RECYCLING IN TRANSPORT INFRASTRUCTURE

SUMMARY

Guidance is provided on increasing the amount of recycling and use of alternative materials in transport infrastructure renewal works. The document is the result of a government sponsored research project. The barriers that inhibit the use of recycling and alternative materials are identified and discussed, and examples of how to overcome them are given. Many of these barriers are non-technical and relate to the perception of new materials and techniques, but some deeper-seated issues are identified. Actions required to overcome these barriers are presented.

Transport infrastructure includes the earthworks, drainage and pavements required for the functioning of roads, railways, airports and canals. Structures such as bridges are not dealt with in this document. The report principally covers renewal works for transport infrastructure, but many aspects are also relevant for new construction.

A number of stakeholders are involved in the renewal of transport infrastructure, and it is important that they are all fully committed to the concept of sustainability if an increase in recycling is to take place. The main groups of stakeholders are listed below:

- Government, principally DTI, DTLR, DEFRA, the Scottish Executive, the National Assembly for Wales and the Northern Ireland Executive.
- Regulatory authorities, principally environmental regulators and planning authorities.
- Infrastructure owners and operators (British Airports Authority, British Waterways, Highways Agency and other Overseeing Organisations, Local Authorities, London Underground, Railtrack, etc.).
- Contractors, specialised recycling contractors and designers.
- Producers of alternative materials and operators of recycling plants.
- Research organisations and universities.

The document will be of interest to managers and technical personnel in each group of stakeholders. A separate chapter is included for each group, in which the relevant issues are identified and existing guidance is presented. A summary of the recommended actions required by each stakeholder to overcome the remaining issues, with an indication of their relative priority, is given in the final chapter. A number of case studies, illustrating how an increase in recycling and use of alternative materials can be achieved, are presented in an Appendix. The main issues, available guidance and recommended actions are summarised in the following table.
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<th>Description</th>
<th>Available guidance</th>
<th>Recommended action required (Chapter 11)</th>
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<tr>
<td>Specifications.</td>
<td>Some materials and methods are excluded from existing Specifications.</td>
<td>A number of Specifications for alternative materials and methods are available (see 4.1)</td>
<td>Update existing Specifications to accommodate new developments more quickly, or write new Specifications for particular applications.</td>
</tr>
<tr>
<td>Test methods.</td>
<td>Existing test methods developed for natural materials are not suitable for some alternative materials</td>
<td>A number of tests have been assessed as suitable. (see 4.2).</td>
<td>Move to performance-based test methods and Specifications.</td>
</tr>
<tr>
<td>Reliability and quality control</td>
<td>Alternative materials perceived as highly variable and of low quality.</td>
<td>Utilise or adapt existing quality control systems to produce a consistent, fit-for-purpose material (see 4.3).</td>
<td>Demonstrate quality of materials produced under a quality plan, upgrade processing plant to produce higher quality material</td>
</tr>
<tr>
<td>Environmental concerns</td>
<td>Potential long term leaching of contaminants into controlled waters; dust and noise during construction.</td>
<td>Assess behaviour using leaching tests and existing models where necessary (see 4.4); CDM/COSHH legislation.</td>
<td>Agreement between environmental regulators and material producers on use of materials in construction.</td>
</tr>
<tr>
<td>Waste regulation including Waste Management Licensing and PPC Regime</td>
<td>Unclear whether materials are waste or covered by exemptions, potential long time scale required by waste permitting processes.</td>
<td>Use available guidance on waste permitting system (see 4.5).</td>
<td>Approach environmental regulators for advice at early stage in design of project. DEFRA are reviewing exemption system to ensure alternative materials can be used in construction.</td>
</tr>
<tr>
<td>Conditions of contract</td>
<td>Some forms of contract may create an environment where there is no incentive for innovation.</td>
<td>Use appropriate forms of contract and adopt partnering (see 4.6)</td>
<td>Review standard conditions of contract to rectify any clauses discriminating against innovative materials or methods.</td>
</tr>
<tr>
<td>Planning</td>
<td>Difficulties getting planning permission for recycling centres in or near urban areas.</td>
<td>Guidance for planners and applicants has been produced by DETR (see 4.7).</td>
<td>Ensure an adequate supply of recycling centres is available to meet local needs.</td>
</tr>
<tr>
<td>Supply and demand</td>
<td>Difficulty in matching supply and demand for some alternative materials.</td>
<td>Plan in advance and stockpile material if necessary; use existing databases to source materials (see 4.8).</td>
<td>Develop long term partnering agreements to enable better prediction of material requirements.</td>
</tr>
<tr>
<td>Economics</td>
<td>Alternative materials and methods may be more expensive than conventional ones.</td>
<td>Ensure comparing like with like; use whole life costing to ensure best practical environmental option selected (see 4.9).</td>
<td>Adjust aggregates levy and landfill tax as necessary to ensure alternative materials remain competitive.</td>
</tr>
<tr>
<td>Lack of awareness</td>
<td>Many individuals and organisations unaware of the possibilities, or only aware of potential problems.</td>
<td>Disseminate existing information from CIRIA, EA, TRL, BRE, AAS and others (see 4.10).</td>
<td>Develop strategies to reach resistant sectors of industry and infrastructure owners.</td>
</tr>
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</table>
ACKNOWLEDGEMENTS

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A steering group with cross-industry representation supported the project. The members of the steering group are listed as follows:

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A survey of transport infrastructure renewal works was carried out by means of interviews with key personnel in different stakeholder groups, case studies, a consultation workshop and responses to articles in technical journals and on the project web site, www.irl.co.uk/waste.htm. TRL wish to acknowledge those who contributed to the project by participating in the consultation workshop, the interviews and case studies. Their enthusiasm and willingness to share their experiences was a major contribution to the success of the project and an encouragement to the project team. The main participants are listed as follows:
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<td>Mr John Thomson</td>
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<td>Mr Tony Trevorrow</td>
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<td>Dr Mike Winter</td>
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</tbody>
</table>

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PART 1: ISSUES

Plate 1 Recycling used railway ballast
(Photograph courtesy of Balfour Beatty Major Projects)
1 INTRODUCTION

1.1 Background

Increasing the amount of recycling and encouraging greater use of alternative materials in construction contributes to sustainable development. The use of alternative materials, for example construction and demolition waste, and the recycling of highways maintenance materials changes them from being a liability, where costs are incurred in their disposal to landfill, into an asset where financial and environmental benefits are achieved. Under certain circumstances waste can be avoided altogether or reduced significantly through cyclic, superficial treatments in situ, and this kind of activity should always be considered within the project evaluation exercise even where major works may otherwise be involved. Examples are mechanical retexturing of polished but otherwise sound roads and the Repave treatment for rutted asphalt surfacing.

The amount of secondary aggregates used in construction in the UK increased from 32 million tonnes per annum (mta) in 1989 to 46 mta in 1999, an increase of 44% during a period when the total demand for aggregates dropped by 23% (Barritt, 2000). New techniques such as deep in-situ recycling of road pavements (Milton and Earland, 1999) contribute to the reduction in demand for primary aggregates and lead to a reduction in the amount of construction material disposed of to landfill. These trends indicate a greater acceptance of recycling and the use of alternative materials in the construction industry.

Despite these trends, it is apparent that recycling and the use of alternative materials are not being carried out to the full extent that is possible. This is especially true in the field of transport infrastructure renewal works. Transport infrastructure includes the earthworks, drainage and pavements required for the functioning of roads, railways, airports and canals. These activities are different from new construction works in several ways. They are extensive rather than confined within one site, and may cause significant interference with the operation of the infrastructure. Also, there is economic and public pressure to complete them as quickly as possible. They may be carried out at night in short possessions or in the winter to minimise disruption to the users of the infrastructure. These factors tend to inhibit the use of innovative techniques and produce a reliance on tried and tested methods of working.

There are many other factors, mainly non-technical, which inhibit the use of recycling and alternative materials. These include:

- lack of suitable specifications for new methods and materials;
- concerns about pollution of the environment through leachate or dust generation;
- the difficulty of balancing supply and demand for alternative materials;
- perceived problems with new methods and materials, either personally or relayed via the press or colleagues;
- concerns over the reliability and quality control of new methods and alternative materials;
- conditions of contract which do not encourage innovation or flexibility;
- the perception that new methods and materials will be more expensive than traditional ones;
- perhaps above all, a lack of awareness of the possibilities and of successful applications of new methods and materials.

Set against these forces and the natural conservatism of the construction industry, there are powerful drivers for change. These include:

- government strategy for sustainable construction (e.g. DETR, 2000a);
- the Egan Report on Rethinking Construction (Construction Task Force, 1998);
- the landfill tax;
- the aggregates levy;
- the revision of MPG6, which will contain revised targets for the use of alternative materials in construction;
- Minerals Planning Guidance (Wales) Planning Policy;
- the waste strategy for England and Wales (DETR, 2000b);
- the national waste strategy for Scotland (SEPA, 2000).

Part 1 of this document sets out the background in terms of definitions, policy and legislation, a description of the works and the quantities of materials involved and a general discussion of the issues and solutions. Part 2 provides the perspective of the various stakeholders, identifying the issues and providing guidance relevant to each group of stakeholders. In Part 3, a summary of recommended actions to enable greater recycling and use
of alternative materials is given for each stakeholder. Case studies illustrating the successful use of recycling and alternative materials are given in Appendix A and a glossary is given in Appendix B. Throughout the text examples of good practice are given in boxes, tables, flow charts and figures.

1.2 Who should read this document

Guidance is provided for government, regulatory authorities, infrastructure owners and operators, contractors and designers, material producers and the research community. It is of interest to managers, engineers and personnel involved in the day-to-day activities of transport infrastructure renewal works as well as those involved in new construction works. The boundary between renewal and new construction is unclear in some cases, and many of the issues are similar.

Relevant stakeholder groups include:

- Government (particularly DTI, DTLR, DEFRA, the National Assembly for Wales, the Scottish Executive and the Northern Ireland Executive).
- Regulatory authorities (environmental regulators, Local Authorities).
- Infrastructure owners and operators (Local Authorities, Highways Agency and other Overseeing Organisations, British Airports Authority, Railtrack, London Underground, British Waterways, etc.).
- Contractors, specialist recycling contractors, designers.
- Producers of alternative materials and operators of recycling plants.
- Research organisations and universities.

2 SUSTAINABLE CONSTRUCTION

Sustainable development has been defined as ‘development which meets the needs of the present without compromising the ability of future generations to meet their own needs’ (World Commission on Environment and Development, 1987). This has been expanded into four objectives in the UK (e.g. DETR, 1999a):

- Social progress which recognises the needs of everyone.
- Effective protection of the environment.
- Prudent use of natural resources; and
- Maintenance of high and stable levels of economic growth and employment.

Applied to construction, the concept of sustainable development implies a commitment to minimisation of waste, maximisation of recycling and use of alternative materials. This contributes to the sustainability objectives of protection of the environment and prudent use of natural resources. This is consistent with the waste hierarchy adopted by the UK and the EC, which suggests that:

- The most effective environmental solution is to reduce the generation of waste.
- Where further reduction is not practicable, products and materials can sometimes be re-used, either for the same or a different purpose.
- Failing that, value should be recovered from waste, through recycling, composting or energy recovery from waste.
- Only if none of these solutions is appropriate should waste be disposed of, using the best practical environmental option.

Construction, building materials and associated professional services account for some 10% of Gross Domestic Product and provide employment for around 1.5 million people (DETR, 2000a). The construction and renewal of transport infrastructure make a significant contribution to this total. The minimisation of waste, recycling of existing materials, and use of alternative materials in preference to natural (primary) aggregates are ways in which the industry can contribute towards sustainable construction.

While recycling is generally beneficial, there may be circumstances where it is not. Examples include:

- cases where long transport distances would be required to use recycled aggregates compared to natural aggregates;
- if the materials are not of adequate quality for the proposed application;
- if the process uses much higher amounts of energy than conventional methods;
- if the process is much more expensive than conventional methods.

Recycling must be viewed in the overall circumstances of each case, and the ‘best practical environmental option’ should always be chosen, whether this involves recycling or not. For instance, it may not be the best practical environmental option to use a lot of energy processing alternative materials to meet high quality end use specifications, if this results in high quality natural aggregates being used in low quality end uses. The total energy balance is the key consideration.
Conclusions: The barriers to sustainable construction are not insurmountable, and are often non-technical, but require a commitment from all the stakeholders to address the issues within their sphere of operations and to move forward in co-operation with each other.

3 QUANTITIES AND DESTINATIONS

3.1 Recycling of existing materials in transport infrastructure

The quantities involved in transport infrastructure renewal works are not clearly known. It is estimated that between 5 mta and 7 mta of asphalt planings are produced each year. It is thought that very little of this is reused to manufacture new bituminous material. Some is recycled as unbound granular capping material and sub-base, some is used as general granular fill and as hard standing, and some is disposed of to landfill. Examples of arisings for two County Councils in England are shown on Figure 1. The increase in the amount recycled in Hampshire between 1997/98 and 2000/01 is striking.

It is estimated that the quantity of dredgings from canals managed by British Waterways (BW) is between 0.8 and 2.0 mta. The quantity dredged from rivers and harbours is thought to be much greater. Most of the dredgings consist of fine-grained soils, often with a high organic content and with very high moisture content. BW has a hierarchy of options for dealing with dredgings, as shown on Figure 2.

The British Airports Authority (BAA) recycled a total of some 210,000 tonnes of concrete at Heathrow, Gatwick and Stansted airports from 1996 to 2000 (Case Study 1).

In railways, ballast is removed and replaced primarily because of inter-particle attrition and aggregate breakdown. In recent years, higher train speeds and increased gross weights have necessitated the use of high quality aggregates such as granite. At present, the majority of the spent ballast is supplied to the construction industry as a fill or sub-base material. The total amount of used railway ballast in Scotland is estimated at 0.13 mta (Coventry et al., 1999), and the total amount of new ballast supplied and spent ballast removed in the UK probably exceeds 2 mta.

In addition to the renewals of pavements and ballast, every year there are repairs to minor slope failures in the earthworks associated with roads, railways and canals. In some cases, the existing materials can be reused in the repairs, though this may require the addition of lime or cement to dry them out if they are too wet, and the use of geosynthetic materials to reinforce the soil. Similar techniques are also used in road widening schemes to steepen the existing slopes so that the road remains within the existing land boundaries. The condition appraisal and remedial treatments for infrastructure embankments are described by Perry et al. (2001).

The costs involved in repairs to failures and renewal of earthworks are significant. Expenditure on remedial earth structures and drainage on local roads, trunk roads and motorways in England and Wales was estimated to be about £16 million in 1993/94 (Reid et al., 2000). British Waterways has an annual expenditure of about £40 million on maintenance, which includes bridges, embankments, cuttings, relining and dredging canals. Railtrack gave a figure of £10.7 million a year over 10 years for remedial

**Conclusion:** There is scope for an increase in the reuse of materials in transport infrastructure renewal works.

### 3.2 Alternative materials

If the in-situ material cannot be reused, reclaimed or recycled in the infrastructure renewal works, there is the option of using alternative materials instead of primary aggregates to replace them. Considerable quantities of some alternative materials are available in most parts of the UK, particularly construction and demolition waste. A survey carried out in 2000 for the Environment Agency revealed that in 1999 72.5 million tonnes (mt) of construction and demolition waste and soil were produced in England and Wales. A breakdown of the uses to which this material was put is given in Table 1.

Quantities of other materials, which may be available for use in transport infrastructure renewal works, are also shown in Table 1.

<table>
<thead>
<tr>
<th>Material from dredging</th>
<th>Quantity (mta)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse material</td>
<td></td>
</tr>
<tr>
<td>Processed for use as construction aggregates</td>
<td></td>
</tr>
<tr>
<td>Fine material</td>
<td></td>
</tr>
<tr>
<td>Condition of fine material</td>
<td></td>
</tr>
<tr>
<td>Best</td>
<td></td>
</tr>
<tr>
<td>Spread on agricultural land adjacent to canal</td>
<td></td>
</tr>
<tr>
<td>Spread on, or adjacent to, canal bank</td>
<td></td>
</tr>
<tr>
<td>Sent to landfill either a BW or commercial tip</td>
<td></td>
</tr>
<tr>
<td>Contaminated or poor physical properties</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2** Utilisation of dredgings from canals operated by British Waterways

<table>
<thead>
<tr>
<th>Table 1 Quantities of alternative materials arisings in England and Wales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
</tr>
<tr>
<td>Construction and demolition waste and soil</td>
</tr>
<tr>
<td>Recycled by screening and/or crushing</td>
</tr>
<tr>
<td>Beneficial use on landfill sites</td>
</tr>
<tr>
<td>Spread on exempt sites</td>
</tr>
<tr>
<td>Landfilled as waste</td>
</tr>
<tr>
<td>By-products of industrial/extractive processes (colliery spoil, china clay and slate waste, pulverised fuel ash and blastfurnace/steel slags)</td>
</tr>
<tr>
<td>Asphalt planings</td>
</tr>
<tr>
<td>Used railway ballast</td>
</tr>
<tr>
<td>Tyres</td>
</tr>
<tr>
<td>Recycled glass</td>
</tr>
<tr>
<td>Incinerator bottom ash</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

<sup>1</sup> Figures from Environment Agency (2001)
<sup>2</sup> Figures from Anon (1998)
<sup>3</sup> Figures from Used Tyre Working Group (2000)
<sup>4</sup> Figures from Barritt (2000)

A detailed survey of recycled aggregates in Scotland has been carried out, based on a desk study and a pilot survey (Winter and Henderson, 2001). The survey found that there were some 10.2 million tonnes (mt) of aggregate arisings in 1999. It was estimated that approximately 5.2 mt were...
landfilled and 5.5 mt recycled (note that the totals of landfilled and recycled exceed the arisings due to the recycling of old materials, and imported industrial wastes for which there are no arisings). Of the recycled aggregates, it was estimated that around 87% were recycled in low utility applications, 5% in intermediate utility applications and 7% in high utility applications. The terms low, intermediate and high utility have been used to describe a typical range of applications in relation to the potential of a given aggregate type. The levels correspond to increasing performance requirements and, in general, to increasing economic value. For example, for bituminous planings low utility application would be general fill, intermediate utility would be as capping layer or sub-base in road construction and high utility would be hot and cold recycled bituminous materials (Winter and Henderson, 2001). The results are summarised in Table 2.

There thus exists considerable potential not only for increasing recycling, but also for increasing the quantities recycled in intermediate and high utility applications. However, it should be realised that there may not be any gain in upgrading of alternative materials if this leads to these being used for higher utility applications with natural aggregates then being used for lower utility applications. The overall environmental and economic balance should always be considered.

It is crucial that alternative materials are sorted at source, so that potentially high quality materials are not contaminated. It is much more expensive to separate materials once they have been mixed than to segregate them at the point of origin. This particularly applies to construction and demolition waste and soil, which form by far the largest category of alternative materials (Table 1). The Environment Agency survey covered 1,400 landfill sites in England and Wales, 660 known mobile crushers and recycling sites, and 3,050 known operators of exempt sites. The operators of these exempt sites are registered exempt, under paragraphs 9 & 19 of the Waste Management Licensing (WML) Regulations 1994, from the need to hold a waste management licence. In broad terms, these allow the spreading of up to 20,000 m³ per hectare of soil, rock, ash, sludge, dredgings or construction and demolition waste for land reclamation (paragraph 9) and the storage and use of construction and demolition waste, excavation waste, ash, clinker, rock, wood or gypsum in connection with recreational or infrastructure projects (paragraph 19). The survey showed that these sites took almost as much material as went for recycling (Table 1). These figures represent a major loss of material that could have been recycled and put to beneficial use in construction.

**Conclusion:** There is scope for much greater use of alternative materials in transport infrastructure, especially for higher value end uses.

### Table 2 Recycled aggregates in Scotland in 1999 (from Winter and Henderson, 2001)

<table>
<thead>
<tr>
<th>Category</th>
<th>Arising (mt)</th>
<th>Landfilled (mt)</th>
<th>Total recycled (mt)</th>
<th>Percentage of total recycled</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low utility</td>
</tr>
<tr>
<td>Construction and demolition waste</td>
<td>8.73</td>
<td>4.50</td>
<td>4.22</td>
<td>94</td>
</tr>
<tr>
<td>Bituminous planings and breakouts</td>
<td>0.61</td>
<td>0.14</td>
<td>0.48</td>
<td>75</td>
</tr>
<tr>
<td>Industrial wastes and by-products</td>
<td>0.91</td>
<td>0.55</td>
<td>0.79</td>
<td>59</td>
</tr>
<tr>
<td>All categories</td>
<td>10.25</td>
<td>5.20</td>
<td>5.49</td>
<td>87</td>
</tr>
</tbody>
</table>
4 ISSUES AND SOLUTIONS

There are a number of perceived issues that inhibit the use of recycling methods and alternative materials. The issues fall into categories, within which several related problems can be identified. For some problems, solutions can be identified from existing practice. For others, however, actions are necessary to help overcome the difficulties. The issues, solutions and actions are discussed in the following sections, and a summary is given in Table 3. The particular issues, solutions and actions relating to each group of stakeholders are then discussed in Part 2 of the document.

4.1 Specifications

A reason often given for the limited amount of recycling is that existing specifications do not encourage the use of new recycling methods or emerging alternative materials. The authorities responsible for specifications have to be sure that the new materials and methods will give satisfactory performance, and the conditions under which they can be used and how their performance is assessed have to be established. This normally requires trials under controlled conditions to build up a body of experience on the use of the materials and methods, which takes time to accumulate. Some authorities have procedures under which departures from the specification can be obtained, provided sufficient information is given to prove that the new material or method will be fit for purpose, including validation procedures during construction.

4.1.1 Specification for Highway Works and HD35/95

The use of materials in the UK motorway and trunk road network is controlled by the Specification for Highway Works (SHW) (Highways Agency et al., MCHW 1) and the Design Manual for Roads and Bridges (DMRB) (Highways Agency et al., DMRB). This permits the use of certain alternative materials, provided that their mechanical and chemical properties comply with stated limits. Further guidance is given in HD35, Conservation and the use of reclaimed materials in road construction and maintenance (Highways Agency et al., DMRB 7.1.2).

In the Specification, certain materials are listed as being permitted for various applications. Other materials, which conform to the appropriate standards, are also permitted, although not mentioned by name. Certain materials are specifically prohibited for particular applications. This classification of some alternative materials is described in HD35 and shown in Table 4. The table includes amendments in the May 2001 edition of the SHW.

The May 2001 edition of the SHW contains clauses permitting the use of recycled aggregate in applications such as general fill, pipe bedding, capping and unbound sub-base. Recycled aggregate is defined as aggregate resulting from the processing of material used in a construction process. A maximum content of 1% for all foreign materials (including wood, plastic, metal, clay lumps and glass) is given. The use of waste from the china clay and slate industries with bituminous and cementitious binders in roadbases is also permitted. Steel slags with ground blast furnace slag and a lime activator (Graves–Laitier) is permitted in sub-bases and roadbases. The CEN specification for hydraulically bound mixtures called up in the SHW permits other slags to be used with various other binders and activators, such as phosphoric slag.

The use of reclaimed bituminous material is permitted in the production of bituminous roadbase, basecourse and wearing course in the Specification for Highway Works (MCHW1). The maximum amount of reclaimed bituminous material is 10% for hot rolled asphalt wearing course complying with BS 594 and has been increased from 30% to 50%, in the latest SHW, for basecourse and roadbase complying with BS 4987 or BS 594. Recycled asphalt is permitted for use as capping material in the SHW and a separate earthworks class, Class 6F3 was created for this material in the 1998 edition. The May 2001 edition permits the use of recycled asphalt as sub-base.

The Specification for Highway Works and associated guidance such as HD35 have been developed for use on the motorway and trunk road network. Local Authorities are responsible for most other roads, comprising about 95% of the total road network. In most cases Local Authorities use the Specification for Highway Works as the basis for specifications for their own road works. However, some Local Authorities have variants that permit the use of certain alternative materials. A survey of specifications used by Local Authorities was carried out by the Aggregates Advisory Service (1997). This gives details of those who have developed additional or amended clauses with respect to the use of alternative materials.

The range of alternative materials that is available is wider than those that are permitted by the SHW. Materials such as incinerator bottom ash (IBA) and shredded tyres are not included. Steel slag is permitted in high value applications such as unbound sub-base, but only if it has been weathered. Similarly, burnt colliery spoil is permitted in a number of applications, but the use of unburnt colliery spoil is restricted. There is a parallel with the processing of natural rock or gravel materials to obtain aggregates that are suitable for high value end uses.

For works on trunk roads and motorways in England, the use of alternative materials can be allowed by obtaining a departure from the Specification for Highway Works on a scheme-by-scheme basis from the Highways Agency (HA). HA aim to respond to 60% of requests within 28 days. However, the applicant must submit sufficient information to enable the client to assess the risks and benefits of the proposed variation. Proposals should be
<table>
<thead>
<tr>
<th>Issue</th>
<th>Description</th>
<th>Available guidance</th>
<th>Recommended action required (Chapter 11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specifications.</td>
<td>Some materials and methods are excluded from existing specifications.</td>
<td>A number of Specifications for alternative materials and methods are available (see 4.1).</td>
<td>Update existing Specifications to accommodate new developments more quickly, or write new Specifications for particular applications.</td>
</tr>
<tr>
<td>Test methods.</td>
<td>Existing test methods developed for natural materials are not suitable for some alternative materials.</td>
<td>A number of tests have been assessed as suitable for alternative materials (see 4.2).</td>
<td>Move to performance-based test methods and specifications.</td>
</tr>
<tr>
<td>Reliability and quality control.</td>
<td>Alternative materials perceived as highly variable and of low quality.</td>
<td>Utilise or adapt existing quality control systems to produce a consistent, fit-for-purpose material (see 4.3).</td>
<td>Demonstrate quality of materials produced under a quality plan, upgrade processing plant to produce higher quality material.</td>
</tr>
<tr>
<td>Environmental concerns.</td>
<td>Potential long term leaching of contaminants into controlled waters; dust and noise during construction.</td>
<td>Assess behaviour using leaching tests and existing models where necessary (see 4.4); CDM/COSHH legislation.</td>
<td>Agreement between environmental regulators and material producers on use of materials in construction.</td>
</tr>
<tr>
<td>Waste regulation including waste management licensing and PPC Regime.</td>
<td>Unclear whether materials are waste or covered by exemptions, potential long time scale required by waste permitting processes.</td>
<td>Use available guidance on waste permitting system (see 4.5).</td>
<td>Approach environmental regulators for advice at early stage in design of project. DEFRA are reviewing exemption system to ensure alternative materials can be used in construction.</td>
</tr>
<tr>
<td>Conditions of contract.</td>
<td>Some forms of contract may create an environment where there is no incentive for innovation.</td>
<td>Use appropriate forms of contract and adopt partnering (see 4.6).</td>
<td>Review standard conditions of contract to rectify any clauses discriminating against innovative materials or methods.</td>
</tr>
<tr>
<td>Planning.</td>
<td>Difficulties getting planning permission for recycling centres in or near urban areas.</td>
<td>Guidance for planners and applicants has been produced by DETR (see 4.7).</td>
<td>Ensure an adequate supply of recycling centres is available to meet local needs.</td>
</tr>
<tr>
<td>Supply and demand.</td>
<td>Difficulty in matching supply and demand for some alternative materials.</td>
<td>Plan in advance and stockpile material if necessary; use existing databases to source materials (see 4.8).</td>
<td>Develop long term partnering agreements to enable better prediction of material requirements.</td>
</tr>
<tr>
<td>Economics.</td>
<td>Alternative materials and methods may be more expensive than conventional ones</td>
<td>Ensure comparing like with like; use whole life costing to ensure best practical environmental option selected (see 4.9).</td>
<td>Adjust aggregates levy and landfill tax as necessary to ensure alternative materials remain competitive.</td>
</tr>
<tr>
<td>Lack of awareness</td>
<td>Many individuals and organisations unaware of the possibilities, or only aware of potential problems.</td>
<td>Disseminate existing information from CIRIA, EA, TRL, BRE, AAS and others (see 4.10).</td>
<td>Develop strategies to reach resistant sectors of industry and infrastructure owners.</td>
</tr>
<tr>
<td>Application &amp; Series in SHW</td>
<td>Specific Provision in SHW</td>
<td>Permitted if complies with SHW requirements</td>
<td>Not permitted</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------</td>
<td>---------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Embankment and fill (Series 600).</td>
<td>Recycled concrete, blastfurnace slag, burnt colliery spoil, PFA, recycled aggregate, asphalt planings.</td>
<td>Unburnt colliery spoil, spent oil shale, FBA, china clay waste, slate waste.</td>
<td>Steel slag.</td>
</tr>
<tr>
<td>Capping (Series 600).</td>
<td>PFA, asphalt planings, recycled aggregate</td>
<td>Recycled concrete, blastfurnace slag, burnt colliery spoil, spent oil shale, FBA, china clay waste, slate waste.</td>
<td>Steel slag, unburnt colliery spoil.</td>
</tr>
<tr>
<td>Unbound sub-base (Series 800).</td>
<td>Recycled concrete, blastfurnace slag, steel slag, burnt colliery spoil, spent oil shale, recycled aggregate, asphalt planings.</td>
<td>China clay waste, slate waste.</td>
<td>Unburnt colliery spoil, PFA, FBA.</td>
</tr>
<tr>
<td>Cement bound sub-base (Series 1000).</td>
<td>Recycled concrete, blastfurnace slag, recycled aggregate.</td>
<td>Asphalt planings, steel slag, burnt colliery spoil, unburnt colliery spoil, spent oil shale, PFA, FBA, china clay waste, slate waste.</td>
<td>None.</td>
</tr>
<tr>
<td>Cement bound roadbase (Series 1000).</td>
<td>Recycled concrete, blastfurnace slag, PFA, recycled aggregate.</td>
<td>China clay waste, slate waste.</td>
<td>Asphalt planings, steel slag, burnt colliery spoil, unburnt colliery spoil, spent oil shale, FBA.</td>
</tr>
<tr>
<td>PQ concrete (Series 1000).</td>
<td>Recycled concrete, blastfurnace slag, PFA, micro silica.</td>
<td>China clay waste, slate waste.</td>
<td>Asphalt planings, steel slag, burnt colliery spoil, unburnt colliery spoil, spent oil shale, FBA.</td>
</tr>
</tbody>
</table>

*PFA = Pulverised fuel ash  
FBA = Furnace bottom ash  
Recycled aggregate is aggregate resulting from the processing of material used in a construction process  
Includes amendments in May 2001 edition of the SHW*
discussed with the client to establish what information will be required before being formally submitted. The HA will normally want information on the implications for programme, durability and performance, any proposed changes to the pavement design (if appropriate) and any traffic management restrictions.

To assist in reducing the time taken to approve departures from the Specification for Highway Works the Highways Agency has for its own use compiled an electronic library of specification items (SPECLIB). This is being revised at present and will contain an index of clauses and three discrete categories of information:

a new clauses that have been prepared and are ready to go into the Specification for Highway Works (SHW) or the Design Manual for Roads and Bridges (DMRB) at the next update;

b clauses that are still under development but are intended for inclusion in the SHW or DMRB when completed;

c information on test sites and trials.

The information in these clauses may save time for the applicant of a departure by reducing the amount of testing and trials required if these have already been undertaken elsewhere. It should be noted that clauses in SPECLIB do not go into the SHW or DMRB automatically. The Overseeing Organisations have to agree to their adoption. For works on trunk roads and motorways in England, access to this information will generally be via the HA Project Manager (see Section 7.3.1).

4.1.2 Other specifications

TRL have produced a design guide and specification for structural maintenance of highway pavements by cold in-situ recycling (TRL Report TRL386, 1999). This is included in the May 2001 revision to the Specification for Highway Works, and is available for use on new schemes and major maintenance works.

The Building Research Establishment has produced a Specification for recycled aggregates as Digest 433 (Building Research Establishment, 1998). This covers the use of crushed concrete and masonry for use in concrete as coarse aggregate, in road construction as an unbound and cement bound material, and as hardcore, fill or general drainage material. The digest recommends maximum levels of impurity for the various applications, and test methods for composition and other properties.

Recent developments have taken place in the use of granular materials treated by hydraulic binders such as fly ash (GFA). This consists of a granular material treated with about 12% of pfa and 3% lime as an activator. The material is placed and compacted as a soil, but pozzolanic reactions occur over time between the pfa and the lime, leading to the formation of cementitious compounds, which produce a gain in strength. The material thus combines laying flexibility and immediate stability under traffic with long term gain in stiffness and strength. The method can be used with a range of recycled or alternative materials; on the Burntwood Bypass, IBA was used as the granular material treated with pfa and lime (see Case Study 3). The UK Quality Ash Association has produced a specification for the use of GFA.

The structural properties of industrial by-products used in road construction were investigated by TRL and the University of Nottingham, focusing on the use of material mixes incorporating by-products and the recycling of aggregates and binders such as GFA. The project report included draft design procedures and specifications for use. The results have been published as TRL Report TRL408 (Atkinson et al., 1999).

The reinstatement of openings in highways is covered by the Highways Authorities & Utilities Committee (HAUC) Specification (HAUC, 1992). This specification is currently being revised and will include additional provisions for the use of alternative options, including the use of recycled, secondary or virgin materials, to take advantage of new or locally available materials, subject to the prior agreement of the Authority. Alternative materials must meet the performance requirements and any compositional requirements detailed in the Specification for the relevant material layer.

For railways, specifications for the trackbed layers (ballast, sub-ballast and sand filter) are set out in Railtrack RT/CE/S/006. The Specification for Highway Works (MCHW1) is generally used for earthworks below the trackbed layers. BAA uses the Specification for Highway Works for unbound materials and pavements. CIRIA Report 157 (Construction Industry Research and Information Association, 1996) provides guidance on the disposal of dredged material to land.

While specifications will inevitably lag behind new developments, there is more guidance available than is perhaps generally realised. Where no suitable specification is available, another option is to write one to suit the needs of the situation. These do not need to be long and complicated, and may be based on the performance that is required.

An important point to consider is to avoid over-specification; that is, putting in more requirements than are necessary to demonstrate fitness for purpose. For new materials or methods, a field trial with appropriate testing will generally give the best indication of its suitability.
Testing regimes should be designed to confirm that the material or method has achieved the performance required, and should not be a list of all the test methods from available specifications, with limiting values that may not be appropriate to the material or application. The quality and consistency of materials can be demonstrated by means of a suitable quality control system (Chapter 4.3).

### 4.2 Test methods

Many alternative materials are similar to natural materials, and the standard tests given in BS812 and BS1377 can be used. However, some alternative and recycled materials have different properties, and standard test methods are not appropriate. Guidance on appropriate tests for construction and demolition waste are given in BRE Digest 433, and for deep in-situ recycled pavements in TRL 386. A test for the composition of recycled aggregates is given in the May 2001 edition of the SHW in Clause 710. The question of which tests are appropriate for alternative materials is discussed by Reid et al. (2001), and the following test methods are recommended for unbound granular materials (Table 5).

### Table 5 Recommended test methods for alternative materials (from Reid et al., 2001)

<table>
<thead>
<tr>
<th>Test method</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods for sampling</td>
<td>EN 932.1</td>
</tr>
<tr>
<td>Methods for reducing laboratory samples</td>
<td>prEN 932.2</td>
</tr>
<tr>
<td>Determination of particle size distribution</td>
<td>EN 933.1</td>
</tr>
<tr>
<td>Determination of the resistance to wear (Micro–Deval)</td>
<td>EN 1097.1</td>
</tr>
<tr>
<td>Methods for the determination of resistance to fragmentation</td>
<td>EN 1097.2</td>
</tr>
<tr>
<td>Determination of water content by drying in a ventilated oven</td>
<td>prEN 1097.5</td>
</tr>
<tr>
<td>Determination of particle density and water absorption</td>
<td>prEN 1097.6</td>
</tr>
<tr>
<td>Method for determination of loss on ignition</td>
<td>EN 1744.1</td>
</tr>
<tr>
<td>One of the standards prEN 13286.2-13286.5 test methods for laboratory reference density and water content1:</td>
<td></td>
</tr>
<tr>
<td>Proctor</td>
<td>prEN 13286.2</td>
</tr>
<tr>
<td>Vibrocompression with controlled parameters</td>
<td>prEN 13286.3</td>
</tr>
<tr>
<td>Vibrating hammer</td>
<td>prEN 13286.4</td>
</tr>
<tr>
<td>Vibrating table</td>
<td>prEN 13286.5</td>
</tr>
</tbody>
</table>

1 For weak alternative materials, tests using vibration (e.g. vibrating table) instead of Proctor (impact) are recommended.

Additional information is needed on:

- an improved method to describe the material composition as to weight proportion of e.g. crushed brick, concrete, asphalt, rock, clay, glass, metals, rubber and plastic (A suitable test for construction and demolition waste is given in BRE 433 (Building Research Establishment, 1998), and a test for recycled aggregates is given in Clause 710 of the May 2001 edition of the SHW);
- an improved method of determination of density grading, e.g. determination of lightweight materials;
- an improved understanding of the test results for the sand equivalent and methylene blue test in respect to alternative materials;
- an improved understanding of freeze/thaw resistance of the mixture and particles;
- test methods for long-term stability (ageing behaviour);
- instructions for storing, handling and compaction to be defined depending on the type of the alternative materials, and test methods to take into account the type of compaction;
- gyratory compaction as a ‘link between laboratory test results and reality’;
- performance related test methods (e.g. triaxial test);
- a test method for the prediction of self-binding capability of alternative materials.

CEN is developing standard test methods for aggregates through TC154, as prEN 13242, Aggregates for unbound and hydraulically bound materials. This is programmed to be issued in 2003, and is expected to state that the tests for natural materials may also be used for alternative materials. Further work on test methods for alternative materials is being carried out through CEN TC154, but

### Conclusion:

A number of Specifications are available for use with new recycling methods and alternative materials. For trunk roads and motorways it is possible to obtain departures in some cases. The lack of suitable Specifications is more apparent than real and should not present a barrier to the use of new technologies or materials. However, there is a need to disseminate information on the availability of Specifications for recycling and alternative materials.
this is not expected to report until 2005. The recommendations will be issued as an amendment to the CEN standards for natural aggregates, or incorporated in a future edition.

In the longer term, a move towards performance based specifications is anticipated. This will remove the focus from the origin of a material, and should help to overcome the unconscious perception of alternative materials as dirty or inferior. The Highways Agency has been carrying out research into the development of a performance based specification for subgrade and capping, based on the use of cyclic load triaxial tests and dynamic plate tests (Lung, 1999). However, a lot of work is required to develop performance-based laboratory tests to the level where they can be routinely used to predict field performance.

Another area where test methods are important is hydraulically bound material. Relevant documents include:

- BS 1924: Parts 1 and 2. Stabilized materials for civil engineering purposes.
- HA74/00 Treatment of fill and capping materials using either lime or cement or both (DMRB 4.1.6).
- Specification for Highway Works, Series 1000: Road Pavements—Concrete and Cement Bound Materials (MCHW 1).

CEN will be introducing work items through TC227 in 2003 for new standards on slag bound mixtures, fly ash bound mixtures (such as GFA), soil cement and cement granular mixtures and associated test methods.

Chemical tests may be required on aggregates, to check for their potential to attack construction materials or to cause harm to human health or the environment. Test methods for use in highway applications are given in the Specification for Highway Works (MCHW 1). Many of the methods relating to attack on construction materials are given in BS1377: Part 3.

There are no officially recognised standard analytical methods for use to assess the extent of contamination in aggregates. For the majority of contaminants a number of possible analytical methods is available. The BS7755 Soil Quality series contains a number of analytical methods specifically developed for contaminated soils. For analysis of water samples, e.g. from leaching tests, some of the methods in the BS6068 Water Quality series may be appropriate. Where chemical analysis for the identification of contaminants is to be undertaken, expert advice on the appropriate test methods should be obtained from an experienced analyst. The testing should be carried out by a suitably qualified laboratory, with UKAS or similar accreditation for the test methods (where appropriate) and with a suitable analytical quality assurance programme in place.

Conclusion: Suitable test methods are available for most applications. There is a need to develop performance based specifications to optimise opportunities to use alternative materials.

4.3 Reliability and quality control

One of the perceived obstacles with the use of alternative materials has been their variability and the presence of deleterious components. Construction and demolition waste, for example, can be extremely variable in composition and can contain significant amounts of undesirable material such as paper, wood, plastic, cloth, topsoil, plant and organic matter, metal, asphalt, tar and clay in addition to inert soil, concrete and brick. This can best be addressed by sorting the material at source into appropriate waste streams to maximise the potential for recycling. However, at present many recycled aggregates such as construction and demolition waste contain significant amounts of impurities that limit their applicability and give a poor visual impression of the material.

These issues have been addressed by introducing quality control systems to demonstrate that the materials have been processed to remove impurities and that the properties lie in a defined band which is suitable for the proposed application. A document giving a protocol for quality control of recycled aggregates—defined as substantially aggregate resulting from the processing of inorganic material previously used in construction—has been produced as BR 392, Quality control: the production of recycled aggregates (Construction Research Communications, 2000). This sets out the requirements for a Quality Plan to be prepared by the material producer, including:

- definition of products being provided;
- reference to the specification requirements for the products being produced;
- acceptance criteria for incoming materials;
- method statement of production;
- inspection and testing regime including frequency and methods of test for finished product;
- records;
- conformity declaration; and
- information to be provided by the producer.
Minimum frequencies of inspection and testing are recommended. Material produced under such a quality control system can be relied on to be fit for purpose, and will generally be much less variable than as-dug natural soils from borrow pits. The aim is a Quality Assurance Scheme registered under BSEN9002. BR 392 is called up by the May 2001 edition of the Specification for Highway Works, and is suitable for use in all transport infrastructure renewal works where recycled aggregates are to be used.

BR 392 has been developed specifically for recycled aggregates that have previously been used in construction (i.e. construction and demolition waste), but the principles can equally be applied to other alternative materials such as steel and blastfurnace slag and incinerator bottom ash (IBA).

Perceptions of material performance are often based on the untreated raw material, whereas what is supplied under the quality control system is a controlled, treated product. An example of the consistency, which can be achieved with recycled aggregates, is shown in Figure 3. The gradings of 17 samples from a recycling plant processing construction and demolition waste in an urban area, taken over a period of 4 months, all lie within the Type 1 sub-base limits.

Problems with materials are not limited to alternative materials (see Box 4.1). The problem is not the origin of the material, but a failure to understand its properties and how it will behave in an engineering situation. When these processes are understood, many of the problems can be overcome.

**Conclusions:**

- **Quality Control Systems are available which will ensure that alternative materials are fit for purpose.**

- **It is important to understand the chemistry and mineralogy of any material, natural or alternative, before using it in construction. Apply the precautionary principle.**

- **Problems of quality control are often due to perception of the untreated material rather than the properties of material produced under a quality control system.**

**Box 4.1 Potential problems with materials**

Problems have been reported with both natural and alternative materials in construction, often due to chemical reactions occurring after the materials were placed. Some examples are listed below:

- some unweathered steel slags are liable to absorb water and swell after placement, leading to disruption of the pavement where it is used as unbound sub-base or capping (Smith, 1987);

- unprocessed construction and demolition waste may contain significant quantities of paper, wood and cloth, which look unsightly and may lead to settlement;

- unburnt colliery spoil can generate acidic, ferruginous leachate and is prone to combustion, especially in old railway and canal embankments where it is loosely placed (West and O’Reilly, 1986; Perry et al., 2001);

- problems of heave are experienced with some overconsolidated clays, such as the Gault Clay, which have a high proportion of expansive clay minerals;

- oxidation of pyrite in materials such as clays and mudstones can lead to attack on construction materials such as concrete (Thaumasite Expert Group, 1999) and high sulfates, causing expansion in lime-stabilised capping material (Snedker and Temporal, 1990).

**Solutions**

- allow material such as slag and incinerator bottom ash to age before use;

- check chemistry and mineralogy of materials such as clays, mudstones, colliery spoil and spent oil shale before use to ensure harmful compounds such as pyrite are within acceptable limits for the proposed application;

- process construction and demolition waste to reduce deleterious components to below the limiting values in SHW Clause 710.

**Know your material and use it accordingly**
Consistent grading of recycled aggregates: 17 samples over 4 months all lie within Type 1 sub-base limits.

(Data courtesy of Tarmac Recycling Ltd)

Figure 3 Consistent grading of recycled aggregates: 17 samples over 4 months all lie within Type 1 sub-base limits.
(Data courtesy of Tarmac Recycling Ltd)
4.4 Environmental concerns

Many alternative materials contain varying concentrations of chemicals, such as metals or organics, which could potentially cause pollution of surface water or groundwater. There may also be concerns with dust and fumes during the placing of these materials. The construction aspects are generally adequately covered by the CDM Regulations (House of Commons, 1994a), which require a COSHH assessment (House of Commons, 1994b) of all materials involved in construction. However, the long-term leaching of contaminants is an area where there has been little research, and it is difficult to quantify the possible effects. Most contaminants are unlikely to be a concern if the materials are used in cement bound or bitumen bound form, as the exposure to percolating water is greatly reduced. If it is proposed to use the materials in unbound form, however, it may be necessary to carry out a risk assessment to demonstrate that they will not pose a threat to controlled waters.

4.4.1 Agreement between producers and environmental regulators

Discussions are in progress between the EA in England and the Energy from Waste Association (EWA) regarding the use of incinerator bottom ash (IBA) in construction. The discussions cover bound and unbound applications of IBA, conditions of handling and storage, testing protocols and take into account the vulnerability of any underlying aquifer. It is intended that the discussions lead to the production of a Guidance Document on the use of IBA in construction. This could be used as a basis for agreements on the use of other materials and processes.

4.4.2 Models for risk assessment

If a risk assessment is required, several methods are available. These include the following:

- CIRIA Report 167 method.
- Environment Agency R&D Publication 20 method.
- ALT-MAT method.

CIRIA Report 167 *Use of industrial by-products in road construction: water quality effects* (Baldwin et al., 1997) examines whether industrial by-products and reclaimed materials used in road pavement foundations and earthworks are likely to cause contamination of groundwater and surface water. The publication focuses on unbound granular materials, such as might be used in sub-base or capping layers.

The authors concluded that none of the by-products considered would give rise to serious concerns about ground and surface water pollution if used in normal applications. The data from the study were analysed by calculating the degree of dilution required to reduce the concentration of chemical species in leaching tests to below the corresponding environmental quality standard/water quality standard (EQS/WQS) reference value. All results are compared to those of a control material, natural limestone. Three categories are established, as shown in Table 6.

Table 6 Use-group categories based on leaching tests (From Baldwin et al., 1997)

<table>
<thead>
<tr>
<th>Group</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>(no restrictions based on potential to affect water quality; similar to limestone)</td>
</tr>
<tr>
<td>Group 2</td>
<td>(may need some restrictions based on potential to affect water quality)</td>
</tr>
<tr>
<td>Group 3</td>
<td>(will need restrictions based on potential to affect water quality)</td>
</tr>
</tbody>
</table>

The leaching test proposed for use by Baldwin et al. (1997) is the draft CEN 2 stage batch compliance test (prEN 12457-3). The NRA leaching test, which is a 1 stage batch test (Lewin et al., 1994), can also be used to determine into which group a material should be classified. More complex leaching tests are available, including availability tests, pH-static tests, tank tests and column tests (Reid et al., 2001). These are characterisation tests and are not appropriate for routine compliance testing.

An alternative compliance test is being developed by CEN TC154 (Bialucha, 2000). However, this test has not yet been fully developed and should not be used as a substitute for the NRA or prEN 12457 tests. Similarly, the USEPA Toxicity Characteristic Leaching Procedure (TCLP) tests should not be used for assessing the suitability of unbound granular materials in transport infrastructure. The TCLP test was developed to assess the long-term leaching properties of landfilled waste, and is not appropriate for engineered fill in transport infrastructure applications.

The Environment Agency has produced for England a methodology for setting targets for the remediation of contaminated land. This is set out in R&D Publication 20 (Marsland and Carey, 1999). The method could be applied to the use of alternative materials in roads, railways, airports or canals. It sets out a tiered approach to risk assessment, based on a source-pathway-receptor analysis. At each tier a remedial target is derived, but this is likely to be less onerous at the next tier as additional processes (such as dilution and attenuation) are taken into account. With successive tiers, the data requirements and the sophistication of the analysis increase, as does the cost of obtaining the necessary information. The methodology operates on a site-specific basis, and cannot
be used to derive generic limiting values. The procedure has been incorporated in the computer program ConSim.

A model for the assessment of the environmental risk of the use of alternative materials for road construction has been developed as part of the ALT-MAT project (Reid et al., 2001). It can also be used for embankments, pavements and for other forms of transport infrastructure. The model is site specific and is based on the allowable increase in concentration of contaminants in the groundwater. The model is conservative in that it does not account for the attenuation of contaminants during transport from the application through the unsaturated zone and the aquifer to the point of groundwater extraction. For best results it is necessary to carry out characterisation leaching tests on the material, such as column tests and pH-static tests. The data from these tests can then be used at a number of sites, with the site-specific data on geometry, infiltration, etc. varied to suit the site conditions.

4.4.3 Material behaviour during leaching

The same principles apply to natural materials as alternative materials in respect of leaching. It is the chemistry and mineralogy of the material that are important, not its origin. The presence of sulfides such as pyrite can cause problems when the materials are placed in a free-draining fill. Exposure to air and percolating water create ideal conditions for the oxidation of sulfides and the generation of acidic, ferruginous leachate. The iron is frequently deposited as an amorphous orange precipitate of hydrous oxides, known as ochre, in watercourses adjacent to the embankment. This has been recorded for colliery spoil (West and O'Reilly, 1986; Perry et al., 2001) and for pyritic mudstone in embankment dams (Davies and Reid, 1997; Macdonald and Reid, 1991).

Oxidation of sulfides has also been noted in studies for blastfurnace slag (Reid et al., 2001). A variety of reactions can occur in the field, including oxidation, hydration and carbonation of minerals. These reactions affect the pH, and hence the composition of the leachate, and are not well simulated in laboratory leaching tests. It is thus essential to understand the mineralogy of the material and its likely behaviour in the engineering structure in which it is placed in order to make sensible predictions about its leaching behaviour.

Some alternative materials, such as steel slag and incinerator bottom ash, have very high pH when they are fresh. With time, hydration and carbonation reactions occur and the pH drops to less alkaline values. This generally leads to a reduction in the mobility of most contaminants. This is one of the reasons for requiring these materials to be aged before they are used in earthworks. If a risk assessment is carried out on these materials, any leaching tests should be on material of the same age as the material to be used, so that the results are compatible.

The greatest influence on leaching is the pH that is developed in the material in-situ. If the pH is likely to change over time, as a result of oxidation, hydration, carbonation or other reactions, predictions of leachate quality should be made on the basis of pH-static tests at the appropriate pH (Reid et al., 2001).

Detailed characterisation tests (such as column and pH-static tests) only have to be carried out once on each material. Compliance tests such as the prEN12457 batch test can then be carried out from time to time to check that the leaching behaviour of the material has not changed significantly. The characterisation test results can then be used to assess the suitability of the material for a number of sites, taking into account the site-specific conditions for each site. If the composition of the material changes significantly, further characterisation tests may be required. The following leaching tests are recommended for use with alternative materials (Reid et al., 2001):

- Draft prENV12920 Characterisation of waste: Methodology guideline for the determination of the leaching behaviour of waste under specified conditions.
- Column leaching test NT ENVIR 002.
- Batch compliance test prEN 12457-3.
- The pH-dependency of the leaching behaviour should be investigated, e.g. using a pH-static leaching test.

4.4.4 Site observations

Problems with water quality due to leaching from construction materials have been experienced with natural materials containing sulfides, such as colliery spoil and some clays and mudstones. This can also lead to sulfate attack on construction materials (Thaumasite Expert Group, 1999; Winter et al., 2000). However, few observations have been made of the leachate from transport infrastructure.

Inspection and monitoring of existing road materials was carried out in Sweden, Denmark, the United Kingdom and France as part of the ALT-MAT project (Reid et al., 2001). The materials examined included crushed concrete, demolition rubble, incinerator bottom ash, air-cooled blastfurnace slag and natural reference materials. The materials were used as unbound granular sub-base and capping. The subgrade materials included clay, sand and glacial till. Leaching tests and monitoring of groundwater, where available, indicated that there were no significant effects on groundwater quality. However, chemical analysis
of the materials revealed that in some cases, the subgrade below the alternative materials had higher concentrations of certain constituents than the subgrade below natural reference materials. This was noted in Denmark and France below incinerator bottom ash and in the UK below demolition rubble. The increases were limited to a few constituents in each case, principally metals and sulfate, and were recorded in both clay and sand subgrade.

The significance of leaching depends not only on the mobility of individual constituents, which can be assessed by means of leaching tests, but also on the total amount of water which passes through the material. This depends on the infiltration rate of water, which is a function of rainfall, evaporation and the permeability of any cover materials. There will be much greater infiltration into an uncovered railway embankment, for example, than into the sub-base or capping layer of a road with a high quality pavement of low permeability asphalt. In an aged and poorly maintained road, with significant cracking of the pavement layers, a greater amount of infiltration may be anticipated (Baldwin et al., 1997).

4.4.5 Mitigation measures

If leaching tests suggest that there may be problems with water quality if materials are used in unbound applications, a range of mitigation measures may be employed. These may be either source-based or pathway-based, it being generally impracticable to move the receptors.

Source-based methods include:

- ageing of materials such as steel slag and MSWI ash (IBA);
- removing metals by use of magnets;
- washing to remove lightweight materials such as paper or plastic;
- sieving to separate out contaminated fines.

Pathway-based methods include:

- placing a break layer of inert material around the alternative material;
- placing a low permeability geotextile or clay layer above the alternative material;
- ensuring the road has a low permeability pavement such as dense asphalt;
- stabilising the material with cement, lime, pfa, or bitumen.

**Conclusions:**

- In most cases, alternative materials are unlikely to cause pollution of groundwater or surface water if they are produced and used in accordance with appropriate specifications, standards and quality control procedures.

- It is beneficial for material producers and environmental regulators to draw up agreements governing the use of alternative materials.

- Various models and a range of leaching tests are available if it is necessary to carry out an assessment of the risk to surface water or groundwater.

- If there are concerns about adverse environmental effects from the use of alternative materials, mitigation methods can be used to treat the material at source or break the potential pathway for leachate.
Figure 4 Chemical analysis of sub-base materials, Bracknell site
(Data from the ALT-MAT project, Reid et al., 2001)

Figure 5 Chemical analysis of subgrade, Bracknell site
(Data from the ALT-MAT project, Reid et al., 2001)
4.5 Waste management licensing regime

4.5.1 Definition of waste

The definition of waste is a major issue that affects the extent of the use of alternative materials. The legal definition derives from Council Directive 75/442/EEC of 15 July 1975 on Waste (Waste Framework Directive), under which any material, which is discarded, or is required to be discarded, is classed as a waste; this is the so-called 'Directive Waste'. It is important to note that ‘discard’ has a special meaning in the Waste Framework Directive as the original WFD text was French, there were translational issues and the matter is still subject to continuing legal debate. Thus the definition takes in both the intention of the producer and the requirement to subject the ‘material’ to a recovery or disposal operation in determining whether the material is a waste or is not a waste. Thus a material may be a waste in one situation but not in another.

The relevant UK legislation is contained in:

- The Environmental Protection Act 1990 (as amended).
- The Environmental Protection (Duty of Care) Regulations 1991.
- The Controlled Waste Regulations 1992 (as amended).
- The Special Waste Regulations 1996 (as amended).

These statutes establish a framework of permits and exemptions to ensure that waste does not have an adverse impact on the environment. The Pollution Prevention and Control regime is unlikely to affect recovery operations unless it involves recovery of material classed as ‘Hazardous Waste.’

Various activities involving waste are excluded from the requirements of Waste Management Regulations if they are already controlled by other legislation. These activities are defined in Regulation 16 (as amended) and are not likely to be relevant to transport infrastructure renewal works. Various activities are also exempt, and these are listed in Schedule 3 of the Regulations. These activities are generally waste recovery operations, and conditions are specified as to the types and quantities of waste that may be treated at any time. This includes the use of a number of materials in transport infrastructure renewal works, including pfa, slag, asphalt planings and crushed concrete. The WMLR Regulations require that exempt activities have to be registered with the ‘competent authority’ which in England and Wales is generally the Environment Agency.

Even if recycling takes place at the site of generation, this is not a factor that influences whether or not the activity comes under the Regulations. It is clear however, that any surplus material disposed off site would be classified as waste, would be subject to the Duty of Care Regulations and the person transporting the waste would be required to be registered with the relevant regulatory authority as a waste carrier. In England and Wales the relevant authority is the Environment Agency and in Scotland it is the Scottish Environment Protection Agency.

A further complication is that material, which has been subject to a specialist recovery operation, may no longer be classified as a waste but as a product. As a general rule, the material does not cease to be waste when it arrives at the treatment facility, but only when the recovered material can be used as a raw material, in the same way as raw materials of non-waste origin by a person other than a specialised waste recovery establishment or undertaking. In practice, a substance or object will usually be recovered at a site which is the subject of a waste management licence or which is registered as benefiting from an exemption from licensing. Thus, untreated uncontaminated construction and demolition material delivered to a recycling centre is a waste. However, after it has been processed to remove impurities and to comply with a Quality Control system such as BR 392 (Construction Research Communications, 2000) it would be no longer be a waste, as it could be used in construction in exactly the same way as a natural aggregate.

Conversely untreated incinerator bottom ash is clearly a waste, but processed material for use in construction is never likely to be regarded as a product and thus its use in construction would have to be registered under a paragraph 19 exemption, provided it was not classed as a hazardous waste.

A material proposed for use in transport infrastructure renewal works may or may not be subject to an exemption, with various restrictions attached; or it may have been subject to a specialised recovery operation and may no longer be a waste but a product. A general consensus has evolved regarding the classification of most of the materials commonly used in transport infrastructure renewal works. This is presented in Table 7. The table should be used as a general guide, and should not be
<table>
<thead>
<tr>
<th>Activity/material</th>
<th>Is material a waste?</th>
<th>Is it exempt?</th>
<th>Conditions</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-situ recycling of road pavements.</td>
<td>No</td>
<td>NA</td>
<td>NA</td>
<td>Material is being reused, hence not waste.</td>
</tr>
<tr>
<td>Use of processed IBA in bound or unbound form in road construction.</td>
<td>Yes</td>
<td>S3 Paragraph 19</td>
<td>Not stored for longer than 3 months before work starts.</td>
<td>Processed IBA used in bound form in some areas away from major aquifers.</td>
</tr>
<tr>
<td>Use of pfa in bound or unbound form in road construction.</td>
<td>Yes</td>
<td>S3 Paragraph 13</td>
<td>Quantity stored on site not to exceed 20,000 tonnes.</td>
<td>Widely used in unbound and bound form in roads for many years.</td>
</tr>
<tr>
<td>Use of slag in bound or unbound form in road construction.</td>
<td>Yes</td>
<td>S3 Paragraph 13</td>
<td>Quantity stored on site not to exceed 20,000 tonnes.</td>
<td>Widely used in unbound and bound form in roads for many years.</td>
</tr>
<tr>
<td>Use of road planings in bound or unbound form in road construction.</td>
<td>Yes</td>
<td>S3 Paragraph 13</td>
<td>Quantity stored on site not to exceed 20,000 tonnes.</td>
<td>Widely used in unbound and bound form in roads for many years.</td>
</tr>
<tr>
<td>Use of crushed concrete in bound or unbound form in road or airport construction.</td>
<td>Yes</td>
<td>S3 paragraph 13</td>
<td>Quantity stored on site not to exceed 20,000 tonnes.</td>
<td>Widely used in unbound and bound form in roads and airfields for many years.</td>
</tr>
<tr>
<td>Use of recycled construction and demolition material to BR 392 in construction.</td>
<td>No</td>
<td>NA</td>
<td>NA</td>
<td>Material classed as a product because it has been subject to a specialised recovery operation.</td>
</tr>
<tr>
<td>Ex-situ hot mix recycling of road planings.</td>
<td>No</td>
<td>NA</td>
<td>NA</td>
<td>Material is being reused, hence not waste.</td>
</tr>
<tr>
<td>Use of gravel dredged from rivers in construction.</td>
<td>No</td>
<td>NA</td>
<td>NA</td>
<td>Agreement reached with environmental regulators that material is a product, not a waste.</td>
</tr>
<tr>
<td>Placing of canal dredgings on agricultural land.</td>
<td>Yes</td>
<td>S3 Paragraph 7</td>
<td>No more than 5,000 tonnes per hectare spread in any 12 months.</td>
<td></td>
</tr>
<tr>
<td>Placing of canal dredgings on the bank or towpath.</td>
<td>Yes</td>
<td>S3 Paragraph 25</td>
<td>No more than 50 tonnes per metre of bank or towpath on any day.</td>
<td></td>
</tr>
<tr>
<td>Storage of demolition and construction waste at site where it is to be used.</td>
<td>Yes</td>
<td>S3 Paragraph 19</td>
<td>Not stored for longer than 3 months before work starts.</td>
<td></td>
</tr>
<tr>
<td>Storage of road planings for use elsewhere.</td>
<td>Yes</td>
<td>S3 Paragraph 19</td>
<td>No more than 50,000 tonnes and for no longer than 3 months.</td>
<td>The so-called ‘exempt tips’, often used as a cheap substitute for landfill or recycling.</td>
</tr>
<tr>
<td>Spreading of soil, rock, ash, etc. on land for the purposes of improvement.</td>
<td>Yes</td>
<td>S3 Paragraph 9</td>
<td>Planning permission for improvement: no more than 20,000 cubic metres per hectare.</td>
<td></td>
</tr>
<tr>
<td>Deposit of spent ballast on operational land of a railway.</td>
<td>Yes</td>
<td>S3 Paragraph 34</td>
<td>No more than 10 tonnes per metre of track from which the ballast derives.</td>
<td></td>
</tr>
<tr>
<td>Deposit of samples of waste at establishment for testing and analysis.</td>
<td>Yes</td>
<td>S3 Paragraph 38</td>
<td>For the purposes of research.</td>
<td></td>
</tr>
</tbody>
</table>

Note: The above examples are illustrative only. The particular circumstances of each site will determine whether a material is a waste and whether it qualifies for an exemption. The local EA licensing officer should be consulted if there is any doubt about the classification of a material at a particular site.

taken as a definitive statement. For some materials a range of options is possible, as the classification is very dependent on the particular circumstances of the material and the site. If there is any doubt, the local environmental regulatory authority should be consulted. In England and Wales this is the local Environment Agency Waste Officer.

Table 7 represents the position as it is at present. DEFRA are currently revising the system of exemptions, and the system may be subject to change in the future. A different set of exemptions applies in Northern Ireland.

In Scotland, the Scottish Environment Protection Agency (SEPA) carries out a similar function to the Environment Agency in England and Wales. The Waste Management Licensing Regulations 1994 also apply in Scotland. The relevant legislation is the Control of Pollution Act, Pollution Control and Local Government (N. Ireland) Order 1978. Under this legislation, Local Authorities in Northern Ireland are responsible for licensing waste disposal sites. The Waste Collection and Disposal (N. Ireland) Order 1999 is currently being implemented. It introduces controls on contaminated land and waste management similar to those operating in the rest of the UK. The legislation is enforced by the Waste Management and Contaminated Land Inspectorate of the Environment and Heritage Service, an agency of the Northern Ireland Department of the Environment.

4.5.2 The waste management licensing process

The Environment Agency issues waste management licences, registers most exemptions, and inspects licensed sites in England and Wales. The obligations imposed by a waste management licence are proportionate to the environmental risk and obtaining a license can be slow and incurs some expense. This is partly due to the requirements of the process, which includes a statutory 28-day period for consultation with the HSE and Planning Authority and agreeing financial provisions with the applicant. If the situation is straightforward, a ‘shell’ licence may be used, which will speed up the process. However, because of the statutory procedures, a period of several months will be required in most cases.

In Scotland, The Scottish Environment Protection Agency (SEPA) carries out similar functions. A different system operates in Northern Ireland (see above).

The process of deciding whether a licence is required is shown on Figure 6. The licence has to cover:

- the types and quantities of waste;
- the technical requirements;
- the security precautions to be taken;
- the disposal site;
- the treatment method; and
- long term monitoring.

Applications for a licence in England and Wales are covered by the Environment Agency’s Waste Management Licensing Process Handbook. This document was introduced in 1998 and is regularly updated. It provides a standard, which should ensure that licence applications are treated in the same way in all parts of the country. The Process Handbook is an internal EA document, but large sections of it, including guidance notes and templates, are available on the EA website (www.environment-agency.gov.uk). Information on the regime in Scotland may be obtained from the SEPA website (www.sepa.org.uk), and for Northern Ireland on www.northernireland.gov.uk.

Conclusions:

- A consistent framework for waste management licences and exemptions is available from the Environment Agency in England and Wales.
- A similar system applies in Scotland but there are differences in the system for Northern Ireland.
- Applicants should have reasonable expectations of the length of time required to obtain a licence, which is due to the nature of the statutory procedures.
- In a number of scenarios common in transport infrastructure works, materials may be classified as a waste but may be subject to an exemption under the existing regulations.
- The definition of waste is an area of controversy and confusion. Guidance should be provided by government.
- In all cases where there is any likelihood that a waste management licence or exemption may be required, the Environmental regulators should be consulted at as early a stage as possible and kept informed as the project develops.
4.6 Contractual issues

The forms of contract under which transport infrastructure renewal works are carried out can have a significant influence on the extent of recycling and the use of alternative materials. Traditional Conditions of Contract, such as the ICE 6th edition, can lead to adversarial conditions and a determination by the Engineer to adhere rigidly to the Specification and the original design. Contractor-led systems, such as Design and Build (D&B) and Design, Build, Finance and Operate (DBFO) encourage greater flexibility and innovation, as the Designer and Contractor are part of the same team.

Perhaps more important than the form of the contract is the spirit in which it is operated by all parties. If all parties try to pass risk to each other instead of allocating it to those best able to handle it, the person who is left with material excavated from a site may have little incentive to recycle it, and may only be concerned with disposing of it cheaply and quickly. It is better to adopt a partnering approach where all parties in the supply chain work together to deliver continuous improvement in the construction process. This has been demonstrated by the BAA pavement team (Case Study 1), and embodies the principles set out in the Egan Report.

Another factor, which can discourage innovation and recycling, is the imposition of onerous warranties in the Conditions of Contract. Warranties should reflect the degree of risk fairly, and should not be used as a cheap form of insurance by the client. Excessive liquidated damages also act as a disincentive to the use of new...
techniques or methods. An alternative to liquidated damages is to allow the tenderers to set their own time for the completion of the works. It is important for the client to understand how the proposed work needs to be carried out in order to set a reasonable timescale for completion.

An area where action is needed relates to the issue of collateral warranties and other forms of contract which include conditions barring the use of so-called ‘deleterious materials’ or requiring the use of ‘new’ and ‘best’ products. While these latter clauses are usually aimed at manufactured items they do have the unfortunate effect of precluding the use of secondary and recycled materials in what might otherwise be appropriate situations.

Forms of contract can do a lot to encourage recycling and the use of alternative materials. A number of Local Authorities include deep in-situ cold recycling and the use of planings and other arisings as options in tenders for highway renewal works (e.g. Fife, Leicestershire, Surrey, Staffordshire). The percentage of recycled material used in the work could be used as a factor in the assessment of tenders. The reuse of highway maintenance arisings will contribute to Local Authorities reaching their statutory targets for reduction in the amount of material sent to landfill. Local Authorities should draw up policies for encouraging recycling, and implement them by adapting their Specifications and Conditions of Contract accordingly.

There may be conflict with Public Sector Financial Rules, which require Local Authorities to provide ‘best value’ services. These may require revision to ensure that Local Authorities are not inhibited from adopting recycling policies. However, the whole life costs of recycling and/or using alternative materials as opposed to new construction using natural aggregates should clearly indicate the benefits of the recycling approach. Leicestershire County Council, for example, operate a green policy where rates are allowed to be 10% higher when recycling is used.

4.7 Planning issues

The planning system interacts with recycling because planning permission is normally required for sites for the production of recycled and secondary aggregates. In order to meet the targets for these materials in MPG6, there is a need to provide locations for both new and expanding operations. Regional Technical Advisory Boards are charged with identifying options for waste management at the regional level, including recycling facilities. However, due to local environmental effects and a traditionally poor image, recycled and secondary aggregates operations are often regarded as ‘unneighbourly’. Planning permission is often refused because the local environmental effects are considered to be greater than the environmental sustainability benefits of the development.

In Wales, Minerals Planning Guidance (Wales) Planning Policy states that:

- minerals should not be wasted;
- minerals should be used for the purposes stated in the planning permission and not lower grade purposes;
- the method of extraction and processing to minimise waste production should be taken into account in determining planning proposals;
- Local Authorities should encourage the practice of on site recycling;
- development plans should encourage the recycling of construction and demolition wastes as well as mineral and industrial wastes;
- local planning authorities or neighbouring authorities should make provision for storage and processing of inert materials arising from construction, demolition and maintenance operations by the identification of preferred locations for recycling facilities in unitary development plans.

The government have acted to provide guidance to planners through PPG10, Planning and Waste Management (DETR, 1999). In Wales the equivalent planning advice to PPG10 is contained in Planning Policy Wales. This is supplemented by (draft) Technical Advice Note 21 on waste. The government has also produced good practice guidance on controlling the environmental effects of recycled and secondary aggregates production (DETR, 2000c). The guidance outlines:

- Siting considerations.
- Management controls.
- Physical measures.

**Conclusion:**

- Conditions of Contract should be formulated so as to encourage greater use of recycling and alternative materials.
- Excessive liquidated damages will act as a disincentive to the use of new techniques and alternative materials.
- Avoid forms of contract which discriminate against the use of alternative materials.
These measures should be employed to reduce the local environmental impacts of producing recycled and secondary aggregates.

**Conclusion:** Applicants and planners should act in accordance with the guidance in PPG10 and the DETR Good Practice Guidance on Controlling the Environmental Effects of Recycled and Secondary Aggregates Production.

### 4.8 Supply and demand

There can be difficulties with alternative materials in matching supply with demand. Whether the materials come from reprocessing construction materials or as by-products of industrial processes, the rate of supply cannot be guaranteed in the same way as for a quarry in natural soil or rock (example Box 4.3: Burntwood Bypass). Recycling centres thus have to be large enough to hold considerable stockpiles of material. This should be a factor in deciding the size of such plants, and is covered by the good practice guidance (DETR, 2000c).

Where large projects such as a new motorway are proposed, it is important to set up recycling centres close to the site in advance of construction, or alternative materials will be uneconomic because of transport costs. As planning permission is required for such sites, it is important to submit applications well in advance of the works.

These problems can be minimised by using on-site recycling wherever possible, for instance deep in-situ recycling of road pavements. In new construction projects, it may be possible to recycle materials that would otherwise be considered unsuitable in order to avoid sending the material to landfill and importing natural material (example Box 4.4: A12 to M11 Link Road).

**Conclusions:**

- Ensure recycling sites have sufficient capacity to cope with fluctuating supply and demand.
- Plan ahead for major projects so that recycling centres are in place before construction starts.
- Consider on-site recycling wherever possible.

### 4.9 Economic factors

Economics is the ultimate arbiter on the use of recycling and alternative materials. The government has acted to adjust the economic balance in favour of recycling by means of the landfill tax and the aggregates levy. The aggregates levy will be introduced at a rate of £1.60 per tonne from April 2002. It will apply to sand, gravel and crushed rock. Materials which have been previously used in construction or which are secondary materials, such as blastfurnace and steel slag, are exempt from the tax. The objectives of the levy are:

- To make the price of aggregate better reflect the true social and environmental costs of quarrying.
- To reduce demand for virgin aggregates and encourage the use of alternative and recycled materials.

When comparing recycling with conventional treatments, it is important to ensure that a fair comparison is being made. If deep in-situ recycling of a road pavement is compared with putting on an overlay, the recycling option will seem much more expensive. However, it will last much longer than the overlay, so in whole life cost terms...
it will be the cheaper option. This will not be apparent from the initial cost of the two options, so a like-for-like comparison should be made. Either:

- Compare deep in-situ recycling with conventional reconstruction; or
- Calculate the whole life costs for both options.

The true savings from recycling and use of alternative materials may not be appreciated if every project is costed on an individual basis. Where there is a rolling programme of maintenance, surplus material generated on one project can be utilised on the next. By looking at costs on a global basis, the savings can be significant (Box 4.5).

**Conclusions: to encourage recycling**

- Compare like with like.
- Use global rather than project-specific costing.

### 4.10 Lack of awareness

From the previous sections, it will be seen that, while there are some issues that still require resolution regarding recycling and the use of alternative materials, in most cases there are solutions available. Perhaps the biggest factor limiting the use of these materials and methods is simply lack of awareness of the possibilities. The construction industry is conservative by nature, and there is a tendency to stick with tried and tested ways of doing things. The image of recycled materials as being dirty and inferior also discourages their use, though as shown in Chapter 4.3 this relates more to the untreated raw material than to the processed, quality controlled product.

The case studies in this document demonstrate the benefits, both environmental and economic, that can be gained from the use of recycling and alternative materials. The guidance will enable managers and engineers to proceed with the use of these methods and materials with confidence, and hence contribute to the aims of sustainable construction.

**Conclusion: Ask, ‘Why are we not recycling and using alternative materials?’ not ‘Why should we recycle and use alternative materials?’**

### Box 4.5 BAA Pavement Team

The BAA Pavement Team is responsible for a rolling programme of runway renewals and new build and reconstruction of taxiways and aprons at Heathrow, Gatwick and Stansted airports. Initially, if break-out material could not be used on that project, it was sent to landfill and natural aggregate brought in to make new concrete. The Pavement Team has moved to a situation where all broken-out concrete is stored on site and reused in future projects as aggregate for lean concrete and as unbound sub-base. By moving to a global costing basis, the benefits to BAA have been significant:

- 210,000 tonnes of concrete recycled.
- 42,000 lorry movements saved (40 per day).
- Estimated cost saving of £1.8million.
PART 2: STAKEHOLDERS

Plate 4 Demolition of bridge on M20 widening scheme: the concrete was recycled as unbound sub-base and capping material

(Photograph courtesy of Balfour Beatty Major Projects)
5 GOVERNMENT

5.1 Introduction

The arms of government most involved in transport infrastructure are the Department for Transport, Local Government and the Regions (DTLR), the Department of Trade and Industry (DTI), and the Department of the Environment, Food and Rural Affairs (DEFRA). In Scotland, the relevant body is the Scottish Executive Development Department (SEDD), in Wales it is the National Assembly and in Northern Ireland it is the Northern Ireland Executive. The following functions of these bodies are relevant to recycling in transport infrastructure:

- Delivering a policy for efficient and sustainable transport.
- Delivering policies on rethinking construction and sustainable construction.
- Delivering the National Waste Strategy.
- Ensuring protection of the environment.
- Ensuring that the above objectives do not contradict each other ('joined-up government').
- Delivering programmes of research to support the above objectives.

5.2 Issues

The role of government is to set policies, monitor their implementation and take action to remove any obstacles. The policies set out above and discussed in Chapter 2 provide a clear framework for how government wishes transport infrastructure, and other areas of the construction industry to develop. The main issues for government are monitoring the effect of the policies and dealing with factors that are preventing them being implemented. The following issues were identified as significant:

- Lack of adequate baseline data to judge the extent of recycling.
- Widely held view in industry that the waste management licensing system is too cumbersome and inflexible and acts as a deterrent to recycling.
- Concern that a large amount of material which could be recycled is being lost to exempt sites and that the system is being abused.
- Potential for conflict between policies to protect the environment and to encourage greater use of recycled materials.
- Need to provide guidance for Local Authorities on planning issues relating to recycling centres.
- Need to revise MPG6 and equivalent documents in Scotland and Northern Ireland to reflect current situation and future developments.
- Provision of adequate resources for the Environment Agency, Scottish Environmental Protection Agency in Scotland and Local Authorities in Northern Ireland to undertake policing of exempt sites and increased role in liaison, education and training with the construction industry.
- Need to disseminate best practice to all sectors of the construction industry, especially SMEs.
- Need to decide how to use the aggregates levy sustainability fund and monitor its effect.

Available guidance is summarised below and further suggested actions to increase recycling are given in Chapter 11.2.

5.3 Available guidance

5.3.1 Baseline data

- Baseline data for construction and demolition waste in England and Wales has been provided by the Environment Agency survey for 1999 (Environment Agency, 2001). The survey gives detailed data for each planning region in England and Wales in a series of Strategic Waste Management Assessments (SWMAS). National data on recycled aggregates for Scotland are given by Winter and Henderson (2001), including information on the level of utility to which recycled aggregates are put. This confirms the generally held view that recycled aggregates are dominantly used for low utility applications. Data on the present and potential future availability of a number of alternative materials is given by Barritt (2000).

- A concern with all the surveys is the considerable margin of error associated with many of the estimates, especially in relation to exempt sites. It has been suggested that major contractors are well placed to know about the extent of use of alternative materials, and should be consulted in any future survey.

- A further survey is planned by government for 2002, to cover the year 2001. This is to provide baseline data to monitor the effect of the aggregates levy.

5.3.2 Waste management licensing regime

- A review of the exemption system by DEFRA is currently in progress. It is important that this makes it easier to use alternative materials for constructive
purposes, such as in transport infrastructure, and harder to dispose of them cheaply to exempt sites or landfill. Existing guidance is based on DOE Circular 11/94; Welsh Office Circular 26/94 and Scottish Office Environment Department Circular 10/94.

5.3.3 Guidance for planning authorities

- This is provided in the following documents:
  a. PPG10 Planning and Waste Management.
  b. PPG11 Regional Planning.
  c. Controlling the environmental effects of recycled and secondary aggregates production (DETR, 2000c).
  e. Planning Policy Wales, draft Technical Advice Note 21 and Minerals Planning Guidance (Wales) Planning Policy.

5.3.4 Dissemination of information

- A considerable amount of information on waste minimisation and recycling is already available in the public domain, through publications and training packs by organisations such as CIRIA, the environmental regulators, TRL, BRE and the former Aggregates Advisory Service (AAS). Much of this work was funded by government. A selection of the more relevant publications is given Box 5.1.

- Best practice is also disseminated through the Construction Best Practice Programme (CBPP) and the Movement for Innovation (M4I), which were set up to help deliver government policies on Rethinking Construction and Sustainable Construction. Information, including guidance and case studies, can be obtained from the relevant web sites, www.cbpp.org.uk and www.m4i.org.uk.

- The government is introducing a new initiative, the Waste and Resources Action Programme (WRAP), to promote recycling and reprocessing. WRAP is also supported financially by the devolved administrations. It will be an independent private sector not-for-profit company which will seek private sector funding as well as being funded by government to the tune of £40 million over 3 years. Its functions will include market facilitation, promoting investment in recycling/reprocessing, research and information management and giving advice, guidance and technical support. More details can be found on the WRAP website, www.wrap.org.uk. All these activities should help to achieve the objectives of sustainable development, and should help to tackle many of the issues identified in the field of transport infrastructure.

- The European Commission has produced a working document on the management of construction and demolition waste (European Commission, 2000). This document makes a series of proposals for interventions to boost prevention, re-use and/or recycling. These proposals include:

Box 5.1 Existing information on sustainable construction

- AAS Digest 101. Secondary and recycled aggregates uses in road construction under existing specifications.
- CIRIA Managing materials and components on site (SP146).
- CIRIA Reclaimed and recycled materials handbook (C513).
- CIRIA The Observational Method in ground engineering: principles and practice (R185).
- CIRIA Waste minimisation and recycling in construction (SP122).
- CIRIA Waste minimisation and recycling in construction training pack (C555).
- CIRIA Waste minimisation in construction reports (PR28, SP135 Boardroom, SP134 Designers, SP133 Site).
- CIRIA Waste reduction, reuse and recycling in construction (C536).
- Environment Agency Pollution Prevention Guidance (PPG) Notes, e.g:
  a. PPG26 Pollution Prevention Storage and Handling of Drums & Intermediate Bulk Containers.
  b. PPG5 Works in near or liable to affect watercourses.
  c. PPG6 Working at construction and demolition sites.
i adoption of performance-based specifications for the use of C&D waste derived aggregates;
ii suggested overall reuse and recycling rates of between 50% and 75% in 2005 and between 70 and 85% in 2010;
iii identification of zones and/or locations in land use plans where C&D waste recycling would be considered acceptable;
iv a C&D waste management plan to be submitted before a demolition permit is issued.

- A further useful report was produced for the European Commission by Symonds (1999) on construction and demolition waste management practices and their economic impacts.
6 REGULATORY AUTHORITIES

6.1 Introduction

The principal regulatory authorities concerned with transport infrastructure are environmental regulators and planning authorities.

The relevant environmental regulators are the Environment Agency (EA) in England and Wales and the Scottish Environment Protection Agency (SEPA) in Scotland. In Northern Ireland, the functions are currently carried out by Local Authorities on behalf of the Department of the Environment for Northern Ireland. These functions will in time be taken over by the Northern Ireland Executive. The role of the environmental regulators includes:

- Issuing waste management licences and exemptions.

- Enforcing legislation to protect the environment.

- Providing education and training to the construction industry and others to avoid pollution of the environment.

Planning authorities have the responsibility for making policies in development plans and for deciding planning applications for development. Where a two-tier system of local authorities exists then it is the county that is responsible for planning for management of wastes. Elsewhere the local authority is also the waste planning authority.

6.2 Issues

6.2.1 Environmental regulators

- Widespread perception that regulations are interpreted differently by staff in different areas.

- Pressure to adopt additional roles, such as policing exempt sites and greater liaison with industry, without additional resources.

- Need to balance support for sustainable construction with protection of the environment and enforcement of legislation.

- Need for environmental regulators to set an example where they act as a client in construction work.

- Develop agreements with producers of alternative materials setting out how and where they may be used, to avoid the same questions being asked on every occasion.

6.2.2 Planning authorities

- Setting out policies in development plans.

- Considering planning applications for development.

- Assessing the requirements for recycled and secondary aggregates production facilities and their impact on neighbouring properties.

- Enforcing planning conditions.

Available guidance is summarised below and further suggested actions to increase recycling are given in Chapter 11.3.

6.3 Available guidance

6.3.1 Environmental regulators

- The Environment Agency has produced a Statement on Sustainable Construction (contact 0845 933 3111 for further information). Among other things, the statement restates EA's commitment to partnering to promote good environmental practice, promoting the use of recycled and secondary materials and implementing a new construction procurement strategy that takes account of sustainability.

- EA has also produced ‘An environmental vision: the Environment Agency’s contribution to sustainable development’ (EA, 2000). This is a wide-ranging document, covering topics such as global warming, social and economic change, flood risk, protection of air, soils and water and wiser, sustainable use of natural resources. There is an emphasis on ‘joined-up’ policy to address these problems. It restates EA's commitment to greater reuse and recycling of materials, using economic and non-regulatory approaches to achieve the sustainable use of resources.

- EA have produced a Process Handbook for Waste Management Licensing. This is an internal document, but sections of it are available on the Agency’s website (www.environment-agency.gov.uk). The handbook has been in operation since 1998, and has been updated on several occasions. If this handbook is followed, difference in interpretation between staff in different regions should be minimised. If questions are raised, the Local Licensing Team Leader has the facility to register a query in the Regulatory Review Process within EA. This will bring a rapid response on how similar problems are handled in other areas, and allow EA to identify issues that are becoming a problem.

- EA have produced extensive technical guidance for the construction industry on the avoidance of pollution and environmentally-friendly ways of working. These
include the ‘Building a cleaner future’ video and training pack and a number of Pollution Prevention Guidance (PPG) notes, on subjects such as working on construction and demolition sites, working in or near rivers, silt pollution and the Oil Care Code. EA have also collaborated with CIRIA and government in the production of site guidance, such as CIRIA SP133, waste minimisation in construction.

- Discussions on the use of incinerator bottom ashes (IBA) in construction have taken place between EA and the Energy from Waste Association (EWA). The discussions aim to lead to a guidance document on applications for IBA in construction.

- A survey of construction and demolition waste arisings and utilisation in England and Wales in 1999 was funded and project managed by EA. The results were published as a series of Strategic Waste management Assessments (SWMAs) for each planning region in November 2000. A technical summary of the overall results has been published (EA, 2001), and the full report will be published during 2001. The findings of the survey are discussed in Chapter 3.2. This provides baseline data against which the effect of future changes in the waste management licensing regulations and exemptions, and changes in the level of the landfill tax and aggregates levy, can be assessed.

- The basic legislation relating to exempt sites is given in the Waste Management Licensing Regulations, 1994, Schedule 3, paragraph 9. This covers the spreading of waste on land carried out in accordance with a planning permission for the reclamation or improvement of the land, which results in benefit to agriculture or ecological improvement. There is a limit of 20,000 cubic metres per hectare, the land must be incapable of beneficial use without treatment, and the site must not be designed or adapted for the final disposal of waste by landfill. All these conditions must apply not just some of them.

- Another important exemption is given in paragraph 19 of Schedule 3. This allows the use of wastes which arise from demolition or construction work, or which consists of ash, slag, clinker, rock, wood or gypsum, for the provision of recreational facilities or the construction, maintenance or improvement of a building, highway, railway, airport, dock or other transport facility.


- Mobile crushers are regulated by Local Authorities as a ‘Part B’ process in England and Wales. In Scotland they are regulated by SEPA.

6.3.2 Planning authorities

- Guidance for mineral planning authorities is given in MPG6 (DOE, 1994), Minerals Planning Guidance: guidelines for aggregates provision in England. In Wales, guidance is given in Minerals Planning Guidance (Wales) Planning Policy. MPG6 includes a target for the use of secondary/recycled aggregates of 40mta for 2001. This figure has almost certainly been achieved. However, MPG6 is now largely out of date and is currently being revised. It is expected that a draft of the revised MPG6 will be issued for consultation in late 2001 or early 2002.

- The increase in demand for recycled aggregates has led to an increase in planning applications for recycling centres. This has caused difficulties as these centres are often in urban areas, near the sources of construction and demolition material, and other considerations have to be taken into account than those normally associated with quarrying operations. The planning authorities in these areas often have little experience of quarrying issues, as these have generally been dealt with by specialist mineral planners at regional level. Government has acted to provide guidance on dealing with applications for recycling centres in Planning Policy Guidance Note PPG10 Planning and Waste Management (DETR, 1999b). Government has also commissioned research into the specific aspects, which need to be considered when assessing applications for recycling centres. This has been published as ‘Controlling the environmental effects of recycled and secondary aggregates production: good practice guidance’ (DETR, 2000c). The main impacts from recycling centres are summarised in Box 6.1.

- In addition to assessing individual applications, planning authorities are required to have plans to allow sufficient recycling centres in their areas to meet national and regional guidelines. Draft Planning Policy Guidance note 11 (PPG11) Regional Planning (DETR, 1999c) indicates that Regional Planning Guidance has a key role to play in the management of waste because waste arisings and opportunities for treatment or disposal do not occur uniformly across regions. Detailed guidance is given in ‘Controlling the environmental effects of recycled and secondary aggregates production’ (DETR, 2000c). This suggests

2 These should not be confused with Planning Policy Guidance Notes, also abbreviated to PPG (see 6.3.2).

3 These should not be confused with Pollution Prevention Guidance Notes, also abbreviated to PPG (see 6.3.1).
that policies on recycled and secondary aggregates production should be included in Unitary Development Plans, Minerals Local Plans and Waste Local Plans. Ideally, the need for aggregates recycling sites should be identified in a Minerals Local Plan and preferred locations in a Waste Local Plan.

- In Wales, the equivalent planning advice to PPG10 is contained in ‘Planning Policy Wales’. This is supplemented by (draft) Technical Advice Note 21 on waste.

- The Northern Ireland Department of Environment has issued a Planning Policy Statement on planning and waste management for public consultation. The statement PPS11 is intended to update the planning policy framework following changes proposed by the waste management strategy and includes facilities for recycling, sorting and transfer of waste materials. The policies in the statement supersede the provisions of the Planning Strategy for Rural Northern Ireland, including policy PSU14 that covers waste. The draft consultation is available from the web site www.doeni.gov.uk/planning.

- It is particularly important to have this framework in place in areas where major transport projects are expected to take place, e.g. new highway or railway schemes or major renewals of existing transport infrastructure. Because of the relatively short tender periods and construction time associated with such projects, it is important that an adequate number of recycling centres are available in advance of the works.

**Box 6.1 Environmental impacts associated with recycled and secondary aggregates operations (from DETR, 2000c)**

The main environmental impacts include:

- Impacts of landtake and development (e.g. the visual impact of crushing/screening plants and the loss of habitats).
- Dust from the handling, storage, processing and transport of materials.
- Noise from engines which power plants, and from the processing of material and vehicle movements.
- Additional transport impacts such as congestion and delay; and impacts on highway safety.

Other potential environmental impacts include:

- Oil/solvents and suspended matter such as dust and silt which can enter surface and groundwater and contaminate land.
- Vibration from the processing and transport of material.
- Gaseous emissions from plant, vehicles, fuel and stored materials.
7 INFRASTRUCTURE OWNERS AND OPERATORS

7.1 Introduction

The following list indicates some of the larger infrastructure owners and operators:

**Roads**
- DBFO Consortia
- DTLR
- Highways Agency
- Local Authorities
- National Assembly for Wales
- Northern Ireland Executive
- Scottish Executive

**Rail**
- Local Authorities
- London Underground
- Private Companies
- Railtrack

**Air**
- British Airports Authority
- Defence Estates
- Local Authorities

**Water**
- British Waterways
- Port Authorities

7.2 Issues

There are four main issues that concern the infrastructure owner/operator. These are:

- development and implementation of specifications;
- economics of using alternative/recycled materials compared to use of natural aggregates;
- reliability and quality control of the alternative/recycled materials;
- environmental concerns.

These issues can result in a degree of conservatism with the owner/operator relying on tried and tested materials of which he has knowledge and confidence and using alternative/recycled materials in lower grade applications.

Available guidance is summarised in 7.3 below and further suggested actions to increase recycling are given in Chapter 11.4.

7.2.1 Development and implementation of specifications

- Traditionally specifications tend to be recipe and/or method specifications and may be only applicable to local materials and in specific areas.
- There is a shortage of national and international standards/specifications for alternative/recycled materials. There is unlikely to be any European CEN standards for unbound applications of recycled materials until 2005 at the earliest. However CEN standards for bituminous mixtures, including reclaimed asphalt, unbound and hydraulically bound mixtures and concrete pavements, material and functional requirements are scheduled to receive their formal vote of approval by mid 2003, early 2003 and mid 2002 respectively. For concrete, BS EN 206-1:2000 Specification, performance, production and conformity contains a note that provisions for recycled aggregates are not yet included but suitability should be established by obtaining a European Technical Approval or a relevant national standard referring to use in concrete conforming to EN206-1.
- Requesting departures from existing specifications can be a complex, lengthy and expensive process with an uncertain outcome. The time taken to gain approval for departures needs to be short or the opportunity to utilise the alternative/recycled material may be lost.
- New specifications tend to be conservative and can require extensive testing.
- There can be a failure to understand and adhere to new specifications.

7.2.2 Economics

- Alternative/recycled materials may not necessarily be cheaper than natural aggregates unless environmental, global or whole-life costs are also considered. Local Government finance rules may require selection of options on minimum initial cost.
- There is a possibility that the amount of recycling could be reduced because of the constraints in the form of licensing and regulations that have been imposed. These constraints result in additional problems and time in obtaining approval for use of recycled materials and an increase in costs.
- When undertaking maintenance, recycling is often costed against other treatments which may not give the same performance and could take longer to implement, facts that are not considered in the costing.
- Recycling plants need to have a continuing use to be viable propositions.
7.2.3 Reliability and quality control

- The reliability of alternative/recycled materials is often perceived to be poor due to the variability of many of the materials and the lack of quality control during production.

- Alternative/recycled materials are often considered to be of poorer quality and inferior to primary aggregates.

- The reliability of new plant handling new materials may be a problem.

- Alternative/recycled materials are often considered high-risk materials during risk assessment.

7.2.4 Environmental concerns

- The Environmental regulators may be less likely to accept the use of some alternative materials in certain areas, leading to delay and additional expense.

7.3 Available guidance

7.3.1 Development and implementation of specifications

- The Specification for Highway Works permits the use of alternative/recycled materials utilising the same criteria as applied to natural aggregates. A design guide and specification for structural maintenance of highway pavements by cold in-situ recycling is contained within TRL Report TRL386. This presents consistent guidelines on the appropriate use of the recycling technique, binder selection and the structural design. This technique and other developments have been included in the latest edition of the SHW (see Box 8.3, Example of an Evolving Specification). This specification moves away from recipe/method requirements towards those of end-product performance measured by in-situ non-destructive tests or on core specimens where technically feasible.

- Specifications and guides are available for specific applications and/or materials, such as BRE Digest 433 Recycled Aggregates, which covers the use of crushed concrete and masonry and suggests their use in higher grade applications such as structural concrete. British Standards cover materials such as pulverised fuel ash (PFA) and slags. Trade organisations, such as UKQAA, have produced guidance for granular material treated by fly ash (GFA).

- Burt (1996) and CIRIA Report 157 give guidance on the disposal of dredged material to land. BS6349, Part 5, provides general guidance on reclamation using dredged material.

- Local Authorities have produced specifications for the use of alternative/recycled materials in their areas (see Box 7.1).

**Box 7.1 Examples of local authority specifications for recycled materials**

- East Sussex Council has produced a specification for Baseco; a sub-base material derived from recycled aggregates, with limiting values for wood and other contaminants. They have also produced specifications for lower grade earthworks materials derived from recycled aggregates.

- Hampshire County Council has produced a specification for crushed demolition debris, which is called up in lieu of Type 1 sub-base.

- Leicestershire County Council has produced a specification for recycled granular material that can be used as a replacement for Type 1 granular sub-base. It is included with most contract documents.

- Leicestershire County Council has also produced a guidance note for footway recycling using reclaimed bituminous material.

- British Standard BS 6543 (1985) is a guide to the use of industrial by-products and waste materials in building and civil engineering. The materials covered in the Standard are residues from a number of extractive and processing industries, which are available in large quantities and have some potential for use in the construction industry. The standard also deals with the environmental and economic aspects of the utilisation of industrial by-products and waste materials.

- To assist in reducing the time taken to approve departures from the Specification for Highway Works the Highways Agency have compiled for its own use an electronic library of items (SPECLIB). SPECLIB is currently being revised and will contain three discrete categories of information:
  
  a. new clauses that have been prepared and are ready to go into the Specification for Highway Works (SHW) or the Design Manual for Roads and Bridges (DMRB) at the next update;
  
  b. clauses that are still under development but are intended for inclusion in the SHW or DMRB when completed;

  c. information on test and trial sites.
Box 7.2 Examples of useful specifications and guides

- AAS Digest 101 – Secondary and recycled aggregates uses in road construction under existing specifications.
- BR 392 Quality control: the production of recycled aggregates.
- BRE Digest 433 – Recycled aggregates.
- BS 6543 Guide to the use of industrial by-products and waste materials in building and civil engineering.
- BS EN 450 Fly ash in concrete: Definitions, requirements and quality control.
- Design Manual for Roads and Bridges.
- HD35/95 Conservation and the use of reclaimed materials in road construction and maintenance (Design Manual for Roads and Bridges, Volume 7 Section 1).
- Producers’ own Codes of Practice such as those available from UKQAA for pulverised fuel ash (PFA) and granular material treated by fly ash (GFA).
- Railtrack (RT/CE/S/006) – Railtrack specification for track ballast.
- TRL Report TRL200, Re-use of scrap tyres in highway drainage.
- TRL Report TRL386 – Design guide and specification for structural maintenance of highway pavements by cold in-situ recycling.
- TRL Report TRL408 – Enabling the use of secondary aggregates and binders in pavement foundations.

Box 7.3 The owner/specifier’s role in approving departures from a specification

a When contacted by the contractor/designer the specifier/infrastructure owner should clearly identify what information is required to obtain a departure from the specification.

b The specifier should check to see if similar departures have been requested in the past. In the case of the Highways Agency this would be undertaken by checking on SPECLIB, and supplying any relevant data to the applicant.

c It may be appropriate for the owner/specifier and the contractor/designer to work in partnership such that the departure can be incorporated at a later date into the specification for their mutual benefit.

d Once the required data has been collected and the departure submitted it is the responsibility of the owner/specifier to process the application as speedily as possible. For example, the Highways Agency endeavours to complete assessments within six calendar weeks.

The information in these clauses may save time for the applicant of a departure by reducing the amount of testing and trials required if these have already been undertaken elsewhere. SPECLIB clauses do not go into the SHW automatically. The relevant Overseeing Organisations have to approve them first. The benefits of SPECLIB would be improved if wider access were available.

When new, or modified, specifications are produced it is important that dissemination is undertaken such that all parties understand the specification and how it may require variations from standard practice. During the initial use of these specifications increased supervision may be required to ensure compliance. Feedback should be made available to the specifier to facilitate changes should the specification require improvement.

7.3.2 Economics

The use of global costing rather than project specific costing has been used to show that recycling is an attractive proposition (Box 7.4 and 7.5).

- To limit the delays from licensing and regulations problems, infrastructure owners should adopt a partnering approach that allows issues to be fully appraised during the early stages of the design process with all interested parties, including the relevant Environment Agency. This allows early contact with the licensing authorities and thereby minimises delays and saves money.
Box 7.4 Bemersley tip access road

Bemersley tip access road trial utilised cement bound incinerator bottom ash (IBA). A number of Departments of Staffordshire County Council (SCC) were involved. This project resulted in reduced costs when viewed on a corporate basis to SCC. Costs were increased in some departments due to the work involved in setting up, designing and testing the road. Savings were made by not sending the IBA to landfill:

- reducing transport costs;
- saving on landfill tax;
- making landfill space available for other material;
- contributing to meeting Staffordshire’s Agenda 21 targets.

Box 7.5 BAA Pavement Team

The British Airports Authority (BAA) Pavement Team comprises representatives from all the organisations involved in the construction and renewal of pavements at airfields owned by BAA. BAA work in partnership with contractors and suppliers to effect continuous improvement in their processes and operations throughout the supply chain. Continuity of work with good contractors leads to improvements in quality and programme, and significant financial savings. Over £1.8 million is estimated to have been saved in five years since the team was set up on recycled concrete alone.

- The cost benefits of using materials that need processing can be marginal and the imposition of the aggregates levy on these materials would possibly stop them being a viable alternative to natural aggregates. Customs and Excise have confirmed that the tax will apply only to primary aggregates extracted from the ground or dredged from the sea. It will encourage economy in the use of aggregates and recycling. The tax will be introduced in April 2002 (Chapter 4.8).

- To encourage the use of recycled materials Leicestershire County Council has a green policy where rates for recycled materials are allowed to be 10% higher than for natural materials.

- The infrastructure owner should consider the whole life benefits and speed of operation of various maintenance treatments and new construction involving recycled materials when compared to other possibly cheaper treatments, which may result in a shorter life of the pavement (Box 7.6). The future recyclability of all materials should also be considered.

- The problem of matching supply and demand can be overcome by co-operation between producers and clients (Box 7.7).

Box 7.6 Deep in-situ recycling

Deep in-situ recycling is often at a disadvantage compared with traditional methods of planing and replacement because there is not a like-for-like comparison. Prices for deep in-situ recycling may be compared with shallow planing and inlay or with a 50mm overlay, which will inevitably be cheaper but may have a shorter life.

Advantages of deep in-situ recycling to be taken into account:

- Energy saving of up to 80%.
- No material disposed off-site.
- No import of primary aggregate.
- Fewer lorry movements.
- Significant saving in time.
- Cost savings of up to 30% compared to full reconstruction.

Box 7.7 Collaborations between specifier and recycler

- A recycling plant in Newhaven produces a material, Baseco, which is produced to a specification, similar to Type 1, drawn up by East Sussex County Council. This collaboration between infrastructure owner and recycling plant ensures that the output from the plant can be utilised locally.

- Wessex contracting in West Sussex produce a material called Trenchfill, similar to Baseco, which has been approved for utility reinstatements in Hampshire.

7.3.3 Reliability and quality control

The infrastructure owner needs evidence that:

- Adequate quality control procedures are in place to ensure that a consistent, fit-for-purpose material is produced. BR392, Quality control—the production of recycled aggregates offers a suitable protocol, which can be adapted for other alternative materials.
Recycled materials are as suitable for the proposed operation as natural aggregates.

This may be provided by test results using standard tests for natural aggregates, and from experience of the successful use of the materials in similar applications to that proposed (see Box 7.8).

**Box 7.8 ALT-MAT project**

As part of the collaborative European research project ALT-MAT (ALTernative MATerials in road construction), inspections of existing roads which included alternative materials were carried out in Sweden, Denmark, the United Kingdom and France. The materials investigated included crushed concrete, demolition rubble, Municipal Solid Waste Incinerator (MSWI) bottom ash (IBA), air-cooled blastfurnace slag and natural reference materials. The materials were used as unbound granular sub-base and capping.

The case studies showed that the alternative materials gave as good and sometimes better support to the pavement than natural reference materials. This is illustrated by the elastic moduli results shown in Table 8, obtained from Falling Weight Deflectometer measurements. The performance in the field was often better than predicted from standard laboratory tests such as CBR or Los Angeles abrasion value. The results of the project were very positive and provide support for the use of alternative materials in construction.

Some alternative materials may have special requirements for testing, handling and placing. These should be identified at an early stage and agreed with all parties.

It may be necessary to incorporate a trial with the new material, new plant or method as part of the contract. The requirements for this, how it is to be assessed and how it is to be financed, should be established at an early stage.

There are standard procedures for assessing new materials (BBA/HAPAS, see Box 7.9) and methods for reinstating openings in roads for utility works (HAUC). The Highways Agency also has a standard procedure for evaluating and approving new materials for use in pavements (see Box 7.10).

There is criticism from contractors and material producers that these procedures are too lengthy and expensive and restrict the introduction of new materials and methods. Consideration should be given to ways

**Box 7.9 Highways Authorities Product Approval Scheme (HAPAS)**

The HAPAS scheme was set up by the Highways Agency, County Surveyors Society (CSS) and the British Board of Agrément, with the objective of developing national approval arrangements for innovative products, materials and systems for use in highways and related areas, removing the need for individual authorities to carry out their own assessments and tests. The scheme is supported by the Scottish Executive Development Department, the National Assembly of Wales, the Department for Regional Development in Northern Ireland, CSS and TAG (Local Authority Technical Advisers Group). It is aided by TRL, other specialist laboratories, trade and professional bodies and industry experts.

HAPAS Specialist Groups draw up Guidelines, documents giving details of the tests, assessment criteria and quality assurance requirements that the BBA then uses in its evaluations. The BBA's approval process for HAPAS involves laboratory and witness testing, site inspection and evaluation of the source of production of the material under assessment. Existing test or performance information will also be investigated. HAPAS product sectors include:

- High Friction Surfacing Systems.
- Crack Sealing Systems.
- Thin Surfacing Systems.
- Modified Binders and Mix Modifiers.
- Cementitious Repair Materials for Concrete Pavements.
- Permanent Cold-Lay Surfacing Materials for Reinstatements.
- Colour Retention of Pigmented Highway Surfacing.
- Grids and Stress-absorbing Membranes.
- Coloured Resin-bound Surfacing.

When a product has passed the relevant approval process, a HAPAS Certificate is issued by BBA. Surveillance visits are carried out normally twice yearly to ensure the specification of the product is being maintained, and at the end of each five-year period a formal Review is carried out. The BBA's HAPAS Certificates are called up where appropriate in the Specification for Highway Works. Further information is given on the BBA’s web site, www.bbacerts.co.uk/hapas.html.
Plate 5 Testing demolition rubble sub-base in-situ with a dynamic plate tester during the ALT-MAT project

of speeding up the approval process so that clients do not miss out on opportunities for significant financial savings using new materials and methods without prejudicing the assessment of their long term performance.

- The infrastructure owner should base his risk assessment of using alternative/recycled materials on all the available technical data.

- As the contractor carries the main risk on a Design, Build, Finance and Operate (DBFO) contract, there is a greater opportunity to be innovative. The client may be more prepared to give approval for innovative methods or materials on this type of contract because of the lower risk he carries.

Box 7.10 Highways Agency procedure for evaluating new materials

The procedure for evaluating new materials is carried out in five stages.

Stage 1 Desk study
Assess and evaluate existing information on the material.

Stage 2 Laboratory study
Test the mechanical properties of materials to allow theoretical predictions to be made of their performance.

Stage 3 Pilot-scale trials
Evaluation of construction and performance of materials in small-scale trials.

Stage 4 Full-scale trials
Full-scale trial on a trunk road to establish whether the previous assessments obtained from Stages 2 and 3 are realised.

Stage 5 Highways Agency specification trials
This stage is necessary to carry out further evaluation of the material and to test the specification under contract conditions.

Notes

1 Stages 1 to 4 are financed by the manufacturer of the material. For Stage 5, the additional cost, if any, of the material is borne by the manufacturer.

2 Stages 1 to 4 can be carried out by TRL or other independent organisations. In the latter case, HA may request that the reports be appraised by TRL.

3 In all cases, the new materials are compared with conventional materials to obtain comparative performance and benefits.

Table 8 Inspections of existing roads in ALT-MAT project

<table>
<thead>
<tr>
<th>Country</th>
<th>Site</th>
<th>Material</th>
<th>Subgrade</th>
<th>Age (years)</th>
<th>Los Angeles abrasion value (%)</th>
<th>CBR (%)</th>
<th>E-moduli (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Kingdom</td>
<td>Bracknell</td>
<td>Demolition rubble</td>
<td>Clay</td>
<td>5</td>
<td>Nd</td>
<td>66</td>
<td>999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Limestone</td>
<td>Clay</td>
<td>5</td>
<td>Nd</td>
<td>156</td>
<td>284</td>
</tr>
<tr>
<td>Denmark</td>
<td>Skibet Veje</td>
<td>Crushed concrete</td>
<td>Sand</td>
<td>8</td>
<td>36</td>
<td>120</td>
<td>540</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gravel</td>
<td>Sand</td>
<td>8</td>
<td>23</td>
<td>160</td>
<td>215</td>
</tr>
<tr>
<td>Denmark</td>
<td>Skælskør</td>
<td>MSWI bottom ash</td>
<td>Glacial till</td>
<td>5</td>
<td>50</td>
<td>40</td>
<td>128</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sand</td>
<td>Glacial till</td>
<td>5</td>
<td>23</td>
<td>24</td>
<td>180</td>
</tr>
<tr>
<td>France</td>
<td>La Teste</td>
<td>MSWI bottom ash</td>
<td>Sand</td>
<td>22</td>
<td>Nd</td>
<td>125</td>
<td>Nd</td>
</tr>
<tr>
<td>France</td>
<td>Le Mans</td>
<td>MSWI bottom ash</td>
<td>Sandy clay</td>
<td>20</td>
<td>Nd</td>
<td>110</td>
<td>Nd</td>
</tr>
<tr>
<td>Sweden</td>
<td>Nyköping</td>
<td>Air-cooled blastfurnace slag</td>
<td>Sand</td>
<td>12</td>
<td>35</td>
<td>145</td>
<td>600</td>
</tr>
<tr>
<td>Sweden</td>
<td>Helsingborg</td>
<td>Crushed concrete</td>
<td>Clayey till</td>
<td>2</td>
<td>33</td>
<td>245</td>
<td>850</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crushed granite</td>
<td>Clayey till</td>
<td>2</td>
<td>20 - 25</td>
<td>Nd</td>
<td>300</td>
</tr>
<tr>
<td>Sweden</td>
<td>Luleå</td>
<td>Crushed concrete</td>
<td>Silty till</td>
<td>2</td>
<td>Nd</td>
<td>Nd</td>
<td>870</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crushed granite</td>
<td>Silty till</td>
<td>2</td>
<td>Nd</td>
<td>Nd</td>
<td>280</td>
</tr>
</tbody>
</table>

Nd: not determined
Box 7.13 M60 Contract 3

Contract 3 of the M60 forms the final link in the motorway ring road around Manchester. The contract was awarded to Balfour Beatty in May 1998 and was completed in summer 2000. The contract, which has a value of £50 million, was a design and build project which has been undertaken on a partnering basis between Balfour Beatty, Highways Agency, Employer’s Agent and contractor’s designer. Liaison with the Environment Agency took place throughout the project.

Balfour Beatty wished to minimise the amount of material taken off site to tip. This is general company policy, but was accentuated in this case because of the shortage of suitable tips in the Manchester area (the material, which would have been disposed to tip, included peat and contaminated materials). Retaining the contaminated material on site meant that a waste management licence might have been required. A source-pathway-receptor analysis was carried out for each individual site location, and it was agreed that the material could be left on site and that a waste management licence was not required. The local Environment Agency staff were very helpful. This resulted in the following environmental benefits:

- amount of offsite disposal reduced from 621,000 m³ in the illustrative design to 138,000 m³;
- number of truck loads reduced by more than 50%;
- marginal and contaminated material treated and used in the works.

As well as these environmental benefits, the project was completed ahead of programme and under budget. The helpful attitude of the local Environment Agency was vital, as was the partnering approach adopted by all parties in the contract.

Box 7.12 A selection of publications offering technical guidance (see also 7.3.1)

- CIRIA Report 157 Guidance on the disposal of dredged material to land.
- CIRIA Report C513 The reclaimed and recycled construction materials handbook.
- ConSim and ALT-MAT models.
- Design Manual for Roads and Bridges, Volume 4 Geotechnics and Drainage.
- Design Manual for Roads and Bridges, Volume 7 Pavement Design and Maintenance.
- Environment Agency Research and Development Publication 20.
- HMSO – Use of waste and recycled materials as aggregate: Standards and specifications.

Plate 6 Recycling site-won material using a trommel on the M60 Contract 3
included in the contract, they should be set in a way that does not stifle innovation by the contractor.

7.3.4 Environmental concerns

- To determine if there are likely to be any environmental problems, which may restrict the use of a material or incur delays, it is important that the Environment Agency (EA) is involved at the outset of the project. It is important to confirm with the EA that the material/process is acceptable at the planning stage of the project as resolving issues at this stage may well save time later in the project.
8 CONTRACTORS AND DESIGNERS

8.1 Introduction

Contractors and designers are well placed to be innovative and to promote the use of alternative/recycled materials both with the client and the supplier. They can incorporate them in designs, give advice from their experience of using these materials and are in the best position to maximise recycling opportunities at the end of a project’s life. They can maximise the use of alternative/recycled materials within a specification and are in a position to suggest these materials as alternatives where the specification does not specifically allow their use. The main drivers for contractors/designers are economics, controlling risks, minimising costs and maximising profit, ease of construction, minimising waste disposal and using innovative materials and methods.

8.2 Issues

There are a number of issues relating to the designer and contractor. These are:

- specifications that are not written with recycling or alternative materials in mind;
- design costs for the use of recycled materials may be higher than for natural aggregates;
- contractual conditions that discriminate against recycling and the use of alternative materials;
- short tender periods and programmes that do not allow time to obtain the necessary authorisations for recycling from the regulatory authorities;
- the economics of using alternative/recycled materials and the purchasing and running of recycling plant;
- the definition of waste and associated waste management licensing issues;
- the assessment of the risks, when alternative/recycled materials are used;
- the reliability and quality control of alternative/recycled materials;
- ensuring an adequate supply of alternative materials;
- possible objections by the Environmental regulators to alternative materials because of concerns about pollution of controlled waters by leachate.

These issues often result in a degree of conservatism.

Available guidance is summarised below and further suggested actions to increase recycling are given in Chapter 11.5.

8.3 Available guidance

8.3.1 Specifications

- The range of Specifications and Design Guides that deal with alternative materials and recycling is greater than may be realised (Section 4.1). A selection of the more important ones are listed in Box 8.1.

- For Highways Agency schemes, in addition to the existing Specification for Highway Works, the Highways Agency has compiled for its own use an electronic library of specification items (SPECLIB) that can be useful in speeding up applications for departures. SPECLIB is currently being revised and will contain an index of clauses and three discrete categories of information:
  a. new clauses that have been prepared and are ready to go into the Specification for Highway Works (SHW) or the Design Manual for Roads and Bridges (DMRB) at the next update;
  b. clauses that are still under development but are intended for inclusion in the SHW or DMRB when completed;
  c. information on test and trial sites.

- If innovative methods or new materials are being considered, the Contractor should ask the Highways Agency if there is a clause in SPECLIB that could be used to cover the work.

- On a Highways Agency scheme, if the existing Specification does not cover the activities or materials proposed, the Contractor can request a departure from the Specification. Discussions should be held with the HA Project Services Manager at as early a stage as possible, to establish the information that HA will require in order to be able to make a judgement on the application. Applications submitted with insufficient detail will inevitably take longer to process. HA aim to respond to applications for departures within 28 days if sufficient information is included with the application.

- The procedure for obtaining a departure is summarised in Box 8.2.

- When new, or modified, specifications are produced, it is important that the designer ensures all parties understand the specification and how it may require different working practices from those previously used. All new specifications should be contract neutral. As an example of evolving specifications the latest version of the Specification for Highway Works, May 2001, recognises the developments in using alternative/recycled materials in a number of new Clauses and modifications to existing Clauses (Box 8.3).
Various procedures have been established for trialing new materials and methods. The BBA/HAPAS and Highways Agency procedures for materials in pavements are summarised in Chapter 7.3.3. The reinstatement of openings for utility works in highways is covered by the HAUC Specification (HAUC, 1992). Alternative materials and methods are permitted provided they meet the performance requirements and any compositional requirements in the specification for the relevant material layer. The HAUC Specification is currently under revision.

8.3.2 Economics of using alternative/recycled materials

Some clients offer a premium for solutions that involve recycling, e.g. Leicestershire County Council have a green policy where rates are allowed to be 10% higher when recycling is used. Others may use the proportion of recycled materials used as a factor in tender assessment. Check the possibilities whenever a tender is received.

Ensure that comparison with an equivalent method is being made when an alternative solution involving recycling is proposed.

Emphasise the whole life benefits and speed of operation of various maintenance treatments involving recycled materials when compared to other cheaper treatments that may result in a shorter life of the pavement.

The future recyclability of the material should also be considered.

Box 8.1 Examples of useful specifications and guides

- AAS Digest 101 – Secondary and recycled aggregates uses in road construction under existing specifications.
- BR 392 Quality control: the production of recycled aggregates.
- BRE Digest 433 – Recycled aggregates.
- BS 6543 – Guide to the use of industrial by-products and waste materials in building and civil engineering.
- BS EN 450, Fly ash for concrete – Definitions, requirements and quality control.
- Design Manual for Roads and Bridges, Volume 4 Geotechnics and Drainage.
- Design Manual for Roads and Bridges, Volume 7 Pavement Design and Maintenance.
- East Sussex Council Specification for Baseco (similar to Type 1).
- HD35/95 Conservation and the use of reclaimed materials in road construction and maintenance (Design Manual for Roads and Bridges, Volume 7 Section 1).
- Leicester County Council – Specification for the use of recycled materials as a direct replacement for Type 1 granular sub-base in specified areas.
- Producers’ own Codes of Practice such as those available from UKQAA for pulverised fuel ash (PFA) and granular material treated by fly ash (GFA).
- Railtrack (RT/CE/S/006) – Railtrack specification for track ballast.
- TRL Report TRL386 – Design guide and specification for structural maintenance of highway pavements by cold in-situ recycling.
- TRL Report TRL408 – Enabling the use of secondary aggregates and binders in pavement foundations.
The aggregates levy, which will be imposed from April 2002 at £1.60 per tonne, will not apply to recycled/alternative materials. Ensure clients are aware of the potential savings from using alternative materials.

Materials recycled and retained on site will not be liable to the landfill tax, whereas disposing of material to landfill and replacing with natural aggregates will attract both landfill tax and the aggregates levy.

**8.3.3 Definition of waste and waste management licensing**

The regulations that dictate if a material is classified as a waste and whether an exemption applies is the Waste Management Licensing Regulations 1994 In England, Wales and Scotland (SI 1994 No. 1056), DoE Circular 11/94 (SOED 10/94; WO 26/94): Waste Management Licensing – Framework Directive on Waste. A different system applies in Northern Ireland. Some examples of the classification of materials used in transport infrastructure renewal works in England and Wales are given in Table 7. See Chapter 4.5 for more detail. This table is supplied for guidance only and does not constitute a definitive statement of the legal position.

The government is currently reviewing the exemption system for waste management licences. Contractors and designers should look out for changes in the system and ensure they are aware of the latest developments.

The contractor/designer is advised to make contact with the licensing authority at the earliest possible opportunity. The contractor should be aware of the information that he will be required to submit in order to obtain a waste management licence. This can be established through early contact with EA in England.

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**Box 8.2 Procedure to produce a submission for a departure from the Highways Agency**

- Early initial contact should be made by the contractor/designer with the HA Project Services Manager:
  
  a. On non Design Build Finance & Operate (DBFO), non Design & Build (D & B), pre-tender DBFO and both pre-tender and post-award D & B projects this is the HA Project Manager.
  
  b. On DBFO projects during the tender period this is the Commercial Manager.
  
  c. On DBFO projects post-award this is the Department’s Nominee.
  
  d. On D & B projects during the tender period this is the D & B Project Manager.

- Subsequent contact is then likely to be with the Technical Specialist in HA Quality Services, Civil Engineering (HA, QS/CE).

- Determine what information the specifier requires to make a judgement on the departure, even when using relevant clauses from SPECLIB additional information may be required before submitting the departure.

- Agree with the relevant Technical Specialist:
  
  a. a draft clause wording for any trial;
  
  b. what costs are covered by which division/group/team in HA for the actual investigation work, supervision and reporting on the trial, and surveys to inspect the trial after specified periods of time;
  
  c. if a method of measurement departure is also required.

- Submission Forms, supplemented by separate documentation, drawings and sketches, for departures should be sent to the HA Project Services Manager.

- When approved on the grounds of quality, safety or value for money by the Project Manager the departure is sent to the Submission Point for the subject and trial in question.

- The Submission Point for all design and all specification issues, up to the 1600 series in the SHW, is usually the HA, QS/CE. For structures it is the Technical Approval Authority.
Box 8.3 Example of an evolving specification: selected amendments in the May 2001 edition of the Specification for Highway Works

- Clause 710 – Testing for Constituent Materials in Recycled Coarse Aggregate and Recycled Concrete Aggregate. This requires the quality control procedure to be in accordance with the CRC publication BR 392 Quality Control - Production of Recycled Aggregates.

- Clause 801 – General Requirements for Unbound, Hydraulically Bound and Other Materials. Permits the use of recycled coarse aggregate and recycled concrete aggregate in accordance with Clause 710.

- Recycled aggregates may now be used as granular sub-base material Type 1 (Clause 803) or Type 2 (Clause 804), with up to 50% by mass of asphalt and up to 1% by mass of foreign materials, such as wood, plastic or metal, in the recycled aggregate.

- Clause 805 – Slag Bound Material. Permits a granular material bound by granulated blast furnace slag for road pavements and footways.

- Clause 806 – Granular Sub-base Material Type 4 is a material derived from asphalt arisings, either asphalt road planings or granulated asphalt, but excludes material containing tar or tar/bitumen binders.

- Clause 901 – Bituminous Roadbase and Surfacing Materials permits the use of recycled coarse aggregate and recycled concrete aggregate with a foreign material content of < 1%.

- Clause 902 – Reclaimed Bituminous Materials. The maximum amount of reclaimed bituminous material remains at 10% in the wearing course but is increased to 50% in other layers.

- Clause 946 – China Clay Sand Asphalt Roadbase. A roadbase material produced using china clay tip sand aggregate, a washed material produced as a by-product during extraction of china clay.

- Clause 948 – Cold Recycled Bitumen Bound Material. Used for foundation or the main structural layer of a road pavement with aggregate derived from cold pulverisation of the existing road structure. May be mixed in-situ or ex-situ.

- Clause 1001 – Wet lean concrete or cement bound materials may contain recycled coarse aggregate or recycled concrete aggregate.

- Clause 1046 – Cold Recycled Cement Bound Material. Uses aggregate from cold pulverisation of the existing road structure to provide a material that meets specified end product requirements. The aggregate must comply with a given grading curve.

and Wales and SEPA in Scotland. A great deal of guidance on applications for waste management licences in England is available on the EA web site at www.environment-agency.gov.uk, and for Wales at www.environment-agency.wales.gov.uk. For Scotland, information is available on the SEPA web site at www.sepa.org.uk.

The procedure for processing an application for a waste management licence is governed by legislation and includes a number of stages, including a statutory 28-day period for public consultation. If the application is simple, a ‘shell’ licence may be used, which will speed up the process. EA monitor the time taken to deal with licence applications in England, and are endeavouring to increase the speed, but contractors should have realistic expectations of the length of time which will be required to obtain a waste management licence. Several months will normally be required, even if there are no difficulties with the application.

The process to be followed when deciding whether a material is waste, and, if so, whether it qualifies for an exemption, is illustrated in the flow chart in Chapter 4.5. Some major contractors have set up their own internal systems for assessing whether waste management licences are required and setting out the procedures for their staff to follow. An example is shown in Figures 7 and 8. Note that this is included for illustrative purposes only, and should not be regarded as a definitive statement on how the waste management licensing system operates.

The Environment Agency follows procedures set out in the Waste Management Licensing Process Handbook, which has been in operation since 1998. This is a national document, so variations between regions in England should be minimal if it is being applied. If an applicant feels that he has been unfairly treated, an appeal should be made to the Local Licensing Team Leader. Further appeals can be made successively to area, regional and national level if necessary.
Duty of Care

START

No construction wastes, site arisings, planings, earthworks materials will leave the area defined as the contract without following this procedure.

Seek advice from Materials Department/Environmental Manager prior to removing any materials surplus in requirements from site.

1) Information on the classification of waste materials should be obtained from client or previous landowner.
2) All classification of waste materials should be carried out in accordance with DD 175 the re-development of contaminated land.
3) Discuss with the named laboratory the appropriate suite of elements and compounds to be tested.
4) Meet with Environment Agency (Pollution Officer) and discuss trial pit contaminated sites, location, classification criteria, and management of 'duty of care' regulations once classification is agreed.
5) Ensure site team are aware of risks of working in contaminated land, and trial pits operate with a permit to dig system. Refer to waste management procedure in site environmental plan.
6) Interview haulier to establish current Environmental Agency licence for movement of materials.
7) Visit proposed tip facility and request copy of licence and specifically note restrictions on concentration of materials and volumes per day.
8) Ensure disposal log is accurate detailing all waste transfers.
9) Ensure member of staff is given responsibility to implement 'Duty of Care' requirements.
10) Initiate waste segregation during construction to maximise re-use and re-cycle potential of materials.
11) Regularly audit the haulier/tip facility and management of waste materials.

During de-commissioning of the site compounds a full review of best practice indicators 1-11 will be undertaken and an action plan drawn up.

Figure 7 Waste management procedure used by a major contractor
LANDFILL TAX SUMMARY

IS IT WASTE?

No

Yes

Waste Management Regime

Licence / Exemption

Duty of Care

Disposal

What Method of Disposal?

Incineration

LANDFILL

Other

Is Landfill Waste of tax-exempt Type?

Yes

No

Landfill Tax Payable

Is material inert?

Yes

No

Tax at £2/tonne

Tax at £12/tonne from 1/4/2001 (rising by £1/tonne annually to a maximum of £15/tonne)

Certain Contaminated Material
Dredgings
Inert material used in landfill reclamation (from October 1999)
Quarrying / Mining
Pet Cemeteries
No Waste Management Licence required

Figure 8 Landfill tax summary used by a major contractor
8.3.4 Supply and demand

- The supply of alternative/recycled materials in the required quantities and at the correct time can be best assured by the contractor/designer working closely with his supplier such as in the partnering agreements forged by AMEC and BAA with their suppliers. If these agreements are not in place but the supplier is known, then contact can easily be made to ascertain whether there is likely to be a problem. If the supplier or material to be used is not known then details of reclamation and recycling facilities can be obtained from any of the sources indicated in Box 8.4.

8.3.5 Reliability and quality control

The main risks of using alternative/recycled materials and the suggested methods of reducing these risks are as follows:

- To allay the fear that the material will not perform as expected an appropriate amount of testing should be undertaken to assess the performance.
- Carry out trials to demonstrate that the material/method is fit for purpose (Box 8.5 and 8.6).
- To ensure that the material will be supplied to specification use materials from a supplier who has a quality control system in place.
- A suitable quality control system for recycled aggregates (construction and demolition waste) is set out in BR392, Quality control: the production of recycled aggregates (CRC Ltd., 2000). This system can be adapted for other alternative materials; for example, Ballast Phoenix Ltd. has produced a similar document for incinerator bottom ash (IBA).

8.3.6 Environmental concerns

- Use materials where agreement has been reached with the Environmental regulators on where and how they may be used.

Box 8.4 Suppliers of information on reclaimed/recycled materials

- BRE website, www.bre.co.uk. Select ‘our services’ then select ‘waste and recycling’.
- Institute of Wastes Management, website www.iwm.co.uk, tel. 01604 620426.
- The regional Waste Regulation Officer at the Environment Agency, tel. 0845 933 3111 (this connects you to the Waste Regulation Officer in your region).
- The Building Research Establishment (BRE) website allows contractors to interact with each other by advertising available and wanted materials and by giving news of future demolition projects.
- For a consistent supply of alternative/recycled material the contractor should attempt to obtain the material from one source for any specific project. This source should preferably be from a supplier with a quality assurance scheme in place.
- To reduce the risk that the material will not be available in the quantity required and at the time required ensure that at least the amount of material required has been purchased or reserved and that storage has been arranged where required. Draw up a delivery contract with the supplier with penalty clauses should supplies not be available when required.

Box 8.5 Leeds City Council Direct Labour Organisation (DLO)

The Highway Services unit of Leeds City Council annually produces 40,000t of waste, three-quarters of this is bituminous material and concrete. This material is crushed, screened and recycled as sub-base material. Leeds City Council would only accept this as Type 2 material, because it did not comply with the material type in the specification for Type 1 material. Leeds City Council carried out trials which indicated that the performance of the material was as good as natural Type 1 sub-base. A joint venture company was formed in 1996 between Leeds City Council DLO and an Earthworks contractor to produce and market the material. After further trials, and the DLO agreeing to take the risk if failure should occur, the material was accepted as ‘fit for purpose’ Type 1 sub-base by Leeds City Council.

There are other cost and environmental benefits in this arrangement as the vehicles taking the waste to the recycling plant can deliver recycled material on their return journey.
a The positive aspects of not using natural materials, such as from the disturbance caused by the extraction and transport of the raw materials.

b The saving from not having to dispose of the alternative/recycled material, giving savings in noise, pollution, the nuisance effect of landfill and from incinerator residues and emissions.

c The saving in not having to pay the aggregates levy on the alternative/recycled materials

If there are concerns about the use of the material in an unbound application, consider the use of it in cement or bitumen bound form. This greatly reduces the potential for leaching of contaminants.

To reduce the environmental and human health risks undertake a risk assessment to identify sources of possible hazards, identify pathways along which the hazard may migrate and receptors on which any potentially hazardous substance may impact. Various methods are available (Box 8.7).

The contractor/designer should encourage the use of locally available alternative/recycled materials by indicating the environmental advantages over natural materials. These advantages are:

Box 8.6 Leicestershire County Council (LCC) footway recycling

Mineral Recycling Ltd of Leicestershire has developed a machine for recycling bituminous footways. Material is broken out and fed into the machine with a small amount of new bitumen, where it is heated to produce a workable material. This is placed as hot mix bituminous material in the footway with no material being removed to tip (see Plate 7).

Machine trials were required to establish that the machine would function effectively. Leicestershire County Council (LCC) prepared a one-page guidance note for the technique and consider that it can be used for renewing footways and surface patching on roads. The Direct Labour Organisation (DLO) of LCC carried out a successful trial of the machine on a footway contract using the ‘strip and lay at the same time’ technique. There were no significant hold-ups as a result of these trials.

The benefits of the method are minimisation of waste and disturbance and savings in time and money compared to conventional methods.

Box 8.7 Models for predicting impact of leaching

CIRIA Report 167 Use of industrial by-products in road construction: water quality effects (Baldwin et al., 1997).


ConSim model.

ALT-MAT model (Reid et al., 2001).

Plate 7 Footway repairs using reclaimed bituminous material in Leicestershire: before (top) and after

(Photographs courtesy of Leicestershire County Council)
9 MATERIAL PRODUCERS

9.1 Introduction

This includes the supplier of any material that may be used in transport infrastructure renewal works that is not classified as a natural aggregate. The material may be nominally a ‘waste’ product from a main operation, which can be used either with or without processing. Alternatively, it may be a material provided by a recycling company from a number of ‘waste’ sources.

BS 6543, HD 35/95 of the DMRB and CIRIA report C513 identify uses for various alternative/recycled materials in infrastructure works. These materials are indicated in Box 9.1.

Box 9.1 Examples of alternative/recycled materials

Bituminous planings.
Blast furnace slag.
China clay waste.
Colliery spoil (burnt/unburnt).
Crushed concrete.
Crushed glass.
Demolition rubble.
Dredging spoil.
Excavated material.
Foundry sand.
Furnace bottom ash (fba).
Municipal Solid Waste (MSW) incinerator ash (now known as IBA).
Plastic.
Pulverised fuel ash (pfa).
Rubber.
Sewage sludge.
Slate waste.
Spent oil shale.
Spent railway ballast.
Steel slag.

9.2 Issues

The main issues concerning the material producer are:

- proving that the material is ‘fit for purpose’;
- environmental concerns, licensing and exemptions;
- compliance with specifications written for natural aggregates;
- obtaining planning permission for sites to process alternative materials.

These main issues will dictate how much alternative/recycled material is put to use in transport infrastructure renewal works as opposed to possibly sending the material to waste disposal sites.

Available guidance is summarised below and further suggested actions to increase recycling are given in Chapter 11.6.

9.3 Available guidance

9.3.1 Quality control

To give confidence to any user of alternative/recycled materials that the material is of a consistent standard the supplier should have in place a robust quality control system (Box 9.2). Guidance is available on implementing a quality control system for recycled aggregates, for instance in Construction Research Communications Ltd publication BR392, Quality control—the production of recycled aggregates. This incorporates a simple quality control protocol, which can be expanded and improved with time (Chapter 4.3). It is relevant to recycled aggregates for sale as construction materials, or as constituents in a product such as concrete or asphalt.

Box 9.2 Recycled aggregates factory

Day Aggregates have recently constructed a recycled aggregates factory and followed the guidelines produced by the Quarry Products Association (QPA) in their quality assurance scheme, which is due to be registered under BS EN 9002. This quality control procedure addresses:

- The quality control of incoming materials.
- An acceptance criteria for imported materials to enable consistent classification.
- A procedure for suspected contaminated material.
- The processing of construction and demolition waste.
- An inspection and testing regime, including frequency and methods of test, for the finished product.
prospective users, that the material is a quality controlled product and disseminate as much information as possible with regard to the product.

- To improve the quality of some materials it may be beneficial to introduce additional processing stages, such as washing, removal of metals and lightweight material, and additional crushing and screening stages. Even small quantities of material such as wood or paper have a significant visual impact on the prospective user of the material.

- It is very important that materials are properly assessed and assigned to the correct product stream when they arrive at the site (Box 9.3). This is often done by the weighbridge operator, and it is vital that this individual is properly trained. It is much more expensive to treat materials that have become contaminated than to segregate them properly at the site entrance.

9.3.2 Economics of alternative/recycled materials

- Movement of recycled/alternative materials over long distances reduces the economic and environmental benefits of using these materials (Box 9.4). Material suppliers should therefore be actively marketing their material in their local area.

**Box 9.4 Hampshire County Council site trials**

Trials undertaken by Hampshire County Council (HCC) utilising reclaimed asphalt pavement (RAP) were technically successful. However, both the hot mix and the cold mix recycling techniques were more expensive than conventional repairs. This was because the materials were manufactured at Greenwich and transported to the trial sites at Alton and Bentley. HCC is considering setting up a local plant to reduce the haulage costs of the operation.

- The specialised plant for recycling, whether for in-situ recycling, portable crushing equipment on site or a recycling factory needs to be fully utilised to be economically viable. This necessitates smaller suppliers stockpiling raw material until a sufficient quantity is available to warrant hiring in equipment (Box 9.5).

**Box 9.5 BAA Pavement Team**

Concrete and other material arising from renewal works is stockpiled at each airport. When sufficient material is available, a mobile crusher is brought to site and the material is crushed to meet a grading specification. This is similar to the practice adopted at a number of small recycling centres, where crushing and screening plant is only brought to site when a sufficiently large stockpile has been built up to justify the work.

9.3.3 Supply and demand

- The supply of alternative/recycled material is dependent upon the source of the raw material. Therefore, the alternative/recycled material may be a regular amount if it is a waste material from a specific process or industry, or, it may be a random amount if supplied from a recycling plant dependent on the amount of redevelopment in the area at the time. The material supplied by a recycling plant is dependent upon the amount of raw material entering the plant. When the supply of material is less than that required by the client the material supplier will have to arrange...
to stockpile his product in advance to ensure that the required amount of material is available as and when required.

- The possibility of obtaining additional raw material may be investigated by interrogating the Building Research Establishment (BRE) website on www.bre.co.uk and other sites (see Box 8.4). This would allow the recycling plant or material supplier to interact with contractors who may have raw material available for recycling and also to obtain news of future demolition projects.

- As indicated previously some suppliers have found it beneficial to enter into partnerships with contractors and clients to work together to develop innovative procedures, to produce specifications and undertake proving trials of materials. These partnerships also make the supplier aware of the contractor/client’s requirements at an early stage of the project such that the supplier can take appropriate action.

- To allay the customer’s concerns that the material will not be available in the quantity required, or at the time required, the supplier should offer to enter into delivery contracts with the purchaser. These contracts would invoke penalties on the supplier should the material not be available as agreed, and therefore indicate to the customer the supplier’s confidence in meeting his requirements.

9.3.4 Fit for purpose

- The material supplier should be able to prove that his alternative/recycled material will perform as well as natural aggregates used in the same application. The requirements for particular applications can be obtained from the relevant specifications (see Chapters 4.1, 4.2 and 7.3). It may be beneficial for the supplier to collaborate with contractors and specifiers in sponsoring research to determine the suitability of using their alternative/recycled materials (Box 9.6).

- To give confidence to the user that the alternative/recycled material will perform as expected, the supplier should undertake sufficient testing to assess the performance of the material. This information should then be presented in Technical Data sheets, Codes of Practice etc with as much information as possible being disseminated to as wide an audience as possible.

- The supplier should be prepared to take part in trials to establish the suitability of the product for the proposed application. Examples include the BBA/HAPAS system and the Highways Agency’s system for assessing new materials for use in pavement layers (see Chapter 7.3.3).

Box 9.6 Bemersley tip access road

A trial was undertaken using incinerator bottom ash (IBA) on the Bemersley Tip access road in Staffordshire. It was used as the coarse aggregate in a cement bound sub-base/roadbase and also in the bitumen bound basecourse/wearing course, a stone mastic asphalt (SMA), with 30% IBA as the coarse aggregate. This trial was undertaken in a partnership consisting of:

- Ballast Phoenix Ltd.
- Aggregate Industries Ltd.
- JDM Midlands Ltd. (SCC Highways Term Maintenance Contractor).
- MES Environmental Ltd. (Operators of the Hanford Waste to Energy Plant).
- Staffordshire County Council Development Services Department.
- Staffordshire County Council Waste Management Services.
- Stoke-on-Trent City Council Waste Management Department.

The project was initiated by MES and Ballast Phoenix, who suggested to Staffordshire County Council that the treated bottom ash from the incinerator would be suitable for use in roads under the jurisdiction of the Local Authority. Many problems were encountered in the trial such as the complexities of interdepartmental collaboration, and developing the correct mixtures and procedures for construction with the material. These problems required perseverance from all concerned but were rewarded by the successful completion of the project. IBA has subsequently been used in other roads in Staffordshire (Case Study 3 and Plate 8).

9.3.5 Environmental concerns, licensing and exemptions

- Environmental concerns can be addressed by means of leaching tests and risk assessments, as indicated in Chapter 4.4. To alleviate any environmental and human health risks the supplier should undertake a risk assessment to identify sources of possible hazards, identify pathways along which the hazard may migrate and receptors on which any potentially hazardous substance may impact. This should include any production process for the alternative/recycled material and the possible future use of the material (Box 9.7).
An exemption from licensing as a waste is provided by Regulation 17 of the 1994 Waste Management Licensing Regulations. For an activity to be exempt it must satisfy the specific exemption requirements, a number of general requirements and certain environmental objectives. There are 45 categories of exemption, which generally relate to storage or treatment by the waste producer or other treatments that enable reuse or recovery of the waste. Some exemptions also apply for certain construction and engineering works. Most exemptions are subject to types and quantities as indicated in Chapter 4.5.

The exemptions only apply if the activity does not endanger human health or harm the environment such as polluting water, soil or air, endanger plants or animals, cause noise or odours or adversely affect the countryside. These exemptions are designed to encourage the reuse of materials and limit the use of virgin material and should therefore be utilised as fully as possible (Box 9.8).

The material supplier should determine if the material is classified as a waste by reference to Part II of Schedule 4 of the 1994 Waste Management Licensing Regulations (SI 1994 No. 1056), DoE Circular 11/94: Waste Management Licensing – Framework Directive on Waste. Some examples of the classification of materials used in transport structure renewal works are given in Table 7 in Chapter 4.5.

Box 9.7 Use of IBA

Discussions have been held between Ballast Phoenix Ltd and the Environment Agency with regard to the use of Incinerator Bottom Ash (IBA). The discussions cover bound and unbound applications of IBA, conditions of handling and storage, testing protocols and take into account the vulnerability of any underlying aquifer. It is intended that the discussions lead to the production of a Guidance Document on the use of IBA in construction. This could be used as a basis for documents on the use of other materials and processes.

Box 9.8 Recycled aggregates factory

An example of the methods employed to address environmental factors is given by the recycled aggregate factory constructed by Day Aggregates in an urban setting. The processing plant was enclosed in an acoustic clad building with integral dust suppression, whilst camouflaging and landscaping reduced the visual impact of the plant.

If waste is redeposited on the same site from which it was derived then a waste management licence is required unless exemptions apply.

When there is the possibility that a waste licence/exemption is required for an application of a material it is important to make contact with the licensing authority at the earliest possible opportunity. A partnership arrangement between the supplier and contractor may assist in making all parties aware of the need for a licence/exemption and permit an earlier dialogue with the environmental regulator.

The material supplier should persevere when confronted by the constraints imposed by the increasing amount of licensing and regulations that apply to alternative/recycled materials (Box 9.9).

9.3.6 Specifications

Where there is a recipe specification that does not specifically mention alternative/recycled material, the...
Box 9.9 British Waterways use of dredgings

British Waterways (BW) has a statutory obligation to dredge the River Trent to maintain it for navigation. Downstream from Nottingham to below Cromwell Lock, about 62km (39 miles), the dredgings are natural sands and gravels (Trent gravels). About 100,000 tonnes of dredgings are produced each year on this stretch.

In the past, the dredgings were tipped into old sand and gravel pits beside the river. However, British Waterways (BW) needed to secure alternative disposal routes for its dredgings, as its disposal sites were becoming full and it was having to pay others to dispose of the dredgings. Since 1996, the dredgings have been processed by aggregate companies and sold for use in construction. The old dredging tips have also been reworked. Most of the sand and gravel is used for concrete production, and some is used as unbound granular material.

Agreement was reached with the Environment Agency (EA) that the sand & gravel dredgings should not be classified as a directive waste (previously controlled waste under UK law), and hence a waste management licence (WML) is not required for the processing operations. It took two years of negotiations to reach agreement, as legal opinions had to be obtained because all dredgings are technically classified as industrial waste (a subdivision of directive waste), and a WML was required for all sites where dredgings were deposited.

Plate 9 Pit for dredgings at Cromwell Lock, river Trent. Processing plant and recycled gravels in background

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Box 9.10 Leeds City Council

The Highway Services unit of Leeds City Council (LCC) annually produces 40,000t of waste, three-quarters of this is bituminous material and concrete. This material is crushed, screened and recycled as sub-base material. LCC would only accept this as Type 2 material, because it did not comply with the material type in the specification for Type 1 material. However, trials indicated that the performance of the material was as good as natural Type 1 sub-base. A joint venture company was formed in 1966 between LCC DLO and an Earthworks contractor to produce and market the material. After further trials, and the DLO agreeing to take the risk if failure should occur, the material was accepted as ‘fit for purpose’ Type 1 sub-base by LCC.

There are other cost and environmental benefits in this arrangement as the vehicles taking the waste to the recycling plant can deliver recycled material on their return journey.

See also Case Study 12, Recycling Plant at Newhaven.

- To avoid delays in projects due to the time required to obtain departures from the specification, suppliers should offer technical guidance on the use and performance of their materials. The use of Codes of Practice for various materials such as those produced by UKQAA for the use of pulverised fuel ash (pfa) and granular material treated with fuel ash (GFA) have been found to be beneficial in this context. This allows the contractor/designer to determine early in the planning stage of a project whether a departure to the specification is required and therefore to make an application as early as possible.

- Where a material has a proven track record, evidence of this may be used to reduce the time required in preparing the departure application. It is therefore important that the supplier disseminates all available information on the material as widely as possible, to ensure that infrastructure owners, designers, specifiers and contractors are aware of the technical data on any specific material.
9.3.7 Planning permission for recycling centres

- The government have published good practice guidance on ‘Controlling the environmental effects of recycled and secondary aggregates production’ (DETR, 2000c). This includes assessment of the environmental impacts of these sites and details of mitigation measures that can be employed. Any application for planning permission for a recycling centre should be in accordance with this document.
10 RESEARCH COMMUNITY

10.1 Introduction

The research community in relation to transport infrastructure and recycling includes the following groups:

Organisations that fund research programmes, individually and collaboratively:

- Aggregates levy sustainability fund (from 2002).
- British Waterways.
- Construction industry.
- Development Agencies.
- Devolved Administrations.
- Earth and Physical Sciences Research Council.
- Environmental regulators.
- Highways Agency.
- Government Departments.
- Landfill Operators (landfill tax credit scheme).
- Local Authorities.
- London Underground.
- Railtrack.

Organisations that manage research programmes:

- Construction Industry Research and Information Association (CIRIA).
- Environmental Bodies licensed by ENTRUST under the landfill tax credits scheme.
- Professional Institutions.

Organisations that carry out research on behalf of the above organisations:

- Building Research Establishment (BRE).
- Consultants and contractors.
- Hydraulics Research.
- Institute of Hydrology.
- TRL Limited (Transport Research Laboratory).
- University Departments.
- Water Research Centre.
- Other organisations.

10.2 Issues

- Lack of consistent funding to enable research groups to be maintained.
- Government preference for industry-led projects has left research organisations isolated.
- Need for fundamental research and for field trials to enable new materials and methods to be properly assessed.
- Lack of uptake of existing research outputs by industry.
- Need for work on performance specifications and analytical design methods.
- Need for good baseline data on current arisings and usage of alternative materials.
- Dissemination of research findings.

Available guidance is summarised below and further suggested actions to increase recycling are given in Chapter 11.7.

10.3 Available guidance

- The aims and objectives of the Construction Research and Innovation Programme are set out in the Annual Report 1999/2000 (DETR, 2000d). The programme is based on supporting the policies of Rethinking Construction and Sustainable Construction (Chapter 2). ‘Both aim to bring about radical change and continuous improvement in the way the construction industry goes about every aspect of its business.’ The research programme is delivered largely through the Partners in Innovation (PiI) programme, which holds an annual competition for proposals in specific priority areas and an open call for proposals that would help to develop the underlying aims of Rethinking Construction and sustainable development. The present project is part funded under the PiI scheme.

- With the reorganisation of government departments in June 2001, responsibility for the Construction Research and Innovation programme has been taken over by the Department of Trade and Industry (DTI).

- The PiI scheme is collaborative, with government putting up no more than 50% of the cost. There is a preference for projects to be industry led, with research organisations employed to carry out the work. However, to date industry has often been slow to take the lead, and has more often responded to ideas put forward by research organisations.

- Collaborative projects with industry can also be funded under the LINK scheme, funded jointly by government.
and EPSRC. This is designed for technologies that are near-market and require further work to be suitable for routine commercial use.

- A new scheme, WRAP, has been established to promote recycling and reprocessing (Chapter 5.4). The research aspects of WRAP will focus on understanding the waste stream, materials engineering, identifying gaps and commissioning projects to meet them and managing information overload. The exact shape of the research programme is not known as yet, but should offer opportunities for research organisations that can adapt to address these issues.

Plate 10 The cyclic load triaxial test apparatus: an example of a laboratory performance test
PART 3 RECOMMENDED ACTIONS

Plate 11 Deep in-situ recycling of highway pavements: the ‘linear quarry’
(Photograph courtesy of Colas Ltd.)
11 RECOMMENDED ACTIONS FOR STAKEHOLDERS

11.1 Prioritisation

In the following sections the recommended actions for each stakeholder group are summarised and assessed in terms of their relative priority, timescale and the nature of the action. All of these terms are relative, and to some extent subjective, but they are included to give an indication of the relative importance of each topic. The terms are used as they apply to each stakeholder group. The terms are described below:

Priority
- First: These are qualitative judgements from the point of view of the stakeholder concerned and are not an indication of absolute priority; all the actions are important.
- Second
- Third

Timescale
- Short: In next two years.
- Medium: In next five years.
- Long: Likely to continue for over five years.

Nature
- Change legislation: Requires change to legislation.
- Specific action: New action required.
- Good practice: Existing guidance is available.

The actions have been arranged in the following sections by order of priority, with timescale and nature used for further ranking in the order shown above. Thus if two actions are of the same priority, the one with the shorter timescale will generally be ranked above the other. If both priority and timescale are the same, the nature of the action is used to differentiate; thus an action requiring a specific action is ranked above one which merely requires good practice to be followed. Changing legislation is an option only open to Government and Regulatory Authorities.

The actions set out an agenda for change that would remove many of the principal barriers to recycling in transport infrastructure, and would thus contribute more effectively to sustainable construction. Many of the issues require action by more than one stakeholder if progress is to be achieved. It is important that all stakeholders address these issues and move forward on a collaborative basis.
## 11.2 Government

### Recommended actions

<table>
<thead>
<tr>
<th><strong>First priority</strong></th>
<th><strong>Timescale</strong></th>
<th><strong>Nature</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Review exemptions system for waste management licensing to encourage the use of recyclable materials in construction applications such as transport infrastructure and discourage them being sent to exempt sites and landfills.</td>
<td>Short term</td>
<td>Change legislation</td>
</tr>
<tr>
<td>Give clearer guidance on the definition of waste.</td>
<td>Short term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Extend the WRAP initiative to maximise the amount of recycling in transport infrastructure and other construction applications.</td>
<td>Short term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Ensure baseline survey of aggregates for 2001 obtains comprehensive and reliable data, using experience from recent surveys.</td>
<td>Short term</td>
<td>Specific action</td>
</tr>
</tbody>
</table>
| Set targets for recycled aggregates in revision of MPG6 that are reasonable and achievable, taking note of:  
  (i) decline in availability of materials such as steel and blastfurnace slag;  
  (ii) long term trend of overall decline in aggregate consumption;  
  (iii) limits on availability of alternative materials. | Short term | Specific action |
| In view of the above, consider setting targets as a percentage of the total aggregate production. | Short term | Specific action |
| Support innovative, industry-led research in new materials and methods using the Partners in Innovation (PII) and other programmes. | Short term | Specific action |

<table>
<thead>
<tr>
<th><strong>Second priority</strong></th>
<th><strong>Timescale</strong></th>
<th><strong>Nature</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop ways of disseminating best practice and guidance to sectors of industry, which have been slow to respond to existing guidance.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Support research programmes that encourage dissemination of best practice. Reinstate the Aggregates Advisory Service, possibly using the Sustainability Fund set up under the aggregates levy scheme.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Ensure environmental regulators have sufficient funding to undertake education and liaison with the construction industry as a means of achieving objectives of sustainable construction.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Introduce targets for recycling in all government contracts.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Review Waste Management Licensing Regulations to develop a more proportionate regulatory regime, particularly for activities with a lesser pollution potential which are trying to encourage waste recycling.</td>
<td>Long term</td>
<td>Change legislation</td>
</tr>
<tr>
<td>Liaise with Environmental regulators to ensure policies on environmental protection and sustainable construction do not conflict.</td>
<td>Long term</td>
<td>Good practice</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Third priority</strong></th>
<th><strong>Timescale</strong></th>
<th><strong>Nature</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Review the Construction Best Practice Programme and Movement for Innovation to see if changes are necessary to reach untouched sectors of industry.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
</tbody>
</table>
### 11.3 Regulatory authorities

<table>
<thead>
<tr>
<th>Recommended actions</th>
<th>Timescale</th>
<th>Nature</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>11.3.1 Environmental authorities</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>First priority</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liaise with government in review of the exemption system to ensure that it does not discourage the use of alternative materials in construction.</td>
<td>Short term</td>
<td>Change legislation</td>
</tr>
<tr>
<td>Continue to work with government and industry to develop sustainable construction, through initiatives such as the Construction Campaign launched in March 2001. Consult on how best to reach the sectors of industry, which have not responded to previous initiatives.</td>
<td>Short term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Undertake greater liaison with industry and increase role of training and raising awareness, in order to improve the environmental performance of industry</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Ensure a uniform approach is taken by EA staff in dealing with applications for waste management licences and exemptions in accordance with the Process Handbook</td>
<td>Long term</td>
<td>Good practice</td>
</tr>
<tr>
<td>Continue to enforce standards at landfill sites, exempt sites and recycling centres. Liaise with government and the devolved administrations for funding to carry out this work.</td>
<td>Long term</td>
<td>Good practice</td>
</tr>
<tr>
<td><strong>Second priority</strong></td>
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<tr>
<td>Develop guidance documents for the use of alternative materials with producers, similar to that currently under discussion for IBA.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Monitor the speed of dealing with applications for licences and exemptions and attempt to increase this as far as possible, consistent with the statutory requirements. Use ‘shell’ licences for simple applications.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Liaise with government to develop a more proportionate regulatory regime, particularly for activities with a lesser pollution potential which are trying to encourage waste recycling.</td>
<td>Long term</td>
<td>Change legislation</td>
</tr>
<tr>
<td>Continue to support research on environmental and sustainability issues. This will often be in collaboration with bodies such as CIRIA, universities, government departments and devolved administrations</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Review training for EA staff to ensure that all staff are aware of EA position and policies</td>
<td>Long term</td>
<td>Good practice</td>
</tr>
<tr>
<td><strong>Third priority</strong></td>
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</table>
Improve the EA website to make it easier to find guidance  
Continue to participate in networks and support groups to encourage recycling  
Liaise with industry and stakeholders prior to construction and at the early stages of major projects

<table>
<thead>
<tr>
<th>11.3.2 Planning authorities</th>
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</thead>
<tbody>
<tr>
<td><strong>First priority</strong></td>
</tr>
<tr>
<td>Assess individual applications for recycling centres using guidance and research carried out by government and the devolved administrations</td>
</tr>
<tr>
<td>Short term</td>
</tr>
<tr>
<td><strong>Second priority</strong></td>
</tr>
<tr>
<td>Develop Unitary Development Plans, Mineral Local Plans and Waste Local Plans to ensure adequate provision of facilities for the production of recycled and secondary aggregates.</td>
</tr>
<tr>
<td>Medium term</td>
</tr>
<tr>
<td><strong>Third priority</strong></td>
</tr>
<tr>
<td>Inspect sites to ensure they are complying with the conditions of the planning permission.</td>
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<tr>
<td>Long term</td>
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</tbody>
</table>
# 11.4 Infrastructure owners and operators

<table>
<thead>
<tr>
<th>Recommended actions</th>
<th>Timescale</th>
<th>Nature</th>
</tr>
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<tbody>
<tr>
<td><strong>11.4.1 Development and implementation of specifications</strong></td>
<td></td>
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<tr>
<td><strong>First priority</strong></td>
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<tr>
<td>Develop performance-based specifications, which remove the focus from the origin of the materials to ‘fit for purpose’.</td>
<td>Long term</td>
<td>Specific action</td>
</tr>
<tr>
<td>This would also reduce the need to constantly update specifications when a new material or process is developed.</td>
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</tr>
<tr>
<td>The time required to obtain departures from specifications needs to be kept to a minimum.</td>
<td>Short term</td>
<td>Specific action</td>
</tr>
<tr>
<td>The Highways Agency should consider establishing a system for accessing information in SPECLIB concerning materials not yet in the Specification for Highway Works. This would assist in reducing the time required to obtain departures from the SHW.</td>
<td>Short term</td>
<td>Specific action</td>
</tr>
<tr>
<td>HD35/95 and BS6543, although very useful for the materials mentioned, make the acceptance of materials not included in these documents more difficult. Documents such as these need to be updated on a more regular basis. Information on innovative materials needs to be passed to the Overseeing Organisations to keep them informed of developments.</td>
<td>Long term</td>
<td>Good practice</td>
</tr>
<tr>
<td><strong>11.4.2 Economics</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>First priority</strong></td>
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<td></td>
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<tr>
<td>Consider the whole life costs of options, not just the initial capital cost.</td>
<td>Short term</td>
<td>Good practice</td>
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<tr>
<td>Ensure a fair comparison is made between new methods of recycling and conventional treatments</td>
<td>Long term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Schemes should be evaluated on sustainability criteria including any environmental impact.</td>
<td>Long term</td>
<td>Good practice</td>
</tr>
<tr>
<td><strong>11.4.3 Reliability and quality control</strong></td>
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<tr>
<td><strong>First priority</strong></td>
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<td></td>
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<tr>
<td>Include requirements for a quality control system for materials, such as that in BR392, in tender documents.</td>
<td>Short term</td>
<td>Specific action</td>
</tr>
<tr>
<td><strong>Second priority</strong></td>
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<tr>
<td>When new materials/processes are being considered, demonstrate that they are capable of complying with the specification by carrying out trials.</td>
<td>Long term</td>
<td>Good practice</td>
</tr>
</tbody>
</table>
### 11.4.4 Others

**First priority**  
Allow sufficient time to obtain waste management licences and exemptions in the programme for the works. Note there is a minimum statutory consultation period of 28 days in the legislation.  
Adopt partnering approach to allow maximum use of innovation on projects; ensure all parties have a stake in the success of the project.  
Adopt the principles of sustainable construction wholeheartedly; buy into the whole process, do not look at it merely as a way of obtaining cost savings. Use sustainability criteria in tender assessment.

<table>
<thead>
<tr>
<th>Priority</th>
<th>Timeframe</th>
<th>Specific action</th>
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<tbody>
<tr>
<td>First priority</td>
<td>Short term</td>
<td>Specific action</td>
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<tr>
<td>Second priority</td>
<td>Medium term</td>
<td>Good practice</td>
</tr>
<tr>
<td>Third priority</td>
<td>Long term</td>
<td>Specific action</td>
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</table>

**Second priority**  
Make policies to increase recycling in the activities of the organisation, develop relevant key performance indicators, set sensible targets and monitor progress.  
Support underpinning and strategic research to develop new materials and methods, and to address fundamental problems in understanding the behaviour of materials (e.g. performance specifications).  
Ensure conditions of contract do not discriminate against new materials or methods. Avoid excessive warranties or liquidated damages, which will stifle innovation.

**Third priority**  
Participate in networks to share experience on recycling, such as the Movement for Innovation (M4I) and the Construction Best Practice Programme (CBPP).

<table>
<thead>
<tr>
<th>Priority</th>
<th>Timeframe</th>
<th>Specific action</th>
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<tbody>
<tr>
<td>Second priority</td>
<td>Long term</td>
<td>Specific action</td>
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<tr>
<td>Third priority</td>
<td>Long term</td>
<td>Specific action</td>
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<td></td>
<td>Medium term</td>
<td>Specific action</td>
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</tbody>
</table>
### 11.5 Contractors and designers

<table>
<thead>
<tr>
<th>Recommended actions</th>
<th>Timescale</th>
<th>Nature</th>
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<tbody>
<tr>
<td><strong>First priority</strong></td>
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</tr>
<tr>
<td>Respond to consultations on documents such as the revision to MPG6.</td>
<td>Short term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Encourage suppliers to adopt robust quality control systems to ensure consistency and quality of product. Do not use suppliers who cannot provide a quality assured product.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Develop partnering relationships with clients, subcontractors and suppliers. Get input from all parties as early as possible in the life of a project to maximise the opportunities for innovation and recycling.</td>
<td>Long term</td>
<td>Good practice</td>
</tr>
<tr>
<td>Liaise with the Environmental regulators as early as possible in the life of a project to establish procedures for site that will avoid problems later, and to assess the position with regard to the use of alternative materials and requirements for waste management licences or exemptions.</td>
<td>Long term</td>
<td>Good practice</td>
</tr>
<tr>
<td><strong>Second priority</strong></td>
<td></td>
<td></td>
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<tr>
<td>Encourage clients to include options for recycling and use of alternative materials in tender documents, and to ensure a fair comparison is made with conventional methods and materials.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Use new design methods and performance based specifications where technically feasible to maximise the use of site won/alternative/recycled materials.</td>
<td>Long term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Maximise the reuse of recycled products in the highest product value available, not just as low grade materials, e.g. blacktop planings as reclaimed bituminous material not just as capping.</td>
<td>Long term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Raise awareness of successes in recycling by disseminating information to clients and regulators with regard to new materials, processes and applications.</td>
<td>Long term</td>
<td>Specific action</td>
</tr>
<tr>
<td><strong>Third priority</strong></td>
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<tr>
<td>To enhance the cause of alternative materials/recycling a unified approach should be adopted by the construction industry and this should be presented to Government through one body.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Participate in networks such as the Movement for Innovation (M4I) and the Construction Best Practice Programme (CBPP).</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Support underpinning and strategic research into material properties, performance specifications and innovative methods of recycling.</td>
<td>Long term</td>
<td>Specific action</td>
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</tbody>
</table>
### 11.6 Material producers

<table>
<thead>
<tr>
<th>Recommended actions</th>
<th>Timescale</th>
<th>Nature</th>
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<tbody>
<tr>
<td><strong>First priority</strong></td>
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<tr>
<td>Respond to opportunities to discuss documents such as MPG6, which are open to public consultation.</td>
<td>Short term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Liaise with the Environmental regulators to develop guidance documents for the use of individual materials.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Develop and enforce quality control systems for all alternative/recycled materials as per BR 392.</td>
<td>Medium term</td>
<td>Good practice</td>
</tr>
<tr>
<td>Submit Applications for planning permission for recycling centres in accordance with published guidance (DETR, 2000c).</td>
<td>Medium term</td>
<td>Good practice</td>
</tr>
<tr>
<td><strong>Second priority</strong></td>
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<tr>
<td>Adapt and improve the processing of alternative materials to give materials that are fit for higher value end uses as well as general fill.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Raise awareness of successes in recycling by disseminating information to as many people as possible with regard to new materials, processes and applications.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Liaise with central and local government to encourage the use more of recycled material.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Enter into partnering arrangements with contractors and clients. Respond to initiatives on supply chain management and continuous improvement. Look for opportunities to develop innovative uses of alternative materials.</td>
<td>Medium term</td>
<td>Good practice</td>
</tr>
<tr>
<td>Support underpinning and strategic research into material properties, performance specifications and new methods of recycling.</td>
<td>Long term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Offer trials for new materials and methods to establish their fitness for purpose.</td>
<td>Long term</td>
<td>Good practice</td>
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<tr>
<td><strong>Third priority</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participate in networks such as the Movement for Innovation (M4I) and the Construction Best Practice Programme (CBPP).</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>To enhance the cause of alternative materials/recycling a unified approach should be adopted by the construction industry and this should be presented to Government through one body.</td>
<td>Long term</td>
<td>Specific action</td>
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### 11.7 Research community

<table>
<thead>
<tr>
<th>Recommended actions</th>
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<tbody>
<tr>
<td><strong>First priority</strong></td>
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<tr>
<td>Research organisations need to adapt to changing customer requirements. This will increasingly involve working with industry and infrastructure owners to identify problems and ways of solving them, rather than depending on direct government funding.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>The role of dissemination, education and training needs to be emphasised in research organisations and pointed out to funders. These are functions that research organisations are well placed to carry out, but which have often been neglected in favour of further research. Lack of awareness is one of the main factors holding back the amount of recycling in transport infrastructure.</td>
<td>Medium term</td>
<td>Specific action</td>
</tr>
<tr>
<td>Lead the way forward rather than follow current practice</td>
<td>Long term</td>
<td>Specific action</td>
</tr>
<tr>
<td><strong>Second priority</strong></td>
<td></td>
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<tr>
<td>At the same time, the research community should liaise with government to ensure that fundamental science is not squeezed out by the current emphasis on commercial development and dissemination. Fundamental research is the seedcorn for future innovation.</td>
<td>Long term</td>
<td>Specific action</td>
</tr>
<tr>
<td>As research becomes increasingly multi-disciplinary in nature, it will be necessary to work collaboratively with other organisations to provide the best team for each project.</td>
<td>Long term</td>
<td>Specific action</td>
</tr>
<tr>
<td>The research community should liaise with government to invest in long term research programmes in order to safeguard the research base in the UK. The current emphasis on short term, competitive contracts is in danger of reducing the research community to a fraction of its former size, with the loss of many of its best researchers.</td>
<td>Long term</td>
<td>Specific action</td>
</tr>
</tbody>
</table>
12 REFERENCES

12.1 General


Highways Agency, The Scottish Executive Development Department, The National Assembly for Wales and the Northern Ireland Department for Regional Development:


12.2 British Standards


12.3 CIRIA Reports


12.4 TRL Reports


APPENDIX A: CASE STUDIES

Plate 12 Recycling construction and demolition waste
(Photograph courtesy of Balfour Beatty Major Projects)
CASE STUDY 1: BAA PAVEMENT TEAM

Project summary

The Pavement Team is a group with representatives from all the organisations involved in the new construction and renewal of pavements at airfields owned by the British Airports Authority (BAA). BAA work in partnership with contractors and suppliers to effect continuous improvement in their processes and operations throughout the supply chain. BAA has a partnership agreement with AMEC who in turn have partnerships with their main suppliers, such as Lafarge Aggregates for blacktop surfacing and Topmix for cement.

The system has developed over the years with an initial agreement set up for a 5-year period. The partnership works across Heathrow, Gatwick and Stansted. Wherever possible, recycled material such as concrete is collected at each airport for future use. This has led to some projects benefiting from recycled material produced on other projects. By looking at the recycling costs on a global basis, the benefits of recycling are clearly seen by BAA.

Prior to the Framework agreement, broken out concrete was recycled on the project where it was produced or removed from the airport, either to landfill or for crushing and reuse elsewhere, often as hardcore. However since the start of the Pavement Team in November 1995 all ‘waste’ concrete, including test cubes, has been crushed on the airport and reused on the airport. A managed stockpile area has been established at each airport for storing broken out and waste concrete. When there is sufficient quantity a concrete crusher is brought to site, the material crushed to a specification and stockpiled for reuse.

The long-term nature of the Framework has allowed a rolling programme to be established whereby surplus from one project is used on a following project. The controls now in place enable BAA to forecast availability of material and plan its use in the most beneficial manner.

Since the start of the Framework agreement, BAA have recycled approximately 210,000 tonnes of concrete, with a total estimated cost saving of £1.8m, which has resulted in a reduction of 42,000 lorry movements amounting to 1.85 million road miles.

Drivers

- There are two main drivers for BAA towards waste minimisation and recycling:
  a. Cost savings, amounting to approximately £1.8m as discussed above.
  b. Improvement in environmental performance. BAA sets key performance indicators (kpi) and targets for its own environmental performance and for its contractors and suppliers.

Problems and solutions

- Working on a project by project basis proved to be a barrier to recycling as each project was tendered and let to a separate contractor. Partnering with a consistent supply chain over a period of time and across a large number of projects has enabled recycled materials to be collected and utilised on a whole airport basis.
- Storage of recycled materials for use on future projects was a potential problem. However, utilising common resource areas such as batcher compounds has led to this being overcome without difficulty.

Benefits

- These have been both financial and environmental as indicated above.

Lessons learnt

- BAA will continue improving its waste minimisation and recycling practices in line with the Egan Report on Rethinking Construction. The procedures have changed and developed over time, as would be expected in a continuously improving process.
- There have been few intractable problems with recycling; though with some environmental issues there can be a problem in demonstrating cost savings. Changes are likely to be approved if savings are shown on a whole life cost basis even if the immediate costs are higher.
CASE STUDY 2: BEMERSLEY TIP ACCESS ROAD

Project summary

Staffordshire County Council (SCC) required a new access road for a Household Waste Recycling Centre at Bemersley Landfill, north of Stoke-on-Trent. The road was 150m in length and ran across in part an existing landfill site. The opportunity was taken to use the road as a trial for the use of recycled materials. Recycled highway maintenance arisings provided by SCC Development Services Department in partnership with John Doyle Midlands (JDM) was used as capping material and as embankment fill. The Sideway Waste to Energy Transfer plant in Hanford, Stoke-on-Trent, supplied Incinerator bottom ash (IBA) which was used as the aggregate, in bound form, for the sub-base/roadbase and provided 30% of the aggregate used in the wearing/base course. With the exception of cement, bitumen and the remaining 70% of the aggregate in the wearing/base course, the road was constructed entirely from recycled materials. An extension to the area of hardstanding in the Household Waste Recycling Centre was also constructed using the same materials.

The road and extension to the hardstanding area were constructed in November 1999, in very poor weather conditions. 1,700 tonnes of highway maintenance arisings and 2,000 tonnes of IBA were used. The IBA from Hanford was transported to Castle Bromwich incinerator, where it was screened and graded to a maximum particle size of 20mm. Non-ferrous metals were removed at this stage, the ferrous metals having been largely removed at Hanford. The processed material was then transported to Bemersley, where a batching plant had been set up to provide the cement bound material.

Because the road was to be used as an access to an improved household waste recycling centre, SCC had to modify the site licence for the Civic Amenities Site from the Environment Agency (EA). Various ancillary works necessary to comply with planning requirements were also carried out before the road was due to open in November 2000. The EA required SCC to install an impermeable HDPE membrane before construction of the road.

The area of hardstanding has received daily wear and tear involving HGV movements and 18-20 tonne skips being loaded, unloaded and dragged along the surface. The durability of the material is highly satisfactory. Cores have recently been taken from the cement bound sub-base material in the road and indicate that the gain in strength is satisfactory.

Drivers

- The Waste Strategy 2000 for England and Wales set out statutory targets for Local Authorities for recycling and reduction of biodegradable municipal waste going to landfill (Agenda 21 targets). In order to meet these targets, some LAs will need to construct Waste-to-Energy plants. Utilisation of the bottom ash maximises the benefits of this approach and takes the process up the waste hierarchy.
- At present the IBA is sent to landfill, incurring transport costs, landfill tax and using up valuable airspace in landfill sites. By using IBA, income is generated turning it into an asset rather than a liability.
- Use of IBA preserves natural assets for future generations and reduces the impact of quarrying on the landscape and on the highway network. This is important, as tourism also contributes significantly to the local economy.

Problems/challenges

- A partnership group was formed to construct the road, comprising:
  - SCC Development Services Department.
  - SCC Waste Management Services.
  - Stoke-on-Trent City Council Waste Management Department.
  - Ballast Phoenix Ltd.
  - Aggregate Industries Ltd.
  - MES Environmental Ltd. (Hanford Waste to Energy Plant Operator).
  - JDM Midlands Ltd. (SCC Highways Term Maintenance Contractor).
- Translating the vision into reality required a considerable amount of interdepartmental co-operation. In particular, it had to be accepted by all parties that the global advantages of the project were more important than the apparent immediate advantages, or lack of them, to their own organisation.
Particular site difficulties arose because the construction was at a landfill site, where there was a perceived risk of spontaneous combustion. Neighbours expressed their concerns to the partnership.

The IBA had a moisture content on site, which was well in excess of optimum. This problem was exacerbated when the lorries, transporting the material to and from Castle Bromwich, were left unsheeted, and torrential rain caused a further increase in moisture content to uncovered stockpiled material on site.

A problem specific to this site was that the Site Licence for the Civic Amenities Site had to be modified because of the construction of the road.

**Solutions**

- Dealing with the complexities of interdepartmental co-operation, Environment Agency (EA) requirements and problems during construction required perseverance on the part of all concerned.
- The incorporation of a special liner, an impermeable membrane, satisfied the EA’s concerns about migration of landfill gas from the tip and also of any leachate from the road into the tip as a result of construction of the road.
- Better quality control of the moisture content would have resulted in the material being easier to handle and screen, resulting in a better-graded material and would have allowed use of a lower cement content. Sheetimg the lorries would have been beneficial in allowing less water into the material.

**Benefits**

- The project resulted in reduced costs when viewed on a corporate basis to SCC, although costs were increased in some departments due to the work involved in setting up the project, designing, constructing and testing the road.
- The project showed that the IBA could be used as cement bound and bitumen bound material in road construction.
- The IBA was changed from a liability to an asset.
- The total IBA production from Hanford is 60,000 tonnes per year. If all this material were used in construction it would make a noticeable reduction in the quarrying of primary aggregates.

**Lessons learnt**

- Persevere: break down barriers, don’t be put off by difficulties.
- In the course of the trial, a great deal was learned about the characteristics of the material and how it should be processed to achieve the best results, especially to control the moisture content.
- Process locally: it is proposed to set up a processing plant for the IBA from Hanford close to the incinerator. This would avoid the transport costs to Castle Bromwich and back.
- Look at experience elsewhere: IBA is regularly used as bulk fill in the Netherlands and France.
- The trial has successfully demonstrated that IBA can be used in road construction, resulting in benefits to all parties.
CASE STUDY 3: BURNTWOOD BY PASS

Project summary
Staffordshire County Council (SCC) is funding the construction of the Burntwood By Pass, which is being constructed in partnership with Wrekin Construction Ltd. SCC are also responsible for disposing of the ash from Sideway Incinerator Plant. This is currently sent to land fill sites at a cost of £400k per annum, comprised of haulage and tipping costs and landfill tax. Consequently, a specification was written for granular material treated with fly ash (GFA), using incinerator bottom ash (IBA) as the granular material. This was used for the construction of a spur, from the Burntwood By Pass, for access to the Rugby Club. The use of GFA was included in the general specification but not in Appendix 7/1 as an option. The contract generally required the contractor to use environmentally friendly methods; part of the contract was a requirement for the contractor to report the amount of recycled materials used in the whole of the works. UKQAA’s Technical Data Sheets were used for the material requirements and design. After the award of the Burntwood By Pass contract, Wrekin Construction Ltd offered the GFA option as an alternative construction on the main carriageway. There were no technical arguments on the principle of the use of GFA only on agreeing the detail specification i.e. the mix design. The use of GFA was accepted because of environmental as well as economic benefits.

The scheme is approximately 1.5km long and is a wide single carriageway construction. The scheme requires approximately 14.5k tonne of GFA, the construction being 40mm of stone mastic asphalt on 90mm of bituminous basecourse, on two layers of GFA with a total thickness of 350mm constructed on 350mm of capping material. The bulk of the capping came from demolition waste i.e. brick hardcore supplied by a local recycling contractor involved with utility arisings. The GFA mix was 82% IBA from Ballast Phoenix, 15% pfa from TXU Ironbridge power station and 3% lime. Due to a shortage of suitable IBA from Ballast Phoenix, and no material being available from Sideway, approximately 3.5k tonne of planings were used to make up the shortfall in granular material.

Drivers
- The use of IBA and pfa in the GFA for the sub-base and road-base courses and the use of recycled material for the capping layer are being encouraged by SCC as these count towards their local Agenda 21 sustainability targets.
- The use of these materials frees up landfill space for other waste materials that cannot be recycled or re-used.
- If this scheme is successful then the IBA from Sideway Incinerator Plant will become an asset as opposed to a liability, as this would be suitable for use as granular material in GFA.
- A local contractor was prepared to enter into a partnership with SCC in order to establish a GFA site batching plant, again realising cost and environmental savings.

Problems
- Excessively wet weather during the contract has been detrimental to the capping layer and to the sub-base layer containing the IBA, especially during the kerb laying operation.
- The composition of the IBA granular material is variable, making acceptance by comparison to a standard density inexact.
- An initial order was placed for 8k tonnes of IBA and supplied as required. However, the supplier could not meet an additional order for 3.5k tonnes.
- In the early production stages of GFA there was some variability, this may have been due to the moisture content of the IBA, the calibration of the mixing plant, or possibly the batching of the materials.

Solutions
- Limiting the amount of exposed capping layer by laying the lower GFA layer, the sub-base, to protect it. However, this exposed the GFA to the elements.
- Increasing the amount of lime in the mix to ‘dry’ up the IBA aggregate, however, this was an expensive solution.
- Any damage to the top of the lower GFA layer from trafficking in the kerb laying operation was scraped away and a thicker upper layer laid.
- As an alternative solution, the kerbs were laid before paving and the sub-base GFA laid between the kerbs. This eliminated the trafficking on the wet GFA but was a more expensive detail.
To resolve the acceptance problem of material with variable density, the procedure used with cement bound materials of comparing with a refusal density was adopted.

Where damage occurred to the top of the upper GFA layer there were two possible solutions. If the layer could be dried out then it was recomacted by rolling, alternatively the damaged material was removed and replaced.

To make good the aggregate shortfall trials were undertaken with planings, which were stockpiled, for use as an alternative aggregate in the GFA.

To ensure that the mixing plant was using the correct weight of materials the equipment was calibrated each morning and evening and a pH check was undertaken on the GFA before being laid.

**Benefits**

The benefits of using GFA in this road construction were:

- The saving of the cost of sending the material and pfa for landfill.
- The use of ‘waste’ materials in the GFA and capping layer goes towards SCC’s Agenda 21 sustainability targets, the use of IBA was an added bonus.
- The pavement construction employed resulted in financial savings compared to other constructions.
- More competition in the market place with another material option.
- GFA can be laid with a conventional paver.
- The contractor has more control over the material as it is mixed on site.
- The material does not set immediately allowing remedial work for a longer period of time.
- Local proximity of raw materials has environmental benefits.

**Lessons learnt**

- In inclement weather it is advisable to lay short lengths of GFA such that the surfacing material can be laid quickly to reduce the exposure of the GFA to the elements.
- Ensure that materials will be available as and when required.
- Using different aggregates in the GFA presents different problems.
- In winter, GFA should be made with a more sound aggregate, such as planings rather than IBA, unless it can be promptly overlaid with the next layer.

**Plate 13** Compacting GFA on the Burntwood By Pass
*(Photograph courtesy of Staffordshire County Council)*
CASE STUDY 4: THE RECYCLED AGGREGATES FACTORY

Project summary

Day Aggregates, a London supplier of primary and secondary aggregates has recently commissioned a new ‘factory’ to produce recycled aggregates at their Purley roadstone railhead depot. The 250 tonne per hour capacity plant includes primary and secondary crushing, screening and a sorting house.

Environmental considerations were fully addressed by enclosing the processing plant in a building with acoustic cladding and integral dust suppression thus allowing the production of high quality materials on a small site (5 acres) set within a highly populated area of south east England. All the equipment is electrically operated to reduce noise and diesel emissions and all chute and transfer points are rubber lined. Dust generation is suppressed by damping with fine sprays at a number of points during the recycling process. All the surface, yard and roof run-off water and wheel-wash overflow, is harnessed and reused in the production process. The plant is camouflaged, being green on one side to blend in with embankment in the background and silver grey on the other side to match the skyline. A rising, landscaped bund bordered by sleeper walls has been built to reduce the overall effect of the height of the recycling plant and to hide the excavator feeding the plant.

The intention of the factory concept was twofold:

a) an integrated production process reduced the need for double handling material and gave flexibility to manufacture a range of finished products through one system,

b) the process had the obvious environmental benefits of a totally enclosed production unit, which enabled production to take place in a densely populated area.

The principal source material for the plant is demolition concrete but asphalt and hardcore are also processed. Typically, when processing a run of about 100,000 tonnes of demolition concrete less than one percent (750 tonnes) of steel and a tenth of one per cent (80 tonnes) of rubbish would be sorted from the raw material. Therefore 99 per cent of the raw material accepted for processing is resold as aggregate. The steel is reprocessed and only 0.1 per cent of material is sent for disposal.

To ensure a high quality final product Day Aggregates have followed the guidelines set out by the Quarry Products Association (QPA) in their quality assurance scheme, which is due to be registered under BSEN9002, and have formalised a quality control procedure as required by the QPA Quality Control Protocol. The processes used in the factory are illustrated on the flow chart below.

Drivers

- Day Aggregates were fully aware of the ever-increasing demand on the environment from aggregate quarrying and extraction and took a commercial decision to become a forerunning company in the promotion and production of recycled materials.

Problems/challenges

- The site at Purley is set in the centre of the town adjacent to the station. There were obvious concerns from the planning authorities on permitting an increase in the use of heavy duty recycling plant in a densely populated area.

Solutions

- To enable the plant to be constructed and run to the satisfaction of the planning authorities and neighbouring properties environmental controls were fully addressed as indicated above.

Benefits

- The environmental benefits were twofold:
  a) reduction in the extraction of primary aggregates;
  b) reduction in the environmental impact of the plant by adopting the ‘factory concept’ of production.

- Day Aggregates believe that reclaiming and recycling of materials will expand with the backing of Government and they made a commercial decision to play a major role in this expansion.
Lessons learnt

- Gain customer confidence by producing a quality assured material.
- Instigate strict quality control procedures to ensure a consistent supply.
- Involve planning and licensing authorities at an early stage.
- Be sympathetic to the local environment and neighbours.
CASE STUDY 5: HIGHWAY MAINTENANCE USING RECYCLING: HAMPSHIRE COUNTY COUNCIL

Project summary

Hampshire County Council (HCC) is responsible for the maintenance of 8,660km of road. These high levels of road maintenance generate large volumes of material. In 1997/98, 10,000 cubic metres of bituminous material were excavated in Hampshire. The uses to which this material was put are shown in the pie chart as follows. The corresponding figures for 2000/01 are also shown.

The figures show a large increase in the amount recycled over the three-year period. HCC has a policy to encourage waste minimisation. This coupled with government policy of increasing landfill tax and the imminent introduction of the aggregates levy encouraged the county to seek alternative solutions, particularly for the reuse of the large quantities of excavated bituminous materials which were generated from structural maintenance and patching works.

Contemporaneously the University of Ulster in partnership with Aggregate Industries Ltd was seeking sites to trial recycled materials. The objective of the trials was to determine the feasibility of increasing the amount of reclaimed asphalt pavement (RAP) permitted in hot mix applications and to trial a proprietary cold material manufactured from 100 per cent RAP.

Hot mix trial

The Specification for Highway Works current at the time of the works included clauses allowing the recycling of RAP in new mixtures at the rate of 30 per cent for basecourse and 10 per cent for wearing courses.

The site selected for the trial was a busy industrial estate at Alton. Three test sections were constructed containing 10, 30 and 40 per cent RAP in a 55/14 High Stone Content asphalt wearing course laid 45mm thick. Each of the materials was manufactured at Aggregate Industries recycling plant at Greenwich.

The trial showed that hot mix asphalt wearing course requirements could be obtained from mixtures manufactured with up to 40 per cent RAP in the mix. The measurements made in the laboratory identified no detrimental effects of high reuse levels. The only possible problem to recycling even higher levels of RAP into hot mix asphalt wearing courses was the possibility of dangerously high temperatures being generated in the mixing plant’s bag filter unit.

Cold mix trial

In 1998, Hampshire County Council decided to trial cold mix asphalt with 100 per cent RAP. The site chosen was the old A31 at Bentley, which since the construction of the Bentley by-pass had become the local access road through the village.

The work involved reconstruction of a one metre wide haunch to a depth of 450mm with some associated reconstruction over the whole width of the lane. Trial areas were constructed at either end of a control section. The cold mix material used in the trial areas was the Aggregate Industries proprietary ‘Haucphalt’ manufactured with 100 per cent HRA wearing course RAP. ‘Haucphalt’ is a stiff material with a specially developed high viscosity bitumen emulsion containing no cutting agents.

All the materials were laid satisfactorily and cores were taken for laboratory evaluation at one and six months after construction. The evaluation of the cold mix asphalt using 100 per cent RAP as the aggregate identified a significant improvement in the Indirect Tensile Stiffness Modulus (ITSM) when compared with the control lengths of hot mix asphalt. However, the density values for the hot mix asphalt were much lower than normally expected.
Drivers

- Clients such as local highway authorities are required to maximise opportunities to re-use materials and suppliers such as Aggregate Industries are keen to develop technologies to solve the client’s problem.
- With the growth of environmental awareness and the realisation that sustainable construction has to be demonstrated, local highway authorities are keen to promote improvements to the road network within the guidelines agreed at the 1992 Earth Summit in Rio de Janeiro.

Problems/challenges

- In the hot mix trial it was calculated that the recycling option was 21 per cent more expensive than the traditional inlay repair. This was largely due to the material having to be transported from Aggregate Industries depot at Greenwich because the local depot was unable to process the material.
- The cold mix trial showed that the method was 11 per cent more expensive than conventional repair methods but once again a high proportion of the added cost was due to haulage charges.
- The cold mix asphalt trial was carried out in a haunching situation in difficult working conditions, which required a large amount of hand laying in cold and wet climatic conditions. As a result the performance advantages exhibited by the cold mix material may not be achieved in all situations.
- The extraction of cores from the cold mix material was initially found to be difficult.

Solutions

- As the use of recycling becomes more accepted the number of plants available to manufacture materials containing RAP should increase and the additional haulage charges for these materials should consequently reduce.
- By careful site selection the maximum advantage of using novel materials can be achieved enabling them to outperform conventional materials.
- The coring problem was much reduced by changing from a water-cooled system to an air-cooled system.

Benefits

- The use of RAP in this highest added value method of re-use was a significant benefit in trying to achieve the Agenda 21 objectives. The environmental benefits included a reduction in the extraction of primary aggregates and a reduction of materials disposed of off-site.

Disbenefits

- The use of recycling techniques in both of the schemes described above did not result in any cost savings due to the large distances the materials were transported to use the Greenwich mixing plant.

Future recycling developments in Hampshire

- It is proposed to create a market for recycling within Hampshire. This would have the benefits of reducing the costs of these recycled materials and would also minimise landfill costs. The processes would become more cost effective and be more environmentally acceptable than conventional methods currently used.

Lessons learnt

- Currently HCC use the Highways Agency’s Specification for Highway Works. By investigating the possibility of relaxing these specifications on the county road network the demand for recycled materials could be increased.
- A relaxation on the material types that are permitted for various uses could also increase demand for secondary materials. For example HCC permit the use of crushed demolition waste (Type 3 sub-base) as an alternative to Type 1 sub-base.
- Some areas for possibly reviewing contract requirements to encourage recycling are:
  a Write into contracts that only cold lay base, manufactured from RAP, can be used in footways.
  b Hampshire’s street lighting contracts already require recycling of materials such as steel and concrete columns, cardboard and paper, plastic and lamp units. Such initiatives could be used for other contracts.
CASE STUDY 6: FOOTWAY RECYCLING

Project summary

Mineral Recycling Limited, of Leicestershire, has produced a machine for recycling bituminous footways. Material is broken out and fed into the machine with a small amount of new bitumen, where it is heated to produce a workable material. This is placed as hot mix bituminous material in the footway with no material being removed to tip. The machine takes 20 minutes to produce 1.5 tonnes of hot mix. A 3-man team carries out the work and can achieve an average of 13 mixes a day.

Leicestershire County Council (LCC) prepared a one-page guidance note for the technique. They consider that it can be used for renewing footways and for surface patching on roads. The Direct Labour Organisation (DLO) of LCC carried out a successful trial of the machine on a footway contract in November/December 2000 using the ‘strip and lay at the same time’ technique.

Drivers

- LCC encourage recycling in all their operations, as part of their strategy to achieve Agenda 21 targets for reduction of material sent to landfill.
- Economic savings compared to conventional reconstruction of pavement.
- The method minimises disturbance to residents. Conventional repairs require a length to be opened and left for some time as work progresses.

Problems/solutions

- Machine trials were required to establish that the machine would function effectively. There were no significant hold-ups as a result of these trials.

Benefits

- Minimisation of waste produced compared to conventional footway repairs.
- Minimisation of disturbance to residents during the works.
- Savings of time and money compared to conventional methods.

Lessons learnt

- LCC propose further use of the method for footway repairs and small scale patching repairs on local roads. The DLO purchased a new machine in March 2001.
- The manufacturer has developed a machine with a capacity of 2.5 tonnes, utilising information gained during the trials. The new machine is more advanced than the earlier version and has a heating and re-mixing time of between 9 and 15 minutes per load. Information gained from the use of the machines will be utilised to continuously improve the design.

Plate 14 Breaking out the old footway during the trial in December 2000, compacting recycled material in background
CASE STUDY 7: LINEAR QUARRY PROJECT

Project summary

The concept of using the existing highway as a ‘linear quarry’ from which roadstone aggregates can be reclaimed is not new. The Linear Quarry project was established to disseminate information for the highway engineer to use in the structural design, specification and procurement of works involving in-place recycling.

In the context of structural maintenance of highway pavements, the term ‘cold in-situ recycling’ refers to the techniques using specialist plant to pulverise and stabilise existing road materials, in-place, at ambient temperature, with the addition of hydraulic and/or bitumen binders. In the United Kingdom, the bitumen binder used is normally foamed bitumen and the hydraulic binder is generally Portland cement, sometimes used in conjunction with lime or PFA.

A prime objective of the Linear Quarry project was to assess the performance of road pavements containing cold, in-situ recycled material as a means of validating a structural design method. To achieve this, the performance and condition of nine in-service roads, maintained over the previous decade using cold in-situ recycling techniques, were assessed. These roads had been built over a range of ground conditions and were designed to carry traffic loadings from 2.5 to 20 million standard axles (msa). Seven of the sites used foamed bitumen as the binder and two used Portland cement for the recycled layer. Subsequently, these data were supplemented by measurements made during the construction and monitoring of two full-scale trials on the A3088 Cartgate Link Road in Somerset.

During construction of the trials, a programme of quality control and compliance testing of the materials was undertaken. Following construction, the performance of the test sections was assessed for up to 3 years.

Analysis of all the data collected during the Linear Quarry Project enabled a robust structural design methodology and specification for cold, in-situ recycling to be developed and published in TRL Report TRL386, Design guide and specification for structural maintenance of highway pavements by cold in-situ recycling. In particular, guidance is given on the appropriate use of the recycling technique, site evaluation, binder selection and structural design to reconstruct the foundation and/or structural course of a road pavement.

Although assessment of the financial benefits of the techniques was outside the brief of the project, the client believed that the process was 20 to 30 per cent cheaper than traditional reconstruction. These figures concur with work reported by the British Cement Association for in-situ recycling using cement. Furthermore, the work was carried out at twice the speed of conventional works and the excess material from the original pavement was not wasted but used for strengthening nearby rural roads or stockpiled for future use.

Drivers

- Both central and local government were keen to promote improvements to the road network within the guidelines agreed at the 1992 Earth Summit in Rio de Janeiro. The Linear Quarry Project was a partnership research enterprise by the County Surveyors Society (CSS), Highways Agency and Colas Limited. The project was client / contractor driven and TRL were commissioned to carry out the necessary research.
- Somerset County Council, the client for the Cartgate Link Road works, was particularly interested in the in-situ technique as a substitute for primary material. The detrimental effects of the quarry industry and the movement of heavy goods vehicles serving it are important local issues.

Problems/challenges

- At the Cartgate Link Road trial the depth of recycling was variable on occasions and did not comply with the draft specification, also the fabric of the stabilised roadbase material was variable in terms of binder content on occasions.
- The draft specification for the construction of the Cartgate Link Road trial required cores to be extracted from the finished material. The extraction of cores was not wholly successful and as such full compliance with the end-product performance clauses of the specification could not be met.

Solutions

- Changes in procedures, more refined use of the computer controlled settings on the recycling plant, and modifications to the specifications were all suggestions to improve the in-situ recycling technique. Subsequent to the road trials, the specification was modified to place less emphasis on the importance of extracting cores and to give a longer curing period before coring needed to be attempted. It was also found that an air-flush coring technique was superior to water-flush coring for these materials.
A move away from destructive testing to non-destructive testing – Dynamic Plate or Penetration Test has been implemented.

Benefits
The benefits include:

- Reduction in the extraction of primary aggregates;
- Reduction of materials disposed off-site;
- Reduction in the use of energy (up to 80 per cent savings);
- Reduction in the amount of construction traffic servicing the sites;
- Reduction in traffic delays and congestion from shorter duration roadworks;
- Cost savings of up to 30 per cent can be attained when compared with conventional maintenance techniques.

Future recycling developments

- The latest edition (May 2001) of the Specification for Highway Works incorporates the specification clauses given in TRL Report TRL386. This will lead to an increase in the uptake of the techniques within the UK.
- A new project known by the acronym of SMART, Sustainable MAintenance of roads using innovative cold Recycling Techniques, is being jointly sponsored by Government, CSS and Industry. The project will address hydraulic and bitumen binders used to construct flexible composite or flexible road pavements respectively with the aim of meeting three key objectives:
  a Revision of the design curves published in TRL Report TRL386 to address ‘families’ of material/binder types.
  b Development of a validation test for the as-placed material, which can form the basis of contract payment.
  c Revision of the specification published in TRL Report TRL386 to make it more permissive and less prescriptive.

Lessons learnt

- Involve procurement agencies and contractors in the planning and implementation of the works.
- Allow flexibility in the interpretation of the specification.
- Engineering judgement can solve a lot of potential problems.
- Efficient dissemination of results throughout the progress of the project helps promote the uptake of the finished product.

Plate 15 In-situ recycling in the linear quarry project
(Photograph courtesy of Colas Ltd.)
CASE STUDY 8: WASTE MINIMISATION AND SUSTAINABLE CONSTRUCTION ON THE M60

Project summary

Contract 3 of the M60 forms the final link in the motorway ring road around Manchester. The contract was awarded to Balfour Beatty in May 1998 and was completed in summer 2000. The contract, valued at £50m, was a design and build project which was undertaken on a partnering basis between Balfour Beatty, Highways Agency, the Employer’s Agent and the contractor’s designer. In early 2000 the contract was selected as a Demonstration Project for the Movement for Innovation (M4I).

The design provided with the tender showed a considerable earthworks deficit and resulting materials import. The contractor’s strategy from the outset was to redress this imbalance to minimise the impacts of offsite disposal and import. This strategy was particularly relevant considering the urban setting of the project. The key focus areas were:

- Adjustments to vertical alignment, maximising environmental bund volumes and changes to fill specifications to maximise the quantities of material to be left on site.
- Building a 1km pile supported concrete raft over a soft peat area.
- Maximising the amount of lime stabilised capping to reduce the rock import.
- Using thin surfacing to accommodate additional earthworks fill.
- Upgrading contaminated materials, by screening, blending and stabilisation with lime etc, to allow them to be used in environmental bunds.

As a result of these actions, the amount of offsite disposal was reduced by 480,000 m³; the volume of imported material rose slightly by 50,000 m³ and the number of truckloads was reduced by more than 50% to 49,125.

Drivers

- The principal driver for this project was the desire by Balfour Beatty to minimise the amount of material taken off site to tip. This is general company policy, but was accentuated in this case because of the shortage of suitable tips in the Manchester area. The tipped material would have included peat and contaminated material.

Problems

- Retaining the contaminated material on site meant that a waste management licence might have been required. A source-pathway-receptor analysis was carried out for each individual location, and it was agreed that the contaminated material could be left in place and a waste management licence was not required. The Environment Agency staff in the area were very helpful. However, if the site had been in a different area, the attitude of local Environment Agency staff could have been different, and the job could have been stopped.

Solutions

- A strategy was developed from the start to minimise offsite disposal.
- Contaminated, lower quality material was upgraded by a variety of methods including screening, blending, lime stabilisation, drying and reprocessing, and a concrete raft was used to avoid the excavation of peat.
- Adjustments to alignment and environmental bunds were used to minimise the amount of material going offsite.
- The helpful attitude of the local Environment Agency was vital, as was the partnering approach adopted by all parties in the contract.

Benefits

- The project had major environmental benefits, as indicated by the figures for material disposed offsite and truck movements.
- This also resulted in increased ease and speed of construction.
- There were also significant financial savings.
Lessons learnt

- The Client must take responsibility and understand his contract. He should be prepared to facilitate innovation and buy in to the process, not just the financial saving.
- There should be provision at government level to ‘ring fence’ very large contracts such as the M60 to ensure that waste minimisation and recycling are practised.
- There is a need to speed up the processes for obtaining planning permissions, waste management licences and prescribed process authorisations. Given the timescale of most contracts, it is difficult to get these in place before construction starts.

Plate 16 Using a tromel to separate deleterious material from good quality material
CASE STUDY 9: NOTTINGHAM EXPRESS TRANSIT (NET)

Project summary

Nottingham Express Transit (NET) is a £200m modern tram system, which will run from the suburbs to the centre of Nottingham. Construction commenced in June 2000, with the main construction works starting in 2001, and the trams scheduled to start running in November 2003. NET will form part of an integrated transport system for the city.

NET is being developed by the Arrow consortium, with the construction work being carried out by Carillion. The work involves laying 14km of track, associated service diversions, an embankment and a viaduct. This will generate a significant volume of arisings, which will be sent to a Recycling Plant at Colwick Industrial Estate, Nottingham. The material will be reprocessed and used as general fill, capping and sub-base in the new works. Lorries will take arisings to the plant and return with processed fill for use in the works.

The Recycling Plant at Colwick is owned and operated by Tarmac Recycling Ltd., and has been in operation since 1997. It operates under an exemption from the Waste Management Licensing Regulations. The site principally takes asphalt, concrete and brick, which are carefully separated. Clay and topsoil are rejected. The materials are processed by crushing, screening and mixing to produce a range of products such as:

- Type 1 sub-base.
- Class 6F2 capping.
- 40mm down (Class 6F1 capping).
- Class 1A general fill.
- Footpath material (recycled concrete, asphalt and sub-base).

The plant operates an Environmental Management System to ISO 9002, and produces material of very high consistency. The NET project has already generated 17,000 tonnes of bricks from demolition of an old viaduct, which have already been reused.

Drivers

- The NET project is keen to be seen as an example of sustainable development, and hence all aspects of recycling and waste minimisation are being encouraged. The recycling solution limits lorry movements to the city centre and maximises their use. The cost of recycled aggregates is competitive with that of natural aggregates, and the reduced haulage costs give an economic advantage to the system, as well as environmental benefits.

Problems

- The NET project has only recently started, and little recycling has been carried out to date, but no problems have been identified so far. At the recycling plant there is sometimes a problem in balancing supply and demand. There is not a major problem in storing material but occasionally demand almost outstrips supply for certain products.
- Tarmac have encountered resistance from some site staff to recycled aggregates, because they are not used to them and consider them inferior to natural aggregates. Occasionally it is found that small contractors are putting the material to inappropriate use.
- Each County Council or City Council has to sample and test the material before approving it for use. They will not rely on results produced for other authorities, resulting in additional testing and expense for the recycling centre.

Solutions

- Most problems arise through ignorance or preconceptions, and can be overcome by explanation and education. The plant manager tries to go on site with the first lorry when delivering to a new site, so that he can explain the nature of the material.
- Most major clients and contractors in the Nottingham area accept the use of recycled aggregates as an approved option to natural aggregates.
- Local Authorities could help by accepting a standard set of test results rather than requiring separate sets for each authority.
Benefits

- Large amounts of material are now being beneficially recycled into construction, avoiding use of natural aggregates and excessive lorry movements.
- The business is profitable, and recycled aggregates are competitive with natural aggregate.
- The ability to blend materials also leads to new products being developed, such as ‘Toptrec’, a footpath material containing concrete and asphalt fines, which is superior to natural aggregates for this application.

Lessons learnt

- Perseverance is required to overcome preconceptions and ignorance by talking to clients and demonstrating the capabilities of recycled materials.
- Demonstrate a consistent, quality product by means of an Environmental Management System and test results.
- Allow enough space on site to store materials for coping with peaks and troughs in demand.
- Control what comes onto site very carefully to avoid contamination, and take care in assigning materials to the correct stockpile. This gives maximum flexibility for producing materials to meet whatever specification may be required.
- Work with local clients, hauliers and contractors to establish strategies for sustainable construction to maximise use of recycled aggregates.
CASE STUDY 10: DREDGING ON THE RIVER TRENT

Project summary
British Waterways (BW) has a statutory obligation to dredge the river Trent, from Shardlow, just upstream of Nottingham, to Gainsborough, to maintain it for navigation. Downstream from Nottingham to below Cromwell Lock, for approximately 62km, about 100,000 tonnes of dredgings are produced each year which are natural sands and gravels (Trent gravels).

In the past, the dredgings were tipped into old sand and gravel pits beside the river. Since 1996, however, the dredgings have been processed by aggregate companies and sold for use in construction. The old dredging tips have also been reworked. The dredgings contain about 8% fines, which is removed by washing and disposed of in the old pits. Most of the sand and gravel is used for concrete production, and some is used as unbound granular material.

BW has four sites on the riverbank where they land the dredgings. Contractors bid for the right to process and sell the material.

Dredgings are specifically excluded from the landfill tax as dredging is considered to be an environmentally beneficial operation. The material will also be exempt from the aggregates levy, as the prime purpose for excavating the material is to maintain navigation.

Drivers
- The principal driver for the recycling operations was BW’s need to secure long term disposal routes for the dredged material. BW was running out of disposal points on the river.
- Economics was also a major factor. Previously BW had to pay others to dispose of the dredgings. Now the dredgings are an asset, which offsets the cost of the dredging operations.
- At the Cromwell Lock site, Lafarge have taken a proactive approach because their quarry was exhausted and they could not get an extension for it. They approached BW to recycle the incoming dredgings, then worked through the material that had already been deposited in the tip. At the Hazelford Lock site Advanced Materials Recycling have been awarded a contract to remove 100,000 tonnes of dredged materials.

Problems
- The major problem was getting agreement with the Environment Agency (EA) that the sand & gravel dredgings should not be classified as a directive waste. The classification of sand and gravel dredgings in the legislation was not clear, and legal opinions had to be obtained. It took two years to resolve the issue as all dredgings are technically classified as an industrial waste by EA, and a WML is required for all sites where dredgings were deposited.

Solutions
- Clarification that under the legislation sand and gravel dredgings were not a waste.

Benefits
- The main benefit for BW is the continued ability to dispose of the dredgings. They are no longer constrained by lack of space in the old quarries.
- An added benefit is that the revenue offsets the costs of the dredging operations.
- There is a wider benefit for the whole region in that the dredgings provide an important supply of good quality aggregate, thus reducing the amount of quarrying of natural deposits of the Trent gravels. The Nottinghamshire County Council Minerals Plan has a chapter on dredgings, and supports the use of reprocessed dredged material.

Future developments
- The reprocessing operations have been a great success, and BW is becoming more proactive in this field and is looking for opportunities to develop relations with recycling companies.
- BW are considering shipping some of the dredgings by waterway direct to city centres, such as Hull, Leeds and Sheffield, where they can be reprocessed for use in construction, rather than reprocessing them at the landing points and sending them by road to the cities.
- Other waterways where reprocessing may be possible are being considered. The river Severn navigation between Worcester and Gloucester is possibly a suitable area.
CASE STUDY 11: CANAL DREDGINGS (GENERAL)

Project summary

Over most of the canal network, the dredgings are generally fine-grained silt and clay with a high organic content and very high moisture content, which amount to between 0.8m to 2m tonnes per year. The government has given British Waterways (BW) additional funding for dredging arrears over the next 5 years. In 1988 BW operated over 150 sites for the disposal of dredged materials when legislation changed requiring the sites to be licensed. As a result the number of disposal sites has been reduced to about 50 licensed tips, with 22 of these in the North East Region. In rural areas where the dredged material is suitable BW are using exemptions from licensing to dispose of its dredged materials. BW have developed partnering arrangements with selected specialised contractors to undertake the dredging operations and have recently awarded Land & Water Services a contract to undertake the majority of BW’s dredging nationally.

BW has a hierarchy of options for dealing with dredgings as shown as follows:

Various engineering options have been considered for the dredgings:

- A pilot scale soil washing exercise, Project Aquarius, was carried out in Birmingham on contaminated dredgings. This was not wholly successful, as the material in the canal contained more fines than had been expected.

- Stabilisation with lime, pfa and other additives has been tried. A recent successful example is Thornton Lock on the Pocklington Canal in North Yorkshire, which won an environmental award, the National BW Waterway Conservation Award. The canal banks on the Pocklington canal have been raised in the past with dredgings, but were porous. The dredgings were taken off, mixed with pfa and replaced on the banks. The work had to be carried out with great care, because the site was in an SSSI, but was very successful.

Dredgings are classified as a waste, but are covered by an Exemption Order under the Waste Management Licensing Regulations 1994 (See Table 7). The disposal of dredgings is also exempt from the Landfill Tax, and will be exempt from the Aggregates Levy.
Problems

- BW was faced by a lack of recognised technical guidance on the use of dredgings as soil replacement material.
- Because of the complexity of the Waste Management Licensing Regulations, there was a lack of consistency in EA’s interpretation across England and Wales, leading to a different response in different regions. This also reflected differences in hydrogeological conditions in different areas.

Solutions

- BW use ADAS for guidance, because of their recognised expertise in agricultural matters, and work from a combination of the Kelly, ICRCL and other guideline values. Limiting values have been produced for the application of sewage sludge to agricultural land, but not for dredgings.
- BW has sponsored CIRIA projects to produce guidance on the disposal of dredgings. To date, two reports have been produced ‘Guidance on the disposal of dredged material to land’ (R157, 1996) and ‘Inland dredging techniques and operations – guidance on good practice’ (R169, 1997).
- BW is developing a Memorandum of Understanding with EA on dredging techniques and the use of dredgings. The problem is not with the waste management licensing system and the exemptions, but with the lack of guidance on where dredgings may be used on agricultural land.

Drivers

- Economic factors encourage the use of dredgings as soil replacement material. Even without landfill tax, disposal to landfill is the most expensive option. If the material has to be transported before being placed on agricultural land, this is more expensive than spreading it on land adjacent to the canal.
- Environmental issues are a major factor in BW’s activities. There is pressure within BW and from the green lobby outside to carry out more reuse/recycling of dredgings.
CASE STUDY 12: RECYCLING PLANT, NEWHAVEN

Project summary

Hanson and FL Gamble are a joint venture company running the waste processing and recycling plant at Newhaven, East Sussex. The plant accepts all types of demolition rubble, which is sorted and processed to produce several materials. The highest quality is ‘Baseco’ (similar to the Type 1 specification in the SHW) and other lower performance aggregates (meeting the 6F1 and 6F2 specification in the SHW) are also produced.

There is a high demand for products from the plant, especially recently with the nearby Haywards Heath by-pass construction. East Sussex Council specifies Baseco for some of their work, and they have used it on many bridleways and footpaths.

Drivers

- It was felt that the main instigators for the recycling and processing of materials such as demolition rubble are the recyclers themselves. They see a developing market for recycled aggregates, as natural aggregates become scarcer and more expensive.

Problems

- The main problem is contamination in the feedstock, i.e. deleterious components in the raw materials, which are blended during processing.
- Matching supply and demand for excavated material can be a problem as there is no guaranteed supply of material to the plant; the supply of demolition rubble materials is variable. This means that it is difficult to forecast the amount of aggregates that will be produced by the plant.
- Restrictive or inappropriate specifications often result in little incentive to use secondary and recycled aggregates rather than natural materials.
- There was an inconsistent approach by regulatory bodies; the amount of leeway given in certain situations was often dependent on the official undertaking the visit.
- It was felt that the Landfill Tax encourages fly tipping and the bending of rules.
- Often the plant does not run at a profit, and there was the perception that there is little encouragement, especially financial, for the people actually doing the recycling.

Solutions

- The quality and characteristics of the material produced at the plant is assured by using Highways Agency Specifications. The plant produces Baseco (similar to Type 1 aggregate), as its ‘own-brand’ highest quality product. Samples are tested externally and the performance is often much better than the Specification.
- East Sussex Council has a Specification for ‘Baseco’ which allows engineers, etc, to use a published specification for the use of the material rather than simply specifying ‘Type 1 aggregate’.
- One suggestion to assist recycling is to allow a tax rebate, for recyclers, on material that is not used.
- It was thought that an incinerator plant located near to the waste processing plant would be an advantage to the whole recycling process. Any material that can not be processed in the plant could be sent to the incinerator.
CASE STUDY 13: SUPPLY AND RECYCLING/RE-USE OF RAILWAY TRACK MATERIALS

Background
Since the privatisation of the rail industry in the mid-1990’s, the demand for passenger rail travel and the amount of freight on rail have both grown considerably. Investment in the rail network has grown too and much more engineering work is now being undertaken than in the years prior to the demise of British Rail. These twin pressures have made access to the tracks for carrying out engineering work much more difficult. Over the past four years Railtrack has transformed the supply chain for buying, distributing and re-cycling the large quantities of track materials that are required.

The problem
The management of the supply chain had been fragmented by privatisation such that no one party had adequate control: accountabilities were often unclear and obvious economies of scale were not being exploited. Unit costs were escalating; performance was poor and the volume capability of the supply chain was becoming a constraint on delivering new investment. Significant quantities of used material were being landfilled unnecessarily.

The solution
In February 1997, Railtrack formed a small project team to devise and implement effective short and long-term solutions. Solutions were proposed to directors in late 1997. They were immediately cleared for rapid implementation. They involved:

- Centralising industry-wide responsibilities in Railtrack.
- Establishing 15 well-equipped regional supply and re-cycling depots, giving efficient national coverage.
- Forward stockpiling of bulk materials.
- New contracts for materials supply, disposal and engineering train haulage.
- Ending supply monopolies.
- Maximising re-cycling.

The result
A remarkable turnaround!

- Increased recycling of used ballast.
- Consistently high supply reliability.
- Unit costs greatly reduced.
- Increase supply capacity.
- Significant amounts of rail network capacity ‘given back’ to Railtrack’s train operator customers.
- Energy savings as a result of more efficient use of train haulage (1.1 million fewer train miles).

Next steps
Railtrack’s Logistics Unit is now looking at increasing the re-cycling of used sleepers and rails.
CASE STUDY 14: THE ECHLINE EXPERIMENTAL ROAD

Project summary

The Echline project is an experimental road that was constructed near Edinburgh at South Queensferry between November 1999 and April 2000. The objective was to determine what could be achieved using recycled and secondary materials in terms of minimising both energy consumption and virgin aggregate use. The road will not be trafficked in the medium term.

The Echline project was devised by the Scottish Executive Development Department (SEDD) who invited a number of contractors to bid for a chance to partner the SEDD in this unusual and progressive contract. The preferred bidder was Tarmac Group with TRL as design advisors. The project used an innovative design approach and was designed to carry 100msa over a 40-year life. It is a single carriageway, 100m long by 6m wide and incorporates an innovative use of materials. The construction consisted mainly of recycled or secondary material with the only virgin materials used being cement, bitumen and a small amount of new stone. The materials used in the construction were as follows:

- Subgrade – soft clay conditioned in-situ with lime and stabilised in-situ with PFA and cement.
- Sub-base – spent oil shale aggregates bound with PFA and cement.
- Roadbase – crushed construction and demolition waste bound with granulated blast furnace slag and PFA, activated with gypsum and lime.
- Base course – hot-mix asphalt incorporating recycled asphalt planings and foundry sand.
- Wearing course – cold-lay bitumen emulsion asphalt incorporating steel slag coarse aggregate, blast furnace slag fine aggregate and a high performance polymer modified emulsion binder supplied by Nynas UK.

Testing has been performed at one, three, six and twelve months by falling weight deflectometer and coring to a depth of 700mm to determine the strength and stiffness of the layers. Tarmac indicate that the pavement has exceeded the expected performance and is still improving. All the layers were designed with TRL’s guidance. TRL are also monitoring the trial and acting as independent reporters to SEDD.

The experiment has successfully demonstrated the use of innovative designs and the innovative and optimised use of secondary/recycled materials.

Drivers

- The main drivers in this experiment were the desire of the SEDD to reduce the amount of virgin aggregate being used and to reduce the overall energy consumption involved in pavement construction, also ameliorating the environmental impact of past activities as well as current activities.
- Tarmac had the freedom to suggest various concepts that they and TRL had been developing over a number of years.
- The Scottish Executive has a declared policy of encouraging research into greater use of recycled materials in road building and maintenance.
- SEDD’s view is that recycled design should try to make most effective use of project-specific opportunities.

Problems

- The 100msa and 40 year design life ensured that ‘cheap’ and ‘cheerful’ recycling was not a viable option for this project.
- The wearing course was developed and delivered from Darlington Quarry in Derbyshire. This plant is geared for the manufacture of cold mix asphalt and was considered a more viable option than commissioning a Scottish plant to make the required tonnage.

Solutions

- A great deal of stabilising was undertaken in both the ground and in the secondary granular materials using secondary hydraulic binders such as PFA and slag wherever possible.
- Great care was taken in designing each of the layers. This has resulted in the road construction being stronger than a conventional construction. The integrated design approach produced a reduction in the overall pavement thickness, leading to further savings in aggregate consumption.
As demand rises for the use of these cold-lay materials it will be become viable to open more plants for production of the material.

Benefits

- The design developed for the Echline experiment would use approximately 4,700t of virgin aggregate, compared to a conventional design of 43,700t, and the reduction in energy would be over 20% when constructing a 1 km length of dual carriageway.
- The estimated saving in aggregate tax would be over £60,000 per km.
- Cold-lay emulsion asphalt uses less energy in its production, unlike hot-mix materials it does not have to be placed soon after it is mixed and it is particularly user friendly. Similar benefits can be achieved for hydraulically bound materials, whether mixed in-situ or ex-situ.

Lessons learnt

- In practice it is unlikely that all the developments used in the Echline experiment would be incorporated into any one scheme. However, it does indicate what can be achieved with recycled and secondary materials.
- The successful use of a polymer modified emulsion, especially developed for cold-lay applications, was demonstrated.
- The advantages of using steel slag as a coarse aggregate were indicated in the trial.
- The use of recycled planings in hot mixes and the use of slag bound material are not common in Britain but both were successfully demonstrated in this project.
- The use of slag bound material, developed in France and known there as graves-laitier, was also successfully employed.
- Another industrial by-product, spent oil shale or blaes, was stabilised with a hydraulic binder and was used as sub-base material.
Plate 17 Testing an airfield pavement with the falling weight deflectometer
A list of definitions is given below, largely based on the CIRIA Reclaimed and Recycled Materials Handbook definitions (Coventry et al., 1999). The terms ‘recycling’ and ‘alternative materials’ have been used as far as possible in the guidance document. Recycling is used to refer to the in-situ or ex-situ recycling of materials for use in pavements or earthworks at the point of origin. Alternative materials include any materials other than natural materials that are used in pavements, earthworks or drainage. The term includes materials such as asphalt planings that have not been recycled at the point of origin, construction and demolition material and by-products of industrial processes such as steel slag and incinerator bottom ash (IBA). In other publications these have been separated into categories such as secondary materials and recycled aggregates. This appears an unnecessary complication, and the blanket term ‘alternative materials’ is preferred.

**Aggregate:**
Granular material used in construction. Aggregate may be natural, artificial or recycled. (BR 392)

**Alternative materials:**
Materials used in construction, including synthetic aggregate and industrial by-products (such as colliery waste, china clay waste, pulverised fuel ash, slate waste and asphalt planings), which are not normally considered as traditional materials. (CIRIA C513)

**Arisings:**
Material excavated from transport infrastructure during the course of maintenance and renewal works on behalf of owners or utilities. Depending on the source, they may be relatively uniform - e.g. asphalt planings - or highly heterogeneous - e.g. asphalt, granular sub-base and soil from excavations for utilities.

**Asphalt (RA):**
Recycled aggregate consisting of crushed or milled asphalt. (BR 392)

**CEN:** Comité Européen de Normalisation

**CIRIA:** Construction Industry Research and Information Association.

**Cold in-situ recycling:**
Procedures using specialist plant to pulverise and stabilise existing road materials, in-place, at ambient temperature, with the addition of hydraulic cement and/or bitumen binders. (TRL 386)

**Concrete (RA):**
Substantially recycled aggregate consisting of crushed concrete. (BR 392)

**Controlled waste:**
Household, industrial and commercial waste or any such waste. Such definition includes waste arising from works of demolition, construction and preparatory work thereto. (EPA 1990 and the Controlled Waste Regulations 1992)

**DETR:** Department of the Environment, Transport and the Regions (till June 2001).

**DEFRA:** Department of the Environment, Food and Rural Affairs (from June 2001).

**DTI:**
Department of Trade and Industry.

**DTLR:** Department for Transport, Local Government and the Regions (from June 2001).

**IBA:** Incinerator bottom ash.

**Marginal materials:**
Materials that do not comply fully with the relevant specification. (CIRIA C513)

**Masonry (RA):**
Substantially recycled aggregate consisting of crushed masonry. (BR 392)

**Primary aggregates:**
Particulate materials, either naturally occurring or produced by crushing, which, when brought together in a bound or unbound condition, form part or whole of a building or civil engineering structure. Aggregates for use in construction are generally quarried or dredged from the sea. (CIRIA C513, adapted)

**Processed IBA Aggregate:**
A heterogeneous material containing glass, porcelain, particles of brick, stone, concrete and the like in addition to clinker and ash, derived from incinerator bottom ash (IBA). (Ballast Phoenix Ltd., adapted)

**Primary materials:**
Materials whose production has involved extraction from virgin natural reserves. (CIRIA C513)
**PFA:** Pulverised fuel ash.

**Reclaimed material:** A material that has been recovered from the waste stream and is used in another application without undergoing processing to change its physical or chemical form. For example, a timber beam that is recovered from a demolition site would be a reclaimed material. (CIRIA C513)

**Reclamation (or reuse):** The use of waste materials without carrying out any processing that changes their physical or chemical form. For some materials, for example excavation spoil, the accepted industry terminology is ‘reuse’ rather than reclamation. (CIRIA C513)

**Recycling:** The collection and separation of materials from waste and their subsequent processing so that it can be used again. (CIRIA C513)

**Recycled material:** There are two uses of the term recycled material:

- A material that has undergone some form of processing to change its physical or chemical properties. For example, concrete may be crushed to form aggregate and this would be termed recycled aggregate.

- A product that incorporates a material within it that has been recycled. For example, insulation that incorporates recycled paper is termed a recycled material. (CIRIA C513)

**Recycled Aggregate (RA):** Substantially aggregate resulting from the processing of inorganic material previously used in construction. (BR 392)

**Recycled aggregates:** Aggregates resulting from the reprocessing of mineral construction materials (i.e. composed predominantly of crushed concrete and brick masonry). (BRE 433)

**Reuse:** The employment of an article or item once again for its original purpose, or for a different purpose, without prior processing to change its physical or chemical characteristics. (CIRIA C513)

**Secondary aggregates:** Secondary materials - principally colliery spoil, slate waste and china clay waste - that can potentially be used as a substitute for natural aggregates. (CIRIA C513)

**Secondary materials:** Materials used in construction that have been previously used for a primary purpose. (CIRIA C513)

**Spoil:** Soil or rock or other earth material arising from excavation, dredging or other ground engineering work. (CIRIA C513)

**Waste:** Waste is something that ‘the producer or holder discards or intends to or is required to discard’ (Waste Management Licensing Regulations 1994). For a detailed definition of waste, refer to Regulation 1(3) of the Waste Management Licensing Regulations 1994.

In order for a substance to be waste it must:

- Fall into one of the categories (substances or objects which are waste when discarded) set out in Part II of Schedule 4 to the Regulations; and

- Be discarded or disposed of by the holder; or

- Be intended to be discarded or disposed of by the holder; or

- Be required to be discarded or disposed of by the holder.

(from DoE Circular 11/94).