Course content

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2 Performance
3 Design
4 Construction
5 Maintenance
6 Management
7 Investigation & maintenance measure selection
8 Safety aspects
9 Rehab, improvement and upgrading

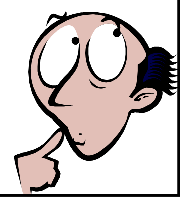
3 DESIGN

3.1 Geometric design
3.2 Cross drainage
3.3 Pavement thickness design
3.4 Wearing course thickness design
3.5 Material selection

3 DESIGN

3.5 Material Selection

- Numerous specifications have been employed for wearing course gravels
- TRH 14 specification was generally used in SA (based on AASHTO spec – essentially sub-base material)
- Comparison with performance showed they were lacking in ability to predict performance
- Many good materials are rejected and many poor materials were accepted
- Extensive research was carried out in 1980s



3. DESIGN

REQUIREMENTS OF UNSEALED ROADS

- Provide a smooth and safe ride with minimal maintenance
- Stability – resistance to deformation
- Shed water without erosion or scouring
- Resist traffic abrasion
- Freedom from dust
- Not become slippery when wet but not wear tyres
- Low cost and ease of maintenance

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REQUIREMENTS OF UNSEALED ROADS

- This is a lot to ask from a few truckloads of soil/gravel !!
- Achieve this through good material specifications and selection
- (Also good construction and maintenance)

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GOOD MATERIAL SPECIFICATIONS

- Simple with as few requirements as possible
- Limits must be as wide as possible
- Properties should require inexpensive, quick, easy, tests with simple equipment and low skills
- Practical and widely applicable
- Adequately define important properties
- Preferably use existing test methods
- Based on performance-related studies

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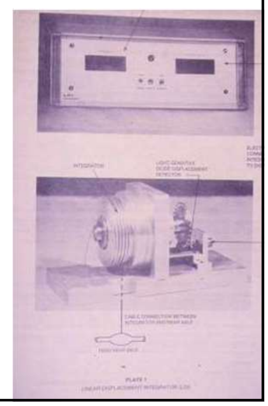
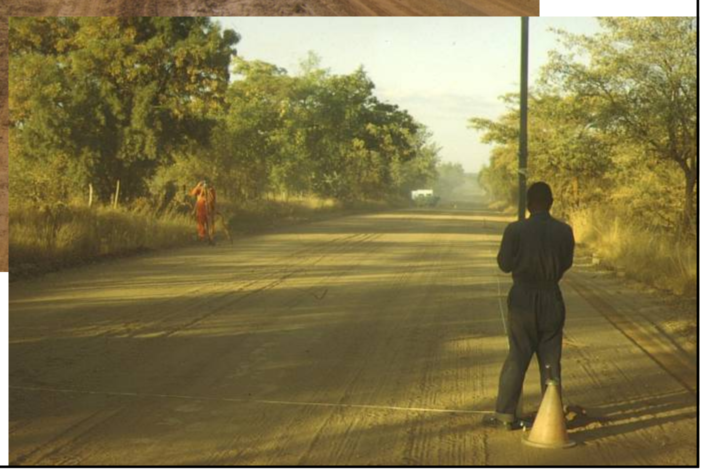
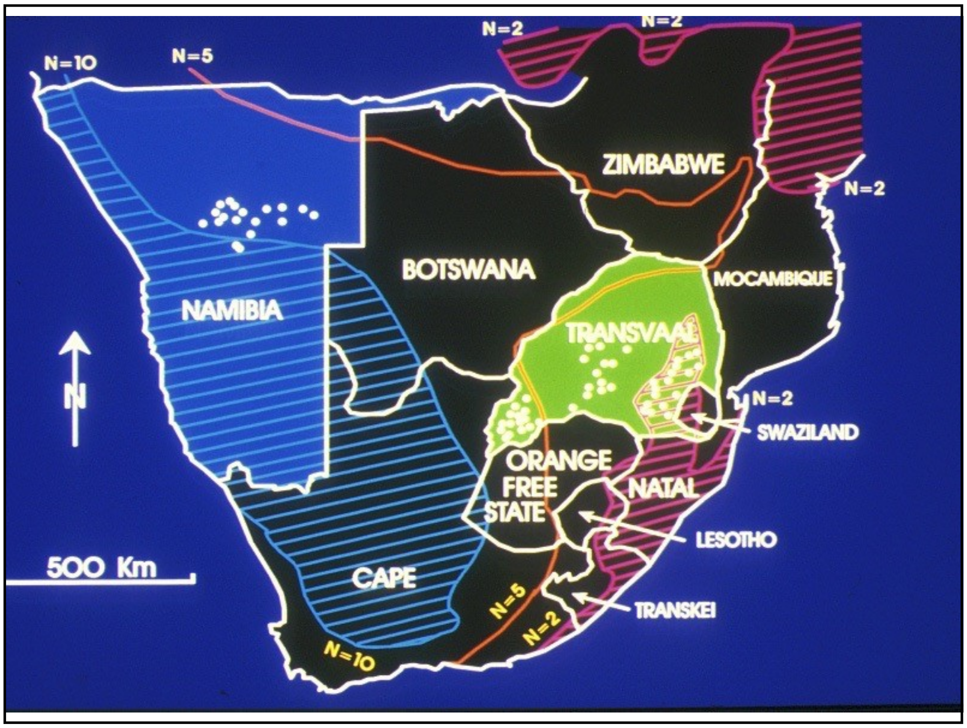
Performance-related specifications were developed in the late 1980s

- Based on sampling, testing and monitoring of 110 road sections for more than 3 years
- Monitoring
- About every 3 weeks
  - Roughness/riding quality
  - Full visual (predecessor of TMH 12)
- Every 3 months
  - Gravel loss by precise levelling surveys
- More than 250 000 km covered







SURFACING MATERIAL		1 ACID CRYSTALLINE	2 BASIC CRYSTALLINE	3 HIGH SILICA	4 ARENACEOUS	5 ARGILLACEOUS	6 PEDOCRETE
CLIMATE	TRAFFIC						
N < 2	< 100 vpd	576 (98/39)	796 (32/34) 1298 (25/16)	625 (57/44) 421 (89/63)	X	210 (92/50) 1008 (37/35)	268 (90/36)
N < 2	> 100 vpd	1560 (333/75) 219 (115/38)	383 (100/28)	P8-4 (111/14)	X	210 (246/34)	1110 (223/25) 1266 (108/36)
2<N<5	< 100 vpd	1439 (5/20)	1561 (61/20)	1886 (69/13)	178 (26/25)	1342 (53/15)	1717 (31/27) 942 (18/7)
2<N<5	> 100 vpd	024 (427/17) 685 (127/15)	1161 (200/10) 685 (132/14)	420 (197/20)	522 (173/14) P175-1 (148/45)	771 (236/29)	327 (395/22)
N > 5	< 100 vpd	017 (58/25) 433 (53/8)	437 (92/21) 14 (22/27)	1479 (20/26)	1141 (46/24) 508 (61/13)	508 (51/10)	167 (56/15) 1216 (11/22)
N > 5	> 100 vpd	502 (112/13)	912 (127/20)	509 (156/16)	611 (100/23)	146 (105/15)	1401 (200/50) 611 (110/30)

NOTE: THE NUMBERS IN EACH CELL ARE THE ROAD NUMBERS WITH THE NUMBER OF VEHICLES/DAY AND PERCENT HEAVY IN PARENTHESES

3. DESIGN

- SAMPLING AND TESTING

- Sample according to TMH 5
- Use TMH 1 (1979 &1986) (or new SANS standards) methods
  - Grading
  - Atterberg Limits
  - Compaction characteristics (Mod)
  - California Bearing Ratio (CBR)
  - Treton Impact Value
- Specifications applicable after placement and compaction
- LAA can simulate these processes

3. DESIGN

- TESTING

- NB:
- Grading parameters must use conventional wet grading analysis
- TMH Method A1(a)
- Now SANS 3001-GR1
- **Must** be normalised for 100% passing 37.5 mm

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Performance-related specifications

- All data entered into a data base
- Average performance for each section using a weighted model was plotted against various material properties
- Eventually a trend was obtained
- NB:
  - Durability of materials was not a factor
  - Certain mudrocks disintegrate rapidly (COLTO 5 cycle soundness test)

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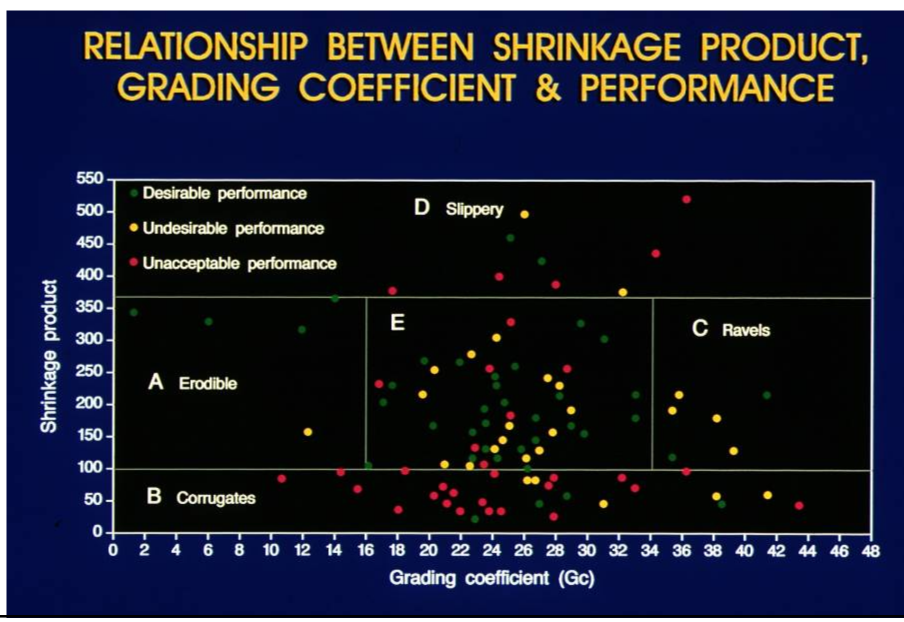

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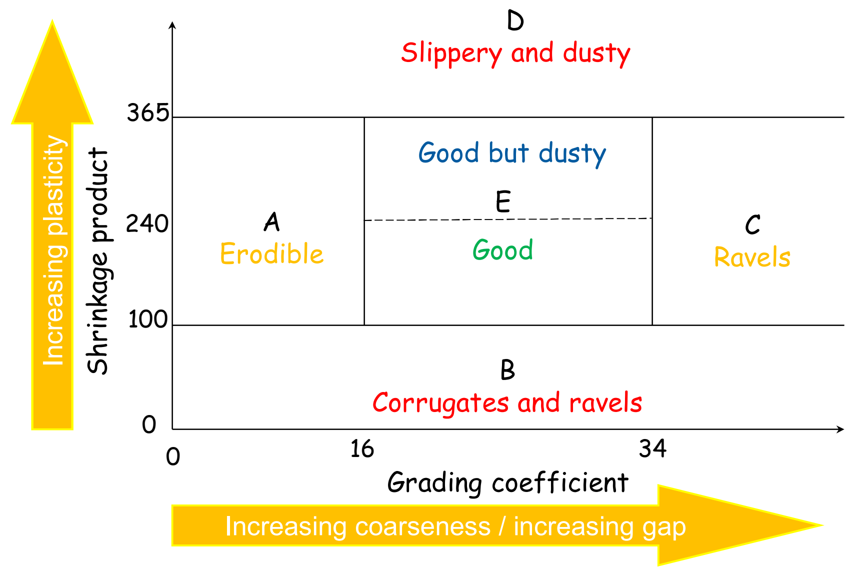
Specification for rural roads

Maximum size	37.5 mm
Max oversize index	5 %
Shrinkage product (S_P)	100 – 365 (240)
Grading coefficient (G_c)	16 – 34
Min CBR (%)	15 at 95% Mod AASHTO
Treton Impact value (%)	20 - 65

Sp – Weighted bar linear shrinkage (BLS * P0.425)

Gc – (P26.5 – P2)*P4.75/100



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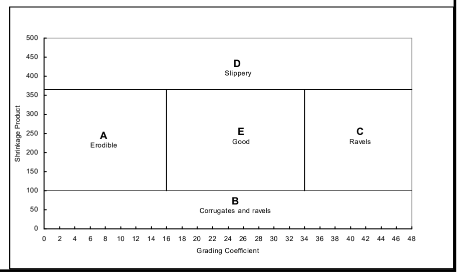
A. Satisfactory – fine grained and prone to erosion – avoid on steep grades – require periodic manual repair – high gravel loss
B. Lack cohesion and ravel and corrugate – require regular maintenance
C. Fine, gap-graded materials lacking adhesion – ravel and loosen
D. Slippery when wet
E. Perform best – remove oversize



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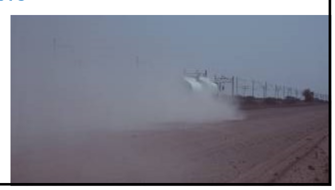
- Zones can be related to crossfall
- 4 – 6% in Zone E
- 3 - 4% in A, C and D
  - Reduce risk of erosion and vehicles slipping off road

- Dust may be unacceptable
- Should be acceptable if SP < 240
- Estimate from :
  - D = 20.88–0.32(PI)+1.24(BLS)–0.04(P075)+0.01(AIV)–9.05(RD)
  - Id D > 0 then dust is likely to be unacceptable to public
  - If D < 0 then dust is likely to be acceptable



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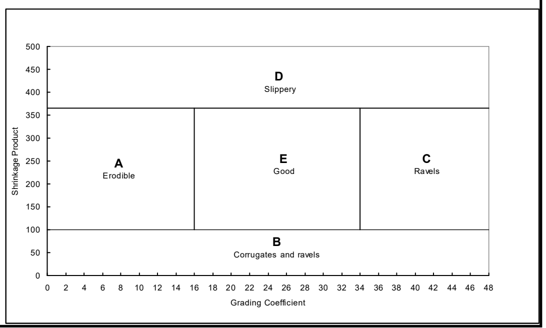
Suitability and potential problems highlighted by selection chart

- Must use judgement
  - In flat dry areas materials in zone A and D may be effective
  - If traffic is low and maintenance “easy” materials in Zone B can be used
  - In arid areas, materials in Zone D are probably the best - warning signs !



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Suitability and potential problems highlighted by selection chart

- Treton Impact Value (TIV) identifies aggregates that are too hard to be broken by a grid roller (TIV < 20%)
- Or too soft – will disintegrate under traffic (TIV >65%)

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Suitability and potential problems highlighted by selection chart

- Is CBR of 15% enough ?
- Material with CBR = 18% - 4 days after heavy rain

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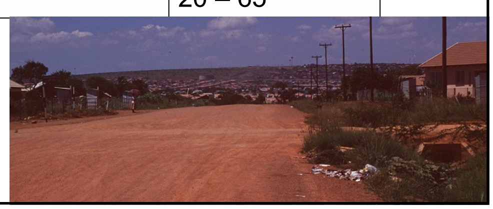
Urban areas

- Oversize index reduced
- SP reduced to minimise dust (probability of unacceptable dust reduced from70 to 40%)

Maximum size (mm)	37.5
Oversize index (I_o)	0
Shrinkage product (S_p)	100 - 240
Grading coefficient (G_c)	16 - 34
Soaked CBR (at 95 per cent Mod AASHTO compaction)	≥ 15 %
Treton impact value (%)	20 – 65



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Haul roads

- Maximum size and oversize index relaxed (bigger wheels)
- CBR increased – higher shear stresses
- > 50 tonnes – Thompson & Visser

Maximum size (mm)	50
Oversize index (I_o)	≤ 5%
Shrinkage product (S_p)	100 – 365 (preferably < 240)
Grading coefficient (G_c)	16 - 34
Soaked CBR (at 95 per cent Mod AASHTO compaction)	≥ 18 %
Treton impact value (%)	20 – 65

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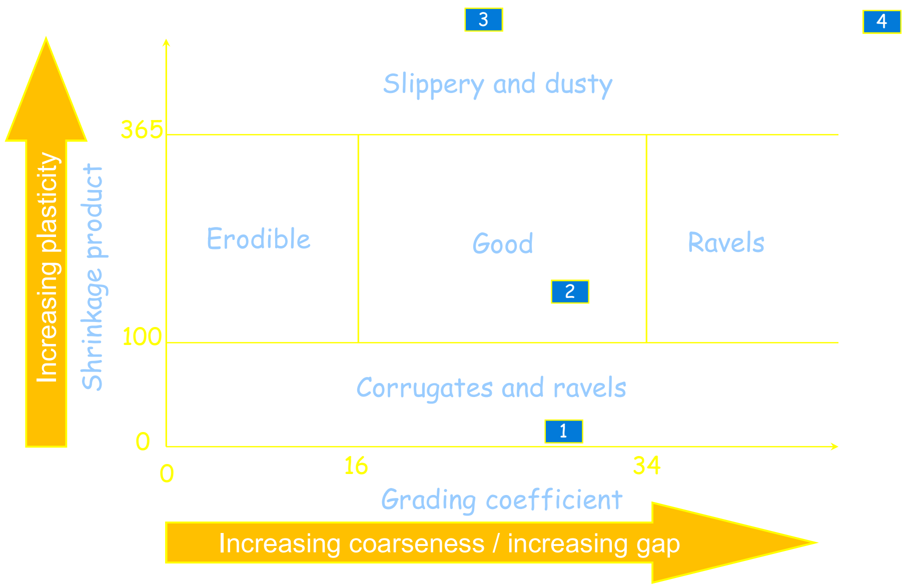
NB: Particle size distribution

- Must be as continuous as possible
- Not gap-graded
- Not necessarily shown by GC

Performance Prediction (AASHTO)



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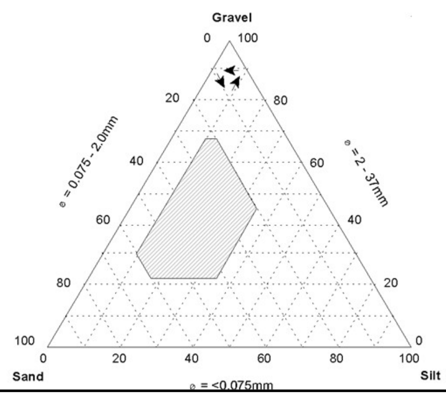
3.6 Material Improvement

- Mixing two or more materials – usually two
- Improve grading, plasticity or strength
- Slower deterioration (roughness and gravel loss) result from getting the GC and SP right
- Care required when modifying plasticity
- Do not cause kinks in grading curve
- Compare grading curves before and after

3 DESIGN

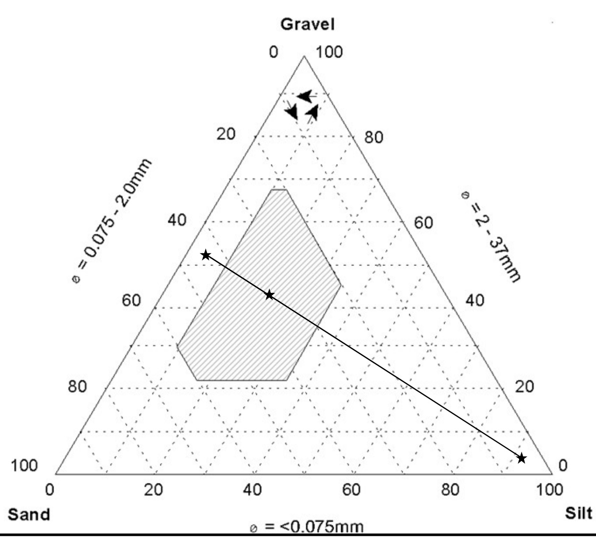
3.6 Material Improvement

- Use of Ternary diagram
- Commonly used in geology, chemistry and metallurgy



Parameter	Material	
	A	B
% passing screen size (mm) 37.5 26.5 4.75 2.0 0.425 0.075	 100 85 42 49 20 6	 100 100 97 96 94 92
Linear shrinkage Shrinkage product Grading coefficient	NP 0 15	5 470 4
% silt/clay (P075) % sand (P2 - P075) % gravel (100 - P2)	6 43 51	92 4 4

Material improvement - blending



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3.6 Material Improvement

- Possible with chemical stabilization
- Discuss later (Section 9)

3 DESIGN

3.7 Material Location