Course content

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2 PERFORMANCE OF UNSEALED ROADS

- Unsealed roads react to traffic and environment more than sealed roads
  - Usually negatively
  - In both rate and degree
- They therefore have characteristic problems in the short term
  - Unlike sealed roads
- Problems include
  - Structural defects such as impassability, potholes and ruts
  - Functional defects such as dustiness, potholes, stoniness, etc
- Both have an impact on performance, maintenance requirements and costs of operating unsealed roads

2 PERFORMANCE OF UNSEALED ROADS

Structural defects

- Relate to the inability of the road structure to support the traffic under prevailing environmental conditions
- Occur within the wearing course or support layers
- Not always a definite distinction between structural and functional
  - Potholes often develop as a result of inadequate support (structural)
  - Can also result from poor material, construction, maintenance or even short-term climate or traffic
- Usually requires more than routine maintenance to repair

2 PERFORMANCE OF UNSEALED ROADS

Passability

- All-weather surface implies passable at all times
- Impassability in wet weather is not acceptable
  - Excluding “selected” water crossings.
- Problem mostly related to earth roads – imported gravel is expected to avoid this
- Two definitions related to inability of vehicles to proceed in a horizontal direction
  - Loss of traction at depth (shearing)
  - Loss of traction at the surface (slipperiness)
- Shearing usually occurs at depth on flatter grades when the shear strength of the material is inadequate
- Slipperiness can occur on flat grades but is more common on steep grades and cambers (discussed further under functional defects)

2 PERFORMANCE OF UNSEALED ROADS

Passability

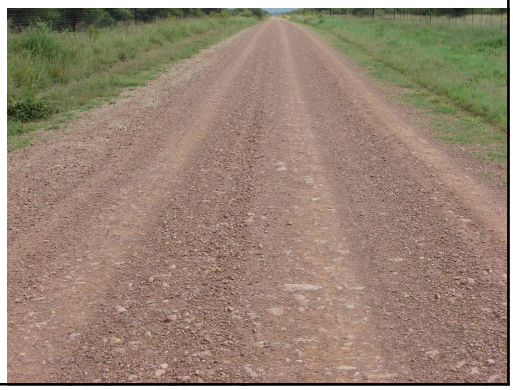
- Requires adequate material strength
- CBR of ≥ 15 at 95% Mod AASHTO
- *Compact to at least 95%*
- Passability is a function of shear strength of the material
- Clayey materials
  - If tractive forces > shear strength (C) → failure
  - Repeated shearing → churning → impassability
- Sandy materials → low shear strengths (low C high φ)

Promotes churning

2 PERFORMANCE OF UNSEALED ROADS

Passability

- Ensure adequate coarse fraction
- Assists with interlock of particles
- NB: CBR tests only < 19 mm
- New test < 37.5 mm ?



2 PERFORMANCE OF UNSEALED ROADS

Potholes

- Significant effect on roughness and possible vehicle damage
- Effect related to both size (diameter) and depth
- Worst are 250 to 1500 mm diameter and > 50 or 75 mm deep

POTHOLES

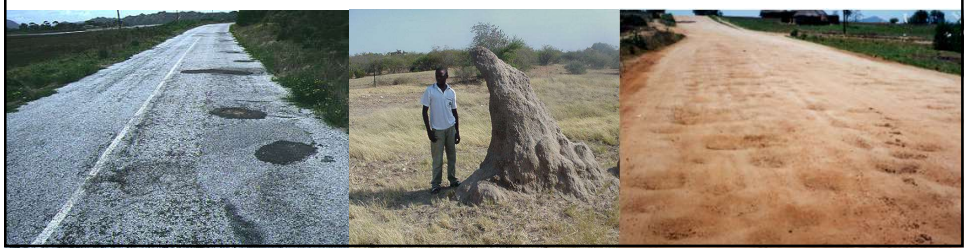
Causes of Potholes

- Deformation of weak subgrades and wearing course
- Poor road shape and drainage
- Plucking of oversize material by graders
- Compaction of material behind large stones
- Enlargement of corrugations

2 PERFORMANCE OF UNSEALED ROADS

Causes of Potholes

- Disintegration of highly cracked roads
- Disintegration of soft oversize material
- Dispersive soils
- Poor compaction
- Material and moisture variability
- Subsidence of animal and insect burrows



2 PERFORMANCE OF UNSEALED ROADS

Potholes

- Once initiated, the drainage deteriorates, water ponds, and potholes are enlarged by traffic
- Enlargement is caused by
  - Compaction of soft material
  - Splashing of mud from hole
  - Adhesion of mud to vehicles
- Potholes seldom occur on grades (good drainage)
- Worst at bottom of vertical curves

2 PERFORMANCE OF UNSEALED ROADS

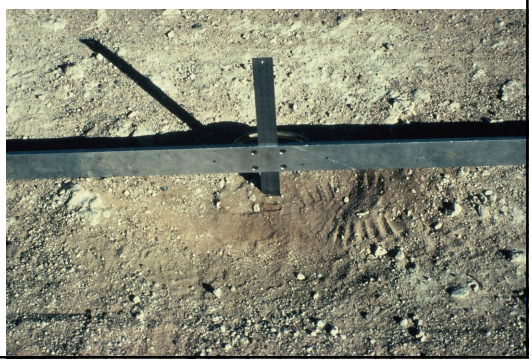
Potholes

- Water in potholes results in deterioration of material quality
- Differential “splashing”

2 PERFORMANCE OF UNSEALED ROADS

Pothole repairs

- Can be a problem
- Seldom repaired by grader maintenance or manual filling behind grader
- Need to enlarge and fill with same material at OMC and compact properly



2 PERFORMANCE OF UNSEALED ROADS

Ruts

- Parallel depressions of surface in the wheel tracks
- Formed by:
  - Deformation (compaction) of subgrade
  - Compaction of wearing course by channelized traffic
  - Loss of gravel through traffic abrasion/wear
- Traditionally the criterion for failure of unsealed roads (overseas)
- Not relevant in SA
  - Generally strong subgrades
  - Deep water tables

2 PERFORMANCE OF UNSEALED ROADS

Ruts

- Main cause in SA is ravelling of low cohesion material
- May be natural low cohesion or developed (loss of fines)
- Also caused by weak wearing course (deformation/shearing of cohesive materials
- Is so, requires new/better gravel
- Road width important – wide roads result in deeper more definite ruts – no need for wander when vehicles pass in different directions

2 PERFORMANCE OF UNSEALED ROADS

Ruts

- Deep ruts retain water = softening of material = additional deformation
- Filled by routine blading
- Masks ruts and new ones form in different positions
  - Increasing wheel paths 2 to 3 to 4 or more
- Natural repair
- May need to be moistened and rolled

2 PERFORMANCE OF UNSEALED ROADS

Functional defects

- Mainly surface defects related to poor materials, construction, maintenance or climate or traffic
- Major influence on the performance and level of serviceability of the road
- Usually repaired by grader maintenance
- Exacerbated by poor construction and/or maintenance

2 PERFORMANCE OF UNSEALED ROADS

Stoniness

- Relative percentage of materials in the road larger than recommended maximum size (preferably 37.5 mm)
- Result in the following problems:
  - Unnecessarily rough roads
  - Difficulty with grader blading
  - Poor compaction of areas adjacent to stones (potholes and ravelling)
  - Development of corrugations
  - Loose large stones on surface after blading
  - Thick loose material to cover stones

2 PERFORMANCE OF UNSEALED ROADS

Stoniness

- One of the few defects that can be controlled
- Remove or reduce in size during construction (Chapter4)
- Can be
  - Embedded in layer (affects maintenance and riding quality)
  - Loose on surface (affects safety and vehicle damage)
- Need to differentiate during visual assessment

2 PERFORMANCE OF UNSEALED ROADS

Stoniness

- Some materials are more prone to stoniness than others
- Difficult to break with grid rollers
  - Dolerites and granites – hard corestones
  - Baked shale and hornfels – flaky and sharp particles
- Crushing may be effective – eg, properly set up vertical shaft impact crushers such as Barmac



2 PERFORMANCE OF UNSEALED ROADS

Dustiness

- Dust is the fine material released from the road by vehicles
- Mostly silt sized (5 to 75 μm)
- Quantity generated by a vehicle depends on:
  - Aerodynamics of vehicle
  - Speed of travel
  - Material properties
  - Moisture content
  - Wind !

2 PERFORMANCE OF UNSEALED ROADS

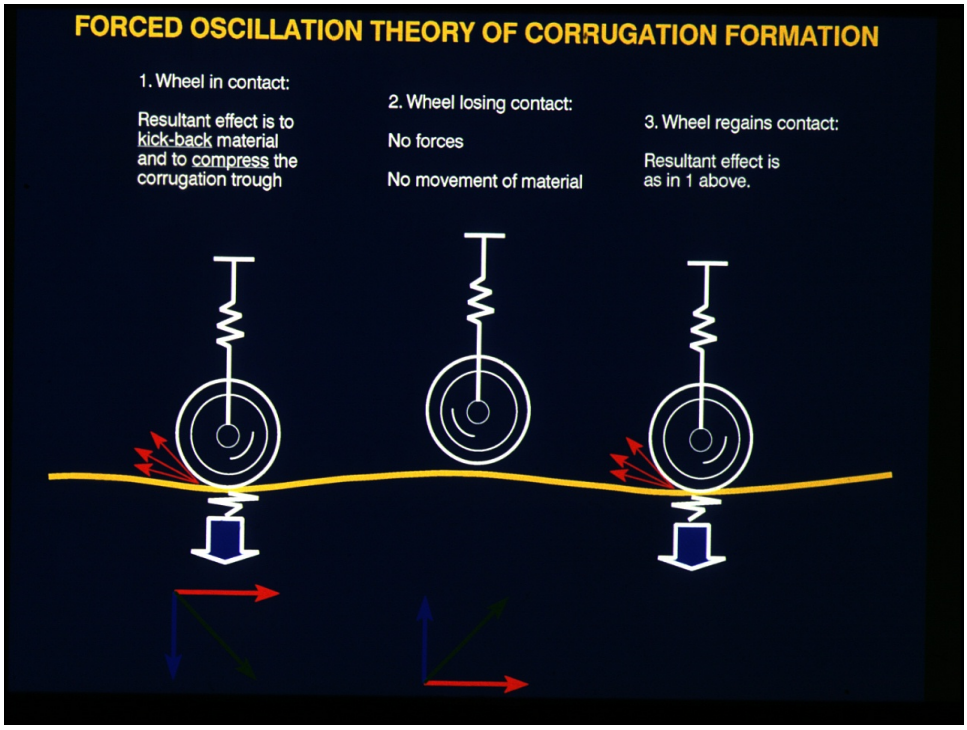
Dustiness

- Undesirable for a number of reasons:
  - Safety – visibility – passing and following
  - Comfort – close windows – hot climate !
  - Vehicle damage – wear of moving parts – sticks to grease – more frequent replacement of filters
  - Vegetation and animals – adjacent to road – difficult to assess – affects crops (particularly fruit), grazing, etc
  - Health – silica and asbestos dust – NB – drivers, occupants and neighbouring communities
  - Environmental – air pollution – inversions in valleys in winter – deposits in water
  - Economic – loss of wearing course – change in properties – cohesive materials start corrugating

2 PERFORMANCE OF UNSEALED ROADS

Corrugations

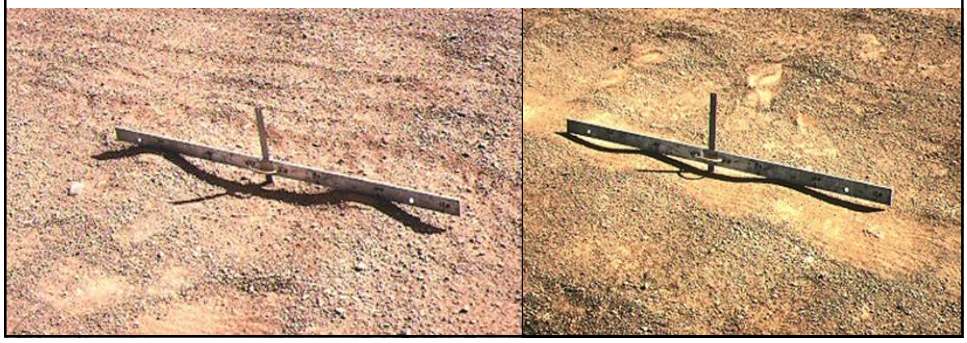
- One of the most disturbing defects in terms of riding quality (and even safety)
- Cause has been extensively researched
- “Forced oscillation theory”



2 PERFORMANCE OF UNSEALED ROADS

Corrugations

- Three kinds:
  - Loose
  - Fixed
  - Long wavelength



2 PERFORMANCE OF UNSEALED ROADS

Corrugations

- Loose corrugations removed during normal light blading
- Fixed corrugations need cutting or even light ripping
- Wave length depends on the modal speed of the vehicles
- Momentum of faster vehicles
- Approx distance in cm = modal speed in km/h
- None where speed < 20 km/h

2 PERFORMANCE OF UNSEALED ROADS

Corrugations

- Formation of corrugations related to material properties
- Fine-grained (< 5 mm or so) with low plasticity
- Also with PI up to 9% after wind blows fines away
- Seldom form during the wet season (apparent cohesion from soil suction)
- Regular maintenance necessary to avoid loose corrugations becoming fixed
- Novel maintenance techniques usually effective
- Sand cushioning (Sec 5.1)

2 PERFORMANCE OF

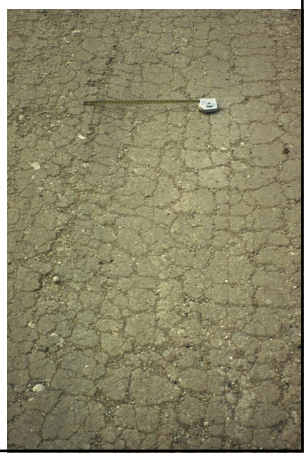
Corrugations

- Long wave-length (2.5 to 3.0 m) at angle of 30 to 45°
- Formed by grader
  - Too much bouncing
  - Too fast
- Not removed by normal grading

2 PERFORMANCE OF UNSEALED ROADS

Cracks

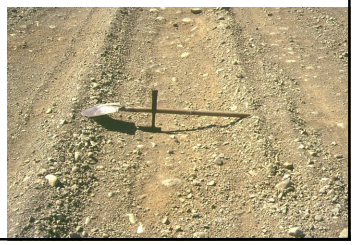
- Not really a major problem
- May break up under traffic and lead to potholes
- Result of volume changes in material
  - PI (BLS) probably too high
  - Material very fine (dolomitic wad)
- Tend to become excessively slippery
- Try and avoid in wet areas



2 PERFORMANCE OF UNSEALED ROADS

Ravelling

- Generation of loose gravel under traffic
- Economic, safety and maintenance problem
- Can be over entire road but usually concentrates in windrows between wheel tracks or alongside road
- Windrows are:
  - Safety problem
  - Likely to contain stones – vehicle and windscreen damage
  - Cause of high rolling resistance – increased fuel consumption and VOC's



2 PERFORMANCE OF UNSEALED ROADS

Ravelling

- Caused by :
  - Deficiency of fine material (cohesion)
  - Gap grading of material
  - Inadequate compaction
  - Disintegration of sedimentary (cemented) materials
- Blending of fine material can assist
- Worse in dry season (effective cohesion)
- Good wet compaction

2 PERFORMANCE OF UNSEALED ROADS

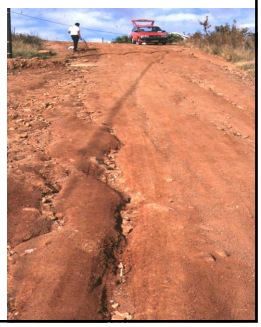
Erosion (scour)

- Loss of gravel caused by flow of water over the road

2 PERFORMANCE OF UNSEALED ROADS

Erosion (scour)

- Erodibility depends on shear strength (=cohesion as normal stress is 0)
- If shear strength is less than tractive force of water, grains become detached and erode away.
- Finer material with little aggregate erodes more
- Longitudinal or transverse



2 PERFORMANCE OF UNSEALED ROADS

Erosion (scour)

- Longitudinal
  - Usually not a major effect on riding quality
  - Form ruts and increases loss of material
  - Deposited in drains and culverts
- Transverse
  - Severe influence on riding quality
  - Dangerous conditions

2 PERFORMANCE OF UNSEALED ROADS

Erosion (scour)

- Prevent by :
  - Increasing shear strength of material
  - Decreasing shear stresses induced by water flow

- Increased strength:
  - Improve grading – well graded with gravel up to 25 mm
  - Good compaction (at OMC) improves strength and interlock
  - Also increased suction and decreased permeability
- Decreasing shear stresses :
  - Retard flow of water
  - Decrease grade and camber
  - Camber steeper than longitudinal grade
  - Care when grade > 5%
  - Erosion of differential fractions
- NB: Drainage

2 PERFORMANCE OF UNSEALED ROADS

Shape

- Most important effect is on drainage
- Water ponds and cannot flow away from road
- → impassability, potholes and ruts
- Maintain camber
- Also has an effect on safety and slipperiness
- Steep camber can result in vehicles sliding off slippery roads
- NB: Ruts on steep grades

2 PERFORMANCE OF UNSEALED ROADS

Slipperiness

- Major safety problem in wet
- Migration of fines to surface
  - Impact of rain
  - Pumping by tyres
- Require underlying aggregate
- “Hydroplaning” fines and not water – function of speed
- Beware slaking mudrocks
- SP > 365 slippery at > 50 kph

2 PERFORMANCE OF UNSEALED ROADS

Slipperiness

- Can also be a safety problem with dry materials
- Layer of fines (0.85 to 2 mm) (“ball-bearings”)

2 PERFORMANCE OF UNSEALED ROADS

Slipperiness

- Overcome by better material selection
- Lower SP
- More aggregate
  - May not always stop migration of fines to surface in wet weather.
- Warning signs ??
- In dry areas – yes !!

2 PERFORMANCE OF UNSEALED ROADS

Gravel loss

- Inevitable under traffic and climate (rain and wind)
- Most costly maintenance activity - regravelling
- Well graded, cohesive and well-compacted materials best
- Section constructed according to spec (Section 3) have about 50% less gravel loss

2 PERFORMANCE OF UNSEALED ROADS

Factors affecting gravel loss

- Material properties
- Geometrics
  - Camber, bends and hills
- Nature of water
  - Impact
  - Flow
- Traffic
  - Adhesion
  - Rutting
- Wind
  - Dust
  - Changes gravel properties
- Maintenance
  - Cut versus cover

2 PERFORMANCE OF UNSEALED ROADS

Gravel loss

- If not timeously replaced, results in exposure of subgrade and culverts
- Leads to impassability and unsafe conditions

2 PERFORMANCE OF UNSEALED ROADS

Loose material

- Result of ravelling, poor compaction, poor blading
- Unsafe, impassable, increased road user costs

2 PERFORMANCE OF UNSEALED ROADS

Traffic

- Greater influence on unsealed roads than on sealed roads
- High shear stresses under acceleration, braking and cornering
- Little difference between heavy and light vehicles
- Speed effects !!
- Different for mine trucks

2 PERFORMANCE OF UNSEALED ROADS

Environment

- Materials in sealed roads are essentially protected from the environment
- Unsealed road materials are exposed directly to temperature, moisture, rainfall impact, traffic shear stresses, etc
- Rapid impact on their performance
- NB: Climate change
  - Resilience
  - Only good gravel roads

2 PERFORMANCE OF UNSEALED ROADS

Summary

- Very different to sealed roads
- Quicker, more direct effects on unsealed roads
- Affects maintenance requirements mainly
- Discuss later, but they are based on the defects
- Quantified during inspections using TMH 12/9E