DIRECT-MAT Final Workshop
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Highlights of WP3 „Hydraulically-bound materials" Best Practices

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Background

EU waste framework directives: 70% recycling rate for construction and demolition waste by 2020.

DIRECT-MAT project: European Web database and Best Practice Guides on demolition and recycling road materials back into roads. WP3 concentrates on hydraulically-bound layers (members: A, B, CZ, DK, F, HU, S, SLO):

Activity phases: European literature review
Field and laboratory data collection
Best Practice Guide

Best Practice Guide in the DIRECT-MAT project

DIRECT MAT WP3

Completed in October 2011 based on WP3 information gathering.

Content

- Overview of recycling processes
- Demolition – crushing – sorting techniques
- In situ and plant recycling techniques
- Future research needs
- Conclusion

Overview of recycling processes, I

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Recycling procedure phases

- detailed **investigation** of „old” unbound, hydraulically-bound or asphalt layer
- **quality** requirements of „new” recycled layer
- available recycling **machinery**
- **mix design** (laboratory tests, previous experience)
- **demolition** of „old” layer
- **crushing, sorting**, (cleaning) of reclaimed material, in situ or plant **recycling** (quality management)

Overview of recycling processes, II

New hydraulically-bound pavement structural layer:

- cement stabilization
- lean concrete, porous concrete, sand cement etc. (sub-)base
- cement concrete pavement

General rules

- usually same criteria for recycled aggregate as for natural aggregate
- stricter criteria for cement concrete pavements than for (sub-)bases

Demolition – Crushing – Sorting Techniques, I

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- Collection of related documents and information
- Detailed visual examination with homogeneity evaluation
- Quantity and quality information of the layers to be demolished

Demolition techniques

- partial demolition
- total demolition
- milling

Demolition – Crushing – Sorting Techniques, II

Partial demolition (sound concrete pavement)

Use of guillotine before asphalt overlay

Total demolition (damaged or weak layer)

- Dedicated platform or fixed installation → deposit
- Mobile recycling equipment (drop ball, guillotine or hydraulic hammer on excavator to max. 0,5 to 1,0 m^3)
- Separate demolition (max. 20% asphalt)

Demolition – Crushing – Sorting Techniques, III

Milling of the layer

- separate milling or together with asphalt → base course (high tensile strength and low elastic modulus) → reduced reflection cracking tendency

Crushing steps

- pre-treatment
- primary crushing with possible screening
- secondary crushing
- (?) washing, sorting

Demolition – Crushing – Sorting Techniques, IV

After crushing, separation of sand → to base courses

New cement concrete pavement

- max 32 mm recycled aggregate
- washing for impurities below 1%

In situ recycling techniques, I

In situ and plant recycling techniques

In situ techniques: recycling with hydraulic binder; recycling with cement and bituminous binder

Recycling with cement or other hydraulic binder

Base course below asphalt surfacing (also heavy traffic)

a) Old material testing (physical, mechanical and chemical tests, grading and fines quality, organic elements)

In situ recycling techniques, II

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b) Mix design

Preliminary tests: binder dosage, additional aggregate, optimum water content, maximum density.

Typical cement dosage: 3,5-6,0 %.

Hydraulic Road Binders are preferred

Additional natural aggregate: sand, stone or mix.

In situ recycling techniques, III

c) Execution process

Additional material on surface; light compaction; fractionate into granulate; (eventual) cement or slurry cement spreading; water; mixing; laying, compaction, curing (e.g. emulsion coating)

Daily sampling and testing

Mixing depth: 200-250 mm (350 mm ?)

Water content = f(climatic conditions)

Typically 6 passes of heavy roller

Effective drainage

In situ recycling techniques, IV

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Recycling (stabilization) with cement and bituminous binder (emulsion or foamed bitumen)

Granular material → base or sub-base (no traffic limitation)

Reclaimed asphalt + unbound base (low traffic)

Reclaimed asphalt → base or binder course (low traffic)

Advantages: lower plasticity of fines, higher early age modulus and strength, limited shrinkage

Rehabilitation of aged and cracked, low-volume asphalt pavements

In situ recycling techniques, V

Usually similar steps as for cement stabilization

Differences

- cement, lime or fly ash added to increase the particle size under 0,063 mm (bound to foamed bitumen)
- typical binder contents: 3% emulsion + 3 to 4% cement
  3 to 4% foamed bitumen +1,5 to 2,0% cement
- additional laboratory tests: expansion rate, half life of foam, water sensitivity
- optimum water content: 4 to 8%

In situ recycling techniques, VI

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Execution process

Spreading of cement on the surface, (eventually) gravel on the surface

Disintegration of asphalt + partly unbound base layer by recycling machine

Mixing with binders (injected to mixing chamber)

Laying

Compaction

Overlaying by asphalt course

Plant recycling techniques, I

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Material from stockpiles or recycling site.

a) Recycling to new cement concrete pavements

Similar technique as for virgin aggregates.

Additional aggregate hoppers for recycled material fractions.

Double-layered concrete pavements: lower layer with less strict requirements.

Formerly unbound layer: widely applied

Formerly hydraulically-bound layer: less experience; restriction in some countries due to polishing resistance (no problem in lower layer)

Plant recycling techniques, II

Problems: rough texture, high angularity and increased water absorption.

Optimum water content higher by 1-3%
Insufficient resistance to water and chemical de-icing substances.

No recycling with high alkali-silica content of concrete.

Limit values of RAP (10-20% in lower layer).

Plant recycling techniques, III

Typical mix requirements: w/c, air voids, compaction rate, compressive strength, tensile strength.

General observation
- higher water dosage,
- lower bulk density,
- lower compressive strength by 10-15%,
- lower modulus of elasticity by 15-20%,
- higher creep up to 50%,
- higher shrinkage up to 20-40%.

Typically 35-60% recycling rate.

Plant recycling techniques, IV

15 kg/m^3 (3-4%) increase in cement content

Low alkali cement can prevent alkali-silica reaction

Typical w/c: 0,42

Mixing in saturate surface dry condition

Formerly asphalt layer recycling is not allowed in many countries (Research is needed)

Plant recycling techniques, V

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b) Recycling to new hydraulically-bound (sub)-base layer

Less strict requirements on lean concrete, porous concrete, roller compacted concrete, sand-cement

Differences from concrete pavement requirements: no PSV test is needed,

- crushed concrete sand 0/4 can be used,
- slip form or modified asphalt pavers can be applied,
- quality check: bearing capacity and degree of compaction,
- RAP with 3-5% cement and 52% water → sufficient strength and modulus of elasticity,
- 120-250 m compacted thickness.

Future research needs

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Some examples:

- more **homogenous** reclamation techniques with **low-energy** demolition methodology,
- **innovative testing** methods for the characterization of reclaimed road material,
- expanded **standardization** for testing parameters,
- identification of **key properties** specific to reclaimed materials with realistic limit values,
- **new reclaimed materials** to new hydraulically bound layers without jeopardizing their good quality,
- **best** recycling **practices** in given practical application cases.

Conclusions

BPG (Best Practice Guide) summarizes **theoretical knowledge and practical experience** of European experts in the field

Any **feedback** to BPG is welcome

Europe-wide **monitoring** of test sections is encouraged

Data gathering on environmental and financial aspects in the topic for the **further development** of BPG

THANK YOU FOR YOUR KIND ATTENTION