Concrete Pavements

Tour of European Practice

Hermann Sommer

Vienna, Austria

Salina, KS

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Main application: heavy duty motorways

Designed for 30 years and little maintenance
Usually 40+ years old when reconstructed
European Roadbuilding:

- Impact of US experience, equipment, and technology.
- Densely populated countries.
- Environmental aspects are of great influence
  - Noise
  - Pollution
  - Congestion
  - Natural Resources
  - Landfill
- The Structure
- Foundation
- Concrete Pavement
- Reconstruction
- Concrete Surface
Most reconstruction is under traffic
Traffic on the base
Minimize transport by upgrading existing material
Structures with a concrete pavement

Concrete pavement
- Thinner than in the USA

Base
- Thicker...

Subbase

Foundation:
- Usually cement-stabilized base (CSB)
- Thick to carry construction traffic
- Granular subbase
Foundation 1: Asphalt Base

- Concrete pavement
- 2.5 to 4 in. (6-10 cm) HMA
  (early 1960s: tar-stabilized gravel in Austria)
- Granular subbase

Durable, drainable, beneficial support.

Requires well-graded granular material.
A2 crossing the Alps towards Italy
Paved 1973; altitude 3300 ft. (1000 m), clay subgrade
Foundation 2: Stab. soil + CSB + HMA Interlayer

Problem (1970): wet cohesive soil, gravel not available

Solution:
• 8.7 in. (22 cm) JPCP
• 2 in. (5 cm) HMA interlayer to protect CSB from brine
• 8 in. (20 cm) CSB (using crushed stone from tunneling)
• 16 in. (40 cm) lime-stabilized soil, 2 lifts, used instead of a deep layer of frost-resistant select

Experience:
• Still in service, though JPCP shows ASR
• CSB and asphalt interlayer still in good shape
• Similar structures have been used in Belgium and France
• → General use of 8 in. (20 cm) CSB w/ 2 in. (5 cm) HMA
Motorway A5 Vienna - Brno 2008
PPP-project 30 mi. (50 km) long

Clayey soil stabilized with mix of lime and cement; 16 in. (40 cm) in 1 lift

6 in. (15 cm) milled asphalt + 2 in. (5 cm) sand, stabilized with cement
Silty soil on A5 mixed with lime + cement
Foundation 3: **CSB + HMA interlayer**

- Concrete pavement
- 2 in. (5 cm) HMA
- 8 in. (20 cm) CSB (mostly recycled or substandard material)
- **Frost blanket** (deep granular layer)

Good load-bearing capacity at low cost

Environmental benefits

Durable support for J PCP
Found. 4: **Bases without HMA interlayer**  
(Germany)

- 8 in. (20 cm) CSB (formerly 6 in., 15 cm) with joints (notches) below the joints of 10.2-in. (26-cm) J PCP  
  or

- 8 in. (20 cm) CSB + geotextile (bond breaker) + 10.6-in. (27-cm) J PCP  
  or

- 12 in. (30 cm) well-draining crushed stone + 11.8-in. (30-cm) J PCP  
  (developed in a sandy (well draining) area for reuse of ASR-afflicted concrete)

- Granular subbase
# Foundations in Europe - summary

<table>
<thead>
<tr>
<th>Base</th>
<th>Subbase</th>
<th>Country</th>
<th>Used often?</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMA</td>
<td>granular</td>
<td>all</td>
<td>no</td>
</tr>
<tr>
<td>HMA+CSB</td>
<td>granular</td>
<td>all</td>
<td>yes</td>
</tr>
<tr>
<td>HMA+CSB</td>
<td>stabilized</td>
<td>several</td>
<td>no</td>
</tr>
<tr>
<td>CSB+geotextile</td>
<td>granular</td>
<td>Germany</td>
<td>yes</td>
</tr>
<tr>
<td>Crushed stone</td>
<td>granular</td>
<td>Germany</td>
<td>no</td>
</tr>
</tbody>
</table>
## Concrete Pavements

<table>
<thead>
<tr>
<th>Pavement</th>
<th>in. (cm)</th>
<th>base</th>
<th>country</th>
</tr>
</thead>
<tbody>
<tr>
<td>J PCP</td>
<td>9.8/10.2 (25/26)</td>
<td>CSB+HMA</td>
<td>all</td>
</tr>
<tr>
<td>J PCP</td>
<td>10.6 (27)</td>
<td>CSB+geotextile</td>
<td>Germany</td>
</tr>
<tr>
<td>J PCP</td>
<td>11.8 (30)</td>
<td>Crushed stone</td>
<td>Germany</td>
</tr>
<tr>
<td>CRCP</td>
<td>9.0 (23)</td>
<td>CSB+HMA</td>
<td>Belgium</td>
</tr>
<tr>
<td>CRCP</td>
<td>9.8 (25) *</td>
<td>CSB+HMA</td>
<td>NL, UK</td>
</tr>
</tbody>
</table>

* plus 2 in. (5 cm) porous asphalt (Netherlands), or 1.4 in. (3.5 cm) SMA (UK)
JPCP in two lifts

Bottom: gravel or recycled aggregate
Top: high quality virgin aggregate
Two lift paving

Spraying unit

Second paver

Bottom lift

Pavers contractor made

Flat drain

Feeder for top lift
Reconstruction: Paving full width requires dowel inserting device
Two-lift paving

Concrete for top lift

Dowel inserting device

Accumulation of fines on low side?
New motorway A5 Vienna – Brno, 2008
Paving width 41 ft. (12.5 m) wide, 0.5 mi. (800 m) per day

Wirtgen pavers
A5, construction traffic uses other direction
Recommendation in A: Bond + subsurface drainage

Flat drain nailed to the base
(below transverse joint of the shoulder, extending into the first lane)

Shallow milling applied to the base to encourage bond
Emergency lane still bonded to the base → subsurface drainage
Joints are sawed and sealed

- Open or ill-maintained joints do not matter with light traffic. With heavy traffic they matter a lot!
- Transverse joint: preformed profiles
- Longitudinal joints: hot poured asphalt compound
Joints open, subsurface drainage clogged
Paving concrete (in Austria):

- Aggregate > 0.16 in. (4 mm) for top lift
  LA Abrasion < 20, Polished Stone Value (PSV) > 40
- Air content 4 to 6%
- Strength at 28 days (site samples):

<table>
<thead>
<tr>
<th>Lift</th>
<th>Flexural psi (N/mm²)</th>
<th>Compressive psi (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom</td>
<td>≥ 800 (5.5)</td>
<td>≥ 5100 (35)</td>
</tr>
<tr>
<td>Top Exposed Aggregate Concrete (5/16 in., 8 mm)</td>
<td>≥ 1000 (7.0)</td>
<td>≥ 5800 (40)</td>
</tr>
</tbody>
</table>
Mobile continuous mixing plant
260 cy/hr. (200 m³/h)
Mobile mixing plant for top lift
130 cy/hr (100 m³/h)
Recycle concrete!

- **Old concrete:**
  - Strength 10,000 to 15,000 (70-100 N/mm²)
  - As good as many natural aggregates

- **RCA bonds well with new cement stone**
  - Strength higher and better than with many virgin aggregates.

- **RCA is high value**
  - Should be used for concrete and not wasted for subbases.
Recycling of concrete

- Processing needs care.
- Same requirements for RCA as for virgin aggregate.
- RCA should be used in a wet condition.

- Hundreds of miles of highway recycled into concrete since 1990.
- Excellent performance; lower E and higher $w_{ads}$ not harmful.
Recycling concept for all existing materials:

Old:
- Crushed material (max. 10% asphalt)
  - 70% 4/32
  - 30% 0/4
- Tar-bound

New:
- 4 cm exposed aggregate concrete MA 8
- 21 cm recycling concrete MA 32
- 5 cm bit. subbase
- 25 cm cement-bound material
Concrete surfaces

- Broom and burlap drag: light or slow traffic.
- Exposed aggregate: heavily-trafficked roads (for durability of noise-reduction and friction)
- EAC first used in Belgium (7/8 in., 22 mm)
- Used since 1990 in Austria (5/16 in., 8 mm)
- Used again since 2001 in Belgium (7/8 in. with surplus 5/16 in.)
- Now also used in Germany (5/16 in., 8 mm).
In Austria and Germany, a retarder/curing compound is used.
Brooming without water
EAS 8 mm after 11 Years’ Service

- Single-sized aggregate 4/8 mm
  - Particles very close to each other
    (gap grading 1/4, sand 0/1)
- No loss of stones, even in the wheel path
Long-time development of tire-road noise

(CPM, J. Litzka, FSV-aktuell 3/07)

![Bar chart showing noise levels over time for different materials]

- **EP-Grip**
- **SMA 11**
- **EAC 8**
- **AC 11**
- **Por. A**

- New: 6-10 years
- > 10 years

Noise levels in dB(A) are displayed for each material category.
Acoustical durability (CPM) on EAC

[ Arsenal report 3.307/M. Haider]

Aggr. 4/11 mm: Lines 1, 5, 7, 10   4/8 mm: lines 2, 3, 4, 6, 8, 9
Potential for optimizing EAS

- Coarse aggregate should be
  - Single-sized → no risk of losing the smaller stones
  - Ideally cubical

- Paver should orient crushed surface of aggregate parallel to road surface.

- Bigger aggregate and less cement could then be used.