Concrete Pavements
Tour of European Practice

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Salina, KS

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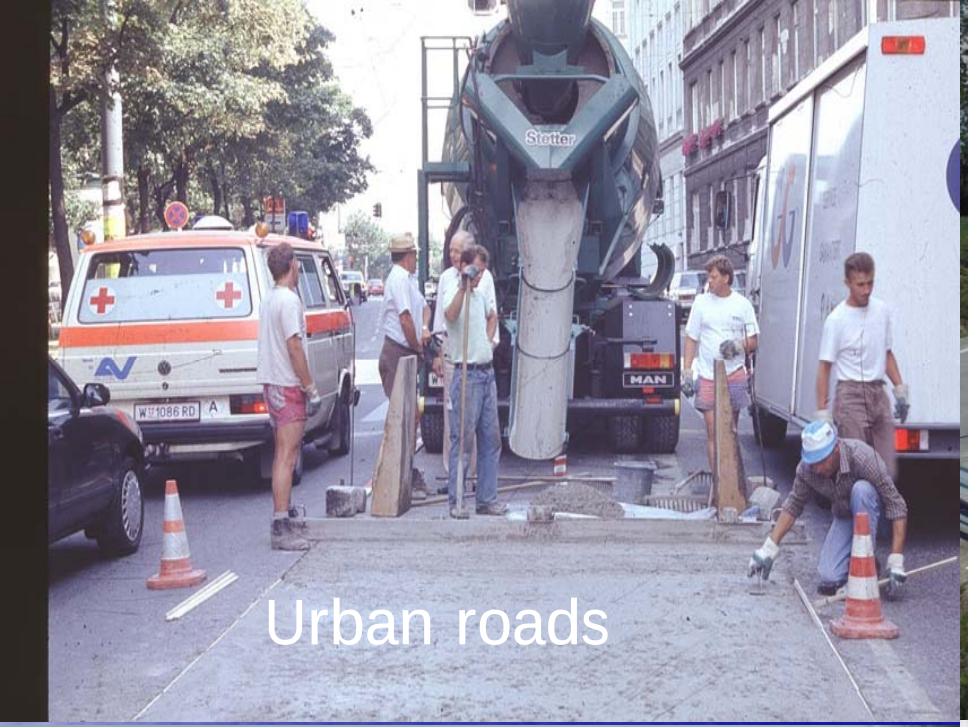

Urban roads


Roundabouts


Minor roads


Agricultural roads

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

A1 Vienna-Salzburg, 1994

Structures with a concrete pavement

Concrete pavement	Thinner...
Base	Thicker...
Subbase	

...than in the USA

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 JPCP

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) JPCP

  or

- 8 in. (20 cm) CSB + geotextile (bond breaker) + 10.6-in. (27-cm) JPCP

  or

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

- Granular subbase

Foundations in Europe - summary

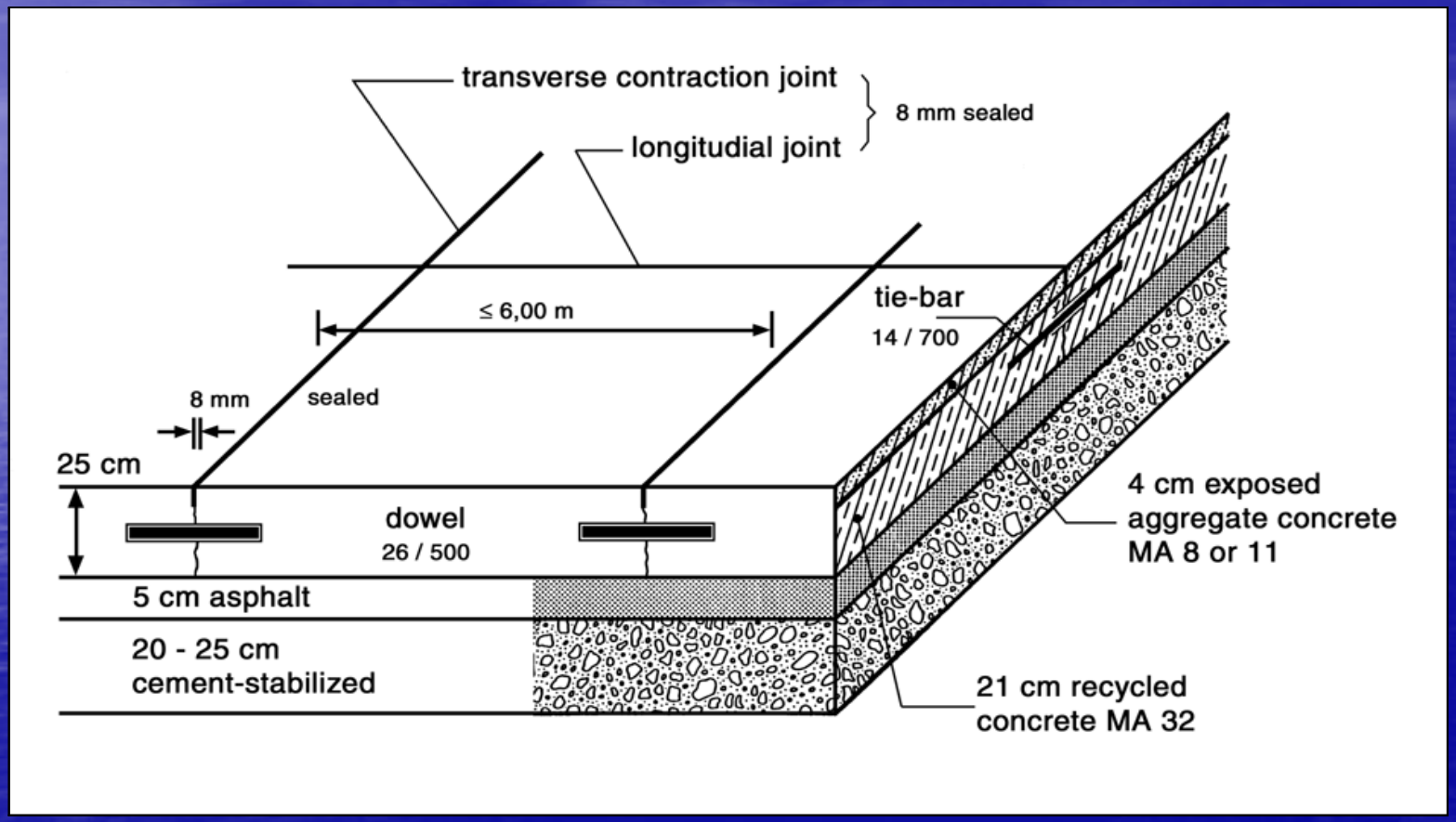
Base	Subbase	Country	Used often?
HMA	granular	all	no
HMA+CSB	granular	all	yes
HMA+CSB	stabilized	several	no
CSB+geotextile	granular	Germany	yes
Crushed stone	granular	Germany	no

Concrete Pavements

Pavement	in. (cm)	base	country
JPCP	9.8/10.2 (25/26)	CSB+HMA	all
JPCP	10.6 (27)	CSB+geotextile	Germany
JPCP	11.8 (30)	Crushed stone	Germany
CRCP	9.0 (23)	CSB+HMA	Belgium
CRCP	9.8 (25) *	CSB+HMA	NL,UK

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

JPCP in two lifts



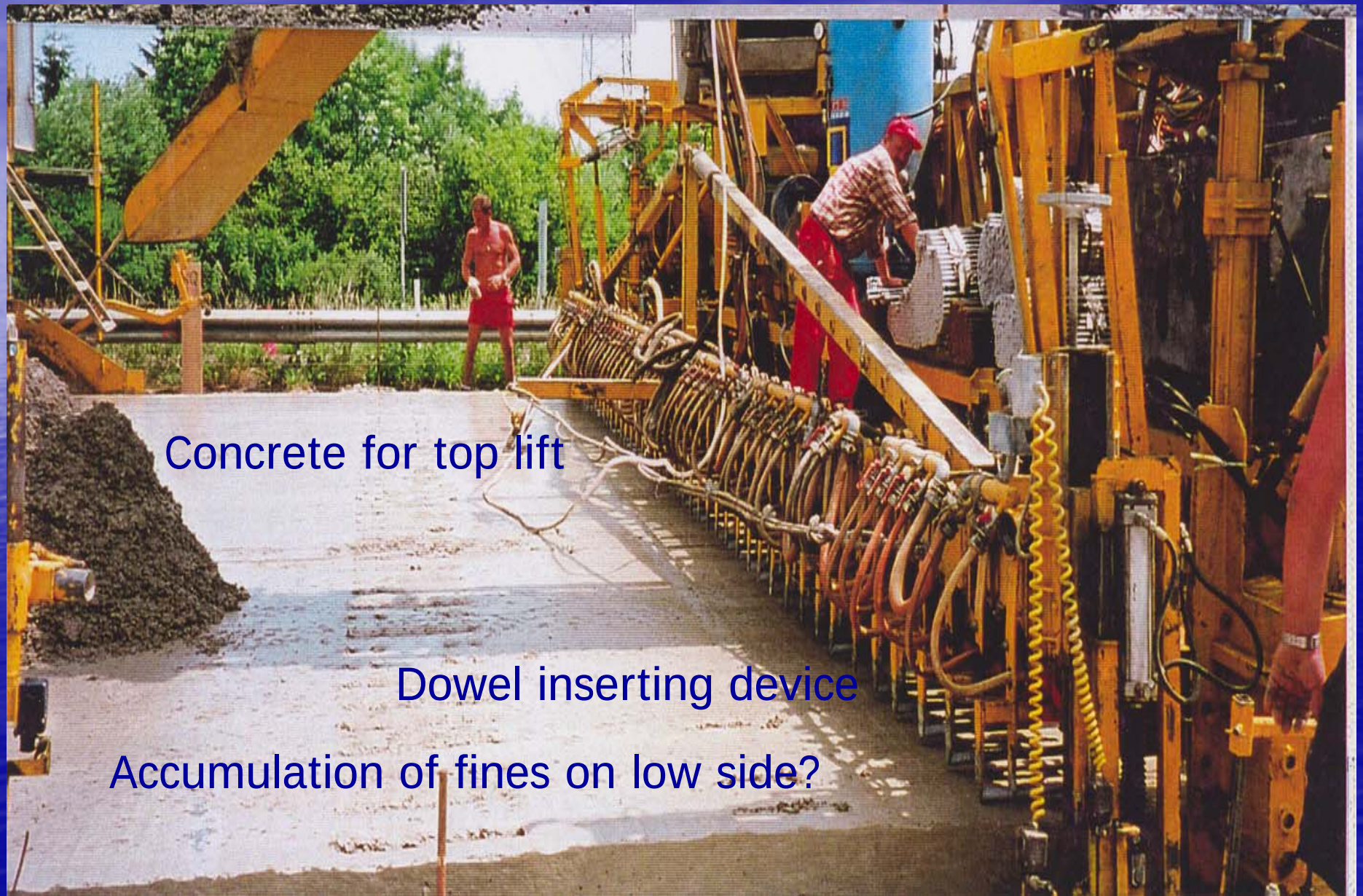
Bottom: gravel or recycled aggregate
Top: high quality virgin aggregate

Two lift paving

Reconstruction:

Paving full width requires dowel inserting device

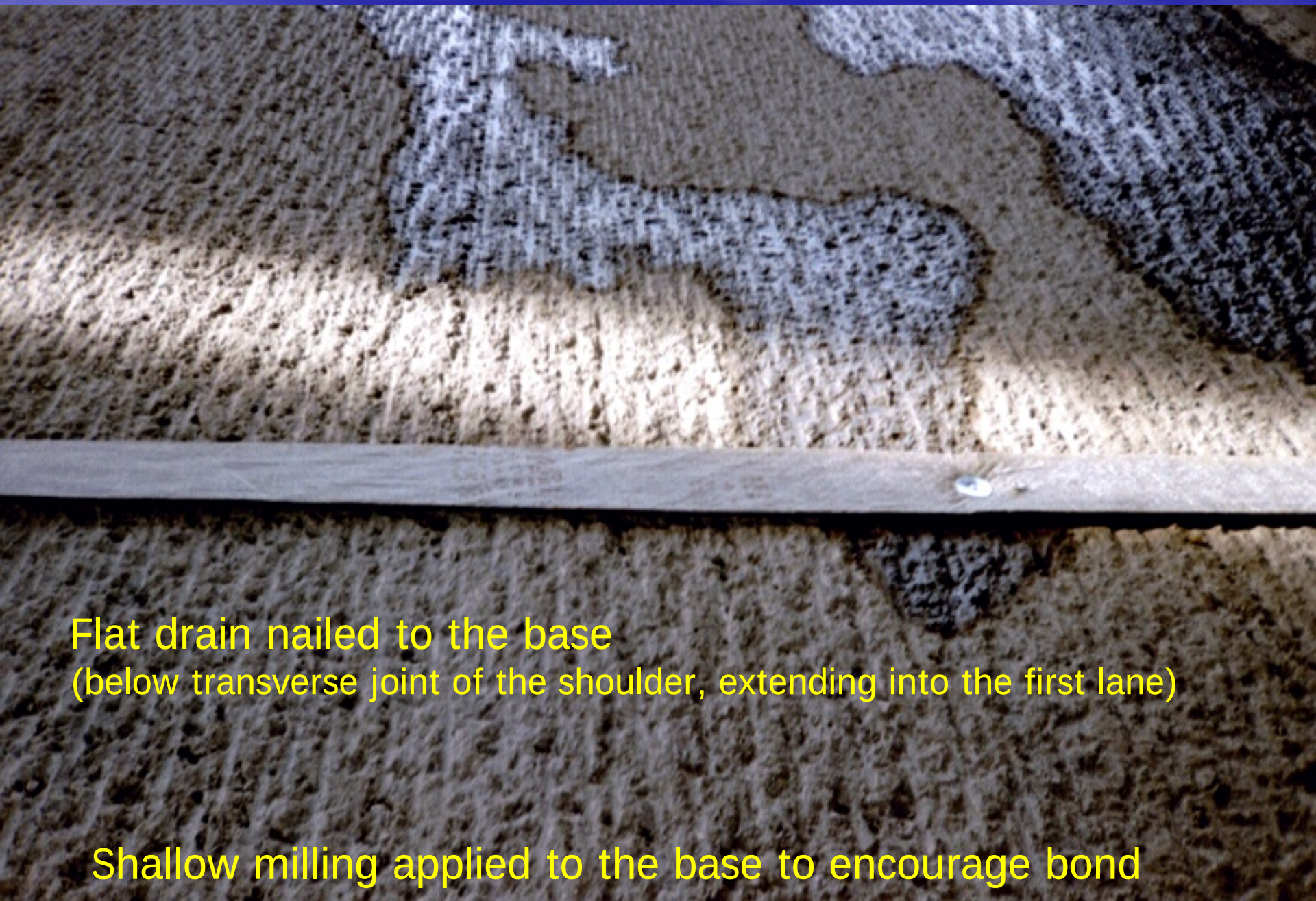
Two-lift paving



New motorway A5 Vienna – Brno, 2008
Paving width 41 ft. (12.5 m) wide, 0.5 mi. (800 m) per day


A5, construction traffic uses other direction

Recommendation in A: Bond + subsurface drainage



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) :

Lift	**Flexural** psi (N/mm²)	**Compressive** psi (N/mm²)
Bottom	≥ 800 (5.5)	≥ 5100 (35)
Top Exposed Aggregate Concrete (5/16 in., 8 mm)	≥ 1000 (7.0)	≥ 5800 (40)

Mobile continuous mixing plant
260 cy/hr. (200 m³/h)

Mobile mixing plant for top lift
130 cy/hr (100 m³/h)

Recycle concrete!

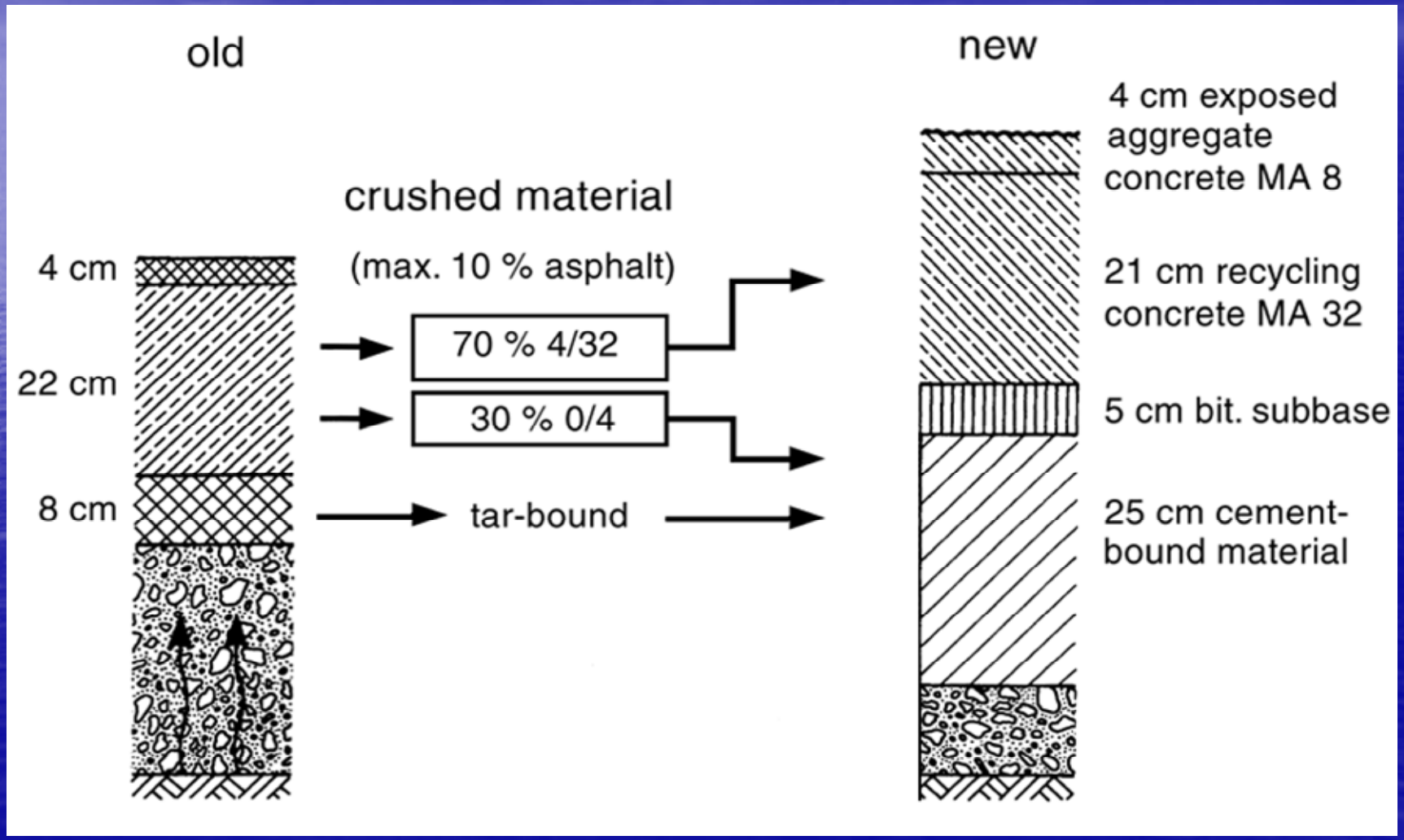
- Old concrete:
  - Strength 10,000 to 15,000 (70-100 N/mm²) compressive!! → As good as many natural aggreagtes
- RCA bonds well with new cement stone
  - Strength higher and better than with many virgin aggregates.
- RCA is high value
  - Should be used for concrete and not wasted for subbases.

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:



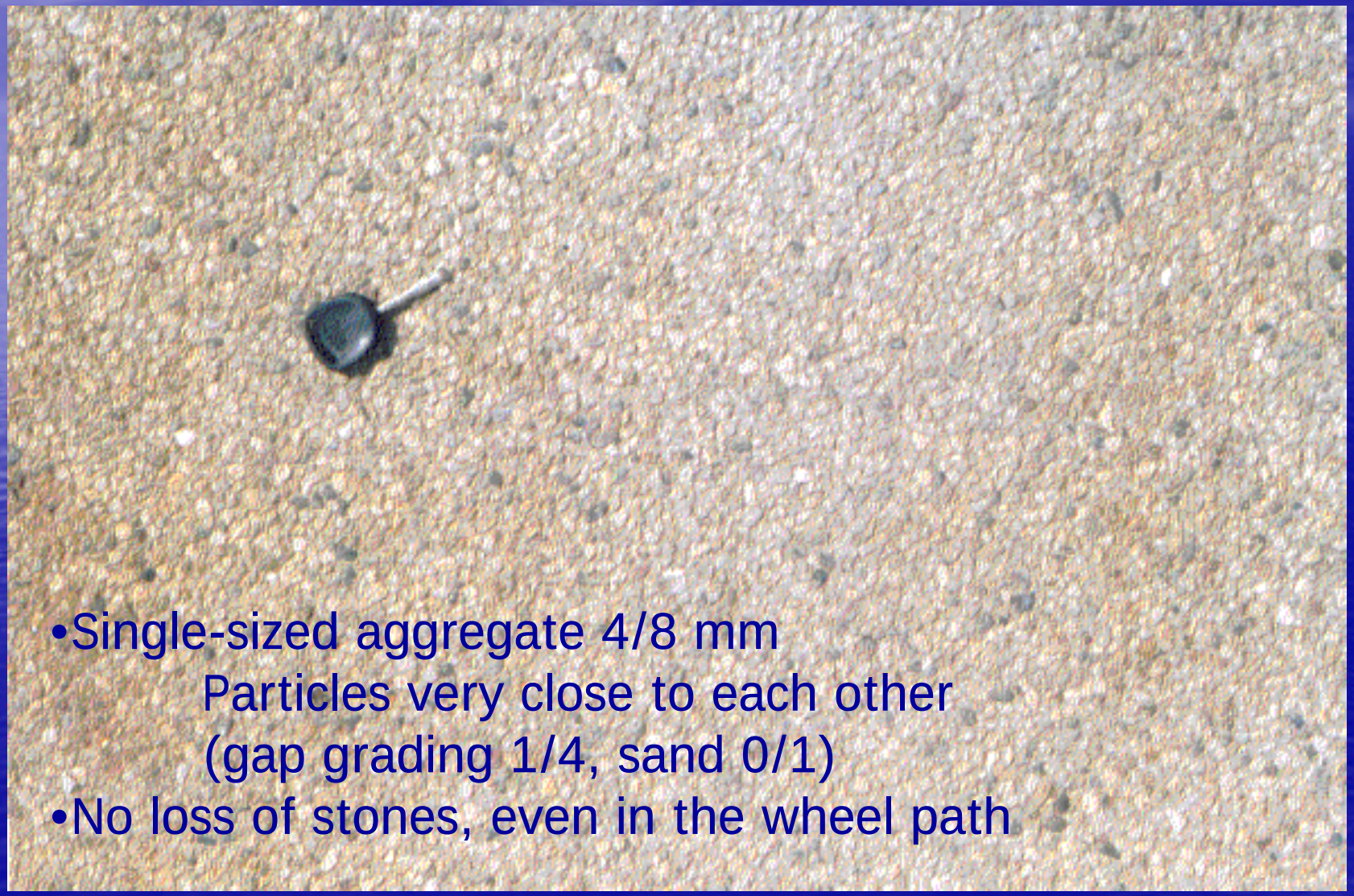
Concrete surfaces

- 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

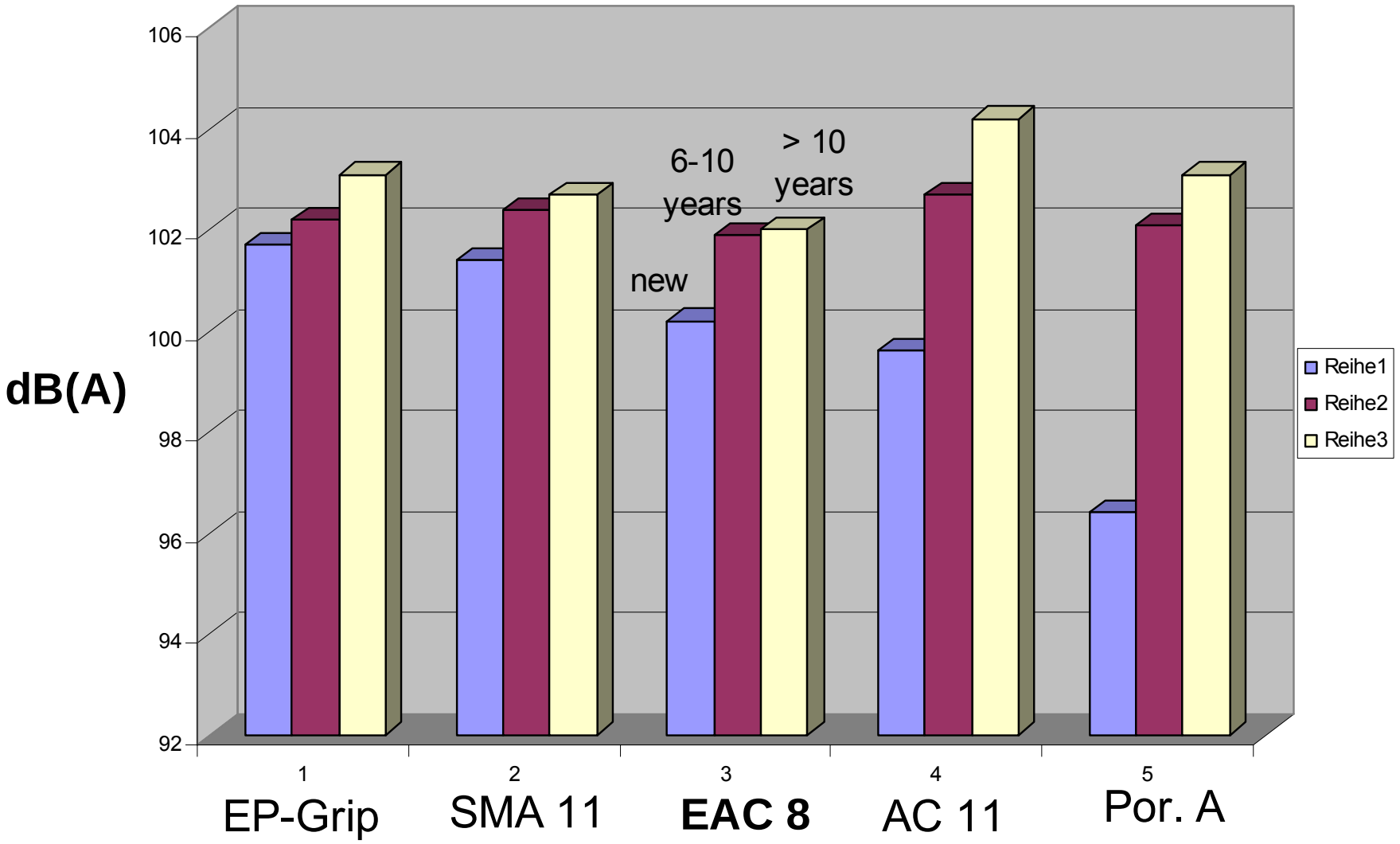
EAS 8 mm after 11 Years´ Service



- 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

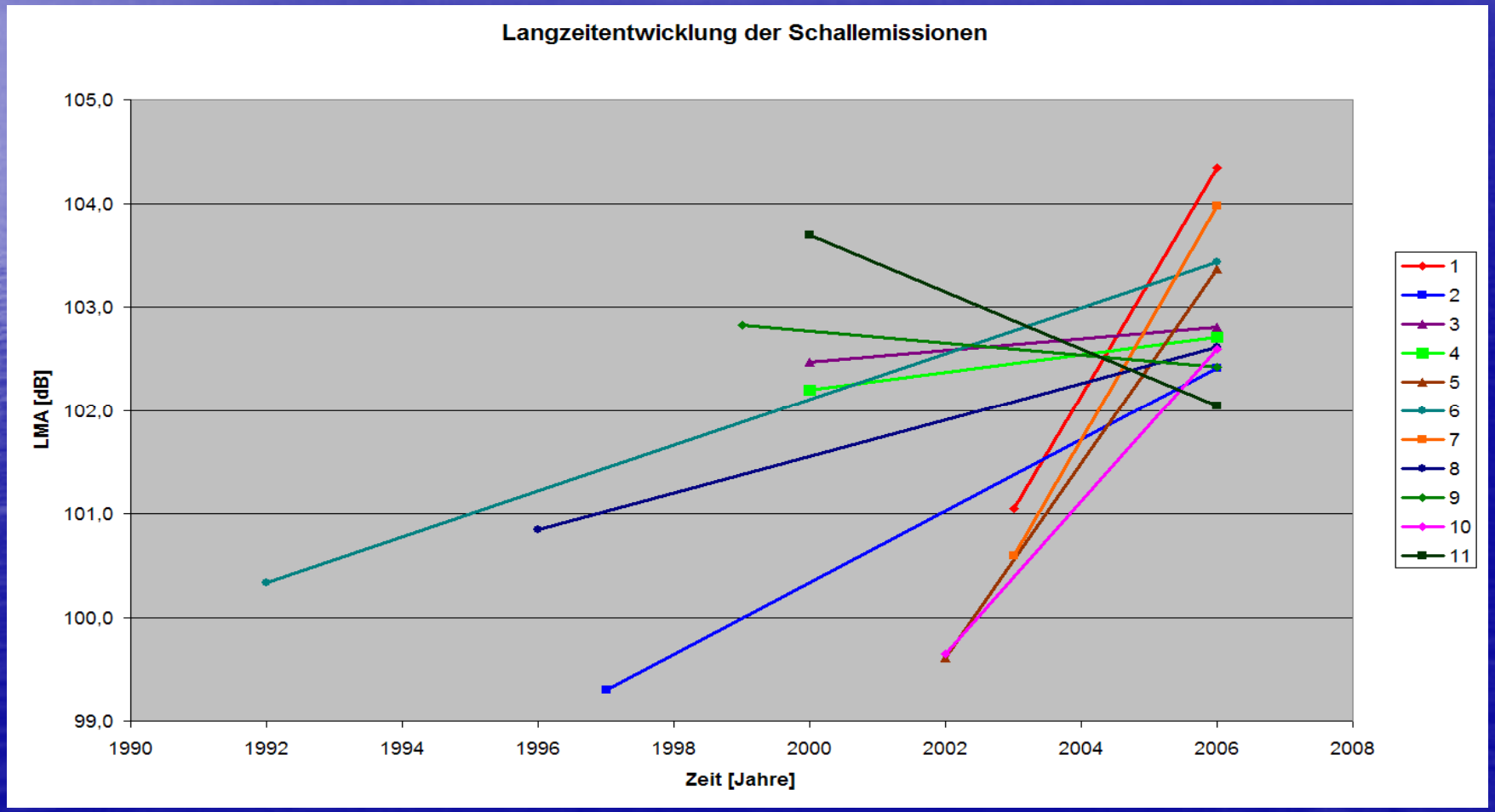
(CPM, J. Litzka, FSV-aktuell 3/07)



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.