The agenda

- Introduction
  - What are “Emulsion Based Cold Mix Paving Systems?"
  - What are they not?

- Gravel-Emulsion
- Cold Bituminous Concrete
- Innovations or not?

- Conclusions
Emulsion Based Cold mix Paving Systems

- They are not cold mix patching
  - No cut-backs any more
  - Emulsion based mixes
    - Manufactured in cold mix plant
    - Applied with grader or paver
    - 1M t in France
    - RO, IRL, UK,…

- THE ULTIMATE WMA!!
Why cold bituminous concrete?:

- Road history
- Needs of our customers for low traffic roads
  - Reprofile needs
- Knowledge of asphalt emulsion
- Function of HMA plants network
Emulsion Based Cold mix Paving Systems

In the 70’s:

- “Grave Emulsion” = Gravel emulsion
- Base coarse
- Use of local aggregates
- Use of Asphalt Emulsion
- 0/14 or 0/20 mm
In the 70’s:
- “Grave Emulsion” = Gravel emulsion
- Use for local roads
- Reprofiling before surface treatments
  - chip seals
  - From 0 to 120mm
  - $f(size)$
Emulsion Based Cold mix Paving Systems

Why cold bituminous concrete?:

- Cold mix plant:
  - Easy to move
  - 5-6000t (European approach)
  - Location in local quarries
  - Use of local aggregates
Why cold bituminous concrete?:

- Cold mix plant:
  - Easy to move
  - 5-6000t (European approach)
  - Location in local quarries
  - Use of local aggregates
Emulsion Based Cold mix Paving Systems

- Main uses for local roads
  - 4.5 % asphalt emulsion
  - 3% water
  - Monitoring
  - Strong contact aggregates
    - 15% Air voids
    - No rutting
Emulsion Based Cold mix Paving Systems

- Asphalt emulsion
  - Monitoring of the breaking
  - CRS 2P for chip seals
  - CSS for cold mix
    - Slow breaking
    - Mixing at the plant; transport on site
    - And laying
    - The emulsion should break after compaction ....
t = 2 min
$t = 5 \text{ min}$
$t = 5 \text{ min}$
Emulsion Based Cold mix Paving Systems

- Base layer ok
- Next step:
  - Full cold mix structure
  - Gravel Emulsion
  - Wearing course
    - Different approach
    - Fully coated
    - Traffic resistance
Emulsion Based Cold mix Paving Systems

Formulation

- No real method
- Not a behavior of an HMA

- COLAS set up one…
SPECIFIC BEHAVIOUR FEATURES
Cohesion versus workability

Cohesion build-up

<table>
<thead>
<tr>
<th>Cohesion build-up</th>
<th>Workability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow</td>
<td>Difficult</td>
</tr>
<tr>
<td>Medium</td>
<td>Fair</td>
</tr>
<tr>
<td>Fast</td>
<td>Easy</td>
</tr>
</tbody>
</table>

- Smoothness pb.
- Compaction pb.
- Smoothness?
- Compaction?
- Favourable Case.
- Acceptable.
- Suitable.
- Unfavourable (and unlikely) case.
- Early traffic resistance pb.
- Early traffic resistance pb.
VOIDS SIZE DISTRIBUTION

Hot mix
330 voids on unit area

0/10 mm diorite
4.8% of 70/100
Air voids ~ 15%

Cold mix
7,200 voids on same unit area
VOIDS SIZE DISTRIBUTION
Effects of compaction

Grave-emulsion
0/14 mm diorite
4.0% of 70/100
Moderately compacted (air voids 21.7%)

The same
after 100,000 passages
of wheel @ 40°C
(air voids 14.4%)
Tiny voids in cold mix result from globule coalescence, are included within the coating mastic.

These features explain the lower densities of freshly compacted cold mix, as compared with “equivalent” hot mix.

Cold mix density (or compaction degree) increases slowly under the prolonged action of curing and consolidation under traffic.
NEED FOR A SPECIFIC DESIGN METHOD

- Empirical approach prevailing so far.
- Existing tests derived from hot mix design, do not reflect in-place behaviour of cold mixes.
- Curing issue not fully addressed.
FLOW CHART OF PROPOSED DESIGN METHOD

Preliminary

Aggregate

Water

NO

Mixing trials
- appearance
- workability
- etc.

NO

Adjust moisture content

YES

Emulsion

Modify emulsion formula

Modify emulsion formula

Mixing trials
- appearance
- workability
- etc.
FLOW CHART OF PROPOSED DESIGN METHOD

Design steps

Manufacture

Coating, stripping, early cohesion

Compactability

Accelerated Curing

Modified Duriez 20 kN or 40 kN fresh mature

Rutting Cured state

Stiffness moduli Cured state
MIX MANUFACTURE
COATING QUALITY
IMAGE ANALYSIS
HANDLING
Susceptibility to mechanical stripping
RESISTANCE TO IMMEDIATE TRAFFICKING (fretting test)
Gyratory Shear Compactors
COMPACTABILITY OF COLD MIXES

PCG 0.9 MPa - 3° - 6 tr/mn

- Number of gyrations
- Compaction degree (%)

Beginning of water expulsion
End

K1
K2
K3
FIELD COMPACTION
ACCELERATED CURING

Procedures evaluated

5°C - 50% Relative Humidity  performances do not take off

18°C - 50% Relative Humidity  moderate increase

35°C - 20% Relative Humidity  marked increase*

50°C - 15% Relative Humidity  rapid increase, but some specimens affected by cracking

*brings the material to a mature state, corresponding approximately to 2 - 3 years of service in situ.
ACCELERATED CURING

Procedure selected: 14 days - 35°C - 20% Relative Humidity

- Water expulsion is relatively rapid.
- Ring & Ball softening point of usual bitumens is not exceeded (min. R & B of 160/220 = 35°C).
- No specimen cracking is induced.
- This procedure does not cause any significant ageing of bitumen.
- 35°C is a realistic in situ summer temperature in pavements.

Nota: This applies to temperate regions. Other climatic conditions may require other curing procedures.
COMPRESSIVE STRENGTH AND SENSITIVITY TO WATER

- Standard Duriez: produces too high densities,
  does not differentiate varied mixes.

▲ Adapted Duriez (load reduced to 20 or 40 kN): strength (18°C)

- Procedure 18 (fresh state)
  . One series 14 days - 18°C - 50% RH
  . One series 7 days 18°C - 50%
    + 7 days immersion 18°C

- Procedure 35 (mature state)
  . One series 14 days - 35°C - 20% RH
  . One series 14 days - 35°C - 20% RH
    + 7 days immersion 18°C

- Water sensitivity
  fresh rf/Rf
  mature rm/Rm
RESISTANCE TO RUTTING
WHEEL-TRACKING TESTS PROCEDURE

- Rutting slab manufactured at ambient temperature.
- Postcompaction after 24 hours.
- Curing: 14 days - 35°C - 20% RH.
- Wheel-tracking test conducted at 60°C.
TWO EXAMPLES OF WHEEL-TRACKING TESTS

![Graph showing compaction degree (%) vs. number of gyrations for M3 and GE samples.](image-url)
STIFFNESS MODULUS
CONCLUSION

The proposed method aims at being:

- as comprehensive as possible,
- relatively simple,
- well connected to field practice.

It should help:

- improve our knowledge,
- develop new products,
- support arguments in favour of emulsion cold mixes...

... the mixes of the future.
Emulsion Based Cold mix Paving Systems

Full range of products

- **Gravel Emulsion**
  - 0 / 10 mm to 0 / 31.5 mm
  - Reprofiling, Utility trench fill,
  - Residual AC: 3.0 to 3.6%

- **Structuring Gravel Emulsion**
  - 0/10 to 0/14 mm
  - 100-120mm
  - Residual AC: 3.6 to 4.2%

- **Wearing cold bituminous concrete**
  - 0/10 to 0/14mm
  - 35 to 80mm
Sustainable development:
« development that meets the needs of the present without compromising the ability of future generations to meet their own needs »
Mrs Harlem Brundtland
United Nations report - 1987