Revision of the
Austrian Flexible Pavement Design Method
On-Going Research

Ronald Blab & Bernhard Hofko
Institute of Transportation
Center of Road and Airfield Engineering

FLEXIBLE PAVEMENT DESIGN WORKSHOP
Ljubljana, 2012

Outline

• European and National HMA Standards
• Performance Based HMA Requirements
• Introduction of PB-Specifications in Pavement Design
• Improvements for Design Traffic
• Life Cycle Cost Analysis
• Conclusions
European and National HMA Standards

New European Standards for Material Specification:
EN 13108:2008 Bituminous Mixtures – Material specifications

EN 13108-1
- Asphalt concrete
  - General requirements
  - Empirical requirements
  - Fundamental requirements
European HMA Standards

Empirical Approach

EN 13108-1:2008

- Composition & Grading Of The Mix
- Void Content
- Coating And Homogeneity
- Resistance To Abrasion By Studded Tires
- Reaction To Fire & Mixture Temperature

Water Sensitivity
Resistance To Permanent Deformation

Empirical Approach

• Grading Of The Mix
• Binder Content
• Marshall Values only for Airfields
• Voids Filled With Bitumen (VFB)
• Voids In Mineral Aggregate (VMA)
• Voids After 10 Gyrations (V10G)

Performance-related
either or

Fundamental Approach

EN 13108-1:2008

- Composition & Grading Of The Mix
- Void Content
- Coating And Homogeneity
- Resistance To Abrasion By Studded Tires
- Reaction To Fire & Mixture Temperature

Water Sensitivity
Resistance To Permanent Deformation

Fundamental Approach

- Stiffness
- Resistance To Fatigue
- Resistance to Permanent Deformation

Performance-based

Performance-related
European HMA Standards

Definition

PERFORMANCE-RELATED TESTS count for material characteristics that have been found to correlate with fundamental engineering properties that predict performance (e.g. wheel-tracking properties, Marshall properties)

PERFORMANCE-BASED TESTS describe fundamental engineering properties predicting performance, and appearing in primary performance prediction relationships (e.g. stiffness, fatigue properties)

European HMA Test Standards

Performance Based (PB) Tests

Low Temperature
- Cooling test

\( \sigma(t) \), \( \varepsilon(t) \)

ÖNORM EN 12697-46

parameter: \( T_{\text{crack}} \)

Rutting
- Triaxial cyclic loading test

\( \sigma(t) \), \( \varepsilon(t) \)

\( \sigma_{\text{ax}}(t) \), \( \sigma_{\text{rad}}(t) \)

ÖNORM EN 12697 - 25

parameter: \( f_{\text{cmax}} \)

Stiffness & Fatigue
- Indirect cyclic loading test

\( \sigma(t) \), \( \varepsilon(t) \)

ÖNORM EN 12697 – 24 & 26

parameter: \( S_{\text{max}} \), \( \varepsilon_6 \)
Performance Parameter

- **Low temp. cracking**: $\sigma_{cry} [N/mm^2]$, $T_{crack} [°C]$  
  - EN 12697-46 (2012)

- **rutting**: $\varepsilon_{perm} [%]$, $\varepsilon_{cry,crack}$  
  - EN 12697-25 (2005)

- **Stiffness & fatigue**:  
  - $\varepsilon << \varepsilon >>$  
  - $\phi [°]$, $f [Hz]$, $|E^*| [MPa]$  

Austrian HMA Standards

**Empirical Approach**

- RVS 08.97.05: 2010  
  - Requirements on Bituminous Mixtures  
  - Material Specification

- RVS 08.16.01: 2010  
  - Requirements on Bituminous Courses  
  - Layer Specification

**Fundamental Approach**

- RVS 08.16.06: 2012 (final draft)  
  - Requirements on Bituminous Mixtures and Courses  
  - Performance Based Specifications
Performance Based HMA Requirements

PB HMA requirements

- low temperature behavior
  - R - cracks
    - AC D deck
      - SMA
      - PA
    - surface course

- rutting resistance
  - V - ruts
    - AC D binder

- Fatigue resistance
  - E - fatigue
    - AC D trag
    - base course

R = Risse
V = Verformung
E = Ermüdung

HMA layer
### Performance Based (PB) HMA Requirements

#### Categories for HMA surface layer RVS 08.16.06: 2012 (final draft)

<table>
<thead>
<tr>
<th>category</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
</tr>
</thead>
<tbody>
<tr>
<td>rutting</td>
<td>$f_{c_{max}0,2}$</td>
<td>$f_{c_{max}0,4}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fatigue</td>
<td>$\varepsilon_{6-NR}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low temp. cracking</td>
<td>$T_{c-30}$</td>
<td>$T_{c-25}$</td>
<td>$T_{c-30}$</td>
<td>$T_{c-25}$</td>
<td>$T_{c-20}$</td>
</tr>
<tr>
<td>stiffness</td>
<td>declare $S_{\min}$</td>
<td>declare $S_{\max}$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Example HMA surface layer
- AC deck 11, R1 ⇒ high resistance against thermal cracking and rutting
- AC deck 11, R3 ⇒ high resistance against thermal cracking and moderate resistance against rutting

---

### Performance Based (PB) HMA Requirements

#### Categories for HMA binder layer RVS 08.16.06: 2012 (final draft)

<table>
<thead>
<tr>
<th>category</th>
<th>V1</th>
<th>V2</th>
<th>V3</th>
<th>V4</th>
</tr>
</thead>
<tbody>
<tr>
<td>rutting</td>
<td>$f_{c_{max}0,2}$</td>
<td>$f_{c_{max}0,4}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fatigue</td>
<td>$\varepsilon_{6-130}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low temp. cracking</td>
<td>$T_{c-25}$</td>
<td>$T_{c-20}$</td>
<td>$T_{c-25}$</td>
<td>$T_{c-20}$</td>
</tr>
<tr>
<td>stiffness</td>
<td>declare $S_{\min}$</td>
<td>declare $S_{\max}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Example HMA binder layer
- AC binder 22, V1 ⇒ high resistance against rutting and moderate resistance against thermal cracking
- AC binder 22, V3 ⇒ moderate resistance against thermal cracking and moderate resistance against rutting
### Performance Based (PB) HMA Requirements

**Categories for HMA base layer** RVS 08.16.06: 2012 (final draft)

<table>
<thead>
<tr>
<th>category</th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>E4</th>
</tr>
</thead>
<tbody>
<tr>
<td>rutting</td>
<td>$f_{c_{max0.4}}$</td>
<td>$f_{c_{max0.6}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fatigue</td>
<td>$\epsilon_{6-190}$</td>
<td>$\epsilon_{6-130}$</td>
<td>$\epsilon_{6-190}$</td>
<td>$\epsilon_{6-130}$</td>
</tr>
<tr>
<td>low temp. cracking</td>
<td>$T_{c-20}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>stiffness</td>
<td>declare $S_{min}$</td>
<td>declare $S_{max}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Example HMA base layer**

- **AC base 32, E1**: high resistance against fatigue and moderate resistance against rutting
- **AC base 22, E4**: moderate resistance against fatigue and moderate resistance against rutting

---

**Performance Based Specification in Pavement Design**

*Image of a brain with the text: I need a change.*
Performance Based Specification in Pavement Design

Revision Goals – Climate

Linking project specific traffic and climatic pavement situation with the HMA performance categories defined in the new RVS 08.16.06

- PB requirements
  - low temperature behavior
  - rutting resistance
  - Fatigue resistance
  - AC D deck
  - SMA PA
  - surface course
  - binder course
  - base course

specifying HMA categories

RVS 08.16.06

R1 bis R5
V1 bis V4
E1 bis E4

Introduction of a Performance Grade PG

<table>
<thead>
<tr>
<th>Nr.</th>
<th>BL</th>
<th>Station</th>
<th>Höhe [m]</th>
<th>( T_{\text{max}} ) [°C] 50%</th>
<th>( T_{\text{max}} ) [°C] 98%</th>
<th>( T_{\text{min}} ) [°C] 50%</th>
<th>( T_{\text{min}} ) [°C] 98%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B</td>
<td>Deutschkreutz</td>
<td>192</td>
<td>52.5</td>
<td>-15.6</td>
<td>-21.8</td>
<td></td>
</tr>
</tbody>
</table>

specified HMA categories

RVS 08.16.06

R1 bis R5
V1 bis V4
E1 bis E4

✓ Climate
✓ Traffic
Performance Based Specification in Pavement Design

Revision Goals – Material Parameter

Replacement of the so called “model asphalt and introduction of HMA material stiffness relations into the Austrian pavement design scheme based on following three methods

- standardized temperature & frequency curves for typical Austrian HMA types
- stiffness tests acc. to ÖNORM EN 12697-24 and standardized statistical data data evaluation of test data
- stiffness prognosis on the basis of a developed Mutiscale HMA model

Introduction of specific HMA material fatigue relations based on following two methods

- standardized fatigue curves for typical Austrian HMA base course types
- stiffness tests acc. to ÖNORM EN 12697-24 and standardized statistical data data evaluation of test data

Macroscopic versus Multiscale Models

- **macroscopic material models**
  identified material parameters applicable to one specific mixture consisting of one specific bitumen (e.g., B50/70), one specific filler (e.g. limestone dust) and one specific aggregat

- **(bottom-up) multiscale models**
  material parameters as functions of composition (mix design), morphology, and the properties of the material phases (e.g., bitumen, filler, ...)

  - applicable to several asphalt mixes
  - consideration of changes in material behavior at respective scale of observation
Multiscale Model for Asphalt

Scales of observation:

- Identification of mechanical properties on each scale
- Upscaling of elastic (aggregate), viscoelastic (bitumen), and fatigue properties

Multiscale Model for Asphalt

Input Parameter:
- Volume fractions HMA (filler, sand stones, bitumen, air voids)
- Viscoelastic Material properties bitumen

Identification Experiments for Bitumen Properties

DSR test (Dynamic Shear Rheometer):
The Power Law parameters $J_0$, $J_1$, and $k$ can be fitted from Cole-Cole diagrams resulting from tests at bitumen scale – dynamic load.
Improved traffic loading assumptions
&
LCCA

Revision Goals – traffic loading

• Evaluation of available toll station (Vehicle Counting Station) & Weigh-In-Motion (WIM) Data for the Austrian motorway system
• Identification of representative HGV types (Vehicle Class VC) with its gross and axle weight spectrum
• Definition of axle weight distribution function of VC as input in pavement design procedure
• Life time calculations on basis of VC distribution and its axle weight distribution to replace ESAL concept
Improved traffic loading assumptions

Revision Goals – traffic loading

<table>
<thead>
<tr>
<th>VC</th>
<th>Bild</th>
<th>$p_{vc}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>113</td>
<td></td>
<td>0.462</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>0.107</td>
</tr>
<tr>
<td>74</td>
<td></td>
<td>0.105</td>
</tr>
<tr>
<td>61</td>
<td></td>
<td>0.0979</td>
</tr>
<tr>
<td>83</td>
<td></td>
<td>0.048</td>
</tr>
<tr>
<td>54</td>
<td></td>
<td>0.0316</td>
</tr>
<tr>
<td>51</td>
<td></td>
<td>0.0313</td>
</tr>
<tr>
<td>62</td>
<td></td>
<td>0.0255</td>
</tr>
<tr>
<td>57</td>
<td></td>
<td>0.022</td>
</tr>
</tbody>
</table>

VC distribution          GW distribution for each VC

Axle weight distribution for each VC

$p_{vc}(Q,W) = \beta + \alpha W$

pavement model

Live Cycle Cost Analysis

Revision Goals – Life Cycle Cost Analysis

- Definition of a standardized life cycle based on Long Term Performance data for different pavement type
- Introduction of a life cycle cost analysis to assess and compare not only the structural life time but also annual cost and net present value (NPV) of different pavement types
Conclusions

- ambitious revision goals are considered to substantially improve today’s Austrian design guide and makes it fit for the upcoming engineering challenges
- Revised version is expected to be drafted until 2015
- .. a long road to ride

Thank you for your attention!