VOLUME 7 PAVEMENT DESIGN AND MAINTENANCE
SECTION 1 PREAMBLE

PART 2

HD 35/04

CONSERVATION AND THE USE OF SECONDARY AND RECYCLED MATERIALS

SUMMARY

This part, previously called 'Technical Information', gives advice on the conservation and use of reclaimed materials in road construction and maintenance. This revised version has been updated and now includes additional materials and the latest advice.

INSTRUCTIONS FOR USE

1. Remove Contents pages for Volume 7 and insert new Contents pages for Volume 7, dated November 2004.

2. Remove HD 35/95 from Volume 7, Section 1 which is superseded by this Standard and archive as appropriate.

3. Insert HD 35/04 into Volume 7, Section 1.

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THE DEPARTMENT FOR REGIONAL DEVELOPMENT
NORTHERN IRELAND

Conservation and the Use of Secondary and Recyclced Materials

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HD 35/04

CONSERVATION AND THE USE OF SECONDARY AND RECYCLED MATERIALS

Contents

Chapter

1. INTRODUCTION

General

1.1 This part contains general items of a technical nature that have relevance to the construction and maintenance of all types of pavement. Advice is given on the conservation and use of secondary and recycled materials in road construction and maintenance. Specific or general provision for the use of recycled and secondary materials within the Specification (MCHW 1) does not automatically infer environmental suitability, and although the increased use of recycled and secondary materials can have a significant positive impact on the environment via reductions in landfilling, quarrying and transportation of aggregates, it is important to assess the acceptable application of these materials in line with current environmental guidelines.

Scope

1.2 This part gives guidance to design organisations on conservation techniques and the use of secondary and recycled materials that are currently permitted in the Specification (MCHW 1) and in the earthworks, drainage and pavement construction parts of the Design Manual for Roads and Bridges (DMRB 4.1, 4.2 and 7).

Implementation

1.3 This part may be used forthwith on all schemes for construction, improvement and maintenance of trunk roads including motorways being prepared, provided that in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay in progress. Design organisations should confirm its application to particular schemes with the Overseeing Organisation. For use in Northern Ireland, this part will be applicable to those roads designated by the Overseeing Organisation.

2. PROVISIONS FOR THE USE OF SECONDARY AND RECYCLED MATERIALS

General

2.1 The attention of those responsible for the design, specification, construction and maintenance of roads is drawn to the opportunities to conserve and re-use materials arising from roadworks, as well as the potential uses for secondary or recycled materials from other sources that may be proposed when cost effective.

2.2 It is Government policy to encourage conservation and facilitate the use of reclaimed and marginal materials wherever possible, in order to obtain environmental benefits and reduce the pressure on natural reserves of primary aggregates. The Landfill Tax and Aggregate Levy are seen as powerful drivers towards sustainable construction with the main aims being the increased use of secondary and recycled materials in construction, a reduction in construction waste going to landfill, and a reduction in primary aggregates output per unit of construction value.

2.3 Suitable materials may be those reclaimed from roads during reconstruction, from residues of industrial processes including mining, and from the demolition of other construction projects. Such materials may provide good value for money, particularly if their use involves less haulage. Where existing road foundations are in good condition, conservation of the pavement structure by strengthening with an overlay or inlay and widening where necessary, can also be an effective strategy for reducing the demand for primary aggregates.

2.4 The Joint Circular from the DoE (20/87), DoT (3/87) and Welsh Office (36/87) entitled 'Use of Waste Material for Road Fill' sets out administrative procedures to ensure that information about future road schemes and their likely fill requirements are given to local Planning Authorities at the earliest possible stage. The circular states that, while it will be for tenderers to choose their sources of fill on a commercial basis, the acceptability of sites for borrow pits is a matter for the land use planning system. It recommends that Planning Authorities should therefore treat planning applications for borrow pits in the same way as applications for other mineral developments, taking into account the availability of suitable material. In Scotland the National Planning Policy Guideline NPPG4, Land for Mineral Working, issued by the Scottish Office Environment Department, gives guidance to planning authorities on the recycling and re-use of construction waste and materials in waste tips where this is environmentally acceptable.

2.5 The Specification for Highway Works (MCHW 1) permits a wide range of reclaimed materials such as road planings, crushed concrete and mineral by-products such as slags, furnace bottom ash (FBA) and the like, to be used in place of primary aggregate. But where the Specification (MCHW 1) refers to individual materials, this may be taken to imply that other materials not specified by name might be inherently unsuitable in some way even if conforming to the appropriate standard. One aim of this advice note is to highlight the existing provisions made in the Specification (MCHW 1) for the reuse and recycling of reclaimed materials and to encourage their widest application.

2.6 The variability of recycled and secondary materials may require more frequent test regimes to enable their re-use at high level within the road pavement construction. Recycling of road planings requires considerable processing and control procedures to ensure standards are maintained. Thus it may prove more efficient and cost effective to re-use such arisings lower down in the pavement or in the foundations, or alternatively to limit replacement levels in higher layers to percentages which will minimise additional testing. Similarly, the re-use of old pavement quality concrete, after crushing and grading, as recycled concrete aggregate for the lower layer of the monolithic slab or as a continuously reinforced concrete base (CRCR) slab, is likely to prove efficient and cost effective.

2.7 The conservation of existing pavements and the use of secondary and recycled materials helps to reduce the impact on the environment by reducing the extraction of primary aggregates and at the same time reduces the amount of waste being generated. Environmental benefits can also arise from the consequent reduction of construction traffic on local roads. Any additional costs of sorting and processing of secondary or recycled materials may be offset by reduced energy requirements compared with the extraction and transportation of primary aggregates. There may also be a reduction in the amount of fresh bitumen required when recycling bituminous bound materials.

Application and Series ▶	Pipe Bedding	Embank-ment and Fill	Capping	Unbound Mixtures for Sub-base	Hydraulically Bound Mixtures for Sub-base and Base	Bitumen Bound Layers	PQ Concrete
Material ▼	500	600	600	800	800	900	1000
Blast furnace Slag	✓	✓	✓	✓	✓	✓	✓
Burnt Colliery Spoil	x	✓	✓	✓	✓	x	x
China Clay Sand/Stent	✓	✓	✓	✓	✓	✓	✓
Coal Fly Ash/Pulverised Fuel Ash (CFA/PFA)	✓	✓	✓	x	✓	✓	✓
Foundry Sand	✓	✓	✓	✓	✓	✓	✓
Furnace Bottom Ash (FBA)	✓	✓	✓	x	✓	x	x
Incinerator Bottom Ash Aggregate (IBAA)	✓	✓	✓	✓	✓	✓	✓
Phosphoric Slag	✓	✓	✓	✓	✓	✓	✓
Recycled Aggregate	✓	✓	✓	✓	✓	✓	✓
Recycled Asphalt	✓	✓	✓	✓	✓	✓	✓
Recycled Concrete	✓	✓	✓	✓	✓	✓	✓
Recycled Glass	✓	✓	✓	✓	✓	✓	x
Slate Aggregate	✓	✓	✓	✓	✓	✓	✓
Spent Oil Shale/Blaise	x	✓	✓	✓	✓	x	x
Steel Slag	✓	✓	✓	✓	✓	✓	x
Unburnt Colliery Spoil	x	✓	x	x	✓	x	x

KEY:

✓ Specific (permitted as a constituent if the material complies with the Specification (MCHW 1)) or General Provision (permitted as a constituent if the material complies with the Specification (MCHW 1) requirements but not named within the Specification (MCHW 1)).

x Not permitted.

IMPORTANT NOTES:

1. Table 2.1 is for guidance only and reference must be made to the accompanying text and the Specification (MCHW 1). Materials indicated as complying with the Specification (MCHW 1) for a particular application may not necessarily comply with all the requirements of the series listed, only particular clauses. For example in the 600 series, Unburnt Colliery Spoil can satisfy the Specification (MCHW 1) as a general fill, but is excluded as a selected fill; and in Series 1000 recycled or secondary materials are not permitted within the running surface of PQ concrete. Reference should also be made to the Specification (MCHW 1) for any maximum constituent percentages of specific recycled or secondary aggregates. For example in the 1000 Series, the maximum by mass constituent of Recycled Asphalt is given under the limits for 'other material' (Table 10/2) within the Specification (MCHW 1).
2. There is no Specific or General Provision for the use of recycled glass as an aggregate in PQ concrete or Hydraulically Bound Mixtures due to the potential for deleterious alkali-silica reaction (ASR). However, its use may be permitted by the Overseeing Organisation if sufficient provisions to minimise the risk of deleterious ASR are included in the mixture design.
3. There is no Specific or General Provision for the use of steel slag as an aggregate in PQ concrete or Hydraulically Bound Mixtures due to the potential for volume instability. However, its use may be permitted by the Overseeing Organisation if sufficient assurance of volume stability is provided.

Table 2.1: Specification for Highway Works (MCHW 1): Application of Secondary And Recycled Aggregates

The Provision for Secondary and Recycled Materials Within the Specification for Highway Works (MCHW 1)

2.8 Table 2.1 illustrates that all the secondary and recycled materials listed **can** be suitable in one form or another for inclusion in drainage work or earthworks or foundations or pavements, providing always that they comply with the requirements of the Specification (MCHW 1). For definitions of terminology used in this section refer to the Glossary of Terms (paragraph 2.37).

Health and Safety

2.9 Although Table 2.1 indicates that all the secondary and recycled materials listed are permitted by the Specification (MCHW 1), consideration must be given to aspects of health and safety. Of particular concern is dust arising from materials, which may affect both workers and others, as well as reducing visibility and hence safety. Leachate from reclaimed materials should be assessed from a health and safety point of view, and appropriate protective equipment used and washing facilities provided.

Series 500 Drainage

2.10 Recycled coarse aggregate and recycled concrete aggregate are specified by name. Maximum water soluble sulphate levels may restrict the use of some of the secondary and recycled materials listed in Table 2.1. Other uses of secondary and recycled materials include recycled tyres as drainage materials in the form of bonded crumb rubber.

Series 600 Earthworks

2.11 The Specification (MCHW 1) permits a very wide range of bulk fill materials under the headings ‘general granular fill’ and ‘general cohesive fill’. Unacceptable materials are listed and include materials having hazardous chemical or physical properties. Thus, the possibility of leachate from any material must be addressed.

Blast Furnace Slag can comply as selected granular fill and is specified by name, but this would be a wasteful re-use of a premium material. Slag is specifically excluded from granular fill overlying buried steel structures.

Burnt Colliery Spoil can comply as bulk or selected granular fill and is specified by name for many applications.

China Clay Sand and Stent, being natural aggregates, can both comply as bulk and selected granular fills.

Coal Fly Ash/Pulverised Fuel Ash is specified by name as PFA in both general cohesive fill containing not more than 20% FBA, and as conditioned ash in selected cohesive fill to structures and for reinforced earth.

Furnace Bottom Ash (FBA) can comply as bulk fill and as selected granular fill that is to be stabilised with cement. However, it is not a named selected granular fill since it would generally fail the strength requirement.

Foundry Sands can comply as a bulk fill and as a selected granular fill.

Incinerator Bottom Ash Aggregate (IBAA) can comply as bulk fill and as a selected granular fill.

Phosphoric Slag can comply both as a bulk fill and as a selected fill. However, as with blast furnace slag, the use of this premium material for granular fill would be wasteful.

Recycled Aggregate, as crushed demolition debris, can comply as bulk fill provided it does not contain unacceptable materials as defined in this series.

Recycled Asphalt can comply as bulk fill, although this would in general be a wasteful re-use of a premium material. Accurate measurement of the moisture content of bituminous planings can be difficult and should be given specific consideration.

Recycled Concrete can comply as a selected granular fill and is specified by name as crushed concrete under a number of applications.

Recycled Glass could comply as a bulk fill and selected granular fill but would be unlikely to be used in these circumstances.

Recycled Rubber in the form of shredded tyres or tyre bales could potentially be used as a lightweight bulk fill or back fill to structures. Rubber is not named in the Specification (MCHW 1) and advice should be sought from specialists, and the Overseeing Organisation consulted with regard to its use. Of note is any potential for pyrolysis or combustion of these materials.

Slate Aggregate is a natural aggregate and can comply as both bulk and selected granular fill.

Spent Oil Shale/Blaise can comply as bulk fill but is not permitted as selected granular fill.

Steel Slags are excluded (except where mentioned below) due to the possible presence of free lime (CaO) and/or free magnesia and the consequent risk of expansion when hydration occurs. Weathering of steel slag over several months allows these hydration reactions to occur and produces a more stable material. **Weathered Steel Slag** (as specified in Series 800) may be permissible if adequately controlled to minimise risk of particle disintegration or expansion.

Unburnt Colliery Spoil can comply as bulk fill but is excluded from selected granular fill.

Series 600 Capping

2.12 Table 2.1 shows that all secondary and recycled materials except steel slag (except where mentioned below) and unburnt colliery shale can meet the Specification (MCHW 1) as capping on their own or as part of a combination, as either unbound selected granular fill or bound with cement and/or other binders. Weathered steel slags can comply as selected granular fill. Selected conditioned PFA for stabilisation with cement to form capping is specified as a separate class. Accurate measurement of the moisture content of asphalt planings, and the determination of optimum moisture content, can be difficult and should be given specific consideration.

Series 800 Unbound Mixtures for Subbases

2.13 Recycled concrete, asphalt (up to 50% by mass as a constituent of recycled aggregate) and aggregate, blast furnace slag, and non-plastic shale (burnt colliery spoil and spent oil shale) can all comply with the Specification (MCHW 1) and are named. Specific provision is given for a sub-base comprised of asphalt planings. Steel slag, well weathered and conforming to the requirements of BS 4987-1 is also specified. China clay Stent and slate aggregate are quarried rocks and can comply when processed. Foundry sand, glass, IBAA (up to 15% by mass) and China clay sand can also comply as components within the Specification (MCHW 1). Higher proportions of IBAA may be acceptable within unbound sub-bases following additional testing.

Series 800 Hydraulically Bound Mixtures for Subbase and Base

2.14 Slag Bound Material (SBM), bound with Granulated Blast Furnace Slag (GBS), and using recycled coarse and/or concrete aggregate is named within the Specification (MCHW 1). All the secondary and recycled materials in Table 2.1 can meet the Specification (MCHW 1) as the coarse aggregate or within blends for SBM. Alternative binders include Fly Ashes (including PFA) to form Fly Ash Bound Mixtures (FABM), Flue gas desulphurised Gypsum and Cement Kiln Dust (CKD). The potential risk of expansive chemical reactions exists with the incorporation of gypsum into a bound material and should be given specific consideration.

2.15 Cementitious binders in this series can include a number of alternatives to Portland cement with well established properties. These include Portland Fly Ash Cement, Portland Slag Cement and various combinations including GGBS and PFA. Where crushed concrete aggregate is used (within recycled concrete/aggregate), it should only be sourced from identified structures with a known history. Appropriate additional testing is required under the Specification (MCHW 1) to detect substances and chemicals harmful to the durability of concrete.

2.16 All reclaimed materials listed in Table 2.1 can be used for Cement Bound Granular Mixtures (CBGM) formally called Cement Bound Materials (CBM) if they comply with the Specification (MCHW 1). Cement Bound Granular Mixtures are now included in Series 800 of the specification (MCHW 1) together with all other Hydraulically Bound Mixtures.

2.17 Any of the reclaimed materials listed in Table 2.1 to comply with the requirements for Cement Bound Granular materials may require washing or processing. Strength requirements for the various Grades of Cement Bound Granular Mixtures are established on a scheme-specific basis.

2.18 Recycled aggregate, recycled concrete, Phosphoric slag, crushed air-cooled blast furnace slag and PFA are all capable of complying with the Specification (MCHW 1). Stent and slate aggregate, crushed and graded, both have the potential to comply with the Specification (MCHW 1) being natural aggregates. The maximum by mass percentage for recycled asphalt is given under the limits for ‘other materials’ within the Specification (MCHW 1). China clay sand, IBAA and foundry sand are also potentially suitable as fine aggregate. There are no Specific or General Provisions for the use of steel slag or recycled glass as an aggregate. However, their use may be permitted by the Overseeing Organisation.

Series 900 Bitumen Bound Layers

2.19 **Industrial By-products.** Blast furnace slag, steel slag (well weathered), China clay sand and slate aggregate can meet the Specification (MCHW 1) and are named. Recycled glass, IBAA, foundry sand, PFA, recycled concrete and phosphoric slag can comply as components of recycled aggregates within bitumen bound layers.

2.20 **Reclaimed Materials.** Reclaimed bituminous materials can be used for hot mix recycling in the production of bituminous base, binder course and surface course; up to 10% of reclaimed bituminous material being permitted without a requirement for trials. The maximum content of reclaimed materials is restricted to 10% for hot rolled asphalt surface course and 50% in other layers. It should be noted that not all road planings are suitable for hot mix recycling as older layers may contain tar. For further advice, refer to HD 31 DMRB 7.4.1.

2.21 **In-situ Recycling. 'Repave'** is a process that conserves existing structurally sound pavements, restoring the surface by bonding a thin overlay or inlay to the pre-heated, scarified and reprofiled existing road surface. The **'Remix'** process is an adaptation of the **'Repave'** system where the machine is fitted with a small mixing unit. Material from the scarified surface is augured into the pug mill mixer where it is blended with hot freshly mixed new material. The recycled mix is placed evenly on the heated surface to form the replacement surface course which must conform to the appropriate standard.

2.22 Cold deep recycling of bitumen bound pavements is covered within the Specification (MCHW 1) and for more detailed information refer to HD 31 (DMRB 7.4.1). The primary aggregate source is from cold pulverisation of part, or all, of the existing road structure, with foamed bitumen or bitumen emulsion used as the primary binding agent. Trials are required to demonstrate that the existing pavement materials are capable of being recycled to form the primary aggregate component of cold recycled bitumen bound material and to achieve the requirements of the Specification (MCHW 1).

Series 1000 PQ Concrete and Cold Recycled Cement Bound Material

2.23 **PQ Concrete.** Recycled concrete, crushed air-cooled blast furnace slag and PFA are capable of complying with the Specification (MCHW 1), but excluding exposed aggregate surfacing. The maximum by mass percentage for recycled asphalt is given under the limits for 'other materials' for recycled concrete aggregate within the Specification (MCHW 1). Stent and slate aggregate, crushed and graded, both have the potential to comply with the Specification (MCHW 1) being natural aggregates. IBAA, phosphoric slag and recycled aggregate also have the potential to comply with the Specification (MCHW1). China clay sand, and foundry sand are also potentially suitable as fine aggregate. There are no Specific or General Provisions for the use of steel slag or recycled glass as an aggregate. However, their use may be permitted by the Overseeing Organisation.

2.24 **Cold Deep Recycling using a Cement Binder.** Existing pavement layers can be recycled to form the foundation or main structural layer of a new road pavement. Hydraulic binder is used as the stabilising agent with the pulverised material recycled for the aggregate. End product performance tests of the recycled cement bound material are required to judge the expected performance of the recycled stabilised material against the performance of standard CBGM base materials as detailed in the Specification (MCHW 1).

Conservation of Existing Pavements

2.25 Numerous opportunities exist for conservation, when maintaining or improving existing roads. By far the most efficient approach is to conserve sound pavement layers or to stabilise and strengthen unsound layers, thus making the best use of materials by leaving them in place. This will require careful attention to the timing of maintenance, and decisions will be influenced by the type of road and the residual life of the pavement. For further advice refer to HD 30 (DMRB 7.3.3). Traffic management alternatives and likely traffic delay costs must be taken into account, to ensure the most cost effective solution overall and in accordance with good practice.

Concrete Pavements

2.26 **Surface Restoration.** Where concrete surfaces are still permitted, the skidding resistance of concrete surfaces that have polished, but are otherwise sound after minor repair, can be restored by transverse grooving or by overlaying with an asphalt surfacing. For further advice refer to HD 32 (DMRB 7.4.2) and HD 38 (DMRB 7.5.3).

2.27 **Strengthening.** Using crack and seat techniques, concrete pavements can be conserved as the lower base

in flexible composite construction or as the subbase for a new pavement. Continuously reinforced concrete pavements (CRCP) can be converted to become the base (CRCR) with a strengthening flexible overlay. Jointed concrete pavements can be converted to function as a lower base with a strengthening flexible overlay of adequate thickness to inhibit the formation of reflection cracks over joints. For further advice refer to HD 30 (DMRB 7.3.3). Concrete pavements which are structurally sound can be strengthened by thin bonded concrete or thick unbonded concrete overlays, using 'fast track' concrete paving techniques where necessary, in accordance with HD 27 (DMRB 7.2.4).

Flexible, Flexible Composite and Rigid Composite Pavements

2.28 **Surface Restoration.** The skidding resistance of flexible surfaces that have polished, but are otherwise sound, can be restored by application of a bituminous overlay or inlay, or by retexturing. Apart from the retexturing option, the systems all help to reseal the pavement against deterioration. For further information refer to HD 31 (DMRB 7.4.1) and HD 37 (DMRB 7.5.2).

2.29 **Strengthening.** Flexible and Composite pavements can be strengthened by the application of a bituminous overlay, with or without the removal of the existing surfacing layers. Where reflective cracking has occurred, restoration of Composite pavements (particularly with respect to Rigid Composite Pavements) can be undertaken by removal of the upper asphalt layers, with subsequent conversion of the concrete layer, using crack and seat techniques, to give a sub-base in a flexible pavement. Depending on design constraints and traffic flows, continuously reinforced concrete pavements (CRCP) or bases (CRCR) can also be used to overlay or as an inlay to flexible pavements. These are probably the best options where significant differential settlement of the existing road has occurred and is likely to continue. For further advice refer to HD 30 (DMRB 7.3.3) and HD 31 (DMRB 7.4.1).

2.30 **Road Widening.** Advice on the widening of roads and motorways is given in HD 27 (DMRB 7.2.4), which stresses that the maximum use should be made of existing construction wherever possible. There is little restriction on the type of material to be laid alongside an existing pavement providing it conforms to the Specification (MCHW 1). There can be positive advantages in having dissimilar construction, for example to increase load carrying capacity of the new lane yet match the thickness of the new pavement with the existing to ensure subsurface drainage is not impeded. Where an existing pavement is to be partially or completely removed, the material arising can be re-cycled and re-used in or under the new construction, subject to compliance with the Specification (MCHW 1).

Protection of the Environment

2.31 Many reclaimed materials and industrial by-products that are available in sufficient quantities for road construction cause no significant environmental problems. However, depending on their former use these secondary and recycled materials may contain varying proportions of chemicals, such as organics and metals. The potential for these chemicals to leach and migrate, and their proximity to surface and ground water, will affect their suitability for use. Mitigation measures at source or site, such as utilisation within bound applications, can be employed to reduce any potential risks.

2.32 The Environment Agency (EA) is responsible for maintaining the quality of surface and ground water in England and Wales. The Scottish Environment Protection Agency (SEPA) is responsible for Scotland. The use of secondary and recycled materials should comply with the relevant guidelines of the responsible agency.

2.33 The handling, storage, processing and deposition of waste materials are subject to separate control by the Waste Management Regulations made under the Environmental Protection Act (EPA) 1990. These will apply to all surplus materials taken off site. The carriage and processing of waste will need to be licensed; however there will be a general exemption from requirements for waste to be deposited at a licensed site, if instead it is to be incorporated into a development which has planning consent. It is presumed that such use of waste materials will be adequately controlled since they must be deposited in accordance with the Specification (MCHW 1) for the development, including any special conditions required to prevent adverse effects on the environment.

2.34 The Waste Management Regulations permit temporary storage on site of restricted amounts of waste materials approved for incorporation in the works, after the award of a contract, but prior to beginning work. Similarly, road planings may be stockpiled off site for reprocessing. Nevertheless, there are good reasons to utilise planings as they arise or as soon as possible thereafter. Stockpiles can become quite difficult to break up if they are allowed to consolidate. On the other hand, if they become saturated with water, then

compaction as fill or to form a capping layer may be difficult and considerable amounts of energy are needed to drive off water if they are to be recycled to form a new base. There may also be concerns about the possibility of both organic and mineral leachate if water begins to drain through a large stockpile. Certain materials are exempt from the regulations under specific circumstances and consultation with the local licensing officer should be undertaken to confirm site and/or activity specific classifications. Exempt activities are still required to be registered with the EA or SEPA.

2.35 Where reclaimed materials are being considered for use in landscaping and areas of planting, care should be taken to ensure that they are compatible with the plants and trees to be grown. For further advice refer to HA 44 (DMRB 4.1.1).

Future Developments

2.36 It is expected that the quantities of materials that can be used will increase as the range of recycled and secondary materials permitted in the Specification (MCHW 1) is extended. A number of research projects are currently underway, including those on recycled plastic and non-ferrous slag from zinc production, which aim to develop suitable acceptance criteria to encourage the wider use of such materials when they offer best value for money. In addition, other materials such as quarry fines, recycled railway ballast and ceramics may be considered by the Overseeing Organisation on a site specific basis.

Glossary of Terms

2.37 The following terms are used in this Chapter:

BLAST FURNACE SLAG:
A by-product from the production of iron, resulting from the fusion of fluxing stone (fluorspar) with coke, ash and the siliceous and aluminous residues remaining after the reduction and separation of iron from the ore. Due to its potential variability and possible inclusion of volumetrically expansive components, 'Old Bank' slag, produced prior to modern high-level quality control procedures, may require additional processing prior to use. Various forms of solidified blast furnace slag are produced dependent on the rate and technique used to cool the molten material. Granulated blast furnace slag (GBS) is formed by quenching the molten material with jets of water. This material is then processed to produce ground granulated blast furnace slag (GGBS) for use as a hydraulic binder.

BURNT COLLIERY SPOIL:
Also known as burnt minestone. The residue following ignition of coal mine spoil heaps which results in partial or complete combustion of coal particles in the spoil, leaving calcined rocks.

CEMENT KILN DUST (CKD):
By-product from the calcining of raw materials during the production of Portland Cement. CKD is extracted from gases generated within the cement kilns during the manufacturing process and comprises a light fine grained particulate material. If chemically suitable, CKD is generally re-used within the cement works. The composition of the CKD will be dependent on the kiln process employed and the degree of separation in the dust collection system.

COAL FLY ASH (CFA):
Pulverised fuel ash or Coal fly ash is extracted by electrostatic precipitation from the flue gases of modern coal-burning power stations and is similar in fineness to cement. It can be used both as a binder in Fly Ash Bound Mixtures (FABM) and as an aggregate.

CHINA CLAY SAND AND STENT:
The by-products from the extraction of china clay from decomposed granite, consisting largely of two distinct materials: 'Stent', which is waste rock, and 'Tip Sand'. China Clay Tip Sand is defined as the washed material produced as a by-product during the extraction of China Clay (Kaolin) from Kaolinitic granite, predominantly comprising quartz with some mica, and is relatively consistent from within each source of production.

FOUNDRY SANDS:
By-product of the castings industry, typically comprising uniformly sized sands with various additives and metals associated with the specific casting process.

FURNACE BOTTOM ASH (FBA):
Furnace bottom ash is the coarser fraction of ash produced in coal burning power stations resulting from the fusion of PFA particles which fall to the bottom of the furnace. It varies in size from fine sand to coarse gravel and has a porous structure.

GBS AND GGBS:
See Blast Furnace Slag.

GYPSUM:
By-product of power stations burning lignite or sulphur contaminated coal. Gas scrubbers remove the gypsum from flue gasses in the desulphurisation process.

INCINERATOR BOTTOM ASH AGGREGATE (IBAA):
IBAA is processed from the material discharged into the burning grate of Municipal Solid Waste (MSW) incinerators and comprises 80 to 90% of the total MSW ash production. It is a heterogeneous material that may contain varying proportions of glass, ceramics, brick and concrete in addition to clinker and ash.

NON-FERROUS SLAG:
Non-ferrous slags include lead-zinc slag, tin slag and copper slag, and are by-products produced during the recovery and processing of non-ferrous metal from natural ores. Slags of note for potential use as secondary aggregates are those associated with the production of phosphorous and zinc.

PFA:
See Coal Fly Ash.

PHOSPHORIC SLAG:
See non-ferrous slag.

QUARRY FINES:
Processing of crushed rock for use as construction aggregate consists of blasting, crushing, washing, screening and stockpiling operations. The production of primary aggregates can involve a number of processes, with quarry fines being the associated by-product. The grading of the material is typically associated with the parent rock and subsequent production process. Chemical and mineralogical properties are directly related to the parent rock.

RECYCLED AGGREGATE:
An aggregate resulting from the processing of material used in a construction process. Recycled Asphalt is noted as an exception to the above and treated as a separate material.

RECYCLED ASPHALT:
Recycled asphalt can comprise millings, planings, return loads and offcuts from bituminous layer joint preparation. Asphalt planings are defined as materials derived from the layers of the pavement using a mobile machine fitted with milling cutters. Granulated asphalt is defined as asphalt bound material recycled from roads under reconstruction or surplus asphalt material destined for bound pavement layers, but unused, which has been granulated.

RECYCLED CERAMICS:
IBAA processed from the MSW stream may contain a component of ceramics. The wide range of ceramic products is reflected within the variation of the materials mechanical properties.

RECYCLED GLASS:
Glass for subsequent recycling via crushing or granulation is typically separated at source, separated in recycling facilities, or collected from bottle banks. The principal raw materials are quartz sand and sodium carbonate with varying proportions of other compounds.

RECYCLED PLASTICS:
Plastics fall into two main categories, broadly defined as Thermoplastics, which can be reheated without significant alterations to their structure, and Thermosets which stiffen under application of heat. This fundamental division dictates applicable recycling processes and subsequent possibilities for re-use.

RECYCLED RAILWAY BALLAST:
Railway ballast is usually replaced due to inter-particulate attrition and filling of the aggregate voids with fines. These fines can enter the railway ballast from a number of on-site sources, and treatment processes such as screening and washing may be required prior to subsequent re-use.

RECYCLED RUBBER:
Used tyres comprise a combination of natural and synthetic rubber. They can either be recycled or used as secondary materials. Recycled products include crumb rubber and granulate. Secondary uses include tyre bales.

SLATE AGGREGATE:
The by-product of slate quarries primarily producing roofing slates. The waste represents 70-90% of gross quarried volume.

SPENT OIL SHALE:
The residue of shale mined in the Lothian Region of Scotland after heating to drive off volatile hydrocarbons. Similar in nature to burnt colliery shale.

STEEL SLAG:
By-product of the manufacture of steel from pig iron. There are two types; basic oxygen slag (BOS) and electric arc furnace (EAF) slag. EAF slag generally has lower free lime and magnesia contents than BOS as a result of the manufacturing process, and is thus more easily weathered.

UNBURNT COLLIERY SPOIL:
Also known as minestone, a by-product of coal mining. It is derived from the rocks which lie above, below and sometimes within the coal measures of Carboniferous geological age. These rocks comprise mainly siltstones and mudstones, and in some areas sandstones and limestones.

3. REFERENCES

1. Design Manual for Roads and Bridges - The Stationery Office (TSO)

HA 44 (DMRB 4.1.1) 'Earthworks: Design and Contract Documents' (includes amendment 1 April 1995)

HD 27 (DMRB 7.2.4) 'Pavement Construction Methods'

HD 31 (DMRB 7.4.1) 'Maintenance of Bituminous Roads'

HD 32 (DMRB 7.4.2) 'Maintenance of Concrete Roads'

HD 33 (DMRB 4.2.3) 'Drainage: Surface and sub surface drainage systems for highways'

HD 38 (DMRB 7.5.1) 'Concrete Surfacing and Materials' (includes amendment 1 dated Feb 1999)

HD 30 (DMRB 7.3.3) 'Structural Assessment Procedure'

HD 37 (DMRB 7.5.2) 'Bituminous Surfacing Materials and Techniques'

2. Manual of Contract Documents for Highways Works - The Stationery Office (TSO)

Manual of Contract Documents for Highway Works, Volume 1 (MCHW 1): Specification for Highway Works.

3. British Standard Institution

BS4987 : 'Coated macadam (Asphalt Concrete) for roads and other paved areas'; Part 1 : 'Specification for constituent materials and for mixtures'. BSI

4. Others

1987

Use of waste material for road fill. DOE Circular 20/87, Department of Transport Circular 3/87, Welsh Office Circular 36/87; TSO

1990

Environmental Protection Act 1990; TSO

1994

Waste Management Licensing Regulations 1994. TSO

4. ENQUIRIES

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

Chief Highway Engineer
The Highways Agency
123 Buckingham Palace Road
London
SW1W 9HA

G CLARKE
Chief Highway Engineer

Chief Road Engineer
Scottish Executive
Victoria Quay
Edinburgh
EH6 6QQ

J HOWISON
Chief Road Engineer

Chief Highway Engineer
Transport Directorate
Welsh Assembly Government
Llywodraeth Cynulliad Cymru
Crown Buildings
Cardiff
CF10 3NQ

M J A PARKER
Chief Highway Engineer
Transport Directorate

Director of Engineering
The Department for Regional Development
Roads Service
Clarence Court
10-18 Adelaide Street
Belfast BT2 8GB

G W ALLISTER
Director of Engineering