Seal and Thin Surfacing Technology

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A Single Surfacing seal is:
- product of application of a SPRAYED bituminous binder
- and application of SINGLE SIZED aggregate to the pavement
- to
  - provide a durable, all weather riding surface with sufficient skid resistance
  - Seal, protect, waterproof the base
Seal process

Spray bituminous binder

Spread single-sized aggregate

Rolling
SCOPE

- South African situation
- Surfacing seal types
- Development of design methodologies
- Design
- Labour intensive surfacings
- Ultra-thin Surfacings
- Way forward
South African Surfaced Road Network

- Total (754,000)
- Surfaced (114,000km)
- Seals = > 80%
TRAFFIC DISTRIBUTION

PROCLAIMED SURFACED RURAL ROADS

(South Africa)

VEHICLES PER DAY (both directions)
Road Pavements in South Africa

- **Pavement Structure**
  - **Fill or In Situ Material**
  - **Selected (Granular)**
  - **Sub-base (Granular or Cemented)**
  - **Base (>90% Granular)**
  - **Bituminous Surfacing (3mm – 50mm)**
  - **Kerb**
  - **Side Walk**
Typical Seals used in SA

- Single seal
- Double seal
- Double seal (1.5)
- Cape seal
Typical Seals used in SA

- Geotextile seal
- Split seal
- Choked seal
- Inverted seal
Typical Seal Types

- Slurry seal
- Grit/sand seal
- Graded aggregate/Otta seal
Seal Type Distribution
Western Cape annual seal programme
(6 – year average)

- Rejuvenation, 13%
- Slurry Seals, 7%
- Asphalt, 2%
- Double seals, 5%
- Sand seals, 22%
- Single seals, 51%
Development of Seal design methodologies

- Formal designs - Late 1930s
- Hansen’s theory of filling voids (1935)
- NDOT, 4 Provinces – each own method
- Significant research 70s
  - Relating embedment to Ball penetration
  - Rational seal design method (Not well accepted by practitioners)
  - TRH3 (1984) – compendium of designs
- Ad hoc studies – improvements to own methods
- Appropriate standards for low volume roads – 1993 (SABITA)
- TRH3 (1998)
Development of Seal design methodologies

- TRH3 (1998)
  - Road authorities’ and consultant’s experience incorporated
  - Improvements to rational design method
  - Modified binders incorporated

Traffic

Binder application

Road authorities’ recommended applications

Minimum

Maximum for target texture

Min

Max

30%
Development of Seal design methodologies

- Numerical behavioural model (T Milne)
  - Loading on a textured surface

\[ \sigma_{\text{Bulk}} \leq \sigma_{\text{Micro}} \]

- Smooth or closely packed asphalt surface
- Textured seal stone surface

\[ F_{\text{Bulk}} = F_{\text{Micro}} \]

Run 3: SBS: Round Stone: Bitumen Interface
Displacement Top of Centre Stone
Rate of deterioration dependent on
- Type of surfacing
- Condition before treatment
- Traffic etc.

Effectiveness = (Area above – Area beneath) x ADT x Length

Immediate improvement
TRH 3 Guideline document

• Part of TRH document series
  – Technical Recommendations for Highways
• Collate existing South African practice
  – Guidelines (not specifications)
  – Aimed at the average engineer (80/20)
  – Applicable only within range of experience
  – Highlights limitations and risks
• TRH3 (2007) – final review
  – Available March 2007
TRH 3 (2007)

Scope of the document

• Background to sealwork
• Investigation & seal type selection
• Pre-treatment
• Design
  – Conventional and modified binder
  – Sand seals, Single & Double seals,
  – Slurry and Cape seals
  – Fogspray and rejuvenators
  – Geotextile seals
  – Graded aggregate seals
• Construction and quality control guidelines
• Labour intensive sealing
• Maintenance
Seal selection

• Initial seals
  – Traffic volume and actions
  – Gradient, base type and quality of construction (urban / rural)
  – Maintenance capability
  – Social environment, cost and purpose
Seal selection

- Reseals (additional information)
  - Condition of existing pavement and surfacing
  - Climatic sensitivity
  - Pre-treatment requirement

Minimum Temperature (Station 589591)

EXISTING TEXTURE DEPTH

ADDITIONAL NET BINDER

EXISTING TEXTURE ADJUSTMENT
PRE-TREATMENT

• Outstanding routine maintenance
  – Patching
  – Crack sealing
  – Edge break repair
• Shape correction
  – Roughness
  – Rut filling
• Texture treatment
SEAL DESIGN

PRINCIPLES TO DETERMINE BINDER APPLICATION RATE

VOID LOSS DUE TO AGGREGATE WEAR

TEXTURE FOR SKID RESISTANCE

MAXIMUM VOIDS TO BE FILLED

VOID LOSS DUE TO EMBEDMENT

TOTAL VOIDS

ALD

MINIMUM VOIDS TO BE FILLED

30 %

100 %
Design parameters for Rational Design Method

• Full rational design method
  – Equivalent layer thickness – ELT (tray test)
  – Wear (based on stone hardness)
  – Embedment (Corrected ball penetration)
  – Existing texture (Sand patch test)
  – Required texture
Simplified design charts

- Accept ELT is a function of ALD
- Accept stone within national specification
  - Hardness (10% FACT > 210kN)
DESIGN PARAMETERS

• Traffic – Equivalent light vehicles per lane per day (1 Heavy = 40 Light)
• Average least dimension (ALD)
• Embedment potential (Ball penetration)
• Preferred texture depth
• Adjustments
  – existing texture
  – slow traffic / gradients
  – climate (macro and micro climates)
  – preferred aggregate matrix
  – modified binder adjustment
  – cold to hot binder
Simplified design charts

- ALD = 10mm
- Traffic (ELV = 10 000)
- Corrected BP = 1mm

- Min binder required = 1.15 l/m²
- Max binder for 1mm texture = 1.25 l/m²

Note: Risk - Too much binder for target texture, yet too little to prevent whip-off
PRACTICAL ADJUSTMENTS

- Additional binder for existing coarse texture
PRACTICAL ADJUSTMENTS

• Reduction in binder for slow-moving vehicles and channelisation
• Up to 10%
PRACTICAL ADJUSTMENTS

• Adjustment for specific climate
  – Reduction in hot humid areas
  – Increase in hot dry areas

• Not applicable to modified binders
PRACTICAL ADJUSTMENTS

• Adjustment for preferred aggregate matrix
• Designs based on shoulder-to-shoulder matrix
• Open textures require adjustment

Note: experience required
PRACTICAL ADJUSTMENTS

- Adjustment: conventional to modified binder
- Several contributing factors
  - Less orientation (more voids)
  - Binder properties e.g. viscosity
  - Traffic
- Guidelines based on traffic and binder type
- Factors dependent on modified binder type

S-E1 Conversion Factors

<table>
<thead>
<tr>
<th>Traffic ELV</th>
<th>Single</th>
<th>Double</th>
<th>Split</th>
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<tbody>
<tr>
<td>&lt;5000</td>
<td>1.4</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>5000 - 10000</td>
<td>1.3</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>10000 - 20000</td>
<td>1.2</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>&gt;20000</td>
<td>1.1</td>
<td>1.0</td>
<td>1.0</td>
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PRACTICAL ADJUSTMENTS

- Adjustment cold to hot binder
- Designs based on residual binder (net cold binder)
- Typical conversions
- Some products – supplier specific

<table>
<thead>
<tr>
<th>Binder type</th>
<th>Cold to hot</th>
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<tbody>
<tr>
<td>80/100 pen bitumen</td>
<td>1.09</td>
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<tr>
<td>MC 3000</td>
<td>1.19</td>
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<tr>
<td>65% emulsion</td>
<td>1.55</td>
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<tr>
<td>Polymer Modified</td>
<td>1.08</td>
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<tr>
<td>Bitumen Rubber</td>
<td>1.07</td>
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Aggregate Spread rates

- **Function of**
  - Aggregate size
  - Shape
  - Purpose and seal type
- **Guidelines provided**
- **Specification after trials on site**
Labour intensive seals
(Slurry bound Macadam)
Labour intensive seals
(Slurry bound Macadam)

Apply slurry

Protect

Vibratory roll

Smooth slush marks
Labour intensive
(Slurry bound Macadam)

- Cut back to full penetration
- Check penetration at edges and repair
- Drag burlap
- Apply final slurry
Ultra-thin Surfacings (UTFC)

- Paver-laid seal
- Asphalt design principles apply
- Proprietary products
- Excellent initial performance (16 – 20mm)
- Agreement certification required
- Cost (16mm - similar to large aggregate double seal)

Considerations
- Maintenance
- Long-term performance
- Turning actions
Way Forward

• Continuous feedback on TRH3 guidelines
• Ongoing research
• Learn from experience elsewhere
• Regular updates
  – Updates available on NDOT and SANRAL websites
THE END
Thank you very much for your attention!

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