Roller Compacted Concrete

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27th February 2013

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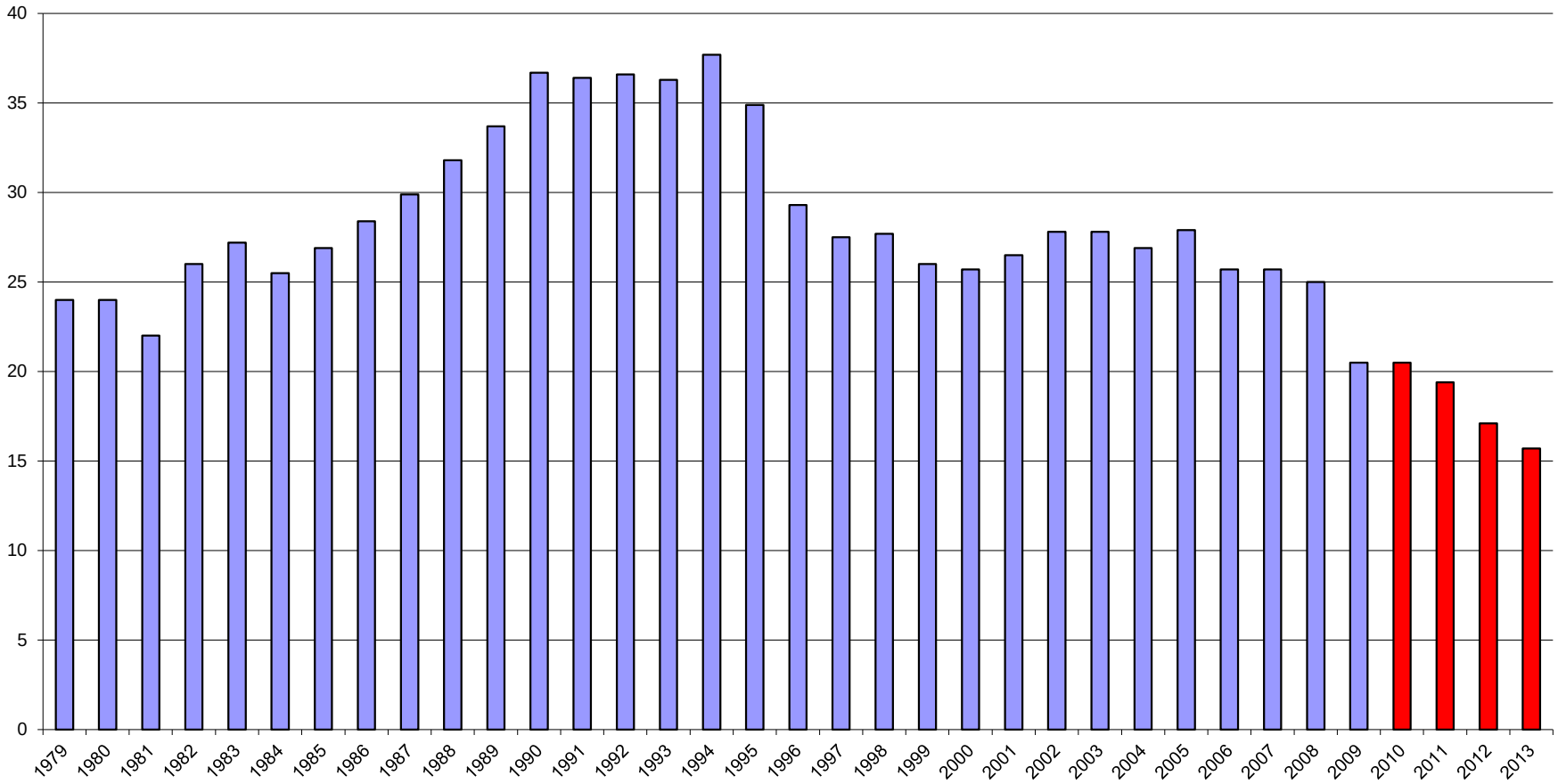
Background

The use of asphalt in infrastructure is often deemed to be the only option to fulfil the requirements of modern day contracts

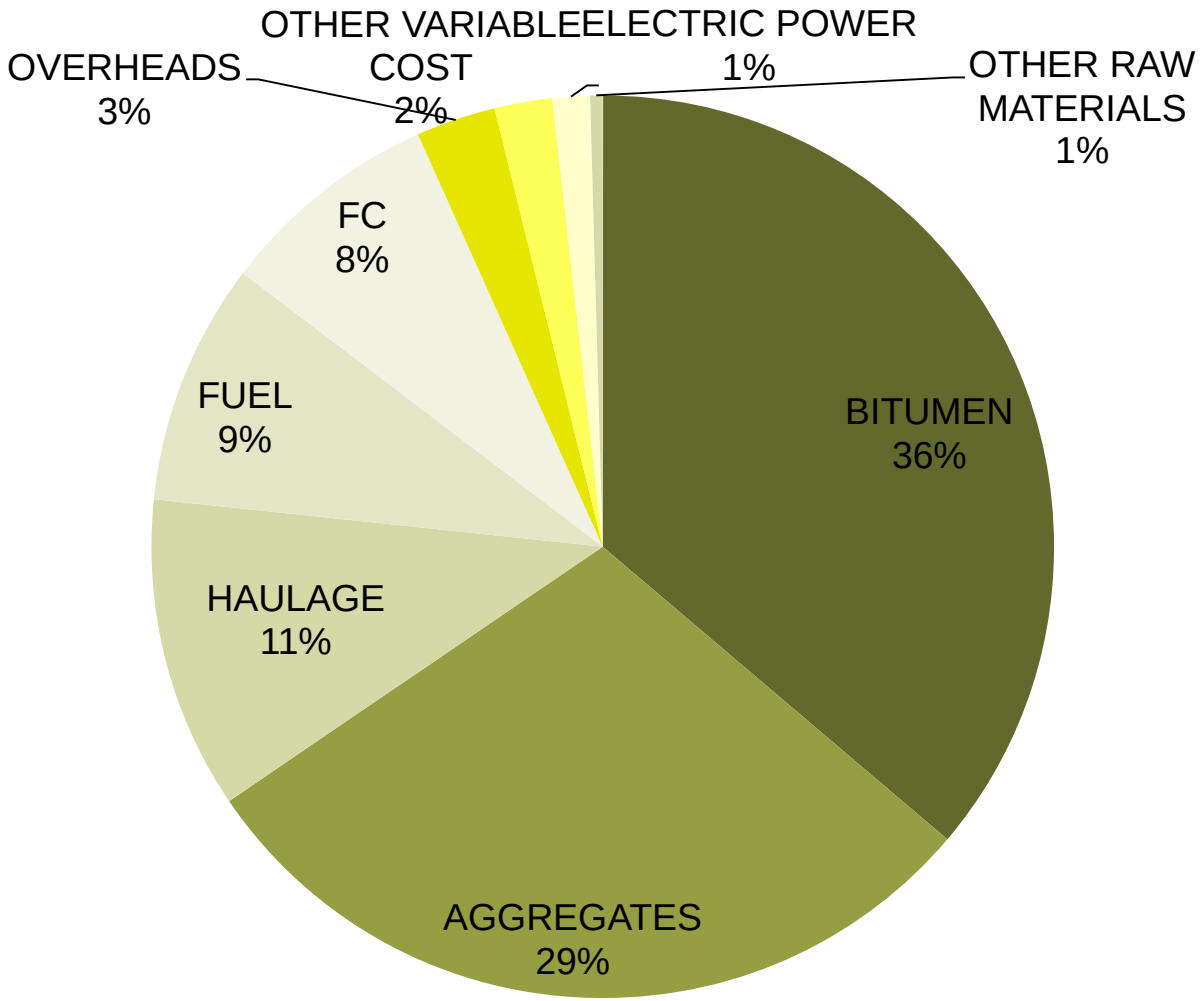
Background

The UK Asphalt Market

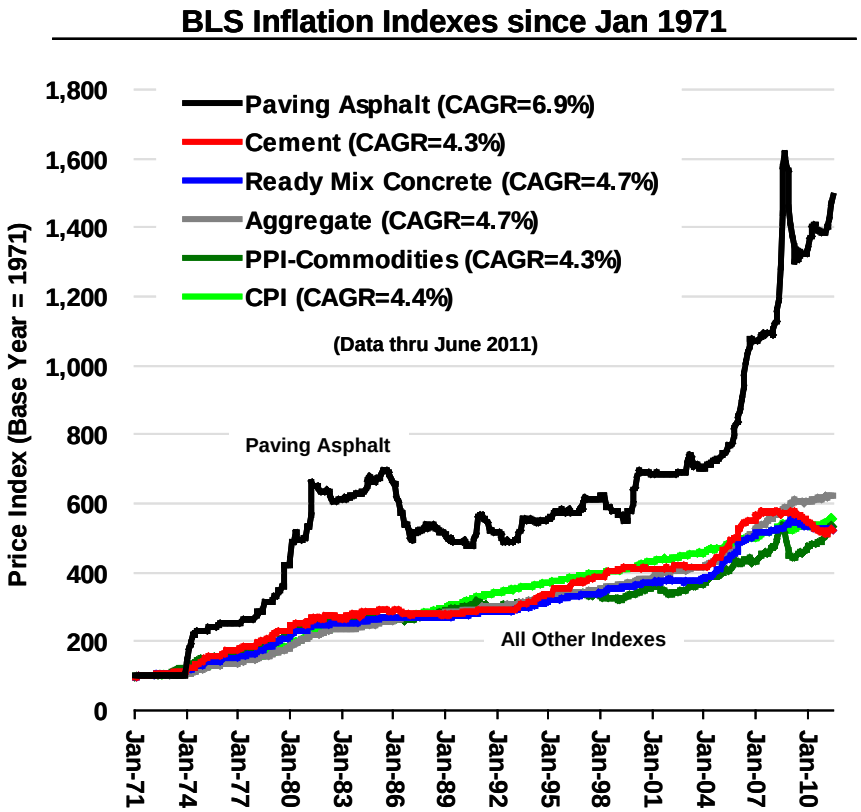


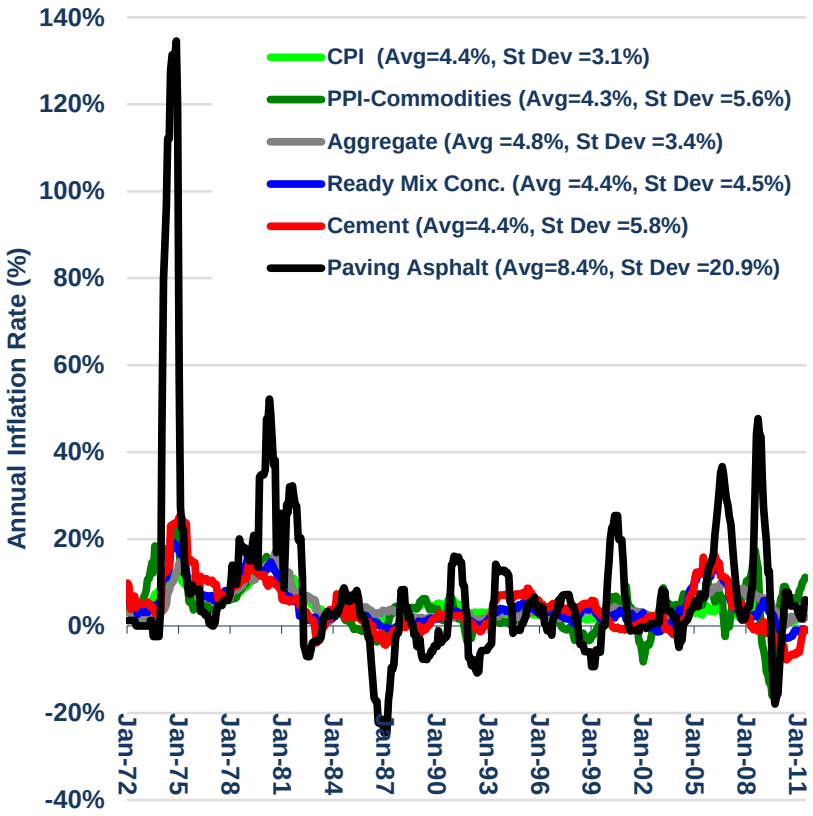
Economic pressures driving ‘More for Less’

Background


OVERHEADS
3%
OTHER VARIABLE COST
2%
ELECTRIC POWER
1%
OTHER RAW MATERIALS
1%
FC
8%
FUEL
9%
BITUMEN
36%
HAULAGE
11%
AGGREGATES
29%

Background





Paving Asphalt's 40-year historical rate is 2 to 4% higher than the general rate of inflation (higher than concrete and cement's and much more volatile)

Background

So why the reliance on asphalt?

‘Time is Money’

+

‘Sticking Plaster’ approach to infrastructure maintenance

+

Tradition ?

What is RCC?

Definition: “Roller Compacted Concrete is a no-slump concrete placed by an asphalt paver and compacted by rollers”

Materials are same as concrete – well graded, angular aggregates, cement, and water – but different mixture proportions. (Cement content around 300kg/m^3)

Zero slump (consistency of damp aggregate)

No pavement formwork, consolidated with paver and vibratory rollers

No reinforcing steel

After curing, RCC properties and performance are similar to PQ concrete

What is RCC?

RCC is a blend of asphalt & concrete Paving technologies

Hot-Mix Asphalt Pavement

Shared construction characteristics

Similar aggregate gradation
Similar placement and compaction

Conventional Concrete Pavement

Shared materials characteristics

Same materials (different proportions)
Similar curing requirements

Production

Central Mix

- Mid size applications
- 100 to 150 tons/hr
- Not all plants have mixers
- Fixed locations
- Capacity reduced due to low water content of mixture

Continuous Flow Pugmill

- High-volume applications
- Excellent mixing efficiency for dry materials
- Consistent mix properties
- 250 to 600+ tons/hr
- Mobile, erected on site
- Lower mobilization costs

Installation

Standard Paver

- Standard paver (80% to 85% initial density)
- Widely available
- High-production (4 to 6 m/min)
- Lift thickness up to 150mm
- May require multiple lift paving
  - Impossible to pave adjacent lanes
- Increased roll down to achieve density (grade control problems)
- Easier to fix segregated areas before compaction

High Density Paver

- High density screed
- High initial density (> 90%)
- Smoother surface with higher initial density
- Less roll down from to achieve density
- High production (4 to 6 m/min)
- Lift thickness up to 250mm
- Adjacent lanes easily paved

Compaction

Initial Compaction

- Initial: 10 - 12 ton static & vibratory roller
  - Thinner lifts may allow smaller roller
- Establish roll pattern (check density a lot!)
- Adjust based on moisture content (visual observation and lab measurements to confirm)
- Compact to 98% of maximum wet density
- Adjust moisture content if needed – impacts smoothness
- Finer mixes achieve density easier

Finish Rolling

- Final: Combination, dual steel or rubber tired
  - Maximum weight - 6 ton
- Remove roller marks
- NO MORE ROLLING!

Quality Control

Moisture & Density

- Density tested with nuclear gauge in direct transmission mode
- Test density behind paver and after roller to establish rolling patterns to achieve density
- Continuously check density until comfortable
- Achieve 98% of maximum wet density
- Nuclear gauge gives general moisture fluctuation indication

Compressive Strength

- Cubes prepared with vibratory hammer
  - 3 to 4 cubes per set
  - Strength timing depends on traffic opening (1, 3, 7, 28 days)
- Cores can be obtained where density is not being achieved

Finishing Touches

Curing

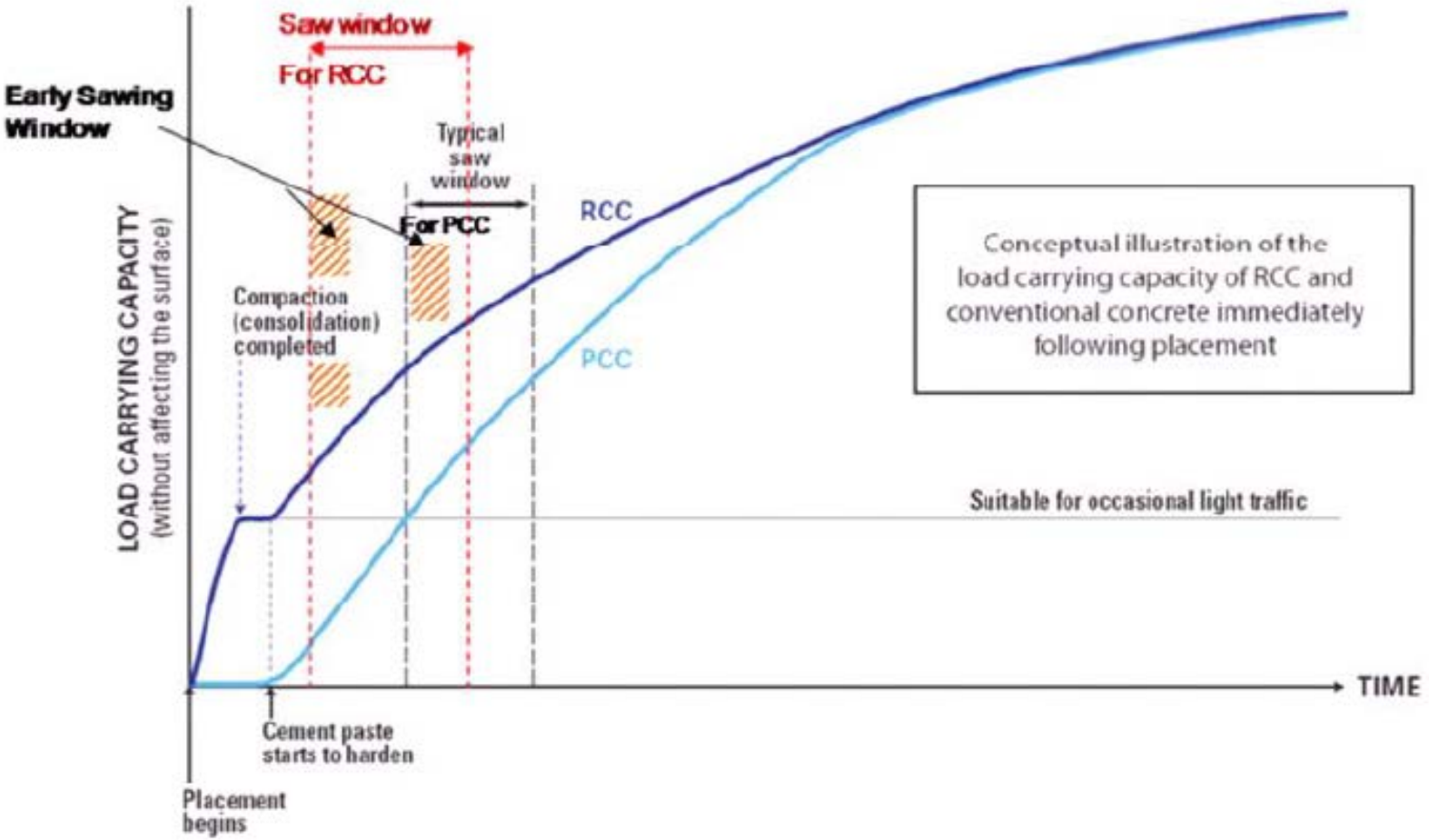
- Applied at same rate or slightly higher than conventional concrete
- Ensure uniformity with application process
- Apply as soon as possible behind roller operation
- Ensures durable surface

Saw Cut & Fill Joints

- More aesthetically pleasing
- Early entry saw very effective, shortly following placement
- Recommend sawing within 2 - 6 hours to avoid uncontrolled cracking
- Depth: 1” to 1.5”
- Spacing: Maximum 36 times thickness, Max 20 ft

The Difference?

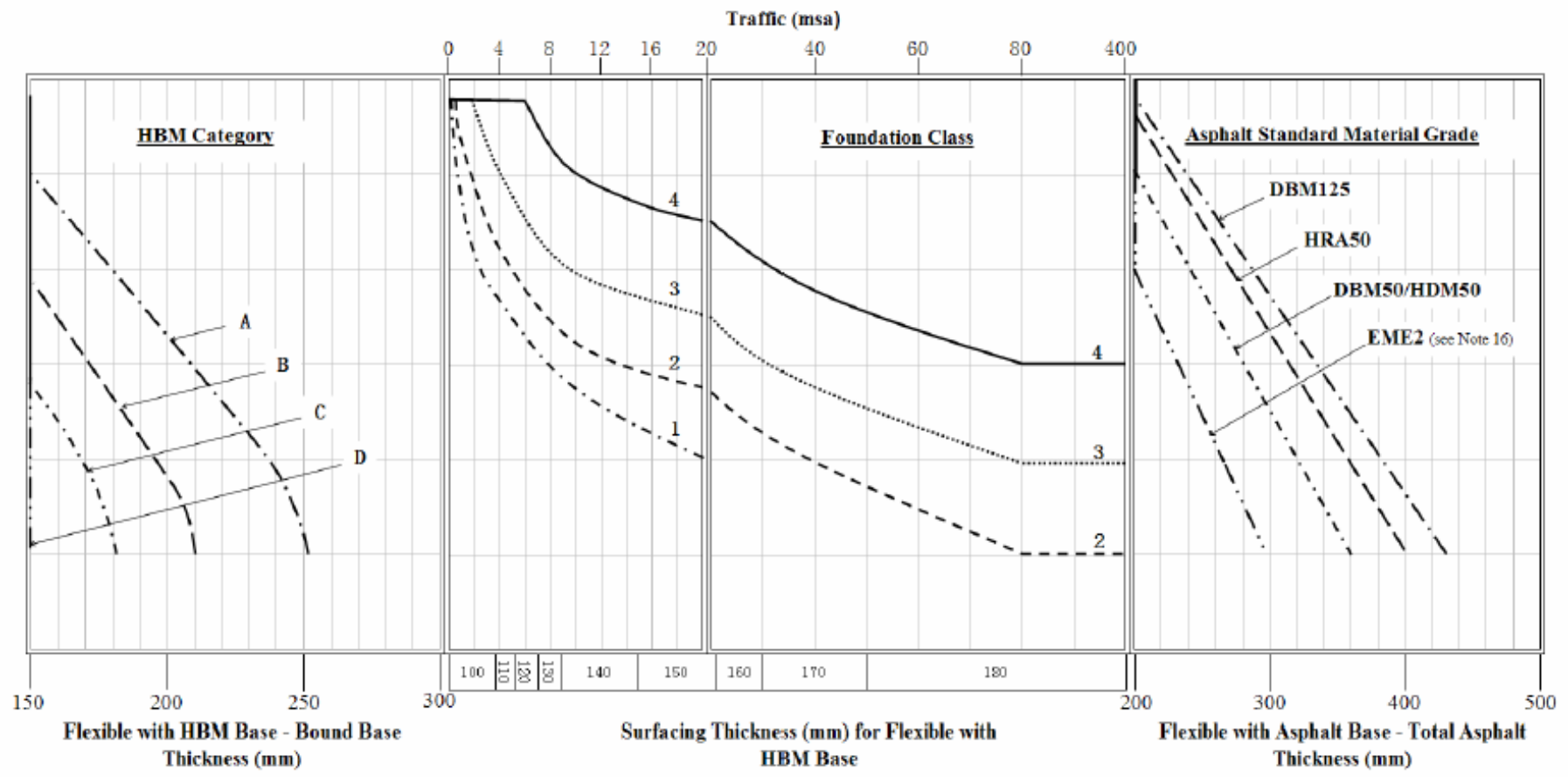
The 'Time' Issue



Applications

- Industrial
- Dockyard
- Container storage
- Airfield refuelling areas
- Roads ?

Pavement Design



HBM ← → Asphalt

(Flexible Composite) (Fully Flexible)

Pavement Design

Examples of Hydraulic Bound Base Materials

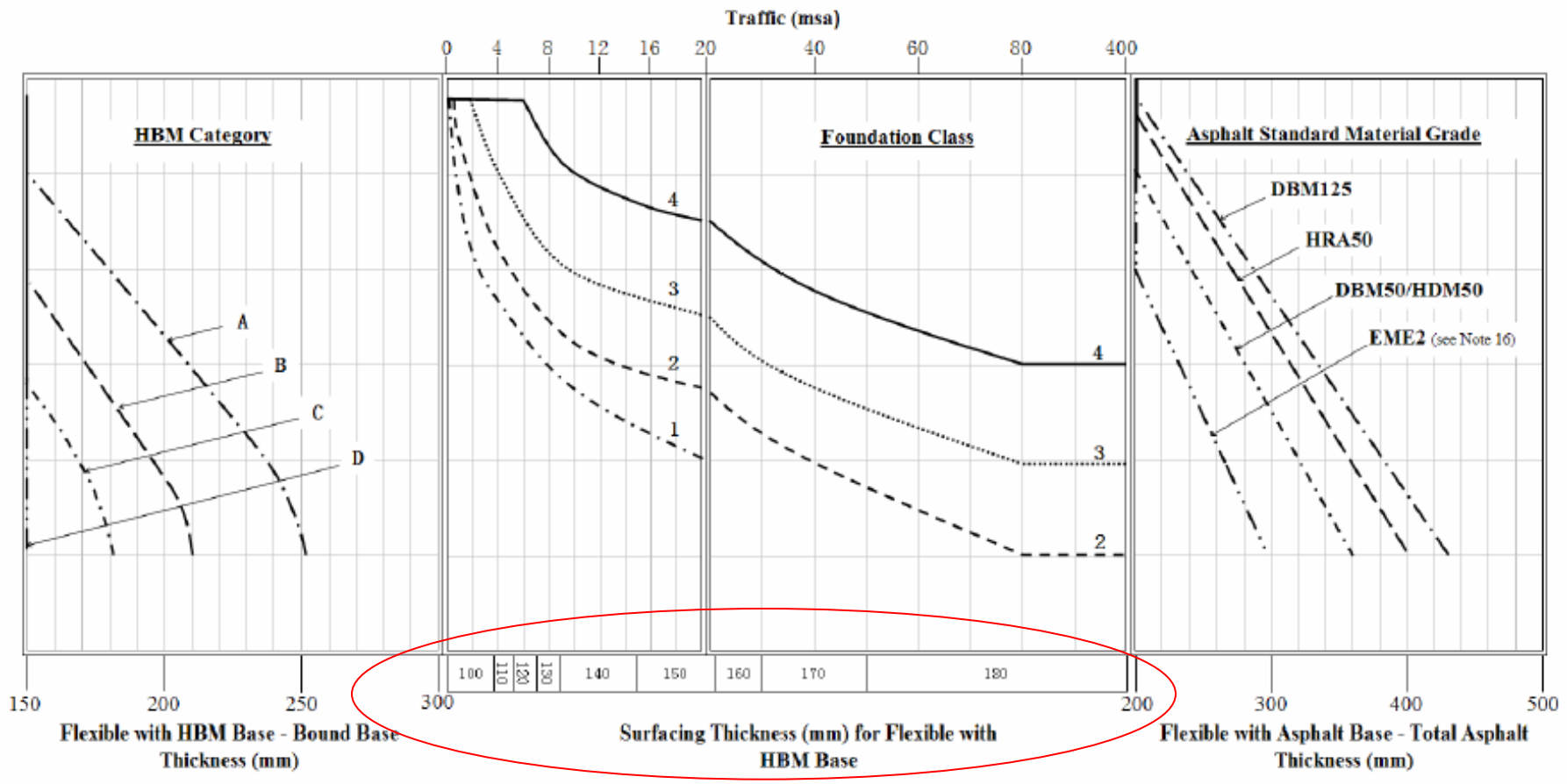
HBM Category	A	B	C	D
Crushed Rock Coarse Aggregate: (with coefficient of thermal expansion <10 × 10 $^{-6}$ per °C)	-	CBGM B – C8/10 (or T3) SBM B1 – C9/12 (or T3) FABM1 – C9/12 (or T3)	CBGM B – C12/15 (or T4) SBM B1 – C12/16 (or T4) FABM1 – C12/16 (or T4)	CBGM B – C16/20 (or T5) SBM B1 – C15/20 (or T5) FABM1 – C15/20 (or T5)
Gravel Coarse Aggregate: (with coefficient of thermal expansion ≥10 × 10 $^{-6}$ per °C)	CBGM B – C8/10 (or T3) SBM B1 – C9/12 (or T3) FABM1 – C9/12 (or T3)	CBGM B – C12/15 (or T4) SBM B1 – C12/16 (or T4) FABM1 – C12/16 (or T4)	CBGM B – C16/20 (or T5) SBM B1 – C15/20 (or T5) FABM1 – C15/20 (or T5)	-

RCC does theoretically fit into to the HBM ‘family’ of materials

But.... the compressive strength of RCC is much higher (C32/40 +)

Therefore no design option is available for RCC in this methodology

Pavement Design



Still a requirement for 100 to 180mm of asphalt overlay

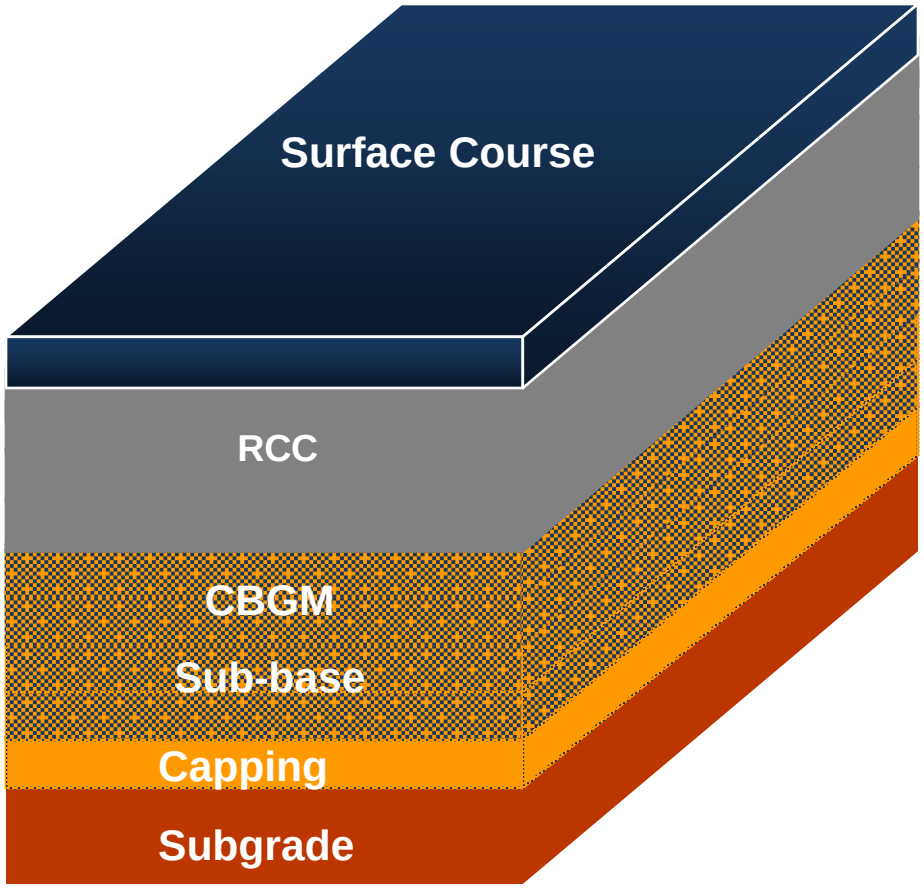
Pavement Design

Potential option

Asphalt surface course to achieve:

Skid resistance and noise reduction

Would require formal RCC specification which in turn would allow inclusion in design charts

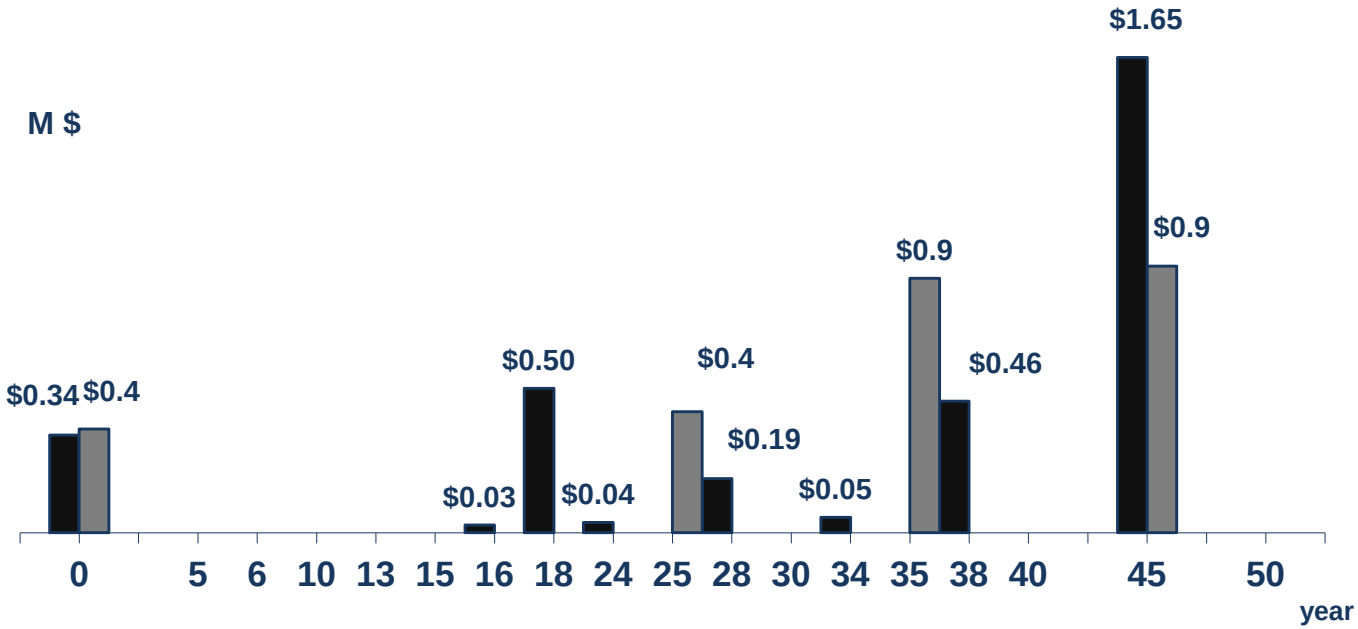


Benefits of RCC

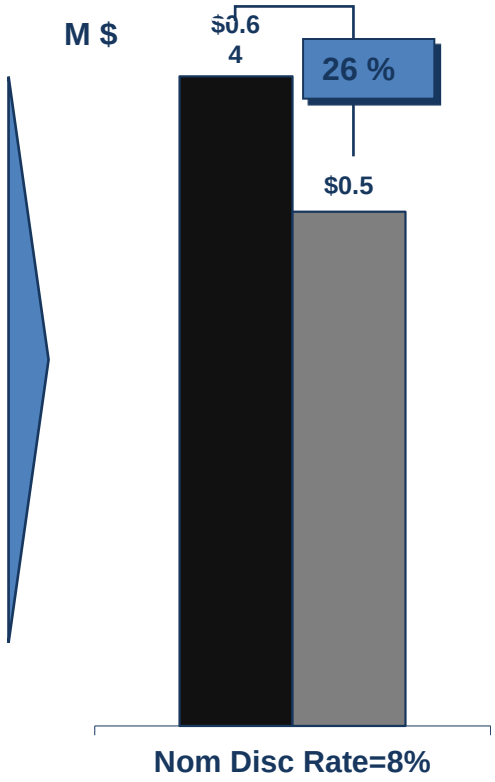
Life Cycle Cost Analysis

Nominal Expenditures by Pavement Type

- Asphalt – Rehab: Crack / cape sealing in years 6, 13, 16, 24, 34, 38
  Microsurfacing in years 10, 28
  Major rehab in year 18 (2" OLAY + PDR)
  Major Rehab in year 45 (Full Replace)
- PCC – Rehab: Patch & diamond grind at years 25, 35, 2" AC Overlay at yr 45



Total Cost Net Present Value



In this example Asphalt is 26% more expensive than RCC throughout the life cycle of the road

Rehabilitation – Activities based on Proper Maintenance Cycles for asphalt pavements. Current year costs are inflated at 4%, Rehab costs also include other Incidental Costs (striping, mob, etc) - 40% of material costs, Traffic Control - 5% of material cost, and Engineering & Inspection - 5% of material cost

Added Benefit – Rolling Resistance

Concrete pavements contribute to decarbonising of transport

EUPAVE
EUROPEAN CONCRETE PAVING ASSOCIATION

Added Benefit – Rolling Resistance

RING ROAD OF ANTWERP

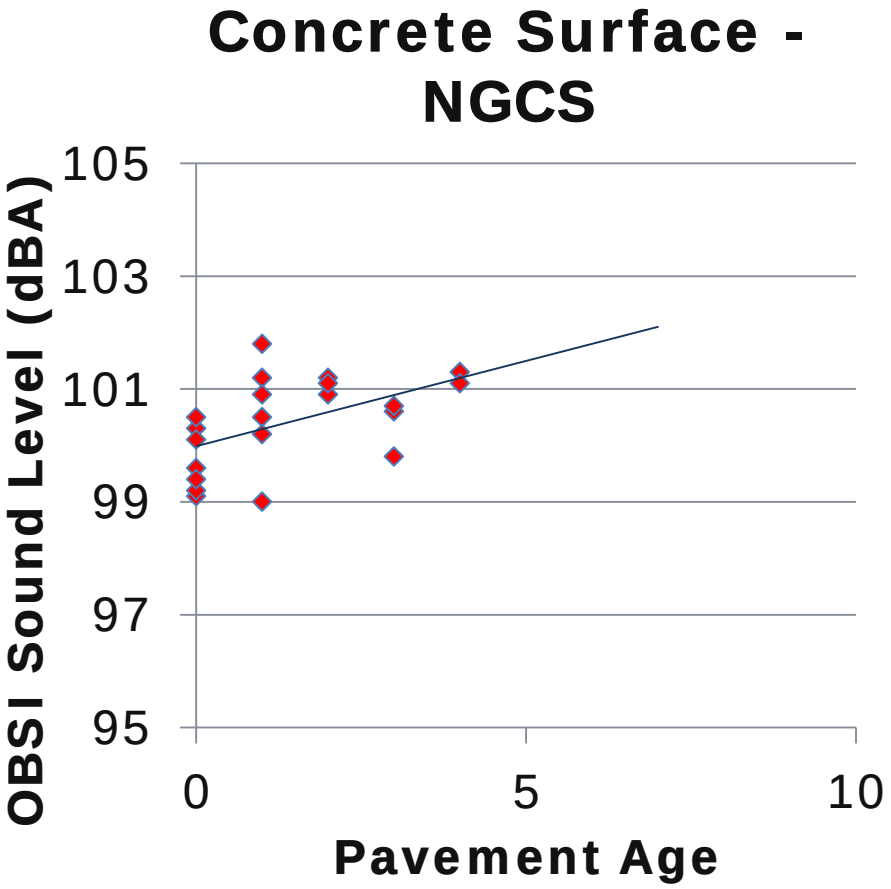
			fuel saving	price diesel	CO_2
km road	number of heavy vehicles per day	directions	l/100 km	7,5 pt/l	kg/l
12	14000	2	0,45	1,5	2,7

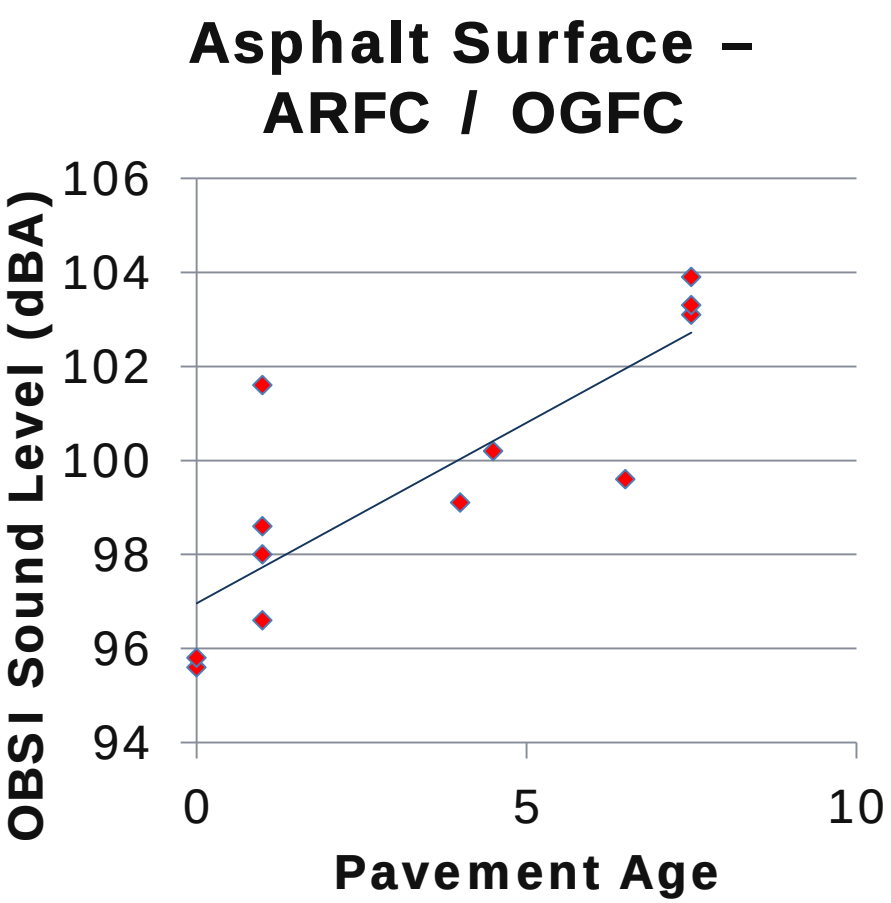
SAVINGS PER DAY					
liter diesel	costs (7,5 pt)	CO_2 (kg)	NOx (kg)	PM (kg)	HC (kg)
1 512	2 268	4 082	40	0	1
CO (kg)	SO_2 (kg)				
6	0				

SAVINGS PER YEAR					
liter diesel	costs (7,5 pt)	CO_2 (kg)	NOx (kg)	PM (kg)	HC (kg)
551 880	827 820	1 490 076	14 625	166	386
CO (kg)	SO_2 (kg)				
2 208	55				

SAVINGS OVER THE 30YEAR LIFETIME OF THE ROAD					
liter diesel	costs (€)	CO_2 (kg)	NOx (kg)	PM (kg)	HC (kg)
16 556 400	24 834 600	44 702 280	438 745	4 967	11 589
CO (kg)	SO_2 (kg)				
66 226	1 656				

The Noise Issue





Advances in Noise Reduction

An innovative, diamond saw-cut surface designed to provide a consistent profile absent of positive or upward texture

- A uniform land profile design with a predominantly negative texture
- A hybrid texture that resembles a combination of diamond grinding (called flush grind) and longitudinal grinding
- Can be done as a single step or a 2 step process
- Visit www.ngcs.info for 25 additional references on the pavement surface type
- Could compete with HRA in terms of noise

Further Benefits - Lighting

US studies have suggested that up to 30% saving in artificial lighting cost can be achieved by using a light coloured surface

CASE STUDIES

Druids Heath Bus Terminus

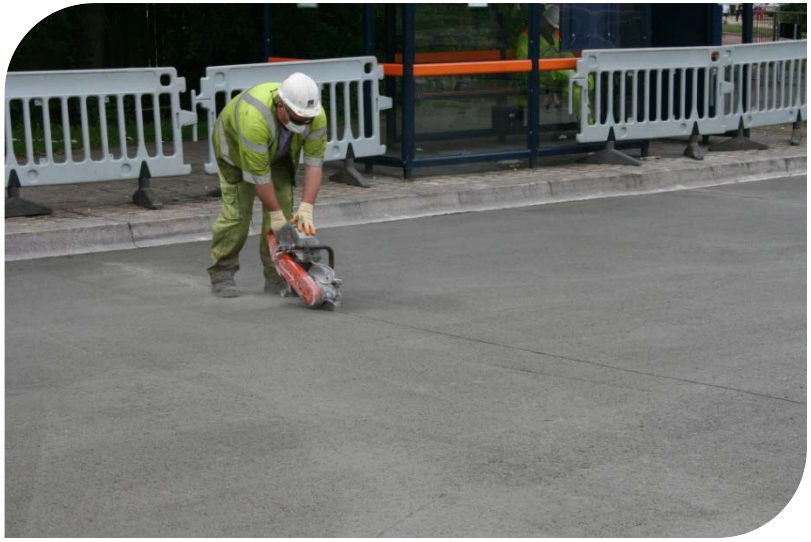
- Repeated heavy loading of parked buses
- Oil spillage
- Disruption to public transport, congestion if re-routing employed
- Options were asphalt or RCC

	Asphalt	RCC
CBR	15	15
Subbase	150mm	150mm
Pavement	260mm	200mm
Overall	410mm	350mm

Druids Heath Bus Terminus

Druids Heath Bus Terminus

- Transverse joints cut every 4 – 5 metres
- Cut using dry blade to one third of the depth
- Filled with bitumen emulsion prior to rolling



Druids Heath Bus Terminus

Impetus Waste Transfer

- Large storage area for compost waste
- Difficult ground conditions
- Time pressure on program
- No asphalt design option

	PAV 2	RCC
CBR	10	10
Subbase	150mm	150mm
Pavement	400mm	400mm
Overall	550mm	550mm
Program	16 weeks	6 weeks

Impetus Waste Transfer

Impetus Waste Transfer

Impetus Waste Transfer

Summary

- RCC is not a new product
- Economics are driving contractors to seek ‘more (and more) for less’
- The challenge is to improve understanding and knowledge of RCC
- Specifications and design charts need to include RCC as an option
- RCC has all the attributes of concrete, with the installation speed of asphalt
- Maintenance options as well as new build is key
- Concrete paving is becoming a viable option in many applications

Questions ?