„Concrete roads in Germany case study: Design parameters and challenges”

Prof. Dr. Thomas Matschei
Germany has the 2nd largest highway network in Europe

Highway Road Network [km]

Spain 14,981
Germany 12,917
France 11,560
Italy 6,844
Netherlands 5,242
UK 3,875
Portugal 3,065
Austria 2,191
Sweden 2,088
Belgium 1,763
Hungary 1,695
Denmark 1,561
Poland 1,482
Switzerland 1,429
Croatia 1,290

With ~5.6% of the total road network highways carry ~ 48% of all traffic related loads in Germany;
Concrete Paving — Very strict national technical design and test guidelines, but so far only limited consideration of environmental impacts

ZTV Beton-StB 07
German Enhanced Technical Specs for Concrete Roads

TL Beton-StB 07
Execution guidelines

TP Beton-StB 10
Testing guidelines
Depending on the expected loads there are different Design possibilities

<table>
<thead>
<tr>
<th>Zeile</th>
<th>Bauklasse</th>
<th>Bk_{10}</th>
<th>Bk_{12}</th>
<th>Bk_{10}</th>
<th>Bk_{12}</th>
<th>Bk_{10}</th>
<th>Bk_{12}</th>
<th>Bk_{10}</th>
<th>Bk_{12}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B [Mio]</td>
<td>&gt; 32</td>
<td>&gt; 10 - 32</td>
<td>&gt; 3,2 - 10</td>
<td>&gt; 1,8 - 3,2</td>
<td>&gt; 1,0 - 1,8</td>
<td>&gt; 0,3 - 1,0</td>
<td>≤ 0,3</td>
<td></td>
</tr>
<tr>
<td>Dicke des frostsch. Oberbaus</td>
<td>55</td>
<td>65</td>
<td>75</td>
<td>85</td>
<td>55</td>
<td>65</td>
<td>75</td>
<td>85</td>
<td>45</td>
</tr>
</tbody>
</table>

Asphalttragschicht und Tragschicht aus frostunempfindlichem Material

1.1 Betondecke
- Vliesstoff
- Hydraulisch gebundene Tragschicht (HGT)
- Frostschutzschicht

Dicke der Frostschutzschicht: ~15cm (typically lower grade concrete)

Main concrete

1.2 Betondecke
- Vliesstoff
- Verfestigung
- Schicht aus frostunempfindlichem Material

Dicke der Schicht aus frostunempfindlichem Material: 3cm

1.3 Betondecke
- Vliesstoff
- Verfestigung
- Schicht aus frostunempfindlichem Material

Dicke der Schicht aus frostunempfindlichem Material: 3cm

Asphalttragschicht auf Frostschutzschicht

2 Betondecke
- Asphalttragschicht
- Frostschutzschicht

Dicke der Frostschutzschicht: ~15cm

Upper layer ≥40mm (min. 420kg cement)

Lower layer (>20cm; min 350kg cement)

Gravel layer 20-40cm (e.g. recycled concrete)
Typical design of today's German highways made of concrete

- **Longitudinal joints**: 3 anchors per slab
- **Press joints**: ~5 anchors / slab
- **Transverse contraction joint incl. anchors**
- **Concrete**: 26 cm
- **HGT (low grade concrete)**: 15 cm
- **Gravel**: 29 – 49 cm

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 4 %</td>
<td>Slope</td>
</tr>
<tr>
<td>≥ 2.5 %</td>
<td>Slope</td>
</tr>
<tr>
<td>5.00</td>
<td>Width of highway</td>
</tr>
<tr>
<td>12 %</td>
<td>Grade of slope</td>
</tr>
<tr>
<td>4,50 m</td>
<td>Passing lane</td>
</tr>
<tr>
<td>4,50 m</td>
<td>Main lane</td>
</tr>
<tr>
<td>3,00 m</td>
<td>Side strip</td>
</tr>
<tr>
<td>12 m</td>
<td>2 lane pavement</td>
</tr>
<tr>
<td>2 lane</td>
<td>Pavement</td>
</tr>
<tr>
<td>4,50 m</td>
<td>2 lane pavement</td>
</tr>
</tbody>
</table>

**Concrete**: 26 cm

**HGT (low grade concrete)**: 15 cm

**Gravel**: 29 – 49 cm
## Asphalt vs. Concrete

<table>
<thead>
<tr>
<th></th>
<th>Asphalt</th>
<th>Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Installation Cost (incl. Manufacturing)</strong></td>
<td>Depending on oil Price, but generally lower than concrete</td>
<td>Higher than asphalt</td>
</tr>
<tr>
<td><strong>Maintenance Cost</strong></td>
<td>Typically higher due to lower mechan. performance</td>
<td>Ideally less maintenance; longer service life</td>
</tr>
<tr>
<td><strong>Construction Speed</strong></td>
<td>Depending (hardens within hours)</td>
<td>Depending (hardens within hours/days)</td>
</tr>
<tr>
<td><strong>Durability</strong></td>
<td>Lower especially at extreme temperatures</td>
<td>Ideally significant higher than asphalt</td>
</tr>
<tr>
<td><strong>Safety</strong></td>
<td>Darker</td>
<td>Advantages due to bright color at night; longer better grip than A.</td>
</tr>
<tr>
<td><strong>Recyclability</strong></td>
<td>Common practice</td>
<td>Doable but more difficult than A.</td>
</tr>
<tr>
<td><strong>GWP</strong></td>
<td></td>
<td>Concrete w. slight advantage</td>
</tr>
</tbody>
</table>
Concrete roads save fuel??

Pavement Deflection (Not to Scale)

Pavement Roughness (Not to Scale)

The graph compares GHG emissions between concrete and asphalt roads. The emissions are categorized into Production + M&R and PVI (Deflection).

High volume road:
- AADT: 25,000 (2500 trucks)
- 2 lanes in each direction

Arterial road:
- AADT: 7500 (750 trucks)
- 2 lane in each direction

Source: MITCSHub 2016
https://www.nrmca.org
Ideally Concrete roads should have lower total cost impact over a longer Service life?
Unfortunately the image of concrete roads suffered, due to durability issues in Germany
Very strict testing scheme in place to avoid deleterious durability problems in the future

Authorities are currently not clear which material concept is the preferred choice for the future!
Challenges to be tackled

Environmental restrictions

Increasing frequency of extreme temperature conditions + global warming

Increased freight traffic especially on highways expected

Aging Infrastructure

Freight traffic in bio tkm

Prognosis Germany

ProgTrans


200 400 600 800 1000 1200 1400