Collaborative Research into the New Generation of Asphalt Surfacing

Project Number: 60484040

January 2016

Prepared for:

Highways England, MPA and Eurobitume UK

REVISION SCHEDULE

Rev	Date	Details	Prepared by	Reviewed by	Approved by
1	January 2016	Notes from the project workshop	Jessica Tuck Chibuzor Ojum	Daru Widyatmoko	Paul Edwards

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1 INTRODUCTION

On 2 June, a one-day workshop on Future Surfacing was organised by AECOM (formerly URS), as a part of a Collaborative Research Project funded by Highways England, Mineral Products Associations and Eurobitume UK. The aim of this project is to review bitumen based surfacing materials, drawing upon international experience, with the view to developing a new asphalt surfacing material which has significantly enhanced durability, whilst balancing other performance demands such as noise and safety.

The workshop took place on 2nd June 2015, from 9am to 2pm, at Lea Marston Hotel in Warwickshire.

In this workshop, the participants were challenged with the following question: "*What are your ideas for the next generation of asphalt surfacing for use on Highways England's Network that will increase durability without compromising the current performance?*"

The reference to *the current performance* is Clause 942 of the Specification for Highway Works; specifically the new material must not generate louder noise than the current thin surface course system, and it must remain safe meeting the surface texture and/or wet friction requirements.

This brief report presents notes and photographs taken from the workshop and summarises key finding (Sections 2 to 5).

Outcomes from discussions during the workshop evaluation exercise, and immediately post the workshop, between the steering committees and the research team are also presented (Section 6). This includes high level actions for the next stage of the research program.

2 AGENDA

The following outline agenda and process was used during the workshop.

Time	Activity
09:00 – 09:30	Registration & Coffee
09:30 – 09:45	Welcome & Housekeeping
09:45 – 10:00	Project Overview & Context of this part of the project
10:00 – 10:10	Ice Breaker
10:10 – 11:00	Brainstorm – what & where are the opportunities to develop the next generation of surfacing to be used on Highways England's Network
11:00 – 11:15	Coffee
11:15 – 12:30	Feedback by each group – 10 minutes
12:30 – 13:30	Lunch
13:30 – 14:00	Feedback on the next steps
14:00 – 14:10	Thank you & Close

3 FACILITATORS AND ATTENDEES

The workshop was attended by over 40 experts and professionals from UK, France and Germany with various backgrounds; including consultants, contractors, road authorities, asset managers, academics and industry associations. Affiliations of the attendees are illustrated in Figure 1 and the detailed list is presented in Appendix A.

Figure 1: Affiliations of the attendees

The main facilitator for this workshop was Emma Wigham from Atkins, supported by Jessica Tuck and Sam Nicklin (both from AECOM).

Participants were distributed into six discussion tables, and discussion on each table was facilitated by a member of the Collaborative Research team: Malcolm Simms – MPA (Table 1), Paul Sanders – Highways England (Table 2), Daru Widyatmoko – AECOM (Table 3), Mike Lancaster – Eurobitume UK(Table 4), Tim Smith – MPA (Table 5) and Gary Schofield – Eurobitume UK (Table 6).

Donna James (Highways England), Paul Edwards (AECOM), Paul Phillips (MPA) and Chris Southwell (Eurobitume UK) were the four panel members who were tasked to summarise feedbacks from the participants at the end of the workshop session.

Snapshot photographs of the workshop are presented in Figures 2 to 4.

Figure 2: Table discussion and brainstorming

Figure 3: Feedback session by each group

Figure 4: Feedback session by panel members

4 NOTES FROM THE WORKSHOP

The workshop generated enthusiastic discussions, debate and innovative ideas. These ideas range from those which may be graded as potential for immediate implementation, to a much more outer space futuristic concept.

For completeness, all the unfiltered ideas from the brainstorming session are presented in Section 4. The "top" ideas volunteered from each group were then ranked and refined (within the group, but supported by facilitators). These are listed for completeness in Section 4.2.

4.1 Streams of ideas

The following slides capture "typed up" flip charts populated during the initial brainstorming session within each group (table of between 5 and 7 people).

Noise
- A/C / SMA Hybrid
- HRA – Size of chips
- Porous - Twin

- Design
- Negative texture
- Aggregate Size

Durability
- Components & Additives
- Design (inc. Pavement)
- Predictable failure
- Monitoring
- Installation

Design Process
- Mixture
- Pavement

Safety
- Both user and worker
- Construction practice

- Components
- Design

Sustainability
- Long life
- 'Green'
- Recycled content
- Recyclability
- Locally sourced
- Reduced temperature

Cost – Whole Life
- To include binder course

Workmanship
- Access
- Competence
- Traffic Management
- Compaction

Approval Process
- Cost
- Time

Uncontrollable Factors
- Climate – Extremes
- Traffic

High Binder / Low Voids

High Binder / Low Voids
- Type (mod / un-mod)
- Properties

Performance-based Specification
- Durability
- Noise
- Defm. Resistance
- Minimum b/c
- Grading
- Voids
- Skid resistance
- In-situ measurable?

Installation
- Thickness
- Experience
- Traffic Management
- Availability / Access
- Sub-strate

Aggregates
- Type (quality / artificial)
- Grading (shape)
- Source (sands)

Fillers and Fibres

Self - Healing

Accelerated Testing

Echelon

Twin Layer

Prefabricated roads
- On rolls (carpet on a stable base)
- As slabs

- Velcro / artificial grass

Monolithic Construction

Graduated not layered structure

Very thin top surfacing (high performance)

Mix Design

Nano material fillers

Aramid / carbon fibre reinforcement in binder

Waste glass fibre / container glass

Bonding Layers

Void replacement (remove air)
- Super hydroprobic

Reduce ageing rate (rubber)

Replace bitumen with polymer
- Plant based ploymers
- Rubber
- Thermoset
- Thermoplastic

Joint Fillers

Remove aggregate from surface

Combine concrete and asphalt

Self – healing
- Automated
- Activated externally
  - Microwave
  - infrared

Generate electricity through vehicle action

Recycled materials
- Quantify performance before re-use
- Recycle forever

Re-thinking durability
- Lasts 1/10 time
- Costs 1/100

Continuous re-surface

Speed layering – Forth Bridge Principle

Material improves with traffic – vehicles repair road, via vibration

Temporary hardening with rainfall / temperature

Moving traffic from lane

Noise cancelling
- Textured surface for given frequency

Robot pavers / resurfacing
- Quality
- Time of day / year
- Weather
- At night

Crack repair automated (RACA)

Rubber road and rubber wheels

Seed like surfacing
- Or 'salt'
- 'Growing'
- Self crystallising

Spray-on preservatives (paint)

Conservation of asphalt

Increase traffic speed

Mollusc teeth surface

Mushroom Spore

Sharks teeth / skin

Hover cars / trucks

Interface lubricant
- 'Air cushion'
- 'Fluid cushion'

Noise
- Rutting
- Regularity / ride quality
  - Screed
- Chips
  - Application
  - Availability
  - Do we need them?
  - Size
    - Smaller, less fretting, lower noise
- Can we still achieve negative texture?
- Dense bitumen
- Low voids (not connected)
- Thick
- Compactable
- Tolerant
- Joints
- High stone contents
- Challenge surface texture

Quite HRA ?

Rut resistance?
- Tyres
- PMB

Glass Fibre
- Polymer waste
- Astro recycling
- Polyfibre

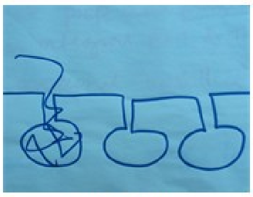
Over Chip HRA
- 16 kg/m²
- Negative texture effect
- Quieter
- 14mm or 10mm chips
- SBS PMB modified
- Chip loss
  - Embed deeper
  - Shape important
    - Cubical
    - Flakiness
  - Alternative coatings
    - Adhesion agent
      - Promote adhesion
      - Reduce loss
      - PMB

Crossfall

Spray
- Unsure if spray is increased

Less material equipment options
- Develop new chipper
  - Chipper teeth to embed hips
- Continuity
  - Young people
  - Skills
- Installation competency
  - Training
  - Supervision
- Procurement
  - Enable investment
    - Visibility
  - Whole life cost
  - Supply chain commitment
  - Relationship between client & supply chain
- Mix Design
  - Design process
  - Material selection

Dense
- Generating noise (26mm)
- Absorbing noise (P.A)



Patterned Roller

Dense (high psv fine aggregates) product with a 'printed' surface

What does the fine aggregates do?

EME!

Can you design and control an asphalt concrete for surface course – adequate texture

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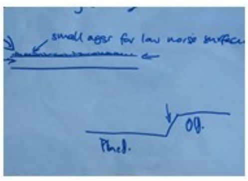
How we tie in to existing? – Whatever solution we choose

Site preparation and planning needs to be an integral put of the process

Operational 'upskilling'



Laid in a single layer

Small aggregate for low noise surfacing

Dense receiving course

How do we align aggregate particles – special dual pavers

Additives!!
- Adhesion agents
- Epoxy? – can we add a curing accelerator?
- Limestone filler
- Warm-mix additives – wider working window

Durability

- Keep water out
  - All Levels
    - Interface
    - Material
    - Surface
  - Marshal Asphalt?
    - 'Grooving' / texture
  - (Highly) modified binders

- Mitigate if water does ingress – binder / aggregate interface
  - Dual layering paving
    - Between b/c and s/c laid at same time
    - Echelon joint

- Cons – Voids / Dense
  - Interface between s/c and b/c
  - Nom. Aggregate Minimum – 4 to 10mm
  - Thickness – 25 to 70 mm
  - Aggregate 'packing' / compactability ← **Be more prescriptive to design an asphalt – agreed framework**
  - Gyratory compare in LMB
  - Joint failures
    - Handability / ease of compaction

Skid Resistance
- Small nominal size
- Tyre interface

Waterproofing asphalt
- Sprayed on system?
- After surfacing

How low can texture depths go?
- High speed
- Shedding water

HRA Type material without chips
- Use a dual system, skid resistant
- Add aggregates / grit into surface – process

PMB
- Adhesion agents to minimise impact of water ingress

Aim
Maximise durability

Issue
Water, water, water
Mechanical performance

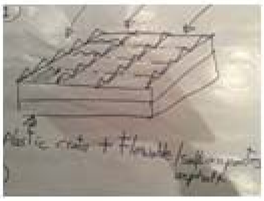
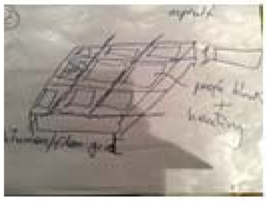
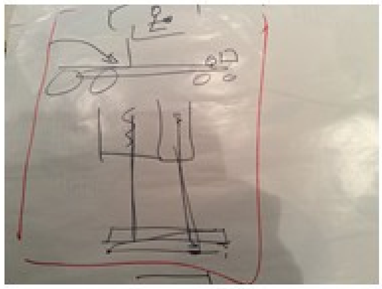
Constraints
Noise
Skid resistance

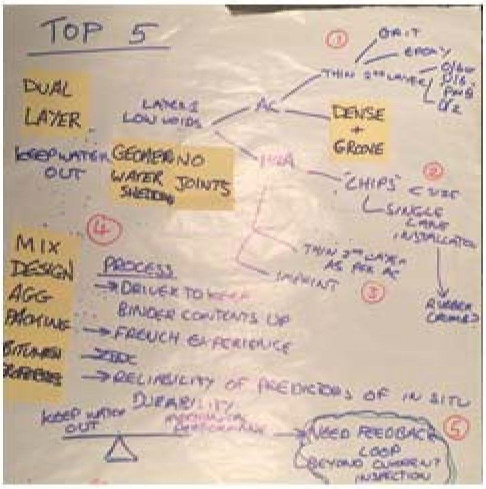
Recyclability
Aggregate balance

4.2 Top ideas from each group

The following section captures the "top" ideas (as determined within each group), derived from the initial thought process and discussions detailed in Section 4.1.

Group 1	1. Composite material I. Densiphalt II. Coated porous aggregates III. Twin layer T/S IV. Example. Grass Grid 2. Binder Capsules (condition response) 3. Pre-packed ('mastic) 4. Artificial / manufactured aggregate shape 5. Binder replacement epoxy 6. Road on a Roll 7. Sacrificial utlac (maintenance routines)
Group 2	**1. Prefabricated Roads** i. Carpet on (Velcro) stable base ii. Build in features, road markings, signs etc. **2. Continuous resurfacing** i. Lay at speed ii. Rethinking durability iii. 1/10 time, 1/100 cost **3. Temporary hardening** i. Material improves with traffic / rainfall / temperature **4. Self – Healing** i. Automatic (micro balloons) ii. Activated externally (microwave / infrared) **5. Replace Bitumen – Polymer** i. Rubber ii. Thermoplastic iii. Thermoset **6. Seed-like surface** i. 'Grit' road crystallises and compacted by traffic ('the grit that grows' !) **7. Generate cushion to reduce wear by reducing contact with road**

Group 3	 1. Plastic crate and flowable / self-compacting asphalt  2. Bitumen / fibre grid 3. Flowable asphalt 4. Closed-graded binder rich pmb and adhesion agent to reduce permeability Anti-ageing treatment (pre close binder) 5. Super micro-surfacing (improved emulsion technology)
Group 4	1. Glass Fibre i. Polymer waste ii. Recycling iii. Polyfibre 2. Over chip HRA with 14mm or 10mm chips 3. Use of an adhesion agent (PMB) i. Promote adhesion ii. Reduce loss 4. Installation Competency i. Training ii. Skills iii. Supervision 5. Procurement i. Whole life cost  6. New Chipper, to over chip
Group 5	1. Dense fine high PSV mix imprinted pattern 2. Well designed asphalt concrete 3. Additives i. Epoxy ii. Adhesion agents iii. Limestone filler iv. Hot warm mix v. Wider workability window 4. Twin layer i. Dense receiving layer with 6mm surface 5. Site Operations i. Angle cut joint ii. Skills and training iii. Shuttle buggy – eliminating cold load ends iv. Preparation and planning • Durability • Do we understand NOISE? • Skid resistance

Group 6		**6. Magic Coatings** • Seasonal waterproof spray • Use gritter fleet? **Other ideas** • Bond coat • Adhesion agents • Self healing

5 EVALUATION OF IDEAS

Ideas presented in the workshop were collated into broad concept groups and an initial high level evaluation of each broad concept was undertaken against durability, ease of implementation and likely relative cost. This coarse evaluation was primarily undertaken by the panel, to produce a quick visual feedback on initial thoughts to the workshop audience. Figure 5 presents an overview of the initial evaluation, with ease of implementation increasing up the y axis and durability increasing towards the right of the x axis. The size of the circle represents an estimate of relative cost. Some concepts are shown as clouds due to a high degree of uncertainty on how they could be valued or ranked on the day. The initial output was used to indicate the potentially most promising concept(s) in the project timescale, which are those shown towards the top right of the chart.

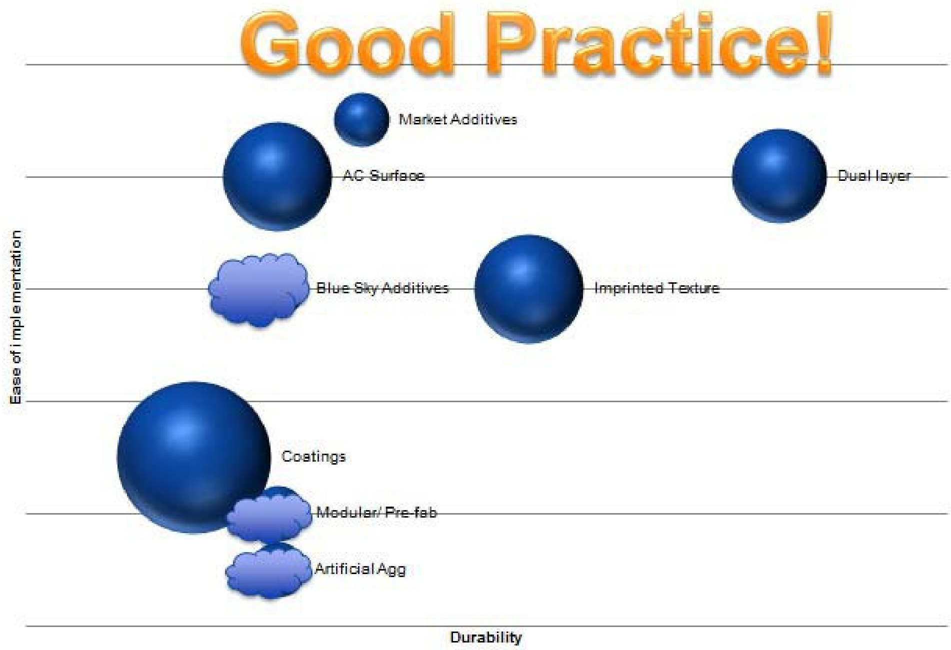


Figure 5: Summarised concepts

Several ideas generated at the workshop related to the category of “good practice” (shown across the top of Figure 5). It was agreed, that whatever the ideas taken forward, that they should keep these concepts in mind.
Key themes discussed under the broad banner of ‘good practice’ include;-

- Improvements to mix design process
- Better understanding of aggregate packing
- Improving workmanship / operational upskilling / training
- Procurement and ‘risk sharing’ / investment in plant and equipment / visibility of programme
- Better feedback loop on performance
- Substrate condition
- Bond between layers
- Access / traffic management / full road closure – improved safety and joint workmanship / enable echelon paving
- Relationship with supply chain
- Temperature control (use of shuttle buggies)

5.1 Overview of key concepts

Further detailed discussion was generated during the workshop round table discussions of the output shown in Figure 5. These are summarised in the following subsections.

5.1.1 *Dual layer*

‘Dual layer’ is furthest towards the top right of the chart and covers a range of ideas. It was agreed during the workshop that a more appropriate name for the concept is required.

The concept broadly comprises a low void, dense body of material with surface characteristics (such as texture, skid and noise) applied at the top of the layer.
Ideas for achieving this include;-

- Over chipped Hot Rolled Asphalt (HRA) type material, creating effectively a negative texture, with 6, 10 or 14 mm chippings embedded (example given on M6 Junction 10 in 1996). Use Polymer Modified Binder (PMB).
- Dual layer with chippings applied.
- Dual layer surfacing with grit applied (on top or embedded).
- Dense body with surface dressing / bonded solution.
- Composite material, such as grouted macadam.

5.1.2 *Imprinted texture*

As above, this concept comprises a dense material body only this time the surface characteristics are achieved by applying mega texture to the surface.

- Flowable dense asphalt course with mega-texture imprinted.
- Groove or imprinted texture of dense material.
- Design to achieve noise cancelling properties.

5.1.3 *Market Additives*

Improve durability of existing (or new) asphalt designs/mixtures via the use of:

- Adhesion agents
- Rejuvenators
- Pavement life extenders

5.1.4 *AC Surface Course*

This concept comprises optimising the design process to achieve durable asphalt concrete (AC) with desired surface characteristics.

- Design and control AC surface course
- Consider Enrobé à Module Élevé (EME) design approach for AC
- EME could offer required characteristics – optimise for surface course application

5.1.5 *Blue sky additives*

This concept includes blue sky ideas for resilient asphalt that responds to the environmental conditions.

- Self-healing additive / bitumen capsules
- Temperature hardening additives
- Externally activated self-healing additives (microwave / infrared)

5.1.6 *Coatings*

'Magic coatings' were discussed as a blue sky idea.

- Seed like surface – road crystallises and is compacted by traffic 'grit that grows'

5.1.7 *Modular / prefabricated roads*

Prefabricated or modular road constructions were discussed by a number of groups. Ideas include:

- 'Road on a roll'
- Slab installation
- Use of Velcro / artificial grass
- Use of plastic crates with flowable asphalt infill, or use a bitumen/fibre based grid

5.1.8 *Other ideas*

Other ideas included the following concepts:

- Continuous resurfacing (the Forth Bridge principle): design cheap and low cost surfacing and repair, and continuously resurface the network.
- Use glass fibre or a waste source such as recycled astroturf, or polymer waste as a source of fibres to incorporate into the asphalt mixture – increase stability and reduce deformation.

6 ACTION PLAN

6.1 Analysis of the key concepts

Amongst the key concepts gathered during the workshop, the "dual layer" approach was considered a practical idea which could be trialled within the current project timeframe. This approach was; therefore, explored further immediately post the workshop, prior to discussion with the project steering committee. The following section details this work.

There are a number of ways to produce the "dual layer" as illustrate in Figure 6. These approaches are discussed further as follow:

a) Conventional two stage installation involving dense asphalt concrete treated with surface dressing has been used in the past; the dense asphalt concrete can provide durability and the surface dressing provides safety requirements. However this installation method is not suitable for application in SRN due to the very high traffic level and work restrictions.
b) Current design principle of Stone Mastic Asphalt (SMA) system with two target volumetric composition within a single layer, specifically 1/3rd of the upper layer thickness should be relatively permeable to provide texture and spray reduction, with air voids around 6%, whilst the remaining 2/3rd of the lower layer thickness should be dense and impermeable. However, this principle does not always work with proprietary thin surfacing (TS) as there were many cases where TS was

relatively permeable to the full layer thickness and consequently more prone to moisture induced damage. Nevertheless there is a room to improve the current specification by:

1) Introducing a more-guided mix design procedure, to improve the structure of aggregate packing and composition within the mixture to reproduce the principle of having two target volumetric compositions within a single layer;
2) Adapting the principle of in-line paving or compact asphalt to produce two different grades of SMA, an ultra-thin permeable SMA (UTSMA) on the upper side feed and a dense impermeable SMA (DSMA) on the lower feed.

c) Improving the current technology to install HRA with embedded heavy application of 10mm chipping, by integrating the chipping application as a part of the laying and compaction process.

d) Machine laid flowable asphalt simultaneously treated with imprints or grooves. Flowable asphalt may be designed to the family of gussasphalt or mastic asphalt.

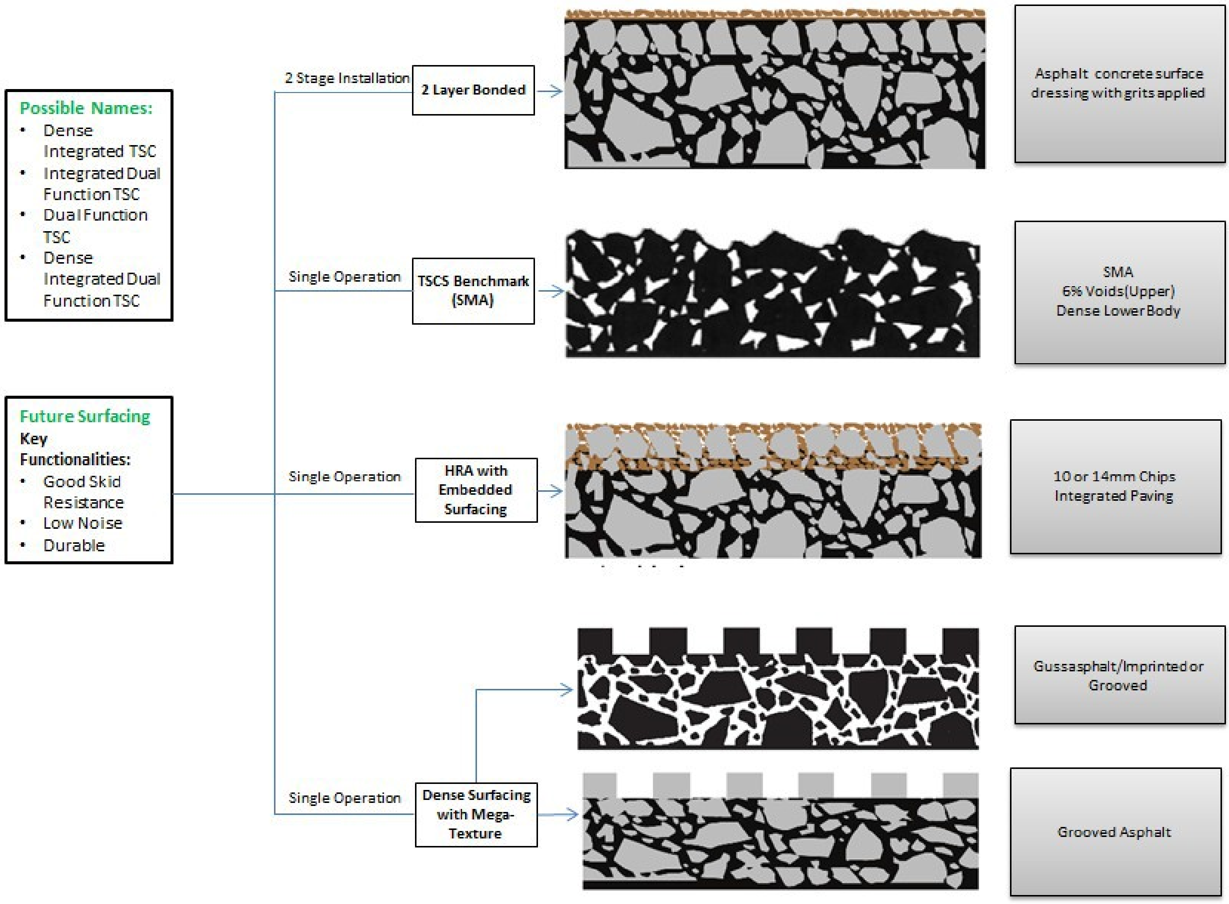


Figure 6: Some “dual layer” approaches

The construction plants which may be considered for adaptation under Option b.2:

Inline Pave

This involves paving the upper (UTSMA) and lower (DSMA) courses in immediate succession hot on hot. The mobile feeder supplies in succession asphalt materials to both the upper and lower course hoppers. The paver places the lower course material which is compacted with a high compaction screed which facilitates the possibility of the paver for the upper course to travel on the lower course layer. An illustration is shown in Figure 7.

Figure 7: Inline Pave setup (top – side view; bottom – elevated view)

Very high pre-compaction of the lower course prevents the material mixing with that of the upper course in immediate succession at the required temperature (hot on hot) and application rate which can be paved in a single pass. Inline pavers permit continuous flow of traffic during paving which is an advantage.

Compact Asphalt

Compact asphalt paving method also lays the lower and upper course in one work process hot on hot having the added benefit that no tack coat is required in between the two layers and providing superior interlocking which improves the durability of pavement in comparison with the conventional asphalt laying method. An illustration is shown in Figure 8.

Figure 8: Compact Asphalt setup

The mobile feeder machine which is capable of feeding 27 tons in 35 seconds is used to feed both the lower and upper course hoppers. The top two layers can then be laid in one process continuously hot on hot.

The construction plant which may be considered for adaptation under Option d is illustrated in Figure 9.

Figure 9: Machine laid gussaphalt

Imprint can be laid in a number of ways and patterns as illustrated in Figure 10 and grooves can be cut as shown in Figure 11.

Figure 10: Pavement Imprints

Figure 11: Grooving on asphalt pavement

Considering the shortlisted approaches and material options, the following broad points were agreed by the steering committee during the project meeting in July 2016:

1) Surface dressing and twin layer approach was discounted on the basis that:
   - Mixing and delivery capacity for two separate materials is a challenge
   - Concern over bond failure and long term durability vs other options
2) Grooved and imprinted surfacing was discounted as they may not be the most durable option.
3) HRA type material with embedded surface (smaller chip size), where the chippings effectively embed deeper into the body to create an aggregate matrix was believed to be a concept worth progressing further. HRA with high rate of chipping have worked well for local authorities and there was a good case study on M6.
4) 'Dual layer' – a single operation surfacing which creates a dense body with surface characteristics, possibly based on AC type material designed using EME principles is considered to be worth progressing. This can be approach by introducing a more-guided mix design procedure, to improve the structure of aggregate packing and composition within the mixture to reproduce the principle of having two target volumetric compositions within a single layer.

6.2 The next stage of work

For the next stage of the work, three sets of materials have been proposed:

1) HRA incorporating polymer modified binder with embedded heavy application of 10mm chipping, aiming to create additional aggregate body through embedment of chippings.
2) 'Dual layer', incorporating polymer modified binder and 10mm nominal size aggregate.
3) An agreed sample of proprietary thin surface course for use as a control set.

Each of the three material sets will be subjected to the following minimum suite of testing during mix design and plant trial:

Tests	Mix design	Plant trial
Visual assessment of vertical section (cut face) of sample	X	
Mixture volumetrics (air voids)	X	X
Workability to EN 12697-31	X	
Determination of surface texture to EN 13036-1	X	X
Resistance to moisture damage, measured by indirect tensile strength test to EN 12697-12	X	X
Resistance to deformation, measured by using wheel track testing (small device, in air) to EN 12697-22	X	X
Determination of skid resistance by Pendulum Test Value (EN 13036-4)	X	X
Determination of noise by acoustic impedance tube method (ASTM E1050)		X

Further details and actions from the Workshop were discussed and agreed at the following project steering committee meeting on the 1st July 2015.