SPENS Final seminar
27 – 28 August 2009

WP3 Improvement of Pavement Structures
Task 3.1 Long-Term Performance of Reinforced Pavements

Presentation by
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Objectives

The main objectives are:

• To establish the efficiency of reinforcement in flexible pavements
• Modelling of reinforced pavement structure
• Methodology for evaluation of reinforced pavement performance
Modelling

**Demand:** a user-friendly pavement design methodology
- a multi-layer linear elastic model
- Reinforcement defined as an Equivalent layer (REFLEX approach - Kolisoja et al 2002)

Verification? Validation?
Accelerated Loading Test

Test site
Structure of test sections

SMA - Stone Mastic Asphalt 11s, 4 cm
AC_{55} - Asphalt Concrete 0-22S (B 50/70), 6 cm
 Crushed Stone 0-32, 25 cm
 Rock Material Resistant to Freezing

SMA - Stone Mastic Asphalt 11s, 4 cm
AC_{55} - Asphalt Concrete 0-22S (B 50/70), 6 cm
 Reinforced Grid made of Steel
 Crushed Stone 0-32, 25 cm
 Rock Material Resistant to Freezing
Response measurements by horizontal strain gauges

Longitudinal direction

Transversal direction
Transverse strains $\varepsilon_{yy}$

- With friction
- Without friction

Graphs showing the transverse strains $\varepsilon_{yy}$ for T5 un-reinforced and T5 reinforced with and without friction.
ALT: Rut development

SPENS HVS Structure 5
Cross profile 52

SPENS HVS Structure 6
Cross profile 62
Field test: Falling Weight Deflectometer

If $\Delta_u > \Delta_r$ for $d_i^r = d_i^u$ then $r_r > r_u$

where: $d_1, d_2, d_3', \ldots, d_7$ mean deflections measured every 30 cm (deflections in section 2' are assumed to be symmetrical to deflections in section 2)

Schematic curvatures of deflection curves in FWD test for reinforced pavement (curve R) and unreinforced (curve U)
Deflection curve radius between geophone 2 and 2’ and deflection d1 under load plate
<table>
<thead>
<tr>
<th>Road section</th>
<th>Arc section radius of the deflection curve</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arc 2’ – 2 ↓</td>
</tr>
<tr>
<td>Reinforced, m</td>
<td>3106</td>
</tr>
<tr>
<td>Unreinforced, m</td>
<td>2695</td>
</tr>
<tr>
<td>Difference, %</td>
<td>15</td>
</tr>
</tbody>
</table>

Arc section radiuses of the deflection curve for deflection under load plate d1 = 250 mm.
Field test: Strain measurements

Steel reinforced test sections
Field test: Load Transfer efficiency
Field test: measured strains
Field test: FWD - BISAR

Calculated strains of the reference test sections using backcalculated moduli with BISAR programme.
Calculated strains using measured moduli of bituminous layers and calculated modulus of EL with PMS Objekt programme
Determined strains and ranking of the structures by different methods

<table>
<thead>
<tr>
<th>Structures</th>
<th>Strain at the bottom of the bituminous layer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Measured</td>
</tr>
<tr>
<td></td>
<td>Strain, µs</td>
</tr>
<tr>
<td>Reference (Sec.1)</td>
<td>126</td>
</tr>
<tr>
<td>Reinforced (Sec.2)</td>
<td>94</td>
</tr>
<tr>
<td>Reinforced (Sec.3)</td>
<td>37</td>
</tr>
<tr>
<td>Decrease of strain in average</td>
<td>52%</td>
</tr>
</tbody>
</table>
Filed test: Rutting

Propagating rut depth (mm) over time for different sections:
- Sec. 1 Reference
- Sec. 2 Reinforced L1
- Sec. 3 Reinforced L1-2

Year: 2000 to 2008
Economical evaluation

![Graph showing costs without reinforcement and costs with reinforcement over years. The graph compares the costs in €/m² as a function of years. The costs without reinforcement are represented by a blue line, while the costs with reinforcement are shown in pink. The graph indicates a pattern where costs increase at specific intervals over time.](image-url)
Conclusions

- Reinforced structure has prolonged the service life of pavement with at least 20%.
- Less maintenance frequency.
- Less costs.

Deliverable D9

LONG-TERM PERFORMANCE OF REINFORCED PAVEMENTS

(including guidelines)
Thank you