		≥1700	≥1700	≥1700	≥1700
Dryback %		≤ 85	≤ 85	≤ 85	≤60

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REQUIRED CLASSIFICATION NUMBERS FOR LATERITIC GRAVEL (WELL DRAINED) (MRWA, 2002)

Climate	Traffic Loading (ESA) [6]				
	≤5x10[6]	≤10[6]	≤5x10[5]	≤10[5]	≤5x10[4]
Sub humid hot	Lt6	Lt6	Lt6	Lt10	Lt10
Semi arid hot	Lt10	Lt10	Lt10	Lt16	Lt16
Arid hot	Lt10	Lt10	Lt16	Lt16	Lt16
Arid warm	Lt10	Lt10	Lt16	Lt16	Lt16
Semi arid warm	Lt10	Lt10	Lt10	Lt10	Lt16
Sub humid warm	Lt6	Lt6	Lt6	Lt10	Lt10
Humid warm	Lt6	Lt6	Lt6	Lt6	Lt6

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TYPICAL SELECTION CRITERIA FOR LATERITIC GRAVEL BASED ON STRENGTH AND CLASSIFICATION TESTS (MRWA, 2002)

DESIGNATION	Lt6	Lt10	Lt16
WACCT			
Class No	2	2	2.3
Cohesion kPa	85	85	85
Tensile Strength kPa	55	55	55
CBR Soaked	80	60	60
Unsoaked	80	80	80
Maximum Size mm	37.5	37.5	37.5
Grading Modulus	1.5	1.5	1.5
Dust Ratio	0.3-0.7	0.3-0.7	0.3-0.7
Plasticity Index %	6	10	16
Linear Shrinkage %	3	5	8
$P_{0.425}$ x LS	150	200	250
Dryback %	85	85	85

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SUMMARY OF BRAZILIAN SPECIFICATIONS FOR LATERITE BASE COURSE

Property	Limits		Comments
Silica-sesquioxide ratio	≤ 2		
California Bearing Ratio	≥ 60%		For base at 56 blows compaction and at design moisture content
Liquid limit	≤ 40%		
Plasticity Index (%)	≤ 15%		
Los Angeles Abrasion	≤ 65%		
Grading	Grading A	Grading B	Maximum tolerances
Passing sieve size (mm)			
50.8	100		
25.4	100 - 75	100	± 7
9.5	85 – 40	95 – 60	± 7
4.8	75 – 20	85 – 30	± 5
2.09	60 – 15	60 – 15	± 5
0.42	45 – 10	45 – 10	± 5
0.075	30 – 5	30 – 5	± 2
Grading modulus[1]	1.65 – 2.70	1.65 – 2.70	
Dust ratio[1]	≤ 0.67	≤ 0.67	
Sand equivalent	≥ 30%		

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SUMMARY OF SPECIFICATION REQUIREMENTS

- Best indicators appear to be in situ strength at expected moisture and density (CBR/Texas triaxial, etc)
- CBR swell seems to be a useful parameter as well
- Must ensure that the material is actually a pedogenic material
- Aggregate strength will ensure that the material retains some structure
- Most importantly – test methods must be adapted to the material properties

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CONSTRUCTION AND USE

- A number of characteristics relating to construction practices were found in the literature
- In general conventional construction processes are adequate
- However, to improve quality the following are noted:
  - The material should be stockpiled to reduce variability
  - Compaction moisture is critical – drip irrigation used in Australia
  - High degree of compaction is essential (even in support)
  - Must be dried back before sealing (not > 80% OMC – impact on suction which appears to be critical)
  - Large particles must be broken down to get acceptable finish
  - Compaction difficulties often related to poor gradings (mass and not volume?)

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5. CONSTRUCTION AND USE

Quality control

- Good quality control essential
- Note change in MDD as a result of change in grading during construction
- Excessive iron in the material can affect nuclear density readings
- Problems regarding moisture content determinations if drying temperatures not adequately considered

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5. PERFORMANCE RELATED STUDIES

- Various investigations have been carried out on laterite roads in Malawi, South Africa, Botswana, Kenya and Zimbabwe
- Useful information is available and this information should be assessed in more detail
- Preliminary details included

Standard construction (foreground), LVSR construction (background) - Ntchisi road

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