Sustainable Development through Asphalt Recycling in Switzerland

by

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Outline

- **Introduction** (Definitions, EN)
- **Hot Recycling**
- **Low-Temperature recycling**
- **Application (Switzerland)**
- **Conclusions**

Introduction

What is Asphalt Recycling?

= Reclamation of Old Materials for Re-use in Asphalt Pavements

Old Materials means:

- **Asphalt RAP** (EN 13108-8): reclaimed by milling of asphalt road layers, by crushing of slabs ripped up from asphalt pavements or lumps from asphalt slabs and asphalt from reject and surplus production
- **Secondary Materials:** manufactured material that has already been used at least once (…typically for another purpose)

Re-cycling and Re-Use

Recycling RAP:

Re-Use of old **pavement materials** in new pavements

Goal:

- **No down-cycling:** use 100% in same function w. same or improved prop. & performance as „new"; sustainable, energy saving
- Repeated recycl. (perpetual re-use)

Re-Use of Second. Material:

Re-Use materials of **non-pavement origin** in pavements (crushed building or demolition waste, industrial & private waste)

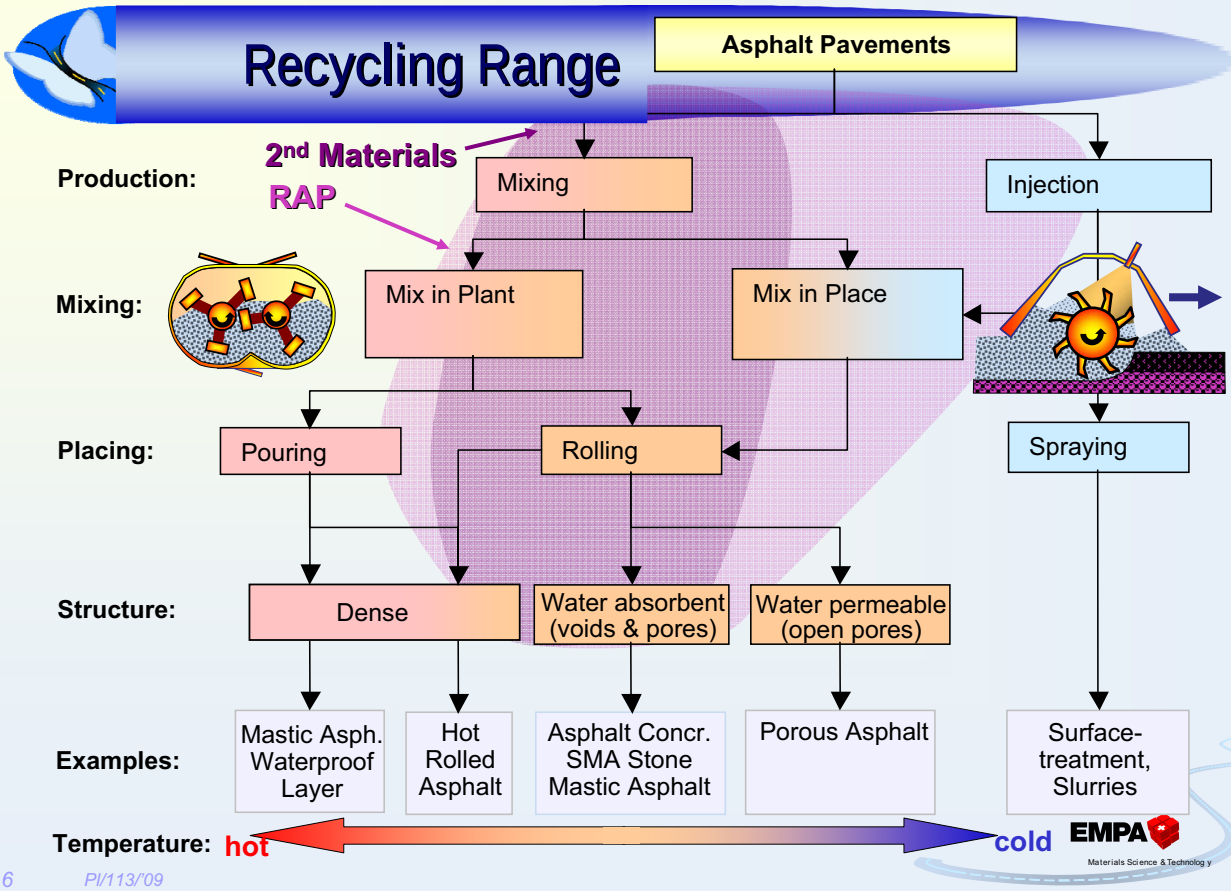
Goal:

- **No linear landfill:** use 100% to obtain equal or improved prop. & performance as with new material; sustainable
- Repeated recycl. (perpetual re-use)

Roofing Shingles

Tire Scrab

Recycling Range



Swiss Recycling: Main Principles

FOEN Federal Office for the Environment

- **Promotion of Closed Loop Material Cycles**
  - Recycle for **same** material application, **i.e. only recycled materials from roads shall re-used for new roads**, because
    - nature & composition of the material is known
    - material with already proven good mechanical properties
  - Recycle to highest possible **quality**
  - More than 95M% **must** be **mineralic**
- Recycling with **Principle of Precaution**
  - Avoid **risky** materials from the very beginning
  - Check **technical practicability** of recycling early
- **No Problem Shifting**
  - Don't recycle **hazardous** materials with future risks
  - No **shift** from one media to another, e.g. air→water
- **Economic Cost - Ecological Benefit**
  - **Economically** & **ecologically** reasonable (e.g. energy)

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Europe

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EN Standards EN 13108-8

Bituminous mixtures — Material specific. — Part 8: Reclaimed asphalt

EN defines:

- Material prop. (asphalt, aggregates)
- Binder type new mix (ex. PmB)

EN does NOT define:

- Mix design
- Max. content of RAP (w. exceptions)

Reclaimed Asphalt is defined by:

- Max. size of **RAP particles** U
- Lower (d) & upper (D) **aggregate sizes** in asphalt particles d/D
  U RA d/D mm, e.g. 40 RA 0/8mm
- Aggregate **grading**
- Binder **properties** (Softening Point and Penetration)
- Binder **content**
- Concentration of **foreign matters** *Group 1* (cement concrete & mortar, bricks, metal, etc) & *Group 2* (wood, plastics, synthetic materials; etc.):
  - Category **F1**: content of *Group 1* ≤ **1**%-W and of *Group 2* ≤ 0,1%-W
  - Category **F5**: content of *Group 1* ≤ **5**%-W and of *Group 2* ≤ 0.1%-W
  - Category **Fdec**: content & nature of all foreign matter declared.

  → "Content" means: Remains in two 8mm sieves (EN12697-42)

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Hot Recycling

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Hot Mix Asphalt Paving

Manual Paving

Machine-Paving

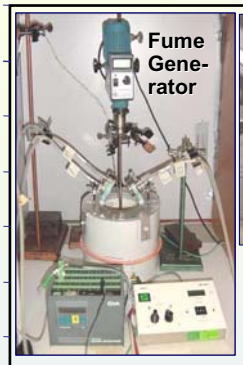
AC

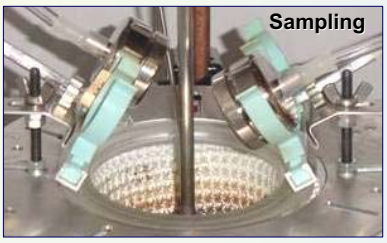
Recycling: Tar-Issues in EU, e.g. CH, DE, NL, BE

MA

TPM (Total Particulate Matter) Fume Emissions vs. Temp (Lab Tests)

(M. Hugener EMPA)





Bitumen 70/100 +
33 w% TB2000,
EPA-PAH: **5100** mg/kg

Bitumen 70/100 +
3.3 w% TB2000,
EPA-PAH: **600** mg/kg

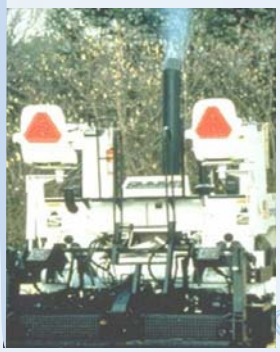
EPA: US Environmental Protection Agency
PAH: Polycyclic Aromatic Hydro-Carbonate

Mass Flow & Emission Sources/Locations

(M. Hugener EMPA)

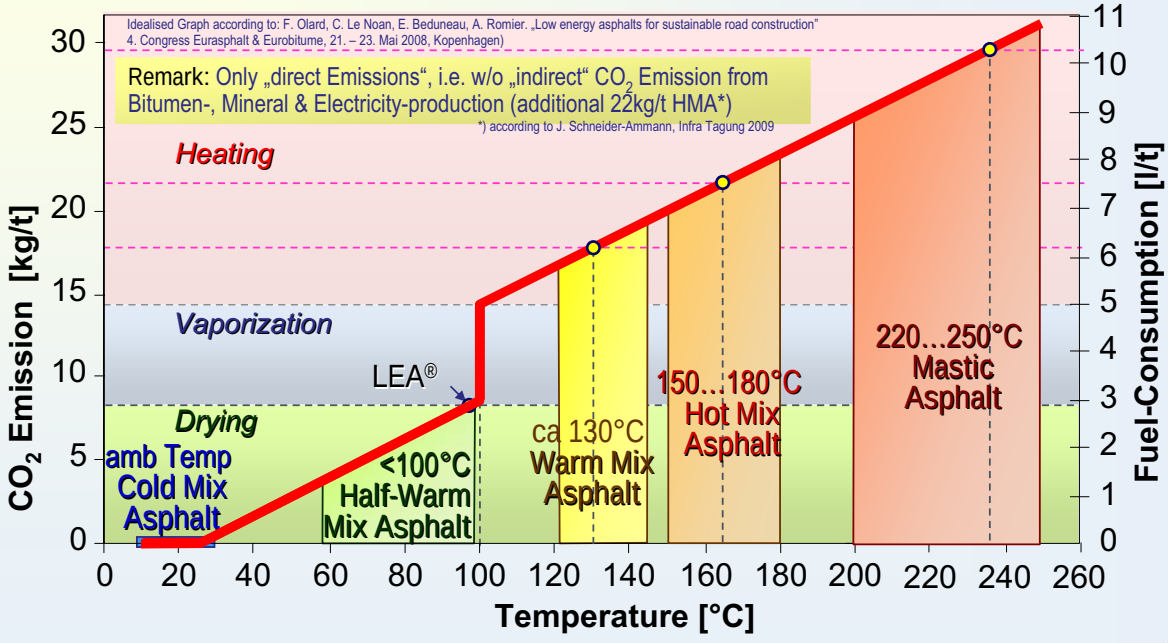
Reduction of Emissions at Paver

- Use **components** with low emissivity
  - **Main components:**
    - **Bitumen:** low content of hazardous substances
    - **Stones**: in most cases inert
  - **Other components:**
    - **Solvents:** evaporates
    - **Polymers:** mostly no emissions (to be verified)
    - **Tar:** high concentration of PAH and Phenol
- **Vapor collectors** and **paver cover**
- **Respect** work instructions and max. temperatures
- **HRA:** if little tar (<20'000ppm) temp <160°C ok
- **Mastic Asphalt:** collect vapor, **no** tar contamin.
- Develop tech. processes to reduce **working temperatur**



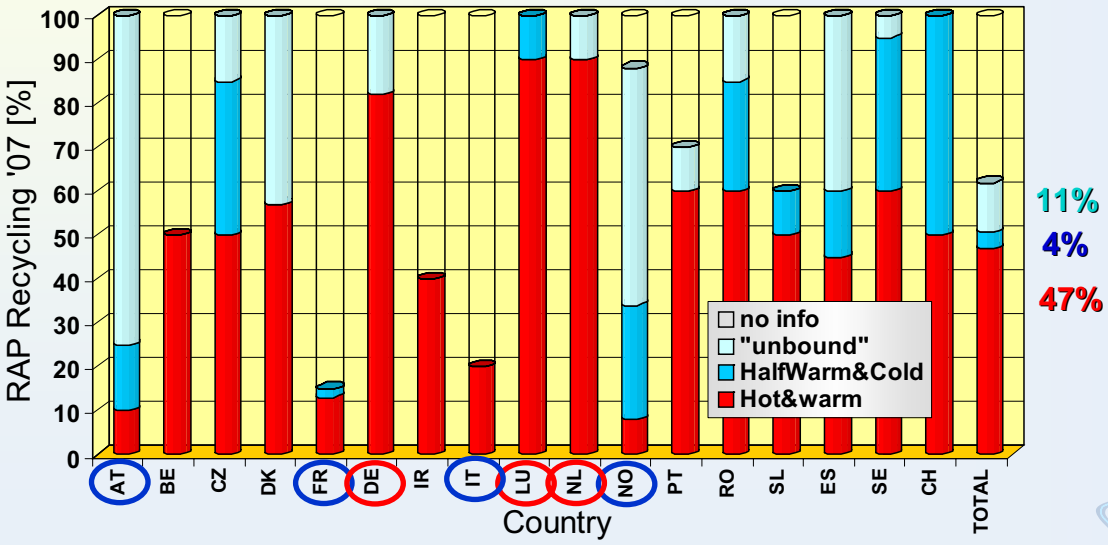
Low Temp Recycling

Energy Consumption & CO_2 Emission



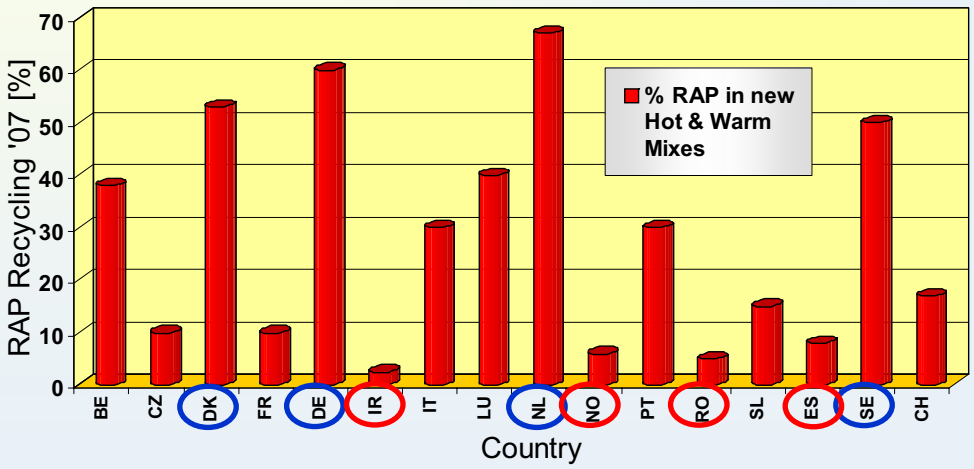
Hot-Cold RAP Recycling in Europe (from EAPA 2007)

Total RAP in 17 European Countries: ca. **45 mio t**
(AT, BE, CZ, DK, FR, DE, IR, IT, LU, NL, NO, PT, RO, SL, ES, SE, CH)



% of new Hot&Warm mixes with RAP in Europe (from EAPA 2007)

16 Countries: (BE, CZ, DK, FR, DE, IR, IT,
LU, NL, NO, PT, RO, SL, ES, SE, CH)

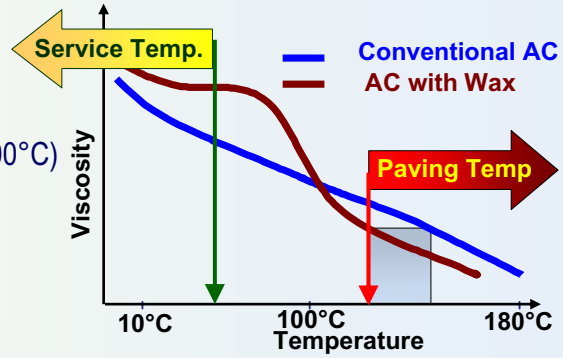


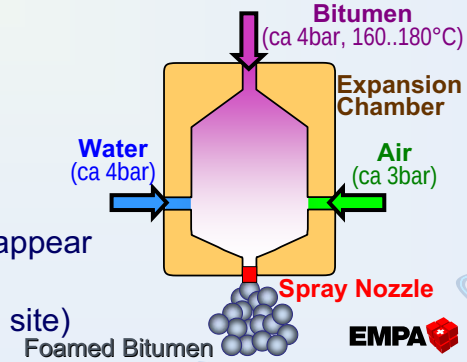
"Greener" Asphalt Pav.

(M. Hugener EMPA)

Promote **Hot→Cold** Recycling!

- **Warm: Temp-Reducing Additives**
  - **Wax** additives (reduction by 10..20°C)
  - **Rapeseed-oil** ester addit. (Place @100°C)
- **Lukewarm: Foam Bitumen**
  - Greater **know-how** required
  - New **test** methods required
  - Problem: **Coating** of minerals
  - Waiting **time** until ready for traffic
  - Only for **compacted** asphalt
- **Cold: Emulsions**
  - Complicated, greater **know-how** required
  - Other **test** methods
  - Pav. **thickness** limited, to allow water disappear
  - Only for **compacted** asphalt
  - **Logistics** (Water-Transport to construction site)
  - **Expensive**





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CH-Applicationss

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RAP in Switzerland (FOEN & SN 670141)

- **Dosage** (only valid for RAP Ø<35mm from Surface Courses):

Mixture Type	RAP Content for Admixture	
	Cold [M-%]	Hot [M-%]
AC Surface C.	10…15	20…30
AC Base C.	15…25	30…60
AC Subbase	20…30	50…80

(SN670062)

Recycl. Mat.	RAP
Asph. Surf. C	Ideal Use
Asph. Base C	
Asph.Subb.	
Bit Stab Subb.	Possible Use
Concr. Pav.	NO
Hydr Stabi	NO
Un-bound Subbase	Use under Bound Layer OK
Un-bound Suface	Possible Use
Concrete	NO

- **Some Special Regulations:**
  - **Re-Recycling** must be possible
  - Do **NOT mix** RAP with recycl. gravel/sand
  - Do **NOT** use RAP with **hydr. binder**
  - Do **NOT** use Concrete mat. w. **bitum. binder**
  - Do **NOT** use RAP if in **permanent** contact w. ground water (min. distance required ca. **2m**)
  - Do **NOT** use RAP for drainage layers
- **Tar contaminated RAP:**
  - No Restriction if PAH in Binder <5000 ppm
  - Restricted if PAH in Binder 5000..20'000 ppm (Dilute to 5000 ppm & stay below MAK for BaP while construc.)

- PAH Polycyclic Aromatic Hydro-Carbonate
- MAK: Max. Tolerance of Canc. Mat. at Work
- BaP: Benzo[a]pyrene

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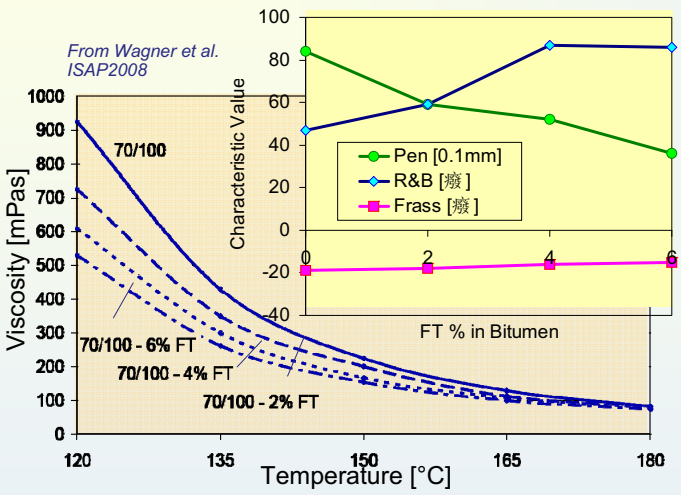
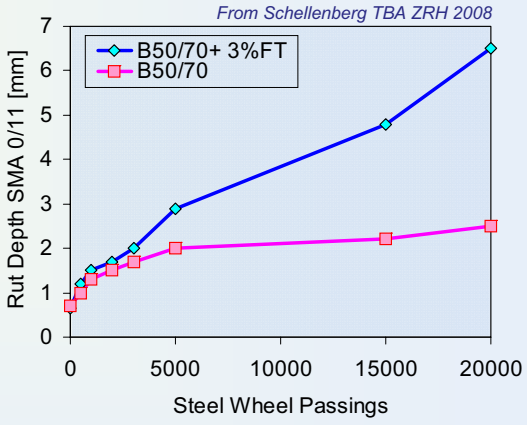
Use of Wax



Fischer-Tropsch-Paraffin = aliphatic hydrocarbonate w. high molecule mass (C_{40}…C_{120}) from cole or gas



- Used in Zurich for MA on Bridges since 2004 and for AC since 2005 (**positive for layers hot in hot = time reduction**); used in ZRH Airport; new focus: Roundabouts
- Special points
  - Faster opening to traffic
  - Faster aging… use for dense courses
  - Overdosage may lead to problems

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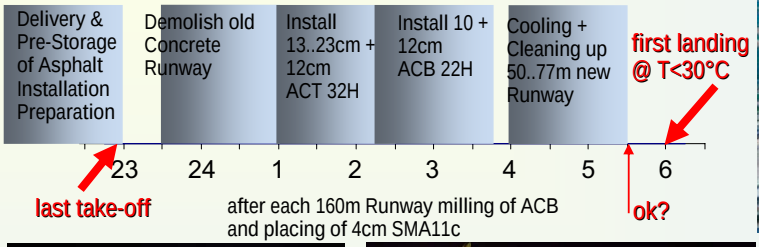
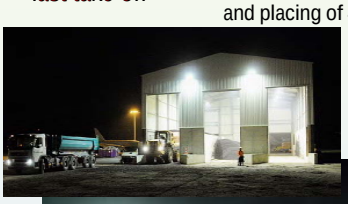
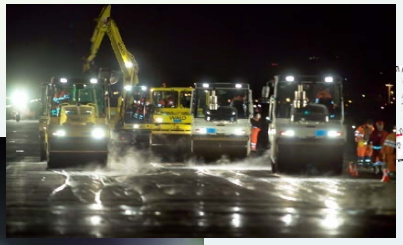
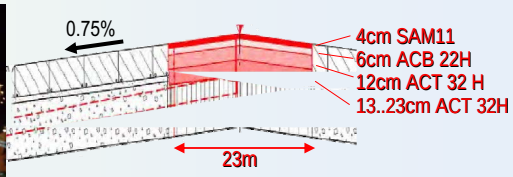
Case Study: Airport Zurich Runway 16/34

S. Dünner & U.Stalder, Walo Bertschinger AG, Fachkolloquium '09, TBA Zürich









ACT and ACB
130..150°C
use of Fiber to avoid drainage
Binder with low viscosity

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Case Study: Cold Recycl. in Zurich

- Some Typical Subbases

	KMF (H)	KMF (B) Foam Bit.	KMF (B) Emulsion
Basic Mater.	RAP	RAP	RAP
Added Mater.	0..40 %-W	-	-
Crushed Sand	-	0..20 %-W	0..20 %-W
Added Water	0..4 %-W	0..2 %-W	0..2 %-W
Bit. Emuls. (60%)	-	-	3..5 %-W
Foam Bitumen	-	3..4.5 %-W	-
Hydraul. Bind.	3..9 %-W	0..3 %-W	0..3 %-W

- Some Early Trials

Baudirektion Kanton Zürich
U. Schellenberg, TBA Zürich

Early Trials 2003: KMF32 (B) w. PC

Early Trials 2003: KMF32 (B) w. Foam Bit.

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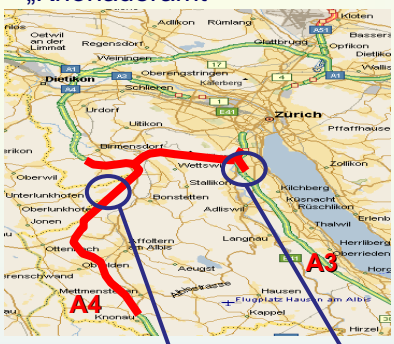
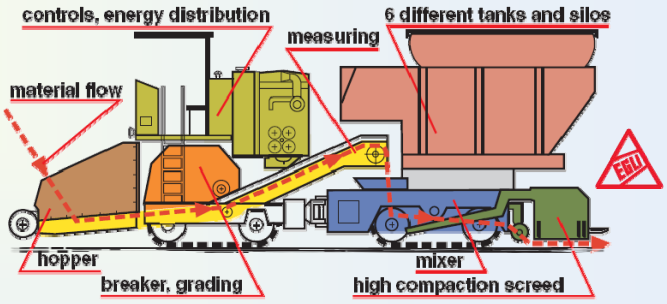
Case Study: Cold Recycl. in Zurich

- A4 West Peripheral of Zurich „Knonaueramt“



- A3 West Peripheral of Zurich „Entlisberg“ - Use of „Egli“ Total-Recycler (in Place)

Baudirektion Kanton Zürich
U. Schellenberg, TBA Zürich



Structure A4:

Materials	Thick. [cm]
SMA 8	3
AC B 22 H	8
AC T 22 H	8
SAMI 8/11	1
upper KMF(H)	18
lower KMF(H)	>22
Subgrade ME_1:	>30MN/m^2

Structure A3:

Materials	Thick. [cm]
SMA 11	3.5
AC T 32 H	12
AC F 32 H	15
SAMI 6/11	1
upper KMF(H)	18
lower KMF(H)	20
Subgrade ME_1:	>30MN/m^2

ca. 40% RAP in KMF(H) from intermediate stock

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Structural Numbers Comparison

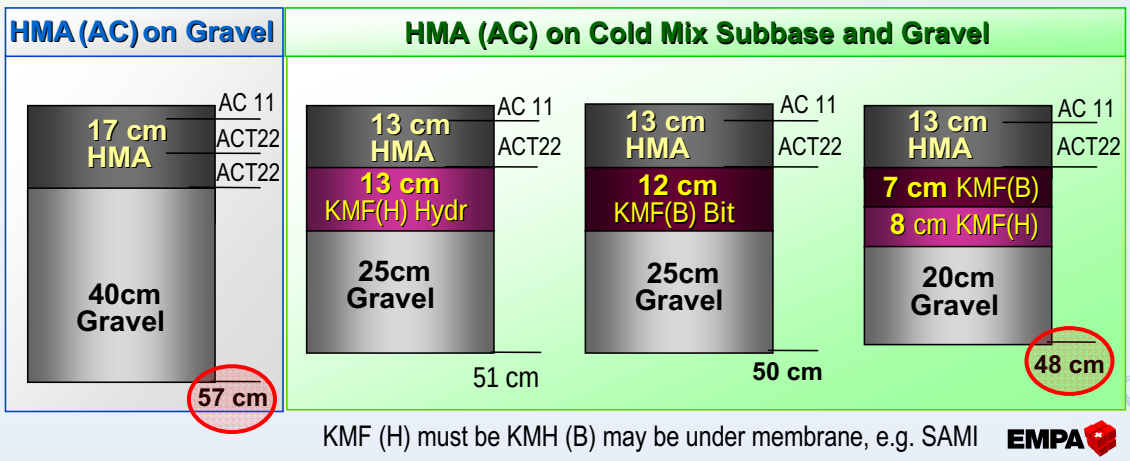
U. Schellenberg, TBA Zürich

- Comparison Structural Number a (AASHTO 1986) for Subbase

Baudirektion Kanton Zürich
U. Schellenberg, TBA Zürich

1 cm Cold Mix Subbase (KMF)= 1.1 cm Hydraulic Stabilized Subbase
2.7 cm Gravel
0.8 cm AC F Hot Mix Subbase

- Comparison of Structures T4 (300…1000ESALs/d), S2 (i.e. ME_1=15...30 MN·m^{-2})



KMF (H) must be KMH (B) may be under membrane, e.g. SAMI

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Conclusions

Conclusions

- RAP introduces many **new parameters** into an already complex system, that we must learn to manage
  - Reduce diversity of RAP and **homogenize** as much as possible in order to improve quality and fascilitate logistics
- Improve design, engineering and production of RAP
  - learn to **up-grade RAP** to the highest technical and economically feasible level before using it (pre-processing)
  - Improve chemo-physical **understanding**, characterization & modeling of the RAP in the pavement (materials technology)
- **Low temperature** recycling is the most sustainable way to go, but there are challenges regarding
  - **production** and **placing**
  - **performance**, **durability** (aging, moisture)

Annex