



CODE OF PRACTICE FOR IN-SITU STRUCTURAL ROAD RECYCLING



Urban environment



Rural countryside

Foreword

This first edition of the Code of Practice has been produced by the RSTA Recycling Sub-Committee. It has been reviewed in the context of existing guidance documents published by TRL Limited (Transport and Road Research Laboratory) namely TRL 386 and TRL 611. The production of both documents was sponsored by the Highways Agency and the County Surveyors Society (now ADEPT) together with a number of other private sector companies.

This document has been peer reviewed by ADEPT Soils, Materials, Design and Specifications Committee.

The information contained herein is intended to represent industry best practice. No liability is accepted by RSTA or ADEPT for any damages caused to property or personal injury resulting from using the guidance contained within this document.

RSTA is the Road Surface Treatments Association.

www.rsta-uk.org

ADEPT is the Association of Directors of Environment, Economy, Planning and Transport.

www.adeptnet.org.UK

RSTA Code of Practice for In-situ Structural Road Recycling 2012

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1. PREAMBLE

- 1.1 Too often today's highway engineer is prevented from carrying out large scale highway structural repairs due to inadequate funding allocations. Instead, patching and / or bituminous overlay is often the only affordable solution available. It is hoped that this Code of Practice will not only bring to the engineer's attention the substantial cost saving potential of In-situ Structural Road Recycling together with the many social and environmental benefits attributed to it but also assure the engineer that contractors who adhere to this Code will deliver the quality of product and service expected.
- 1.2 In-situ Structural Road Recycling is not only an economical solution to road pavements in need of reconstruction but is also well suited to the rehabilitation of pavements that are contaminated with 'tar'. Tar is derived from the distillation of coal in the production of domestic 'town' gas and was widely used in UK road building from the mid 1800's. 'Tar' is a possible carcinogenic and is therefore considered hazardous. The Structural Road Recycling process is acknowledged as being the preferred method of dealing with 'tar' residues in road construction in that the resultant recycled mix encapsulates the hazardous contaminants, rendering them harmless to the environment and avoids the need to remove them by excavation so that they can be disposed of in a licensed hazardous waste facility. In some cases where concentrations of the 'tar' is particularly high incineration may be the only other option. For further advice the Engineer should refer to the ADEPT Guidance Note - ROAD MATERIALS CONTAINING TAR.
- 1.3 To obtain the best results it is necessary to give careful consideration to a wide range of issues and to plan and design the work as thoroughly as possible. It is therefore strongly recommended that early contractor involvement (ECI) is initiated whenever possible. The speed of execution of the In-situ Structural Road Recycling process is such that the inconvenience to the motorist and general public is greatly reduced when compared to traditional reconstruction techniques, thereby offering the highway engineer a cost effective and 'green' solution that will often fit well with Council Tax payers and their Elected Members, local businesses, pedestrians and the motorist alike.
- 1.4 The structural maintenance options available to the highway engineer will vary depending on the amount of funding available and the physical constraints of the site. Some sites may have structurally deteriorated to a 'critical' condition so that full depth reconstruction is considered the only option available whereas others may be deemed to be less serious and may therefore be strengthened by the provision of a substantial overlay or inlay.
- 1.5 In urban areas the overlay option, by its very nature, will require that kerbs are raised and footways resurfaced to accommodate the works. This option is not only very costly but can cause considerable inconvenience to the householder, pedestrian and motorist alike. A traditional bituminous inlay will contribute less to the overall strength and longevity of the pavement, will generate waste and increase the carbon footprint of the scheme. Rural roads are often strengthened by overlaying and generally have fewer constraints than those in urban locations however it is important that the implications of frost susceptibility at levels up to 450mm and inevitable drainage inadequacies are taken properly into account.

- 1.6 The purpose of Structural Road Recycling is to effectively restore a failed road pavement by recycling and reusing the existing construction materials to construct a new pavement with strength and life expectancy that is equal to that of a traditionally designed and reconstructed pavement. The need to dispose of huge volumes of waste materials, import processed virgin aggregates and hot bituminous bound material is greatly reduced resulting in a lower carbon footprint overall. Structural Road Recycling can often be a cheaper and more effective solution in both the urban and rural situation by virtually eliminating accommodation works and by providing a 20 to 40 year design life with a construction which is non-frost susceptible regardless of site conditions or constraints. Whichever the case the engineer should give consideration to the anticipated life expectancy and whole life costing (WLC) of the options available balanced against the funds allocated to ensure that real value for money is attained.
- 1.7 Depending on the design traffic predictions for the pavement and the severity and nature of the structural failure a Structural Road Recycling solution may require recycling thicknesses ranging from 125mm to 325mm with additional overlay requirements of between 45mm and 160mm. Most commonly the structural design of a recycled pavement can be adjusted in accordance with TRL Guidelines TRL 386/TRL 611 to minimise the thickness of new hot bituminous surfacing by increasing the thickness of the recycled roadbase where conditions allow thereby resulting in a final surfacing requirement in many cases of just 45mm.
- 1.8 The purpose of this Code is to identify the important aspects of the process and to refer to other documents relating to good practice and so give practical guidance on achieving the highest quality.

2. HEALTH, SAFETY & ENVIRONMENT

- 2.1 All those involved in preparing and executing Structural Road Recycling operations have a legal duty of care for the health and safety both of the operatives carrying out the works, and those who come into contact with the operation whilst in progress and during aftercare.
- 2.2 The planning and organising for health, safety and environmental issues must commence as soon as a Structural Road Recycling scheme is identified. The Construction Design and Management Regulations 2007 will apply to most Structural Road Recycling operations and therefore clients are urged to follow closely the advice in the relevant Approved Code of Practice as they have the responsibility under the new version of the Regulations for initiating the framework for safe working practices. This will enable the CDM Co-ordinator and Principal Contractor to plan and prepare the information and documentation necessary to ensure the specific hazards are identified on the various sites and the level of risk that is envisaged. This must take into account the nature of the site, the materials to be used, the traffic management requirements and any special health, safety and environmental issues that have become evident during the pre-tender stage, (ensure the right information is provided to the right people at the right time). Protection of the environment and the reduction of CO₂ emissions is a Corporate and Social Responsibility (CSR) requirement balanced against Whole Life Costing (WLC).

- 2.3 The client should employ a competent contractor. It is recommended that the simplest way for a client to achieve this is to select at tender stage contractors accredited to National Highways Sector Scheme 13 (NHSS13). This is the procedure of selection recommended in the Specification for Highway Works. Once the contractors have been selected, the pre-construction information contained in the tender document should be detailed enough for the prospective contractors to take account of the health, safety and environmental issues in their tender submission. It may well be the case that the accredited contractors will be asked to advise the Engineer on a number of specialist technical issues relating to the works in terms of materials to be treated, materials to be used and other operational requirements that may affect the Health and Safety Plan.
- 2.4 On the appointment of the Principal Contractor it will be his duty to prepare a detailed Health and Safety Plan for that particular contract or works from the pre-construction information supplied by the Client, Designers, CDM-Coordinator and the specialist In-situ Structural Road Recycling contractor. This must itemise the methods to be employed to overcome the specifically identified hazards and risk reduction measures that will be in force for the duration of the contract. It must also address issues such as the provision of a storage compound with adequate welfare facilities in close proximity to the site; the authorisation of an adequate water supply to meet the needs of the contract and specification; the disposal of hazardous or non-hazardous waste materials resulting from the works and the control of dust emissions emanating from the works.
- 2.5 Once the works commence the Principal or Term Contractor will be responsible for Health, Safety and Environmental matters and this will demand close liaison with the client, the appointed Structural Road Recycling contractor, police, local businesses and the general public on issues of access to properties, running traffic on the newly processed layer, traffic congestion, traffic diversions or road closures that must be ongoing throughout the course of the contract.
- 2.6 The Principal or Term Contractor has additional duties under other legislation to look after the health and safety not only of his own employees but of other persons who work alongside them and also of the passing public. Written specific risk assessments must be prepared which can be used to identify control measures for both physical and chemical hazards. The measures must form the Contractor's safe systems of work which enhance the safe behaviour of the workforce as well as protect the general public during the various stages of the works. Particular measures must be taken in relation to the identification of underground services and the protection of drainage and other Statutory Undertakers apparatus during the course of the works. These measures must be communicated to all personnel involved in the project.
- 2.7 Account must also be taken of environmental factors with pollution from fumes, noise and dust being the main concern during the work phase. Disposal of waste, protection from spillage and contamination are other considerations when looking at the overall Structural Road Recycling activity.

3. TRAINING

- 3.1 The intention is to incorporate Structural Road Recycling techniques into NHSS13.
- 3.2 The design of an Structural Road Recycling scheme and its safe execution is dependent on a wide range of factors and close attention to detail.
- 3.3 The National Highway Sector Scheme 13 will define the minimum qualifications required for all personnel involved in the design, supervision and installation of a Structural Road Recycling scheme. It is the Association's view that a competent qualified workforce makes a fundamental contribution to achieving a safely executed, high quality and long lasting product. The RSTA runs regular training courses, details of which can be obtained from the RSTA website.
- 3.4 Operatives should hold NVQ level 2, Construction Plant Competence Scheme (CPCS) and Supervisors NVQ level 3 qualifications plus CSCS cards. Supervisors shall attend the RSTA Training course on Structural Road Recycling every 5 years and obtain a silver certificate as evidence of maintained competency.

4. QUALITY ASSURANCE

- 4.1 The Road Surface Treatment Association continues its commitment to quality assurance and is committed to incorporating Structural Road Recycling, within NHSS13 at the earliest opportunity.
- 4.2 The Sector Scheme 13 Document has recently been reissued after combining Part A (Surface Dressing) with Part B (Slurry Surfacing) and is available on the UKAS website. www.ukas.com The RSTA's Chief Executive currently chairs the National Highway Sector Scheme 13 Technical Advisory Committee and can provide further information by request.
- 4.3 RSTA members have a commitment to operate to BS EN ISO 9001 Quality Management Systems and to be registered to NHSS13.
- 4.4 Membership of the Road Surface Treatment Association is available to contractors who have third party quality assurance (BSEN ISO 9001) for Structural Road Recycling. It is the unanimous decision of the Association to adopt this principle as an indication of its commitment to quality in all its undertakings. The setting up and maintenance of a quality assurance system represents a substantial financial commitment to member companies. Those costs will inevitably have been reflected in the unit prices tendered for Structural Road Recycling schemes. Structural Road Recycling contractors who are not members of the RSTA and have not invested in quality assurance may therefore be in a position to offer lower contract rates, but it follows that their work may well be of a lower quality than that carried out by RSTA member contractors.
- 4.5 Quality controlled RSTA member companies need much reduced supervision by highway authority representatives and should decrease the call for tests and checks on machinery and workmanship which form part of a quality assurance system.

- 4.6 The Association does not see the requirement for quality control as a restriction to competition but rather a method of ensuring fair competition between contractors giving maximum value for money that should be implicit in all work undertaken for public bodies.

5. PLANNING & CO-ORDINATION

- 5.1 Careful and detailed planning before work commences is an important element of a successful Structural Road Recycling scheme. It is considered imperative that early contractor involvement (ECI) is instigated not only to ascertain site suitability but also to decide on the appropriate construction methods to deploy by taking into account not only the physical constraints of the site but more importantly the root cause of the failure. Other considerations will be the allocated timescale for construction and the needs of residents, pedestrians, motor traffic and local business. It is also essential that the client and principal contractor are fully briefed as to how the Structural Road Recycling process works, what it aims to achieve and the intricacies of how it will be done. There should be close co-ordination between the client, the Principal Contractor and the nominated Structural Road Recycling contractor at concept stage (ECI), throughout the procurement process and during the course of the works. Bringing the three parties together early on will invariably pay dividends later.
- 5.2 It is in the interests of both the contractors and the client that the programme of works flows smoothly and that both the Principal Contractor and the Structural Road Recycling contractor fully understand and accept their individual responsibilities and co-operate at all stages of the contract.

6. DETERMINING SITE SUITABILITY

- 6.1 Structural Road Recycling produces a recycled roadbase / binder course layer comparable to a traditional bituminous or hydraulically bound roadbase/binder course material and is often considered as a more cost effective and environmentally friendlier alternative to traditional full or partial reconstruction of an existing road pavement.
- 6.2 The recycling / manufacturing process utilised in Structural Road Recycling can also be used to manufacture structural layers for new build by its ability to process regular virgin or secondary graded aggregates or used aggregate recovered from highway or construction maintenance works elsewhere. In either case it is essential to prove the strength capability and dynamic performance of the processed material and to demonstrate its suitability for the application proposed.
- 6.3 There are 4 main elements that determine site suitability:
- Root cause of failure of an existing road pavement
 - Proposed design traffic in Million Standard Axles (MSA)
 - Suitability of the existing pavement materials
 - Underground utilities

- 6.4 The design recommendations for the use of Structural Road Recycling (TRL 611 or TRL 386) states that current knowledge of the performance of recycled material justifies its use for roads which are expected to carry up to 80 million standard axles (MSA).
- 6.5 The specialist plant available to carry out in-situ Structural Road Recycling can process widths from 1.000m to full width of pavement whilst the machines themselves vary in overall width between 1.600m and 3.100m. It is therefore important to ensure that the selected Structural Road Recycling contractor has equipment that is suitable for both the site in question and the traffic management (TM) arrangements that are available.
- 6.6 Both In-situ and ex-situ Structural Road Recycling can be carried out under a range of different TM options including full road closure (generally considered the safest, quickest and cheapest) or half width working under temporary traffic control or 'one way' system configuration.
- 6.7 Ex-situ Structural Road Recycling requires a mobile plant to be installed near to the site therefore it is important to identify a suitable compound (often a field or car park) which is at least 2,000 m² in area and has safe access for heavy lorries. Due to the nature of the ex-situ mixing process and the intensity of vehicle movements it is important to locate a compound away from private dwellings if possible. In the case of a field being utilised for the purpose of locating a mobile mixing plant and taking into account the time of year, consideration may need to be given to the provision of a hard standing area made up of hardcore or road planings prior to the plant being installed. A hard standing may need to be removed later and the grass reinstated. Permission will need to be sought from the owner of the land and in some cases a rent will need to be paid.
- 6.8 Both in-situ and ex-situ Structural Road Recycling processes require large volumes of water. Water is needed to hydrate the hydraulic binder in the mixture (in the case of Hydraulically Bound Mixtures HBM). Water is also required for the purposes of moisture content control. On occasions up to 60,000 litres of water may be required to complete each day's work therefore it is important that the Principal contractor provides the Structural Road Recycling contractor with an official local Water Authority metered stand pipe for the duration of the contract. It is also necessary to clearly identify the nearest available Water Authority hydrant valves prior to tendering or quotation as the importation of water long distances by road may have an impact on the Structural Road Recycling contractor's outputs, costs and the environment.
- 6.9 The most common reason for the in-situ Structural Road Recycling contractor to decline a potential recycling scheme is the existence of a conglomeration of statutory undertaker's appliances within the proposed recycling layer. This is usually only a concern for urban sites. The intensity of apparatus may increase the risk of damage to apparatus to such an extent that the in-situ Structural Road Recycling contractor considers the scheme not feasible. It is important therefore that a thorough and accurate ground radar survey is carried out at an early stage if practical so that a clear picture of any offending apparatus can be located and a judgement made.

- 6.10 Regardless of whether a traditional reconstruction or recycling solution is being considered it is recommended that the Engineer carefully examines the drainage conditions and associated assets that exist within the site under consideration so as to be certain that they function adequately. Drainage improvements may need to be carried out prior to the recycling works commencing in order to protect the significant investment involved in reconstruction or recycling and to ensure that the actual life expectancy of the repaired pavement lives up to the theoretical design life.
- 6.11 For Structural Road Recycling schemes the size of job is an important factor, both practically and economically. The set-up costs for both in-situ and ex-situ Structural Road Recycling are relatively high in comparison to traditional reconstruction which generally utilises readily available localised plant and labour skills. Both in-situ and ex-situ Structural Road Recycling requires the use of specialist plant and a highly trained labour force with rare expertise. Only a small number of contractors have the specialist plant and expertise to carry out these processes and in most cases the plant and labour crews are required to travel the length and breadth of the UK to satisfy demand thereby incurring substantial costs in terms of heavy transport and subsistence payments to operatives. Relatively small sites of 1,000 m² or less can be put together in a programme of work to reduce unit costs and thereby demonstrate best value. Larger schemes of 3,000 m² or more will show the greatest cost savings and environmental benefit.
- 6.12 There are however some materials that cannot be treated economically by the standard process of in-situ Structural Road Recycling and these generally fall into the categories of oversized hard stone rock including granite sets, large pitching / capping rocks, pavement quality concrete, organic peat and some clay deposits.

Site investigation

- 6.13 All sites to be considered for both in-situ and ex-situ Structural Road Recycling should be properly investigated and the materials recovered tested in accordance with TRL guidelines prior to acceptance for treatment.
- 6.14 Despite the exceptions outlined earlier most materials typically found in UK roads are suitable for treatment by Structural Road Recycling including successive layers of asphalt and bituminous bound macadam, tar bound macadam or granular materials contaminated with tar, granular sub-base, burnt colliery shale, quarried scalplings (maximum size 100mm), soft sandstone pitching and brick hardcore. In the case of tar bound or tar contaminated materials Structural Road Recycling is considered by many to be the safest and most economical method of avoiding huge costs associated with their landfill or incineration. The Structural Road Recycling process dilutes, disperses and encapsulates hazardous tar contaminants into the recycled road structure thereby rendering them safe. Should tar be identified in the trial holes then a representative sample should be taken and sent for PAH and phenol analysis.
- 6.15 It is normal for the Structural Road Recycling contractor to include the cost of testing in the tendered price and for the client to arrange and stand the cost of the trial pit excavation including TM to facilitate the investigation work. It is also generally considered reasonable for the costs associated with on site attendance

and laboratory work, carried out by a UKAS accredited laboratory and initially organised and paid for by the Structural Road Recycling contractor, to be reimbursed to the contractor in the event that the works fail to proceed within a reasonable lapse of time for reasons outside the contractor's control.

- 6.16 Trial pits should be excavated at a maximum frequency of one per 500 m² however a more realistic approach may consider one trial hole per 800 – 1000 m² as being acceptable providing that materials and depth of construction found are broadly similar and depending on the size of the site. Trial pits should be at least 450mm deep and large enough to facilitate the recovery of representative material samples and to enable proper inspection and assessment of the foundation platform and sub-grade where possible. In the event that there is found to be an inconsistency in the materials and depth of construction further trial pits may be considered necessary in an attempt to identify the extent of the variation. The Structural Road Recycling contractor's representative should supervise the investigation work and direct the UKAS accredited technician accordingly to ensure that all available information about the existing road construction is obtained and recorded. Digital images of each and every trial pit alongside its excavated contents should be recorded. Trial pits should be systematically numbered and their locations logged either in relation to adjacent house numbers, numbered street furniture or longitudinal chainage to facilitate later identification. Where possible volume samples weighing up to a safe lifting weight of 20kg of each excavated layer should be recovered and collected in clear polythene sacks with the site reference, the trial pit number, the date and the layer depth clearly marked on the outside of the bag. Sample bags should be closed and sealed tightly with nylon cable ties to prevent moisture loss or spillage in transit. A log sheet should be completed and should record the layer thicknesses and the descriptions of materials found. In the event that all trial pits reveal materials of a similar type, depth and consistency then it is recommended that a combined minimum weight of material samples of 160kg be recovered from the exact layer range appropriate to the anticipated treatment depth.



- 6.17 In the event that large rocks are found within the existing construction then a simple test that can be carried out on site to assess its hardness and therefore its suitability for pulverisation. Place the rock on the road surface and hit it as hard as possible with the lump hammer a number of times. If the rock shatters into more manageable pieces then it should be suitable for treatment. The size of all rocks found in trial holes should be recorded and digital images taken with a tape measure strategically placed.
- 6.18 Where possible historical information about the site should be sought from the Engineer and taken into consideration along with the Site Investigation data before the Design Proposal is submitted to the Engineer for approval.

7. DETERMINING SITE SPECIFICATION

- 7.1 Structural Road Recycling is covered in the Specification for Highway Works Clause's 947 and 948 and in the Specification Guidelines for Structural Road Recycling contained within published documents TRL 386 or TRL 611 referred to earlier. In these publications the materials produced by in-situ and ex-situ Structural Road Recycling are referred to as Cold Recycled Bound Material (CRBM). The available binders fall into 5 basic categories – see Section 13.
- 7.2 The choice of Structural Road Recycling binder may depend on a number of factors including funding restraints, sustainability or environmental considerations, the anticipated intensity of traffic usage, the sub-grade CBR and any other underlying ground conditions. The application of lime may also be required, prior to the in-situ Structural Road Recycling process commencing, in order to modify cohesive sub-grade soils that will be incorporated within the recycled roadbase/binder course layer in order to satisfy the structural design requirements of the site.
- 7.3 TRL 386 contains a useful flow chart which helps the Engineer decide whether Structural Road Recycling is a viable option for a site under consideration, (Flow Chart A below) and indeed which binder option may be the most appropriate for the scheme under consideration, (Flow Chart B below).
- 7.4 Most in-situ Structural Road Recycling schemes in the UK have involved the use of either Quick Hydraulic (QH), more recently Medium Hydraulic (MH) binders or Quick Visco Elastic (QVE) Foamed Bitumen binders. Interestingly QVE Bituminous Emulsion binders were used extensively in the late 80's and early 90's to great effect but as with all bituminous binders they have fallen out of favour in recent years because of their high cost. The choice of binder will often be determined by cost and its local availability to the site under consideration. Other potential hydraulic binders are granulated blast furnace slag (GBS), ground granulated blast furnace slag (GGBS) both of which are by-products of the steel industry.
- 7.5 A Bituminous Bound Mixture (BBM) is considered to be a flexible recycled roadbase, which to the Engineer, is often a desirable quality, however BBM's are considerably more expensive to produce than the alternative, cheaper, rigid Hydraulically Bound Mixtures (HBM). The concerns regarding potential thermal cracking of rigid HBM's is believed to have been largely overcome by the

introduction of Pulverised Fuel Ash (PFA) into the binder mixture at manufacture and a corresponding reduction in the Ordinary Portland cement (OPC) content, thereby producing a weaker strength pavement initially but one that increases strength gradually over weeks, months and even years. It is the OPC content that gives the HBM its immediate strength and stability allowing it to withstand HGV loadings almost immediately however it is largely the hydration of the PFA that is believed to produce the gradual long term strength gain of the recycled pavement thereby reducing the risk of thermal cracking later in the pavements life.

7.6 The specification for in-situ Structural Road Recycling provided by the Specialist Sub-Contractor should contain the following key requirements:-

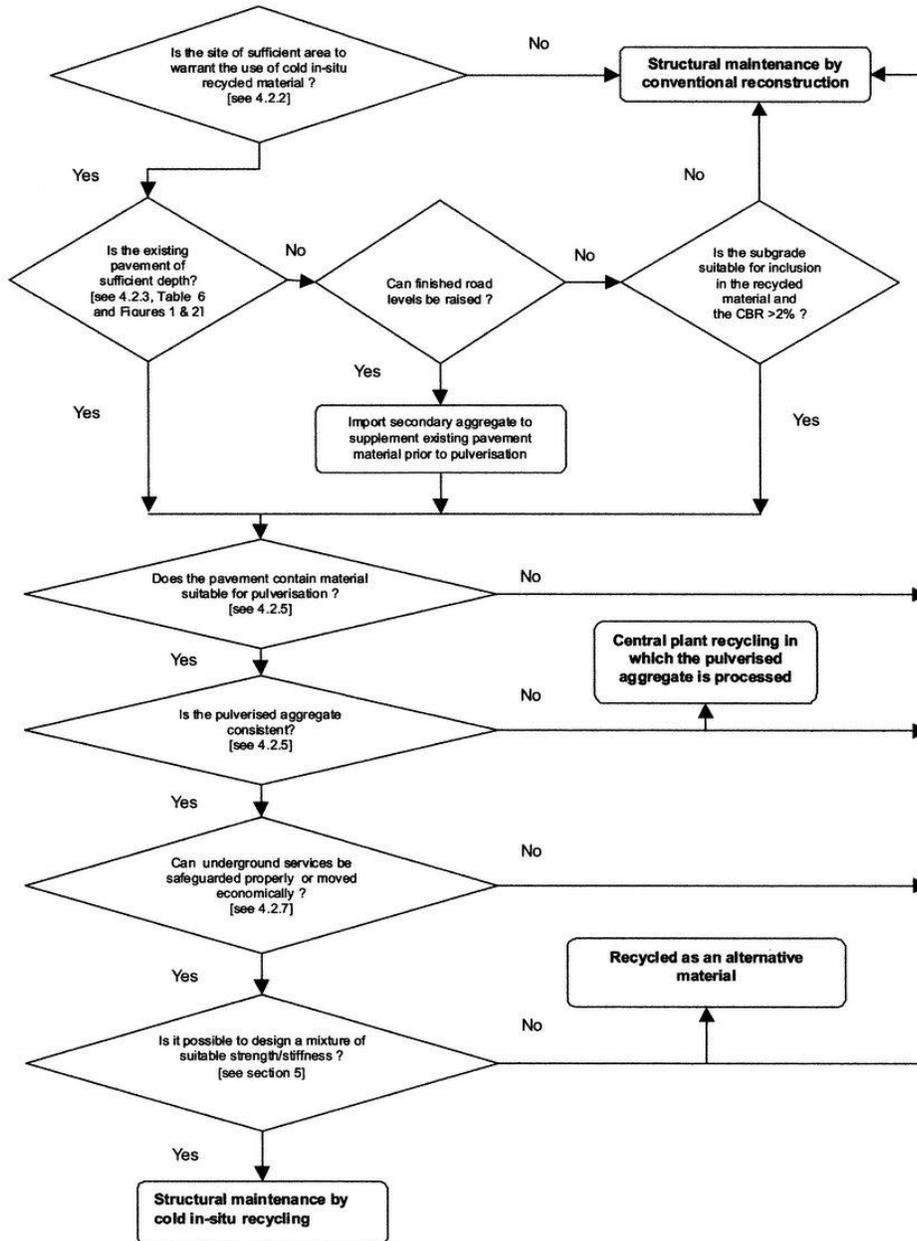
- Detailed Quality Plan
- Site investigation report
- Grading analysis of material to be treated
- Mix Design or Job Standard Mixture
- Process controls
- Inspection and testing regime
- Compaction requirements
- Sealing with bituminous emulsion and grit
- Product control testing criteria for constituents and final mix

7.7 Full specification details can be found in the Specification for Highway Works CI 947 In-situ Cold Recycled Bound Material. The Engineer should specify the following in Appendix 7/1 – Permitted Pavement Options:-

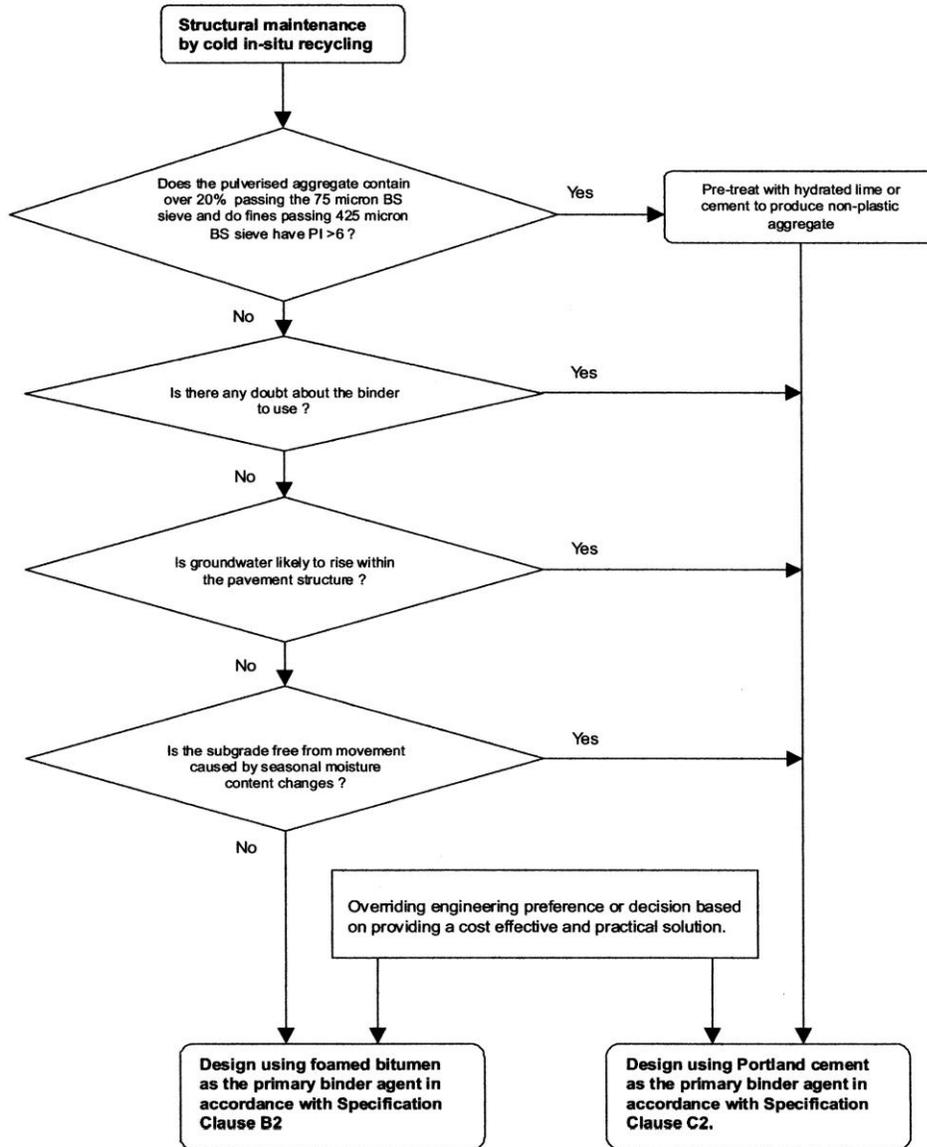
- Depth of Structural Road Recycling
- Amount of material to be removed (if any)
- Site limits
- Compound areas available for storage and stockpiles
- Frequency of test by Portable Dynamic Plate
- Minimum Surface Modulus as per Interim Advice Note (IAN) 73/06
- Minimum compaction requirements
- Need for a trafficking trial if applicable

The contractor should deliver to the Engineer the results of the End Performance tests in a timely fashion.

Flow Chart A: Site Evaluation



Flow Chart B: Primary Binder Agent Selection



- 7.8 The single most important criterion for a Structural Road Recycling mixture is the grading of the materials to be treated. The particle size distribution chart below indicates Zone A (ideal) and Zone B (suitability but subject to trial mix validation).

Sieve size (mm)	Percentage by mass passing (%)	
	Zone A	Zone B
50	100	-
37.5	94 – 100	-
20	66 – 100	100
10	48 – 75	75 – 100
5	35 – 57	57 – 95
2.36	25 – 42	42 – 77
0.6	13 – 28	28 – 52
0.3	10 – 24	24 – 45
0.075	5 – 20	20 – 35

8. SITE INFORMATION

It is important that the Principal or Term Contractor in charge of a Structural Road Recycling scheme is in possession of all relevant information appertaining to the site. One way of achieving this is to produce a specific Contract File for the site. In this file should be found the following information:-

- Information Sheet detailing all Contact Details necessary to carry out the works safely and efficiently within the guidelines of the CDM regulations.
- Site drawings showing the extent of the works, the location of any statutory undertakers apparatus and / or radar survey reports, location of compound and material storage area together with details of any specific restrictions that may be imposed
- Site Specific information sheet detailing the method of working, depth of treatment, type of binder and percentage binder additions, optimum moisture content, refusal density
- A Programme of the Works detailing phasing of each element and who is responsible
- The specification for the works together with a complete copy of the site Investigation Report including the Quality Plan, Job Standard Mixture and on-site testing regime
- Health Safety file including the Health and Safety Plan for the works and all COSHH Assessments appertaining to the nature of the works
- Traffic Management Plan detailing the way in which road traffic, pedestrians and operatives will be protected and controlled throughout every phase of the works

9. PLANNING THE EXECUTION OF THE WORK

- 9.1 When appointing or approving of the Structural Road Recycling contractor it is important that the Engineer takes into account the company's capabilities both from the point of view of their technical expertise and the scope of specialist plant that they have at their disposal. Structural Road Recycling demands the use of highly specialist plant in order to cope with a wide variety of road conditions. Recycling machines must be capable of pulverising through hard road surfaces without frequent breakdowns and repairs. The widths of plant must be suitably matched to the sites to be treated.
- 9.2 When planning the execution of the works the contractor must take into account the width variability of many sites and choose the appropriate machinery in order to execute the works quickly and efficiently so as to avoid unnecessary disruption to the road user and householder alike. Narrow rural lanes demand specialist plant that is capable of performing the recycling task without damaging or flattening grass verges. Major highways demand powerful recycling machinery capable of pulverising layers of hard asphalt and wide enough to affect a speedy repair.
- 9.3 The planning process should also take into account the timing and needs of other contractors working on the site, carrying out works such as pre-planing, ironwork adjustment, drainage installation or final surfacing. Method Statements are required for all ancillary operations.
- 9.4 Poor planning can result in low daily output, increased costs and public criticism. Supervisory staff must give proper consideration to the order in which various sections are treated, the number of vehicle movements transporting materials to the site and residents who may require access to their properties during the course of the works. Particular consideration should be given to residents who are disabled or those who have specific medical conditions requiring regular visits from nurses or carers.

10 CONTROLLING MATERIAL INSTALLATION

- 10.1 It is a requirement of the Specification that a UKAS accredited laboratory technician attends the site throughout each stage of the Structural Road Recycling process and that the technician is fully briefed as to the sampling and testing regime required.
- 10.2 Prior to the installation of the Structural Road Recycling roadbase there are a number of necessary measures that should be carried out. With urban sites all ironwork within the pavement to be treated should be lowered to a level at least 100mm below the proposed treatment depth wherever possible. Heavy gauge steel plate should be used to protect manhole chambers from the ingress of pulverised material whilst strong marine plywood may be deemed sufficient to protect road gully chambers that are located away from vehicular wheel tracks. The position of all ironwork and underground services affecting the works should be clearly marked on the footway, road surface, kerb line or grass verge with road paint. All overhead cables should be clearly marked with high visibility 'goal posts' and low overhanging tree branches should be removed prior to works commencing. All of this work would normally be carried out by the Principal Contractor.

- 10.3 Where it is not possible or practical to lower road gullies on either urban or rural sites then measures should be taken to cover the gratings to prevent the ingress of material from the recycling works. Road gullies in particular, whose covers and frames can be removed but whose chamber brickwork or gully pots cannot be lowered to 100mm below the proposed construction depth should be clearly marked on the footway, road surface, kerblines or grass verge warning the machine operators and banksman of the potential hazard. Always at these points the banksman should indicate to the recycling machine operator to lift up the cutting drum sufficiently so as to avoid contact with the installation. On completion of the Structural Road Recycling works all gullies should be inspected to check that they are working properly and any materials found resulting from the recycling works should be removed.
- 10.4 With rural sites it is important that the Engineer inspects and where considered necessary improves the drainage characteristics of the site well in advance of the works. This may involve arranging for grips to be re-opened or new ones cut, clearing ditches and even installing land drains or cut off drains where practical to protect the newly recycled pavement and to increase the structural life expectancy of the road pavement.
- 10.5 Throughout the course of an in-situ Structural Road Recycling scheme it is essential to monitor and record the depth of pulverisation regularly and to ensure that after the pulverisation stage but prior to the mixing stage the granulated material is levelled and graded back to a similar shape and level as that of the original road surface. This is necessary to ensure that the correct depth of treatment is achieved and that the correct amount of binder is added throughout the course of the works. An overlap of at least 150mm should be made between adjacent passes of the recycling machine and a 0.5m reformed joint should be made into a previously treated bay.
- 10.6 Material that cannot be reached by the recycling machine should be excavated and spread uniformly over the main carriageway for treatment and then pushed back into its original location to be compacted. This will often apply to material immediately adjacent to the road kerb where the concrete kerb bed prevents the recycling machine gaining close access or around irregular shaped build outs or island refuges.
- 10.7 The moisture content of the pulverised material should be measured and recorded immediately prior to stabilisation and any necessary adjustments made to achieve + or – 2% of optimum either prior to treatment by aeration or during mixing by the addition of additional water through a computer controlled pump and spray bar on the recycling machine.
- 10.8 The addition of both bituminous and hydraulic binders demands great care, not only to ensure that a high quality mixture results but also to make sure that the resultant mixture compares favourably with the Job Standard Mixture. In the case of hydraulic binder application it is important that the binder spreader is regularly calibrated and that the spreader outlet is adequately skirted and shielded to ensure that little or no dust emissions occur as this can become a serious hazard to operatives and the public alike during operation.

- 10.9 Grading and level control is clearly an important aspect of any Structural Road Recycling scheme. Failure to control levels properly can result in expensive blacktop regulating later which can in some cases result in the scheme going over budget. The grade and shape of the recycled pavement is achieved with a motorised grader and the accuracy of the finished recycled roadbase is largely down to the skill and expertise of the operator. With urban sites level control is usually achieved by dipping from a string line held tightly from kerb to kerb at intervals of 10 metres along the road. With rural sites then level control is usually left up to the operator of the grader as any general and specific shape and level requirements are usually agreed with the Engineer prior to the works commencing. Once grading is complete then final rolling can take place, usually involving a further 2 or 3 passes of the roller in vibration mode in order to fulfil the specification.
- 10.10 It is important that the Engineer understands that when carrying out the Structural Road Recycling process on narrow country lanes (4m or less) then it is virtually impossible to grade the shape of the road to a camber because of the width of available motor grader machinery and blades. On narrow lanes current machinery will only allow the operator to grade to a cross fall or level flat grade. In exceptional circumstances the Engineer may wish to allow for a degree of regulating within the surfacing layer if a camber is specifically required.
- 10.11 When compaction is complete, density tests have been taken and the specification requirements fulfilled it is time to seal the surface of the recycled layer. A K1-40 bituminous emulsion should be applied at a minimum rate of 0.5 litres/m². If the surface of the recycled layer is starting to dry out then additional water should be sprayed on to the surface of the recycled layer to ensure that it is moist prior to application of the seal coat. A lightly coated bituminous grit should then be applied immediately on to the bituminous tack coat layer at a rate of 5.5 – 7.0 kg/m² to provide a non stick surface for public vehicles, pedestrians and construction traffic and to facilitate the curing of the recycled layer.
- 10.12 Structural Road Recycling should only be carried out when the air temperature is at least 3°C and rising. Any extreme weather condition can affect the quality of Structural Road Recycling especially heavy persistent rain. In the event that rainfall starts to increase the moisture content of the pulverised material then it is recommended that the area of road that has been pulverised is rolled back tightly until such time as the weather improves.

11. TRAFFIC MANAGEMENT

- 11.1 Traffic Management is usually the responsibility of the Principal Contractor.
- 11.2 Please refer to specialist TM contractors qualified and operating to NHSS12 A-D as appropriate.
- 11.3 In undertaking Structural Road Recycling the needs of road users must be considered at all stages. The safety of operatives and the public, whether on foot or in motor vehicles, is paramount.

- 11.4 It must always be remembered that the needs of any site should be considered as unique and each Structural Road Recycling crew should contain properly trained and competent personnel. A proper risk assessment should be undertaken for each specific site by an appropriately trained person well in advance of the works and acted upon before Structural Road Recycling equipment and operatives are dispatched to the site. At some sites, this will require discussion between the contractor and representatives of the highway authority at the pre-contract stage. Where this is the case, the agreement reached between the parties should be passed on to the person controlling site operations. The National Highway Sector Scheme 13 document details these requirements.
- 11.5 The correct selection of traffic management system to be adopted is important and should comply fully with Chapter 8 of the Traffic Signs Manual (Traffic Safety Measures and Signs for Road Works and Temporary Situations). The public should not be unduly inconvenienced by detours or long delays, or the reputation of Structural Road Recycling as an efficient and economic process may be put at risk. The Engineer should be aware that if a Road Closure is deemed necessary in order to carry out the works safely and speedily then it is normal to expect 13 week's notice to be required before such a closure can be legally implemented.
- 11.6 Publicity
- Road users do not like being delayed and will take alternative routes if they are given adequate information. As Structural Road Recycling works are normally of a short duration and dependent upon favourable weather forecasts, it is difficult to predict accurately when traffic flow at any particular site is likely to be affected. Nevertheless, principal roads carry many thousands of vehicles per day. It is essential therefore that every possible method should be utilised to inform the road user that a site is to be affected. Press releases to local papers, district and parish councils, local radio etc can all help.
- 11.7 The most effective methods are the display of information boards at each site saying, for example, that a green and sustainable Road Recycling solution is being deployed at this site to reduce costs and to minimise disruption. The work is to be carried out and when.
- 11.8 The distribution of letters to all dwellings and premises and also attached to all vehicles (loosely under windscreen wipers) detailing what works are to take place and when. In addition, emergency services, bus operators and any other organisation likely to be affected by work at a particular site should be notified in advance. Good communications can make all the difference between a contented or complaining public.

Traffic control and signing

- 11.9 For the safety of drivers, pedestrians and operatives, traffic passing over newly treated roads or alongside Structural Road Recycling works must be properly controlled. Such control includes adequate advance warning of the works, regular reminders throughout the site of the risk of loose chippings and the proper management of vehicles by the use of traffic lanes. Some instructions such as "stop" and "give way" are indicated both by carriageway markings and by mounted

signs. When these carriageway markings are removed by Structural Road Recycling works it is important to replace them as soon as possible or to provide some temporary signs during the period between the covering of the markings and their permanent replacement. This is particularly important at junctions with high-speed roads.

- 11.10 The careful control of traffic and the maintenance of speeds of 20 mph or less over newly-completed Structural Road Recycling works is necessary in order to give the material time to cure and to prevent unnecessary damage prior to final surfacing.

12. ROAD PREPARATION

Pre-Planing

- 12.1 When considering the use of Structural Road Recycling in the urban environment it is often necessary to pre-plane the road pavement in advance of the works in order to maintain levels and thresholds. All Structural Road Recycling schemes require the application of at least a new final surface course and this together with a degree of bulking caused by the recycling process will mean that if thresholds are to be maintained then some material will have to be taken away from the site. The most economical and fastest way of achieving this is by pre-planing the pavement prior to the recycling process commencing. This is normally the responsibility of the Principal Contractor however it is essential that the Structural Road Recycling contractor is consulted early on in the planning stage and is asked to give advice on the amount of pre-planing that is deemed necessary. As a rule of thumb the Engineer should allow for pre-planing the thickness of any final surfacing plus an amount equal to 10% of the proposed recycled roadbase thickness. Resultant road planings should be taken to the Engineer's own recycling facility for later re-use or to the nearest commercial recycling HUB.
- 12.2 The alternative solution to pre-planing in advance of the works is to remove excess material during the pre-pulverisation stage itself. This method requires that tipper lorries are loaded by excavators after the pre-pulverisation of the bay is complete and the material has been trimmed and compacted to the required levels. This in itself can be difficult especially on narrow roads or when operating under temporary traffic control traffic management arrangements. This method, whilst technically advantageous in terms of distributing high quality aggregates from the surface layers of the road down through the layer to be recycled, is much slower and consequently more expensive to execute than the pre-planing option. It is generally considered that the cost benefit, construction time saving and overall safety improvements of pre-planing the site first outweigh any technical or material improvements gained from the alternative.
- 12.3 Rural sites in need of Structural Road Recycling rarely require pre-planing or necessitate the disposal of excess materials.
- 12.4 Weed killing

Both urban and rural roads that are being considered for Structural Road Recycling may benefit from weed treatment prior to recycling commencing. Weed growth along the middle of narrow country lanes can undermine the long term life

expectancy and structural integrity of roads treated with the Structural Road Recycling process. Urban roads can deteriorate prematurely in the channel line if weeds are allowed to become established.

13. BINDERS

There are 5 main binder categories that are used in Structural Road Recycling.

QH Quick hydraulic - Ordinary Portland Cement (OPC) as the main hydraulic component

SH Slow hydraulic - binders such as Pulverised Fuel Ash (PFA)/lime or Granulated blast furnace Slag/lime but excluding bituminous binders and OPC

MH A medium strength gain hydraulic binder containing both OPC and PFA thereby offering the advantages of both QH and SH binder categories

QVE Quick visco-elastic - Bituminous binder as the main component but also including OPC

SVE Slow visco-elastic - Bituminous binder as the main component but excluding OPC

14. AGGREGATES AND FILLERS

It is rare that additional aggregate or fillers are required for a Structural Road Recycling process. Pulverised Fuel Ash (PFA) is, on occasions, used as a filler to correct inadequacies in material grading. Additional aggregate, in the form of road planings, Type 1 sub-base or other recycled / secondary materials are sometimes used in areas of road widening or where road levels need to be raised to increase construction depth or improve drainage. Imported road planings and other granular materials such as recycled or virgin aggregate can be used as the basis of a new Structural Road Recycling construction project.

15. COMPACTION

The compaction of an in-situ Structural Road Recycling scheme should be carried out with a twin drum vibrating roller with a minimum dead weight of 10 tonnes. Vibration mode should be used at all times. Each pass of the vibrating roller should be overlapped by at least 100mm and a defined rolling pattern should be adhered to. On a cambered road then rolling should commence from the lowest point and proceed in stages up to the high point of the camber. Care should be taken not to roll over the apex of the camber. Similarly on a road with a cross fall rolling should commence from the lowest point and proceed in stages overlapping each pass. After approximately 5 passes the grading operation should commence.



Compacting to achieve a minimum 95% of refusal density

16 ALL PLANT

- 16.1 The process of Structural Road Recycling requires the use of specialist plant and at the heart of the process is the pulveriser/recycler machine.
- 16.2 Most in-situ recycling machines are capable of pulverising and granulating road constructions to a depth of 325 mm in a single pass and at a pace similar to a slow walking pace. The machines are manufactured with varying cutting widths ranging from 1.000 m to 2.500 m and some have sophisticated computer controlled pumps and spray bars to allow the application of various liquids such as water, bituminous emulsion and foamed bitumen. Others are built with an integrated powder spreader which allows the application of powdered binders or fillers to be applied directly into the mixing chamber thereby avoiding even the slightest discharge of dust particles into the atmosphere. This method of binder application, whilst environmentally preferable in some circumstances is slow and laborious and increases costs significantly.
- 16.3 In most situations and weather conditions powdered binders can be laid directly on to the surface of the pulverised material without cause for concern. A bulk binder spreader used for this purpose can hold up to 22 tonnes of powder and facilitates high production rates. It is essential that the recycler/mixer machine maintains a close proximity to the spreader whilst mixing the binder into the road layer thereby reducing the risk of any powder accidentally becoming air-borne. The binder spreader itself should be equipped with effective skirts and cowling to eliminate dust emissions.



Structural Road Recycling – bulk binder spreader

16.4 Other items of plant required include a motor grader, twin drum roller, self propelled water bowser, bituminous tack coat sprayer and a heated bitumen tanker (Foamed Bitumen only).

16.5 The noise levels of all plant should be ascertained from manufacturers or suppliers. If they are not available, the user must take measurements themselves and ensure that all operatives are provided with the correct hearing and face protection where necessary. All plant and vehicles should be adequately maintained with regular inspection reports available.

17. METHOD OF WORKING

17.1 Prior to works commencing it is important that the Structural Road Recycling contractor ensures that the UKAS Accredited Laboratory Technician is in possession of the Laboratory Testing File for the job in question in which the following data should be found:-

- Quality Plan
- Job Standard Mixture
- Natural and optimum moisture content
- Density target
- Specification and Process Control requirements

17.2 Structural Road Recycling can be carried out under a variety of different traffic management scenarios. A road or lane closure will always be the safest and most cost effective environment for operatives and the public alike. It also facilitates rapid completion of the works without hindrance or restriction. Closures are not always possible though so the Engineer must consider alternative traffic

management solutions such as temporary traffic control or 'one way' traffic combined with a temporary diversion route.

- 17.3 On all but very lightly trafficked schemes the main contractor should be responsible for all traffic management and this clearly needs to be in place before any other operations commence. If pre-planing of the existing carriageway is required then this should be carried out in advance of the Structural Road Recycling process together with the lowering of any ironwork deemed necessary. All ironwork should be clearly marked on the road surface and footway as well as any utility apparatus which, when identified from the Ground Radar Survey (GRS), is expected to be within or in close proximity to the layer being treated.
- 17.4 It is usual to divide the section of road to be treated into 'bays' and to endeavour to complete each bay before starting work on the next. There are a number of factors that may influence the size of a bay, such as; traffic management arrangements; restricted working hours; the number of daylight hours that are available per shift; impending weather conditions; physical characteristics and accessibility of the site; availability of water and binders; the hardness of the existing road construction.
- 17.5 During periods of dry settled weather and when working on sites that are closed to through traffic the Structural Road Recycling contractor may decide to pulverise and prepare for processing a larger than normal area by combining a number of bays together. This operation may take 1 or 2 days in itself before binder application and processing can take place and is often beneficial to the progress of the works in that machinery and labour are utilised more effectively. Care should however be taken before pulverising large areas of pavement, especially in rural locations where drainage assets are often few and far between, as unexpected down pours of rain can not only result in the saturation of the pre-pulverised material but can also penetrate the pavement sub-grade both of which can result in delaying the progress of the works in opposition to the intended increased productivity. Additional moisture may be added to the material being pulverised at this stage, especially if the material is particularly dry or if dust emissions become problematic.
- 17.6 After pulverisation is complete it is necessary to grade and shape the road to the required profile and to lightly compact the material prior to the addition of the binder. It is not necessary to measure or monitor the degree of compaction at this stage.



- 17.7 Prior to binder application it is essential that the Structural Road Recycling contractor accurately measures the area of road to be treated in order that the right amount of binder can be calculated so as to meet the requirements of the Job Standard Mixture.

18. POST INSTALLATION, SITE PROTECTION AND CURING

- 18.1 Structural Road Recycling materials can usually be trafficked after 2 hours of completion and indeed straight line trafficking is often encouraged. This usually applies to all binder categories except SVE which normally requires a 24 hour period for curing.
- 18.2 All ironwork should be re-located and raised to the new finished road level. Some additional works may be required to grass verges on rural sites where levels have increased significantly. Any road gullies that could not be lowered prior to recycling should be cleaned thoroughly and any foreign matter removed to allow water to drain freely. On heavily trafficked roads that require the recycled roadbase to be subjected to live traffic the final surfacing should be applied within 2 days of completion of the recycling process. On lightly trafficked roads or roads that are closed to through traffic for the entire duration of the works then final surfacing can be delayed for up to 1 week without any cause for concern.

19. END-PRODUCT SPECIFICATION CONTRACT

- 19.1 Specification for Highway Works Clause 947 and TRL 386 or TRL 611
- 19.2 Because of the specialist nature of the recycling process the majority of Structural Road Recycling schemes are designed by the Structural Road Recycling contractor and this design is subsequently approved and adopted by the Engineer in charge of the works. The guarantee period for such works is usually 12 months from completion.



The mixed material (HBM)



Level control for Structural Road Recycling schemes should be as stringent as that for conventional reconstruction.



The finished product - a typical unclassified road in Wales

APPENDIX A

CHECK LISTS

1. PRE-CONTRACT CHECKLIST

- a) Are all the necessary traffic management orders in place and have all stakeholders been notified?
- b) Is the contractor in possession of all relevant site information i.e. Ground Radar Survey, location of schools, bus route, market days, events etc?
- c) What type of traffic control is to be operated and is there enough labour to carry out the works in a safe and proper manner?
- d) Have all labour received the appropriate training?
- e) Has the correct and adequate plant been allocated as required under the contract?
- f) Are the materials specified under the contract available when required?

2. SITE CHECKLIST

- a) Has the road been pre-planned as per the contract requirements?
- b) Have all utilities apparatus that are deemed to be within or in the immediate proximity of the proposed recycled layer been clearly marked on the site?
- c) Has all ironwork affected by the works been lowered and / or protected and has it all been marked clearly on site?
- d) Is the road clear of parked vehicles or any other obstructions?
- e) Is the TM all in place and are all the signs correct?
- f) Is there a Quality Plan?
- g) Are the operatives all present and correct and wearing the relevant Personal Protection Equipment?
- h) Is there a UKAS Accredited Laboratory technician in attendance and is he in possession of all the test results including the Job Standard Mixture, Target Densities and Specification of the Works?
- i) Have all operatives been fully inducted?
- j) Is all the plant present and in safe working order?
- k) Are the weather conditions appropriate to commence work i.e., weather forecast, air temperatures?

- l) Is the planned method of operation safe, both to the operatives and the public?
- m) What type of traffic control is to be implemented and does everybody understand the method of operation?

3. POST CONTRACT CHECKLIST

- a) Have arrangements been made for a post-contract inspection and interview?
- b) Have all the required contract information and test results been collected, documented and presented to the Engineer?

APPENDIX B

GLOSSARY OF TERMS

ADEPT

Association of Directors of Environment, Economy, Planning and Transport, previously known as the County Surveyors Society (CSS).

ADHESION

The property by means of which a binder sticks to the surface of a solid body, e.g. the road surface.

AGGREGATES

Aggregate from mineral sources which has been subjected to nothing more than mechanical processing and which has a particular grading.

BINDER

Material serving to coat the particles of an aggregate and to assure its cohesion. The binder component of an in-situ recycling operation is typically a bituminous emulsion or foamed bitumen or a hydraulic cementitious binder.

BINDER CONTENT

The amount of binder in the mixed material as a percentage by mass of the total.

BITUMEN

Virtually involatile, adhesive and waterproofing material derived from crude petroleum, or present in natural asphalt, which is completely or nearly completely soluble in toluene, and very viscous or nearly solid at ambient temperatures.

BSI

British Standards Institution.

BSEN 13043:2002

European Product Standard for Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas.

CDM

The Construction (Design and Management) Regulations 2007 which place duties on clients, designers and contractors in relation to management arrangements and practical measures for construction projects.

CE MARKING

The CE marking (also known as CE mark) is a mandatory conformance mark on many products placed on the single market in the European Economic Area (EEA). The CE marking certifies that a product has met EU consumer safety, health or environmental requirements.

C E N

The European Committee for Standardization or Comité Européen de Normalisation (CEN), is a non-profit organisation whose mission is to foster the European economy in global trading, the welfare of European citizens and the environment by providing an efficient infrastructure to interested parties for the development, maintenance and distribution of coherent sets of standards and specifications.

COST LIFE INDEX

The cost expressed as the cost per square metre divided by the service life.

CPR

Construction Products Regulations.

DURABILITY

Ability of a product to maintain its required performance, under the influence of foreseeable actions, for a reasonable economic working life.

LAYING RECORD

A documented record providing details of the material laid.

MIX DESIGN

A laboratory process for determining the optimum combination of mixture components necessary to achieve the desired level of in service performance.

NVQ

National Vocational Qualifications (NVQ's) are work based awards in England, Wales and N.Ireland that are achieved through assessment and training. In Scotland they are known as Scottish Vocational Qualification (SVQ). To achieve an NVQ, candidates must prove that they have the ability (competence) to carry out their job to the required standard. NVQs are based on National Occupational Standards that describe the 'competencies' expected in any given job role. Typically, candidates will work towards an NVQ that reflects their role in a paid or voluntary position. For example someone working in an admin office role may take an NVQ in Business and Administration. There are five levels of NVQ ranging from Level 1, which focuses on basic work activities, to Level 5 for senior management.

QA

An abbreviation for Quality Assurance.

QUALITY ASSURANCE

Quality assurance, or QA for short, is the systematic monitoring and evaluation of the various aspects of a recycling operation to maximize the probability that minimum standards of quality are being attained by the production process. Registration to BSEN ISO 9001 given to a contractor by a certification body indicates minimum standards are being attained.

ROLLER

Mobile plant/equipment used to compact road layers

RSTA

The Road Surface Treatments Association is the trade body representing the road surface treatments industry. www.rsta-uk.org .

TRAFFIC SIGNS MANUAL

Regulatory guidance on the use of traffic signs at mobile works. Traffic Signs Manual Chapter 8: Traffic Safety Measures and Signs for Road Works and Temporary Situations.

UKAS

National Measurement Accreditation Services.

APPENDIX C

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