VOLUME 7 PAVEMENT DESIGN AND MAINTENANCE

SECTION 4 PAVEMENT MAINTENANCE METHODS

PART 1

HD 31/94 AMENDMENT NO. 2

MAINTENANCE OF BITUMINOUS ROADS

SUMMARY

This amendment revises Chapter 1 'Introduction' and Chapter 2 'Surface Treatments'. A paragraph on headrooms has been added to Chapter 1 and Chapter 2 has been amended to include the latest advice on Crack Sealing and information on other surfacing treatments.

INSTRUCTIONS FOR USE

1. Insert the replacement pages listed on the amendments sheet (Amendment No. 2), remove the corresponding existing pages which are superseded by this amendment and archive as appropriate.

2. Insert the Registration of Amendments sheet at the front of the document after the new front sheet.

3. Sign and date the Registration of Amendments sheet to confirm that the amendment has been incorporated.

4. Archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd.

DESIGN MANUAL FOR ROADS AND BRIDGES **HD 31/94**
incorporating Amendment
No. 2 February 1998

THE HIGHWAYS AGENCY

THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT

THE WELSH OFFICE
Y SWYDDFA GYMREIG

THE DEPARTMENT OF THE ENVIRONMENT FOR NORTHERN IRELAND

Maintenance of Bituminous Roads

Summary: This amendment revises Chapter 1 "Introduction" and Chapter 2 "Surface Treatments". A paragraph on headrooms has been added to Chapter 1 and Chapter 2 has been amended to include the latest advice on Crack Sealing and information on other surfacing treatments.

AMENDMENT NO. 2 (FEBRUARY 1998)

Replacement Pages

Page number	Date
Chapters 1 and 2 - Pages 1/2 -2/4	**February 1998**

The replacement front sheet supersedes that dated January 1994. The superseded pages should be archived as appropriate.

Implementation

The replacement pages should be used forthwith on all schemes for the construction, improvement and maintenance of trunk roads, including motorways.

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

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PART 1

MAINTENANCE OF BITUMINOUS ROADS

Contents

Chapter

1. INTRODUCTION

General

1.1 The standard procedures for inspection and monitoring of flexible pavements and the design of major maintenance measures (ie. overlaying and reconstruction) have been given in HD 28, 29 and 30 (DMRB 7.3) - Pavement Maintenance Assessment. This Part concentrates on the methods to be used for minor repairs and surface treatments as well as major strengthening works and is concluded by looking at the current methods for recycling of bituminous pavements.

Headrooms

1.2 At the end of all surfacing operations, it is essential that the headroom beneath all overbridges is surveyed by the contractor carrying out the work to ensure that heights have not been reduced below the required minimum for that bridge. See also TD 27 (DMRB 6.1.2.5). Survey measurements should be recorded and included with 'as-built' information. Instructions to carry out these surveys are to be included on drawings and in specifications as appropriate by Design Agents and Maintenance Agents.

Implementation

1.3 This Part should be used forthwith on all schemes for the construction, improvement and maintenance of trunk roads including motorways, currently being prepared provided that, in the opinion of the Overseeing Organisation this would not result in significant additional expense or delay progress. Design organisations should confirm its application to particular schemes with the Overseeing Organisation.

Mutual Recognition

1.4 The construction and maintenance of highway pavements will normally be carried out under contracts incorporating the Overseeing Organisation's Specification for Highway Works (MCHW1). In such cases products conforming to equivalent standards and specifications of other member states of the European Community and tests undertaken in other member states will be acceptable in accordance with the terms of the 104 and 105 Series of Clauses of that Specification. Any contract not containing these Clauses must contain suitable clauses of mutual recognition having the same effect regarding which advice should be sought.

2. SURFACE TREATMENTS

CRACK SEALING

2.1 Cracking in asphalt road surfaces can develop in a number of ways. The extent and severity of cracking together with its detrimental effect on the integrity of the road pavement will determine the appropriate maintenance treatment. There are a number of options available depending on the nature of the cracking, and that chosen should be the most cost effective option which prolongs the life of the road pavement and protects the road user.

2.2 Crack sealing is carried out to extend the useful life of the road pavement, by protecting the edges of cracks and joints from attrition by heavy traffic and by preventing the ingress of water. (See Figure 2.1)

Figure 2.1 Sealed Cracks

Before commencing a programme of sealing, it is important that consideration be given to possible alternative treatments and their cost effectiveness. For example, if a pavement appears crazed with numerous superficial cracks of limited depth, then surface dressing or bituminous thin surfacing of the section of the road affected may be a more cost effective and safer treatment. For smaller, more widely scattered areas so affected, it may be more appropriate to remove the affected area and insert a patch.

2.3 Well defined cracks of limited width where the edges are sound may be prepared and directly infilled with sealant to just below the surface. Wider cracks, or cracks where edges are vulnerable and in need of reinforcement may be prepared and sealed using a suitable overband sealing compound. As an alternative to overbanding, cracks may be widened by milling out to a shallow depth, between 20mm and the full depth of the wearing course, and reinstated with a repair material capable of accommodating the anticipated movement. Repairs of this nature, where wider than 20mm, must be surfaced with aggregate, finished to the same level as the adjacent surfacing and provide an enduring texture and skidding resistance not less than that of the adjacent pavement surfaces. Cracks and fissures which require reinforcement but are too closely spaced to allow overband sealing should be repaired and reinstated in this manner or by cutting out and patching if further movement is not anticipated.

2.4 The skidding risk to road users is negligible if the widths of cracks and crack seals are narrow. Narrow cracks can be sealed by infilling, wider cracks require surface sealing using textured skid resistant materials.

Cracks to be sealed by filling or overbanding less than 20mm wide

2.5 Well defined linear cracks or joints, where edge damage is not present, should be sawn or routed out and sealed to within 3mm of the surface with a hot-applied joint sealant Type N2 to BS2499 or a sealant having a BBA Roads and Bridges Certificate or Assessment, capable of accommodating the likely thermal and tensile/compressive movements. This method is particularly appropriate where a prime objective is to prevent the ingress of water. The sealed width should not exceed 20mm. The sealant should have a shape factor of 1 (Depth/Width) and be applied onto debonding tape or backing rod, as appropriate, to avoid adhesion to the base of the groove.

2.6 Where sealing by overbanding is necessary and where the width in-service will not exceed 20mm, then a hot-applied joint sealant Type N2 to BS2499 or a sealant having a BBA Roads and Bridges Certificate or Assessment may be used. Bituminous-based overband materials are visco-elastic in nature and are likely to soften and flow under high temperatures or repeated trafficking. If the in-service width may exceed 20mm then an overband treatment capable of providing an initial Skidding Resistance Value (SRV) of at least 60 should be used.

Crack sealing by overbanding wider than 20mm

2.7 Crack sealing, especially when indiscriminately applied, may pose a potential accident risk particularly when used to seal longitudinal cracks or joints and therefore it is important to use a treatment which will minimise this risk. When applied longitudinally, it is necessary that overbanding should not be mistaken for road markings, particularly in high reflective, wet and night conditions.

2.8 Where overband widths exceed 20mm, the materials shall be selected to provide adequate wet skidding resistance and to minimise the likelihood of the treated area being mistaken for road markings.

2.9 The thickness of the sealing compound on the road surface shall not exceed 3mm and the width of the band shall not exceed 40mm. The materials used shall contain grit or have grit added to provide a fine macro-texture surface.

2.10 The applied materials shall have an initial SRV greater than 60. The suitability of proprietary systems or ad hoc systems using readily available binders and aggregates shall be either certified by the BBA or tested by an independent testing laboratory to confirm that a sample area of the system when laid on a road pavement will give the required SRV and have a fine macro-texture. This shall be evidenced by testing by a U.K. Accredited Services (UKAS) accredited laboratory.

2.11 Samples of proprietary systems shall be taken from production at least once per annum and shall have an SRV greater than 60 as evidenced by testing carried out by a UKAS accredited laboratory.

2.12 Where overbanding is carried out on high skid-resistant surfacings (those treatments containing calcined bauxite chippings or equivalent) the treated width of the applied material must have an SRV and texture at least equal to that of the existing adjacent surfacing. For safety reasons the edges of the overbanding shall be feathered to avoid a ridge. The treated width of the overband need not be limited to 40mm in this specific case.

2.13 Measurements of SRV shall be made with the portable skid-resistance tester. The method used shall be that described in Road Note 27 (1969) but utilising the narrow slider (31.75mm) specified in BS812: Part 114, over the 126mm sliding length.

2.14 Overbanding either containing grit or with grit added may not always provide a totally effective seal against the ingress of water. Where it is judged essential that the crack be entirely sealed against the ingress of water and where an overband width will exceed 20mm, it may be more appropriate to repair using a treatment described in 2.2 or 2.3 above.

Inspection

2.15 It is important that road surfacings, which have had cracks sealed or overbanding applied, provide an adequate level of SRV with a reasonable working life.

2.16 Monitoring of treated areas by visual assessment should be carried out during routine inspections of the road network. If appreciable loss of texture is observed, measurement of SRV should be carried out. Remedial measures should be considered where the SRV is below an investigatory level of SRV 50. Such sites should be investigated to assess the extent of the risk and to determine the appropriate remedial work, as necessary.

SURFACE DRESSING

2.17 Surface dressing is one of the most common methods used for the maintenance of road surfaces. In its simplest form, a thin layer of bituminous binder is applied to the road surfaces and stone chippings are spread and rolled. Other more sophisticated multi-layer systems are available to suit a variety of surface conditions and traffic levels. Surface dressing retards the deterioration of the road structure by sealing the surface and increases texture and skid resistance. Fuller details of the various techniques and advice on their specification are given in HD 37 (DMRB 7.5.2.8).

THIN SURFACING

2.18 Thin surfacings are proprietary systems in which a hot bituminous bound mixture is machine-laid onto an emulsion tack or bond coat. They are generally between 15 and 40 mm thick compared to conventional hot rolled asphalt at 45-50 mm, and are gaining popularity as costs are reduced, and the speed at which maintenance can be carried out is much enhanced. Most systems permit minor regulation of existing surfaces, for example to remove existing ruts, as well as increasing texture and skid resistance. A number of

proprietary Thin Surfacing systems have been approved for use on Trunk Roads. Details of the various systems and techniques and advice on their specification will be provided in HD 37 (DMRB 7.5.2).

SLURRY AND MICRO SURFACING

2.19 Slurry and Micro surfacings are machine-laid mixtures employing plain or polymer modified bitumen emulsions as the binder. Slurry surfacings range in thickness from about 3 to 8mm, and Micro surfacings from about 10 to 20mm. Both permit only limited surface regulation when laid in one pass. If greater surface regulation is required, an initial pass may be made to fill in surface irregularities, such as minor rutting, followed by a second pass to provide the complete overlay. Slurry surfacings are suitable for areas that are trafficked only occasionally and at low speeds, and for traffic delineation. Micro surfacings are targeted at roads that may carry significant traffic volumes, and therefore require the appropriate levels of skid resistance and texture retention. Details of the various systems and techniques and advice on their specification will be provided in HD 37 (DMRB 7.5.2).

RETEXTURING

2.20 A variety of proprietary retexturing systems are available that can be effective in the restoration of the skid resistance of bituminous road surfaces. Low speed skid resistance can be improved by, for example, bush hammering or flailing techniques that restore the microtexture of surface chippings that have polished under the action of traffic. Similarly the high speed skid resistance can be improved by grooving or water jetting to restore macrotexture. The most appropriate technique to be employed in any given situation depends upon the nature of the existing surface and the fault or faults to be remedied. The life of the improvements achieved will vary, ranging from only a short term enhancement of 2 to 3 years, to a more long lasting effect, again depending on the nature of the existing surface and the faults to be remedied. Details of the various systems and techniques for the retexturing of bituminous road surfaces and advice on their specification will be given in HD 37 (DMRB 7.5.2).

SURFACE DRESSING WITH MODIFIED BINDER RECORD SHEET

Location
County
Road Name and Number
Site Identification
National Grid Reference
Road type, length, width

Design Parameters
Type of existing surface
Hardness
Total 2-way traffic flow and proportion HGV
Date and place of traffic survey
Design HGV for each lane
Lane Traffic Category

Construction
Main Contractor
Sub-Contractor(s)
Cost of Work
Date Executed
Maintenance Period

Materials Used

Chippings
Size
Grading
Source and Rock Type
PSV
AAV
Flakiness index
Coated or Uncoated
Rate of Spread - specified (by whom)
- achieved

Binder
Name
Type (constituents)
Supplier
Binder properties (specified and achieved)
eg stability in storage
break vs time characteristics
Rheological properties at in-service temperatures such as stress/strain characteristics and elastic recovery
Rate of spread - specified (by whom)
- achieved
Temperature at laying
Batch Number

Workmanship and External Conditions

Type of roller used for compaction
- dead weight
- width
Type of binder sprayer
Type of chipping spreader
Weather Conditions
- at time of laying
- immediately after laying
After Care
- what
- for how long

Any Other Comments/Problems

Figure 2.4 Details requested on the use of Modified Binders in Surface Dressing

3. MINOR MAINTENANCE

CARRIAGEWAY PATCHING

3.1 Patching is used to replace defective materials predominantly in the surfacing courses. The intention of patching is to provide a permanent restoration of the stability and riding quality of the pavement. If correctly carried out, deterioration of the surface can be arrested and serviceable life extended. The patching operation is becoming an increasingly vital technique in highways maintenance and it is therefore economically sound to treat patching as an important maintenance operation and assign to it the necessary skill, quality materials and tools.

3.2 The need for patching arises from three main causes:-

a) Failure of road foundation due to poor drainage or other subgrade problem.

b) the gradual deterioration of the bituminous surfacing material with age with it eventually breaking up and forming crazed areas and pot holes.

c) water penetration and frost damage of the pavement layers reducing the load bearing capacity of the structure and causing the road surface to break up.

d) Volume of traffic causing failure through overloading.

3.3 Patching includes the repair of random areas of defective pavement, but not continuous lengths or whole widths. There is a great variety of bitumen bound materials suitable for patching work but it is desirable to use only those materials contained in the Specification (MCHW1) Series 900. However, there are circumstances when an emergency pot hole 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.

3.4 The procedure for patch repairs is as follows (see Figure 3.1):-

a) Mark out a square or rectangular area for the patch to embrace all unsound material.

b) Form the edges of the excavated area by saw cutting or planing on straight lines to a firm, undisturbed vertical edge. The depth of a patch excavation will not normally exceed wearing course depth.

c) For deeper excavation, no step is required between wearing course and base course, although a minimum of a 75mm step should be made between basecourse and roadbase.

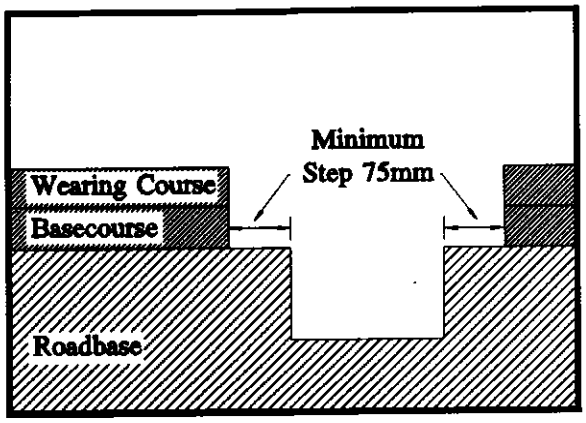
d) Ensure all edges are trimmed and sweep clean.

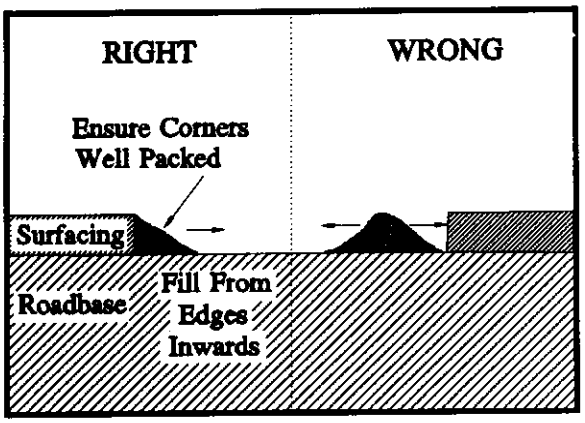
e) Paint the edges of the area with hot 50 penetration bitumen.

f) Spray the base of the area with tack coat.

g) Place patching materials in a uniform layer, levelled and shaped to maintain existing carriageway camber / crossfall following compaction. The new material must be flush with all joints, channels and projections and be level or not more than 3 mm above adjoining pavement surfaces.

h) Compact all parts of the patch to refusal avoiding roller marks on the surface and damage to adjacent sound





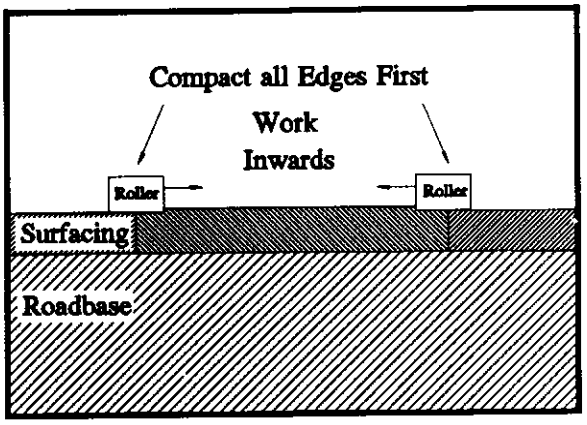


FIGURE 3.1 Patching Procedure

material. Care should be taken to ensure that no material is pushed or displaced during compaction.

i) On completion of the operation, clean the site thoroughly.

Porous Asphalt Repairs

3.5 The repair of small potholes, or the reinstatement of utility trenches and the like, should be carried out promptly with PA or open graded macadam complying with BS 4987: Part 1. Dense bitumen macadam may also be used if necessary, however, it should be replaced with a permeable material as circumstances permit.

3.6 For the repair of larger potholes, the damaged material should be dug out to form an irregularly shaped section. A coating of bitumen emulsion should be applied to the base of the patch to provide bond and the patched area should be filled with either PA or open graded macadam. This should assist in minimising local flooding caused by any restriction to the flow of water through the area after repair. HRA may be used if the area to be patched is not large, say no more than 0.5m x 0.5m, as long as it will not prevent a barrier to the flow of water through the surrounding PA.

3.7 The deterioration of PA may accelerate towards the end of its life. If patching requirements exceed ten per cent of the surface area, the PA may be deemed to have failed. Consequently, in order to restore the desired road surface properties, a new PA surface will be required. This will necessitate removal of the existing surface by cold-milling, followed by a regulating course and then replacement of the PA. Judgement should be exercised in respect of the intervention level given above, the failed areas should be random rather than localised when using the ten per cent criterion recommended. A particular localised failure can be dealt with as appropriate rather than resurfacing the whole section.

TRENCH REINSTATEMENT

3.8 Patching is often necessary due to the opening of the road surface for the laying or maintenance of underground services. This type of patching is referred to as 'Trench Reinstatement' and is a form of patching in which very similar procedures are used. It is covered in the Specification (MCHW1) Series 700 for traffic in excess of 30 msa. For traffic under 30 msa, the Specification for the Reinstatement of Openings in Highways (1992) should be complied with.

3.9 Special trenching machines are now being used more widely. These are capable of cutting fairly narrow trenches very quickly which should cause less disturbance to the road and reduce the time the subgrade is exposed to the elements. It is still very important that backfill materials are adequately compacted to the required standard and because this is more difficult to achieve in a narrow trench with conventional plant, foamed concrete backfill is a recommended option.

3.10 Foamed concrete may be poured into the trench and requires no compaction; in principle, it overcomes many trench reinstatement problems. However the effect of a vertical foamed concrete barrier on moisture movements in the soil and the sub-base has to be considered. Also the effect of long term trafficking over pipes at the bottom of the trench and other services crossing the trench might be detrimental.

4. MAJOR MAINTENANCE

COLD-MILLING AND REGULATING

4.1 Where it is decided to remove part or all of the existing surface of a carriageway, the usual method is to use a planer. The choice ranges from 300 mm up to 2200 mm cutting width. The machines can be set to the required depth of cut and this can be as much as 150 mm in one pass. The planed material is normally collected by a scoop and conveyor and loaded directly on to tipper lorries.

4.2 Improvements in the design of planers have now made cutting tolerances for some machines accurate to ± 2mm. Consideration has to be given to planing tolerances when re-profiling an existing pavement to improve ride quality. The manufacturers of this equipment will give details of the machine performance and this should be taken into account in planning the maintenance operation.

4.3 In some cases it may be necessary to regulate the existing surface to take out depressions in the longitudinal profile. Care must be exercised in the choice of material for this operation and the designer must be wary of introducing another layer in the pavement structure that may be a cause of weakness. Large scale regulating of trunk road and motorway surfaces before overlays is not recommended.

OVERLAYS/RESURFACING

4.4 Overlaying and resurfacing of an existing pavement is usually carried out for one of the following reasons:-

a) strengthen the pavement structure;

b) replace defective surfacing material;

c) restore skidding resistance (although surface dressing may be appropriate);

d) improve the riding quality.

4.5 The strengthening requirements are determined by methods described in HD 30 (DMRB 7.3.3) and this is usually given in terms of a required overlay thickness to give additional life to the pavement. Overlays of 50mm thickness or less are not considered to strengthen the pavement.

4.6 When resurfacing is being carried out to correct for loss of skidding resistance alone the minimum thickness at which the material can be laid (see the appropriate British Standard specification) is sufficient. Where pavement surface levels are governed by kerbs or drainage outlets or headroom considerations, resurfacing shall be preceded by removal of existing surfacing by planing.

4.7 *Application of an overlay requires* verges and central reserve levels to be made up, french drain filter media to be brought up to the new level and gully gratings etc lifted. Marker posts, telephone posts and hardstandings, communication cabinets and other roadside furniture may also have to be lifted. Safety barriers may have to be raised. Attention must be paid to underbridges, where dead load considerations may limit the thickness of, or preclude, overlays, and to headroom considerations at overbridges.

REFLECTION CRACK TREATMENT

4.8 Overlaying of flexible composite pavements where reflection cracking has occurred or to jointed rigid pavements can present problems. Transverse reflection cracking in isolation, at intervals of 4 m or more, generally indicates a pavement with a strong cement bound base which has cracked due to thermally induced strains. In this case, some form of treatment should be carried out to the reflection cracks prior to overlaying. Once reflection cracks have formed the road may deteriorate more quickly under the action of traffic. Water may enter the pavement structure and weaken the road foundation around the crack; the loss of support will depend on moisture susceptibility of sub-base and subgrade. The action of traffic may cause vertical movements at the crack as the wheel load is transferred from one side of the crack to the other. Interlock in the lean concrete roadbase may be eroded

and eventually secondary cracks can form around the transverse crack as the pavement deteriorates.

4.9 A combination of laboratory and analytical work has shown that surface initiated cracking is the most likely mechanism of reflection cracking in roads with a lean concrete roadbase (Nunn, 1989). Note that this may not necessarily be the case for overlaid concrete pavements. Surface initiated cracking is more likely to occur in winter and generally depends on:-

a) The relationship between temperature and the brittleness of the wearing course

b) The thickness of the bituminous layer

c) The resistance of the binder to age hardening due to its exposure to the environment

d) The temperature regime at the site; high summer temperatures cause hardening and low winter temperatures cause embrittlement

e) The trafficking regime at the site; reflection cracking can occur in untrafficked hardshoulders, but not in adjacent lanes where surface cracks appear to be closed up by the action of vehicle tyres

4.10 Coring through the reflection cracks may help to determine whether the cracks are only in the wearing course (surface initiated) or through the full thickness of existing bituminous material. In the former case, planing off the existing wearing course may be sufficient treatment prior to overlaying. If badly cracked, or pavement level constraints dictate, all of the existing bituminous materials may need to be removed.

4.11 The method which is generally recommended on flexible composite pavements is to entirely remove the transverse shrinkage cracks to full depth by excavating a trench through the cement bound material using a specially developed planer. The trench is then filled with bituminous material, sometimes with the incorporation of a modified binder. Other methods may be used subject to approval by the Overseeing Department.

4.12 For bituminous overlays some basic ways to help delay/resist reflection cracking are:-

a) Using thicker bituminous layers than required on purely structural grounds.

b) Using modified binders to improve the elastic recovery and fatigue cracking properties of the bituminous materials.

c) Using stress-absorbing or "reinforcing " materials to distribute strains by partial debonding or other mechanisms.

4.13 The methods listed in b) and c) are relatively new and there is insufficient evidence to date to prove their long term effectiveness and overall economy.

HAUNCHING

4.14 A haunch is constructed to tie into the existing pavement structure and is usually of greater thickness than the original structure. The nearside wheelpath often carries the majority of the vehicle loading due to the camber of the carriageway. Therefore, it is this part of the road that starts to exhibit most distress particularly when it is close to the edge of the road. Haunching is far cheaper than full reconstruction of the road to a greater width and therefore often becomes an attractive alternative.

4.15 The verge is excavated to formation level. The edge of the existing construction is cut back until sound pavement layers are found. The excavation width must always be sufficient for compaction of the replacement materials. All materials used shall conform to the Specification (MCHW1) Series 800 and 900. Generally the total thickness will be designed as in HD 26 (DMRB 7.2.3). During

the works it may be necessary to allow for some variation in thicknesses of the constituent layers and materials choice, this will be dependent upon actual site conditions and any local restraints. Departure from the standard design requires approval by the Overseeing Department.

4.16 The procedure for carriageway haunching is as follows (Figure 4.1):-

a) Mark out the extent to which the existing carriageway is to be excavated.

b) Form the edges of the excavated area by saw-cutting on straight lines to a firm, undisturbed vertical edge.

c) Inset the excavation of the roadbase by 150 mm from the initial cut.

d) Excavate to the depth required by the haunch design.

e) Place and compact pavement foundation layers according to the Specification.

f) Paint the remaining edge of existing construction with hot 50 penetration bitumen.

g) Place, compact and finish the pavement layers as in the Patch Repair procedure.

h) Inset both the basecourse and wearing course layers each by 150 mm.

4.17 It is essential to provide new drains and additional gullies to prevent possible build up of the water table and to take surface water, also the provision of new kerbing should be considered as this will help restrain the new road haunch. Due to the confines of the highway boundary, working space is very limited and careful planning, site organisation and traffic control are all important considerations.

CARRIAGEWAY RECONSTRUCTION

4.18 Reconstruction is normally considered appropriate in cases of severe or widespread failure of the pavement. There are other cases in which it may be considered for example; on a multi lane highway it may be cheaper to reconstruct the left-hand rather than to apply a thick overlay to the whole carriageway width (provided the other lanes are structurally sound); where bridge headrooms or kerb levels militate against the application of an overlay; where there is considerable variation in the standard of a pavement, reconstruction of the worst parts may enable a considerable reduction in the thickness of overlay over the whole length.

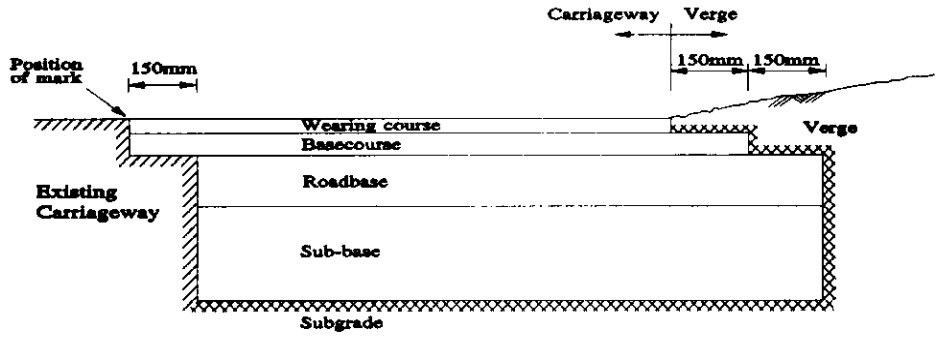


FIGURE 4.1 Haunching Detail

4.19 Care shall be taken, particularly in the case of reconstruction of only part of the carriageway, that the design is compatible with the existing pavement; for example forms of construction which could trap water under the existing pavement shall be avoided. The working shall be planned so that the lower pavement layers and particularly any non-cementitous or non-bituminous materials, are open to the elements for the shortest possible time.

4.20 Reconstruction of very heavily trafficked pavements within the highway boundary is made extremely difficult due to the demands of traffic control and the limited working space. The actual pavement layer thickness will normally be as for new construction although limiting site conditions and local restraints may dictate the use of innovative materials and improved construction techniques.

4.21 During reconstruction the formation becomes exposed and vulnerable to weather effects. The risk is reduced if the new pavement can be accommodated within the depth of the old pavement.

4.22 When excavating the existing pavement, care must be taken to avoid damaging existing material below the bottom of the excavation. Plant shall always work from the existing carriageway surface or from a cement or bituminous-bound roadbase, as appropriate. Joints with the existing pavement shall be stepped, vertical sided and sawn, and existing bituminous faces shall be coated with suitablebitumen when the new material is placed against them. Excavation below existing formation level may affect existing drainage systems and cable ducts and the necessity for protection or relaying must be considered.

4.23 If the required pavement depths cannot be easily accommodated the technique of asphalt substitution may be employed. This technique is used to replace some or all of a granular sub-base with a structurally equivalent but less thick bituminous roadbase and may be justified where good quality aggregates are expensive or construction depth is limited. HD 25 (DMRB 7.2.2) advises on such design.

4.24 RR58 (1986) established that thick lifts of bituminous roadbase could be properly compacted even on a foundation too weak to support a normal paver or the supply vehicles. A conventional wheeled paver was able to lay bituminous material directly onto a strong clay with a CBR of 12 - 15 % without difficulty. Weaker clay, CBR 2 - 3 % required a tracked paver and timber roadway for asphalt lorries to prevent damage to formation. However careful use of this technique must be employed. The contractual nature of road construction demands that the works are specified well in advance. Changes of design in the light of actual site conditions may prove difficult and expensive. Asphalt substitution requires evaluation of subgrade compaction condition and where necessary methods of improving it.

5. RECYCLING

GENERAL

5.1 Recycling of road materials is not new. Re-use of asphaltic materials can be traced back to the early part of the century. Recycling has developed and has been used in areas of the world where raw materials are scarce or haulage routes from available sources are excessive. Comparisons between recycled and conventional materials are difficult to make, particularly in respect of long term performance. Monitoring of the controlled use of recycled pavement materials indicates satisfactory performance can be expected, provided the constituents of the reclaimed materials are suitable for recycling.

5.2 The principal benefit derived from recycling is the economic use of readily available materials resulting in competitive pricing of road construction contracts. Savings result from reduced energy requirements for mineral extraction, transport and mixing and the reduced quantity of bitumen required both of which account for a large part of the cost of bituminous bound materials. Reuse of materials contributes to environmental conservation by reducing the extraction of new material along with a corresponding reduction in the disposal of excavated material arising from pavements being reconstructed.

5.3 Not all recycling processes are suitable for the amount of traffic normally expected on trunk roads but may be worth considering for lightly trafficked roads or parking areas for light vehicles.

5.4 Recycling processes can be categorised into in-situ recycling, (where processing takes place on-site), and central plant recycling (where reclaimed material is processed off-site). Unless a mobile plant is brought onto or near the site, reclaimed materials have to be transported for re-use on other sites. The processes can be further sub-divided into hot and cold processes.

CURRENT PRACTICE

In-situ hot recycling

5.5 The Overseeing Department permits partial hot in-situ recycling, Repave, as a suitable alternative to conventional resurfacing when carried out in accordance with the Specification (MCHW1) Series 900 and where the suitability of the process complies with paragraphs 5.16 to 5.29. Repave is essentially a process that restores the surface of roads, which are still in sound structural condition, by bonding a thin overlay or inlay to the preheated, scarified and reprofiled road surface. The process is not recommended for surfaces showing signs of cracking, indicating a potential deficiency in the material which heating by the Repave process could worsen.

5.6 Remix, an adaption of Repave where the machine is fitted with a small mixing unit, enables the softened existing material to be mixed with specially designed new materials to restore the necessary properties of a wearing course, (see Figure 5.1). Other in-situ hot recycling systems using proprietary plant need individual assessment in the absence of performance testing.

In-situ cold recycling

5.7 Cold in-situ recycling has been used for many years. The Retread process, where the existing road surface is scarified, reshaped, new binder added - usually an emulsion - and compacted, is included in BS434: Part 2 (1984). More recently techniques have been developed for restoring the structural integrity of the scarified road to a depth of up to 350mm using cement or foamed bitumen, a patented means of expanding bitumen to about 15 times its original volume to facilitate efficient coating of the material to be processed. Cold in-situ processes are more applicable to lightly trafficked roads but have the advantage that the vertical geometry of the road is preserved avoiding the ancillary work resulting from changes in finished road level that may occur when an overlay is used and enables these processes to be used where access to side roads and adjacent premises must be maintained. Trials using foamed bitumen indicate that this technique should be limited to roads expected to carry no more than 2 msa cumulative traffic until further trials have been conducted on roads carrying higher traffic loads.

Central plant hot recycling

5.8 Recent research into the use of centrally processed recycled pavement materials has indicated

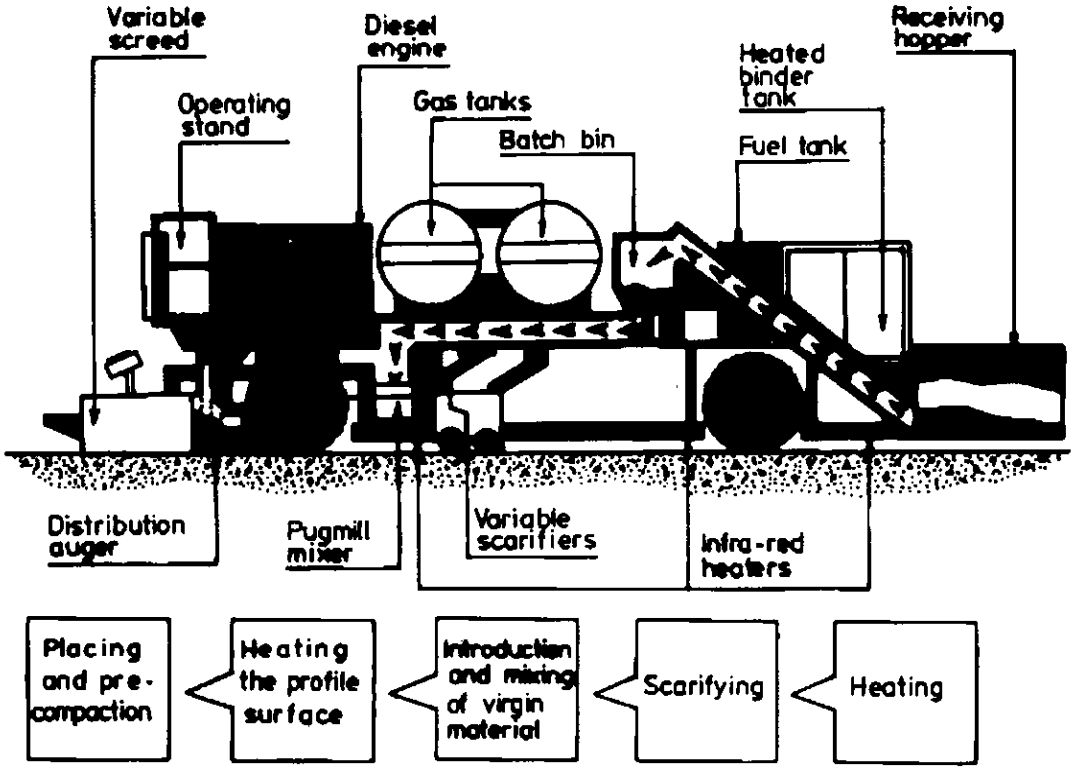


FIGURE 5.1 Repave/Remix Machine in Remix Mode

that bituminous bound materials containing limited amounts of reclaimed pavement arisings of suitable quality can provide an equivalent performance to conventionally produced new material. With the advent of increasingly more powerful cold planers and more widespread use of continuous drum mixers for bituminous materials, central plant recycling has become more viable than with the older batch type mixers. Various modifications to drum mixers have been introduced to control the emission of vaporised bitumen which occurs if the bitumen in the reclaimed material comes into direct contact with the very high gas temperatures in the drum. Many drum mixers are now manufactured with an additional annulus part way down the drum allowing reclaimed material to be introduced into the mix some distance from the source of heat. Heat is usually transferred to the whole mix by heating the new aggregate to which the recycled material is added. The reported maximum amount of central plant hot recycling has generally been limited to about 60%.

5.9 As a large proportion of potential savings result from reduced transport costs for materials, the proximity of the mixing plant to the source of the reclaimed material and the site, where the recycled material is to be laid, may be reflected in lower tender rates. The use of mobile mixing plants could further reduce transport costs, but mobilisation costs have to be balanced against the amount of material to be recycled.

Central plant cold recycling

5.10 Central plant cold recycling where existing pavement materials, both cement bound and bituminous bound, are broken down to be recycled as capping material, has been used successfully on major maintenance contracts. The compacted capping material shall comply with the Specification (MCHW1) Clause 613. Usually a mobile crusher is brought onto site for the purpose of providing capping material from the existing pavement when the quantities are sufficient to justify this. Caution should be exercised when using bituminous planings as these have been found to be unstable, performing at times like a Type 2 gravel sub-base, lacking cohesion.

5.11 Bituminous bound material alone can be difficult to process in a jaw type crusher as the material tends to clog the jaws, adversely affecting the grading of the recycled material. The use of a granulator instead of a crusher may help overcome this problem

and reduce the material to an acceptable and consistent grading.

Central Plant Recycling to produce Bound Materials

5.12 Recycling bitumen-bound pavement materials by processing planings in a pugmill, together with bitumen, fluxed bitumen or bitumen extracts (rejuvenators), has been carried out elsewhere. These uses have been generally confined to relatively low volume applications. As UK trials have not yet been fully evaluated under heavy traffic conditions, only limited advice can be given. Initial results are, however, encouraging.

Suitability of Materials

5.13 Recycled materials have to provide similar performance to conventional materials as well as demonstrating cost effectiveness, in order to be acceptable. HD 26 (DMRB 7.2.3) requires materials to comply with the Specification (MCHW1) Series 900. The Specification (MCHW1) requires materials to meet the appropriate Standards which have usually been prepared on the basis that the constituent materials have been derived from new sources. Where existing pavements have performed satisfactorily it is likely that the original aggregates will comply with the Standard requirements although some degradation can be expected on reclamation. Blending of new aggregate will probably be necessary to meet grading requirements. Bituminous binders tend to harden during the mixing process and with age which necessitates the addition of a softer binder to restore the equivalent properties as required under BS3690: Part 1 (1989).

5.14 It is essential the reclaimed materials to be recycled are consistent, as variable materials will cause problems with the control of quality and impede the efficiency of the recycling operation. Suitable sources of consistent material of sufficient quantity for the scheme being considered need to be identified either in existing pavements, from stockpiled planings of known origin or from another suitable source.

5.15 The assessment of the properties of the existing material proposed for recycling can be made using cores sampled from the carriageway or from samples taken from stockpiles in accordance with current practice. The sampling frequency shall be sufficient to determine how consistent the reclaimed material is and to provide representative samples for composition analysis and measurement of properties of recovered binder.

5.16 A flow chart for assessing the suitability of reclaimed materials and the proportion to be recycled is shown in Figure 5.2.

REPAVE

5.17 With Repave, the existing surfacing is initially heated to soften the surface and permit its easy and uniform scarification by rows of tines located across the full working width of the machine. The amount of heat applied to the road surface is controlled by either raising or lowering heater banks, switching individual heaters on or off, or by adjusting the rate of progress of the repaver.

5.18 Surface irregularities such as rutting are corrected once the surfacing has been scarified by means of an auger or levelling blade mounted behind the tines. Where street furniture such as gullies, manhole covers etc exist the tines are raised and adjacent material loosened manually.

5.19 New surfacing material is then laid on the preheated, scarified and reprofiled road surface by a conventional paver which may or may not be integral with the heater/scarifier unit. The resulting composite surfacing is compacted to form a new wearing course,

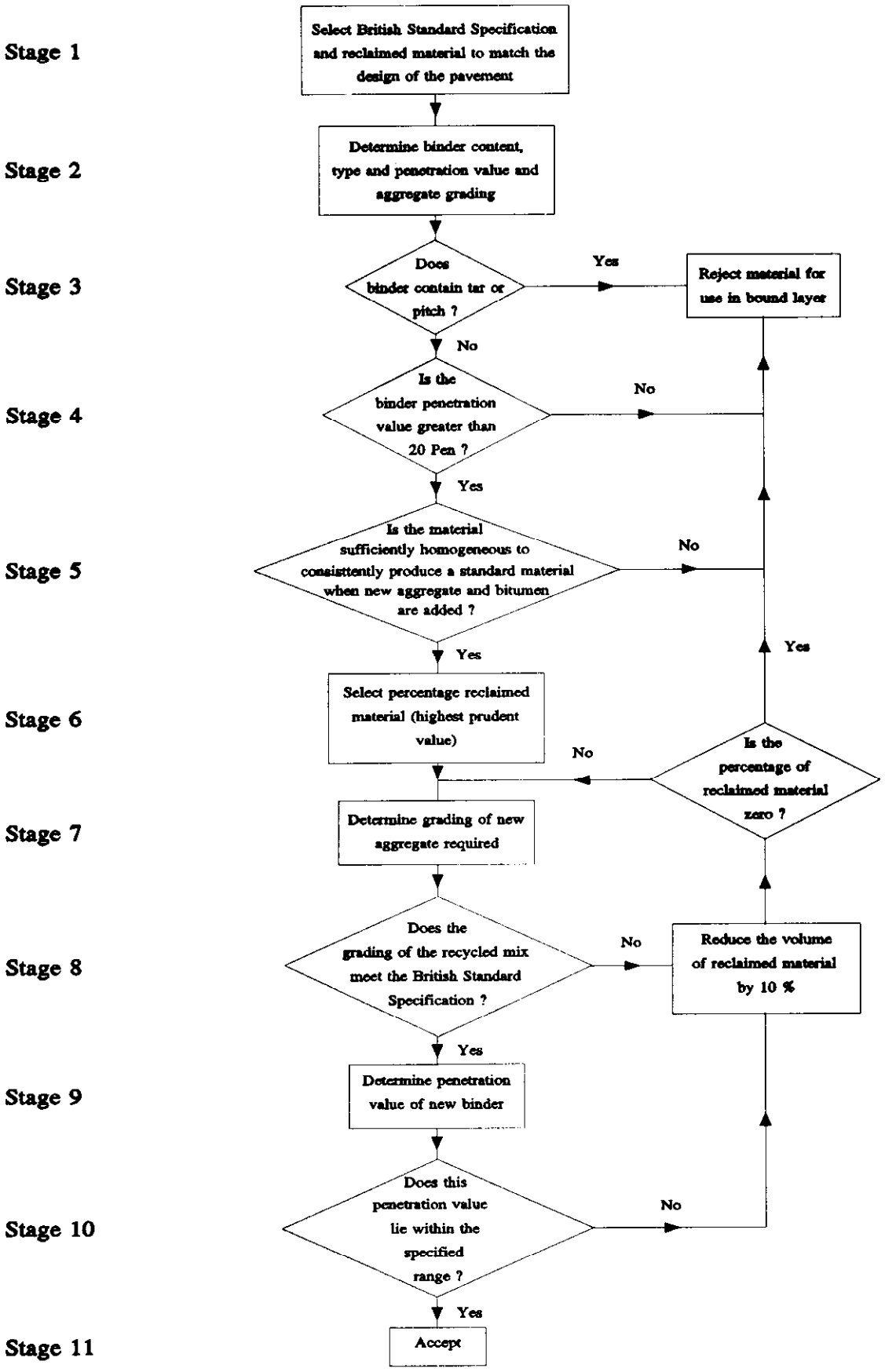


FIGURE 5.2: Flow Chart for the Assessment of Reclaimed Materials and the Design of Recycled Mixes

with coated chippings being applied prior to rolling in the normal way. The characteristic feature of Repave is that a 20mm thickness of heated and loosened existing material is overlaid with not less than 15mm of new material.

Applications of Repave

5.20 Repave is a process that is essentially related to the restoration of worn surfaces on road bases free from structural defects and where there is no call for structural enhancement, although it may provide an economic short term solution on pavements with structural defects prior to major strengthening.

5.21 For inlay treatment, existing surfacing is firstly removed by planing out to a specified depth, usually a nominal 20mm. The Repave process, as described above, is then carried out on the newly exposed surface to restore the profile and match adjoining surfacing levels. The process therefore offers a saving of about 50% in new material compared with a conventional 40mm inlay.

5.22 For overlay treatment, planing is not normally required unless surface dressing is present, in which case it must be removed before Repave can be carried out to avoid enrichment of the scarified material and excessive smoke emission. The thickness of new material in an overlay is normally 20mm, again offering a saving of about 50% in materials compared with a conventional 40mm overlay. This means that the road surface level is raised by only 20mm and in some circumstances the use of Repave could obviate the need for raising kerbs.

Suitable Sites for Repave

5.23 Repave has been found to be a technically viable process on all classes of road provided certain criteria are met. A visual inspection is the first step in determining whether a site is suitable. Evidence of gradual deformation of a surface over a number of years suggests that the wearing course material is basically sound and that Repave is likely to be a suitable treatment. Evidence of rapid deformation on the other hand indicates a defect in the material that may not be remedied by the process.

5.24 Surfacing which shows signs of general cracking is unlikely to be suitable for Repave even though the underlying structure is known to be sound. The cracking would indicate a deficiency in existing surfacing such as low binder content or hard binder which would be hardened still further by the heating process employed in Repave. Where a combination of low penetration binder and pre-coated chippings exists, the use of Repave is not likely to be found suitable for overlay when the surfacing is analysed as in paragraphs 5.25 to 5.27.

Analysis of Existing Surfacing

5.25 Having decided from visual inspection that the site is potentially suitable for the Repave process, the existing surfacing materials must then be analysed to ascertain whether they are suitable or not. This depends upon the penetration value of the old bitumen in the road surface. This is established by cutting core samples and recovering the binder for testing. The existing wearing course must also be of sufficient thickness to ensure that under-lying layers are not disturbed by the scarification tines.

5.26 Cores shall be positioned to avoid road surfaces contaminated with engine oil and be of 200mm diameter to allow for binder recovery. Where 200mm cores are not available pairs of 150mm diameter cores may be substituted. The number of cores required depends on the area and the variability of existing surfacing to be treated, however the following serves as a minimum requirement:-

a) Where the surfacing has a consistent appearance, one core shall be cut for each 500mm length of lane underconsideration, with the proviso that a monimum of two cores shall be taken for each continuous Repave length. Where more than one lane of a multi-lane carriageway is to be repaved, and where the whole carriageway surface is consistent, only one lane need be cored. Coring of adjoining lanes is at the discretion of the Engineer.

b) Where the surfacing appears variable the length under consideration shall be split into sections of similar visual characteristics and each section cored as in (a). However where the surfacing shows excessive variability it is unlikely to be suitable for Repave.

5.27 Core samples shall be taken and analysed in accordance with BS598:Part 100 (1987) and BS598:Part 102 (1989) to determine the penetration of the recovered binder. To be considered suitable for the Repave process this shall be within the range 20 pen to 80 pen for straight run binder. However where the binder is pitch bitumen or where a 20mm depth of scarification includes coated chippings the binder shall not be harder than 30 pen.

New Surfacing Material

5.28 New hot rolled asphalt surfacing material for use in Repave works must comply with the requirements of the Specification (MCHW1) Series 900. The minimum compacted thickness shall be specified as not less than 15mm.

5.29 Due to the existing surfacing being heated and scarified as part of the Repave process, no difficulty should be encountered in embedment of coated chippings which should be of 14mm or 20mm nominal size.

5.30 Experience in this country extends only to its use on rolled asphalt; however, Repave may also be suitable for use on other surfacing materials.

MIX DESIGN

Central Plant Hot Recycling

5.31 The Overseeing Department permits reclaimed bituminous materials to be recycled into bituminous materials supplied for trunk roads, provided the properties of the materials meet the requirements of the Specification (MCHW1) Series 900 for the appropriate material being produced. Reclaimed materials containing tar binders or pitch-bitumen should not be recycled into bituminous mixtures.

5.32 Up to ten per cent reclaimed material can be incorporated into bituminous mixtures without specific approval being sought. Advice and approval shall be obtained from the Overseeing Department when it is proposed to incorporate more than ten percent reclaimed material into bituminous material to be placed on trunk roads.

5.33 After selecting the proportion of reclaimed materials to be recycled, the grading of the mix may need adjustment, to meet specification requirements, by the addition of selected aggregate sizes.

5.34 Hardening of the old binder, during the original mixing process or through ageing, can be compensated for by adding a softer bitumen, to obtain the appropriate final grade of binder.

5.35 The penetration of the binder of the final mix (pen_v) depends on the penetration and proportions of the new bitumen and existing binder (pen_v and pen_r), which is given by the expression:-

$$Pen_v = (pen_r/pen_r^b)^{1/a}$$

where a and b are the proportions of the new bitumen and old binder (a + b = 1). The penetration of the resulting binder can be determined from the amount required.

CONTRACTUAL ARRANGEMENTS

Central Plant Hot Recycling

5.36 Provided not more than ten percent of reclaimed material is added to bituminous mixes and the requirements of the Specification (MCHW1) are satisfied, experience has shown it is not necessary to carry out any mix design process other than that already advised or required by BS594 (1992) or BS4987 (1988). Prudent suppliers may still wish to check the resultant materials before submitting a proposal to recycle reclaimed materials.

5.37 To obtain data for resurfacing schemes where recycled materials have been used, the Overseeing Department should be notified by sending the information listed in Figure 5.3.

BITUMINOUS MIXTURES CONTAINING UP TO 10% RECYCLED MATERIAL RECORD SHEET

TO: Department of Transport
Highways Engineering Division
St Christopher House
LONDON SE1 OTE

LOCATION:	County Road Name and Number Site Identification O S G R Road Type, Length, Width
DESIGN PARAMETERS:	Traffic flow cvd
CONSTRUCTION:	Main Contractor Sub-Contractor Cost of Work Date Executed
PAVEMENT LAYER:	
Wearing Course:	HRA
Base Course:	HRA, DBM, HDM, DBM_{50}
Roadbase:	HRA, DDM, HDM, DBM_{50}
WEATHER CONDITIONS:	At time of laying

ANY OTHER COMMENTS/PROBLEMS:

Signed _____

For _____
Highway Authority/Consulting Engineer

Figure 5.3 : Recycled Material Record Sheet

6. REFERENCES AND BIBLIOGRAPHY

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BS434; Part 2; "Bitumen Road Emulsions (Anionic and Cationic)", BSI.

1987

BS598; Part 100, "Sampling and Examination of Bituminous Mixtures - Methods for Sampling for Analysis", BSI.

1988

BS4987; Parts 1 and 2; "Coated Macadam for Roads and Other Paved Areas", BSI.

1989

BS598; Part 102, "Sampling and Examination of Bituminous Mixtures - Analytical Test Methods", BSI.

BS3690; Part 1; "Specification for Bitumens for Roads and Other Paved Areas", BSI.

BS812; Part 114; "Methods for Determination of Polished Stone Value (PSV)", BSI.

1992

BS594; Parts 1 and 2, "Hot Rolled Asphalt for Roads and Other Paved Areas", BSI.

Road Note 39; "Recommendations for Road Surface Dressings", TRL and Department of Transport.

Specification for the Reinstatement of Openings in Highways; Department of Transport.

1993

BS2499; "Specification for hot applied joint sealants for concrete pavements", BSI.

1994

HD 25 (DMRB 7.2.2) Foundations.

HD 26 (DMRB 7.2.3) Pavement Design.

HD 28 (DMRB 7.3.1) Skidding Resistance.

HD 29 (DMRB 7.3.2) Structural Assessment Methods.

HD 30 (DMRB 7.3.3) Structural Assessment Procedure.

Undated

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1969

Road Note 27; "Instructions for using the Portable Skid Resistance Tester", HMSO.

1986

RR58; Nunn M E and Leech D, "Substitution of Bituminous Roadbase for Granular Sub-base", TRRL.

1989

Nunn M E, "An investigation of reflection cracking in composite pavements in the United Kingdom", RILEM, Liege.

1991

TR303; Leech D and Nunn M E, "Asphalt Substitution; Road trials and design considerations", TRRL.

7. ENQUIRIES

All technical enquiries or comments on this Part should be sent in writing as appropriate to:-

Chief Highway Engineer
The Department of Transport
St Christopher House
Southwark Street
LONDON SE1 OTE

T A ROCHESTER
Chief Highway Engineer

The Deputy Chief Engineer
The Scottish Office Industry Department
Roads Directorate
New St Andrew's House
EDINBURGH EH1 3TG

J INNES
Deputy Chief Engineer

The Director of Highways
Welsh Office
Y Swyddfa Gymreig
Government Buildings
Ty Glas Road
Llanishen
CARDIFF CF4 5PL

K J THOMAS
Director of Highways

Chief Engineer - Roads Service
Department of the Environment for Northern Ireland
Roads Service Headquarters
Clarence Court
10-18 Adelaide Street
BELFAST BT2 8GB

W J McCOUBREY
Chief Engineer - Roads Service