GUIDELINE ON IN SITU RECYCLING WITH CEMENT

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INTRODUCTION

• Common part on pavement recycling
  – Definition
  – Historical development
  – Objectives
  – Types
  – Advantages and limitations of in situ recycling

• Particular features of in situ recycling with cement
CEMENT RECYCLING

- Purpose:
  Transforming a degraded and heterogeneous pavement into a consistent and more homogeneous structure, adequate to actual traffic, by milling, mixing with a hydraulic binder and compaction

PARTICULAR FEATURES OF IN SITU RECYCLING WITH CEMENT

• Deep treatment (20 - 35 cm):
  – substantial increase of bearing capacity
  – great decrease of
  • pavement deflections
  • subgrade strains and stresses
  – correction of deformed pavements (rut)
• Shrinkage cracking → joints (precracking)

HISTORICAL DEVELOPMENT

• Antecedent → retread process (U. K.)
• Development since middle of 80s:
  – better knowledge of cement treated materials
  – more powerful and reliable equipment
  – increasing ecological concern

IN SITU RECYCLING WITH CEMENT

The Spanish experience

• First work: 1991 (non - Spanish contractor)
• First recycling equipment: 1996
• Currently: 22 recyclers
**PRELIMINARY STUDIES**

- Examination of the existing road
- Core sampling
- Characterization of the materials (grading, plasticity, moisture content, setting inhibitors)
- Drainage and climate
- Traffic
- Widening works

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**MECHANICAL PROPERTIES OF CEMENT RECYCLED MATERIALS**

- Compressive strength
- Modulus of elasticity

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**CEMENT RECYCLED MATERIALS**

*Strength*

- Factors:
  - cement content
  - existing materials (quality of aggregates, clay, % bituminous mix)
  - effectiveness of milling and mixing processes
  - moisture
  - dry density after compaction
  - age

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**Influence of content of milled bituminous mix on compressive strength**

- 28 days
- 1 year
**CEMENTS**

- **Desirable characteristics:**
  - high active addition content
  - low - medium strength
  - slow strength development at early ages

- **Preferred cements:**
  - CEM IV, CEM II (EN 197-1 Standard)
  - hydraulic road binders (EN 13282 Standard)

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**MIX DESIGN**

- **Similar to other cement treated materials**
  - water content by mixture – density tests
  - cement content by compressive strength

- **Difficulties**
  - grading after milling
  - properties dependent on recycled thickness

- **Types of cement**
- **Workability time**

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**PAH**
polycyclic hydro–carbons in leachate
tar–bearing material stabilized with 5 %
CEMENT - RECYCLED MATERIALS

Cement content

- The minimum to obtain the required strength
  (2.5 MPa at 7 days; 4 - 6%)
- Use “aggregates” with expected grading after milling
  (+ grading corrector, if needed)
- Specimens compacted at required density
  (modified Proctor compacting device)

THICKNESS DESIGN

- Information to use existing methods
  - multilayer models (E, v)
  - Structural coefficients (AASHTO)
- Catalogues of pavement sections (Spain)
  Design curves (UK)

MACHINERY FOR RECYCLING

- First phase: specific machines
  - cement distributors (powder, slurry)
  - recyclers (milling and/or mixing machines)
- Second phase: similar to other cement-treated layers
  - [equipment for precracking]
  - rollers
  - graders
  - emulsion tankers

CEMENT SPREADERS

- Spreaders for powdered cement
  (self - propelled, towed, coupled)
- Slurry feeders
  (cement hopper + water tank + slurry mixers + pump)
- New developments
  (direct injection of powdered cement ...)

Guideline on In Situ Pavement Recycling With Cement
**RECYCLERS**

- Stabilizers / recyclers
- Modified machines for pavement milling
- Double drum machines (milling drum + mixing drum)
- Mixing machines of previously milled material
- Recycling machines with milling drum, crusher and mixing drum
FRESH - MADE JOINTS

Equipment

- Notches < 1/3 recycled depth (hand – guided or self - propelled)
  - vibrating plate with welded blade
  - vibrating roller with cutting flange or cutting disk

- Notches taking in most of recycled depth (self - propelled)
  - emulsion (CRAFT)
  - flexible plastic ribbon (Olivia)
  - rigid plastic profile (Active Joint)

EXECUTION OF THE WORKS

- Application of imported aggregate and binder
- Addition of water
- Milling and mixing
- Precracking
- Compaction
- Trimming
- Curing and protection seal
- Asphalt surfacing
**COMPACTION**

- Compact as soon as possible
  - avoid moisture losses (and increases)
  - not after end of workability period (bonding between recycling strips)
- Future pavement performance heavily dependent on adequate compaction (100 - 97 % Modified Proctor)
- Use suitable equipment (test section)

**TRIMMING**

- To eliminate surplus material
  - To correct surface evenness
- Only remove
  - Do not fill depressions with loose material
- Take into account trimming
  - to estimate recycling depth (1 - 2 cm more)
  - for workability period

**CURING AND OPENING TO TRAFFIC**

- Usually bituminous emulsion
- Spread chippings if traffic is allowed on top of recycled layer
- Opening to traffic after emulsion breakdown (some hours)
- Take measures (speed limitations) to avoid distresses
- Bituminous layers
FACTORS INFLUENCING COSTS

- Size of the work:
  - thickness
  - total area
    - (mobilisation of equipment)
  - shape (regular, irregular)
- Characteristics of existing pavement
- Recycling equipment
- Cement content
  - (cost, output)

COST SPLITTING

5 to 15% less expensive than overlay or reconstruction

QUALITY CONTROL

- Controls during construction
- Controls after construction
CEMENT RECYCLING vs OVERLAY

Factors to be considered

- Total costs of construction
- Expected results from recycled material
  (strength ...)
- Final quality of new pavement
  (adequacy to present and future traffic)
- Availability of local materials
- Bridge clearance, side accesses ...

SUMMARY

- Cement recycled pavements:
  - less homogeneous than new ones
  - much homogeneous than existing ones
    needing to be rehabilitated
- Economical and reliable option
- Extensive experience in many countries

SUMMARY

- Satisfactory results if
  - recycled thickness 20 - 35 cm
  - distresses: from pavement
    not from subgrade
  - target compressive strength > 2.5 MPa
- Cement recycled materials similar to
  soilcement or cement treated bases
  (used for all traffic classes)

SUMMARY

- All types of cement can be used
- Existing bituminous materials can be
  recycled with cement
  (< 1/3 of total treated thickness)
- Precracking (joints) always advisable
  When really necessary?
- Specifications and/or design methods
  available in several countries
CONCLUSION

In situ recycling with cement should always be considered for the rehabilitation of fatigued pavements.