Toll Concessions: Life Cycle Strategy and Performance

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Introduction

• Introduction & overview of N3 Toll Road
• Key Pavement Management Processes
• Concessionaire Responsibility
• Pavement Rehabilitation Strategy
• N3TC Pavement, Design and Performance
• Impact of Deflections on Capacity
• Analysis of 3 Categories of Pavement
• Summary
• Closing thoughts
The Concession Contract

• 30-Year Concession Contract with Government (SANRAL) 1999 to 2029

• Public Private Partnership (PPP) requires N3TC to:
  • Design; • Construct; Finance; Operate; Maintain

• N3TC committed to spending R25-billion on the development of the N3 Toll Route.

• Rehabilitation and Periodic Maintenance expenditure approximately R600 million per annum.

• Routine maintenance expenditure approximately R40 million per annum.

• Customer service oriented.
Toll roads have become a distinct feature of the South African roads landscape

N3 Toll Road one of three privatized concessions
N3TC Network – Key Characteristics

- 415 km length = 1660 lane km:
  - 15 Highway Sections
- 141 Bridges + 181 major culverts
- 4 Mainline Toll Plazas + 4 Ramp Plazas
- Total of 90 toll lanes all with e-Tag payment option
- Traffic volumes: 6000 to 19000 vehicles/direction/day
- Heavy vehicles: 1800 to 3800 per direction per day
- E80/heavy varies 2.6 to 2.8
- Current total traffic growth
  - 2017/18/19: +2.8% p.a (lv 0%, hv 4%)

- Routine Road Maintenance in 4 x 100km section.
- Route Services Patrols 24/7. Approx. 1.5 million km /annum.
N3TC Network – Description

156 km - 2 x 2 Lane Divided Highway
N3TC Network – Description

197 km - 4 Lane Undivided Highway
N3TC Network – Description

62 km - 2 x 2 Lane Divided Concrete Highway
All concrete now have bituminous wearing course
N3TC Annual Pavement Management Process

- Condition Data
- Traffic Data
- Data Management & Condition Analysis System
- Condition & Compliance Reporting
- Deterioration Modelling
- Pavement Engineering Strategy
- Financial Model
- Contract Requirements
- External Audit
N3TC Pavement Management System

- N3TC uses a Pavement Management System developed by Juno Services in New Zealand. (Fritz Jooste)
- Web based: [www.junoviewer.com](http://www.junoviewer.com)

### Condition strip map

### Network trends

### Deterioration modelling
N3TC Concessionaire Responsibility

• Manage functional condition of the network
  • *Rutting; Roughness & Surface Texture measured annually using RSP*
  • *Deflection measured annually at same time of year (end summer rains)*

• Efficient strategy
  • *Predicted traffic*
  • *Pavement condition and capacity*
  • *Financial and timing flexibility*
  • *Effective contracting*

• Hand back the network, complying with certain performance criteria. Pavement must have remaining life of 18 MESA with Deflection thresholds.
Reconstruction options:

- In-situ asphalt and granular material
- Cement or bitumen treatment
  - If bitumen – Emulsion vs Foamed bitumen
- Asphalt will become thick over time
- Need to be aware of potential deformation
- Steel slag and other cubical shaped aggregate

Polymer modified bitumen: 4.2% SBS
Pavement Performance: Deflections for Highway Section

N = 1 135 42 80 131 2 0 0 0 0 0 69 53 26 88 253 28 207 53 97
N3TC Annual Pavement Management Process

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- Financial Model
- Maintenance and Rehabilitation Projects

Flow Diagram:
- REVENUE
- ENGINEERING INPUT
- FUNDING
Pavement Rehabilitation Strategy

- Original Strategy based on Systematic Periodic Maintenance – Asphalt Overlays.
- **A CONCESSON RISK - INHERENT PAVEMENT / MATERIALS DEFECTS NOT IDENTIFIED. LARGE CLAIM AGAINST DESIGNERS.**
- Re-engineered strategy developed 5 years into Concession for the remaining 25 years.
- Required innovative methods of dealing with marginal materials.
- New strategy increased Capital cost by 20%.
- Luckily, traffic growth greater than original forecast.
- Strategy development now by Rule Based Modeling and Bill of Quantity based Manual Check.
N3 Rehabilitation Design Considerations

- Minimize disruption to road user
- At least one lane remains open to traffic in each direction
- Reuse existing materials wherever possible
- Achieve balanced flexible pavement
- 8 – 10 year forward maintenance cycle
- End of Concession hand-back requirements
## Managing a Network: PPP vs Public Agency

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<td>Rule based</td>
<td>Mechanistic based</td>
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N3 Pavements

- N3 Pavement layers in general
  - 5 to 12 cm asphalt
  - 12 to 16 cm crushed stone base
  - 30 cm cement stabilized subbase (UCS > 1.5 MPa)
  - 30 cm gravel subgrade (CBR > 15)
- Predominant failure mechanism
  - Rutting
  - Cracking and pumping
  - Mostly related to loss of density, moisture ingress, smectite group of clays
Common Understanding: Design Methods
Deflection increases with time

Change in effective dynamic modulus
N3 Network: Deflection Trend 2000 - 2019
Comparison of a variety of Pavements
Actual Capacity vs Pavement Number

• Recalibrated Pavement Number (PN new) is a measure of strength and thickness
• An adaption of the Structural Number

• Assessment is sensitive to
  • Accuracy of traffic data
  • Accuracy/frequency of deflection measurements
  • Frequency of maintenance
Comparison of a variety of Pavements
Actual Capacity vs Pavement Number
Understanding our Pavements Better: Deflection Study

- Three types of pavements were identified on a qualitative basis
  - “Strong”
  - “Intermediate”
  - “Weak”
- Sections of pavements were chosen in the three categories based on intimate knowledge of the pavement structure, treatment history and intervals between treatments.
- Discrete sections were chosen to ensure the pavement structure is the same.
- The Pavement Number was also calculated and used in the comparison.
“Strong” Example: N3-5 North

Cumulative Traffic Carried (MESA)

Deflections (microns)
“Weak” Example: N3-4 South
“Strong” Pavements
“Intermediate” Pavements

Deflections (microns) vs. Cumulative Traffic Carried (MESA)
Conclusion of Study

• “Strong” Pavement Sections
  • *Some variability in deflection but section has carried significant traffic (>20 MESA)*

• “Intermediate” Pavement Sections
  • *Less variability in deflections but carried less traffic in analysis period*

• “Weak” Pavement Sections
  • *Highly variable deflections with traffic 20 MESA and shorter intervals between treatments*

• Deflections stable with time, showing no increasing trend
Summary

• A Concessionaire approach is to ensure an optimized life cycle cost taking cognizance of Concession Period and end of Concession requirements.
  • *Accurate traffic and deflection data is important.*
• Better quality data allows the Network Manager to predict performance with more confidence.
• The ongoing study of deflections and change in structural capacity over time for the N3TC Network indicates expected trends underlying design methods are conservative, and perhaps even inappropriate.
  • *Is the design approach appropriate?*
• Assuming a competent pavement structure, regular maintenance cycles efficiently maintain an adequate structural capacity, with stable deflections.
Question: TRH12: Is this still relevant?
Thank you