Pavement response due to different tyre configuration
- a full scale HVS study

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Background
**Background**
Type of tyres and their configurations has changed throughout the years as new tyres have been launched. Different tyres and their configuration affects the degradation of the road network. In this project the VTI:s HVS machine is used to get direct measurements of pavement response to quantify their impact.

**Objectives**
To get direct measurements of the response of typical pavement structure from different tyres and their configuration.

**Results**
Direct measurements of pavement response that can be used with transfer functions to predict their degradation rate.
The HVS Nordic is a mobile APT test facility.
Construction of a test object #1
Construction of a test object  #2
Construction of a test object  #3
Construction of a test object #4
Construction of a test object  #5
Tyre configuration

**Lateral wander**

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Configuration</th>
<th>Brand</th>
</tr>
</thead>
<tbody>
<tr>
<td>275/80 R 22,5</td>
<td>Twin / Dual</td>
<td>YOKOHAMA Supersteel RY103</td>
</tr>
<tr>
<td>295/80 R 22,5</td>
<td>Twin / Dual</td>
<td>Marshal KRS 15</td>
</tr>
<tr>
<td>315/80 R 22,5</td>
<td>Single</td>
<td>Michelin X Multiway 3D</td>
</tr>
<tr>
<td>385/65 R 22,5</td>
<td>Single</td>
<td>Michelin X Multi</td>
</tr>
<tr>
<td>425/65 R 22,5</td>
<td>Single</td>
<td>Goodyear G165</td>
</tr>
<tr>
<td>455/40 R 22,5</td>
<td>Single</td>
<td>Goodyear Marathon LHT+</td>
</tr>
</tbody>
</table>

Wearing course, ABT 16, 70/100
Road base, AG22, 160/220

subgrade, sand

subgrade, silty sand

Base course

Subbase

Subgrade, sand

Depth [cm]
Tyre configuration

S3
425/65 R22.5
Goodyear G165

S2
315/80 R22.5
Michelin X Multiway 3D

S1
385/65 R22.5
Michelin X Multi

S4
455/40 R22.5
Goodyear Marathon LHT

P2
275/80 R22.5
Yokohama Supersteel RY103

P1
295/80 R22.5
Marshal KRS15
The response scheme

Temp.: $T = 10^\circ C$
Speed: $v = 12 \text{ km/h}$
Loading: $W = 40; 50; 60 & 80 \text{ kN}$
Tyre pressure: $p = 700; 800; 900 & 950 \text{ kPa}$
Loading configuration: Single & Dual
Typical response

Transverse strain (bottom of asphalt concrete layer)

Vertical stress

Depth [cm]
Response

Tyre configuration $L_A = 100 \text{ kN} \& p = 800 \text{ kPa}$

Tensile strain

![Graph showing tensile strain vs. wheel position for different tyre configurations.](image)
Response

Vertical strain

Tyre configuration $L_A = 100 \text{kN} \& p = 800 \text{kPa}$

**Bärlager**

- P1 - 295 Marshal
- P2 - 275 Yokohama
- S1 - 385 Michelin
- S2 - 315 Michelin
- S3 - 425 Goodyear
- S4 - 455 Goodyear

**Förstärkningslager**

- P1 - 295 Marshal
- P2 - 275 Yokohama
- S1 - 385 Michelin
- S2 - 315 Michelin
- S3 - 425 Goodyear
- S4 - 455 Goodyear

**Ny Sand (upper part)**

- P1 - 295 Marshal
- P2 - 275 Yokohama
- S1 - 385 Michelin
- S2 - 315 Michelin
- S3 - 425 Goodyear
- S4 - 455 Goodyear

**Ny Sand (lower part)**

- P1 - 295 Marshal
- P2 - 275 Yokohama
- S1 - 385 Michelin
- S2 - 315 Michelin
- S3 - 425 Goodyear
- S4 - 455 Goodyear

**Undergrund: sisá**

- P1 - 295 Marshal
- P2 - 275 Yokohama
- S1 - 385 Michelin
- S2 - 315 Michelin
- S3 - 425 Goodyear
- S4 - 455 Goodyear

**Depth [cm]**

- 0.0
- 4.9
- 9.6
- 21.8
- 35.6
- 65.0
Response

Tyre configuration $L_A = 100$ kN & $p = 800$ kPa

![Graph of vertical stress vs wheel position at different depths]
Moist vs. wet

Transverse strain (bottom of asphalt concrete layer)

Moist

Wet

Average transverse strain

Vertical strain [µε]

Wheel position [cm]

Depth [cm]
Distress development

Design criteria according to MPS Objekt:

\[ N_f = k_1 \cdot \varepsilon_t^{-4} \]
\[ N_f = k_2 \cdot \varepsilon_v^{-4} \]

For the standard axle loading case:
\[ L_A = 100 \text{ kPa} \quad \text{and} \quad p = 800 \text{ kPa}: \]

<table>
<thead>
<tr>
<th></th>
<th>Tensile strain $\varepsilon_t$ [με]</th>
<th>Vertical strain $\varepsilon_v$ [με]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual wheel (average)</td>
<td>285</td>
<td>663</td>
</tr>
<tr>
<td>Single wheel (average)</td>
<td>422</td>
<td>785</td>
</tr>
<tr>
<td>S/D</td>
<td>1.48</td>
<td>1.18</td>
</tr>
<tr>
<td>Reduction in live (D/S)$^4$</td>
<td>4.79</td>
<td>1.94</td>
</tr>
</tbody>
</table>
Pavement response from different tyres has been measured in a full scale testing from four single tyres and two dual tyres configurations.

» Great difference between dual tyre configuration vs. single tyres is observed in the upper part of the structure. This is true for tensile strain $\varepsilon_t$, vertical strain $\varepsilon_v$ & vertical stress $\sigma_v$. The difference decreases with depth.

» As the tyre width increases the response generally decreases.

» The response increase ($\varepsilon_t$, $\varepsilon_v$ & $\sigma_v$) as the water table is raised.

Note that this is only based on one thin pavement structure that has been tested.
Thanks & Questions?
Tyre footprint measurements

- 315/80R22.5
  - Wheel load increased from 50 kN to 80 kN @ 800kPa

  

- Tire pressure increased from 500 kPa to 950 kPa @ 80kN
Selection of tyre types

Distribution of tyre widths – Nordic survey