Two-Lift Construction
The European Experience

Hermann Sommer
Vienna, Austria

Two-Lift Construction in Austria, Contents:

- Conventional: 8/22 (mm) in the top lift (until 1990)
- Exposed 4/8 or 4/11 (since 1990)
- Recycling the old pavement
- Equipment, laying the pavement
- Requirements and tests for and
- Experience with exposed aggregate surfaces

Austria:

- 32,000 square miles, mainly hilly to mountainous
- 8 Million inhabitants
- Legal single axle load: 11.5 t (25 kips)
- Severe winters
- Center of Europe
- Up to 30 % of heavy vehicles on transit routes
- 1300 miles of motorways and expressways
- 500 miles with concrete pavements
- continuous concrete paving since the fifties

Concrete pavements on motorways

- 25 or 22 cm (9.8 or 8.7 in.) PCC in two layers
  - plain, jointed, dowelled
  - joints sealed
  - expansion joints only at bridges
  - length of the slabs ≤ 5.0 m (16 ft.)
- 5 cm (2 in.) asphalt subbase
- granular or cement-stabilized subbase

Concrete pavements 1954 – 1990

- 6 cm (2.4 in.) top lift: crushed stone 8/22 mm (chippings, studded tyres, snow chains)
- 16 cm (6.3 in.) bottom lift: gravel 4/32 mm
- Flexural strength (Center Point): ≥ 5.5 N/mm² (800 psi) for both layers
- Compressive strength: ≥ 40 N/mm² (5800 psi) top and ≥ 35 N/mm² (5100 psi) (bottom)
- Two mixing plants and two pavers
- No debonding if placed fresh on fresh

Longtime Performance

- 15 -20 years very little maintenance
- First intervention: sealing of joints, local repairs
- Second intervention: thin bituminous overlay (to fill ruts produced by studded tyres)
- Reconstruction when > 35 years old[1)]
- Compressive strength found to be 70 to 100 N/mm² (10,000 to 15,000 psi) !!

[1)]Design life: 30 years

Problems in 1990:

Traffic noise - ban on concrete surfaces imminent

- coarse aggregate exposed by studded tyres
- Increasing (transit) traffic

→ fine-grained exposed aggregate concrete

Reconstruction of a 300 km- (186 mile-) motorway pending

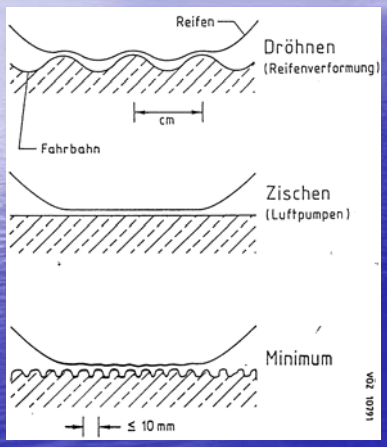
- thick overlays not feasible (too many bridges)
- dumping facilities and virgin aggregates scarce

→ recycling concept

Noise-reducing surfaces - Pros and Cons

Surface	cost	noise	friction	dura-bility
Longitudinal texture	+	(+)	-	-
Exposed aggregate	-	+	+	+
Porous concrete	---	+	+	-

Minimizing tyre-road noise



- Distance between profile peaks ≤ 10 mm and
- texture depth sufficient:

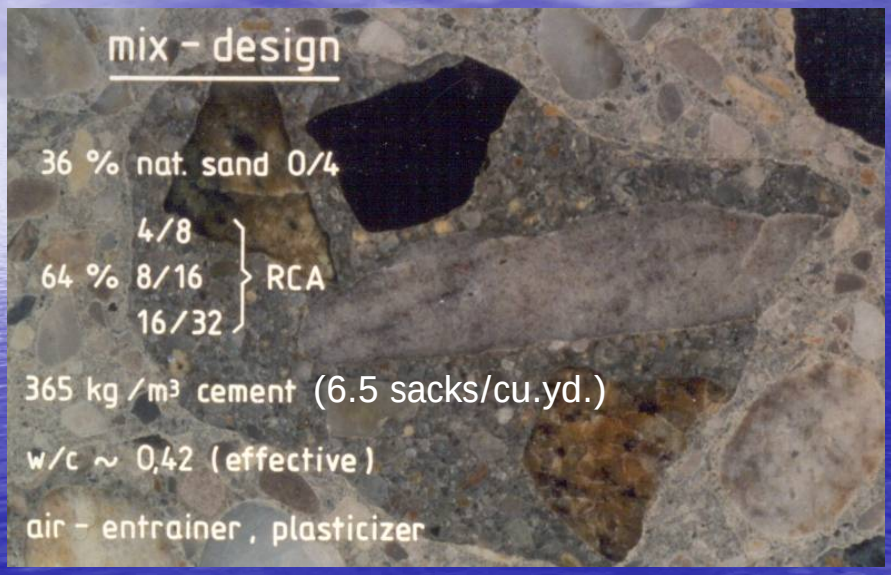
→ tyre-road noise minimum

Drawing (simplified) from Descornet and Sandberg

Exposed aggregate Concrete

- Aggregates 4/8 (4/11) mm: content ≥ 68 (65) %
  PSV ≥ 50
  LA ≤ 20
- Sand 0/1 or 0/2 mm
- Air content ≈ 5.0 %, spread ≥ 300 mm
- 28-day strength: flexural 7.0 N/mm² (1000 psi)
  (w/c 0.38)
  compressive 40.0 N/mm² (5800 psi)

New pavement concrete from old

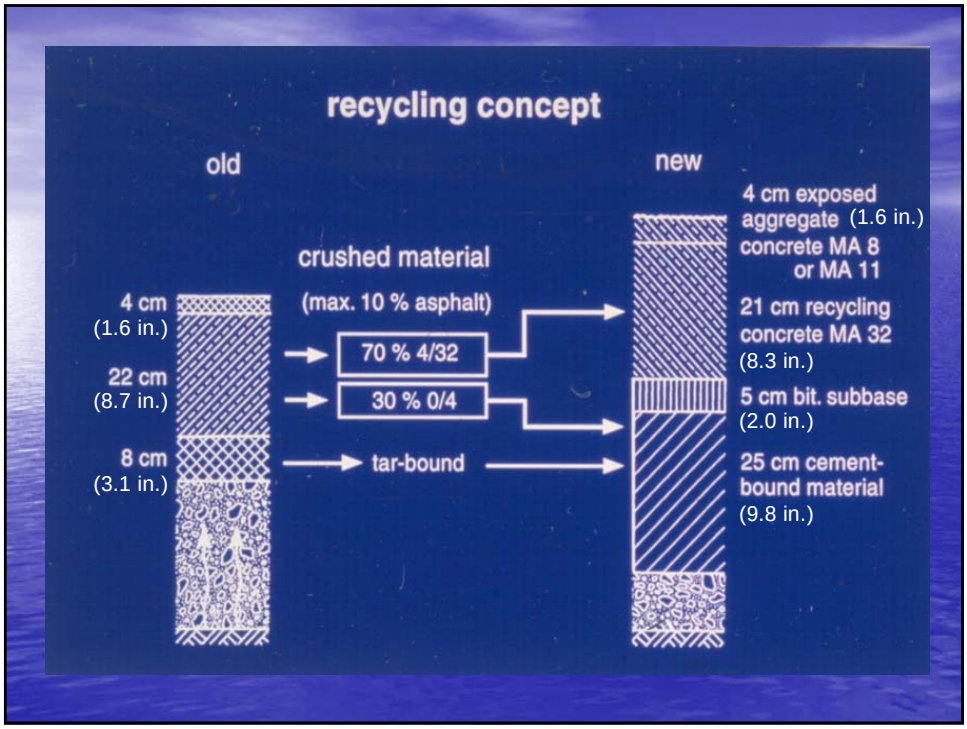


New Paving Method since 1991

- 4 cm (1.6 in.) of exposed aggregate concrete with MA 8 or 11 mm, flexural strength ≥ 7.0 N/mm² (1000 psi)
- 21 cm (8.3 in.) of concrete with RCA 4/32 mm (reconstruction) or with gravel MA 32 mm (new motorways), flexural strength 5.5 N/mm² (800 psi)

Avoid single lift use of EAC

(450 kg cement/m³ - 8 sacks/cu.yd.)!


recycling concept
old
new
crushed material
(max. 10 % asphalt)
4 cm
(1.6 in.)
22 cm
(8.7 in.)
8 cm
(3.1 in.)
70 % 4/32
30 % 0/4
tar-bound
4 cm exposed aggregate (1.6 in.)
concrete MA 8
or MA 11
21 cm recycling concrete MA 32
(8.3 in.)
5 cm bit. subbase
(2.0 in.)
25 cm cement-bound material
(9.8 in.)


Recycling old pavement concrete

Recycling pavement concrete:

- Sort out wood and sealants when shattering the old pavement.
- Use impact type crusher and operate at less than maximum output.
- Dowels and reinforcement no problem for magnetic separator.
- Use RCA 4/32 only for new concrete.
- An old 2-lane pavement will provide all the aggregate 4/32 for a new 3-lane pavement.
- Keep RCA wet and monitor its density.

Continuous mixing plant for bottom lift

4/8 for top lift

Paving train from front

Container for top lift, pavers, spraying unit

Container for top lift, flat drain in front

Bottom lift compacted, dowels inserted

Stiff concrete for bottom lift

Paver for top lift

T-shaped vibrators (instead of pokers)

Paver with longitudinal smoother

Paving train from behind

Curing compound on top of retarder

Spraying the combined(retarding and curing) compound

Shallow milling of bituminous subbase to improve bond

Power broom

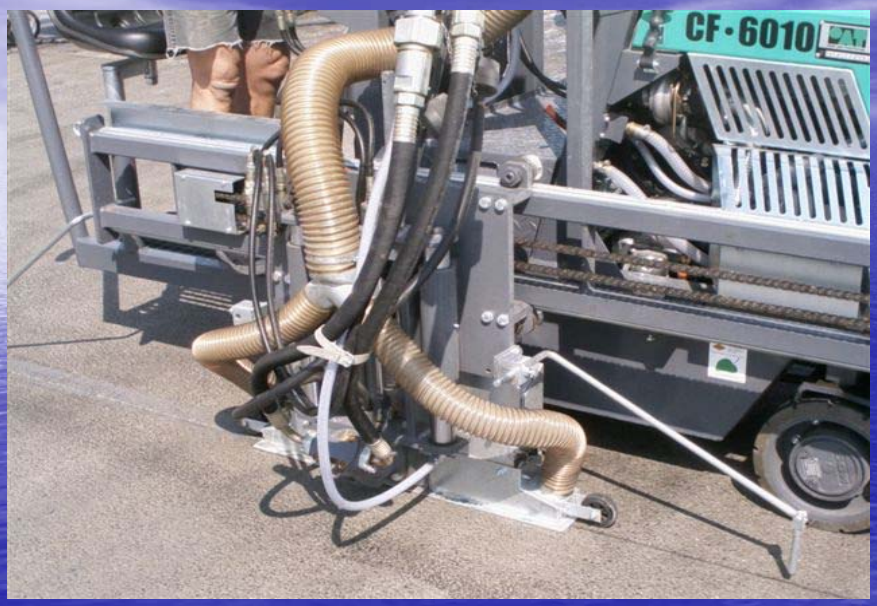
Brushing (always dry!)

Brushing, detail

Surface after brushing

Curing (immediately!) after brushing

Sawing the joints



Paving in a tunnel

Requirements for materials:

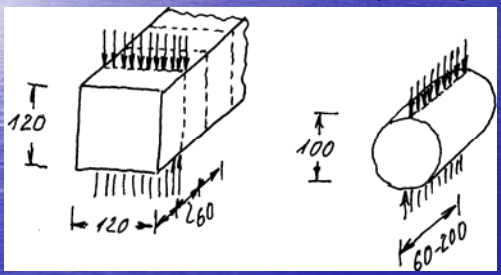
- Pavement quality cement:
  - CEM II/..S (DZ): 15 -25 % slag, Blaine < 4000 cm^2/g
- Aggregate > 4 mm for top lift:
  - LA < 20, PSV > 50
  - non alkali-silica-reactive
- Curing compounds, efficiency:
  - > 90% (first 24 hours) for first curing,
  - > 85 % for second curing

Tests for mix-design (top lift):

- Aggregate > 4 mm: ≥ 68 (65) %
- Consistence and cohesion
- Air-void characteristics
- Strength (prisms)
- Surface texture:
  - Slab ≥ 1000 cm^2 (1.1 sq. ft.)
  - Spray with retarder and curing,
  - Brush (at different times),
  - Stone count/25 cm^2 and sand patch test

Strength at 28 days

- Formerly flexural (7.0/5.5 N/mm² - 1000/800 psi) at 28 days) and compressive (40/35 N/mm² - 5800/5100 psi) strength on prisms
- As from March 1, 2007 splitting tensile strength:



Prisms: mix-design and control tests

cores: acceptance testing

28-day splitting tensile strength, N/mm² (psi), requirements for mix-design and control

prisms

Concrete	Mix-design	Control[1)]: each prism (3 results)	Control[1)]: mean of 3 prisms
top	4.4 (640)	3.2 (460)	4.2 (610)
bottom	3.7 (540)	2.5 (360)	3.5 (510)

[1)]1 prism per day's work

28-day splitting tensile strength, N/mm² (psi), requirements for acceptance testing

cores

Concrete	Bay (3 cores)	Mean of 3 bays[1)]
top	2.2 (320)	3.2 (460)
bottom + top	1.9 (280)	2.9 (420)

[1)]For every 20.000m²:
at least 3 evenly distributed bays

Other acceptance tests

Thickness of pavement	Determined as soon as guiding strings are laid
Thickness of top lift	9 cores per 20,000 m² (24,000 sq.yd)
Aggregate > 4mm for top lift	LA and PSV on samples taken at the mixing plant
Evenness	4mm/4m-straightedge
Cracks	Number of cracked bays
Air-void characteristics	on cores

Requirements for EAC-Surface

Requirement MA	8 mm	11 mm
Stones/25 cm²	≈ 60[1)]	≈ 45[1)]
Texture depth [mm]	0.8–1.0	1.0–1.3
Noise (CPM, 100 km/h) [dB(A)]	< 101 (<104 OBSI, Aqua)	<102 (<105 OBSI, Aqua)

Skid-resistance, 60 km/h: 0.59 (after 5 years 0.49)

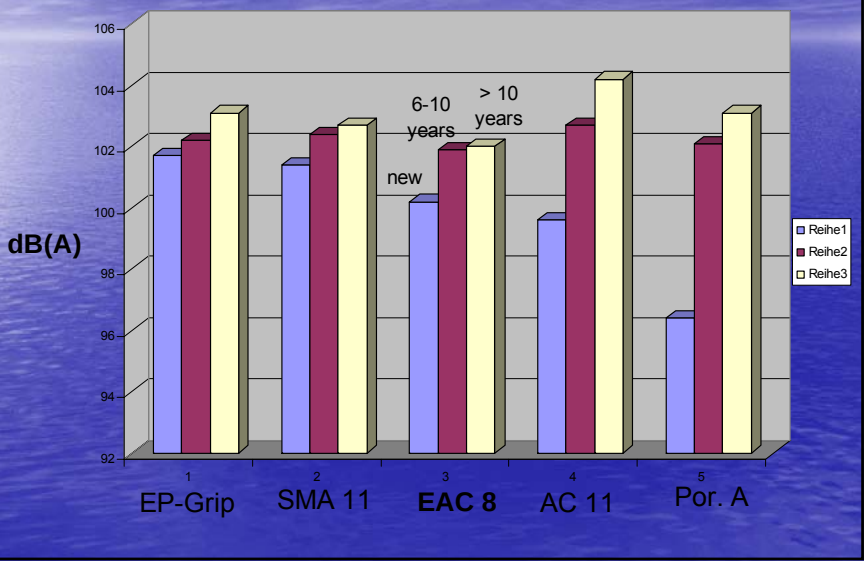
[1)]The stone number to be achieved with a specific concrete is determined in the course of mix-design.

EAS 8 mm after 11 Years' Service

Skid resistance

Tyre-Road Noise

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



Attention: to be avoided

- Segregation due to overcompaction; mind:
  - consistency/cohesion of concrete
  - position, frequency, amplitude of vibrators

- Hairline cracks due to inadequate curing; use
  - high efficiency curing compound and
  - spray immediately after brushing