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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	*Austria*	*Belgium*
France	*Germany*	*Greece*
Spain	*United Kingdom*	

- *Contributions*

Canada	*Czech Republic*	*Japan*
South Africa	*Switzerland*	*USA*

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*

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)*

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*

MECHANICAL PROPERTIES OF CEMENT RECYCLED MATERIALS

- *Compressive strength*
- *Modulus of elasticity*

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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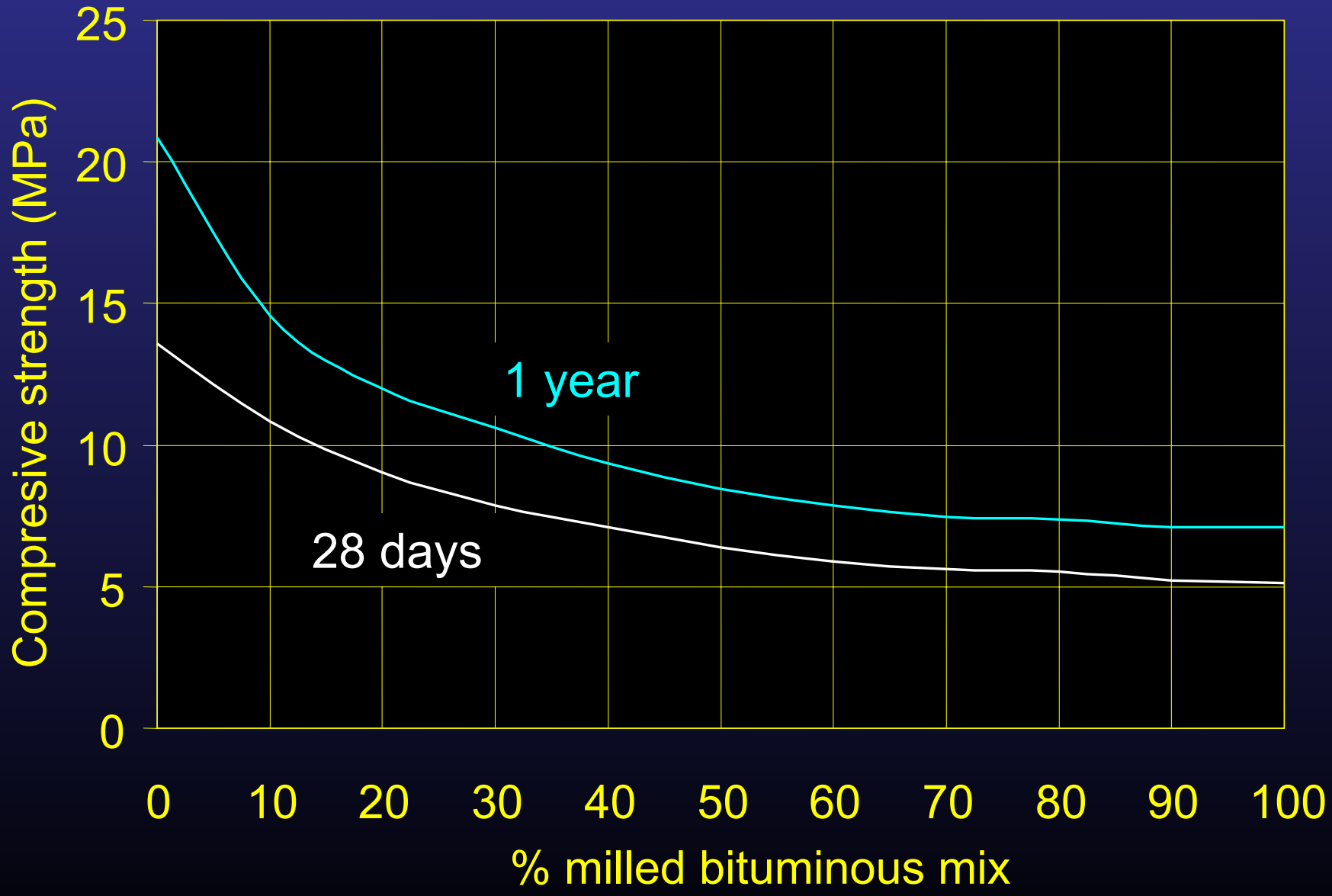
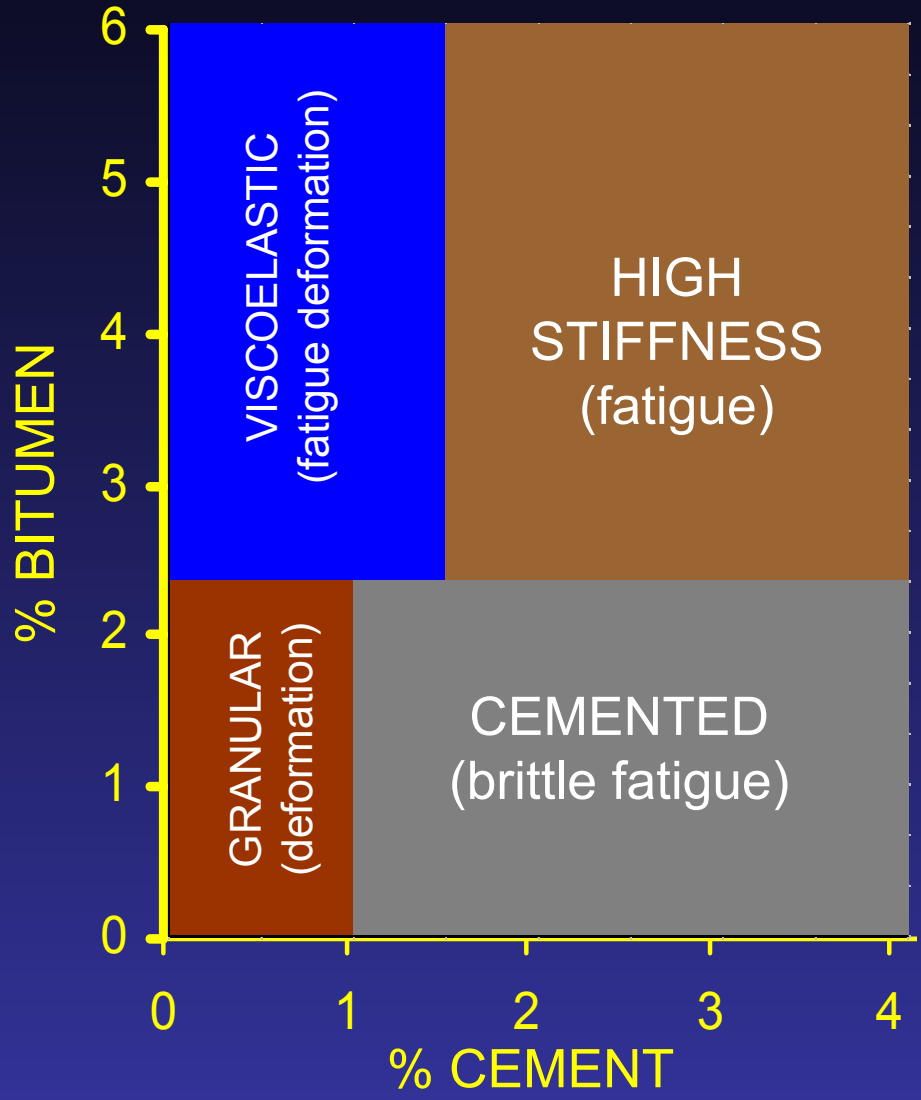
Influence of content of milled bituminous mix on compressive strength



COMBINED RECYCLING (CEMENT - EMULSION)



MIX DESIGN

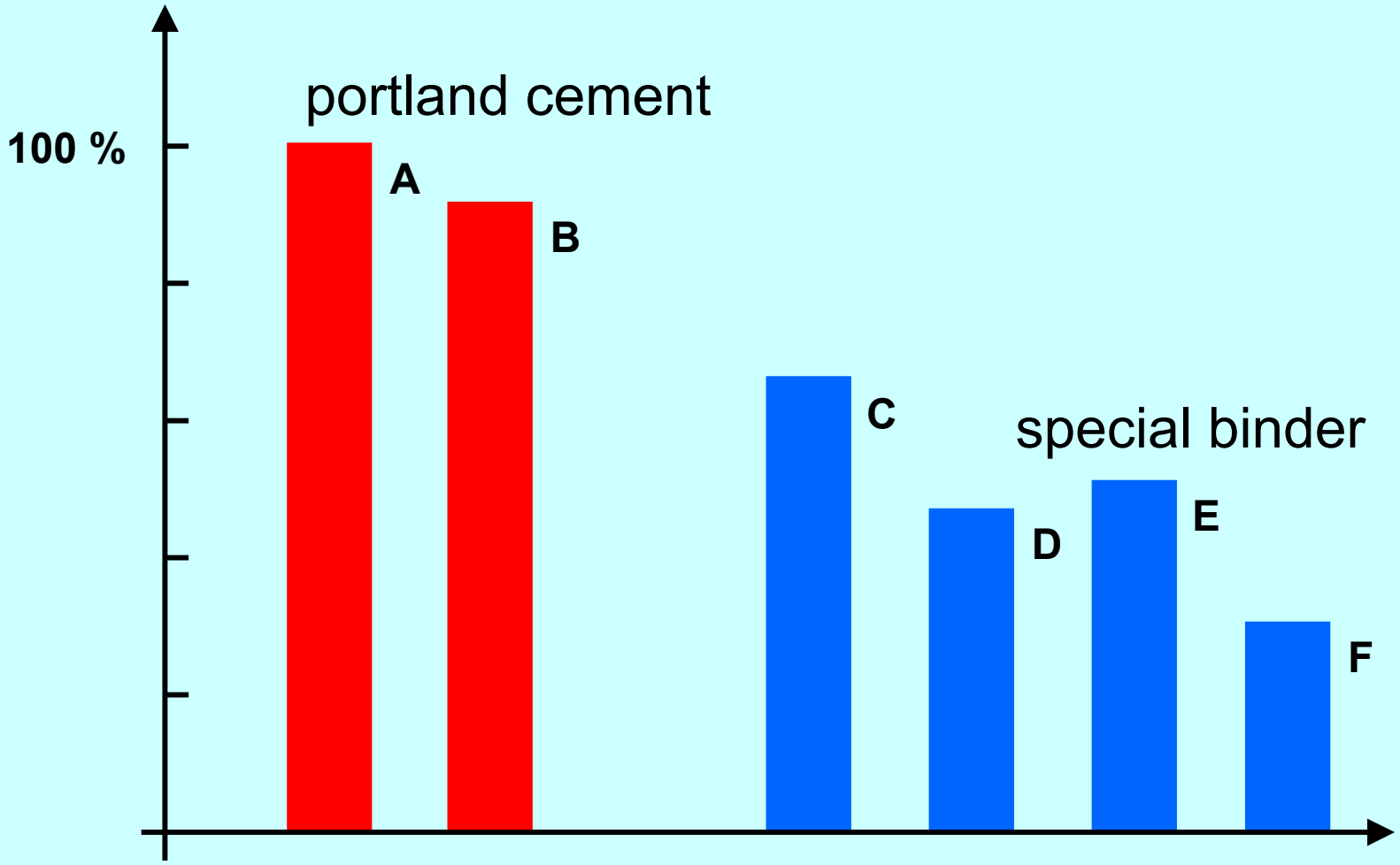
- *Similar to other cement treated materials*
  - *– water content by misture – density tests*
  - *– cement content by compressive strength*
- *Difficulties*
  - *– grading after milling*
  - *– properties dependent on recycled thickness*
- *Types of cement*
- *Workability time*

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)*

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 coeeficients (AASHTO)*
- *Catalogues of pavement sections (Spain)*
  Design curves (UK)

MACHINERY FOR RECYCLING

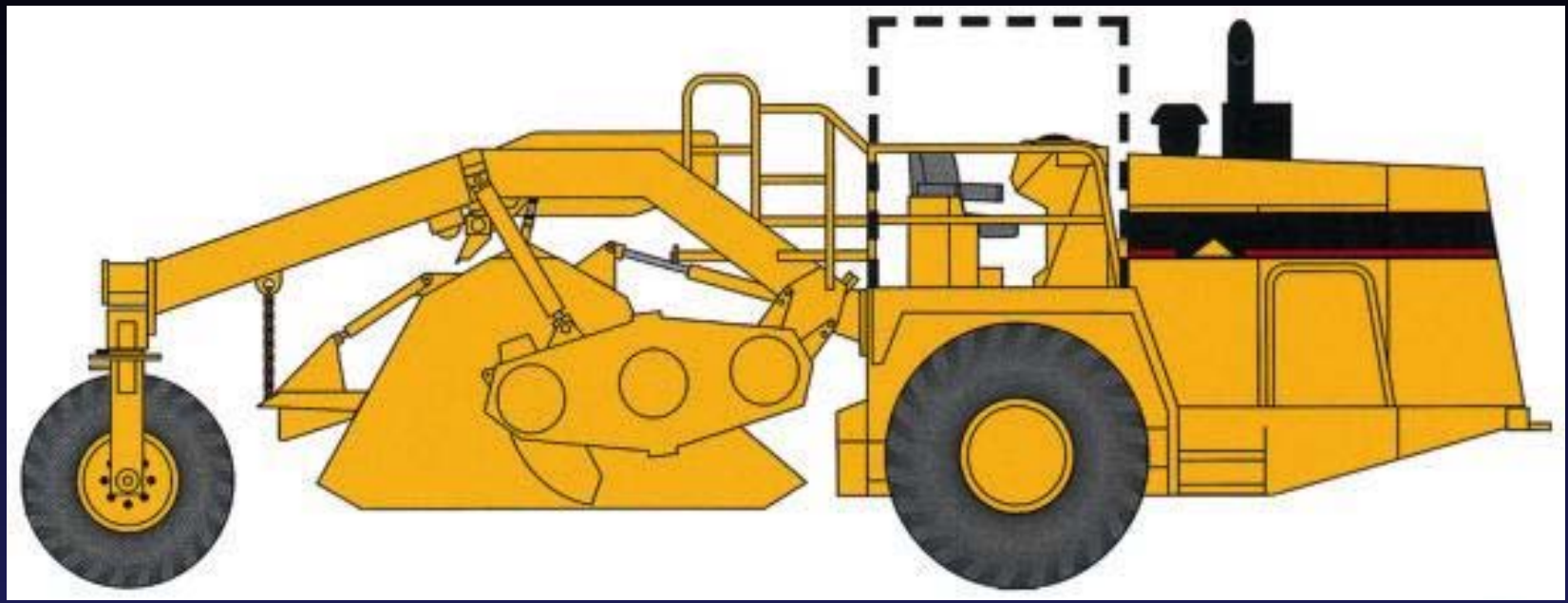
- *First phase: specific machines*
  - *cement distributors (powder, slurry)*
  - *recyclers (milling and/or mixing machines)*
- *Second phase: similar to other cement-treated layers*
  - *[equipment for precracking]*
  - *rollers*
  - *graders*
  - *emulsion tankers*

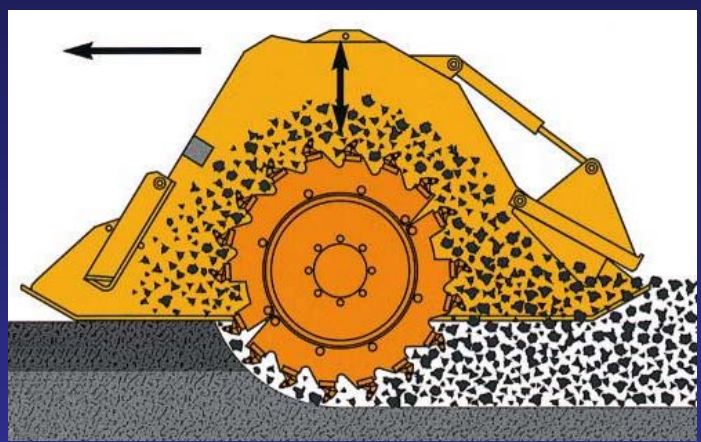
CEMENT SPREADERS

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

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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Wirtgen

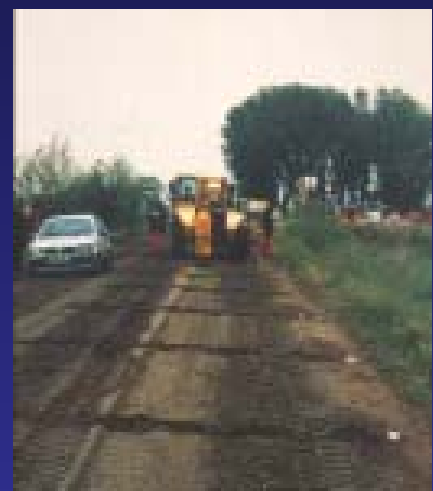

Iber Caldmix, S.A.


A.R.C. 700

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*


DYNAPAC


RUS

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)*


DYNAPAC

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*

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MONIFRA

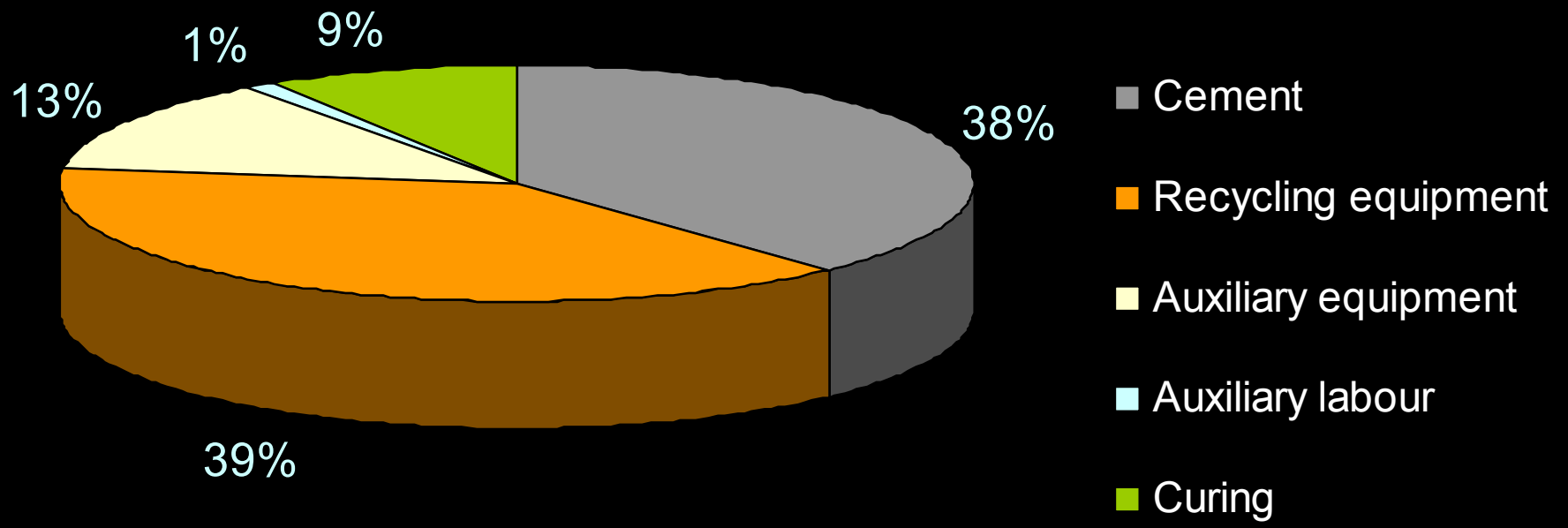
QUALITY CONTROL

- *Controls during construction*
- *Controls after construction*

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

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 homogeneou 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