Long Life Surfacings for Busy Roads

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by

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Long Life Surfacings: Background and Context

- National road networks are amongst largest community assets
- predominately government-owned in most countries
- Road administrations are increasingly adopting life cycle / asset management approaches
- Long service life of road pavements on high traffic roads has long been a key goal for road professionals
- Surface layer or wearing course is the Achilles' heel of the long life pavement concept
- Trends in traffic growth leading to increasing proportions of highly trafficked roads - which become candidates for more durable pavements at higher construction costs

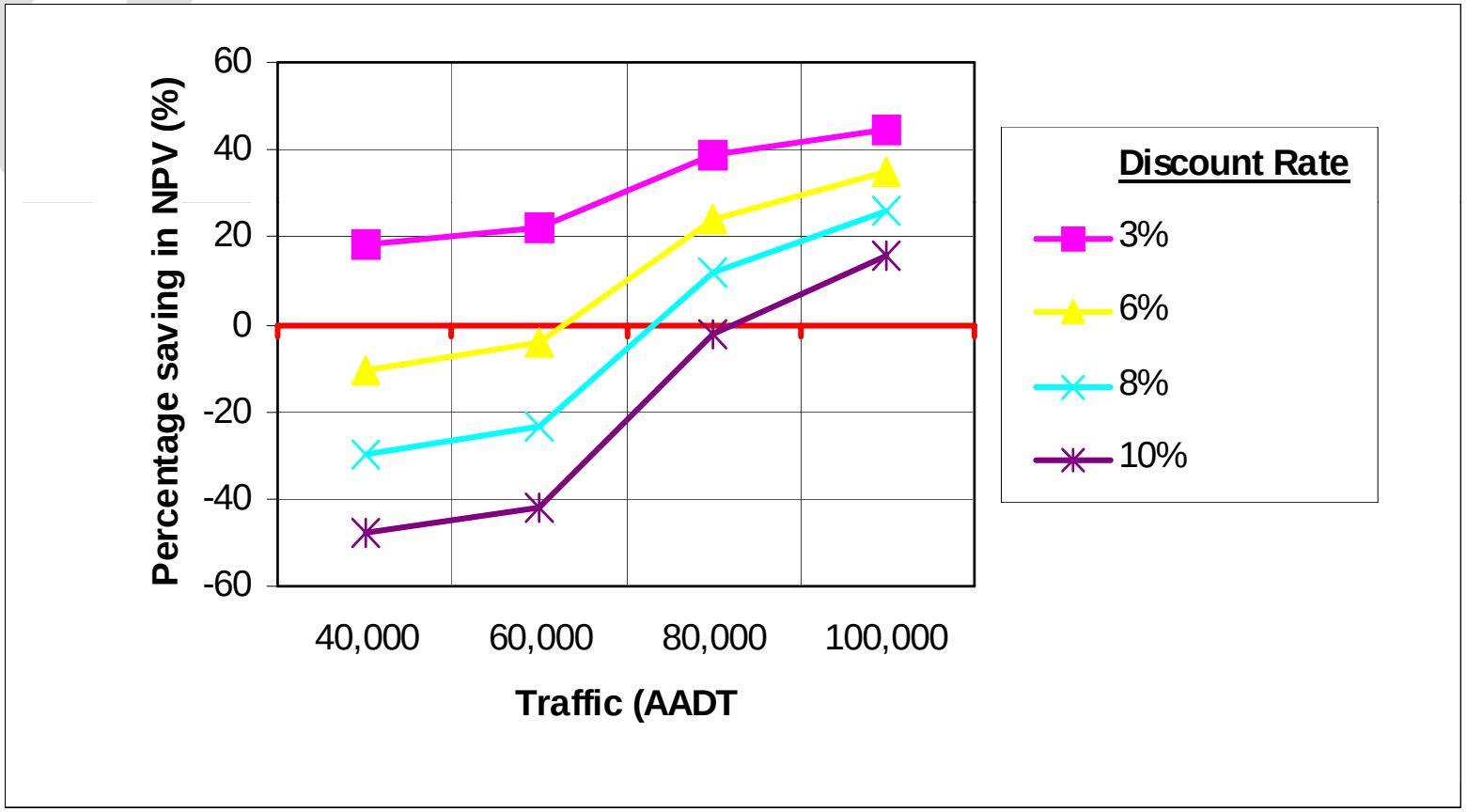
Long Life Pavements – Phase I Report: Economic Evaluation Findings

- LLP Phase 1 Report was published by OECD in 2005
- Economic analysis in Phase I study explored potential economic benefits of long life wearing courses able to meet performance requirements over 30-40 years
- Findings: long-life surfacing costing around three times that of traditional wearing courses would be economically feasible for a range of high-traffic roads
- Emphasises importance of taking user costs into account

Economic Evaluation of Long Life Pavements – Phase I Findings: 1 km of 3-lane motorway surfacing Indicative Economic Evaluation results

Surface Treatment Costs	**Present Value ($000s)**	
Contributing Factors	***Traditional***	***Advanced***
Initial works costs	480	1 440
Maintenance works	1 080	280
User costs (Delays)	1 280	520
Traffic Management Costs	260	170
Residual value	- 40	- 90
Net Present Value (NPV) =	3 060	2 320
Difference in NPV of costs:		**- 740**
Percentage difference		**- 24%**

Economic Evaluation of Long Life Pavements – Phase I Findings: 1 km of pavement surfacing Potential Benefits (considerable)



Long Life Pavements – Phase I Report: Phase I Findings

Phase I Study

- Maintaining safe, comfortable and durable surfaces on heavily trafficked motorways is a major challenge to road owners
- Economic Findings: long-life surfacing costing around three times that of traditional wearing courses could be economically feasible
- Findings on Materials: Two long life surfacing materials warrant further investigation:

- Epoxy Asphalt
- High Performance Cementitious Materials (HPCM)

Long Life Pavements – Phase II project

Phase II Testing Programme

- Phase II project adopted by JTRC Committee in 2004
- Participation in Working Group nominated by member countries in 2004
- National laboratories involved in coordinated testing programme which began late 2004
- Testing to be undertaken over period from end of 2004 until end 2006

Long Life Pavements Phase II project: Mandate

- Scope of the Phase II study as approved by Transport Ministers of OECD and ECMT countries in May 2004 was:

- *"This next phase of the project will coordinate sufficient initial testing by national testing laboratories to assess the durability of the wearing courses. This will involve small-scale testing (laboratory testing and accelerated load testing) of the most promising pavement materials".*

Administration, user and industry interests

Administrations

- Better value roads
- More effective use of road construction and maintenance budgets
- Further insights on production and laying long life surfaces using advanced surfacing materials
- Indicative costs of advanced surfacing materials (cf. economic feasibility of long life pavements identified in Phase 1)

Users

- Improved service levels / reduced traffic congestion by administrations avoiding the need for road maintenance over an extended (30 year +) service life
- Better value roads with lower present value of life-cycle costs

Industry

- Innovation and opportunities for lowering whole of life project costs
- Further development of long life pavement materials by industry

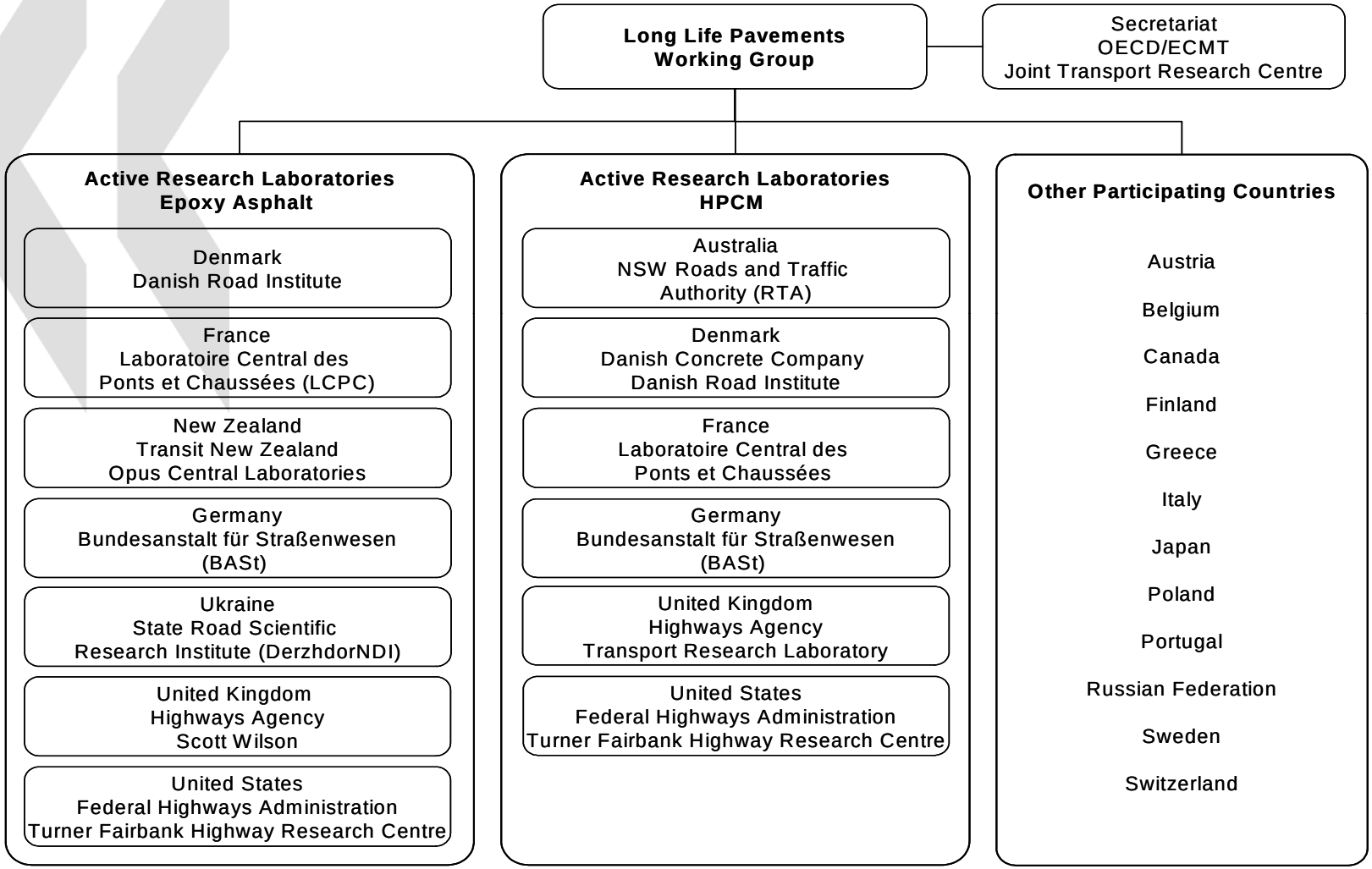
Long Life Pavements Phase II project: Objectives

- Phase II aimed to strengthen knowledge about the potential and limitations of *Epoxy Asphalt* and *High Performance Cementitious Materials (HPCM*), by:
  - Establishing properties and behaviour of the two materials
  - Optimising material mixes
  - Testing their performance / suitability for long-life wearing courses
  - Proposing Phase III full scale tests if performance results are positive and indicative costs generally consistent with Phase I

Long Life Pavements Phase II project: Participation

- **Laboratory testing***: 9 active laboratories from 8 countries*
  - Australia, Denmark, France, Germany, New Zealand, Ukraine, United Kingdom (x2), United States
- **Working Group members***: 37 members from 18 supporting countries and JTRC Secretariat*
  - Australia, Austria, Belgium, Denmark, France, Germany, Greece, Italy, Japan, New Zealand, Poland, Portugal, Russian Federation, Sweden, Switzerland, Ukraine, United Kingdom, United States.
- **External Reviewers of Final report***: from 2 other countries:*
  - Canada and Finland

Organisation of the project



Epoxy Asphalt Surfacing

Epoxy Asphalt Surfacing

- Epoxy Asphalt is a premium material, which has been used for many years as a road surface on stiff bridge decking.
- The first such application, in San Francisco in 1967, is still meeting performance requirements, after 40 years of service.
- Over time, Epoxy Asphalt has been more widely used for stiff bridge decking applications in a number of other countries
- Epoxy Asphalt has recently been used extensively for bridge deck applications in China.
- Epoxy Asphalt is a material with high stiffness that can be applied in thin surface layers.
- Acid-based Epoxy Asphalt mixtures have been found to have greatly improved performance compared to conventional mixtures.

Epoxy Asphalt Surfacing

Two components of epoxy asphalt

Part A Part B

Demo of handling characteristics

Epoxy Asphalt
Testing and Test Results

Cured epoxy asphalts are **significantly**:

- Stiffer (higher modulus) at service temperatures, with greater load spreading ability.
- More resistant to rutting.
- More resistant to low temperature crack initiation and propagation.
- More resistant to surface abrasion from tyre action, even after oxidation.
- More resistant to fatigue cracking (although the benefits are less marked at higher strain levels)
- Less susceptible to water induced damage
- More resistant to oxidative degradation at ambient temperatures.

Epoxy Asphalt Performance Assessment

- Type of epoxy materials needs to be chosen carefully
- Great care needed in choice of aggregates for best performance
- Epoxy asphalt needs close supervision at time of production and laying to ensure full mixing is carried out
- Time and temperature need to be carefully monitored to achieve the best performance outcomes.
- Overall, the testing indicated that Epoxy Asphalt should provide a durable surfacing, even in the most heavily trafficked road situations
- With a much extended, practically maintenance-free life of 30 years or more.

Epoxy Asphalt
Research issues

Important issues for consideration in future research include:

- *Curing and construction time*. Some laboratory work is needed prior to any demonstration projects to optimise the curing profile with the desired rate of reaction for the local conditions (time for curing, distance of transport and laying etc).
- *Curing period.* It is important to establish when after the initial blending of the epoxy asphalt the reaction is complete.
- *Curing temperature.* Some epoxy systems have shown the ability to cure rather rapidly at a lower temperature than might be expected. The prospects for lower temperature curing – and the related potential for energy and cost savings during production - need further research.

Epoxy Asphalt
Construction issues

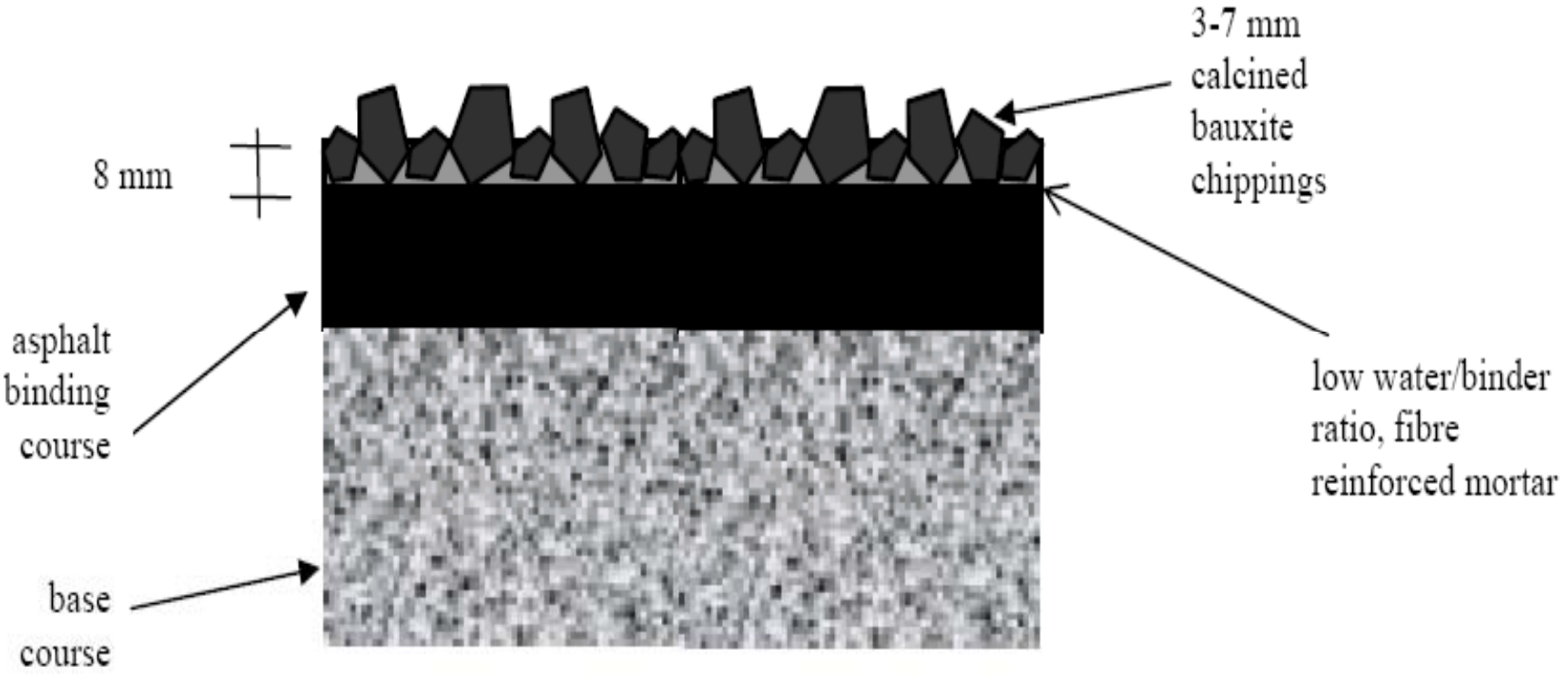
- Production experience to date has almost exclusively been with a batch plant that gives good control of mixing time
- The risk of construction failures and damage to plant is greater than with conventional bitumen
- Due to the thermosetting nature of the material, extra care is required in the timing of manufacturing and construction phases to ensure the product is not over-cured before compaction
- When uncured, certain epoxy materials are strong allergy provoking compounds. These were not used for the Epoxy Asphalts in this project. However, if such materials are used, special equipment and safety precautions would be required

High Performance Cementitious Materials (HPCM)

High Performance Cementitious Materials (HPCM)

- High-Performance Cementitious Material (HPCM) is an innovative product developed and tested for road surfacing applications for the first time during the present project.
- This advanced pavement surfacing consists of a layer of ultra-high performance, fibre-reinforced fine mortar, in which hard, polish resistant aggregate particles are embedded, forming a 10 mm composite layer.
- As a new surfacing material with no obvious reference material, considerable work was undertaken on the development of HPCM mixes with the most suitable properties
- Evaluation of the HPCM needed to focus principally on the actual test results.

High Performance Cementitious Materials (HPCM)



High Performance Cementitious Materials (HPCM)
Testing and Test Results

- The test programme was undertaken primarily at laboratory scale and focussed on the main performance issues, including general physical properties of HPCM, particularly in regard to:
- bond to substrate and capability to establish a lasting bonding of chippings to the matrix
- Ductility and fatigue properties
- Durability under environmental impact
- Surface properties, noise and skid resistance
- Testing of the HPCM matrix showed that the material can be characterised as High Strength/High Modulus.
- The results indicate HPCM wearing courses will have good bonding properties as well as durability, confirming these objectives have been achieved.

High Performance Cementitious Materials (HPCM)
Performance Assessment

- A number of requirements need to be met - including a lower layer which is strong and even, and careful embedding of chippings - to ensure maximum performance.
- By comparison with Epoxy Asphalt, the HPCM solution needs more development, including operational laying techniques, before being ready for *commercial* introduction as a long life surfacing.
- However, testing has shown that HPCM has great strength and integrity and indicates there is a high probability that the remaining uncertainties about HPCM applications will be overcome.
- From the testing and the performance in the tests, it is expected that this surface, based on further trials, can be developed into a final product characterised by high safety, comfort, durability and limited noise emission.

High Performance Cementitious Materials (HPCM)
Research issues

A number of issues were identified for future research and testing, including:

- *Effect of water dosage on HPCM properties.* The water dosage has a significant impact on mortar engineering properties, such as: ease of mixing (at industrial scale) and workability; chippings loss; and bond with the asphalt.
- *Industrial application technology.* The adaptation of existing equipment or the practical development of new pavement laying equipment needs to be given a high priority to support the proposed Phase III field testing.
- *Two-dimension cracking tendency.* The test pad chosen for testing *two-dimension cracking tendency* needs to be fully representative of a real pavement and laid on a sufficiently stiff asphalt material

High Performance Cementitious Materials (HPCM)
Construction issues

- Production of HPCM is seen as a manageable process using existing know-how and equipment.
- However, some modification of existing equipment or development of new equipment will be required for laying the HPCM mortar and inserting the chippings.
- Construction factors that are important include the availability of constituent materials, the mixing process and the workability of the freshly mixed material.
- The application of the chippings should ideally take place immediately after placing the thin mortar layer, i.e. with the same machine or with a chip spreader.
- A light rolling or tamping action is required to ensure the desired embedment of the chippings and a flat, even running surface.

Expected Advantages of Long Life Wearing Courses

- Epoxy Asphalt and HPCM surface pavements types which have been the objects for the research described in this report are intended to serve as a cure to the problems of today's pavements on densely trafficked roads.
- They are both developed with a target service life minimum of 30 years
- Interpretations and extrapolations of the results of the tests conducted during this project do not contradict the assumptions that this target is achievable
- However, they also need to be able to lower overall life cycle costs – despite higher initial costs – to be economically viable.

Indicative Cost Estimates:
Comparison of EA, HPCM & Reference mixes

Table : Comparison of costs between materials

TYPICAL SURFACING COSTS IN €/M^2 FOR WESTERN EUROPE			
Description	**Epoxy Asphalt 30mm wearing course**	**HPCM 10mm wearing course**	**Conventional 30mm asphalt solution**
Expected Lifespan	30 years?	30 years?	7-15 years
Milling 50-100mm	0.75-1.25	0.75-1.25	0.75-1.6
Binder course (50mm)	6-10	8-12	6-12
Tack/bond coat	0.25		0.1
Wearing course	18-31	20	6-12
Total costs	25-42.5	29-33	13-25

Interpretation of Indicative Cost Estimates

- In Phase I work, significant benefits were expected if long life pavement surfacings cost no more than around 3 times conventional surfacing costs
- The indicative cost estimates identified in Phase II work would appear to be broadly consistent with the Phase I envelope of costs, suggesting there could be significant benefits in their use.
- Indicative costs of an advanced surfacing could be between 2 and 3 times the cost of a conventional resurfacing treatment.
- These cost premiums for the Epoxy and HPCM wearing courses, by comparison with conventional (reference) surfacing costs, are probably less than assumed for the Phase I study, due in part to:
  - having a better understanding of the costs and production processes involved
  - the significant increase in the cost of asphalt surfacing, particularly in Western Europe, in recent years.

Phase II project: Conclusions

- The project has succeeded in demonstrating the scope for significant advances in surfacing materials that are not normally considered in the traditional thinking for highway pavement development.
- The expectations for the long-life capabilities of the materials are based on extrapolations of observations made during the testing, but nobody can give full guarantees for the behaviour of materials in the extrapolated time domain.
- If the potential economic benefits of these advanced technology pavements types are to be realised, then the innovation process must be taken to the next phase, in which the materials are tested in larger scales under real traffic on roads or off roads.

Phase II project: Conclusions (continued)

- Field Trials are necessary if the potential economic benefits of these materials and techniques are to be realised
- The project has progressed to the point where limited Field Trials under traffic - either on the road network or off-road - are the logical next phase
- As always, with such larger-scale trials of new materials and techniques, there are risks.
- Nevetheless, some road authorities, perhaps in partnership with industry, will probably be prepared to take this step.

Phase III Field Trials: Overall Aims

The overall aims of a coordinated programme of field trials of the Epoxy Asphalt and HPCM surfacings are:

- To demonstrate that the performance envisaged on the basis of the laboratory tests and the accelerated testing will hold within the period of the trial under real traffic and environmental conditions.

- Collateral aims include to: develop construction methods, improve cost estimates, optimise material mixes and increase contractor experience levels.

Recommendations for Phase III

The Report from Phase II recommends that:

- Interested road authorities be invited to register with the JTRC Secretariat their interest in joining the proposed trials as soon as possible after the publication of this report
- When at least three trial offers have been received involving use of Epoxy Asphalt or HPCM surfaces, a preparatory meeting be called by the host organisation.
- Such preparatory meetings will appoint a coordinator and agree on the plans and principles for the management of the trials.
- Participants may begin trials whenever it suits their plans after the preparatory meeting, but not later than May 2009.
- The trials must last a minimum of 2 years and must be terminated no later than May 2011.

Recommendations for Phase III (continued)

- Participants are to deliver their final report within 3 months after their trials have been completed and no later than in July 2011.
- Coordinators to prepare consolidated reports for the two pavements types in cooperation with participating countries

The Report further recommends that:

- The JTRC assumes the role of the host organisation and responsibility for calling the meetings of the participants in this Field Trial phase.
- The responsibility for the funding and management of the field trials as well as recording and disseminating of the results of the trials rests with the sponsoring organisations, the participants and the project coordinators.

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“Long Life Surfacings for busy roads”

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For further information, see :
http://www.cemt.org/JTRC/WorkingGroups/Pavements/index.htm