Implications of the harmonisation of construction product standards for the use of recycled and secondary aggregates

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Executive Summary

Our overall objectives in this work have been to:

1. Assess what, if any, implications the withdrawal of national standards for aggregates by the scheduled date of June 2004 will have for the development and use of recycled and secondary aggregates.
2. Identify any emerging CEN standards that are likely to have an impact on the development and use of recycled and secondary aggregates.
3. Develop recommendations for further work to support the implementation of these standards in the UK so that their introduction has a positive effect on the market for recycled and secondary aggregates.

Because the new European Standards for aggregates include recycled and secondary aggregates within their scope, the effect of their introduction to the UK is expected to have an overall positive effect on the use of these materials. However, clauses and test methods for these materials have not yet been included in the standards and due to a loss of impetus in the work of CEN/TC 154, it is likely be some time before these can be agreed and published. There is need to maintain the UK input to this work.

Until properly covered in the ENs, the use of these materials will depend heavily on the adequacy of the existing UK Guidance. In the highways field the guidance is well developed and there should be little effect on markets. In the building field the position is more patchy although the new guidance and requirements in BS 8500 should help the usage in concrete. There continues to be a need to develop better UK Guidance for the wider use in building.

Despite the positive aspect of the inclusion of the recycled and secondary materials in the new aggregate ENs there is also the threat that harmonised European Environmental Requirements could undermine their use. There is need for a stronger input into the Committees developing these requirements to ensure that the use of recycled and secondary materials is not unnecessarily prevented or adverse perceptions about their use allowed to develop.

This report was prepared for DTI. The views expressed are those of the authors and not necessarily those of DTI.
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1 Introduction

Under the European Commission Mandate M 125, aggregates, CEN TC 154 has prepared a suite of eight harmonised product standards and supporting test methods for aggregates. These are:

- BS EN 12620:2002 Aggregates for concrete
- BS EN 13043:2002 Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas
- BS EN 13055-1:2002 Lightweight aggregates - Part1: Lightweight aggregates for concrete, mortar and grout
- prEN 13055-2 Lightweight aggregates - Part 2: Lightweight aggregates for bound and unbound applications, excluding concrete, mortar and grout
- BS EN 13139:2002 Aggregates for mortar
- BS EN 13242:2002 Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction
- BS EN 13450:2002 Aggregates for railway ballast

At the date of writing (March 2003) all of these standards except 13055-2 have been approved at Formal Vote, the final stage in the CEN voting procedure, and have already been published by BSI as BS ENs. There will be a period of transition but after the official Date of Withdrawal, June 2004, all national standards for aggregates must be withdrawn and replaced by the ENs. See Graphical Timetables in Appendix C. It should be noted that much of the aggregates supply industry, the Highways Agency and other aggregates purchasers are transferring to the new European Standards on 1 January 2004.

Because these new European Standards are written in response to an EC Mandate, which itself is issued in support of the Construction Products Directive, they will have a much stronger legal position than the present BSI Standards. The UK is not, in fact, insisting on CE marking for construction products put on the market nationally. Nevertheless, it will effectively be mandatory for such products, including aggregates, to conform to the ENs. For example the Public Purchasing Directive will ensure that all publicly funded projects use materials as specified in the appropriate EN.

Clearly the content of these new standards will be fundamental to continuing and greater use of recycled and secondary aggregates in the UK. In this report we make a thorough investigation of the current situation and derive recommendations for further work to ensure that the advent of the new ENs has a positive effect on the use of recycled and secondary materials.

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2 Description of the project

Our overall objectives in this work have been to:

- Assess what, if any, implications the withdrawal of national standards for aggregates by the scheduled date of June 2004 will have for the development and use of recycled and secondary aggregates.
- Identify any emerging CEN standards that are likely to have an impact on the development and use of recycled and secondary aggregates.
- Develop recommendations for further work to support the implementation of these standards in the UK so that their introduction has a positive effect on the market for recycled and secondary aggregates.

Our approach to addressing these objectives has been first of all to examine the current situation to give a starting point to analyse the effect of changes which will result from the introduction of the new standards. Issues that have been examined are the current regulations and guidance which govern the use of recycled and secondary materials and whether these impose any restraint on present utilisation.

We then examine in detail the new documents that will govern the future use of these materials. In addition to the ENs themselves this includes the Mandate and the draft response to this by CEN TC 154, ENs for appropriate end uses, the developing environmental standards and the UK Guidance. We also examine the amendments to these ENs and accompanying guidance because the specific clauses for recycled and secondary aggregates are still being developed.

From this detailed examination we analyse the impact that these new requirements will have on the use of recycled and secondary materials, in the light of both our own experience and discussions of the likely impact with key producers and users. A workshop held at BRE in February 2003 has been an important aspect of this consultation with producers and users. Additionally, relevant BSI Committees have been consulted and discussions held with key individuals.

In the light of these findings we then make recommendations for further work to ensure that the introduction of these new ENs has a positive effect on the utilisation of recycled and secondary materials in the UK.

This has been carried out through the following work programme:

1. Review the current regulations, standards and guidance governing the use of recycled and secondary materials in the UK, and the influence that these have on the current level of use. Identify the current restraints on increased utilisation (task 1).

2. Outlining the background to the new European Standards, how they relate to the Construction Products Directive, CE marking and their legal status. Examining how this will differ from current European Standards and the effects that this will have on the implementation of the requirements for recycled and secondary aggregates (task 2).

3. Examining the requirements in the following documents that will govern the use of these materials after June 2004 (task 3):
   - The Mandate M 125, the TC 154 "answer" to the Mandate and the forthcoming ENs for aggregates.
   - The ENs for the end uses of aggregates, viz; concrete, concrete products, roads, masonry.
   - The environmental requirements and the role of test regimes being produced by CEN TC 292 “Characterisation of Waste”.
   - The UK Guidance documents to the use of the ENs for aggregates.

4. Examining the amendments to the ENs which are currently being drafted to cover the use of recycled and secondary materials more specifically (task 4):
   - Clauses for recycled aggregates drafted by TC 154 Task Groups following the work of the CEN ad hoc group for recycled aggregates.
   - The work of TC 154 TG 10 "Aggregates from secondary sources".
   - New/modified test methods to cover recycled aggregates.

5. Analysing the impact that these new requirements will have on the use of recycled and secondary aggregates (task 5). This has been done by:
   - Examining their content and comparing with the current situation in the light of BRE’s experience.
In particular, examining whether they will overcome or increase current constraints on increased usage.
Discussing with key producers and users in the industry to see what is the industry perception of their effect.

6. Drafting the final report with an analysis of the above work and recommendations to support the implementation of the new ENs so that they will have the most positive impact on the utilisation of recycled and secondary materials in the UK. (task 6).
3 Review of current regulations, standards and guidance governing the use of recycled and secondary materials in the UK

3.1 Background
The specification environment for aggregates divides roughly into two main areas – Highways Specifications and building regulations, although there are a number of other areas of significance such as the water industry, railways, airfields and maritime structures.

There is a long history in Britain of the use of recycled and secondary materials dating back to Roman times, but the build-up of regulations and standards in the modern era has often tended to imply that these materials were in some way inferior to natural materials. Standards were built up on practice prevailing at the time, which was generally based on the use of natural materials. A prime example of this is the British Standard BS 882, the most general specification of aggregate for use in concrete, which refers to natural sources in its title. When this standard first came out in 1940, there was no need to consider any future use of recycled materials, but in recent years this has discouraged developments in this area.

Sand in concrete is also covered by BS 882; other uses (for plaster, render, mortar and granolithic flooring) were standardised in BS 1198, BS 1199, BS 1200 and BS 1201, all referring to natural materials, although this has proved less restrictive since recycled materials have proved less suitable for these purposes. BS 1201 was later incorporated into BS 882.

Where markets already existed for alternative materials, separate standards were developed (BS 877, BS 1047 for lightweight and dense blastfurnace slag aggregates and BS 1165 for clinker). Apart from the development in 1964 of BS 3797 for sintered pulverized-fuel ash (Lytag) and some other lightweight aggregates made from natural materials (BS 3797 later incorporated BS 877 and BS 1165), there was essentially nothing further until BS 6543:1985 “Guide to the use of industrial by-products and waste materials in building and civil engineering”. This standard, however, has been little used apart from brief mentions in the Specification for Highway Works which in itself has shown a considerable development over the past 50 years in promoting the use of recycled and secondary materials.

With an increasing need to promote the efficient use of aggregate resources, the Minerals Planning Division of the Department of the Environment commissioned BRE to make a study of standards and specifications for the use of waste and recycled materials as aggregates and bulk construction materials. The results, which were published by HMSO in 1995, indicated that it was possible to specify a much wider range of these materials that had previously been thought, but that many of the specifications in use at that time discouraged such use. Many of the issues raised in the report have been addressed, or are currently in the process of being addressed, but application has often been slow due to unfamiliarity and lack of incentive.

Some secondary sources such as china clay sand or crushed slate waste where the production processes (crushing, washing and sieving) are essentially the same as for natural aggregates, are treated as such for specification purposes. However one large gap in UK specification guidance identified in the 1995 report was the lack of any information on the suitability of recycled aggregates, particularly in relation to the level of impurity that could be tolerated in various applications. This gap was first addressed in 1998 with the publication of BRE Digest 433, followed by the Highways Specification in 2001 and by BS 8500:2002.

BS 8500:2002 although a current standard, has yet to come into general use, and even the major changes in the May 2001 revision of the Highways Agency have not been taken on board by a significant number of specifiers. It has normally been the case that there is a significant lead time before changes in specifications have "filtered through the system" and become accepted in local regulations and guidance. Thus in the analysis given here, the historical context is important in understanding how the choice of materials has developed and what future projections might be.
3.2 Highways specifications

The UK national highways authority (currently the Highways Agency) has, from a fairly early stage, recognised the possibility of making savings through the use of materials from secondary sources. It has often led the way in naming the use of such materials in the Highways Specification, which directly or indirectly controls specification of nearly all road pavements and highways structures. Crushed concrete from airfields left redundant after World War II was recognised as a convenient source of sub-base material and was named alongside crushed rock, slag and well burnt non-plastic shale as a suitable material for sub-base material Types 1 & 2 (Clauses 803 and 804). By the 1991 edition of the Specification, its use in various types of concrete was recognised through a clause permitting its use in pavement construction if conforming to the "quality and grading requirements of BS 882" (i.e. complying with everything in this standard except the title and scope). The main use for this material was envisaged as in "cement bound materials" (CBMs) for road base and sub-bases, and not particularly in surface layers (pavement quality or PQ concrete). Additional specifications for aggregates in concrete at the road surface are unlikely to be met by aggregates from crushed concrete, although there is widespread such use in the USA.

Crushed concretes were originally taken from old airfields and road pavements, but in the late 80s and early 90s increasing amounts of material were becoming available from the demolition industry. Such materials were often mixtures of concrete and brick masonry and all the materials contained various other impurities such as wood, plastic and metals. Until guidance on impurities (based on experience in other countries) was published in BRE Digest 433 (1998) and subsequently in the major revision of the Highways Specification in May 2001, the acceptance of such materials was largely entrusted to the experience of the engineers on individual road contracts.

3.2.1 Concrete and cement bound material

In the Highways Specification, concrete may be specified in pavements (1000 Series) or for structures (1700 Series). In May 2001 revision the 1000 Series divides recycled aggregates into two groups:

- Recycled concrete aggregate (RCA): masonry < 5%; asphalt < 5%
- Recycled coarse aggregate (RA): masonry up to 100%; asphalt < 10%

Both RCA and RA need to contain less than 1% of foreign materials (less than 0.4% by mass of materials less dense than water in the case of RCA). Both need to be derived from structures "with a known history of use" to avoid contamination.

RA is restricted to grade C20 or less and intended for wet lean concrete (ST1 – ST3) and cement bound material (CBM – all categories up to CBM5) which are used for road base and sub-base construction.

RCA has a restriction of “grade 30 or higher” suggesting that C30 is the normal limit but that with appropriate supervision and control, including selection of blends with other aggregates, higher grades are permissible. Although excluded from general use in the 1700 Series for structures, additional clauses for RCA are available to the Highways Agency’s list of competent contractors.

CBM2 and 2A, as well as naming RCA, RA and blastfurnace slag, will include a wider range of materials as “washed or processed granular material”. Requirements for these materials are less onerous than for concrete and CBM3-5: the product must reach the required strength after 7 days without swelling or cracking and there is a wide grading and fairly low strength requirement for the aggregate.

CBM1 and 1A, as in previous editions of the Highways Specification, has only upper grading limit for the aggregate and could potentially accept a very wide range of materials, subject to the product showing satisfactory results after 7 days.

3.2.2 Unbound, hydraulically bound and other materials

In the May 2001 revision of the Highways Specification, granular sub-base material Types 1 & 2 may now contain up to 100% masonry or up to 50% asphalt (e.g. derived from road planings). Foreign materials in recycled aggregates including wood, plastic and metal are limited to 1%. Also, materials containing a high proportion of masonry may have greater difficulty meeting frost heave test limits (for layers sufficiently close to the surface for such limits to be required). Permitted materials, as in previous editions, include slag (blastfurnace and steel slags) and well burnt non-plastic shale (i.e. red shale from old colliery spoil tips in which loose tipping resulted in sufficient air voids to support combustion). Crushed slate waste is also a permissible material as it comes within the definition of crushed rock. Some specifiers have expressed concern about flakiness but there is no flakiness requirement for Type 1 and Type 2 materials.
The new edition also saw the introduction of two new clauses:

- Clause 805 (Slag bound material) using ground granulated blastfurnace slag with an activator as binder. This can contain RCA or blastfurnace slag to BS 1047 as well as natural aggregate to BS 882.
- Clause 806 Granular sub-base material Type 4. This is made essentially from 100% asphalt (road planings or granulated asphalt). Tar is excluded, presumably because of environmental concerns.

### 3.2.3 Bituminous bound materials

The traditional requirement for aggregates has been “clean, hard and durable” rather than source, and there has been a long history of use of slags (blastfurnace slag and steel slag) as well as natural aggregate. Specified requirements for strength were introduced at a later stage, and these are considerably lower for blastfurnace slag than for other materials (both in the Highways Specification and BS 63:Part 2). Positive discrimination is unusual in such a context and is normally strongly resisted. Steel slag is a high density, high strength material and the high polishing resistance of materials from the electric arc process has ensured a high demand for the material in skid-resistant road surfacings.

In the May 2001 edition of the Highways Specification, RA and RCA, along with “recovered unbound and artificial aggregates” are specified as suitable materials. These materials would presumably need to comply with the higher strength requirement for materials other than blastfurnace slag. This is unlikely to be met by RA and difficult to meet consistently for RCA. At present there does not appear to be any great interest in the use of RA and RCA for these purposes due to the expectation that RA will have a greater bitumen requirement because of high porosity, and that RCA will be adversely affected by heat in hot mix.

Incinerator bottom ash (IBA) from municipal solid waste incinerators has seen an increased use in recent years as bituminous bound material, and there are draft clauses to formalise this in the Highways Specification, but, at the time of writing (March 2003), this is awaiting further discussion with the Environment Agency.

There has been an increasing interest in recycling old bituminous pavements and road planings into new bituminous mixes and the scope and guidance for this has been considerably increased in the May 2001 edition of the Highways Specification, in comparison with the 1991 edition. However, interim guidance has been issued by the Highways Agency from time to time during this period as the field has developed. In-situ recycling may be by hot or cold methods and can use up to 100% recycled material. "New” material prepared off site may contain up to 50% of recycled material for base layers although this is restricted to 10% for the surface layer.

### 3.2.4 Earthworks (including capping layer)

All layers below the sub-base are included in Series 600 (Earthworks). Some of these, such as the capping layer, have a significant engineering function and have seen a significant use of recycled aggregates and materials from secondary sources.

Many of these materials are individually named for specific uses in Clause 601 and in Table 6/1 of the Specification, which takes up a total of 20 pages. As well as recycled aggregates, materials named include slag, pulverized-fuel ash, furnace bottom ash and colliery spoil (both burnt and unburnt). Other argillaceous rocks and chalk, which may have been excavated as part of the road construction, are also named materials for various purposes.

### 3.2.5 Drainage (pipe bedding and filter media)

Series 500 now specifically mentions RCA and RA as well as granular material conforming to BS 882.

### 3.3 Specifications for building construction

#### 3.3.1 The Building Regulations

The Building Regulations (2000) aim to ensure that building work is carried out:

(a) with adequate and proper materials which
   (i) are appropriate for the circumstances in which they are used;
   (ii) are adequately mixed and prepared; and
   (iii) which are applied, used or fixed so as adequately to perform the functions for which they designed; and
(b) in a workmanlike manner

The main provisions of this are overseen by building control officers who will inspect virtually all construction and structural refurbishment work in buildings. In any case, construction clients, specifiers, developers and any other people
legally responsible for any part of the construction will need proof that they have complied with the Building Regulations in order to provide a legal defence. This is also important to ensure that professional indemnity insurance is not declared null and void. Insurance companies are likely to consider this a basic requirement for Duty of Care.

The Building Regulations put forward a number of ways in which the suitability of a material for use or for a specific purpose may be assessed:

a) British Standards. This is the most usual route and a number of standards including BS 882 (for natural aggregates) are referenced in the Building Regulations.

b) National and international technical specifications “of other Member States which are contracting parties to the European Economic Area.” There is an onus on the user or specifier to demonstrate that such specifications when used in the UK will provide at least an equivalent level of performance to construction with relevant British Standards.

c) Technical approvals – a national or European certificate issued by a European Technical Approvals issuing body, and where necessary demonstration of equivalence as in (b).

d) CE marking – the declared values or class of performance must conform with the requirements for the intended use in the UK.

e) Independent certification schemes, normally with UKAS accreditation. In most instances this will normally (but not always) satisfy building control.

f) Tests and calculations. A material can be accepted when it “can be shown that the material will be capable of performing the function for which it is intended. The Accreditation Scheme for Testing Laboratories run by UKAS together with similar schemes run by equivalent certification bodies, including accreditation schemes operated by other Member States of the EU, and recognised by that State’s government, provide a means of ensuring that such tests can be relied on.”

g) Past experience. A material can be accepted when it “can be shown by experience, such as in a building in use, to be capable of performing the function for which it is intended.” This should assist the use of reclaimed building materials e.g. whole bricks for a similar or less onerous use.

h) Sampling. “Local authorities have the power to take samples of materials to be used for building work. Regulation 17 allows the local authority…to take such samples as they consider necessary to establish compliance with the provisions of the Regulations.”

Recycled and reclaimed materials have not generally been covered by British Standards. When delivered on site they have risked rejection by building control as not being “adequate and proper materials.” In an attempt to redress the balance the following paragraph has been added in a fairly prominent position:

“The environmental impact of building work can be minimised by careful choice of materials, and where appropriate the use of recycled and recyclable materials should be considered. The use of such materials must not have any adverse implications for the health and safety standards of the building work.”

Any positive effect on the use of recycled materials is probably more than counterbalanced by heightened concerns regarding contamination, an area where there is usually much less knowledge about realistic levels of measurement and control. For instance, recycled aggregates have sometimes been rejected for use as hardcore under concrete floors “because the wood content could support the propagation of dry rot infestation in other areas of the building.” There is no information either to accept or reject this, but with wood restricted to less than 1% in Type 1 and Type 2 materials, which are frequently specified for such purposes, the chances of this occurring seem fairly low.

3.3.2 Concrete

As already detailed, the most general specifications for aggregates in concrete refer to natural aggregates only. However, most concrete, including ready-mixed concrete, falls within the scope of BS 5328, which does not demand that aggregates need to comply with British Standards in all circumstances. This standard details four types of concrete mix:

<table>
<thead>
<tr>
<th>Mix Type</th>
<th>Main compliance route</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designed</td>
<td>28 day test cube results</td>
</tr>
<tr>
<td>Prescribed</td>
<td>Individually prepared mix proportions</td>
</tr>
<tr>
<td>Standard</td>
<td>Mix proportions chosen from table (low-grade applications)</td>
</tr>
<tr>
<td>Designated</td>
<td>Quality assurance to ISO 9001</td>
</tr>
</tbody>
</table>

Implication of new ENs on recycled and secondary aggregates
In most instances aggregates are required to comply with BS 882, BS 1047 (air-cooled blastfurnace slag), and sometimes BS 3797 (lightweight aggregates). This is not so for prescribed mixes, although the aggregate is required to be fit for purpose. However job specifications prepared for individual construction contracts exclude this option in most instances, by specifying both the concrete (BS 5328) and the aggregate (normally just BS 882). For anything else to be used, it will be necessary to obtain agreement that a variation can be made – this will have to be backed up by suitable data and assurances (including apportionment of any extra risk, however small this may be). This route has been followed to enable the use of recycled aggregates but in very few construction projects.

Job specifications are normally derived from in-house guidance held by structural engineers and other specifiers. Many are taken from or are strongly influenced by the National Building Specification (NBS) which adheres fairly closely to British Standards. The NBS is hoping to reduce the lead time for the introduction of new or revised standards to the industry through an on-line service. Thus the introduction of standards like BS 8500 (which contains clauses for recycled aggregates) could potentially reach practitioners at a much earlier stage.

BS 8500:2002 is the complementary British Standard and UK Guidance document to BS EN 206-1:2000 Concrete (Part 1). These two standards together currently co-exist with BS 5328 which is due to be withdrawn on 1 December 2003. The clauses on recycled aggregates in BS 8500, which are essentially the same as those published in the Highways Specification in May 2001 (see above), have been available for use by the construction industry since the publication of BS 8500 on 27 February 2002.

3.3.3 Manufactured concrete products

Products may be specified by the product specification and not necessarily by specifications for the constituent materials. In some instances this may give manufacturers the option to use recycled and secondary aggregates, but mainly for applications with lower structural requirements. As indicated above, precast concrete products prepared to BS 5328 could potentially use such materials, but individual construction projects may have overall requirements for all aggregates to conform to BS 882.

Building blocks and bricks, cast stone, “reconstructed stone” masonry units and block paviours have their own product standards (respectively BS 6073, BS 1217, BS 6547 & BS 6717). These standards have traditionally relied on recipes for constituent materials, omitting some (but not all) secondary materials and making no mention of recycled aggregate. However, the revision of BS 6717 which came out in September 2001 places no restriction on constituent materials and the requirements are based solely on performance tests.

The other three standards rely on recipes which include blastfurnace slag aggregate to BS 1047, lightweight aggregates to BS 3797 and pulverized-fuel ash to BS 3892:Parts 1 & 2 (i.e. both as cement replacement material and as a filler aggregate respectively). BS 6073 also includes the use of milled softwood chips.

3.3.4 Lightweight aggregate

BS 3797 includes in its scope pumice, expanded clay, shale and slate; clinker and furnace bottom ash; and lightweight aggregates based on pulverized-fuel ash and blastfurnace slag. Lightweight aggregates made from expanded clay, shale and slate can and have been made from various sources of waste e.g. slate waste, colliery spoil and miscellaneous settlement sludges. In this way, BS 3797 is similar to BS 3921 for clay bricks which does not discriminate between primary and secondary sources for constituent materials.

In BS 3797 clinker and furnace bottom ash refer only to coal-burning furnaces, and not strictly to IBA (incinerator bottom ash from municipal solid waste incinerators). Nevertheless IBA is very similar to these materials in its major constituents, and material conforming to all other requirements in BS 3797 has been used for the manufacture of lightweight building blocks.

3.3.5 Hardcore

No guidance on materials is given in British Standards; reference where necessary is made to BRE Digest 263. This indicates that a wide range of materials, including recycled and secondary materials, should be suitable, subject to:

- A good level of compaction
- Adequate measures to prevent sulfate attack on concrete
• Rejection of expansive material e.g. steel slag, old bank slag (includes steel slag and blastfurnace slag not complying with the limits in BS 1047), old furnace linings containing free magnesia, and mixtures which could lead to the formation of thaumasite (e.g. a mixture of gypsum mine waste and limestone).

3.4 The water industry

BS 8007:1987 Design of concrete structures for retaining aqueous liquids, will accept only natural aggregates (BS 882) or blastfurnace slag (BS 1047) subject to a maximum water absorption value of 3%.

BS 1438:1971 Media for biological percolating filters, will accept “crushed stone, gravel, clinker, coke, slag and other similar materials”. Evidence of good performance is acceptable, otherwise a soundness test (detailed in an appendix) is recommended.

3.5 Railway ballast

The industry currently uses its own specifications. Natural aggregate is used, but this is now recycled after cleaning and regrading.

3.6 Airfields

These are developed from the Highways Specification with some additional requirements.

3.7 Maritime structures

BS 6349 Maritime structures, comes in seven Parts, and requirements for materials are given in Part 1. In the 1984 version only natural aggregates were allowed; in the revised version issued in July 2000 there is a comment that European Standards were in the course of preparation and reference is made to BS 5328 and BS 8007 (Code of practice for design of concrete structures for retaining aqueous liquids).
4 Background to the new European Standards

4.1 The Construction Products Directive

The development of European Standards needs to be seen in the context of the desire by the European Commission to create a single European market for goods and services. Their objective is to eliminate any artificial barriers to trade within this market. To achieve this they want to create a system within which a customer will have confidence that a product or service purchased anywhere within the EU will be basically fit for purpose and safe. European Standards are seen as a key component in this.

The approach that has been adopted by the EC is to identify the Essential Requirements necessary for a family of products to be traded and used safely in a series of New Approach Directives. Compliance with these Essential Requirements is then to be ensured by the appropriate European Technical Specification.

In the construction sector the key Directive is the Construction Products Directive (CPD). Its aim is to remove technical barriers to trade for all products permanently incorporated in buildings and civil engineering. Products complying with the CPD must be allowed on the market everywhere within the EU. In particular the Public Procurements Directive requires specifiers in the public sector to use European Standards in their purchasing and to give equal opportunity to products from anywhere within the EU.

The Construction Products Directive is applied through an integrated system that comprises:

- Harmonised product standards
- A system of attestation of conformity
- A framework of notified bodies
- The CE marking of products

Through this system the CPD aims to harmonise throughout the EU:

- Methods of test
- Methods of declaration of product performance
- Methods of conformity assessment

It does not harmonise the actual values of properties which are specified for a particular product or job.

4.2 Harmonised standards

These are produced by the European Standards Organisation, CEN, in response to an instruction (Mandate) issued by the European Commission.

The Mandate applies to a family of related products to be used in defined fields of application. It identifies the Performance Characteristics that must be satisfied by the product in order for that product to meet the Essential Requirements of the CPD.

These Performance Characteristics must be included in a harmonised standard. The standard may also contain other requirements judged necessary or desirable by the responsible Technical Committee. These are known as voluntary requirements and are not part of the conformity assessment for CE marking. However, because they come within the scope of the standard they may legitimately be required by the purchaser.

4.3 Essential Requirements and the Mandate

4.3.1 The Essential Requirements

The Essential Requirements identified by the CPD are:

- Mechanical resistance and stability
- Safety in fire
- Hygiene, health and the environment

Implication of new ENs on recycled and secondary aggregates
• Safety in use
• Protection against noise
• Energy, economy and heat retention

The Mandate then expresses these in terms of the Performance Characteristics which the product must have and which must be required by the harmonised standard for the product.

An example for aggregates is:
The Essential Requirement of safety in use of an aggregate requires that the skidding resistance of an aggregate used in a road is adequate. This translates into a Performance Characteristic in the harmonised standard of a certain level of resistance to polishing.

Therefore the harmonised standard must contain tests for resistance to polishing and a means by which a purchaser can identify and specify a certain level of resistance when needed for a particular job. In the CEN aggregate standards this is done by defining Categories of polishing resistance.

4.3.2 The Mandate for aggregates, M 125

This Mandate has a field of application which covers the preparation of concrete, mortar, grout and mixes for construction and for the manufacture of construction products as well as other bound and unbound mixtures for use in roads and other civil engineering works. It identifies the materials which it covers as being:

• aggregates from natural sources
• manufactured or by-product materials from industrial processes
• recycled materials

It divides the end uses of aggregates into the following:

• Aggregates for concrete, mortar and grout
• Aggregates for bituminous mixtures and surface treatments
• Aggregates for unbound and hydraulically bound mixtures
• Armourstones
• Railway Ballast
• Fillers

For each end use the specific Performance Characteristics necessary to ensure compliance with the Essential Requirements of the CPD and which, therefore, must covered by the harmonised standard are identified. Thus for aggregates for concrete, mortar and grout these are:

• Particle shape, size and density
• Percentage of crushed particles
• Cleanliness
• Resistance to fragmentation/abrasion/wear
• Composition/content (e.g. chloride, sulfur, ...as relevant)
• Volume stability
• Water absorption
• Durability characteristics against freeze-thaw, weathering, de-icing salts and alkalis.... as relevant
• General hazard requirements against emission of radioactivity or release of heavy metals, polyaromatic hydrocarbons or other dangerous substances.

Similar lists are provided for each of the other end uses. These include characteristics specific to that end use, e.g. affinity to bituminous binders for aggregate for bituminous mixtures and surface treatments and electric conductivity for railway ballast.

4.3.3 Response to the Mandate

The responsible CEN Technical Committee (in this case CEN TC 154) was required to give a formal response to the Mandate, detailing how each mandated property is specified in the aggregate standards. Once this response was accepted an extra clause, Annex ZA, was inserted in each product standard. This shows in detail the clauses and tests which satisfy each of the Essential Requirements. Annex ZA then becomes a check-list for CE marking and the standard becomes a harmonised standard.
CE marking is a "passport" allowing a product to be legally placed on the market in any Member State of the EU. It demonstrates that the product meets the minimum applicable requirements of the CPD. It does not, however, necessarily mean that the product will be suitable for all end uses. Affixing the CE marking is the responsibility of the manufacturer.

One of the important aspects of the CE Marking is that it includes technical information in the form of declared values. Where minimum or maximum (threshold) values are set in the standard itself these are not repeated in the CE marking. Similarly, classes of performance may be declared in the CE marking with the "key" to the classes appearing in the standard. For example, the CE marking of an aggregate for concrete might have:

- A declared value of (say) 0.4% chloride
- An acid soluble sulfate category AS$\text{_{0.2}}$ (i.e. $\leq 0.2\%$ SO$\text{_{4}}$)  
- A total sulfur content of 0.8% S, i.e. below the pass/fail threshold value of 1% S for an aggregate other than a blastfurnace slag

Hence the CE marking is in effect a harmonised technical data sheet. Together with the standard it gives all the information needed to judge whether the aggregate is suitable for its intended use in the Member State where it is sold. Note that the manufacturer is not required to determine or declare characteristics for which regulations do not exist in the chosen market (i.e. Member State). In these cases he may declare "no performance determined" or NPD. In the UK, however, there are no specific regulations covering aggregates and the de-facto regulations are the recommendations in the BS Guidance on the use of aggregates (to the new standards). This guidance does not specifically identify any properties where NPD is appropriate but in practice many characteristics where there has been no requirement in pre-existing BSs have simply been omitted from the lists of recommended characteristics. It is unclear as yet whether this is an acceptable practice.

Attestation of conformity

A manufacturer has to make a Declaration of Conformity that a product conforms to a harmonised European Technical Specification and may carry a CE Marking. To give users reassurance that products produced across the EU can be traded with confidence, the CPD requires that the product is produced under a factory production control system (fpc) and, depending on the product and its end use, there is some degree of third party testing. The amount of involvement of third parties in assessing conformity is termed the attestation system. The level of attestation for a particular product is determined by the European Commission.

The levels of attestation are:
1. Certification of product and surveillance of factory production control by third party
2. Certification of fpc by a third party
3. Initial type testing by a third party
4. Manufacturers declaration (but there must be a fpc system)

For aggregates, system 4 is identified as appropriate except where the aggregates are to be used in applications with high safety requirements when 2+ is appropriate. The 2+ designation indicates that there must be continuous surveillance of the fpc as well as the initial certification. The determination of when a use requires "high safety" is derogated to the national regulations in Member States and in the UK the only applications where a high safety level is required have been identified as the use in surface courses where the exposed aggregate is subject to skidding.

Notified bodies

These are organisations/laboratories which have been approved to carry out either the third party attestation procedures or to issue European Technical Approvals. Such bodies are first approved by their Member States and notified to the Commission and to other Member States.

The work of CEN TC 154 and its response to the Mandate M 125

CEN TC 154

The CEN Technical Committee responsible for the standardisation of aggregates is CEN TC 154. The UK (BSI) holds the secretariat of TC 154 and throughout its work has had a strong involvement in and influence on its work. TC 154 carries out its work through six sub-committees; five concerned with the specification of aggregates for different end uses and one that develops the test methods for all uses. The sub-committees are assisted by task groups of experts; currently
there are seven of these (see Figure 1). It is noteworthy that there is one (TG 10) specifically for aggregates from secondary sources.

As of January 2003, seven specifications have been agreed by formal vote and published by BSI as BS ENs, while one more is in preparation:

Agreed:
- BS EN 12620    Aggregates for concrete
- BS EN 13043    Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas
- BS EN 13055-1  Lightweight aggregates - Part 1: Lightweight aggregates for concrete, mortar and grout
- BS EN 13139    Aggregates for mortar
- BS EN 13242    Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction
- BS EN 13383-1  Armourstone - Part 1: Specification
- BS EN 13450     Aggregates for railway ballast

In preparation:
- prEN 13055-2,  Lightweight aggregates. Lightweight aggregates for bituminous mixtures and surface treatments and for unbound and bound applications excluding concrete, mortar and grout.

Additionally, at the time of writing (March 2003), 34 test methods have been agreed, leaving five in preparation. These are mainly tests to cover the use of recycled and secondary aggregates.

![Figure 1. The structure of CEN TC 154](image)

Because of the need to accommodate a wide range of geologies, climates and construction practice across Europe the aggregate specifications make extensive use of Categories:

*Category: “level of a property of an aggregate expressed as a range of values or a limiting value”*

Example:
Los Angeles coefficient of 45 falls in Category LA₅₀ (the highest category, LA₅₀, covers Los Angeles coefficients >40 and ≤50)

Values outside the specified limits of the categories should be declared as:
XX Declared value
e.g. Los Angeles value of 60 should be declared as: LA_60 (Declared value)

A few characteristics have limits which must not be exceeded for particular applications
e.g. volume stability
total sulfur

These are known as Threshold Limits.

4.5 National Guidance Documents

4.5.1 National Guidance Documents

National Guidance Documents provide guidance to producers and users in a particular Member State on the application of a CEN Standard in that country. They must not alter or exceed the requirements of the CEN Standard but they can give advice on which Category is recommended for a particular end use. They can be included in the EN published by the national standards body or published separately.

4.5.2 UK Guidance on the CEN aggregate standards

BSI is producing a guidance document for the application of each of the aggregate specifications in the UK. These recommend limiting values for Categories for use in UK. They also provide an example specification for most general uses of aggregates and make additional requirements and recommendations for particular end uses. Because of their specific applicability to the UK industry these guidance documents will be at least as influential in determining the effect of the new CEN Standards in the UK as the standards themselves.

For example, Table 1 below shows the recommended requirements in the UK for aggregates for use in concrete.

4.5.3 Timetable for the introduction of the new standards

After the harmonised EN becomes available national standards are expected to remain in force for 21 months. After about 9 months the period of coexistence starts. After another 12 months conflicting national standards must be withdrawn. The Date of Withdrawal proposed by TC 154 and agreed by the European Commission is 1 June 2004. However, it should be noted that much of the aggregates supply industry, the Highways Agency and other aggregates purchasers are transferring to the new European Standards on 1 January 2004.

4.6 Implications of the introduction of the new European Standards

4.6.1 General

The new European Standards differ from the present British Standards in two very important ways.

Firstly they will have a different and much firmer legal basis. Much is still unclear about the extent of this and will only become so with experience and possibly with the accumulation of case law. However, as far as can be seen at present, and despite CE marking not being compulsory in the UK, it will effectively be a legal requirement for specifiers to use the new ENs as, at least, the basis for their specifications. This will be particularly so for public specifiers. From the point of view of the use of recycled aggregates, it will be seen from the analyses in the later tasks that the use of recycled and secondary material is well catered for in the scope of the standards. Therefore there is no barrier to their use in a legal sense.

Secondly the standards themselves contain a wide range of options, in order to accommodate the various geologies and practices around Europe. This means that specifiers will need a great deal of guidance in their application in the UK. This is well advanced for natural aggregates. However, as will be seen from the later tasks this is still embryonic for recycled and secondary aggregates. To get the full benefit from the legal inclusion of these materials in the standards there will be a need to give much more comprehensive guidance on the details of their use.
Table 1. Recommended requirements for concreting aggregates for general uses

<table>
<thead>
<tr>
<th>Properties</th>
<th>Category to BS EN 12620</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse aggregate</td>
<td>In accordance with annex C</td>
</tr>
<tr>
<td>Fine aggregate (sand)</td>
<td>In accordance with annex D</td>
</tr>
<tr>
<td>All-in aggregate</td>
<td>In accordance with annex E</td>
</tr>
<tr>
<td>Filler aggregate</td>
<td>In accordance with BS EN 12620:2002, Table 7</td>
</tr>
<tr>
<td><strong>Gradings</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Flakiness index</strong></td>
<td></td>
</tr>
<tr>
<td>Uncrushed gravel</td>
<td>$F_{I60}$</td>
</tr>
<tr>
<td>Crushed rock or crushed gravel</td>
<td>$F_{I5}$</td>
</tr>
<tr>
<td><strong>Shell content of coarse aggregate</strong></td>
<td>$\leq 10%$ by mass</td>
</tr>
<tr>
<td><strong>Fines</strong></td>
<td></td>
</tr>
<tr>
<td>Uncrushed, partially crushed or crushed gravel coarse aggregate</td>
<td>$f_{1.5}$</td>
</tr>
<tr>
<td>Crushed rock coarse aggregate</td>
<td>$f_4$</td>
</tr>
<tr>
<td>Uncrushed, partially crushed or crushed gravel sand</td>
<td>$f_2$</td>
</tr>
<tr>
<td>Crushed rock sand</td>
<td>$f_{16}$ ($f_{10}$ for heavy duty floor finishes)</td>
</tr>
<tr>
<td>Gravel all-in aggregate</td>
<td>$f_5$</td>
</tr>
<tr>
<td>Crushed rock all-in aggregate</td>
<td>$f_{11}$</td>
</tr>
<tr>
<td><strong>Resistance to fragmentation</strong></td>
<td>$LA_{40}$</td>
</tr>
<tr>
<td><strong>Acid soluble sulfate content</strong></td>
<td></td>
</tr>
<tr>
<td>Aggregates other than air-cooled blastfurnace slag</td>
<td>$AS_{0.2}$</td>
</tr>
<tr>
<td>Air-cooled blastfurnace slag</td>
<td>$AS_{1.0}$</td>
</tr>
<tr>
<td><strong>Total sulfur</strong></td>
<td>$\leq 1%$ by mass</td>
</tr>
<tr>
<td>Aggregates other than air-cooled blastfurnace slag</td>
<td>$\leq 2%$ by mass</td>
</tr>
<tr>
<td>Air-cooled blastfurnace slag</td>
<td>Free from dicalcium silicate and iron disintegration</td>
</tr>
</tbody>
</table>

### 4.6.2 Legal implications for producers and users

As explained above, there is still much that is unclear about the legal implications of these new standards and for specifiers/users and for producers. What is clear, however, is that they are part of a legal framework that is much stronger than the existing British Standards and that the objectives of this framework are also different to the current position. The overriding objective of the Commission as expressed through the CPD and then through the standards is freedom of trade across the EU and removal of barriers to free trade. Thus in the background there is always the possibility that users or producers who depart from the system will be involved in legal challenges on the basis of barriers to free trade.

Equally, it is important to recognise that the system of attestation and CE marking is designed to ensure that the product satisfies minimum requirements for safety, health and so on. It is not a guarantee of quality or fitness for purpose. There will still be a need for quality systems such the QSRMC system for concrete alongside the CE marking.

With these caveats we give below the legal implications as far as they can be foreseen.

**Legal implications for producers**

The UK is one of four countries in the EU who have not made CE marking a legal requirement for construction products. Hence there is no obligation on aggregate producers who only intend to sell in the UK to CE mark their products or to implement the necessary systems of attestation.

Equally there is no legal requirement to produce aggregates in accordance with the new ENs. However, as all the major specifications will be written in terms of the new ENs it will, in practice, be a commercial necessity to do so. In practice,
it is anticipated that the major producers, many of whom export some of their production, will CE mark their products whereas the smaller producers will only produce to comply with the ENs.

The major producers who do decide to CE mark their products will also have to decide whether to do so in accordance with a system 2+ or 4 level of attestation. This will depend on the EU markets into which they will sell (many of the Northern European countries are insisting on system 2+ attestation for all end uses). It will also depend on whether or not they produce for end uses such as skid resistance where system 2+ has been identified as necessary in the UK.

**Legal implications for specifiers/users**

For private sector users, the position will be little different to today; i.e. there is no legal obligation to use products to an existing British Standard or to the new ENs. However, just as at present, a user or engineer who decides to work outside the standards is taking on a heavy legal responsibility if anything goes wrong. This will be particularly so as all the major specifications and guidance documents will be rewritten in terms of the new standards.

An engineer who does decide to order aggregates in accordance with the new ENs will also have to decide whether or not to do so using the UK Guidance documents. Again there is no obligation to do so but it will be seen as good practice to follow this guidance unless there are overriding reasons to depart from it.

The position is different in the public sector where the Public Procurement Directive obliges purchasers in the public sector to make use of European Standards. Not to do so will open them to challenge under fair trade legislation. Probably the only acceptable defence will be one of safety. However, given the wide range of options within the standards it seems unlikely that this will cause major difficulties.

One area of potential difficulty for engineers, particularly in the public sector, is if they are offered imported aggregates, from a source with which they are unfamiliar and perhaps suspicious. Provided this aggregate is CE marked, the legal onus is on them to accept it as a fair competitor. If it is offered cheaper than the comparable UK product they will be vulnerable to legal challenge if they do not buy it. It is permissible to insist that the testing underpinning the CE marking is in accordance with the UK Guidance for that end use but it is not permissible to insist on extra testing in this country. Given that CE marking is not mandatory in the UK it is not clear what the position is if an engineer is offered a non-CE marked product from elsewhere in the EU. It would seem reasonable that he could insist on evidence that it was of a quality that would satisfy the UK Guidance. Note, further advice on the Public Procurement Directive is available from http://www.ogc.gov.uk/.

With recycled and secondary aggregates this is initially not too much of a problem as the EU have acknowledged that at present the requirements for these aggregates are not sufficiently developed to ensure their safe use. Extra testing in accordance with the regulations in the country of use is permitted until the full requirements are implemented in the ENs.
5 Requirements for recycled and secondary aggregates in the “first generation” European Standards

5.1 Requirements for recycled and secondary aggregates in the Mandate M 125, the TC 154 “answer” to the Mandate and in the new ENs for aggregates

5.1.1 Mandate M 125

Mandate M 125 makes it clear that recycled and secondary aggregates are completely valid materials for use as aggregates and are on an equal footing with natural materials. Thus in Annex 1 Field of Application, the Materials usable as aggregates are identified as:

- Natural, e.g.
  - stone,
  - sand,
  - gravel,
  - lava and tuff

- Manufactured or by-products of industrial processes, e.g.
  - ashes
  - clays
  - slags
  - vermiculite
  - perlite
  - brightening materials
  - incinerator residues

- Recycled, e.g.
  - concrete
  - masonry
  - asphalt

A note makes it clear that material from these groups can be used for aggregates and fillers on its own or in combination. Otherwise the Mandate implicitly expects that all aggregates will meet the performance characteristics for the particular end use.

5.1.2 TC 154 answer to Mandate 125

TC 154 delivered its “answer” to Mandate 125 in an internal document; CEN/TC 154/-/1N315, in February 2002. In it the specification clauses and test methods necessary to enable products to meet the performance characteristics in the Mandate, are detailed.

The document begins by giving the Scope of the specification standards for each end use; these are reproduced from the relevant European Standards. This is noteworthy from the point of view of recycled and secondary aggregates because, firstly, it makes it clear that these materials are fully within the scope of the standards, and secondly, because, in Note 1 to the Scope, it gives a warning that some such secondary aggregates may need extra evaluation and testing. For example, the Scope of EN 12620, aggregates for Concrete, is given as the first sub-clause, 1.1.:

"Scope: This European Standard specifies the properties of aggregates and filler aggregates obtained by processing natural, manufactured or recycled materials and mixtures of these aggregates for use in concrete. It covers aggregates having an oven dry particle density greater than 2.00Mg/m^3 (2000kg/m^3) for all concrete, including concrete in conformity with EN 206-1 and concrete used in roads and other pavements and for use in precast concrete products."
It also specifies that a quality control system is in place for use in factory production control and it provides for the evaluation of conformity of the products to this European Standard. This Standard does not cover filler aggregates to be used as a constituent of cement or as other than inert filler aggregates for concrete.

Note 1 The requirements of this European Standard are based upon experience with aggregate types with an established pattern of use. Care should be taken when considering the use of aggregates from sources with no such pattern of use, e.g. recycled aggregates and aggregates arising from certain industrial by-products. Such aggregates, which should comply with all the requirements of this European Standard, could have other characteristics not included in Mandate M 125 that do not apply to the generality of aggregate types with an established pattern of use and when required, provisions valid at the place of use can be used to assess their suitability.

Note 2 Properties of lightweight aggregates are specified in BS EN 13055-1.

A Scope with equivalent wording is given for each end use. However, that for Armourstone has a specific exclusion of incinerator residues (see 7).

In the rest of the "Answer" there is little specific reference to recycled and secondary materials. The implication is, as in the Mandate, that these materials are required to meet the same requirements as natural aggregates.

Specific references are confined to the following (clause numbers refer to the clauses in the Answer, not in the standard):

1. BS EN 12620 Aggregates and fillers for concrete
   • Clause 1217: requirement and test for volume stability of blastfurnace slag aggregate in concrete by determination of unsoundness to BS EN 1744-1.

2. BS EN 13139 Aggregates and fillers for mortar and grout
   • Clause 2314: requirement and test for volume stability of fillers by chemical analysis to BS EN 1744-1 with supporting note that this is only applicable to manufactured aggregates.
   • Clause 2315: requirement and test for loss on ignition to BS EN 1744-1 of ashes used as fillers.

3. BS EN 13055-1 Lightweight aggregates
   • No specific references to recycled or secondary materials.

4. prEN 13055-2, Lightweight aggregates. Lightweight aggregates for bituminous mixtures and surface treatments and for unbound and bound applications excluding concrete, mortar and grout
   • Not yet compiled.

5. BS EN 13043 Aggregates and fillers for bituminous mixtures and surface treatments
   • Clause 5218: requirement and test for volume stability of blastfurnace and steel slags used as aggregate in bituminous mixtures by determination of unsoundness to BS EN 1744-1.
   • Clause 5316: requirement and test for loss on ignition to BS EN 1744-1 of ashes used as fillers in bituminous mixtures.

6. BS EN 13242 Aggregates for unbound and hydraulically bound mixtures
   • Clause 625: requirement and test for volume stability of blastfurnace and steel slags used as unbound or hydraulically bound aggregate by determination of unsoundness to BS EN 1744-1.

7. BS EN 13383-1 Armourstone
   • Clause 7.1(ii) Scope: the "Answer" specifically excludes incinerator residues from scope of this standard. N.B. this exclusion does not appear in the standard itself!
   • Clause 7.2.6 Durability against weathering: statement that this characteristic is covered by "Dicalcium silicate disintegration of air-cooled blastfurnace slag", "Iron disintegration of air-cooled blastfurnace slag", "Disintegration of steel slag" in BS EN 1744-1 Part 1: Chemical Analysis.

8. BS EN 13450 Aggregates for railway ballast
   • No specific references to recycled or secondary materials.
5.1.3 The new European Standards for aggregates and accompanying UK Guidance

These are considered together as for use in the UK the accompanying guidance is an integral part of using the standards. The analysis refers to the currently published versions of the standards, the “first generation”, and, as will be seen later, further work to improve and extend their coverage of recycled aggregates is in hand.

1. AGGREGATES FOR CONCRETE, BS EN 12620:2002 AND UK GUIDANCE, PD 6682-1

Scope: As detailed in the TC 154 Response to the Mandate (above), the Scope of BS EN 12620 establishes two important principles. Firstly it makes it clear that recycled and secondary materials are fully within the scope of the standard. Secondly, the note to the Scope warns that for aggregates from unfamiliar sources, in particular recycled aggregates and aggregates from certain industrial by-products, the requirements in the Mandate and hence in the harmonised standard, may not be sufficient and that provisions in the place of use can be used to assess the suitability of such materials.

The Introduction to PD 6682 notes this and advises that in the UK, reference should be made to the complementary BS to BS EN 206-1(Concrete), BS 8500, which contains requirements for both the use and testing of recycled concrete aggregates and recycled aggregates. These requirements will be examined below.

Terms and definitions: Definitions of recycled and manufactured aggregates are given, viz:

- **Recycled aggregate**: aggregate resulting from the processing of inorganic material previously used in construction.
- **Manufactured aggregate**: aggregate of mineral origin resulting from an industrial process involving thermal or other modification.

N.B. the clause numbers below refer to those in BS EN 12620.

Chemical requirements:

1. **Acid soluble sulfate, clause 6.3.1;** Specific categories are given in BS EN 12620 for the acid-soluble sulfate content of air-cooled blastfurnace slag, i.e.

   \[
   \begin{align*}
   \text{AS}_{1.0} & \leq 1.0 \\
   \text{AS}_{\text{declared}} & \geq 1.0 \\
   \text{AS}_{\text{NR}} & \text{No requirement}
   \end{align*}
   \]

   PD 6682 recommends \(\text{AS}_{1.0}\). This is a slight relaxation of the 0.7% limit in BS 1047

2. **Total sulfur, clause 6.3.2;** A pass/fail threshold limit of 2%S by mass for air-cooled blastfurnace slag is required. This is no change from BS 1047.

3. **Constituents which affect the volume stability of air-cooled blast-furnace slag, clauses 6.4.2.1 and 6.4.2.2;** BS EN 12620 requires that the slag aggregate shall be free from dicalcium silicate disintegration when tested to BS EN 1744-1:1998,19.1 and from iron disintegration when tested to BS EN 1744-1:1998,19.2. The specification requirement is the same as BS 1047 except that the test method for the presence of dicalcium silicate is simpler, and probably less conservative, than in the BS. This should encourage the use of this material.

   In Annex G6 of BS EN 12620 it is additionally noted that, whereas some constituents of air-cooled blastfurnace slag can adversely affect its volume stability, slag from modern production units is less likely to be unsound in this way.

   The only other specific references to recycled or secondary materials are in relation to the minimum test frequencies for factory production control for attestation for CE marking. Here it is required that for blastfurnace slag aggregate the minimum test frequency for sulfur compounds, dicalcium disintegration and iron disintegration shall be 2 per year. This frequency of testing of slag aggregate for sulfur compounds is greater than for natural aggregates (1 per year) and of course, the natural aggregates have no requirement for testing for dicalcium disintegration or iron disintegration.
2. AGGREGATES FOR BITUMINOUS MIXTURES AND SURFACE TREATMENTS, BS EN 13043 AND UK GUIDANCE IN PD 6682-2

Scope: This contains the same inclusions of recycled and secondary materials and warnings about the need to assess materials without an established pattern of use in accordance with regulations valid in the place of use as BS EN 12620.

Terms and definitions: The same definition of recycled and manufactured aggregates as in BS EN 12620 are given.

Chemical requirements:
1. Volume stability of blastfurnace and steel slag, clause 4.3.4;
The same requirement of freedom from dicalcium silicate disintegration and iron disintegration of air-cooled blastfurnace slag aggregate as in BS EN 12620 is given. This is essentially the same as BS 1047 except that the test method for the presence of dicalcium silicate is simpler, and probably less conservative, than in the BS. For the volume stability of steel slag, categories of expansion, determined according to BS EN 1744-1:1998,19.3, are given. The time over which this test should be carried out depends on the total MgO content of the slag.

<table>
<thead>
<tr>
<th>Type of steel slag</th>
<th>Expansion % by vol.</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic oxygen/electric arc</td>
<td>≤3.5</td>
<td>V_{3.5}</td>
</tr>
<tr>
<td></td>
<td>≤6.5</td>
<td>V_{6.5}</td>
</tr>
<tr>
<td></td>
<td>≤10</td>
<td>V_{10}</td>
</tr>
<tr>
<td></td>
<td>&gt;10</td>
<td>V_{declared}</td>
</tr>
<tr>
<td></td>
<td>No requirement</td>
<td>V_{NR}</td>
</tr>
</tbody>
</table>

PD 6682 points out that there have been no similar tests in British Standards and no experience of its validity or specification limits. No recommendations for categories are given and it is recommended that advice is obtained from the supplier of the steel slag. It is clearly important that independent and authoritative guidance on this is prepared and published.

Requirements for filler aggregate: In clause 5.5.3 there is a requirement that the loss on ignition of pulverized-fuel ash used as filler should not exceed 6% by mass. However, PD 6682 recommends that for this and all other requirements for fillers other than “grading” and “loose bulk density” a “No Requirement” category is specified in the UK.

Minimum test frequencies for factory production control: The requirements for tests of the volume stability of blastfurnace slag and steel slag aggregates are 2 per year. For loss on ignition of pulverized-fuel ash used as filler the required frequency is 1 per week but, as seen above, this characteristic need not be determined in the UK.

3. AGGREGATES FOR MORTAR (INCLUDING GROUTS); BS EN 13139 AND UK GUIDANCE, PD 6682-3
(SUPERSEDES THE EXISTING BRITISH STANDARDS BS 1199 AND 1200:1976, WHICH WILL BE WITHDRAWN IN JUNE 2004)

Scope: This contains the same inclusions of recycled and secondary materials and warnings about the need to assess materials without an established pattern of use in accordance with regulations valid in the place of use as BS EN 12620.

Terms and definitions: The same definition of recycled and manufactured aggregates as in BS EN 12620 are given.

Chemical requirements:
1. Acid soluble sulfate, clause 7.3.1; The only category for blastfurnace slag aggregates is AS_{1.0}. This is recommended by PD 6682-3. It is the same as the recommendation for aggregates for concrete in PD 6682-1.

2. Total sulfur, clause 7.3.2; A pass/fail threshold limit of 2%S by mass for air-cooled blastfurnace slag is required. Again this is no change from BS 1047.

3. Additional requirements for manufactured aggregates; Additional requirements for water soluble matter and for loss on ignition are given in BS EN 13139. It is not specific as to which manufactured aggregates the water soluble matter refers but the loss on ignition is specific to air-cooled blastfurnace slag and pulverized-fuel ash.
**Water soluble matter:** The limit on water soluble matter is a pass/fail limit of 1% by mass. PD 6682-3 recommends that this limit is applied only to air-cooled blast furnace slag and pulverized-fuel ash.

**Loss on ignition:** Pass/fail threshold limits of 3% by mass for air-cooled blast furnace slag and 5% by mass for pulverized-fuel ash are given but with a caveat that for pulverized-fuel ash 7% loss on ignition may be tolerated at the place of use depending on the environmental class to which the structure is exposed. However, in fact PD 6682-3 recommends a limit of 7% loss on ignition for all uses of pulverized-fuel ash in mortar in the UK.

The minimum test frequencies for factory production control are 1 per year for the acid soluble sulfate and total sulfur with no differentiation between natural and recycled or secondary aggregates. For the water soluble matter and loss on ignition, which are requirements only for manufactured aggregates, test frequencies of 1 per week are required.

### 4. LIGHTWEIGHT AGGREGATES FOR CONCRETE MORTAR AND GROUT, BS EN 13055-1 AND UK GUIDANCE IN PD 6682-4
(SUPERSEDES THE EXISTING BRITISH STANDARD BS 3797:1990, WHICH WILL BE WITHDRAWN IN JUNE 2004)

**Scope:** This standard has a scope which specifically covers:

- natural aggregates
- aggregates manufactured from natural materials and/or from by-products of industrial processes,
- by-products of industrial processes
- recycled aggregates

but as in BS EN 12620 there are warnings about the need to assess materials without an established pattern of use in accordance with regulations valid in the place of use.

**Terms and definitions:** The same definition of recycled and manufactured aggregates as in BS EN 12620 are given. Additionally, a definition of By-product aggregates is given, viz.:

- **By-product aggregate:** aggregate of mineral origin from an industrial process which subsequently has been subjected to nothing more than mechanical processing.

There are no other specific references to recycled or secondary materials but in the case of this standard it is expected that the whole standard will be used to a great extent for such materials. The complete list of characteristics that are identified by BS EN 13055-1 to meet the needs of the CPD are:

- **Particle shape**
- **Particle size**
- **Loose bulk density**
- **Percentage of crushed particles**
- **Cleanliness**
- **Resistance to fragmentation/crushing**
- **Composition/content**
  - Chloride
  - Acid soluble sulfate
  - Total sulfur
- **Volume stability**
- **Water absorption**
- **Emission of radioactivity**
- **Release of heavy metals**
- **Release of polyaromatic carbons**
- **Release of other dangerous substances**
- **Durability against freeze-thaw**
- **Durability against alkali-silica reactivity**

In the UK Guidance however only the characteristics of:

- Loose bulk density
- Aggregate size
- Grading

are identified as necessary for initial type testing or factory production control. This selection is on the basis that there is no obligation to determine or declare a value for a characteristic in a Member State where there is no regulatory requirement for that characteristic unless it is subject to a “threshold” value.
In additional notes on special considerations attention is drawn to:

1. The need to select aggregates free of materials such as iron pyrites, particles of coal and lightweight contaminators where the appearance of the concrete is an essential feature.

2. The need to use with discretion clinkers derived from lump coal burned in older types of furnace because of the possible presence of nodules of free lime. In this case a water slake test is advocated (but no test method is identified). This warning reproduces that in BS 3797:1990 which in turn superseded the requirements in BS 1165, Clinker and furnace bottom ash.

**Requirements for lightweight filler Aggregate:** In clause 5.4 there is a requirement that the loss on ignition of pulverized-fuel ash used as filler should be determined and declared.

5. **AGGREGATES FOR UNBOUND AND HYDRAULICALLY BOUND MATERIALS BS EN 13242:2002 AND UK GUIDANCE IN PD 6682-6**

(NO CURRENT BRITISH STANDARD IS SUPERSEDED)

**Scope:** This contains the same inclusions of recycled and secondary materials and warnings about the need to assess materials without an established pattern of use in accordance with regulations valid in the place of use as BS EN 12620.

**Terms and definitions:** The same definition of recycled and manufactured aggregates as in BS EN 12620 are given.

N.B. the clause numbers below refer to those in BS EN 13242.

**Chemical requirements:**

1. **Acid soluble sulfate, clause 6.2:** The same categories are given in BS EN 13242 for the acid-soluble sulfate content of air-cooled blastfurnace slag as in BS EN 12620. PD 6682-6 recommends AS₁₀. This is the same as PD 6682-1, i.e. slightly less onerous than the 0.7% required by BS 1047 for use in concrete but more onerous than the limit of 2.0 g/litre of water-soluble sulfate specified for unbound uses in BS 1047.

2. **Total Sulfur, clause 6.3:** In this case, rather than the pass/fail threshold limit in BS EN 12620, categories of total sulfur content of air-cooled blastfurnace slag are given in BS EN 13242. However, the category recommended, S₂, which equates to an upper limit of 2%, is the same as for BS EN 12620.

3. **Volume stability of blastfurnace and steel slag, clause 6.4.2;**

   The same requirement of freedom from dicalcium silicate disintegration and iron disintegration of air-cooled blastfurnace slag aggregate as in BS EN 12620 is given. This is essentially the same as BS 1047.

   For the volume stability of steel slag, categories of expansion, determined according to BS EN 1744-1:1998.19.3, are given. The time over which this test should be carried out depends on the total MgO content of the slag.

   PD 6682 points out that there has been no similar test in British Standards and no experience of its validity or specification limits. No recommendations for categories are given and it is recommended that advice is obtained from the supplier of the steel slag.

4. **Impurities, clause 6.4.4:** Aggregates are required by this clause not to contain any foreign matter such as wood, glass or plastic that will cause damage to the end use of the product. No tests or limits are given, however.

   PD 6682 does not comment on this clause.

**Minimum test frequencies for factory production control:** The requirements for tests of the volume stability of blastfurnace slag and steel slag aggregates are the same as for bituminous mixtures i.e. 2 per year.

No test frequencies are given for sulfur contents.

6. **ARMOURSTONE, BS EN 13383-1:2002 AND UK GUIDANCE IN PD 6682-7**

(NO CURRENT BRITISH STANDARD IS SUPERSEDED)

**Scope:** This contains the same inclusions of recycled and secondary materials and warnings about the need to assess materials without an established pattern of use in accordance with regulations valid in the place of use as BS EN 12620.

**Terms and definitions:** The definitions of recycled and manufactured armourstone are the same as in BS EN 12620 with the use of the term armourstone instead of aggregate except that the modification of concrete armour units is
specifically excluded from the definition of manufactured armourstone (presumably these are covered by the definition of recycled armourstone).

**Durability requirements; Constituents which affect the durability of blastfurnace and steel slag, clause 7.2:**
The same requirement of freedom from dicalcium silicate disintegration and iron disintegration of air-cooled blastfurnace slag aggregate as in BS EN 12620 is given. This is essentially the same as BS 1047.

For the durability of steel slag, however, categories are given for the disintegration of the slag based on a test in BS EN 13383 Part 2. PD 6682-7 recommends that in the UK the most onerous of these classes, DSA, is chosen.

**Minimum test frequencies for factory production control:** The requirements for tests of the durability of blastfurnace slag and steel slag aggregates are the same as for bituminous mixtures i.e. 2 per year.

7. **AGGREGATES FOR RAILWAY BALLAST, BS EN 13450:2002 AND UK GUIDANCE IN PD 6682-8 (NO CURRENT BRITISH STANDARD IS SUPERSEDED)**

**Scope:** This contains the same inclusions of recycled and secondary materials and warnings about the need to assess materials without an established pattern of use in accordance with regulations valid in the place of use as BS EN 12620.

**Terms and definitions:** The definitions of recycled and manufactured railway ballast are the same as in BS EN 12620 except for the use of the term railway ballast instead of aggregate.

There are no other specific references to recycled or secondary materials in BS EN 13450 or in PD 6682-8.

5.1.4 Overall adequacy of the requirements for recycled and secondary aggregates in the Mandate 125, the TC 154 “answer” to the Mandate and in the CEN standards for aggregates and accompanying UK Guidance

From the point of view of the future use of recycled and secondary aggregates the important and positive aspect of the Mandate, the CEN TC 154 response to the Mandate and the new ENs, is that they all make it clear that recycled and secondary materials are fully within the scope of the standards.

However, they all also make it clear that the requirements in this “first generation” of standards are not on their own sufficient. Thus the note to the Scope warns that for aggregates from unfamiliar sources, in particular recycled aggregates and aggregates from certain industrial by-products, the requirements in the Mandate and hence in the harmonised standard, may not be sufficient and that provisions in the place of use can be used to assess the suitability of such materials. The EU is insisting that this note is changed so that additional requirements are on a contract by contract basis but they also accept that there is a real need for additional requirements.

The only materials that are covered sufficiently in the standards so that additional requirements are not needed are blastfurnace and steel slags. The requirements for blastfurnace slag are effectively the same as in existing British Standards (BS 1047) except that the test method for the presence of dicalcium silicate is simpler and probably less conservative than that in BS 1047. The use of steel slags is mostly not covered by British Standards, so for these two materials the advent of the new ENs is a positive step.

For the rest of recycled and secondary materials, however, the current work to introduce specific requirements into the standards (the "second generation") is clearly vitally important. In the interim the existing national guidance, outlined in Task 1, should enable the continued use of such materials in the UK. There should be little effect on their use in highways as the Highways Agency Specification gives comprehensive guidance and requirements. In building the position is not so good although the guidance in BS 8500 should enable their continued use in concrete.

There is an urgent need for better guidance on other building uses. In the UK, national guidance to the aggregate ENs there is relatively little guidance specifically on secondary and lightweight materials, and what there is, is scattered. As will be seen, however, there is more guidance in relation to the use in concrete in BS 8500.
5.2 End use standards

5.2.1 BS EN 206-1: 2000 Concrete - Part 1: Specification, performance, production and conformity and BS 8500: 2002: Concrete - Complementary British Standard to BS EN 206-1

BS EN 206-1 is not a harmonised standard, i.e. there is no Mandate for it. Additionally it has not yet proved possible to agree uniform requirements for concrete across Europe because of the different practices, materials and, in particular, durability requirements. Hence, in many respects BS EN 206-1 is a framework standard within which the national standards for concrete fit.

The result of this is that there is a lot more freedom to continue national provisions for concrete than for aggregates and it is possible for there to be an accompanying British Standard which not only interprets the provisions of the ENs, as is the case with the UK Guidance documents on the ENs for aggregates, but which can also include some specific national requirements. Thus, for example, BS 8500 includes provisions for alkali-aggregate reactivity that are quite specific to the UK. In the case of aggregates, as will be seen below, it includes requirements and guidance for the use of recycled aggregates in concrete that go well beyond what is in the ENs for aggregates.

BS EN 206-1 refers to aggregates in Clause 5.1 Basic Requirements for Constituent Materials. Clause 5.1.3 states:

- normal and heavy weight aggregates conforming to BS EN 12620:2002
- lightweight aggregates conforming to BS EN 13055-1:2002

Note: Provisions for recycled aggregates are not yet included in these standards. Until provisions for recycled aggregates are given in European Technical Specifications suitability should be established according to the note in 5.1.1

This note states that in the case of there being no appropriate EN, suitability can be established by demonstrating conformity with either:

i) a European Technical Approval
ii) a relevant national standard or provision in the place of use of the concrete

For the use of recycled aggregates in concrete, therefore, BS EN 206-1 makes it clear that additional requirements on a national basis are both permissible and necessary.

BS 8500 takes up this challenge and makes quite extensive reference to and requirements for the use of recycled aggregates in concrete. In BS 8500 Part 1: Method of Specifying and Guidance for the Specifier, definitions are given for:

Recycled aggregate (RA): aggregate resulting from the reprocessing of inorganic material previously used in construction.

Recycled concrete aggregate (RCA): recycled aggregate principally comprising crushed concrete.

Additionally, in clause 5.2 Information from the producer of the concrete to the specifier or user, it requires the following information where RA or RCA is to be used:

- the type of material and the proportion to be used.
- where the RCA or RA is not classed as highly reactive with respect to alkali-silica reaction, the proof on which this lower classification is based.
- where the RCA or RA is to be used in concrete in exposure other than those allowed in Table 3 in BS 8500 Part 2, the evidence that the concrete is suitable for the intended environment.

In BS 8500 Part 2: Specification for constituent materials and concrete, detailed requirements for the use of RA and RCA in concrete are given in Clause 4.3: Aggregates. These comprise:

i) A test method for determining the composition of RA and RCA and a table of requirements for the maximum content of:
   - masonry
   - fines
   - lightweight materials
   - asphalt
   - other foreign material e.g. glass, plastic, metals
   - acid soluble sulfate (SO₃)

Additionally there is guidance on the determination and declaration of the chloride and alkali contents of RA and RCA.
ii) Table 3 - Limitations on the use of coarse RCA and coarse RA, sets limits on the strength class of the concrete in which these aggregates can be used according to the exposure class of the resulting concrete.

A note to this table allows (i) the use of crushed hardened concrete of known composition that has not been contaminated by use, in any strength class and (ii) the use of these aggregates in other exposure classes provided that the resulting concrete has been demonstrated to be suitable for use in the intended environment (e.g. freeze thaw resisting, etc.).

B 517-1, the BS Committee responsible for BS 8500, is currently developing amendments that will facilitate the classification of RCA and RA in lower alkali-reactivity classes and that will also clarify and make less onerous the restrictions on "alkalis from other sources" in relation to the alkali reactivity of RA and RCA.

5.2.2 Adequacy of the requirements for recycled and secondary aggregates in the standards for concrete

Because of the non-harmonised status of BS EN 206-1, it has been possible to give extensive guidance and requirements for the use of recycled aggregates in concrete in the complementary BS. Although these requirements are quite conservative, their existence, coupled with the inclusion of recycled materials in the scope of BS BS EN 12620, aggregates for concrete, goes far beyond what has previously been in British Standards and should encourage the greater use of these materials in concrete.

There are, as yet, no similar requirements for secondary aggregates. This is not surprising as the classification of the nature of such materials and the knowledge of their properties and use is much less well developed. This is the next challenge.

5.2.3 Precast concrete

The generality of precast concrete is covered by the scope of BS EN 206-1 and so the discussion above applies. Additionally, there are a number of European Standards for specific precast concrete products. These are prepared by different Technical Committees to different Mandates and may not therefore be well co-ordinated with the requirements of the aggregate Technical Committees or with BS EN 206-1.

The two European Standards for precast products that have been published are:

BS EN 1917 Concrete manholes and inspection chambers, unreinforced, steel fibre reinforced and reinforced.

BS EN 1916 Concrete pipes and fittings, unreinforced, steel fibre reinforced and reinforced.

Both of these are prepared to Mandate M 118, Wastewater engineering products. These standards have identical clauses on aggregates; viz:

"Aggregates shall not contain harmful constituents in such quantities as may be detrimental to the setting, hardening, strength, watertightness or durability of the concrete, nor cause corrosion of any steel. It is permissible for the manufacturer to modify standard gradings to suit the manufacturing process."

There are no specific references to the ENs for aggregates.

Three further ENs have been published recently (April/May 2003):

BS EN 1338 Concrete paving blocks - Requirements and test methods
BS EN 1339 Concrete paving flags - Requirements and test methods
BS EN 1340 Concrete kerb units- Requirements and test methods

which are prepared to Mandate M 119, and:

One further EN has completed formal vote but has not yet been published (as of October 2003):

BS EN 771-3 Specification for masonry units - Part 3: Aggregate concrete masonry units (dense and light-weight aggregates), which is prepared to Mandate M 116, Masonry and related products.

These ENs simply refer to the need to use appropriate European Standards for component materials.

5.2.4 Adequacy of the requirements for recycled and secondary aggregates in the standards for precast concrete
The references to aggregates in these precast concrete product standards are so minimal that they can be said to neither inhibit nor encourage the use of recycled or secondary aggregates.

5.2.5 Road materials

CEN/TC 227 Road Materials is producing specifications and test methods appropriate to the mixtures used for road pavement layers. The preparation of these standards is generally about two years behind the preparation of standards in CEN/TC 154 Aggregates, and the main package of standards from TC 227 is likely to come into force in 2005 or 2006. Unlike the main TC 154 package, not all of these standards will be fully harmonised. Many of them do not supersede existing British Standards, although the area is in general covered by the UK Highways Specification. This will be updated as appropriate to cope with the introduction of these new standards.

All of these standards will refer, where appropriate, to the relevant TC 154 standards, and thus the use of recycled and secondary materials is within their scope. In addition TC 227 will cover specifications for the recycling of bituminous materials into new bituminous materials, as this is the recycling of a product for essentially the same use without breaking it down to its constituent materials. In the case of unbound materials, BS EN 13285 contains advice in an informative annex on the specification of recycled aggregates and incinerator bottom ash (IBA). This is no doubt inspired by the delay in the introduction of specification clauses for these materials in BS EN 13242. This advice is not mandatory and but could prove of assistance in countries where such advice is lacking. Recycled aggregates are already well covered in the Highways Specification and the national guidance document to BS EN 13285 refers UK users to the relevant clauses (600, 700 and 800 series) within this specification. As explained in section 4.2, no specific provision has yet been made for IBA in the UK Highways Specification, and thus the guidance in BS EN 13285 may be of interest and is given below.

**Incinerator bottom ash (taken from BS EN 13285 Table A.5)**

<table>
<thead>
<tr>
<th>Components</th>
<th>Percentage by mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main</td>
<td>≥ 90</td>
</tr>
<tr>
<td>Mineral based granular, including glass, ceramics, slags, etc.</td>
<td>≥ 90</td>
</tr>
<tr>
<td>Other</td>
<td>≤ 5</td>
</tr>
<tr>
<td>Iron and other metals</td>
<td>≤ 5</td>
</tr>
<tr>
<td>Contaminants</td>
<td>≤ 5</td>
</tr>
<tr>
<td>Non-incinerated material</td>
<td>≤ 6</td>
</tr>
<tr>
<td>Organic material</td>
<td>≤ 5</td>
</tr>
<tr>
<td>Incinerator fly ash</td>
<td>0</td>
</tr>
</tbody>
</table>

5.2.6 Adequacy of the requirements for recycled and secondary aggregates in the standards for Road Materials

The use of recycled and secondary materials is already well covered in the Highways Specification and the new standards from TC 227 will have little effect on this.

5.3 Environmental specifications

5.3.1 Coverage in the Mandate M 125 for aggregates

The Mandate for aggregates requires control of the emission of radioactivity and release of polyaromatic carbons, heavy metals and other dangerous substances. The maximum levels of these materials permitted in certain circumstances is controlled in national regulations, but the method of achieving this needs to be detailed in the product standards. The CEN/TC 154 answer to the Mandate with regard to the product standard for aggregates for concrete (BS EN 12620) is given below:

"Control of the source and production of aggregates for concrete to ensure that they do not emit radioactivity or release polyaromatic hydrocarbons, heavy metals and other dangerous substances (as defined in Council Directive 76/769/EEC, as amended) in excess of national regulations, is covered by the requirements for initial type tests as given in prEN 12620, 7.2 and by H.3.3 Knowledge of the material and H.4 Management of the production."

Similar comments are made with regard to the other six product standards in the TC 154 package. A note to H.3.3 in BS EN 12620 is given to the effect that "most of the dangerous substances defined in Council Directive 76/769/EEC are not usually present in most sources of aggregates of mineral origin". From this there may well be a presumption that recycled and secondary materials require a greater frequency of testing. This is a disincentive to the use of these materials. Materials currently regarded as exempt may suffer little from this at present, but it will become significant with the tightening up of regulations including those for the definition of "waste". New sources of material trying to enter the market place already face these disincentives.
There is little if any guidance on methods and frequencies of environmental testing and this has been the subject of lengthy discussions between TC 154 and the authorities arranging implementation of the Mandate (viz. the CEN consultant working on behalf of the EC). TC 154’s position is essentially a holding position allowing publication of the “first generation” of product standards, and it is expected that more detailed regulations will need to be implemented in due course. It will be important to ensure that these do not create too great a disincentive for the use of recycled and secondary materials.

There is in addition an ongoing argument between TC 154 and TC 292 “Characterisation of Waste” regarding the jurisdiction of leaching tests. TC 292 has produced a suite of tests, BS EN 12457 Parts 1-4, which it intends should be used for all materials, not just wastes, and is compatible with the Dutch Building Materials Decree. This Decree is far more onerous than is considered necessary for the UK and most other countries in Europe, although it has not stopped the use of recycled and secondary materials in the Netherlands. TC 154 considered that a test prepared for waste would not be appropriate and has produced its own test BS EN 1744-3 "Preparation of eluates”.

5.3.2 Construction products in contact with drinking water

The issue here is that the European Acceptance Scheme (EAS) will approve products/materials for use via CE marking procedures which require specific tests on finished products under the 1+ Attestation of Conformity system given in Mandate M 136 ‘Construction products in contact with water intended for human consumption’. The purpose of this is to ensure that water at the tap, after contact with such products/materials, will conform to the Drinking Water Directive (DWD).

While this Scheme could be viable for precast concrete products such as pipes, it is not feasible for ready mixed or site mixed concrete for two reasons. Firstly, such concrete does not have a Mandate. Secondly, to test each and every concrete mix would be impossibly expensive and cause unacceptable delays.

Accordingly TC 104, the Technical Committee responsible for concrete, with the support of TC 51 Cement, and TC 154 Aggregates, has proposed an alternative route for acceptance of “site-applied” cementitious materials, i.e. concrete and mortar. This route would be through a list of “Approved Constituents”, generic types of constituents of concrete or mortar that are currently regarded as posing a minimal risk to consumers. Concrete or mortar made entirely with such materials would not then need further testing. The constituents on the list would be in accordance with European Technical Specifications.

Such a route would be of great benefit to the generality of constituents for concrete and mortar. Unfortunately it is unlikely that, initially, recycled and secondary materials would be included because of the lack of experience in their use and the difficulty of defining their origin sufficiently precisely. This would clearly pose an additional barrier to their use. Even though the market for products/materials directly in contact with drinking water is not a large proportion of the whole market for concrete or mortar, the perception of their suitability in wider uses would inevitably be undermined.

The proposal does, however, include routes by which constituents could be added to the list. These are based either on submission of documentary evidence that a particular material or a constituent group of materials pose minimal risk or by undertaking testing to demonstrate that such materials pose minimal risk.

Discussions on this issue are on-going at the present and it is unclear whether the TC 104 proposal will be accepted by the EU. If the proposal does develop, it will be important to demonstrate that defined classes of recycled and secondary materials are suitable and can be added to the list of Approved Constituents.
6. Amendments to ENs; the “second generation” standards

6.1 TC 154 Amendments for recycled aggregate

Specification clauses for recycled aggregate have been produced by TC 154 but there has been a delay in including them within the product standards. This delay has been caused by a desire to concentrate efforts in achieving publication of the “first generation” of standards. From about 1999 onwards, any activity not contributing towards this goal was essentially pushed to the bottom of the agenda by a wide variety of issues related to the issue of harmonised standards. In particular there were a series of protracted discussions with EU and CEN officials with regard to demonstrating how the new standards would satisfy the essential requirements of the Mandate.

Now that the specification standards in the TC 154 "package" have been published (2002) there is a reluctance for the product sub-committees (SCs) to hold any further meetings for the time being. The SCs are the committees with the authority to implement new specification clauses. The immediate priority for members of these sub-committees is seen as arranging the changeover to the new standards in their respective countries by 1 June 2004.

Implementation of the clauses for recycled aggregate must also await publication of the additional test methods required. Fortunately, the work on amendments for recycled aggregate was sufficiently well advanced for these additional test methods to have been identified and for drafting work to be carried out by the relevant Task Groups. The Task Groups concerned had time to do this as they needed to meet to clear up remaining issues with the 36 test method documents in the initial "package" prepared by TC 154, but in general these demands were not onerous. Nevertheless, a fairly generous timescale for the publication of these test method standards has been laid out by TC 154, with the last ones expected by 1 March 2005.

At some stage the SCs will need to hold meetings, certainly before 2007 when the product standards come up for 5 year review. At this time TC 154 is being expected to clear up a number of issues that were not fully dealt with to the satisfaction of CEN and the EU. In particular there is a need for a fuller consideration of the environmental requirements in the Mandate which are expected to be applied to all aggregates. There is also a need for greater clarity on the issue of “harmful fines” (i.e. harmful to the performance of an aggregate). Additionally there is pressure in some quarters to work towards amalgamation of all the product standards. For most committee members, these activities appear to represent huge expense without any tangible benefit. The consequence is inertia and the desire to put off subsequent meetings as long as possible. This is not helpful to the implementation of clauses for recycled aggregate.

There had been some hope that with the publication of test methods in 2005, clauses for recycled aggregate could be quickly introduced by amendment, but it now looks increasingly likely that such clauses will not be implemented until the "second generation" of standards are produced in 2007. Even if these clauses are looked at with a view to implementation in 2005, there are likely to be further rounds of consultation and amendment, because these clauses are now nearly four years old, and views will have changed in the intervening period. Many countries in Europe have been developing the use of recycled aggregates during this period, including the preparation of local specifications for their use – a necessity as the ENs take over from national specifications (until the introduction of specific clauses for recycled aggregate in these ENs).

The clauses for recycled aggregate produced by the specification Task Groups of TC 154 (TG 2, 3 & 4) were developed from the work of the TC 154 ad hoc group for recycled aggregates which produced its final report in 1998. The TGs agreed only to consider clauses for inclusion in three of the nine new ENs (12620 for concrete, 13043 for bituminous bound and 13242 for unbound and hydraulically bound). No instances were put forward of use of crushed concrete or masonry for mortar, armourstone and railway ballast, and with regard to lightweight material an additional type of material was introduced in clauses for BS EN 13242.

The clauses were supposed to take a pragmatic approach from the viewpoint of the aggregates industry as a whole, but some fairly major changes were made from the recommendations of the report of the ad hoc group with little supporting evidence or practical experience in the use of these materials. They do not reflect the way that specifications have developed in the UK, and for this reason we believe that the clauses cannot now be said to be ready for implementation but may take several more years of development. If this is the case, then implementation by 2007 may already be looking optimistic rather than pessimistic.
Various other factors suggest that the clauses prepared by the Task Groups will end up being "reworked". Firstly they were prepared on drafts of the specifications which are now five years old, and this will trigger all sorts of other questions. Many of the original members of the committees have now retired so almost any issue, whether pertinent or not, is likely to be raised. Many of the arguments of the past are certain to be revisited.

The range of types of material specified by the Task Groups now seem unduly complicated, and the groupings given in the 2001 revision of the Highways Specification and in BS 8500:2002 seem much simpler and more practical. In addition, the requirements for density ranges and density grading seem quite onerous compared with recent UK practice. An editorial note in one of the drafts requests information in support of the density ranges specified, an admission that this clause could be subject to change. Density grading tests can be quite expensive in terms of materials, so there is some relief that the drafting of a test for this has now been dropped from the TC 154 work programme. Nevertheless reference to such a test will need to be removed from the clauses prepared in 1999.

Task Group 4 on chemical specifications voted to specify a water soluble sulfate requirement for recycled aggregates rather than acid soluble sulfate as recommended in the report of the ad hoc group. Although a scientific justification is given for this, there is no practical experience of its implementation and this could end up increasing the cost of testing and uncertainties in applicability of the recommended testing limit. Test limits for methylene blue values have been recommended as a way of limiting clay impurity in recycled aggregates for bituminous applications, but there is unlikely to be much experience of the test in this application, and the precedents for quoting values of this test may raise a whole range of other issues which have yet to be resolved on the use of this test for natural aggregates.

There is no doubt that all of these problems are soluble, but the amount of effort and drive to see that clauses for recycled aggregates are properly introduced into European Standards within a reasonable time scale should not be underestimated.

6.2 TC 154 Work on aggregates from secondary sources

Task Group TG 10 "Aggregates from secondary sources" was set up by CEN/TC 154 primarily in response to the need to ensure that municipal waste incinerator bottom ash (MSWIBA or IBA for short) was adequately covered by the new European Standard specifications for aggregate. The first meeting was held in September 2001. The setting up of TG 10 was one of a number of actions which followed discussions on issues raised from the content of the EC Mandate for European Standard specifications. The Chairman's Panel later retreated from its earlier position and in plenary session, TC 154 agreed to the setting up of TG 10 with the remit to look at any secondary materials needing additional coverage in the product standards. Because of the strength of their original objection, the Netherlands were asked to convene TG 10. The UK mirror group for this is BSI Sub-Committee B/502/8.

After five meetings of TG 10, a list of secondary materials and uses (in relation to divisions defined by the product standards) has been compiled for Member States contributing delegates to TG 10, together with some ground rules for determining which specification requirements (and additional test methods where necessary) to be applied if required to the various product standards. This is all taking quite a long time, and it seems unlikely that any new clauses for IBA would be published in the standards either in an amendment or in revisions of the standards before 2010 at the earliest. This means that the UK will need to rely on national guidance on the use of IBA until at least this date.

Table 2 gives a list of aggregates from secondary sources which are currently being used in Member States subscribing to CEN and which TG 10 is currently intending to consider in relation to the adequacy or otherwise of coverage within the TC 154 product standards. No indication is given at this stage as to whether or not changes or additions will be recommended for any of these materials, and it is likely that a number of them will be "passed" without requiring any changes. Slags D1 – D4 in Table 2 are already well covered in the TC 154 product standards and recycled aggregates A1 – A4 are in the process of being dealt with (see section 4.1 above).

For IBA there are likely to be some additional requirements and tests, particularly in relation to residual organic material and ferrous and non-ferrous metals, including aluminium. In anticipation of a long wait before these specifications and test methods become available, guidance on the use of IBA is given in an informative annex to BS EN 13285 for unbound layers in road construction (see section 3.2 above). In the UK, clauses have been drafted to make specific provision for IBA in the Highways Specification, but this is awaiting agreement with EA/DEFRA/DTI on permissible levels of dioxin (as of March 2003). No recommendations on levels of leachates and other emissions are being given by TG 10.
(see section 3.3 above) and similarly testing for such materials must be appropriate to all aggregates and is a matter for TC 154.

Table 2 – TG 10 List of aggregates from secondary sources (Dec 2002)

<table>
<thead>
<tr>
<th>Nr.</th>
<th>Source</th>
<th>Subnr.</th>
<th>Specific material</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Construction and demolition recycling</td>
<td>A1</td>
<td>Reclaimed asphalt</td>
</tr>
<tr>
<td></td>
<td>industries</td>
<td>A2</td>
<td>Crushed concrete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A3</td>
<td>Crushed bricks, masonry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A4</td>
<td>Mix of A1, A2 and A3</td>
</tr>
<tr>
<td>B</td>
<td>Municipal waste industry (MSWI)</td>
<td>B1</td>
<td>MSWI Bottom ash (excl. fly ash)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B2</td>
<td>MSWI Fly ash</td>
</tr>
<tr>
<td>C</td>
<td>Power generation industry</td>
<td>C1</td>
<td>Coal fly ash</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C2</td>
<td>Fluidized bed combustion fly ash (FBCFA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C3</td>
<td>Boiler slag</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C4</td>
<td>Coal bottom ash</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C5</td>
<td>Fluidized bed combustion bottom ash</td>
</tr>
<tr>
<td>D</td>
<td>Iron and steel industry</td>
<td>D1</td>
<td>LD steel slag</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D2</td>
<td>Crystallized blastfurnace slag (air-cooled) (CBFS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D3</td>
<td>Vitrified blastfurnace slag (VBFS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D4</td>
<td>Electric arc furnace steel slag (EAF slag)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D5</td>
<td>Stainless steel slag</td>
</tr>
<tr>
<td>E</td>
<td>Non ferrous industry</td>
<td>E1</td>
<td>Copper slag</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E2</td>
<td>Burned bauxite slag</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E3</td>
<td>Zinc slag</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E4</td>
<td>Phosphorous slag</td>
</tr>
<tr>
<td>F</td>
<td>Foundry industry</td>
<td>F1</td>
<td>Foundry sand</td>
</tr>
<tr>
<td>G</td>
<td>Mining and quarry industry</td>
<td>G1</td>
<td>Red coal shale</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G2</td>
<td>Refuse from hard coal mining (black coal shale)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G3</td>
<td>Pre-selected all-in from quarry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G4</td>
<td>Spent oil shale</td>
</tr>
<tr>
<td>H</td>
<td>Maintenance dredging works</td>
<td>H1</td>
<td>Dredging material (sand, clay, various)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>H2</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Miscellaneous</td>
<td>I1</td>
<td>Excavated soil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I2</td>
<td>Paper sludge ash</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I3</td>
<td>Sewage sludge ash</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I4</td>
<td>Biomass ash</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I5</td>
<td>Crushed glass</td>
</tr>
</tbody>
</table>

6.3 Test methods for recycled aggregates

Several new test methods or amendments to existing methods have been proposed to support the inclusion of clauses for recycled aggregates within the TC 154 product specifications:

Sorting method

A method is needed to support specification limits on the amounts of lump impurities such as wood, glass and metals. This is the same in principle as the method in BS 8500 and in Clause 710 of the Highways Specification. A sorting method also appears in BS EN 933-7:1998 for the shell content of marine aggregates. A draft (prEN 933-11) has been prepared by TC 154 TG 11 and the target date for ratification (i.e. ready for printing) is 1 September 2004.

Acid soluble chloride

Chlorides in concrete need to be limited in order to protect reinforcement from corrosion. A method for water soluble chloride is used for marine aggregates but it is not known how appropriate this would be for recycled aggregates. Chlorides tend to be retained in hardened concretes through the formation of chloroaluminates, and so significantly lower results are obtained for water soluble chloride than for acid soluble chloride. There is insufficient data on the mobility of chloride retained in recycled aggregate, particularly over the lifetime of new concretes, so the safest policy is
to assume that it may become available. Hence the need for acid digestion of the samples before determination of chloride. A draft (prEN 1744-5) similar in principle to BS 1881-124 has been prepared by TC 154 TG 12 and the target date for ratification is 1 March 2005.

**Effect on cement hydration**

TC 154 have published a test method for determining the effect of organic contaminators in fine aggregate on the setting of cement. This appears as clause 15.3 of BS EN 1774-1. The method compares the stiffening and hardening of mortars made with the aggregate both with and without organic contaminant. The sample of aggregate without organic contaminant is prepared by heating it to 480°C. This is clearly inappropriate to testing of recycled aggregates, and so an alternative method was required. In the Netherlands there is a test method (NEN 5944) which measures the retardation properties of leachate from recycled aggregates. A draft based on this method (prEN 1744-6) has been prepared by TG 12 and the target date for ratification is 1 March 2005.

**Drying shrinkage**

Concretes made with recycled aggregates will have higher drying shrinkage than with the majority of other aggregates, but BS EN 1367-4:1998 for the drying shrinkage of aggregates (based on BS 812-120) is only appropriate for normal weight aggregates with water absorption values below about 3.5%. This is because the concrete test specimens are made with fixed proportions including water content. Crushed concrete aggregates typically have an absorption value of about 5%. An amendment to BS EN 1367-1 has been proposed in TG 12 for the addition of a normative annex (alternative method) which would allow preparation of test specimens with the aggregate in the saturated and surface dry condition. It is hoped that will be introduced through the unique acceptance procedure. All standards come up for reconsideration/confirmation every five years, and this is due for BS EN 1367-4 during 2003.

**Density grading**

This has now been dropped from the TC 154 programme of work (see comment in section 4.1).

No other test methods are being prepared for recycled aggregates but there are some unanswered questions with regard to methods and limits currently in the product specifications.

**Sulfates**

The issue of testing for sulfates has been raised in section 4.1. Both acid- and water-soluble tests are given in BS EN 1744-1 but the acid soluble test is the one called up for specification limits or categories in the product standards. It is also the method used in Dutch standards and by BS 8500 for recycled aggregate. The water soluble method was preferred in TG 4 as it does not attack sulfates in the cement hydrates which do not cause a problem, but will dissolve only the excess gypsum derived from plaster. However, gypsum only has a limited solubility in water and so there may need to be repeated extractions with this method. No guidance has been given on the number of repeat extractions that would be necessary, or any justification for the proposed limiting value of 0.2%.

**Freeze/thaw resistance**

Two main methods for the weathering properties of aggregates have been prepared by TC 154:

- BS EN 1367-1 Freeze thaw test (based on the German method)
- BS EN 1367-2 Magnesium sulfate test (based on BS 812-121)

BS EN 1367-1 is not a very severe test and is not recommended for use in the UK by the national guidance documents. BS EN 1367-2, for which there is a lot of experience in the UK, is not appropriate for use with recycled aggregates because of reaction between the sulfate and the cement paste. In some circumstances this can lead to an increase in weight of the test specimens (i.e. a negative test value) or in others to premature disintegration. There is no knowledge of the suitability or otherwise of BS EN 1367-1 for recycled aggregates. From the UK point of view there is no alternative but to test the product i.e. for use in concrete, a freeze thaw test should be carried out on the concrete, or for unbound use, a frost heave test (BS 812-124).
7. Analysis of the impact of the new standards on the use of recycled and secondary aggregates

7.1 Introduction

This task has been addressed in a number of ways. Firstly, the reviews and examination of the new standards, as undertaken above, gives clear pointers to their likely impact. Secondly, views of users and producers have been sought through:

i) a questionnaire distributed at relevant meetings and workshops

ii) a discussion session held at the DTI/WRAP Workshop on Recycled and Secondary Aggregates held at BRE on 26th February 2003

iii) discussions with individuals and with the members of the BSI committees on lightweight aggregates (B502/5) and recycled and secondary aggregates (B502/8)

Thirdly, by examination of the effects on key specifications such as those of the Highways Agency, NHBC and the National Building Specification.

7.2 The results of examination of the current and new requirements

The important implications have been identified in each section through the report. Here we summarise these and draw overall conclusions.

There has been a long history of the use of recycled and secondary materials in construction in the UK and there has been standardisation of some materials for some uses. Overall the availability of standards has been patchy especially in the building field, though their use in roads has been better catered for through the Highways Agency specifications. The exclusion of recycled and secondary materials from the main aggregate standard, BS 882, which only covers natural aggregates, has undoubtedly had an adverse effect on their utilisation as even when specific end uses were covered by other standards there was a perception that these were inferior. It was too easy and tempting for the engineer to specify: aggregates shall be to BS 882.

The advent of the new European Standards gives the use of recycled and secondary materials a different and much firmer legal basis. In the Scope of the new ENs for aggregates, recycled and secondary materials are put on an equal basis with aggregates from natural sources. In the Mandate, the CEN TC 154 response to the Mandate and the new ENs, it is made clear that recycled and secondary materials are fully within the scope of the standards. Moreover, it will effectively be a legal requirement for specifiers to use the new ENs as, at least, the basis for their specifications. This will be particularly so for public specifiers. Therefore there is no barrier to their use in a legal sense.

However, these documents (the Mandate, the CEN TC 154 response to the Mandate and the new ENs) all also make it clear that the requirements in this “first generation” of standards are not on their own sufficient. Thus the note to the Scope warns that for aggregates from unfamiliar sources, in particular recycled aggregates and aggregates from certain industrial by-products, the requirements in the Mandate and hence in the harmonised standard, may not be sufficient and that provisions in the place of use can be used to assess the suitability of such materials.

The only materials that are covered sufficiently in the standards so that additional requirements are not needed are blastfurnace and steel slags. The requirements for blastfurnace slag are effectively the same as in existing British Standards whereas the use of steel slags is mostly not covered by British Standards. So for these two materials the advent of the new ENs is a positive step.

For the rest of recycled and secondary materials, however, the current work to introduce specific requirements into the standards (the “second generation”) is clearly vitally important. In the interim the existing national guidance, outlined in Task 1, should enable the continued use of such materials in the UK.
There should be little effect on their use in highways as the Highways Agency Specification gives comprehensive
guidance and requirements.

In building the position is more patchy. For the use of recycled aggregates in concrete, the guidance in BS 8500,
although quite conservative, coupled with the inclusion of recycled materials in the scope of BS EN 12620, aggregates
for concrete, goes far beyond what has previously been in British Standards and should encourage the greater use of
these materials in concrete. There are, however, as yet, no similar requirements for secondary aggregates. This is not
surprising as the classification of the nature of such materials and the knowledge of their properties and use is much less
well developed. The references to aggregates in precast concrete product standards are so minimal that they can be
said to neither inhibit nor encourage the use of recycled or secondary aggregates. Nevertheless, this is a considerable
improvement on prescriptive British Standards which excluded the use of such materials.

Our analysis of the ongoing work to introduce specific requirements in the "second generation" standards is that the
timescale for this is likely to be long. Although useful work on the requirements and tests for recycled aggregates has
been done, much of the impetus has gone out of the work of TC 154 with the publication of the “first generation”
standards and the industry is more concerned with ensuring smooth implementation of the “first generation” than in
pursuing further amendments. With the passage of time even the work that has been done on recycled aggregates now
needs re-examination. The work on secondary aggregates is even further from achieving real results in terms of revised
standards.

Environmental issues are also likely to complicate advances in the standardisation of recycled and secondary aggregates.
There are great variations in the approaches to environmental issues across Europe but the pace tends to be set by
those Member States, such as the Dutch, who have very strong environmental legislation. At present, the main issue is
the European Acceptance System for concrete in contact with drinking water but in the background is the prospect of
wider European legislation on the leaching of harmful substances from construction materials. This could be a particular
problem for unbound recycled and secondary aggregates.

7.3 Views of producers and users

i) Results of the questionnaire

A questionnaire to establish the views of users and producers on the likely implications of the advent of the new
standards was designed in collaboration with WRAP and distributed to delegates at the annual BRE Durability by Intent
workshop, the WRAP/DTI Workshop on Recycled Aggregates, to the BSI Committee on recycled materials (BS502/8), and
to selected individuals. The recipients were from a broad spread across the industry, including users and producers in
the aggregate, concrete and waste industries although by the nature of the target events and bodies they were more
aware than the normal professional of the issues. A copy of the questionnaire distributed at the WRAP DTI Workshop is
reproduced as Appendix A.

The general consensus from the returns was that European Standards should make it easier to use recycled and
secondary materials, although one reply was qualified with the rider that this may not necessarily be the case unless
environmental concerns were properly dealt with. Another reply expressed concerns that European Standards tended to
go for the lowest common denominator which was contrary to initiatives to improve durability.

- For people with experience predominantly in highways, the answer was "easier" or at the very least they
  thought that there would not be a great deal of difference. For use in concrete, there was a concern that the
  complexities of the specification might possibly make things more difficult.

- Exclusion by the specification was seen as a frequent problem but certainly not always the case. This was
  predominantly in the client specification and was not helped by "catch all" clauses such as "new materials shall
  be used unless otherwise specified" which appears in NBS.

- Where recycled and secondary materials were included in the specification, non-use due to unfamiliarity was
  recognised as a problem, but replies showed a fairly even spread. One respondent felt that there was often no
  persistent intention at all levels, although Building Regulations Inspectors were singled out as a particularly
  influential group.

- Professional indemnity risks came out as a slightly stronger driver than unfamiliarity. Consultants were
  frequently unwilling to take perceived risk other than for paving sub-base. A demonstration building project
  was having difficulties through this cause.
• Cases where recycled and secondary materials were nominally included but could not be used because the specification itself was too restrictive was also seen as a common cause of non-inclusion. One respondent reported that there was frequently concern about the test reports.

• With regard to environmental restrictions, the answers were rather more polarised, some having no problems, others frequently. This may be to do with the materials dealt with.

• Other problems included cost/benefit, supply, quality, lack of appropriate specification.

ii) Discussion at the WRAP/DTI workshop

This workshop was held on 26th February at BRE. The agenda is included as Appendix B.

The “break out” session on implications of moving to new European Standards attracted 11 participants with a good spread of producers and specifiers. The key outcomes of the session were:

• Uncertainty whether or not the effect of the publication of the “first generation” standards, in which the requirements for recycled and secondary aggregates are not well developed, will be positive or negative. Depends on the adequacy of the existing UK Guidance on the use of these materials. Thus in the highways field will probably not make a big difference but could be a problem in the building field.

• The advent of the full developed European Standards will be certainly be an encouragement for the use of recycled and secondary aggregates. However, the timescale for their full implementation is uncertain and could be several years. With the publication of the “first generation” there is something of a relaxation in the CEN Technical Committees.

• In the concrete field there are counteracting effects of the new concrete standard BS EN 206-1 and its accompanying British Standard, BS 8500. On the one hand there is a new requirement on the concrete producers to demonstrate compliance with specification. This could make them cautious and less willing to risk new materials. On the other hand there is a new category of “proprietary” concrete which gives the producer the opportunity to develop special mixes. This is an opportunity to use recycled and secondary aggregates.

• To ensure that the advent of these standards has a positive effect on the market for recycled and secondary aggregates, there was agreement that there is need for:
  − A strong and continuing input by the UK into the CEN aggregate committees and also into related key committees concerned with end uses such as concrete, roads.
  − Also a stronger UK input into the committees developing environmental requirements in the construction fields as these have the potential to undermine the use of recycled and secondary aggregates.
  − More and better UK Guidance.
  − More and better dissemination of information about the advent of the new standards.

iii) Discussions with individuals and BSI Committees

The views of the people who are knowledgeable and have an interest in aggregates, both natural and secondary, have been obtained through the consultations with the BSI Committees and through the workshops and the questionnaire (see above). Additionally, discussions were held with:

Professor Tom Harrison, chairman of B517/1 Concrete, on the requirements for recycled and secondary materials in BS EN 206-1 and BS 8500. These have been incorporated into the sections on use in concrete above.

Mr Mike Taylor, standards Manager at British Cement Association, in particular on the European Acceptance Scheme for products in contact with drinking water.

Mr John Lay, Chairman of B502/2 Aggregates for concrete and member of B517/1. John has concerns about the testing regimes required for RA and RCA in BS 8500 e.g. for chlorides which will discourage people from using these materials in concrete.

Dr Jim Troy, Chairman of B502/1 Aggregates for mortar. Information given to assist preparation of changeover timetable for mortars in Appendix C. Jim considers the effects of changeover to European Standards to be less certain for mortar than for other uses (concrete, bituminous bound, unbound) because a number of decisions / changes yet have to be made with regard to standards for the products. Comment: Recycled aggregates for mortar and related products are covered in the scope for BS EN 13139 but there is no guidance because of perceived problems with such use. The scope for secondary materials however will be widened.
7.4 Effects on specifications

Work is already under way on the revision of the Highways Specification to make reference to the new European Standards in good time for new contracts to be drawn up using the new standards in preparation for the industry changeover at the end of the year. Recycled and secondary aggregates are already covered by specific provision in the Highways Specification, and this will not be changed with the introduction of European Standards. Thus the changeover should not have any major effect on the use of these materials. Any effect would be positive due to the inclusion of recycled and secondary aggregates within the scope of the new standards.

With regard to the National Building Specification there has been a rolling programme of updates such that each section is revised about every two years. The section on aggregates and concrete is being revised in the summer of 2003 and will reflect the changeover to the new European Standards. With regard to the NHBC handbook, a “standards extra” leaflet is sent out every three months to inform subscribers of the changeover to the new standards. Zurich are updating their Foundation 15 handbook annually to reflect changes in the standards. Thus in essence the major part of the industry should be using the new standards within about a year. There may however be an issue with smaller organisations which do not subscribe to any of the major specification providers. It could well be that their in-house specifications will continue for some time to use obsolescent standards and other restrictive clauses which exclude the use of recycled and secondary materials. It may be useful to consider whether an education programme could assist in helping such organisations to move over quickly to specifications which do not put up unnecessary barriers to the use of recycled and secondary materials.

The National Structural Concrete Specification (2nd edition 2000) will probably be updated less frequently, but this will obviously need to be done for the withdrawal of BS 5328 Concrete on 1 December 2003. NSCS requires materials to be specified to the current versions of the relevant British Standard. BS 882, BS 1047 and BS 3797 are listed in the references but they are only referred to for specific types of mix in BS 5328 e.g. in standard mixes but not designed mixes. Thus when BS 5328 is withdrawn, the specifier should not be prevented from using recycled aggregates where they meet the specification requirements.

With regard to suppliers of aggregates, the majority of the industry including all the large companies has decided to move over to using the new aggregates standards as from 1 January 2004. The large companies are expecting to CE mark their products but this is not mandatory in the UK. Smaller companies, which will include a significant number of suppliers of recycled and secondary materials, will still be able to supply materials much as at present without needing to CE mark their products. It will be a legal requirement for them to supply materials to the new standards, but national guidance documents show how previous UK specifications translate into categories within the European Standards. Thus it will probably be possible to show retrospectively that materials as currently supplied do comply with the relevant European Standard. The advent of the European Standards is thus unlikely to cause any serious problems to either large or small suppliers. There will be a net gain as far as recycled and secondary materials are concerned through the inclusion of these materials in the Scope of these standards.
8 Conclusions and recommendations

8.1 Summary

There are potentially very positive effects of the introduction of the new European Standards on the market for recycled and secondary aggregates in the UK. The most important thing is that these materials are accepted on an equal basis with natural aggregates in the key documents; the Mandate M 125, the CEN TC 154 response to the Mandate and in the new aggregate ENs. Moreover, as the new ENs are part of a much firmer framework, designed to ensure freedom of trade across Europe, it will effectively be a legal requirement for specifiers to use the new ENs as, at least, the basis for their specifications. This will be particularly important for public specifiers.

That having been said, however, the necessary requirements and tests in the new standards covering the use of recycled and secondary aggregates, have not yet been developed to a sufficient degree and it is recognised in the response to the Mandate and in the ENs themselves that for most recycled and secondary materials provisions in the place of use will still be needed to assess their suitability. Although there is work in hand in TC 154 to develop and agree the necessary supplementary clauses and test methods, it looks as though the time scale to their implementation will be five years or more.

Accordingly, in the short term, the maintenance and expansion of the market for recycled and secondary aggregates depends heavily on the adequacy of the existing UK Guidance. In the highways field the guidance is well developed and there should be little effect on markets. In the building field the position is more patchy although the new guidance and requirements in BS 8500 should help the usage in concrete. There continues to be a need to develop better UK Guidance for the wider use in building.

Despite the positive aspect of the inclusion of the recycled and secondary materials in the new aggregate ENs there is also the threat that harmonised European environmental requirements could undermine their use. There is need for a stronger input into the committees developing these requirements to ensure that the use of recycled and secondary materials is not unnecessarily prevented or adverse perceptions about their use allowed to develop.

8.2 Recommendations to ensure that the introduction of the new aggregate ENs have a positive effect on the market for recycled and secondary aggregates

In the light of these conclusions we make the following recommendations:

1. It is clear that there is much further work to be done to introduce clauses to adequately cover, in the new ENs, the use of recycled and secondary materials as aggregates. There is need to maintain the UK input to this work. Currently UK has a strong input through BRE but the contract from DTI covering this and other work on standardisation of aggregates, cements and concrete will end in March 2004. There are currently no indications from DTI that the contract will be renewed beyond that time. It is recommended that funding is identified to continue this work.

   Importance: high. Timing: mainly from April 2004 onwards, but will need preliminary consideration this year.

2. There is also much needed work to improve the UK Guidance in respect of the use of recycled and secondary materials as aggregates in accordance with the new ENs. Such guidance (PD 6682 Parts 1-9) is well developed for primary aggregates but scattered and scanty for recycled and secondary materials. BS 8500 (UK complementary standard to BS EN 206-1 "Concrete"), while including the use of recycled aggregates, needs to be made much more "user friendly". Action: DTI/WRAP to pursue this, with funding where required.


3. There is little knowledge in the industry and among specifiers on how the advent of the new ENs affects their ability to use recycled and secondary materials as aggregates. There is need for an education and dissemination programme to increase awareness. It is suggested that if possible this should be done in conjunction with the dissemination programme on the new standards being proposed by QPA. Action: DTI/WRAP to pursue this, with funding where required.
4. Environmental controls on all aggregates required by the EC Mandate for aggregates may impinge badly on recycled and secondary materials. As well as input to standards development in (1) above, UK input needs to be backed up by research relevant to recycled and secondary materials. Although this may take several years it is recommended that such work start in the next financial year. The findings from such work may give assistance to improving the situation with regard to the definition of waste and to clarify concerns with regard to subsequent recycling and the traceability of waste. Action: DTI/WRAP to consider funding work in this area from April 2003.

Importance: high. Timing: several years, but should be started as soon as possible.

5. Various other issues which are expected to be tackled by CEN/TC 154 “Aggregates” e.g. alkali-silica reaction, harmful clay fines, frost resistance, etc. will also need input with regard to the use of recycled and secondary aggregates to ensure that they are properly covered. This requires input in (1) and research work with a similar timing to (4) above. Action: DTI/WRAP to consider funding work in this area from April 2003.

Appendix A - DTI/WRAP workshop 26 Feb 2003. Short questionnaire - recycled and secondary aggregates

1. Have you had anything to do with the specification or use of secondary or recycled aggregates? y or n:

<table>
<thead>
<tr>
<th>Brief details for:</th>
<th>Example 1</th>
<th>Example 2</th>
<th>Example 3</th>
</tr>
</thead>
</table>

Type of structure:

Specification used:

PLEASE CONTINUE TO Q2 – Q4 WHATEVER YOUR ANSWER TO Q1!

2. For the use of these materials, have you had or heard of difficulties with standards and specifications? Please ring choices below (a – always; f – frequently; s – sometimes; o – occasionally; n – never)

<table>
<thead>
<tr>
<th>Exclusion by the specification</th>
<th>a</th>
<th>f</th>
<th>s</th>
<th>o</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comment:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Included but not used due to unfamiliarity</th>
<th>a</th>
<th>f</th>
<th>s</th>
<th>o</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comment:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Included but not used due to personal indemnity risks</th>
<th>a</th>
<th>f</th>
<th>s</th>
<th>o</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comment:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Included but specification itself is too restrictive</th>
<th>a</th>
<th>f</th>
<th>s</th>
<th>o</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Details:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental restrictions:</th>
<th>a</th>
<th>f</th>
<th>s</th>
<th>o</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Details:</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Any other difficulties:</th>
<th>a</th>
<th>f</th>
<th>s</th>
<th>o</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Details:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. What is your perception of the effect of changing to European Standards on the use of these materials? (Tick one box below)

<table>
<thead>
<tr>
<th>Should be easier</th>
<th>No difference</th>
<th>More difficult</th>
<th>No idea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comment:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. How do you expect to manage changeover to European Standards?

<table>
<thead>
<tr>
<th>Subscribe to BS</th>
<th>Use HA Spec.</th>
<th>Subscribe to NBS</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comment/details:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If you would be happy for us to follow up or clarify any answers given above, please would you give below your name and phone no. and/or email address. Thank you for helping us.
## AGENDA

<table>
<thead>
<tr>
<th>Time</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>09.30 -10.00</td>
<td>Reception and Coffee</td>
</tr>
<tr>
<td>10.00</td>
<td>Chairman’s Introduction</td>
</tr>
<tr>
<td>10.10</td>
<td>Introductions to current projects:</td>
</tr>
<tr>
<td></td>
<td>• The Role of Construction Clients</td>
</tr>
<tr>
<td></td>
<td>• Supply Chain Barriers</td>
</tr>
<tr>
<td></td>
<td>• Development of Indicators for Markets</td>
</tr>
<tr>
<td></td>
<td>• Implications of Harmonising standards on the Market</td>
</tr>
<tr>
<td></td>
<td>• New Materials</td>
</tr>
<tr>
<td>11.00</td>
<td>Break-out groups to examine one of the following topics:</td>
</tr>
<tr>
<td></td>
<td>• the implications on the market for recycled and secondary aggregates in construction of moving to European Standards</td>
</tr>
<tr>
<td></td>
<td>• the appropriateness of key draft papers to support construction clients in their use of recycled and secondary aggregates (summaries will be distributed in advance of the workshop)</td>
</tr>
<tr>
<td></td>
<td>• the role of contractual arrangements and risk management in the supply chain for recycled and secondary aggregates</td>
</tr>
<tr>
<td></td>
<td>Coffee / tea in groups</td>
</tr>
<tr>
<td>12.00</td>
<td>Mini plenary for feedback from Break-out groups</td>
</tr>
<tr>
<td>12.15-13.00</td>
<td>Lunch</td>
</tr>
<tr>
<td></td>
<td>Break-out groups to examine one of the following topics:</td>
</tr>
<tr>
<td></td>
<td>• the most effective routes for engagement of clients and client bodies</td>
</tr>
<tr>
<td></td>
<td>• key indicators for recycled and secondary aggregates</td>
</tr>
<tr>
<td></td>
<td>• key outcomes needed from research to develop sustainable markets for new aggregate materials</td>
</tr>
<tr>
<td>14.00</td>
<td>Plenary for feedback from Break-out groups</td>
</tr>
</tbody>
</table>
Appendix C - Change over timetables for the new European Standards

<table>
<thead>
<tr>
<th>Aggregates in concrete</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Apr</td>
<td>May</td>
</tr>
<tr>
<td>BS 6062 Aggregates for concrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS EN 12620 Aggs for concrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2C 0062 1 Guidance for EN 12620</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS 0326 Specification for concrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS EN 200-1 Spec for concrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS 8500 Guidance for EN 200-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HA spec, NBS etc</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key: Mainstream use

Key: Coming in or out of use

Implication of new ENs on recycled and secondary aggregates
# Timetable for changeover to European Standards

## Implications of Harmonisation of Construction Products Standards

<table>
<thead>
<tr>
<th>Bituminous/Aggregates</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Apr</td>
<td>May</td>
</tr>
<tr>
<td>BS 68 Road aggregates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS EN 13048 Bituminous agg.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PD6602-2 Guidance for EN 13049</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS 4887 Coated macadam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS 594 Hot rolled asphalt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highways Specification</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Key:**
- **Mainstream use**
- **Coming in or out of use**

- Not source-specific
- Withdrawn
- Refer to Highways Specification
- Refer to natural or slag aggregates; update in hand for changeover
- Update in hand for changeover
## Timetable for changeover to European Standards

### Implications of Harmonisation of Construction Products Standards

<table>
<thead>
<tr>
<th>Aggregates for mortar</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Apr</td>
<td>May</td>
</tr>
<tr>
<td>BS EN 11986-4:2006 Buildings and Structures</td>
<td>Excludes recycled aggregate</td>
<td></td>
</tr>
<tr>
<td>BS EN 13139 Aggregates for mortar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P0682:2002 Guidance for EN 13190</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS4721 Specification for mortar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS EN 908-2 Spec for mortar</td>
<td></td>
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</tr>
</tbody>
</table>

**Key:**
- Mainstream use
- Coming in or out of use
<table>
<thead>
<tr>
<th>Lightweight aggregates</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS EN 13065-1 Lightweight aggregates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part 1 for concrete, mortar and grout</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PD 6662-4 Guidance: EN 13066-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PD 6662-5 Guidance: EN 13065-2</td>
<td></td>
<td></td>
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<tr>
<td>Refers to BS 3797</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS 5028 Specification for concrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS EN 209-1 &amp; BS 6600 concrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS 6007 Concrete blocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EN 7713 Concrete blocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Key: Mainstream use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Key: Coming in or out of use</td>
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</tr>
</tbody>
</table>

Implication of new ENs on recycled and secondary aggregates
# Timetable for changeover to European Standards

## Implications of Harmonisation of Construction Products Standards

<table>
<thead>
<tr>
<th>Aggregates: unbound &amp; hydraulically bound</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highways Specication</td>
<td></td>
<td>Update in hand for changeover</td>
</tr>
<tr>
<td>BS EN 13242 Aggregate spec.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PD 6682-8 Guidance for EN 13242</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EN 13242 Unbound road layers</td>
<td></td>
<td>Refer to Highways Specification</td>
</tr>
<tr>
<td>prEN14227-1 Cement bound base</td>
<td></td>
<td>Refer to EN 13242 Passed at formal vote</td>
</tr>
<tr>
<td>prEN14227-2 Slag bound base</td>
<td></td>
<td>Draft for formal vote in preparation</td>
</tr>
<tr>
<td>prEN14227-3 Fly ash bound base</td>
<td></td>
<td>Draft for formal vote in preparation</td>
</tr>
</tbody>
</table>

**Key:**
- Mainstream use
- Coming in or out of use