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## **GUIDELINE ON IN SITU RECYCLING WITH CEMENT**

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## **GUIDELINE ON IN SITU RECYCLING WITH CEMENT**

- *Working group*

*Australia  
France  
Spain*

*Austria  
Germany  
United Kingdom*

*Belgium  
Greece*

- *Contributions*

*Canada  
South Africa*

*Czech Republic  
Switzerland*

*Japan  
USA*

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## **GUIDELINE ON IN SITU RECYCLING WITH CEMENT**

- *Introduction*
- *Preliminary studies*
- *Properties of cement bound recycled materials*
- *Mix design*
- *Thickness design*
- *Machinery for recycling*
- *Execution of the work*
- *Quality control*
- *Cost analysis*



## **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*



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## 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*

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## 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 (ruts)*
- *Shrinkage cracking → joints (precracking)*

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## 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*



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## IN SITU RECYCLING WITH CEMENT

### *The Spanish experience*

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

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## 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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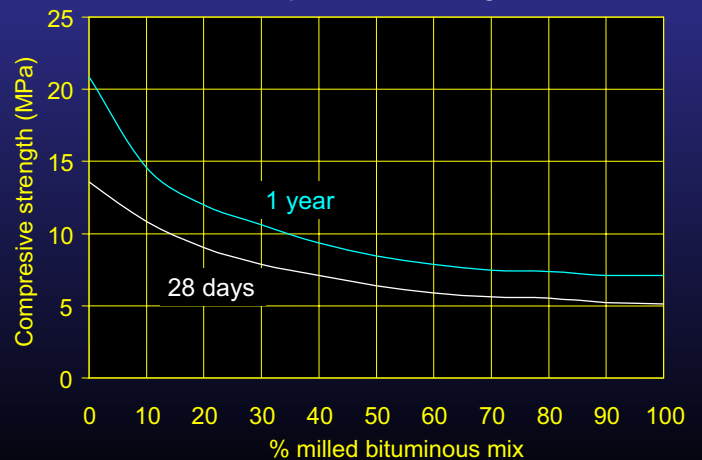
## CEMENT RECYCLED MATERIALS Strength

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

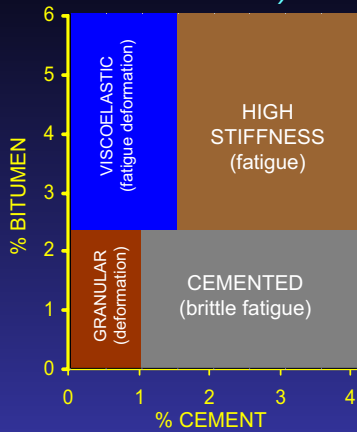


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### Influence of content of milled bituminous mix on compressive strength



## COMBINED RECYCLING (CEMENT - EMULSION)



## MIX DESIGN

- Similar to other cement treated materials
  - water content by moisture – 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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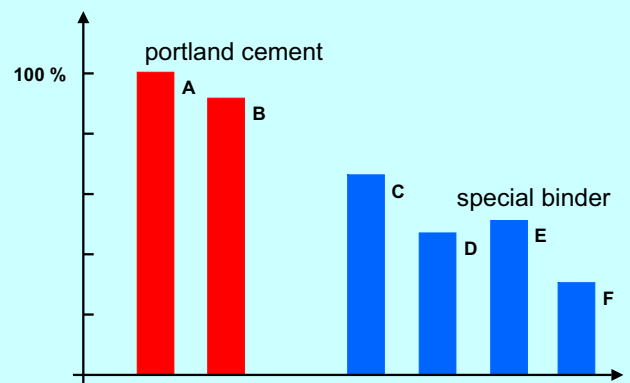
## CEMENTS

- 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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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)



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## THICKNESS DESIGN

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



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## 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



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## 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 ...)



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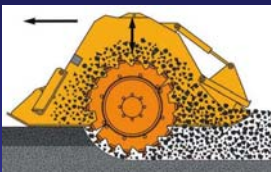
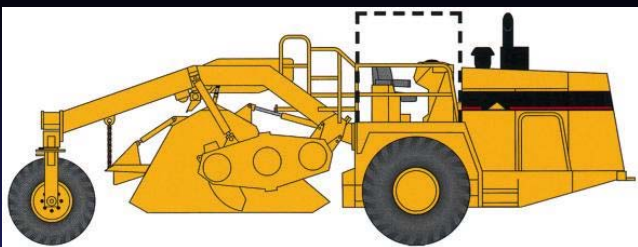


## RECYCLERS

- 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



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## 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)



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## 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



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## 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)*



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## 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*



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## 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*



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## QUALITY CONTROL

- Controls during construction
- Controls after construction



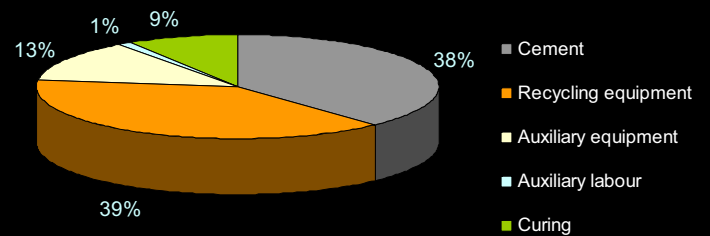
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## FACTORS INFLUENCING COSTS

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

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## COST SPLITTING



5 to 15% less expensive than overlay or reconstruction

## **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 ...*

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## **SUMMARY**

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

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## **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)*

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## **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*

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## ***CONCLUSION***

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