# Durability and Carbon Footprint

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# Carbon – I’m doing my bit!

# Durability and Carbon Footprint

**Exciting Stuff!**

**Please leave quietly**

**Others may be asleep!**

# Durability, Sustainability and Carbon Footprint

- What does durability have to do with carbon footprint?



# Calculation of Embodied Carbon

- Constituent production
- Constituent transport
- Heating and drying
- Mixing
- Delivery transport



# CO2 CALCULATOR for ASPHALT

Plant: **Loanhead Asphalt Plant**

Mix Type: **AC 6 DENSE SURF 160/220 H/S**

AC 6 DENSE SURF 160/220 H/S
AC 32 DENSE BASE 100/150 REC
HRA 30/14 F SURF 40/60 REC 1A H/S

| Constituents Used | Source | kg/tonne | Total $CO_2$ for the mix ($kg\ CO_2$/tonne) |
|---|---|---|---|
| 32mm | 0 | 0 | 0.00 |
| 20mm | 0 | 0 | 0.00 |
| 14mm | 0 | 0 | 0.00 |
| 10mm | 0 | 0 | 0.00 |
| 6mm | Ravelrig | 452 | 1.44 |
| CFA | Ravelrig | 453 | 1.45 |
| Sand | 0 | 0 | 0.00 |
| Reclaim Filler | Loanhead Asphalt Plant | 30 | 0.07 |
| Limestone Filler | 0 | 0 | 0.00 |
| 40/60 Pen Bitumen | 0 | 0 | 0.00 |
| 160/220 Pen Bitumen | Nynas Dundee | 65 | 17.24 |

| | | | |
|---|---|---|---|
| Carbon Emissions for | Loanhead Asphalt Plant - Mixing | | 3.98 |
| Average Carbon Emissions for | Loanhead Asphalt Plant - Heating | | 30.92 |
| Adjustment for Mix Type | Base / Binder | 0.80 | |
| Adjustment for Dryer Temperature | 180 | 0.86 | |
| Specific Carbon Emissions for | Loanhead Asphalt Plant - Heating | | 21.27 |

**Total kg $CO_2$ for 1 tonne asphalt (Ex Works)** **45.46**

Transport to Site

| Distance (km) | Method of Transport | $CO_2$ / km / tonne | $CO_2$ for Journey (per tonne) |
|---|---|---|---|
| 60 | 8-wheeler | 0.05 | 2.83 |

**Total kg of $CO_2$ for 1 tonne asphalt (Delivered)** **48.29**

## *Asphalt Mixture $CO_2$ Production & Transport*

$CO_2$ multipliers – to allow for different mixture temperatures and throughput rates

Total of all $CO_2$ per tonne asphalt (ex Works)

CO2 for transport – depends on vehicle and distance travelled

Total of all $CO_2$ per tonne asphalt (Delivered)

# Embodied Carbon in Asphalt

| Component | $CO_2e$/tonne-asphalt |
|---|---|
| aggregate | 4 |
| binder | 18 |
| mixing | 4 |
| Heating and drying | 21 |
| delivery | 3 |
| **TOTAL** | 50 |

# Carbon in life cycle

- Carbon/year across the life cycle is more important than initial embodied carbon

# 2.5kg $CO_2$e/tonne-asphalt per annum

# 1.25kg $CO_2$e/tonne-asphalt per annum


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# Embodied Carbon in Asphalt

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# However

- Asphalt can be recycled as asphalt!

- All is not lost……

# 44% $CO_2e$ recovered on recycling

| Component | $CO_2e$/tonne-asphalt |
|---|---|
| Embodied carbon in aggregate and binder | 22 |
| ‘Energy’ carbon from mixing, heating, drying and transport | 28 |
| **Total** | **50** |

# 1.4kg $CO_2$e/tonne-asphalt per annum


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# 0.7kg $CO_2$e/tonne-asphalt per annum


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# Action to reduce asphalt carbon

- Design and build asphalt pavements to last as long as possible

- Make sure that asphalt materials are fully recyclable



# Asphalt - Durability and Sustainability

- Highways Agency/Quarry Products Association/Refined Bitumen Association Collaborative Research



# Collaborative Research at TRL

- 2002-5 Sustainability Indicators
  Evaluation of EME 2
- 2005-8 Durability
- 2008 - Sustainability/carbon footprint



# Current Collaborative Research

- Sustainability criteria
- Carbon Footprint declaration protocol (mix specific) mid 2009
- Responsible Sourcing criteria 2010
- Involves HA and CSS
- Working through TRL C4S



# Sustainability

- Reduce carbon
- Reduce primary content
- Reduce energy
- Increase recycling
- Improve durability



# Durability

- We have made durability and extending life a key ongoing theme in our research programmes



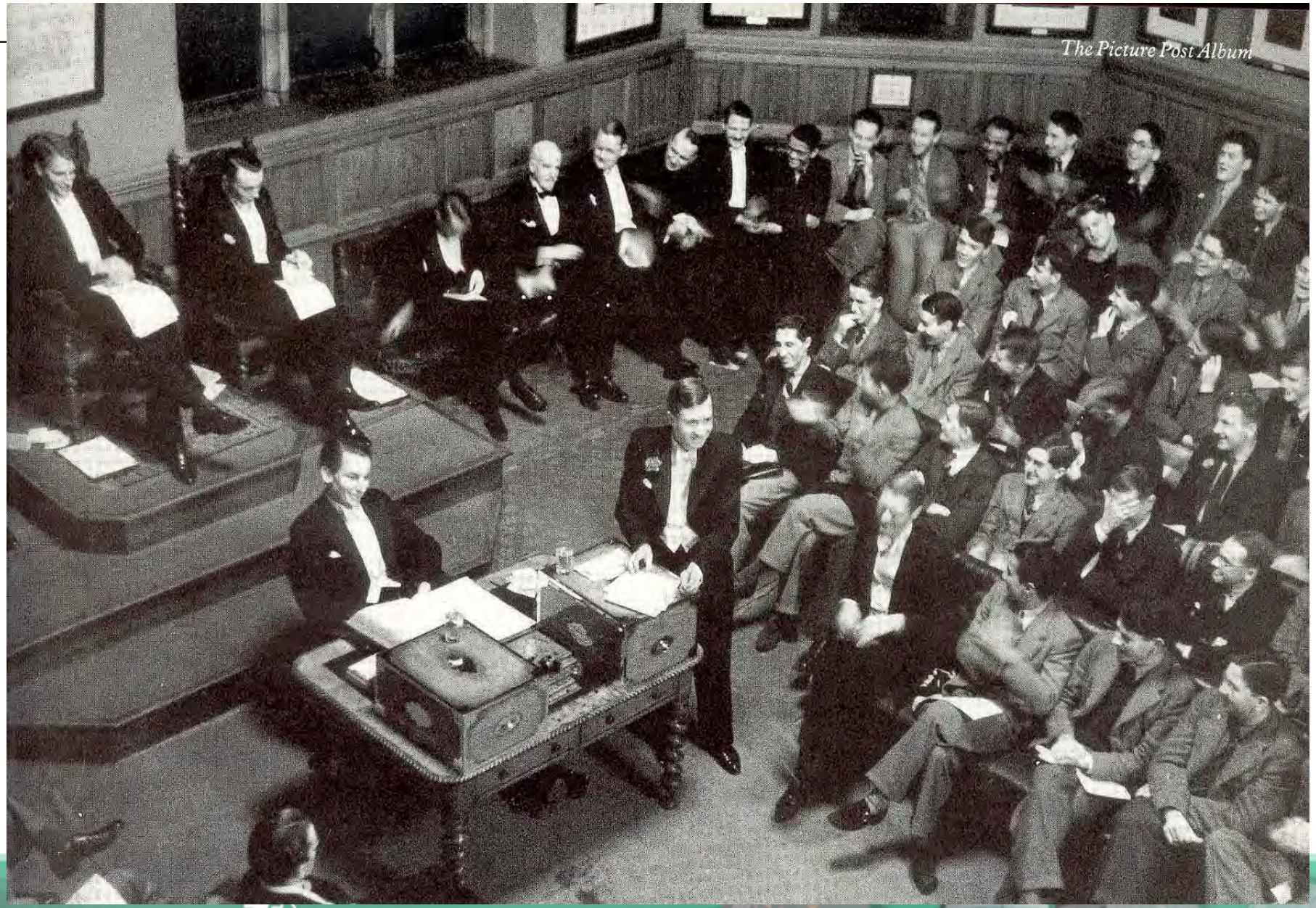
# Collaborative Research on Durability

- Best Practice Focus Group (BFG)

- Donna James (HA)
- Chris Southwell (RBA)
- Colin Loveday (QPA)
- David Williams (QPA)
- Cliff Nicholls (TRL)

# Typical BFG progress meeting…….

# Consulted all sides - Workshops



# Everyone had successes

# Everyone had failures

# General Conclusion

- Design too focused on stiffness/thickness
- The great Pascal Race!
- Construction detail overlooked
- Insufficient thought on drainage and drainage maintenance

# Broad agreement on the issues

- Water
- Bonding
- Joints
- Drainage
- Water
- Bonding
- Joints
- Drainage



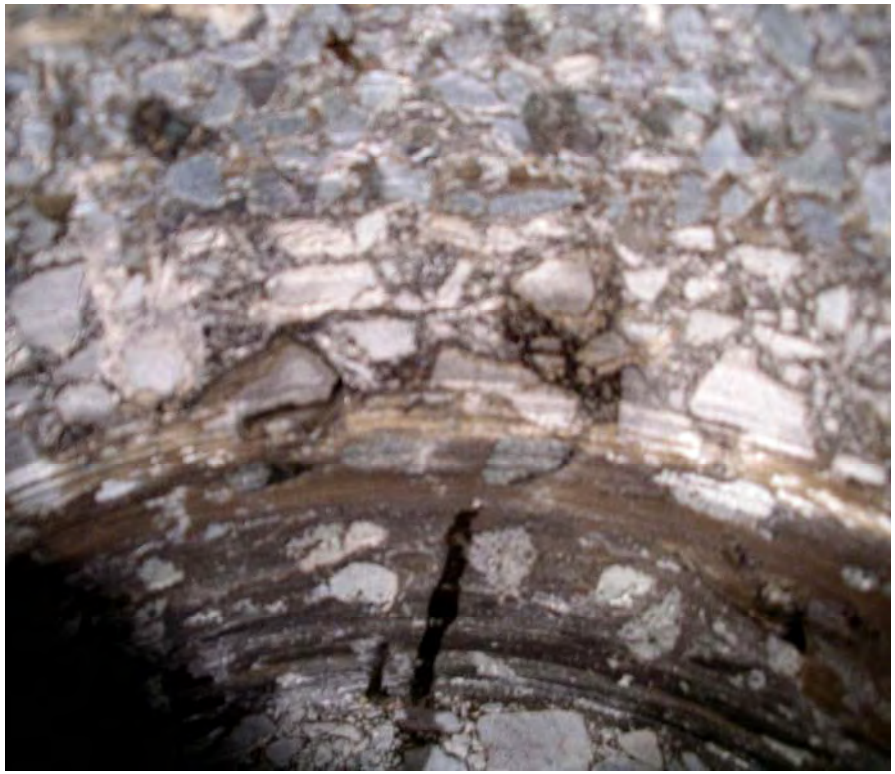
# Climate Change? Insidious change

An increase in water inside pavement structures

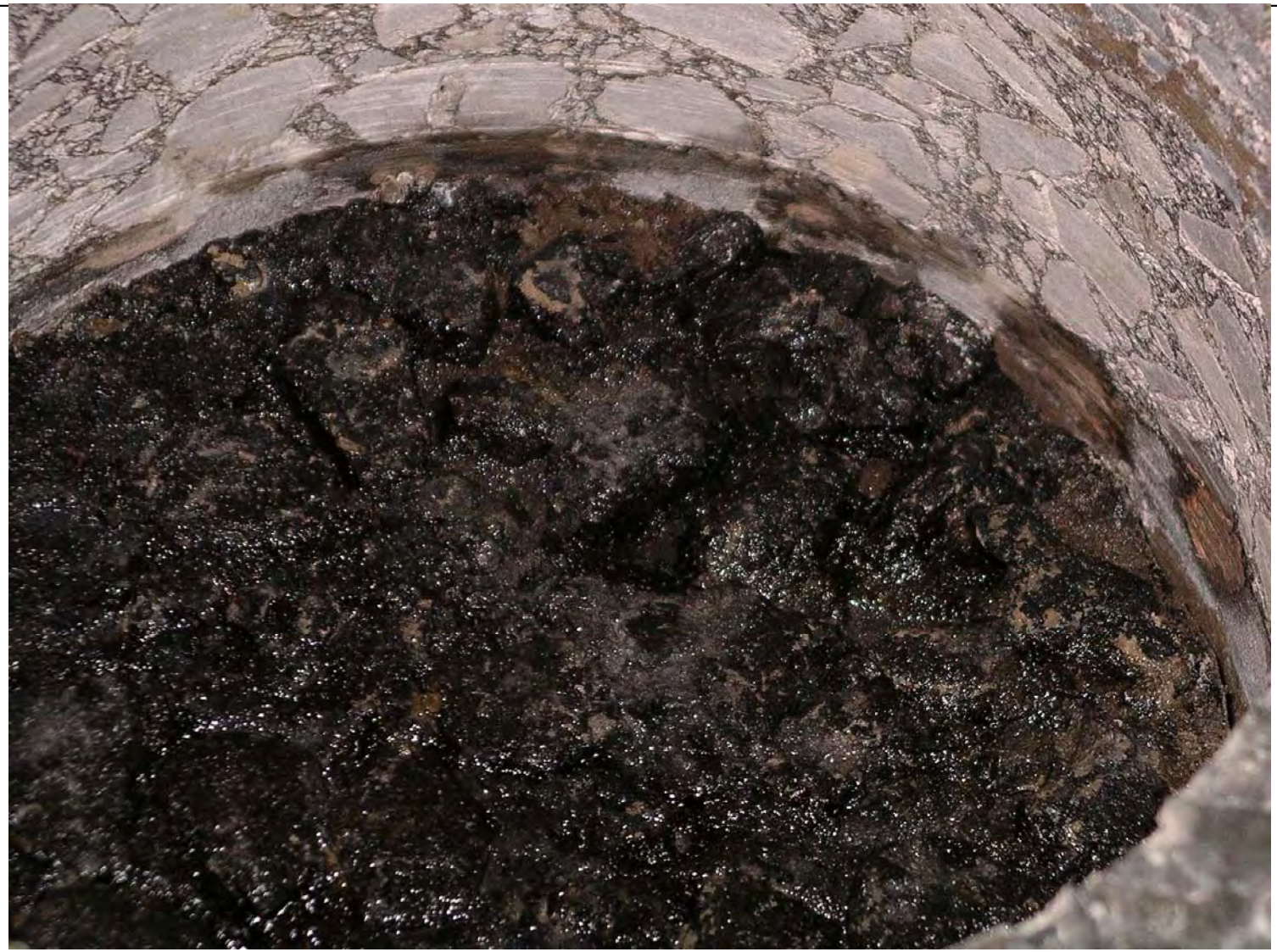
# Water moves within pavements

# Dry coring – motorway overlay

Bone dry on top – water flowing at interface

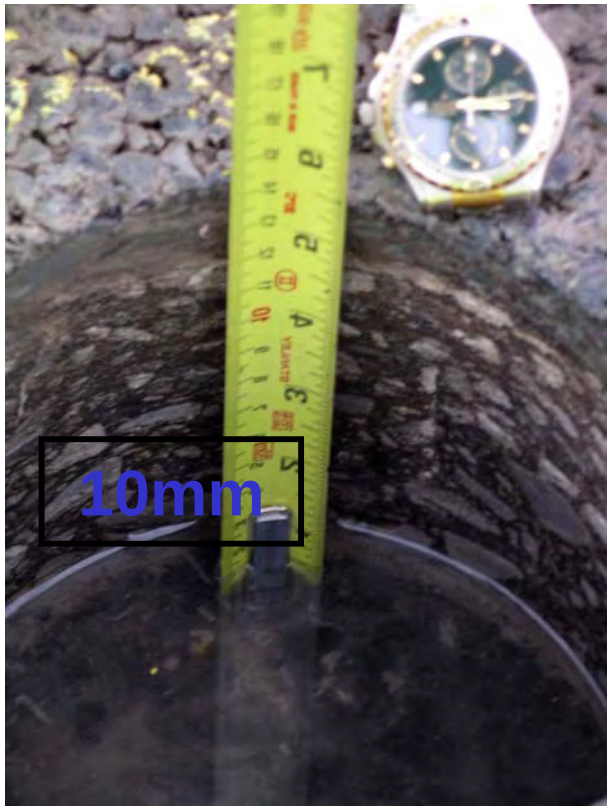



# Water flowing at interface



# Significant Water Flow

## Water flowing along unbonded interfaces






**3 Minutes** | **30 Minutes** | **60 Minutes**

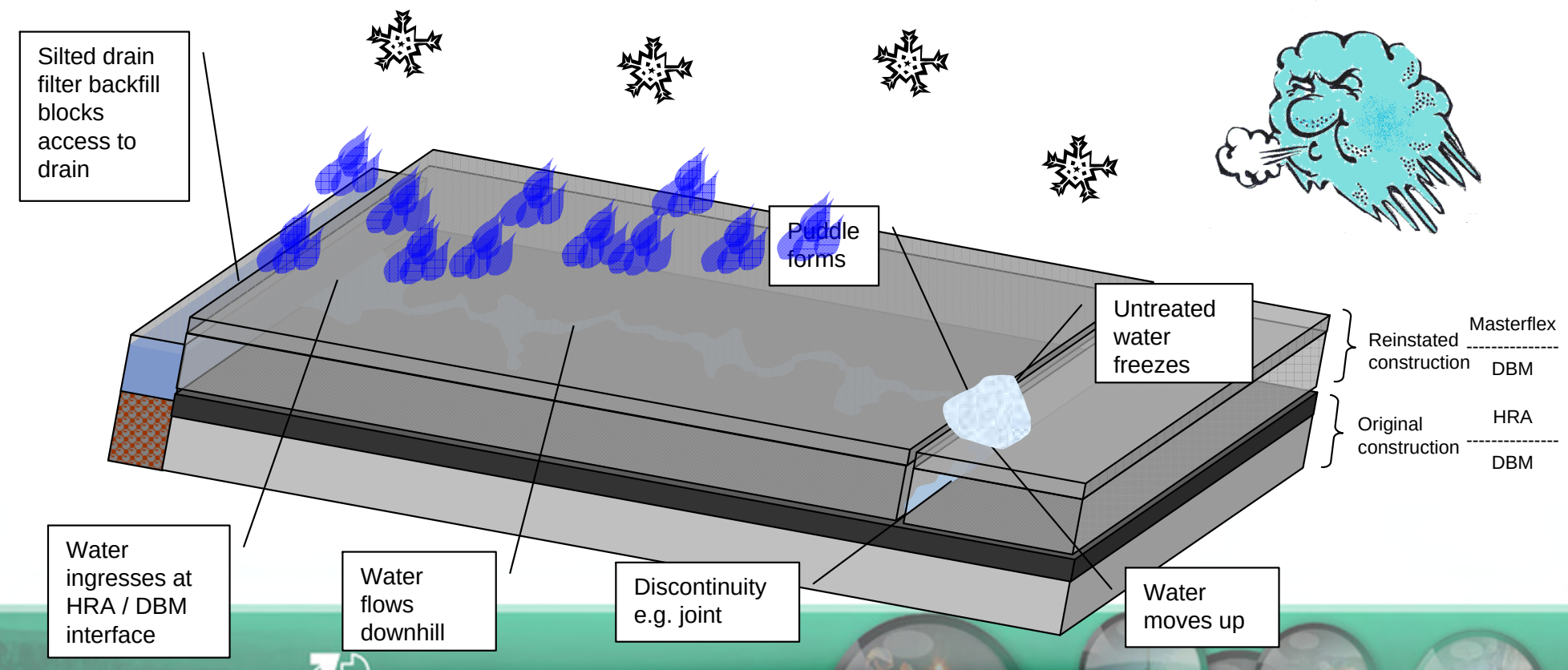
# Water enters from side

## Water the great enemy

Silted drainage

s

Unbonded layers


Silted drain filter backfill blocks access to drain
Puddle forms
Untreated water freezes
Reinstated construction
Masterflex
DBM
Original construction
HRA
DBM
Water ingresses at HRA / DBM interface
Water flows downhill
Discontinuity e.g. joint
Water moves up

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# Water erodes asphalt base under traffic

# Collaborative Research on Durability

- Revised all SHW 900 series laying requirements

- Published a Best Practice Guide – Road Note 42

# Changes to SHW 900 series

- Replaced negative clauses with positive clauses
- Greater emphasis on durability

# Enhanced SHW 900 requirements

- Bonding
- Joints
- Sealing

# Revised SHW 900 Series

- Completely new clause 903 for laying

# Recognises importance of bonding

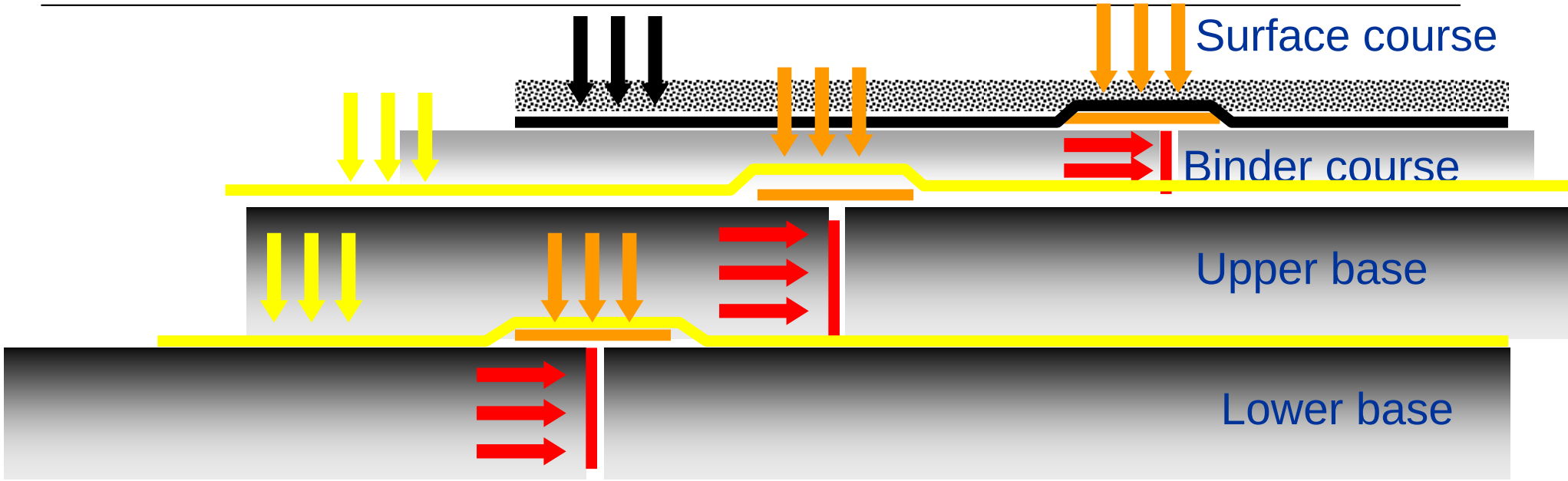
- Bonding every Interface
- Always required
- Better defined

# Joints always fail first

# Close attention to joints

- compaction and voids
- sealing
- overbanding

# Joint sealing summary




Faces of all cold upstanding edges treated (Cl. 903.22)

Sealant applied to top surface of base and binder course joints (Cl. 903.25)

Tack or bond coat (Cl. 920)

Tack or bond coat Specific to TSCS (Cl. 942)

# Even better - avoid joints where possible

- Echelon paving
- Thick base layers

# Road Note 42

- The answer to life, the universe and Everything…….

# Enhanced Laying Standards

- Modest cost increase
- Huge durability gain
- Not rocket science
- Will significantly reduce carbon footprint

# What are others doing?- Kompaktasphalt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# One paver – two screeds

- Paves two layers in one pass

- No interlayer joint

# Complex feed arrangements

- **Prodigous outputs**
- **Needs total possession**

# Seamless durable construction

- Where could we use this on our network?

# New Material – EME2

- 2001 Tarmac studies
- 2002-5 TRL
- 2005 TRL 636
- 2005 Scottish trials
- 2007 HA trials
- 2008 SHW 930

# Qu’est que c’est l’EME?

- Enrobe a Module Eleve
- ( French High Modulus Base)
- Small aggregates
- Hard Grade Binder
- High Binder Content

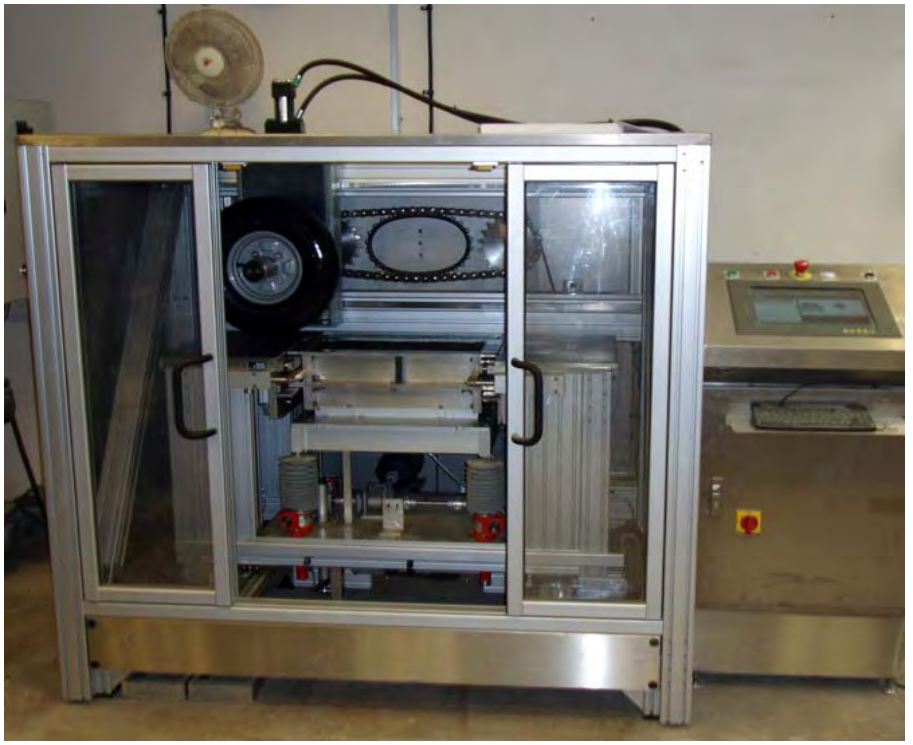


# Special Hard Grade Bitumens

- 10/20 Grade
- 15/25 Grade
- Not blown
- Can use polymer

# Industrial Scale Laboratory Mix Design

80kg batch mixers

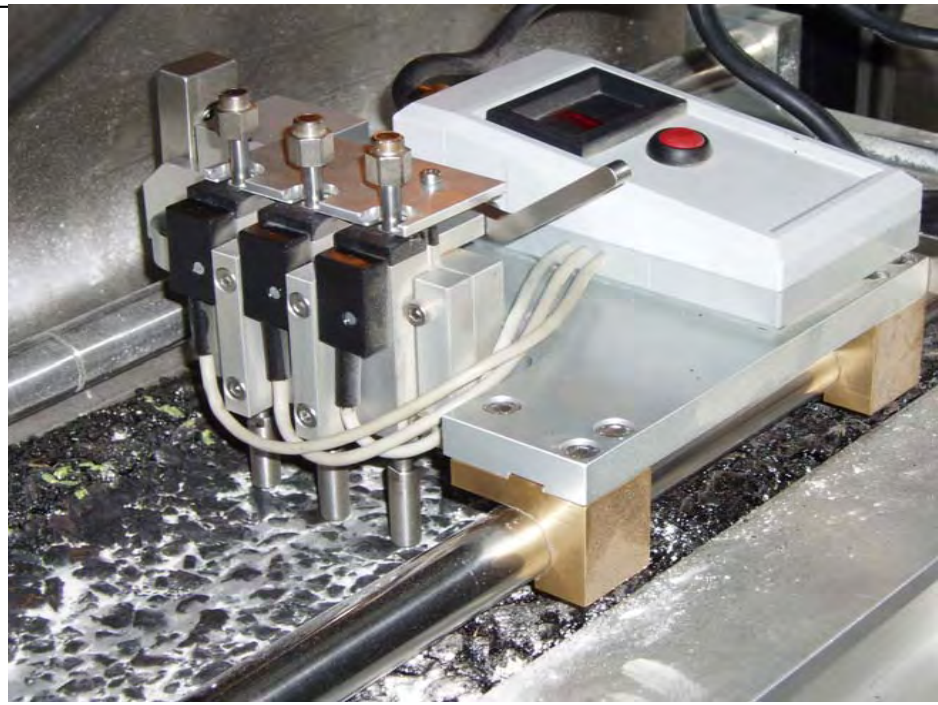
Programmable compactors

# Careful mechanical/volumetric design

- Aggregate packing
- Compactability
- Voids
- Richness Modulus

# Extreme Deformation Resistance

## Large Wheel Tracker



Tested at 60 deg C

# Pourquoi l'EME?

- Durability
- Deformation resistance
- Flexibility
- Structural stiffness

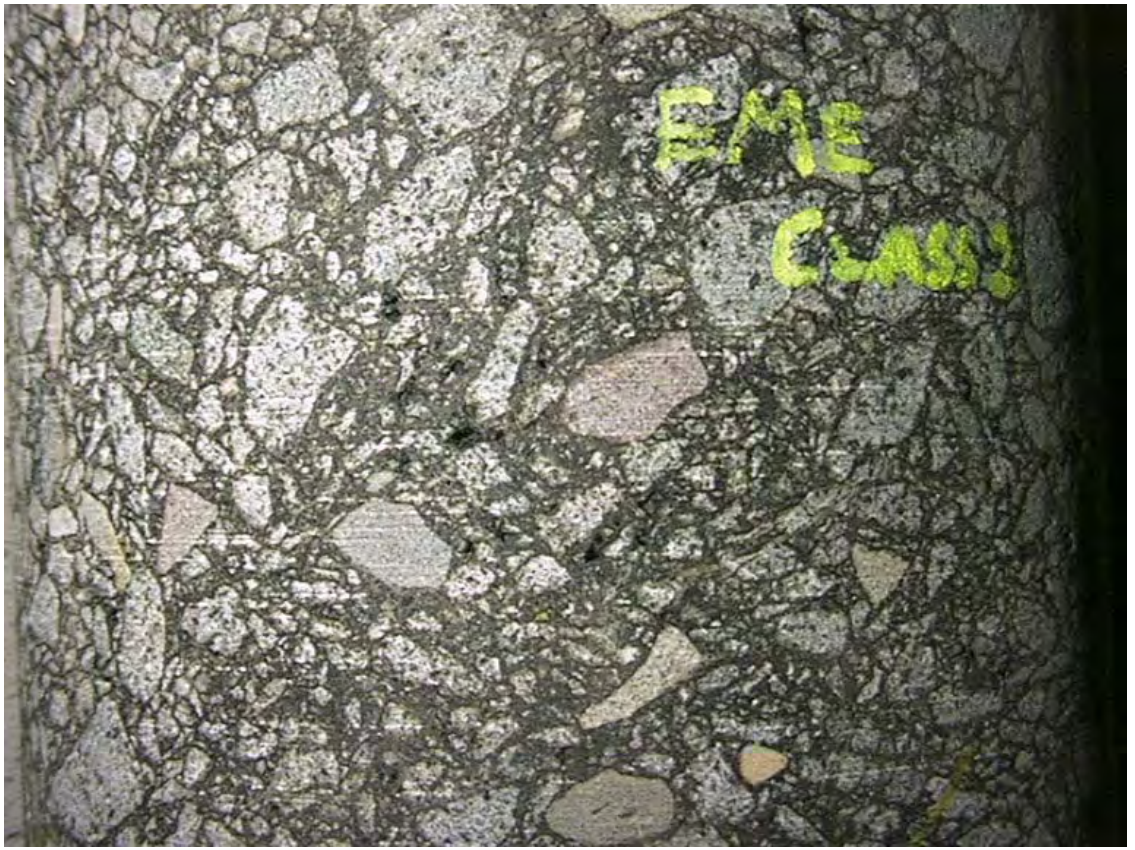


# Pourquoi l'EME2

- Because they tried l'EME1 with a lower binder content
- And it was not durable
- Déjà vu……!!!!!!!!!!!!!!!!!!!!!!!!!!!!

# Why is EME2 better than HMB?

- More deformation resistant
- 30% more bitumen
- More durable
- Stiffer
- Better in fatigue
- More compactable
- Less prone to segregation



# M876 Trial – Stirling 2005

- Total carriageway length 3.4km
- EME trial length 1km
- DBM50 ‘control’ lengths 1.7km and 0.7km.

# M876 Laying 0/20mm EME Class 2

# Lessons from laying

- Thick layers are practical
- Compaction easier than HMB
- Thick layer compacted right through
- PTRs not required

# EME and Pavement Durability

- Binder rich
- Impervious
- Compactability
- Sticky and bonds well
- Eliminates segregation
- Consistent mechanical properties



# 2007 onwards mainstream use

## A90/M9 widening and Forth Bridge Spur

# M69 May 2008

- EME2 Base and Binder Course
- Full contraflow
- Three pavers in echelon
- Joint free

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# Works, materials and construction designed for Durability

# Result – seamless, impermeable, bonded, durable

# Conclusions

- Water is the great enemy
- Assume it will be there
- Lay as thick as possible
- Lay as wide as possible
- Bond and seal and seal and bond
- Embrace EME2
- Don’t compromise recyclability
- Maintain your drainage
- Embrace the new SHW 900
- Embrace RN42
- Plan works properly

- Sleep soundly!

# Watchpoints for carbon reduction

- Design and build for long life
- Cheap is not carbon cheerful
- Build in recyclability
- Attend to detail in construction



# 2.5kg $CO_2$e/tonne-asphalt per annum

# 0.7kg $CO_2$e/tonne-asphalt per annum


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# Afterthought from the Dubliners

- Well we laid it in the hollows and we laid it on the flat,
- And if it doesn't last forever well I'm sure I'll eat my hat,
- I've travelled all around the world and sure I've never felt,
- Any surface with a better carbon footprint than the hot asphalt!

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