Need for developing practical design guidelines for cold recycling
Input materials:

Possible mixes:

- Cement + water
- Emulsion + water
- Foamed bitumen + water
- Cement + emulsion + water
- Cement + foamed bitumen + water
Operating Principle
Strongly cemented
Greater flexibility
Greater resistance to deformation
Bituminous binder

6% Cement
4% Bituminous binder

Strongly cemented
Lightly cemented
Unbound Crushed stone/ gravel
Cemented Foam & Emul Mixes
Granular foamed mixes
Visco-elastic Foam & Emul Mixes
HMA

Less economical mixes
Brittle crack
Fatigue
Deform
Greater flexibility
Greater resistance to deformation
Thoughts on binder selection

- Various design schools.
- Lack of exhaustive research.
- Must be a technical choice; no room for market trends or commercial inputs.
- Which is the best binder? Possibly a wrong question. Binders have different properties, cost, operative pros/cons.
- Choice should be made by designers on a case by case basis.
Examples of cold recycling in Italy (1996-2006)

**AUTOSTRADA BO/BA**
- Rimini Nord - Rimini Sud
- Cesena - Forlì
- Pescara - Vasto

**AUTOSTRADA MI/BO**
- Modena Sud - BO
- Parma - Reggio Emilia
- Piacenza - Parma

**AUTOSTRADA MI/NA**
- Valmontone - Frosinone
- Bettole - Chiusi
- Fabbro - Orte
- Bettole - Montesansavino
- Montesansavino - Chianciano

- ANAS - TRANSPOLESANA (VR-RO strada quattro corsie per circa 4/5 Km.) -schiumato
- ANAS - Foligno-Macerata, (emulsione)
- Tangenziale di San Donà di Piave (schiumato)
- ANAS (SGC) E 45 (Orte-Ravenna) (emulsione polim.)
- Bettole-Siena (schiumato – base)
Cold recycling on SGC FI-PI-LI – May 2006
Typical cross section

22 cm

35 cm

HMA

granular material

subgrade
Cold recycling with foamed bitumen on SGC FI-PI-LI

(600 m – slow lane)
<table>
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<tr>
<th>Progressiva - km</th>
<th>Evd (Mpa)</th>
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<tbody>
<tr>
<td>0</td>
<td>63,300</td>
</tr>
<tr>
<td>50</td>
<td>63,400</td>
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<tr>
<td>450</td>
<td>64,200</td>
</tr>
<tr>
<td>500</td>
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**LFWD test**

**Lineare (Evd 4 h)**

**Lineare (Evd 24 h)**

**Lineare (Evd 48 h)**
INTERSTATE 80 - California

TRAFFIC: 100,000 vpd – 20% heavy
(50 x 10^6 ESAL design)
“5 year” solution 1: Recycle with bitumen emulsion

25mm UTFC

50mm HMA overlay

Recycle 150mm with 2% bitumen emulsion
“5 year” solution 2: Recycle with foamed bitumen

<table>
<thead>
<tr>
<th>Early trafficking</th>
<th>Lower risk</th>
<th>Economics</th>
</tr>
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- 25mm UTFC
- 50mm HMA overlay
- Recycle 100mm with 2.3% foamed bitumen
The Athens – Corinth Project

(+100 x 10^6 Equivalent Standard 80kN Axle Loads)