APPENDIX B2 – TECHNICAL NOTES

B2.1 PAVEMENT DETERIORATION AND PREVENTATIVE MAINTENANCE

Overview

Preventative maintenance is a planned strategy of cost-effective treatments to an existing highway in order to preserve it, prevent ingress of water, reduce the rate of future deterioration and increase service life, without increasing its structural capacity. Preventative maintenance is typically applied to highways with some remaining service life and comprises road surface treatments that include crack sealing, surface dressing, slurry or micro-surfacing and thin and hot-mix asphalt inlay and overlay. Programmes for preventative maintenance should be reflected in the local highway authority's highway asset management plan.

Pavement condition

Preventative maintenance should be applied when the surface shows early signs of distress such as cracking. Typically cracks in pavements are only observed directly when they are at the surface of the wearing course and exceed a visible width. Often the surface manifestation is the final stage of propagation of a crack from lower in the pavement structure, which has had the effect of weakening the asphalt layer.

Cracking can develop in a number of ways. If the road surface appears crazed with numerous superficial cracks of limited depth but otherwise in good repair then veneer dressing, veneer surfacing or overlay may be cost effective. If the cracks are only in the surface course then a plane and replace asphalt inlay may be appropriate.

Any cracks which are present in the pavement surface may act as a pathway for water to enter the pavement structure and may cause pothole formation. If cracks are not treated, the deterioration of the pavement will continue until the cracks become defects such as potholes. On more lightly trafficked roads, particularly unclassified roads, the environment is the primary weakening agent of the structure. These environment effects include wetting/drying, warping through temperature change of freezing of granular layers and embrittlement of the surface course through oxidation of the binder.

Typical defects such as cracking may be identified from SCANNER and other surveys such as CVI, DVI and FNS. For the classified network condition is reported using the Road Condition Indicator (RCI). This uses a red/amber/green rating to report on the condition of the road. Roads in red are in the worst condition and may require structural maintenance. Roads in amber require some investigation to determine whether maintenance treatments are required. Roads in green generally require no maintenance, other than routine activities. Intervention when roads are in the amber condition would generally support a preventative approach to maintenance.

The shape of the surface of the pavement is also important in preventing the ingress of water. A poor transverse profile can cause water to pond in the wheel-paths and likewise a poor longitudinal profile can result in dynamic impact loading from vehicles leading to the same effect. Cyclical pressure and suction caused by the passage of

vehicle tyres in these areas can be the precursor of distress and pothole formation. Dynamic traffic effects can also lead to local cracking distress around 'rigid' areas in an otherwise 'flexing' highway. These rigid areas are usually ironwork features such as gullies or service covers and it may be appropriate to consider these carefully in the selection of maintenance surfacing materials or provide a ductile transition zone to minimise dynamic loading in these areas which can be sensitive to cracking.

If roads are left to deteriorate defects such as cracking will be more severe and reflect deeper structural failure that will require replacement of the pavement layers. Each site must be considered based on the engineering characteristics at that location.

Preventative treatments

Preventative maintenance treatments include; surface dressing, slurry sealing/micro surfacing thin and hot mix asphalt overlays and can be applied to roads, cycleways and footways. To prevent water entering the pavement structure, its surface should be as impermeable as practicable.

Application of surface treatments will seal the road surface and prevent water from entering the pavement structure. This will lengthen the life of the pavement structure and delay intervention with more expensive structural maintenance. It will also help to prevent the formation of potholes. It is particularly important to ensure that all joints in the road surface are thoroughly sealed to keep the surface water out. Joints are caused by paving construction operations, pothole and patch repairs and by utility reinstatements.

It should also be noted that discrete well defined individual cracks may be in-filled to reseal or have over-band sealing applied but for thin pavements, which are constantly flexing, these treatments may have limited life unless formed with strain compatible materials. Further guidance on these treatments is given in Design Manual for Roads and Bridges (DMRB) Volume 7, Section 4 'Pavement Maintenance Methods', HD 31/94 (Ref. 1).

Crack sealing is also covered in HD31/94, in Chapter 2 'Minor Maintenance' for surface treatment and in Part 4 'Major Maintenance' for reflection crack treatment. Use and application for crack sealing are clearly stated in the HD and the basis of selection is either generic or BBA certificated products.

Various local highway authorities are using velocity patching and thermal road repair techniques as tools in their preventative treatment programmes. Both techniques are described more fully below.

Benefits of Preventative Treatments

Pavement Maintenance Management for Roads and Streets Using the PAVER System by M Y Shahin and J A Walther (Ref. 2), shown below in Figure 1, demonstrates early intervention with planned maintenance will provide a more economic solution for maintenance of the road when compared to intervening when the pavement is in a failed state. *Going the distance* (Ref. 3) cited two Councils which estimated that timely planned periodic maintenance saved their agency costs, over unplanned emergency or a 'worst first' philosophy, by a factor varying between 2 ¼ and 3 ¾.

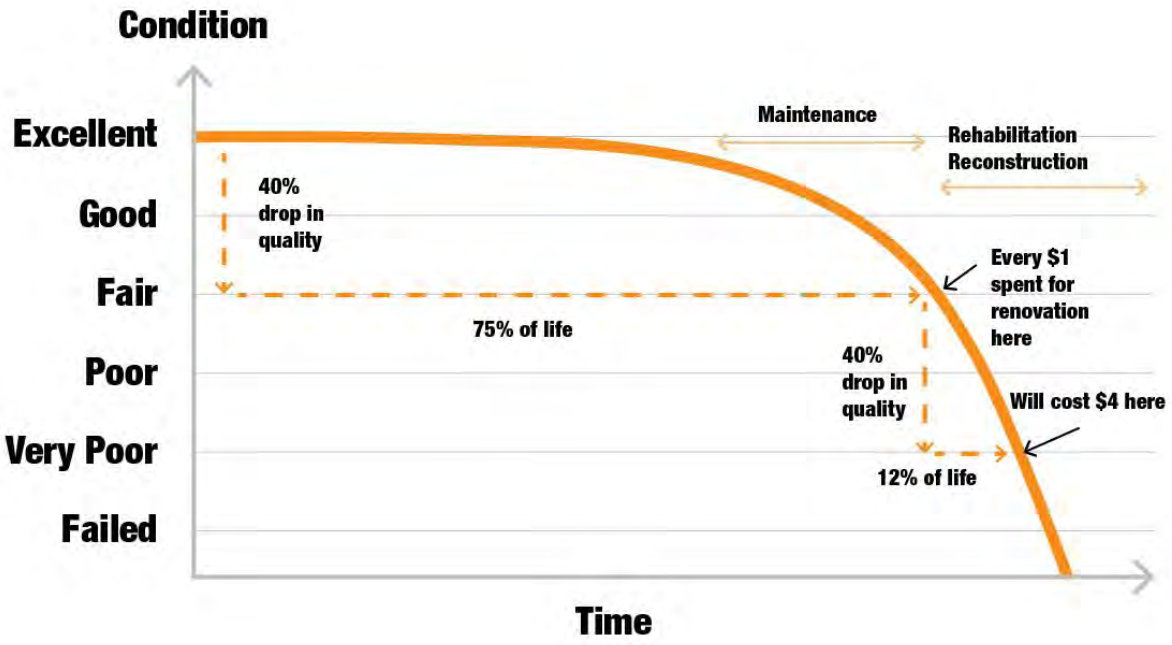

Figure 1: Benefit of Early Intervention

It has been found that the spend ratio of 1:4 shown in Figure 1 is now more realistically 1:5 or 6 based on current UK industry figures.

Expected life of surfacings

Estimated lives of surfaces have been made by TRL in *Increasing the environmental sustainability of asphalt* (Ref. 4), as reproduced in Table 1.

Table 1: Expected service lives of surfacings

Type	Category	Expected life
Thin surfacing	BBTM / TAC	11 to 15 years
	SMA / TSMA	10 to 16 years
	UTLAC / PLSD	8 to 11 years
	Multiple surface dressing	4 to 8 years
	Microsurfacing	2 to 6 years
Hot rolled asphalt	High and medium stability	14 to 24 years
	Low stability	8 to 13 years
Asphalt concrete	Dense bitumen macadam	10 to 16 years
	Open graded macadam	6 to 10 years
	Marshall asphalt	15 to 25 years
Surface dressing	Racked-in or double	4 to 8 years
	Single	3 to 5 years

The above table provides useful information when considering the lifecycle of various treatment options that could be used for preventative maintenance treatments.

In May 2011 ADEPT and RSTA published a joint report entitled *Service Life of Surface Treatments* (Ref. 5) in which agreed industry service life values were provided for various surface treatments. This was undertaken as an essential part of asset management including the requirements for depreciation and lifecycle planning.

Table 2: Expected service lives of surface treatments

Type	Category	Service life
Surface dressing	Low to medium traffic	15 years
Surface dressing	Medium to high traffic	10 years
Micro surfacing	Carriageway	10 years
Slurry surfacing	Carriageway	6 years

B2.2 VELOCITY PATCHING

The RSTA has produced a Code of Practice for Velocity Patching that has been peer reviewed by ADEPT and published on the RSTA website (http://www.rsta-uk.org/publications.htm). The process may be summarised as follows:

Velocity Patching is the generic phrase used within BS434-2 (Ref. 6) to describe the process of using high volume low pressure air to clean the road surface defect, before applying a bond coat of either a hot or cold bitumen emulsion. Aggregate is then propelled, using high volume air at low pressure, before mixing it with the bitumen emulsion moments before it is compacted as it is placed in the ground. The new repairs can then be trafficked immediately after laying. Velocity Patching does not repair underlying road base problems.

The design considerations of Velocity Patching are particularly important in order that the treatment applied to the road surface is right for the circumstances in which it has to operate and the job it has to do. Site inspections will help to determine the specification, i.e. aggregate PSV, binder type and content, required technique, machine type, should the repairs be racked in, screened with dry aggregate, sand, or be rolled, treated with a pad coat to prepare for surface dressing and are they required as a temporary or permanent repair. Each site must be considered in the light of its unique characteristics, including the nature of surface, geography, volume and speed of commercial and other traffic using the section of road. The type of material is designed to reflect the end use of the site; the local highway authority's needs; application techniques; weather conditions; site preparation and after care. The selection and compatibility of the correct materials and application rates of material is as important as the design of other engineering works.

Velocity Patching can be undertaken on a wide range of roads and the location will determine the machine type to be used. The process is included within National Highway Sector Scheme 13 the *Supply and Application of Surface Treatments to Road Surfaces* (Ref. 7).

B2.3 THERMAL ROAD REPAIRS

The RSTA has drafted a Code of Practice for Thermal Road Repairs that is being peer reviewed by ADEPT. It is anticipated that this will be published in summer 2012. The Thermal Road Repair System is a permanent road repair system that re-heats in the range 150-230°C using an infra-red heating process and facilitates recycling of the existing in-situ material. When the surface has been heated to the required temperature a joint is cut into the surface up to 100 mm inside the perimeter of the heated area. The surface is raked thoroughly to expose the maximum surface area within the material and asphalt is added to facilitate the repair of the road surface together with additional bitumen rejuvenator if required. Repairs are fully compacted immediately using conventional compaction equipment.

The following is an extract from the draft code of Practice:

The design considerations of Thermal Road Repairs are particularly important in order that the treatment applied to the road surface is right for the circumstances in which it has to operate and the job it has to do. Each site must be considered in the light of its unique characteristics, including the nature of surface, geography, volume and speed of commercial and other traffic using the section of road.

Authorities proposing to use Thermal Repairs should ensure the systems proposed are suitable for the existing surfacing material including DBM and TSCS. Where HAPAS certificates are supplied local highway authorities should check their suitability for the location proposed. With regard to the right location for use the certificate may state that durability will depend on the surrounding surface, location and traffic levels. If used to repair potholes an increased volume of virgin material will be utilised in order to fill the hole and replace the displaced material; this may result in a more costly solution if bagged material is used as opposed to standard asphalt mix from a hot box.

B2.4 HOT MIX REPAIRS

The Highways Agency has several documents that refer to patching and pothole repairs for their strategic highway network. The Highways Agency's documentation includes:

- SHW clause 946 – Patching and Repairs to Potholes and Depressions (Including Emergency Patching) (Ref. 8)
- IAN 90/07 – Guidance for the use of Emergency Patching Materials which includes a flowchart for the 'Usage of Emergency Patching Materials'. (Ref. 9)
- HD31/94 – Minor Maintenance Carriageway Patching (Ref. 1) which states that the need for patching arises from the gradual deterioration of the bituminous surfacing material with age with it eventually breaking up and forming crazed areas and potholes. There are circumstances when an emergency pothole repair or carriageway patch is required. In these circumstances use of a pre-bagged proprietary material is allowed. This shall be replaced with the appropriate material on a planned patching maintenance operation as soon as possible.
- IAN157/11 – Thin Surface Course Systems (TSCS) Installation and Maintenance (Ref. 10) which states with regard to local repairs that the HAPAS certificates for

TSCS contain instructions and guidance on appropriate methods and materials for repair of local surface defects. These must be referred to for the planning of repairs. For repairs not covered by the information in the HAPAS certificates, Clause 946 of the SHW must be used. For small, local repairs, it is good practice to use a smaller nominal aggregate size for patching than that of the original surface i.e. patch a 14 mm TSCS with 10 mm TSCS.

Local highway authorities often make use of such documents albeit with local variations.

It is evident from consultations with a variety of local highway authorities and research of local highway authority websites that a wide variety of solutions are used. There is no doubt, however, that hot mix asphalt is the preferred, most commonly used solution and the majority of those authorities follow the general practice as described in the ADEPT report *Potholes and Repair Techniques for Local Highways* (Ref. 11) for a permanent repair.

The following is an example of a specification that may be considered as a basis for hot mix pothole repairs and is drawn from information provided by a variety of authorities:

Example specification for hot mix repair

1. All loose material to be removed and the hole stabilised by cutting back the edges to sound material or as indicated on site.
2. The existing surface course to be saw cut to a minimum depth of 35 mm but not exceeding 50 mm to provide vertical edges with the shape of the repair to ideally be a diamond layout in the direction of traffic. For deeper holes the lower layers may be removed by the use of a jack hammer or milling machine/mini planer.
3. All loose material to be removed and the base of the hole cleaned of all detritus.
4. Apply cold poured thixotropic sealer as a bond coat to base and sides for full adhesion.
5. Apply selected infill material as delivered in hot box (based on ease of installation, adjacent surface and good compaction to give low air void content) which will include one of the following:
   a. AC 6 dense surf 100/150 October to March or AC 6 dense surf 70/100 April to September
   b. AC 10 dense surf 100/150
   c. HRA 55/10F
   d. HRA 30/14 with PCC

   Note: PSV of aggregate must be stated by local highway authority.
6. Infill material to be laid in layers not exceeding 40mm.
7. Fully compact laid material using appropriate rollers or vibrating plates depending on the size of the repair to provide finished surface with an air void content between two per cent and eight per cent, dependent on material.

B2.5 COLD REPAIRS

Cold repair materials include the use of Deferred Set Asphalt Concrete and a range of cold applied proprietary products. The following is an example specification clause 971AR for Deferred Set Asphalt Concrete material that could be used as a basis for local highway authorities developing their own specifications.

971 AR Deferred Set Asphalt Concrete

1 Deferred Set Asphalt Concrete materials shall be designed by the Contractor to provide either a deferred set or storage grade material in the following categories:

i. Materials for use on the day of manufacture.

ii. Materials for use on the day of manufacture after a prolonged period of transport.

iii. Materials for use within five days of manufacture.

iv. Materials for depot storage and use at least 21 days from the date of manufacture.

The Contractor may introduce additional categories to the above for storage times to suit the materials proposed for use.

2 The material shall be designed so that wherever possible it can be laid by machine. The method of laying shall be agreed with the Contractor when the order is placed for the material.

3 The material shall be designed to be sufficiently stable to resist deformation by normal traffic loading within one hour of installation.

4 The Contractor shall provide information on storage and installation requirements for these grades of materials and the delivery ticket should confirm which grade of material is being supplied.

5 These materials shall conform where practicable to the requirements of BS EN 13108-1 (Ref. 12) and the guidance in BSI PD 6691 (Ref. 13) for the following mixture designations:

AC 6 Dense surf 100/150

AC 10 Dense surf 100/150

AC 20 Dense bin 100/150

Aggregate

6 Aggregate used for deferred set Asphalt Concrete materials shall conform to the requirements of BS EN 13043 (Ref. 14) and Clause 901.

7 To ensure adequate resistance to polishing and abrasion, the coarse aggregate in surface course mixtures shall have a minimum declared PSV as specified in Appendix 7/1, in accordance with BS EN 13043, clause 4.2.3. and BSI PD 6682-2 (Ref. 15), and shall have a maximum declared AAV, as specified in Appendix 7/1, in accordance with BS EN 13043, clause 4.2.4 and BSI PD 6682-2.

Binder

8 The binder shall be based on 100/150 Grade paving grade bitumen complying with BS EN 12591 (Ref. 16) or polymer modified bitumen complying with BS EN 14023 (Ref. 17). The use of proprietary binders will be permitted.

9 Where a proprietary binder is used, the Contractor shall submit details of the maximum and minimum temperature requirements for handling and storage of the binder and the mixed material.

Cold applied proprietary products

There is a variety of bagged/tubbed proprietary products on the market that purport in the literature to be for filling potholes. Different aggregate size, different aggregates and different polymer additives make it difficult to compare products. Generally materials used are 0/6 or 0/10 with a graded aggregate being mixed with a proprietary binder of bitumen and a viscosity controlling additive. They are supplied in tubs up to 25 kg or in bulk with a storage life of up to 6-12 months and five days respectively.

All products must be used in the correct circumstances of traffic, location and existing pavement. Some product data advises the uses that can be made whilst some have HAPAS certificates which clearly state the narrow range for a particular product. All HAPAS certificates are promoted through the Permanent Cold-Lay Surfacing Material sector. Many authorities have tried various products however few have undertaken extensive trials and even fewer have monitored the trial to provide performance data over time for such products. Some have approved a product or two that suits their needs based on use and cost.

Product data varies however some of the benefits highlighted include the following:

- Permanent repair
- Works in water
- Open to traffic immediately
- Reduced waste
- Speed of operation hence less traffic disruption
- Environmentally friendly – low energy use, cold applied, recyclable

REFERENCES

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13. BSI PD 6691 – Guidance on the use of BS EN 13108 Bituminous mixtures. Material specifications, 2010
14. BS EN 13043 – Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas, 2002
15. BSI PD 6682-2 – Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas, 2009
16. BS EN 12591 – Bitumen and bituminous binders. Specifications for paving grade bitumens, 2009
17. BS EN 14023 – Bitumen and bituminous binders – Specification framework for polymer modified bitumens, British Standards, 2010

GLOSSARY

AAV	Aggregate Abrasion Value
AC	Asphalt Concrete
ADEPT	Association of Directors of Environment, Economy, Planning and Transport
BBA	British Board of Agrément
BBTM	Béton Bitumineux Très Mince (Very Thin Bituminous Concrete)
CVI	Coarse Visual Inspections
DBM	Dense Bitumen Macadam
DMRB	Design Manual for Roads and Bridges
DVI	Detailed Visual Inspections
FNS	Footway Network Survey
HAPAS	Highway Authorities Product Approval Scheme
HRA	Hot Rolled Asphalt
PCC	Portland Cement Concrete
PLSD	Paver Laid Surface Dressing
PSV	Polished Stone Value
RCI	Road Condition Indicator
RSTA	Road Surface Treatments Association
SCANNER	Surface Condition Assessment for the National Network of Roads
SMA	Stone Mastic Asphalt
TAC	Thin Asphalt Concrete
TSMA	Thin Stone Mastic Asphalt
TRL	Transport Research Laboratory
TSCS	Thin Surface Course Systems
UTLAC	Ultra Thin Layer Asphalt Concrete

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