Mending Our Ways: South African Experience

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André Greyling - bvi (Loudens International)

7 December 2022
Narrative

- Transportation infrastructure experiences issues – since always?

Ancient Romans used molten iron to repair their stone-paved roads

Potholes have been causing humans headaches since ancient times.

Narrative

- Transportation infrastructure experiences issues – since always?

- Minding & Mending required
  - 1st understand - then do
    - **Minding** - give stress to statement that one is making so that preceding or following statement will not be misunderstood
    - **Mending** - to begin to behave well, having until now behaved badly

- Some South African experiences
- Co-author acknowledgement
  - André Greyling - bvi (Loudens International)
Minding & Mending our ways

- **Minding**
  - Observe & reflect
  - Build narrative – how to read a road
  - Develop actions
    - Technical, economical, social, etc.

- **Mending**
  - What?
  - Why?
  - Where?
  - Whom?
  - When?
  - How?
Symptoms & social media solutions

- Community / Social media solutions
  - Community efforts
  - Pros & Cons

Our Gatvol Mix fills the gap: How potholes are building relationships

CAN DATA SOLVE THE POTHOLE PLAGUE?
With the recent wet weather creating havoc with our roads, the often-asked question is how potholes can be prevented in the first place. The power of data may hold the answers.
International Road Federation

Total Road Network (by Road Type) – 2020

Source: © IRF World Road Statistics

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Road length [km]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>United States</td>
<td>6,650,000</td>
</tr>
<tr>
<td>2</td>
<td>India</td>
<td>5,603,293</td>
</tr>
<tr>
<td>3</td>
<td>China</td>
<td>4,859,500</td>
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<td>4</td>
<td>Brazil</td>
<td>1,751,898</td>
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<tr>
<td>5</td>
<td>Russia</td>
<td>1,452,200</td>
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<td>6</td>
<td>Japan</td>
<td>1,215,000</td>
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<td>7</td>
<td>Canada</td>
<td>1,042,300</td>
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<td>8</td>
<td>Thailand</td>
<td>1,004,310</td>
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<td>9</td>
<td>France</td>
<td>965,446</td>
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<td>10</td>
<td>Australia</td>
<td>920,217</td>
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<td>11</td>
<td>South Africa</td>
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<tr>
<td>29</td>
<td>Nigeria</td>
<td>493,200</td>
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<td>32</td>
<td>Kenya</td>
<td>161,415</td>
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<tr>
<td>34</td>
<td>Congo, Democratic Republic of</td>
<td>153,497</td>
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<td>39</td>
<td>Egypt</td>
<td>137,430</td>
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<tr>
<td>44</td>
<td>Algeria</td>
<td>113,655</td>
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<tr>
<td>45</td>
<td>Ethiopia</td>
<td>110,414</td>
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<td>46</td>
<td>Ghana</td>
<td>109,515</td>
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<td>48</td>
<td>Libya</td>
<td>100,024</td>
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<tr>
<td>49</td>
<td>Zimbabwe</td>
<td>97,418</td>
</tr>
</tbody>
</table>
**SA Network**

<table>
<thead>
<tr>
<th></th>
<th>Paved</th>
<th>Gravel</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>153 719 km</td>
<td>593 259 km</td>
<td>746 978 km</td>
</tr>
<tr>
<td>Percentage</td>
<td>20.6 %</td>
<td>79.4 %</td>
<td></td>
</tr>
</tbody>
</table>

![Map of South African Roads](image)
World Economic Forum (WEF) - Roads quality - 2019
International Monetary Fund (IMF)

- Road Quality & Mean Speed score
- Cross-country road quality based on travel mean speed between large cities from Google Maps

[Google Maps link]
https://www.imf.org/en/Publications/WP/Issues/2022/05/20/Road-Quality-and-Mean-Speed-Score-518200
International Monetary Fund (IMF) view

- Why does it matter?

A good road is always better

https://www.imf.org/en/Publications/WP/Issues/2022/05/20/Road-Quality-and-Mean-Speed-Score-518200
How to Mend

- Numerous options for mending
  - Maintenance & Rehabilitation
- Depends on
  - Condition
  - Traffic
  - Environment
  - Technology
  - Materials
  - Experience
Introduction – BSM in South Africa

- Developed foamed bitumen application with Wirtgen
- Prototype tested in South Africa in 1996
- Pioneers of technology
- Ongoing research & development

- Technology manual
  - TG2
  - BSM approach
  - Pavement investigation & evaluation
  - Mix design
  - Structural design
  - Construction

https://www.sabita.co.za/non-members-manuals-and-dvds/
### Fundamental differences

<table>
<thead>
<tr>
<th>South African approach</th>
<th>USA approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material-based</td>
<td>Process-based</td>
</tr>
<tr>
<td>Pavement design with BSM as material option</td>
<td>Cold recycling as solution to pavement distress</td>
</tr>
<tr>
<td>No distinction between BSM foam or emulsion</td>
<td>Distinction between process to produce BSM</td>
</tr>
<tr>
<td>Depth &amp; material mix does not affect classification</td>
<td>Recycling depth &amp; mix of asphalt &amp; aggregate affect process</td>
</tr>
</tbody>
</table>
Rehabilitation design – South Africa

- SA design focusses on material behavior
  - BSM produced using foam or emulsion
  - Granular material, reclaimed asphalt or previously cemented material
  - Non-continuously bound material – no fatigue cracking
  - Material behaves like granular material – permanent deformation
  - Design for accumulation of shear strain
Rehabilitation design – South Africa

- Material behavior

Permanent deformation (rutting) design for granular material
## Mix design - Bitumen content, active filler & strength

### South African approach

- Sampled from various layers, *recombined according to milling depth*
- Reference density - Modified Proctor
- Produce specimens - *Vibrating hammer compaction*
- **Determine effect of active filler**
  - 1% cement, 1% lime, no filler
- Tested at 4 *bitumen contents*
  - 1.8%, 2%, 2.2%, 2.4%
- $\text{ITS}_{\text{dry}} > 32.6 \text{ psi}$  $\text{ITS}_{\text{wet}} > 18 \text{ psi}$
- **Shear properties (Triaxial)**

### USA approach

- Sampled from each layer, *reconstituted to specific grading based on recycling method*
- Reference density - Modified Proctor
- Produce specimens - *Marshall or gyratory compaction*
- Active filler *only used if mix does not meet specifications*
- Tested at 3 *bitumen contents*
  - Typically 1.5% to 3%
- $\text{ITS}_{\text{dry}} > 45 \text{ psi}$  $\text{ITS}_{\text{wet}} > 0.7 \times \text{ITS}_{\text{dry}}$
- **No shear properties**
## Construction

<table>
<thead>
<tr>
<th>South African approach</th>
<th>USA approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Layer thickness 6 to 12“</td>
<td>• Layer thickness <em>depends on process</em></td>
</tr>
<tr>
<td>• Active filler <em>placed by hand</em></td>
<td>▪ CIR – 3 to 4“</td>
</tr>
<tr>
<td>• Compacted to 100% <em>modified Proctor</em></td>
<td>▪ FDR – 4 to 12”</td>
</tr>
<tr>
<td></td>
<td>▪ CCPR – 3 to 5”</td>
</tr>
<tr>
<td></td>
<td>• Active filler <em>placed by bulk spreader</em></td>
</tr>
<tr>
<td></td>
<td>• Compacted to 95% <em>modified Proctor</em></td>
</tr>
</tbody>
</table>
Quality control

<table>
<thead>
<tr>
<th>South African approach</th>
<th>USA approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptance based on</td>
<td>Acceptance based on:</td>
</tr>
<tr>
<td>Field density target: 100% modified Proctor</td>
<td>Field density target: 95% modified Proctor</td>
</tr>
<tr>
<td>Density tested at 6 set locations per day with modified Proctor</td>
<td>Rolling pattern established on first day of construction &amp; if significant changes occur in mix</td>
</tr>
<tr>
<td>Field samples</td>
<td>Field samples</td>
</tr>
<tr>
<td>Moisture correction to OMC</td>
<td>NO moisture correction</td>
</tr>
<tr>
<td>Strength: $\text{ITS}<em>{\text{DRY}}$ and $\text{ITS}</em>{\text{WET}}$</td>
<td>Regular testing of bitumen</td>
</tr>
<tr>
<td></td>
<td>Penetration Grade</td>
</tr>
<tr>
<td></td>
<td>Foaming</td>
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</tbody>
</table>
Conclusions

- South African & USA methods
- Fundamental difference
  - SA starts with material, USA starts with process
- Minor differences in structural design, mix design, construction, quality control
Thank you
Prof Imad Al-Qadi
University of Illinois
André Greyling