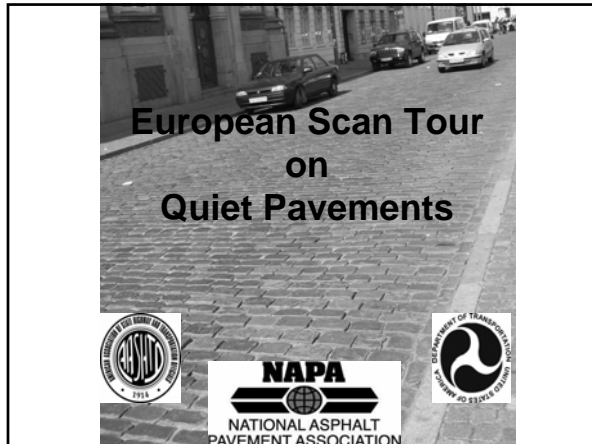



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Who went?

- FHWA
 - Office of Pavement Technology
 - Office of Noise
 - Volpe Research Center
- AASHTO
 - Caltrans
 - Arizona
 - North Carolina
 - Missouri



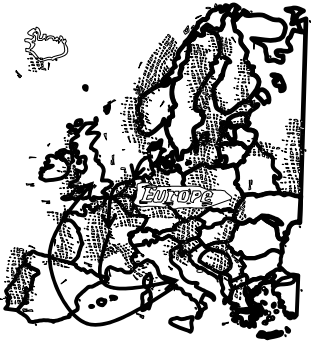

Who went?

- Industry
 - ACPA
 - IGGA
 - RPA
 - NAPA



Where did we go?

- Denmark
- The Netherlands
- France
- Italy
- United Kingdom

Topics

- Thin Surfacing
- Porous Asphalt
- 2-Layer Porous Asphalt
- Exposed Aggregate Concrete
- Innovative Research
- Private Industry Research







EUROPEAN COMMON ISSUES

Highway noise is a common concern

The European Union Directive requires:

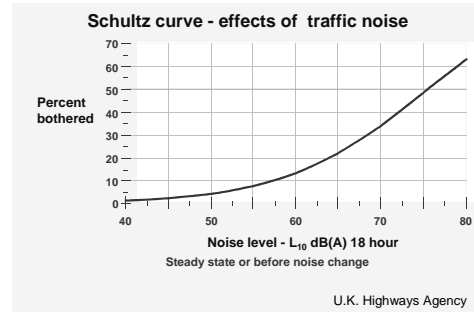
- the development of 10-year plan
- noise mapping (major roads and urban)
- uniform prediction methods within Union
- inclusion of rural areas
- information be made available to public
- adopt of action plans (06/30/07)

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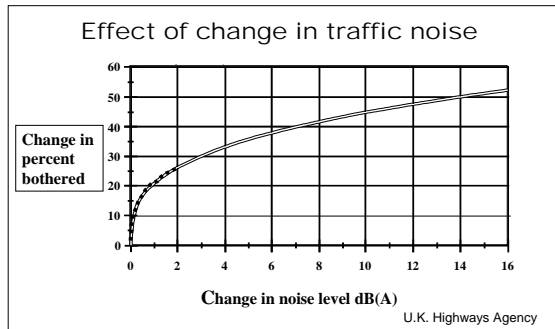
EUROPEAN NOISE POLICY

- All countries visited:
 - Noise is a significant annoyance
 - Noise legislation or a policy in place
 - Have maximum or target noise levels (55-65 dBA)
 - Are working to meet the EU Directive
 - Are using quiet pavements
- Several countries:
 - Conduct noise annoyance surveys
 - Consider noise in pavement selection process

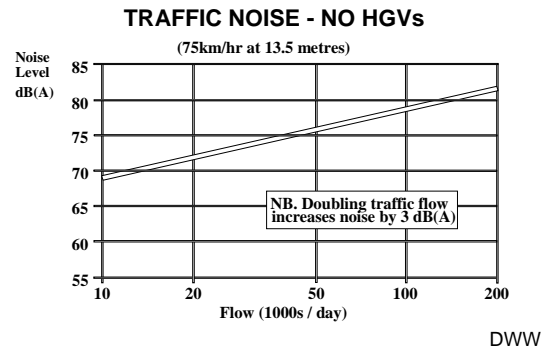
General Issues



General Issues



Noise vs traffic



Expected noise reductions - NL

Goals IPG (2003-2007)

finished products:
 road surfaces : 4 dB(A)
 tyres and vehicles: 2 dB(A)
 barriers: 2 dB(A)
totally: 8 dB(A)

demonstrated products, but further work needed before implementation:
 road surfaces : 6 dB(A)
 tyres and vehicles : 3 dB(A)
 barriers: 3 dB(A)
totally : 12 dB(A)

Cost Effectiveness

€/dB/dwelling

Type of Treatment	City Street	Ring Road	Motorway
Porous Asphalt	100	190	190
Sound Wall	----	850	590
Building Insulation	450	450	720

Danish Road Institute

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Origins of Tire Noise

- Horn effect
- Absorption
- Directivity

Surface Texture

U.K. Highways Agency

Roads to the Future

Development of vision and project execution

Modular Road Surface Project

Characteristic phases RtF project

1. Develop long term perspective
2. Prepare draft functional specifications
3. Build prototype/pilot project
4. Prepare improved functional specifications
5. Build field trial

Absorption

- use porous top layers
- bottom layer of Helmholtz resonators

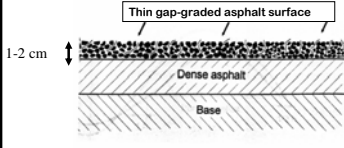
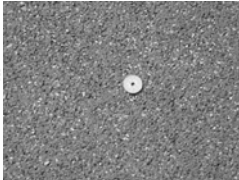
Thin Surfacing

- Implementation
 - Denmark
 - The Netherlands - low speed roads
 - France - low speed or high frost
 - Italy - low speed or mountainous
 - United Kingdom - all motorways

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Thin Surfacing

- 1.5 cm single layer (micro)
- 0/6 & 0/8 gap graded
- 1-5 dB(A) noise reduction
- Cost similar to single layer mixes
- 6-15 years expected pavement life
- 10-14 % air voids






Noise reduction HMA: other directions

COLSOFT:
0/6 or 0/10 mm,
Polymer modified bitumen
Crumb rubber addition



Reduction: 3 to 5 dB

International experiences:
France, Ireland, UK, Poland,
Spain, Australia, Denmark



Summary

- COLSOFT
 - PMA + Crumb Rubber
 - Very efficient
- Always a way to cope with:
 - Thickness
 - Compaction
 - Skid resistance
 - Noise ...and now color

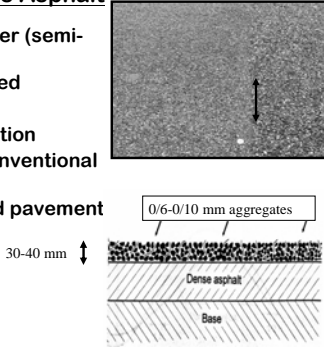
Single Layer Porous Asphalt

- Implementation
 - The Netherlands
 - France
 - Italy



Single Layer Porous Asphalt

- 30-40 mm single layer (semi-dense)
- 0/6 & 0/10 gap graded
- 20-30 % air voids
- 3-5 dba noise reduction
- Higher cost than conventional mix (10-25%)
- 8-10 years expected pavement life

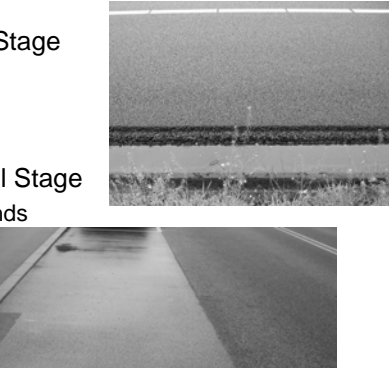


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Two-Layer Porous

- Experimental Stage
 - Denmark
 - France
 - Italy
- Developmental Stage
 - The Netherlands




Two-Layer Porous Asphalt - Denmark

-Design:

- 2.5 cm of 2/6 or 4/8 mm aggregate (top) - filter
- 4.5 cm of 11/16 mm aggregate (lower layer) - drain

-Noise Reduction:

- 8-9 dB(A) quieter than conventional mixes
- 4 dB(A) quieter than single layer porous (high speed)



Two-Layer Porous - Denmark

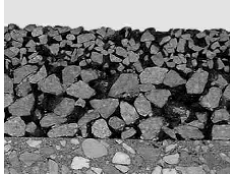
-Construction:

- Higher cost than single layer mix (25-35%)
- Construction of the 2-layer system should be placed "warm-on-warm".
- Tack coats are essential.

-Mix Design:

- Typical voids - >20% (Usually 22 - 26%)
- Typical binder percentages are 5.7% to 6.0% based on aggregate weight.

Two Layer Porous Asphalt (TLPA)



2.5 cm fine graded
Top layer (2/6 or 4/8)

4.5 cm coarse grade
Bottom layer (11/16)

Introduction


Technical aims

(wide application)

- **Initial Noise Reduction** 5 – 6 dB(A) compared to DAC
- **Constructive Durability** 8 – 10 years
- **Cost Effectiveness** 50% cost reduction compared to barriers
- **Safety** comparable to SLPA
- **Acoustic Durability** LTA 4 dB(A)*

* LTA= life time averaged

Safety



Extra attention paid to:

- Initial skid resistance (max. 4 weeks)
 - occasionally under wet and dry conditions
 - speed reduction or post treatment (experimental) necessary
- Winter behavior
 - In Netherlands, mainly black ice
 - measures: communication, lane closure, preventive action
- Long term skid resistance
 - aggregate choice is important

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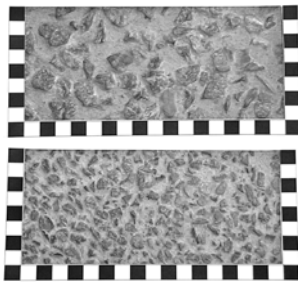
Exposed Aggregate Concrete

- The Netherlands
 - Generally noisier for light vehicles
 - Generally quieter for heavy vehicles
- United Kingdom
 - Did not get the same results
 - Noisier in both cases

Exposed Aggregate Concrete

- Two-layer construction
 - Back the paver up
 - Use two pavers
- Single-layer construction
 - Retardant applied to surface
 - Surface covered with plastic
 - Plastic removed and surface washed

EAC - NL

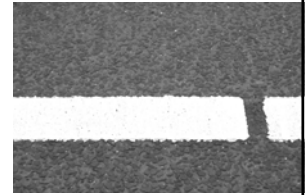


EAC - NL

EAC 4/7 mm



EAC - 10/14

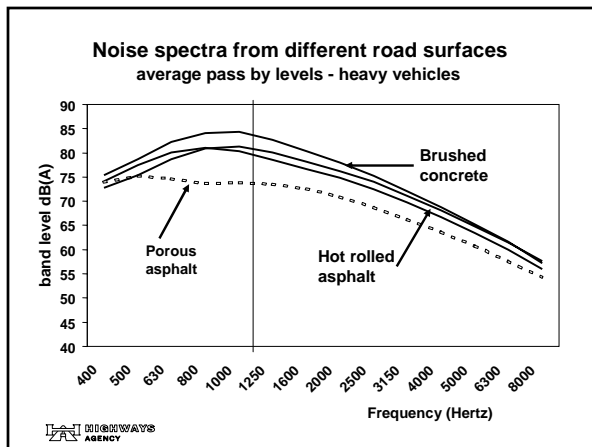
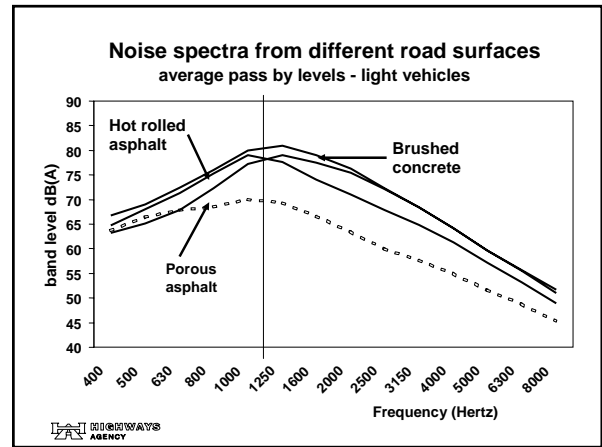
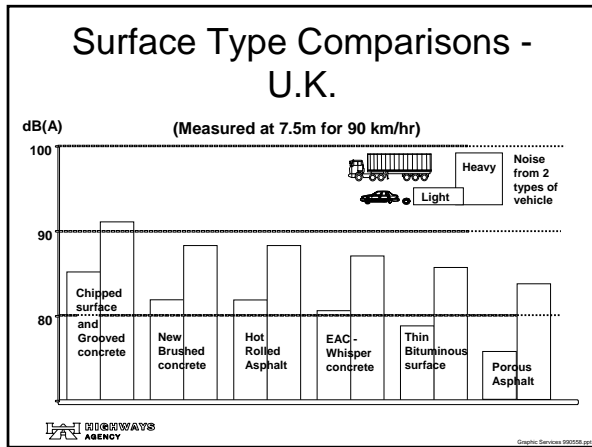
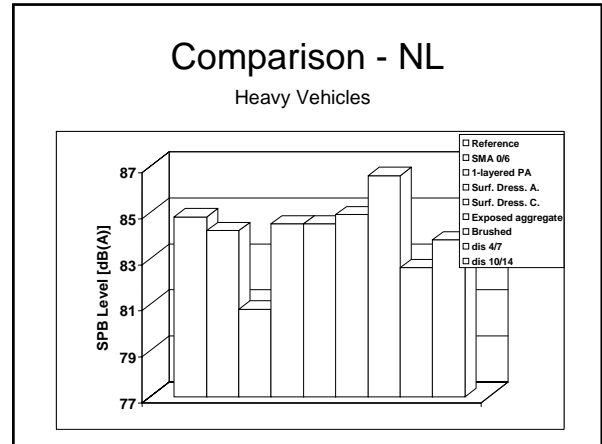
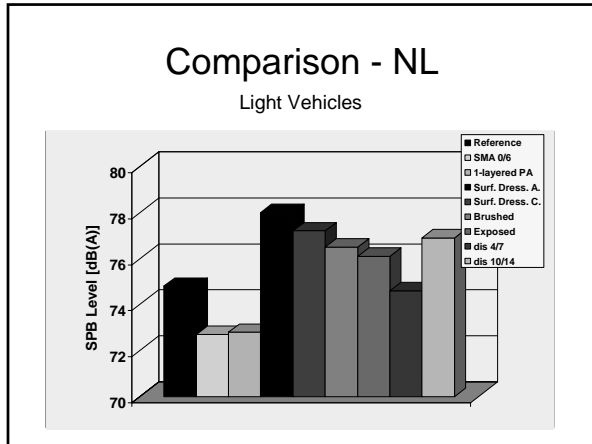


EAC - NL




Comparisons
of
Surfacing Materials

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CURRENT U.S. ACTIVITIES

- Quiet Pavement Pilot Program
 - Considers noise characteristics of pavement surfaces
 - Allows consideration of pavement for noise mitigation
 - Supported by measurements
 - Arizona and California



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IMPLEMENTATION

Immediate Considerations:

- Reduction of aggregate size for wearing course (0/5mm, 0/6 mm, 0/10mm).
- Thin surfaces using a small aggregate are better for urban/low speed applications (<45 mph).
- Highway agencies should begin measuring tire/pavement profile of their commonly used surfaces. Surfaces capable of reducing noise by 3 dba should be considered where noise is an issue.

What Makes a Difference?

- Texture
 - Maximum aggregate size
 - Negative (rolled) surface
- Voids
 - More is better
 - Thicker is better