PIARC Pavement Recycling

Cold in-place recycling with emulsion or foamed bitumen

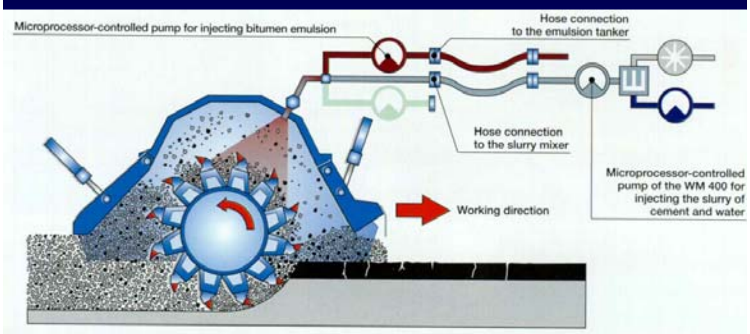
Jean-François Corté

Cold in place recycling

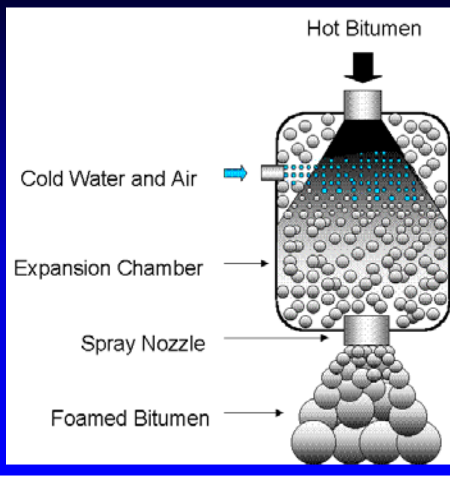
* milling or crushing the materials of the old pavement
* incorporation of a bituminous binder (bitumen emulsion or foamed bitumen)
* placing and shaping
* compaction

to reconstitute the pavement course on the spot

One way of recycling in place with bitumen emulsion (+ addition of cement)

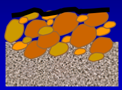


Production of foamed bitumen



Objectives and fields of application

To increase the structural capacity

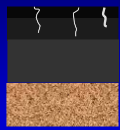


stabilization of granular base course

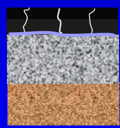
recycle cracked bituminous layers to form a new base or sub-base course

Objectives and fields of application

To correct surface layer problems



Cracking and excessive ageing of the binder



Separation of interface with semi-rigid pavements

Advantages of in-place recycling

Compared to overlay with hot-mixes

Reduction of energy expenditure (no need for drying the materials)

Reduction of transportation of material

Limitation of the ancillary works associated with a raising of the road profile

Advantages of in-place recycling

From a technical standpoint

To recycle only one lane if necessary

To correct the transverse profile

To put up with certain fluctuations in the composition of the materials

To reduce the stresses on sub-grades of low-capacity

To reopen the roadway to traffic at night and during the week-end

Limits of use

Unsuitable characteristics of the materials in-place:

- paving stones or blocks
- large heterogeneity
- important content of clayey materials

Very weak bearing capacity of sub-grade

Presence of many service exits and manholes

Climatic conditions (temperature too low, frequent rainfall)

High level of mechanical performances required

Preliminary studies

To establish if CIR is likely to respond to the objectives of maintenance or rehabilitation

Field investigations

Characterisation of the materials in-place

Feasibility of cold in-place recycling ?

Field investigations

To determine the thickness of pavement layers (transverse and longitudinal profiles)

- borings, trenches

To obtain materials for identification

To check bearing capacity of sub-grade

To locate and record all underground services

Characterization of the materials in-place

Unbound materials

- grading
- cleanliness
- moisture content

Characterization of the materials in-place

Reclaimed bituminous materials

- probable grading after pulverization or milling of the pavement
- binder content
- residual characteristics on the recovered binder (pen., R&B)

Mix design

1. Characterization of the materials to be recycled, in particular:
   - the homogeneity,
   - the grading of the material to recycle to judge if addition of crushed aggregate is necessary for grading correction,
   - the plasticity of the fines,
   - the quality of the aggregate,
   - the content and the nature of the bituminous binder.
2. The selection of the new binder

Mix design

3. Investigation of the compatibility/affinity between the binder and the aggregate (when stabilizing a granular material).
4. Determination of the total fluid content for compaction of the material.
5. Investigation of coating to determine the initial moisture content, to choose the emulsion and the total fluid content.
6. Choice of the residual binder content and determination of mechanical properties

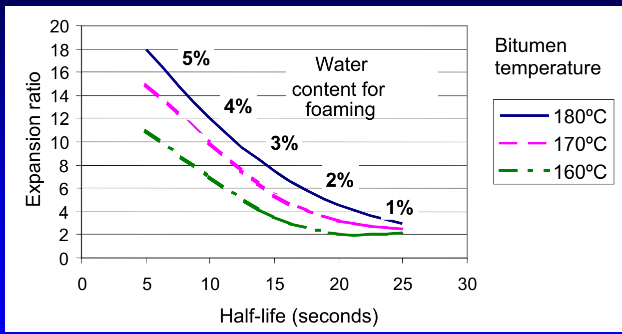
Choice of new binder (bitumen emulsion) (1/2)

Properties of the emulsion		Standard	Case A	Case B	Case C
Binder content		EN 1428	55 - 65%	60 - 65%	60 - 70%
Breaking value		pr EN 13075-1	> 160	120 - 180	80 - 140
Fines time mixing		pr EN 13075-2	> 180	> 180	---
Mixing stability with cement		Pr EN 12848	≤ 2	---	---
Adhesivity by water immersion test		Pr EN 13614	≥ 75%	≥ 75%	≥ 75%
Binder of distillation residue (EN 1431)	Penetration	EN 1426	Adapted to traffic and climatic conditions, and to the viscosity of the aged binder to recycle		
	Softening point	EN 1427			
	Viscosity	EN 12595			
Volume of flux		EN 1431	0 - 2%	0 - 2%	5 - 10%

Choice of new binder (bitumen emulsion) (2/2)

temperate climates
70/100 pen and 180/220
in Scandinavia
up to 400 pen
and even softer bitumen MB 6000 to MB 12000

Choice of new binder (foamed bitumen) (1/2)



Choice of new binder (foamed bitumen) (2/2)

Expansion ratio ER higher than 10

Half-life $\tau 1/2$ of 20 to 30s

Investigation of the compatibility/affinity between the binder and the aggregate

(when stabilizing a granular material.

Determination of the capacity of water absorption

Determination of the reaction of the aggregate in an acid environment (for cationic emulsions)

Determination of cations in solution

Determination of the distribution of the bitumen particles diameters

⇨ composition of the emulsion

Specific aspects of mix design for CIR

Determination of :

- the total fluid content to insure adequate compaction of the mix, for in-place recycling of bituminous mixtures or of “white” materials,

-the quantity of added water at the time of milling to produce later on good coating by the emulsion or the foamed bitumen,

-the binder content to obtain the required mechanical properties.

Determination of the total fluid content for compaction

Most common method:

total fluid content at optimum of Modified Proctor test

(Initial moisture of the recycled materials
+ added water
+ bitumen emulsion before breaking)

Study of coating (1/2)

Good coating by the bitumen emulsion supposes certain initial moisture (about)

1.5 to 2.5% for CIR of bituminous mixes

3 to 5% for CIR recycling of “white” + bituminous materials

moiture content increases with the quantity of fines

determine the quantity of water which can be absorbed by the untreated material

Study of coating (2/2)

Percentage of added water is lowest quantity to obtain a minimum percentage of aggregate covered with binder

quality of coating estimated visually

Selection of the binder content

Empirical approaches with criteria based on:

resistance to water and mechanical performances (stability or modulus)

Methodology derived from tests on hot mixes

(Marshall, Hveem, Duriez)

Various methods for preparation of samples:

- compaction (static, impact)
- curing before testing

In-place recycling with foamed bitumen

Determination of the optimum moisture content of untreated aggregate using modified Proctor test

↓

Determination of a binder content based on the aggregate grading curve (cf. Table 6)

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Optimisation of the moisture content for mixing (OMMC) from indirect tensile strength

↓

Optimisation of the fluid content for compaction (OFC) from the maximum dry density

↓

Determination of the bitumen content from the results of mechanical tests on specimens prepared at the total fluid content (OFC)

Mechanical characteristics of the recycled material

Unconfined compression

Recycling of bituminous mixes

(increases with % of reclaimed bituminous material) from < 2 to > 4 MPa

Stabilization of unbound material

from > 1 to 3 MPa

Mechanical characteristics of the recycled material

Stiffness modulus *(around 15°C)*

Recycling of bituminous mixes

(increases with % of reclaimed bituminous material) from 2000 to 4000 MPa

Stabilization of unbound material

from a few hundred Mpa to 1 Mpa and more

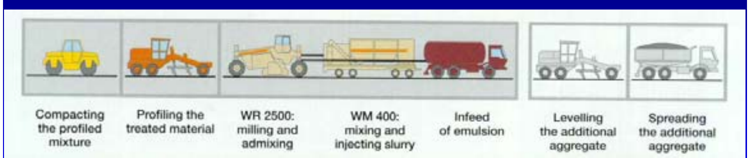
Design of pavements using recycled materials

(see guidelines)

In-place recycling works

Sequence of elementary tasks

One example



Sequence of elementary tasks

Preparatory works

- drainage
- removal of obstacles
- repairing of large localised defects
- cleaning of the pavement…
- correction of the longitudinal or transverse profiles *(milling or addition of aggregate)*

Sequence of elementary tasks

- Addition of aggregate
- Addition of lime or Portland cement
- Milling
- Screening and Crushing
- Mixing
- Placing
- Compaction
- Surface treatment
- Wearing course

Sealing of the surface

When risks of deterioration of the surface (weather conditions, traffic)

- Spraying of a diluted rapid-setting emulsion (residual binder content 250 to 350 g/sqm)

- Light chipping (2 to 3 l/sqm of 4/6 or 2/4) if surface opened to traffic

Laying of the final surfacing

Necessary to protect the pavement (ingress of water and traffic abrasion)

and to provide adequate surface texture

Type and thickness

(depend on traffic and weather conditions and pavement design)

- from surface dressing to thick hot mix

Delay application to facilitate curing

- from a few days to a few weeks depending of the climatic conditions

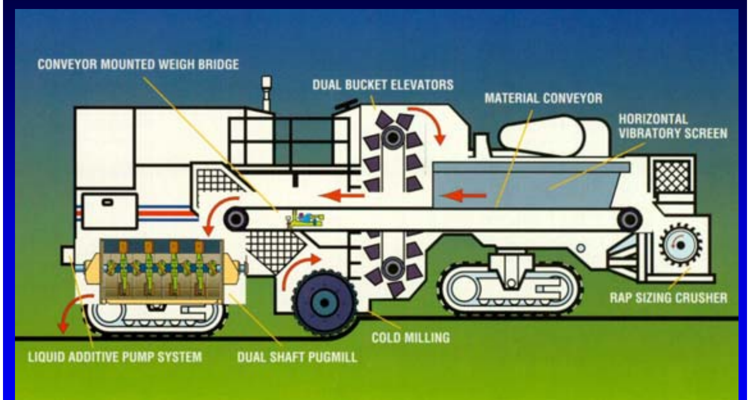
Equipment for in-place recycling

Single-pass recycling train

Portable crusher

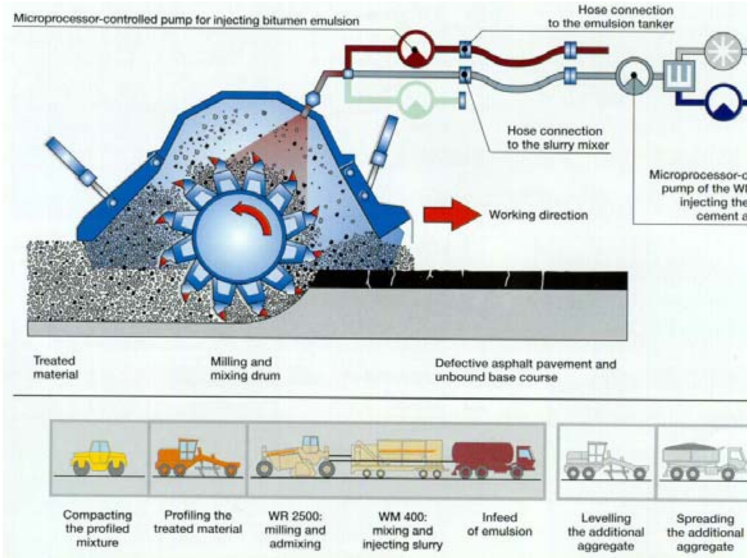
Single-pass recycling train

Integrated milling+ screening + crushing + Mixing machine



Paving behind the recycling machine

Single machine concept



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Compaction

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Quality control

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Specifications and QC/QA

-Characteristics of additives and binder recycling agent

-Top size of the reclaimed pavement materials

- Pulverization depth and recycling depth if they are different

-The pre-mix water content and the binder content

-The density of the compacted material (The use of theoretical maximum density is recommended over the use of laboratory density)

-Equipment calibration

QC/QA

Before the works

- Check of equipment characteristics
- Trial sections
    - -influence of forward speed on particle size distribution and quality of coating
    - - effective depth of pulverization
    - -compaction requirements (optimal moisture content, numbers of passes of the rollers…)
- Calibration of proportioning devices

QC/QA

During the works

- Demonstration section
- Regular checks of
    - proportioning of water and binder
    - max size of reclaimed material
    - moisture content of material in-place
    - depth of recycling