

A Report On The DEMOLITION PROTOCOL



Commissioned by
London Remade

Prepared by
EnviroCentre Ltd



Demolition Protocol

Executive Summary

Origins Of The Project

The development of the Demolition Protocol is the result of discussions initially involving the *Resource Sustainability Initiative* a group formed jointly by the Waste Board of the Institution of Civil Engineers (ICE) and the Institute of Waste Management (CIWM) to support innovative waste management projects. A key aim of the project is to facilitate the planning system, both at local and national levels, to require more effective resource management in demolition and new builds. The project, prepared by EnviroCentre Ltd and commissioned by London Remade, was funded by the ICE and the Landfill Tax Credits of Cory Environmental and Cleanaway.

Summary Of Key Outputs

The link between demolition and new build, in terms of resource efficiency, is poor. The Demolition Protocol, a resource efficiency model, shows how the production of demolition material can be linked to its specification as a high value material (comparable with primary materials) in new builds. A fundamental aspect of this model is that it shows how resource efficiency can be driven through the planning process, for example through the development of Regional Spatial Strategies, Supplementary Planning Guidance, Planning Conditions & Agreements etc.

The key outputs from the protocol, which will provide best practice and opportunities for planning influence, are summarised in the box below.

Building Audit & Planning For Segregation

The protocol shows how a building audit can be performed to produce the Demolition Recovery Index (DRI). The DRI describes the potential for material recovery from demolition and demonstrates resource efficiency to project teams in terms of associated cost benefits and improved environmental sustainability. In addition, the DRI provides planning authorities with a tool for ensuring that demolition methodologies reflect national and local authority policies on waste management and sustainable development.

Standards & Demolition Recyclate In The New Build

The development of standards, for example through the Construction Products Directive, means that the potential for specifying demolition recyclate in new build components is continually increasing. The New Build Recovery Index (NBRI) provides a tool for determining the potential percentage and quantity of recovered materials which can be specified in the new build. The NBRI can then be linked to the DRI and provide project teams with a resource efficiency model which will lead to cost savings, as well as provide environmental sustainability (reducing the demand for primary materials). In addition, this model enables planning authorities to place conditions on demolition and redevelopment to drive improved resource efficiency.

In delivering these key outputs, the protocol is aimed at the following people/groups:

- Planners responsible for planning policy development at a national level
- Planning authorities responsible for development control
- Project teams responsible for managing demolition work
- Project teams responsible for the procurement and specification of new construction materials
- Community groups involved in local recycling projects

A Resource Efficiency Model

The Protocol provides guidance on how demolition recycle can be driven up the value chain. With the development of planning and management models to support resource efficiency, both demand and supply will increase. The result will be that the pricing structure for demolition recycle reaches a more attractive level than currently available.

The resource efficiency process and associated mechanisms influencing supply and demand are shown in Figure 1.

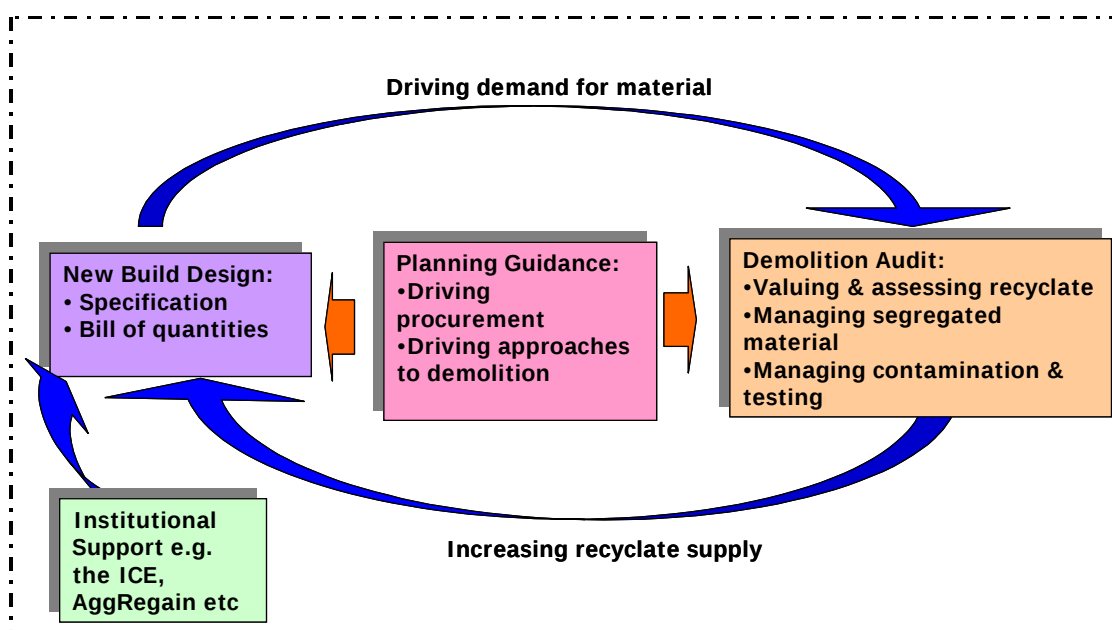


Figure1. Environmental Management System – A Resource Efficiency Process

An important aspect of the supply & demand mechanism will be institutional support, for example, through the Institution of Civil Engineers, AggRegain (WRAP) etc to support programmes which demonstrate acceptable performance of demolition recycle.

The Planning System Driving Resource Efficiency

As mentioned previously, the Protocol provides the planning system with a number of mechanisms which allow the implementation of policies on sustainability, minerals and waste management. An overview of these mechanisms is provided in Figure 2.

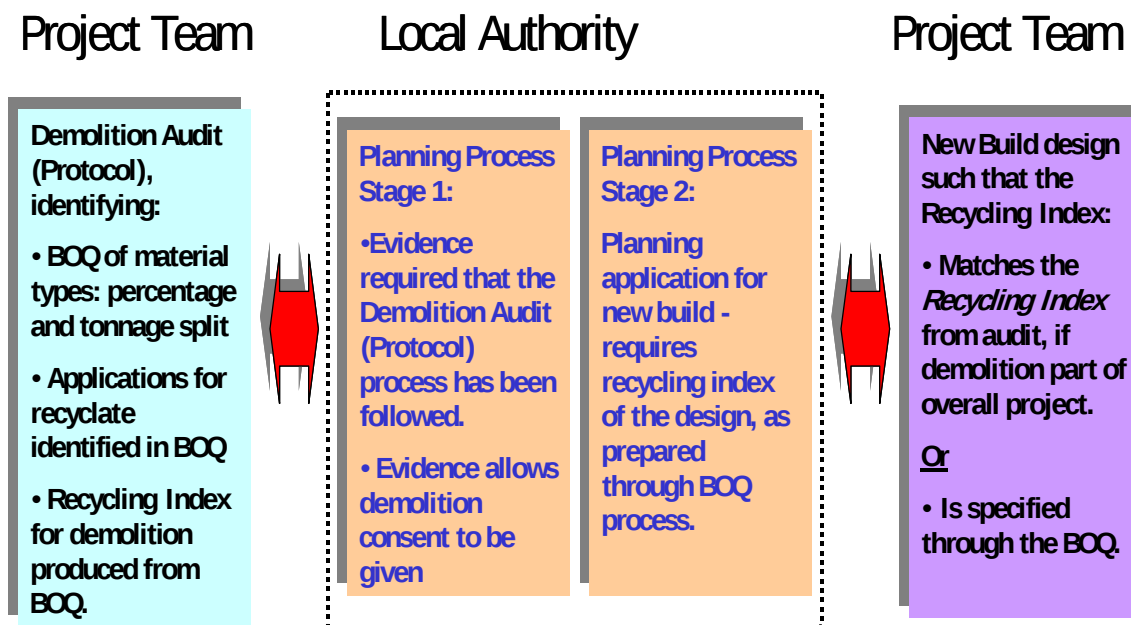


Figure 2. Linking The Project Stages In The Resource Efficiency Model

The planning process can work from the top down to effect change. The Planning & Compulsory Procurement Bill (due for Royal Assent in April 2004) requires Regional Spatial Strategies which have waste and minerals sections. These sections could emphasise that Demolition Waste/Recyclate should be specified and procured in the new build. Local Development Plans would then have to be prepared in accordance with these spatial strategies, with supplementary planning guidance, conditions & agreements used as the implementation mechanisms. Obligations from such planning mechanisms could then ensure that the project team has to provide the DRI and NBRI, with the associated tonnages of material. The planning process could then make the provision of this information a requirement before consent is given for demolition, where it is part of an overall redevelopment project, to proceed.

The result of such requirements (or agreements) may be that the tonnage of demolition recyclate allowable in the new build is produced (through the NBRI), along with the tonnage of recoverable material produced from the demolition itself (through the DRI). An example of how this would work is shown in the table below where such tonnages are presented.

Demolition Arisings		New Build Demand (from BOQ)		
Overall Tonnage	Total Tonnage Of RA & RCA Produced	Max Tonnage Of RA & RCA Potentially Specified In The New Build	Max Tonnage Of RA & RCA Potentially Specified In The Infrastructure	Total Aggregate Demand
2,810t	1,153t	332t	1,377t	1,709t

This example considers the case where redevelopment (new build) follows on from the demolition of an existing building at the site. Note that in this table, RA refers to Recycled Aggregate and RCA to Recycled Concrete Aggregate. Also, that Infrastructure for the new build refers to roads. With this level of data, the planning authority then has the capability to put conditions on the use of material. For the example shown here, there is sufficient demolition recyclate to meet a demand potential of 332 tonnes of RCA & RA. The local authority could therefore require that 332 tonnes of demolition recyclate (from any approved supplier) be used in the new build. Conditions may be the preferred approach (to an agreement) in this redevelopment scenario because conditions refer to the land on which applications apply. Therefore a site containing a building with a significant quantity of recyclable material (demolition recyclate) would be viewed as a resource which should be used sustainably.

Planning agreements, a Section 106 (England & Wales) or 75 (Scotland), could also be used for ensuring the sustainable use of materials, however because of the lengthier process may be more appropriate for greenfield sites with a process of specifying demolition recyclate in the new build which does not involve any reference to previous demolition.

Local authorities are creating Supplementary Planning Guidance to drive more sustainable demolition and construction practice. The mechanisms for employing *Planning Conditions & Agreements* could be described in such guidance on the basis that they would support local authorities to deliver policy on sustainability.

The Demolition Protocol And Best Practice

Planning systems which adapt to embrace the methodologies of the protocol will provide the most effective mechanisms to ensure that resource efficiency models are employed in demolition and redevelopment. However, the protocol as it stands also identifies best practice and therefore guides the project team through new developments in standards (such as the Construction Products Directive), as well as piecing together the various elements required for cost effective material management.

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Section 1

Introduction

1.1 Objective

This section gives an overview of the Demolition Protocol with respect to what it is setting out to achieve. The Protocol, a resource efficiency model, links the production of demolition material to its specification as a high value material (comparable with primary materials) in new builds. The main issue (and opportunity) is that the link between demolition and new build, in terms of resource efficiency, is poor. In addressing this, a fundamental aspect of the model and protocol is that it shows how the planning process can drive improvements in resource efficiency, doing so in terms of Regional Spatial Strategies, Local Development Plans, Supplementary Planning Guidance, Conditions & Agreements.

1.2 Origins Of The Project

The development of the demolition protocol is the result of discussions, initially driven through the Resource Sustainability Initiative a group formed jointly by the Waste Board of the Institution of Civil Engineers (ICE) and the Institute of Waste Management (CIWM) to support innovative waste management projects. A key aim of the object is to facilitate the planning system, both at local and national levels, to require more effective resource management in demolition and new builds. The project, prepared by EnviroCentre Ltd and commissioned by London Remade, was funded by the ICE and the Landfill Tax Credits of Cory Environmental and Cleanaway.

1.3 Overview Of The Project

Construction and Demolition Waste (C&DW) represents both the UK's largest waste stream as well as an increasingly utilized supply of material to the construction industry. However, the challenge for new policy developments is to further stimulate the demand for recycled demolition materials so that the true potential of this material stream (C&DW) is realised. For example, where a building earmarked for demolition is viewed as a resource capable of providing material which is comparable, if not better than primary material.

The model and background research is described in two different documents:

- (i) The Demolition Protocol Report
- (ii) The Demolition Protocol: Implementation Document

The Report (this document) describes the context for the development of the Protocol, including the result of consultations on a variety of case studies, which also includes a European dimension. The Implementation Document is accompanied by the report and is a summarised version which provides the key tools for actually implementing the protocol, with examples of tables which can be used by both planners and project teams to plan demolition and

new build projects. The list of potential users of the Protocol is summarised below:

- Planning authorities responsible for development control
- Project teams responsible for managing demolition work
- Project teams responsible for the procurement and specification of new construction materials
- Community groups involved in local recycling projects

Key outputs from this protocol are those produced from sections 5 & 7, as summarised in the box below.

Building Audit & Planning For Segregation

The protocol shows how a building audit can be performed to produce the Demolition Recovery Index (DRI). The DRI describes the potential for material recovery from demolition and demonstrates resource efficiency to project teams in terms of associated cost benefits and improved environmental sustainability. In addition, the DRI provides planning authorities with a tool for ensuring that demolition methodologies reflect national and local authority policies on waste management and sustainable development.

Standards & Demolition Recyclate In The New Build

The development of standards, for example through the Construction Products Directive, means that the potential for specifying demolition recyclate in new build components is continually increasing. The New Build Recovery Index (NBRI) provides a tool for determining the potential percentage and quantity of recovered materials which can be specified in the new build. The NBRI can then be linked to the DRI and provide project teams with a resource efficiency model which will lead to cost savings, as well as provide environmental sustainability (reducing the demand for primary materials). In addition, this model enables planning authorities to place conditions on demolition and redevelopment to drive improved resource efficiency.

1.4 A Resource Efficiency Model

Effectively, the protocol shows how the planning system can drive two processes: the procurement of material in the new build and the methodology required to demolish a building. The result is a stimulation of demand for recyclate and an increase in the supply of materials to meet this demand. The mechanisms at play are summarised in Figure 1 over the page.

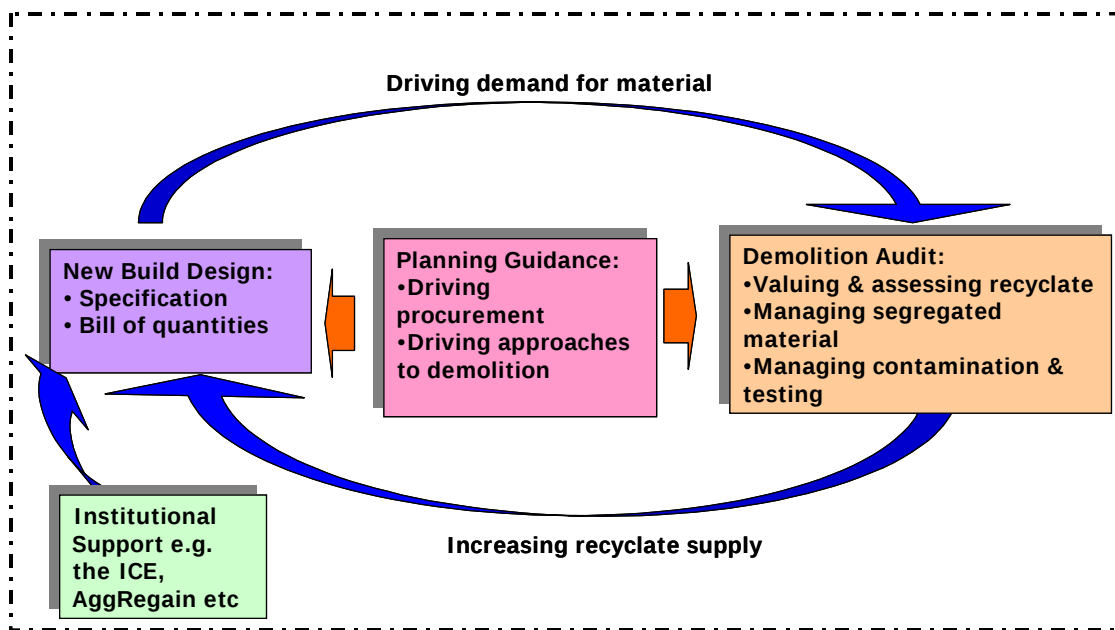


Figure 1. Environmental Management System – A Resource Efficiency Process

The protocol requires a Bill of Quantities (BOQ) to be produced by the project team via a demolition audit, with potential applications, tonnages and percentages of recycling/reuse opportunities detailed. The figure below summarises the steps.

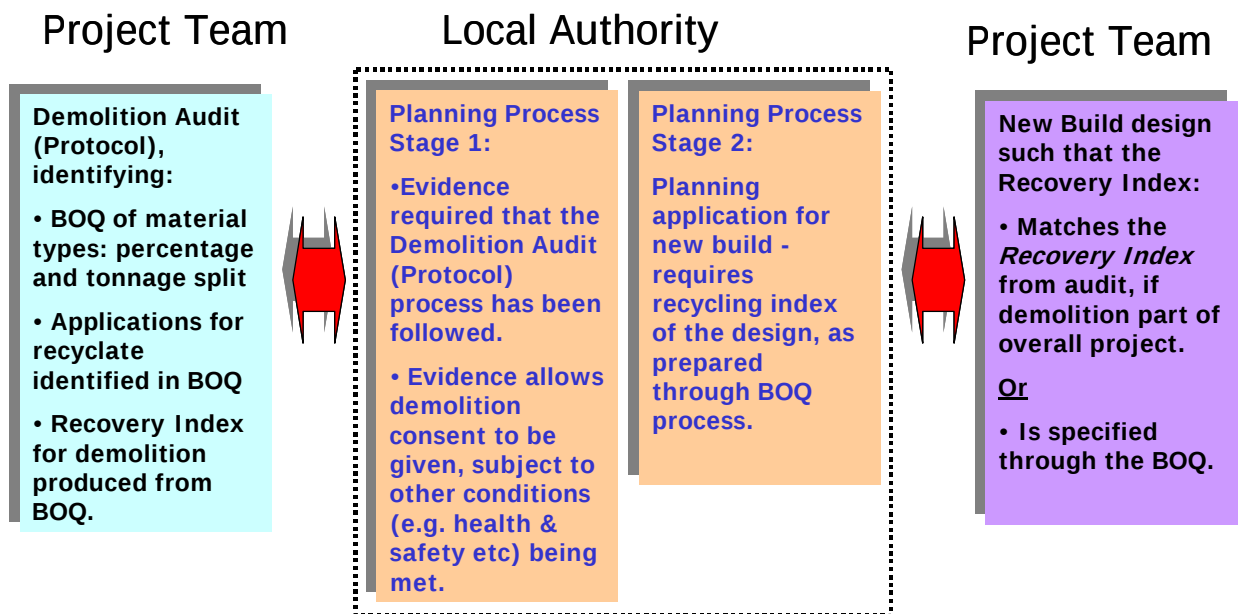


Figure 2 Linking The Project Stages In The Resource Efficiency Model

This BOQ then effectively allows the creation of a recovery index (as mentioned earlier). Forming part of a redevelopment project (with new build replacing the demolished buildings) , which can therefore be driven by the planning process, this information must be supplied by the project team before consent is given for the demolition to proceed.

The project team must then demonstrate that an appropriate quantity of demolition recyclate is specified in the new build, having determined through the New build Recovery Index (NBRI) and the Demolition Recovery Index (DRI) the potential for doing so. If the new build project is independent of prior demolition work the NBRI alone will determine the quantity of recovered material to be specified.

1.5 Best Practice

The protocol is also about describing how project teams can respond to the forthcoming pressures from the planning system. Guidance is given on how to audit buildings and determine the potential for recycling, identifying the opportunities and constraints with respect to both physical and chemical contamination. The outcome of such audits is that material segregation opportunities are identified and the potential for obtaining maximum value for the recyclate is improved. Guidance is also produced for designers on how demolition recyclate is becoming an increasingly acceptable material in high value applications.

For example, the Construction Products Directive now allows the specification of recycled aggregates on a par with primary aggregates in a number of concrete applications. Designers are guided on how the overall recycling index for a new build can be achieved.

Resource efficiency, driven by the planning process, is not a case of *if*, but *when*, with the Planning & Compulsory Purchase Bill leading to reform of the planning system, an important element of which is the need to ensure that sustainability is a key part of future planning policy.

However, even without such pressures resource efficiency is about planning projects differently from current practice. In this sense, a project team which considers the full potential of its material use is undoubtedly looking to not only create a *greener*, more sustainable built environment, but also to save costs.



Figure 3. Segregation of demolition material on the Channel Tunnel Rail Link project

Section 2

Demolition Practice & Policy:
UK & Europe

2.1 Objective

This section sets out the context with respect to the tonnages of waste produced from demolition and construction, as well as the legal framework within which this material stream is managed, particularly through the planning process. The results of consultations with a number of European countries are given, to provide a benchmark against countries which are often quoted as being ahead of the UK – namely Denmark, the Netherlands and Germany.

2.2 Status Of Construction & Demolition Waste

Construction and Demolition Waste (C&DW) is defined by the European Environment Agency as:

Materials resulting from the construction, remodelling, repair or demolition of buildings, bridges, pavements and other structures.

At the time of writing, the most recent report on C&DW arisings is the 2002 publication from the Office of the Deputy Prime Minister (ODPM): “*Survey of Arisings and Use of Construction and Demolition Waste In England and Wales 2001*”. This publication provides an estimate of 94 million tonnes of hard C&DW produced in England and Wales in 2001. For Scotland the most recent report was carried out for the Scottish Environment Protection Agency (SEPA) in 2001 for waste arisings in the year 2000. This report concluded that 6.25 million tonnes were produced in this year. This provides a grand total for Great Britain of approximately 100 million tonnes. Information on Northern Ireland was not available at the time of writing, but is expected at some point in 2003. The information generated feeds into the revision of MPG6 (in England), the Aggregates Technical Advisory Note (in Wales), as well as NPPG 10, Planning and Waste Management (Scotland).

A total of 40.3 million tonnes of C&DW was recovered for use as recycled aggregate across Britain. According to the report for England & Wales, of the estimated 38.02 million tonnes of recycled aggregate, about half was graded aggregate, primarily derived from clean concrete and brick waste. Figure 1.1 takes data from the ODPM and SEPA reports mentioned above and plots this on a geographical basis for different waste management options

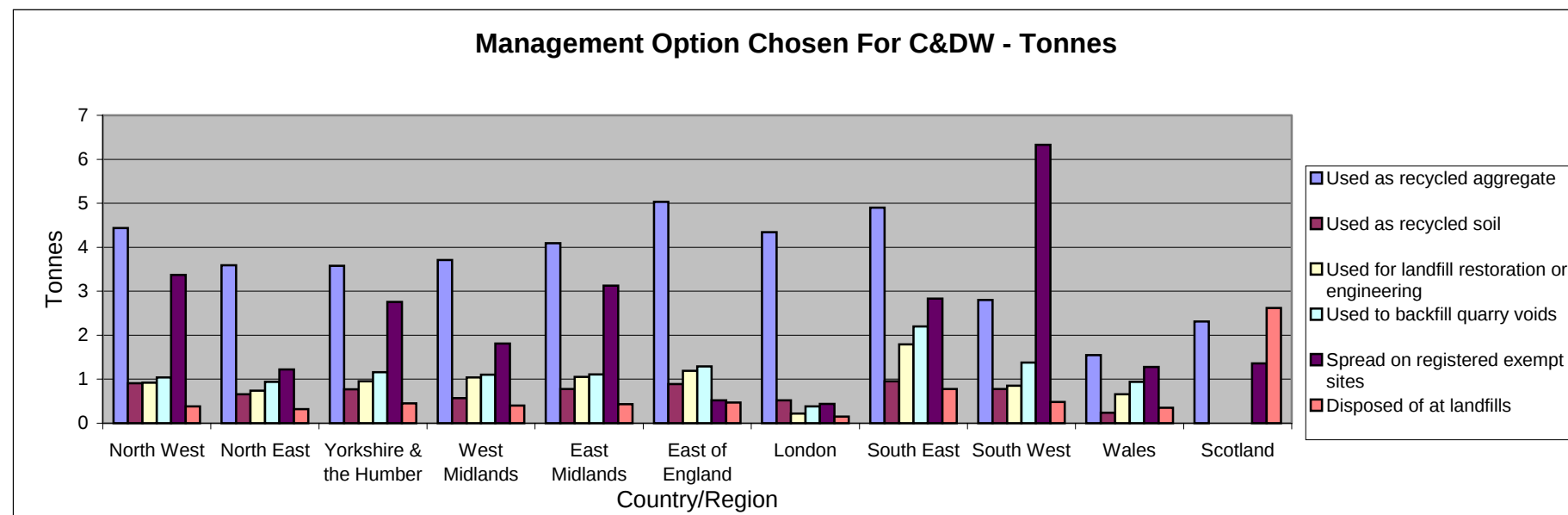
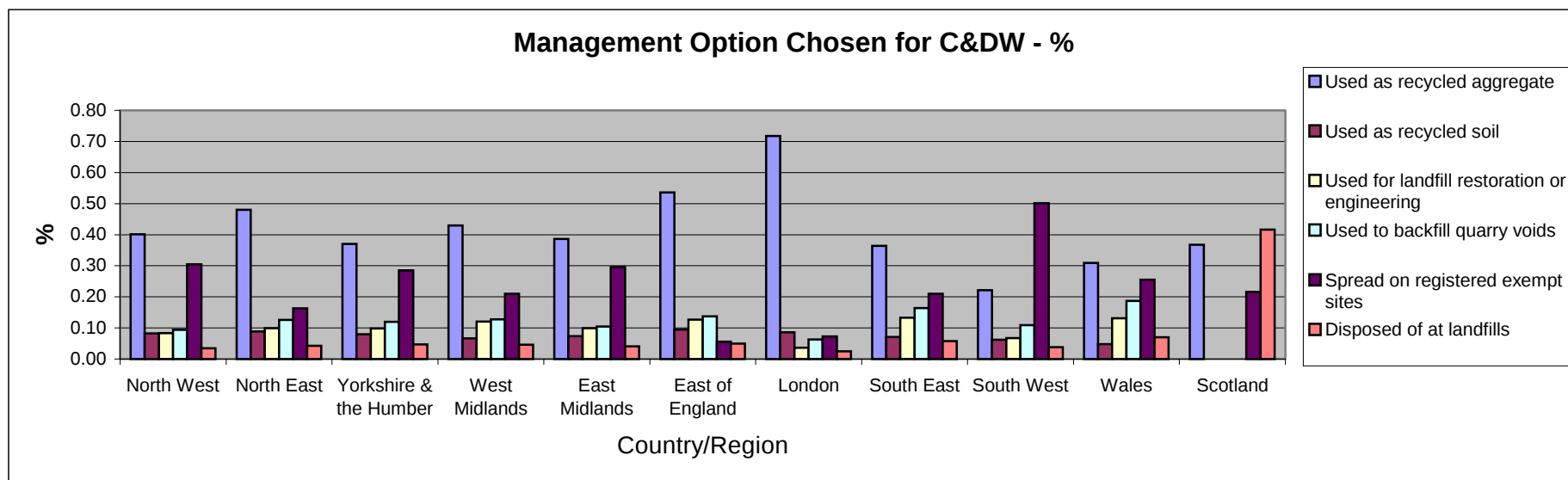


Figure 2.1 Management Options For Construction & Demolition Waste

It can be seen from Figure 2.1 that there are significant geographical differences in the management approaches adopted in different parts of the UK. Some of the extremes are summarised in Table 1.1 below:

Table 2.1 Summary Of Main Geographical Divergences In Waste Management Approaches

Management Option	Max % age	Location	Min % age	Location
Recycled aggregate	72	London	22	South West England
Registered exempt sites	50	South West England	6	East England
Landfill disposal	42	Scotland	2	London

As may be expected, those areas with the highest population densities and therefore more construction & demolition activity, have the highest recycling rates and lowest rates of landfill disposal. The variation in approach to managing construction and demolition waste can be explained in many different ways. In areas such as London with issues regarding the distances involved in hauling waste to landfill the avoidance of road congestion, with respect to transport costs is a clear driver. At the same time this represents significant advantages in using demolition recyclate as a replacement to primary materials, which again have to be transported through the same transportation system. A number of other studies consider these issues and the opportunities represented by using underutilized rivers/canals as potential transport routes of the future.

2.3 Maximising The Potential Of Recycled Aggregates

The statistics demonstrate that significant quantities of construction and demolition waste are being recycled as aggregates. However, an aspect of this behaviour is that recycled construction and demolition waste is often recycled to allow disposal at a site rather than serve a true construction purpose. On occasions this takes the shape of demolition arisings acting as a fill or grading material, where the requirement for such a material is limited. In such scenarios, primary aggregate is unlikely to have been purchased for such purposes. Effectively, the advantage of such behaviour is that it represents local disposal avoiding the need to haul material off site – thereby reducing costs.

Local disposal of material may often be the Best Practicable Environmental Option (BPEO), however an opportunity is being lost, with respect to demolition arisings displacing the purchase of primary aggregates - particularly in high value applications. In other words, in applications in new buildings such as concrete structures, engineered fills etc. Opportunities

therefore exist to develop approaches with the aim of encouraging demolition project teams to maximise the recovery of recyclate, where it is processed to allow the production of high quality material (with a high market value) where practical. This also extends to designers and specifiers, where there is a real need to increase awareness in the industry of the potential to use recyclate in new builds. The planning process, through the development of planning guidance, also has a part to play through the development of policy which requires the procurement of demolition recyclate. The following sections continue to describe current practice both in the UK and abroad, describing how close, or otherwise, existing practice is to resource efficiency.

2.4 United Kingdom

2.4.1 Research Relevant To Demolition Material

A number of projects have been undertaken in recent years with the aim of making the construction and demolition industries more environmentally sustainable and cost effective. Some of these projects and the resulting publications are listed below:

- Developing the Deconstruction Model (DTI Construction Industry Directorate)
- Principles of Design to Facilitate Deconstruction for Re-use and Recycling (CIRIA)
- Construction Recycling Sites Database (website- CIRIA)
- London Waste and Resources River Transport Optimisation (London Remade)
- Construction Industry Mass Balance (
- Capacity Building Project for Secondary & Recycled Aggregates (EnviroCentre)
- DG 433 Recycled Aggregates (BRE)

Most of the above do not address the demolition industry specifically, but instead contribute to the process of removing barriers to the widened use of materials recovered from demolition. In other words, these projects are geared very much towards developing the market potential of demolition materials. For example, CIRIA's database/website facilitates the process of finding secure recycled material supplies, while digests such as BRE's DG 433 have been instrumental in driving forward confidence in the engineering performance of recycled materials in applications such as structural concretes. Recent innovations in European & British Standards mean that those relating to aggregates use are developing to allow recycled and secondary material to be specified on equal terms with primary materials.

The demolition protocol brings together a variety of innovations in recycled material in a manageable package for project teams to use, demonstrating the potential of demolition materials in supplying high quality material in new

builds. In demonstrating the opportunities presented by the protocol, there is value in considering the current status of the demolition industry in the UK, as well as comparing this with other countries. In other words carrying out a benchmarking process. This then sets the scene with respect to explaining why new approaches are required, and just how these will work. The situation in the UK is summarised first before two other European countries are considered - the Netherlands and Denmark.

2.4.2 “Standard” Demolition Process

A **standard** approach to demolition contracts could currently be summarised as follows:

- Tender or contract award to demolition contractor.
- Conditions based on the contractor complying with the legal requirements and providing a sound methodology.
- The methodology refers primarily to health and safety conditions, incorporating a consideration of environmental impacts such as dust generation , noise etc.
- Many demolition contracts require concrete, bricks etc to be crushed and left on site for subsequent use. However, time penalty clauses discourage maximum separation and recovery, driving contractors towards quick and simple methods.

2.4.3 Health & Safety

Many other demolition contracts require that buildings are demolished quickly and material removed from the site as soon as possible. Driving much the methodology are aspects of the work determined by Health & Safety. The main legislation and guidance in this respect is summarised below:

- The management of health and safety at Work Regulations 1999
- The Construction (Design and Management) Regulations 1994
- GS29 Health and Safety in Demolition Work
- BS6187 Code of practice for demolition

All work involving demolition must be subject to an assessment of risk (Reg 4, Management of health and safety at work regulations 1999). Box 2.1 summarises a number of processes to be considered when planning a demolition. These processes include determining baseline information which is also pertinent to the development of more environmentally sustainable practices, as described in other sections of this protocol.

Box 2.1 Project Planning For Demolition

Planning for demolition involves determining the previous use or uses of a building or structure to identify the following:

- The materials used for the construction
- Dangerous substances contained in the building, such as asbestos or lead
- Proximity of the building to the public
- Proximity to private dwellings
- Restrictions with respect to noise or dust

Clients usually have their own system for assessing competence but the assessment should include the following issues:

- The provision of an adequate health and safety policy
- The number of fatalities, major injuries compared with the national average (HSC statistics)
- Number of Prohibition and Improvement notices against the company
- The employment of a competent health and safety professional
- Availability of safety professional to visit the site
- The provision of safety training during the previous 12 months
- Membership of the National Federation of Demolition Contractors

2.4.4 UK Planning Policy

The *Planning & Compulsory Purchase Bill* for England & Wales covers topics that were set out for consultation in the Planning Green Paper and the subsequent policy statement *Sustainable Communities - Delivering through Planning*, as published in July 2002. The Bill relates only to England and Wales (with various elements differing for each country) with Royal Assent expected in April 2004.

The reform of strategic planning, as determined through the bill, will involve the reorganisation of the regional, county and local tiers of development plans. Regional Plans are to be replaced by Regional Spatial Strategies and local development documents will replace local plans, unitary development plans and structure plans. The basic pattern of development plans, to be known as local development plans, are to be retained in Wales.

A key aspect of the reforms will be the creation of a new duty for authorities to exercise their planning functions in a way that contributes to sustainable development.

Also, with respect to England & Wales, Mineral Planning Guidance (MPG) Note 6 is currently in the process of being revised and, in 2001, the Scottish equivalent, National Planning Policy Guidance (NPPG) 4, was revised. Box 2.2, shows an extract from paragraph 53 of this guidance, reflecting the aspiration to manage construction and demolition material more sustainably.

Box 2.2 NPPG4 – Land For Mineral Working (Amended May 2001)

Paragraph 53. The use of suitable mineral and construction wastes as aggregates or in other building materials is sound environmental practice and should be encouraged and facilitated wherever practicable. Increased utilisation of such wastes, while not foreseen as a major source of supply, could reduce the demand for naturally occurring aggregates and at the same time remove existing dereliction and contribute towards sustainable development.

The review of NPPG4 concluded that it is hard to set recycling targets in terms of an annual tonnage as the total amount of recycling in any given year is likely to fluctuate with economic activity. This difficulty is compounded by the fact that a significant proportion of Scottish aggregate production is destined for export markets (although this may change in future). The following ‘achievable and challenging’ targets were suggested for recycling as a percentage of the amount of aggregates reserved for consumption in Scotland:

- 20% of production available for consumption in Scotland in 2000
- 27% in 2003
- 36% in 2006

With respect to England, currently MPG6 demonstrates a requirement for local authorities and policy makers at all levels to work towards more sustainable use of demolition recycle. Some key paragraphs indicating this requirement are shown in Box 2.3.

Box 2.3 MPG6: Paragraphs On Sustainable Use Of Demolition Recyclate

Paragraph 11. The objectives of sustainable development for minerals planning are:

- To conserve minerals as far as possible, whilst ensuring an adequate supply to meet the needs of society for minerals;
- To minimise production of waste and to encourage efficient use of materials, including appropriate use of high quality materials, and recycling of wastes

Box 2.3 (Cont/...) MPG6: Paragraphs On Sustainable Use Of Demolition Recyclate

Paragraph 28. In accordance with the Government's commitment to a sustainable approach to aggregates supply it is necessary to use all construction aggregate materials efficiently. Unnecessary wastage of mineral resources should be avoided as such wastage can increase the volume of extraction and overall level of environmental impact.

Paragraph 54 MPAs in non-metropolitan areas are required to draw up a structure plan and a minerals local plan. In London and metropolitan areas Unitary Development Plans (UDPs) should contain minerals policies. These plans should cover the whole of the local planning authority's area

Paragraph 41 of MPG6 describes the aspirations for increased use of secondary/recycled aggregates in England, increasing from 40 million tonnes per annum (mtpa) by 2001, to 55 mtpa by 2006. However, these targets, or guidelines are superseded by the draft, revised national and regional guidelines for the provision of aggregates in England, which were published for consultation on 5 August 2002. The consultation period ended on 4 November 2002. According to the Office of the Deputy Prime Minister, these new guidelines are being considered as a matter of urgency ahead of a revision of the remainder of MPG6. The draft guidelines are as shown in Tables 2.2 and 2.3.

Table 2.2 Draft National And Regional Guidelines For Aggregates Provision, 2001 -2016 (million tonnes)

New Regions*	Guidelines for land-won provision		Assumed levels of supply from other sources		
	Sand & Gravel	Crushed Rock	Marine Sand & Gravel	Alternative Materials**	Net Imports to England
South East England ***	176	22	127	207	50
East of England	195	7	21	90	16
East Midlands	163	455	0	70	0
West Midlands	153	86	0	62	4
South West	90	320	8	98	0
North West	64	174	3	84	55
Yorks & Humber	68	185	3	145	0
North East	23	91	11	82	3
England	932	1340	173	838	128

Notes:

* See para A10 of Annex A of the Draft Guidance.

** Recycled and secondary materials

*** The standard region plus Greater London.

Table 2.3 Comparison Of 2002 Proposed Revised National Guidelines And 1994 MPG6 Guidelines (million tonnes)

	Sources of supply	2002 Revised estimates (covering 2001-2016)		1994 MPG6 estimates (covering 1992-2006)	
		Whole period	Per annum	Whole period	Per annum
Assumptions	Alternative materials	838	52	530	35
	Net Imports to England	128	8	320	21
	Marine sand and gravel	173	11	314	21
Guidelines	Land-won sand and gravel	932	58	1215	81
	Land-won crushed rock	1340	84	1900	127

Significantly, the draft guidelines propose reduced production of primary materials with the use of alternative material (recycled and secondary) increasing by 17 mtpa.

A number of national and regional policy guidelines impact on how approaches to managing demolition waste are developed. Taking London as an example, RPG3B/9B, Strategic Planning Guidance for the River Thames, discusses (paragraph 2.11) how planning policy should encourage and harness the transport potential of the River Thames, with “riparian planning authorities acting accordingly”. This has significant potential for the movement of demolition recyclate. In guidance document RPG3, paragraph 9.8 describes how strategic planning subscribes to the Best Practicable Environmental Option (BPEO) approach, with waste being disposed of or managed close to the point at which it is generated. Finally the Draft London Plan (at time of writing) is considering how to increase the recycling of construction and demolition waste by 10%, with some consideration of the potential for specifying a recycled material content in new buildings.

The ODPM report “Controlling the Environmental Effects of Recycled and Secondary Aggregates Production - Good Practice Guidance” describes how Regional Planning Guidance is:

“Intended to encourage the sustainable development of regional resources, and should provide a regional dimension to the national policy guidance on encouraging recycled and secondary aggregates production”
(<http://www.planning.odpm.gov.uk/recycled/practice/16.htm>).

In effect, the Regional Aggregate Working Parties (RAWPs) should drive forward the process of identifying suitable infrastructure to support the production of recycled and secondary aggregates. However, policy to support the procurement of secondary & recycled aggregates is not restricted to minerals planning. Recycled and secondary aggregates production also assists in reducing amounts of waste, with valuable resource being managed at waste transfer and reprocessing facilities. To reflect this, the ODPM's publication "*Controlling the Environmental Effects of Recycled and Secondary Aggregates Production Good Practice Guidance*" states that:

"Structure Plans in the shire areas should set out the WPA's overall planning strategy for waste management within the regional context. Policies on recycled and secondary aggregates production should be included in both 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. Combined Minerals and Waste Local Plans can provide a useful means of integrating the need for sites with potential locations."

(<http://www.planning.odpm.gov.uk/recycled/practice/16.htm>)

Paragraph 14.07 of the ODPM reports describes how in London and the metropolitan areas, the overall waste strategy should be set out in UDPs Part I, with the detailed issues and preferred sites covered in UDPs Part II.

2.4.5 UK Planning Controls Relevant To Demolition

For England and Wales the key legislation with respect to the control of demolition through the planning process is The Town and Country Planning (General Permitted Development) Order 1995. For Scotland, this is the Town and Country Planning (General Permitted Development) (Scotland) Order 1994: Demolition, Toll Road Facilities and Miscellaneous Amendments.

The above legislation excludes the demolition of certain types of buildings from planning controls. These exclusions fall into four categories:

- Buildings in Conservation Areas and scheduled monuments from the new controls, which are covered instead by the Planning Listed buildings and Conservation Areas Act 1990 and the Ancient Monuments and Archaeological Areas Act 1979.
- Buildings less than 50 cubic metres (when measured externally)
- Buildings which are not dwellinghouses, or adjoining a dwellinghouse (if not currently in use, then a building last used for dwelling).
- Whole or part of a gate, fence, wall or other means of enclosure, unless in a conservation area.

A dwellinghouse or a building adjoining a dwellinghouse are two of the few examples of buildings whose demolition would require prior approval in order to benefit from permitted development rights. The whole demolition of other buildings is not development. For example, where an operation involves only the total demolition of a factory, church or warehouse, then that would not be development and would not require any form of planning permission (neither planning permission from a planning authority nor via prior approval in relation to permitted development rights)

In Scotland, Circular 2/1995 describes, with respect to non-excluded categories of building, how before exercising a permitted development right to demolish a building the developer should, except in specified circumstances, apply to the planning authority for a determination on whether prior approval of the authority will be required for the demolition and site restoration method. The planning authority then has 28 days to consider if they will give their prior approval to the method and restoration. If the authority does not notify the developer within the 28 day period that prior approval is required, demolition can proceed according to the details submitted to the authority.

The key impacts of legislation on demolition contractors are that applications may be accepted with conditions relating to timescales, typically requiring the minimum time possible. There is no consideration of how demolition material should be managed with respect to resource efficiency.

2.4.6 Environmental Legislation Relevant To Demolition

Key environmental legislation influencing the recovery of demolition recyclate in the UK is summarised as follows:

- Waste Management Licensing Regulations 1994 Schedule 3 .(Exemptions) – with accompanying Circulars 11/94 (DOE), 26/94 (Welsh Office), 10/94 (Scottish Office Environment Dept).
- Environmental Protection Act 1990
- Environmental Protection (Prescribed Processes & Substances) Regulations 1991(g)
- Control Of Pollution Act 1974

The Waste Management Regulations have a significant impact on the potential of demolition recyclate in particular with respect to how waste is defined and also in describing the conditions which result in material processing/storage requiring either a licence or an exemption (i.e. a waste management licence is not required). Conditions for exemptions are explained in Schedule 3 of the regulations with some key elements summarised below:

- Demolition waste to be used in a manufacturing process – storage cannot exceed 20,000 tonnes (Paragraph 13[4]).
- Reuse of demolition material, capable of being used for construction work in its existing state. Storage cannot exceed 100 tonnes and cannot be stored at a premises for longer than 12 months (Paragraph 17[1]).
- Demolition waste moved to another site cannot be stored for more than 3 months before relevant manufacturing (recycling) work begins (Paragraph 17[1]).

The above exemptions highlight that legislation, as it currently stands, is able to facilitate the use of recycled aggregates from demolition by providing a baseline of behaviour which does not require waste management licensing. However, the quantities and timescales allowed for storage can restrict the potential use of demolition recycle.

To ensure that the reprocessing of material to produce recycle has minimal environmental impacts authorisations are required under the 1990 Environmental Protection Act. This applies to recycling plant (crushers, screeners etc) proposed for a material recovery operation which could result in noise, vibration dust and nuisance in general. In addition, waste management licences are required if material separation/segregation processes form part of the process, as inevitably tends to be the case in the UK.

2.5 Europe

The following table describes the status of European countries with respect to arisings of Construction and Demolition Waste. The methodologies for data collection are quite different for each of these countries, however on the basis of this being the best data available, it can be seen that the Netherlands reports one of the highest levels of arisings in the EU, with Denmark shadowing the UK level.

Table 2.4 Annual Per Capita Tonnage For C&D Waste In The European Union*

Germany	1994-96	0.720
Netherlands	1996	0.718
Luxembourg	1997	0.700
Belgium	1990-92	0.666
Austria	1997	0.580
UK	1996	0.509
Denmark	1996	0.509
France	1990-92	0.404
Italy	1995-97	0.348
Spain	1997	0.325
Portugal	1997	0.325
Finland	1997	0.255
Sweden	1996	0.193
Greece	1997	0.172
Ireland	1995-97	0.162
EU-15		0.481

* Symonds, 1999, "Report To DGXI, European Commission – Construction & Demolition Waste Management Practices And Their Economic Impacts".

Three European countries are reviewed here which have significant per capita C&DW arisings as well as high recycling rates: the Netherlands, Germany and Denmark. A brief summary of the three countries' performance is given in Box 2.5, with more detail provided in the following sections. This information followed from consultations with various government and regulatory departments.

Box 2.5. Summary Of Current Practice

Denmark

89% C&D recycling rate achieved, mainly, by high tax on C&D waste and a voluntary agreement by the Danish Demolition Contractors Association on the selective demolition of building material. Some key facts are as follows:

- Approximately 10% of the total volume of waste is mixed – 50,000 tonnes per year.
- Currently concrete is not being used in higher value applications – according to the recycling industry demand is limited because of market uncertainties over the quality and source of concrete.
- The main market for C&D waste is road sub-bases (99%).

Box 2.5 (Cont / ...) Summary Of Current Practice

The Netherlands

The International Recycling Federation (FIR) in the Netherlands believes that 95% of C&D waste is recycled in land levelling and used as sub-base material for road building. A small percentage is used as gravel, concrete or masonry sand. 13mn tonnes of recycled aggregates go into road building, for which there is a market of 16 million tonnes.

Germany

Currently achieves recycling rate of about 80%, a significant reason for which is the result of a voluntary agreement between the government and the federation of demolition companies and a ban preventing mixed C&D waste from being sent to landfill.

A timeline of policy developments for these countries is shown in Table 2.5. Some of the significant developments include the banning of landfill for C&DW and the requirement for source segregation of demolition material over one and ten tonnes, depending on the geographical location.

Table 2.5 Timeline of Policy Developments Affecting C&DW For Denmark, Netherlands & Germany

	1994	1995	1996 / 1997	1998	1999	2000	2001	2002	2004
Denmark	Agreement on the separation of C&D waste over 1 tonne.		Objectives set for 2000, were met. The agreement to separate C&D waste became law.	Waste 21 plan implemented	Act 570- Tax on Waste and Raw materials	Second Waste Plans Submitted. Stat. Order No.665 * Stat. Order No.650 *1	Action plan for Danish Construction and building industries.		Waste 21 plan updated
Germany		Voluntary agreement to increase recycling rates by 2005.	Ban on landfilling mixed C&D waste. Closed Substance Cycle and Waste Management Act, disposal is the resp. of manufacturer.					Ordinance on waste management. Draft for the management of wood. Members of the KWTB agree to halve the amount of waste going to landfill by 2005.	
Netherlands			Ban on landfilling C&D waste that can be recovered.		Building Materials Decree for stony materials.	Wood Action Plan. Tax on surface materials extracted.	SODII Implemented – looks at sustainable use of raw materials.	First NWMP – LAP. WM controlled on a national level. PIA – Limits the extraction of materials for concrete and sand.	Cradle to Grave Design for deconstruction.

2.6 Denmark

The Danish EPA is responsible for the development of an overall waste management plan, with municipal and regional authorities taking charge of the practical administration, as well as being responsible for surveying waste quantities and devising new management plans every four years. Denmark implemented a ban on the landfilling of waste which can be incinerated and has a landfill tax of Euro 50.55 per tonne for waste going to landfill (2002 figures).

In 1994 an agreement was concluded on a number of waste streams, including C&DW. This involved the Minister for Environment & Energy, the National Association of Local Authorities in Denmark, the City of Copenhagen, and the Municipality of Frederiksberg. This resulted in the issue of a circular describing the municipal regulations for separating construction and demolition waste to facilitate recycling. The regulations took effect from 1st January 1997 with the result that local councils, through the planning process, must take into consideration the mandatory sorting and separate collection of different waste fractions.

As part of the process of implementing the regulations requiring source segregation, the Minister for Environment & Energy entered into an agreement with the Danish Demolition Association (DDCA). Currently about 85% of demolition companies belong to the DDCA, which states that if there are breaches of the rules companies may lose their membership (in 2001, 2 companies were removed). Government accepted the targets set by the DDCA for its members, which requires that all waste over 10 tonnes (1 tonne in Copenhagen and other large cities) be separated at source. Government contracts only permit the use of companies that are members of the DDCA. This means that members have a monopoly on public projects, thereby providing an incentive to join the scheme and adopt more sustainable practices. There are some issues over the practical implementation of the agreement. This stems from the difficulty in enforcing the scheme, which means that some companies do not follow the specified procedures.

2.7 The Netherlands

A general ban on the landfilling of recyclable C&D wastes was implemented in 1997 and currently 95% of C&D waste is recycled in roads (13 million tonnes) and land-leveling projects. A small percentage is used as gravel or sand for concrete/masonry. there is a market of 16 million tonnes. The most significant environmental problems, as stated by the Dutch Ministry of Transport, are considered to be sulphate leaching from the unbound sub-base materials and asbestos washed out with the leachate (legacies from the past). The ministry stated that 10mg/kg is the accepted informal maximum level for asbestos. The Building Materials Decree (BMD) is the main piece of legislation driving recycled C&DW use and the testing regime required for the

use of recycled C&DW. The BMD states that leaching tests have to be carried out but the frequency depends on the quality of the aggregates as determined through previous tests. This testing regime takes place approximately for every 15,000 tonnes to 25,000 tonnes of recycled C&DW aggregate produced. If recycling companies can demonstrate that they achieve consistently “good” results.

According to the Ministry of the Environment, Spatial Planning and housing (VROM), due to the high recycling rates already being achieved, driving forward policy to increase C&DW recycling is not a priority. VROM believes that the single greatest influence on recycling has been the introduction of the landfill tax (80 euros combustible and 13 euros non- combustible per tonne). As mentioned previously, the largest market is currently in roads. However, recently the Dutch government launched a programme aimed at encouraging the use of recycled C&DW as aggregate in structural concrete – target of recycled C&DW replacing primary aggregates by 25% in such use. However, there were no mandatory requirements placed on industry and, as a result, with limited interest in the programme the government has dropped the scheme.

As expected, material quality is a key issue and several of the larger recycling contractors have developed “product cards” certification schemes that specify a certain allowable percentage of contaminants e.g. wood, glass etc that may be permitted for certain grades of recycled aggregates. It should be noted that despite the limited success of the programme a number of Dutch companies are selling bagged concrete mixes with an aggregate content of 80% primary, 20% recycled C&DW.

2.8 Germany

In recent years Germany has greatly increased its recycling and reuse of C&DW and now recycles about 80% of the total arisings. It is believed that the high recycling rates are due to a voluntary agreement between the German Federal Cabinet and the federation of demolition companies. There is a ban preventing mixed C&D waste being sent to landfill, through the Ordinance On The Management Of Municipal Wastes Of Commercial Origin And Certain Construction And Demolition Waste (15 May 2002).

The environmental authorities of Berlin and Brandenburg, along with their respective industrial and recycling organisations are working to the following agreements:

- Only allow the re-use or recycling of C&DW - disposal only possible for the non-recyclable fractions
- Proper separation of hazardous materials to be achieved

- C&DW to be sorted on site, or if not possible, separation to be ensured at an adequate sorting/treatment plant
- Comparable quality standards for recycling and disposal of C&DW, particularly through the implementation of the requirements and standards set in 'technical requirements for recycling of mineral waste
- Provide/ensure transparency of the C&DW-stream from source to re-use (after recycling operations) or disposal.

A national Voluntary Agreement contains the following targets and measures (among others):

- A 50% reduction (from 1995 levels) in the disposal of recyclable C&DW by 2005
- Information and advisory services to be made available to construction and demolition companies
- R&D into the avoidance of C&DW arisings, separation and sorting of wastes and recovery measures
- Quality assurance for recycled materials
- Promotion of applications for recycled materials

2.9 Conclusions & Recommendations

The development of policy differs significantly across a variety of European countries. As described in Section 1 of this report, recycling rates for C&DW in the UK vary between 22 % and 72 %, depending on the geographical location. However, even in those parts of the UK with higher recycling rates it is unlikely that the full potential for displacing primary aggregates with recycled C&DW material is being realised.

The potential for producing high value recycled aggregate from C&DW is maximised by source-segregating material. In countries such as Denmark, the extent of segregation required is determined by legislation and industry agreements. In other countries the potential is maximised by banning landfill as a disposal outlet. In the Netherlands, Denmark and Germany the market for recycled C&DW has been mainly in the sub-bases of roads. However, it is recognised that the construction of roads in the future is likely to be significantly reduced, which means there is likely to be an excess of C&DW for the market. Initiatives which lead to the use of C&DW as a replacement for primary aggregates in new buildings are therefore of great interest.

As in the UK, concerns were expressed abroad about the quality and source of C&DW, with respect to use in buildings. However, just as this material has been proven to be suitable for roads, European standards (introduced through the Construction Products Directive) on aggregates are now displacing older discriminatory standards to allow the specification of recycled C&DW in place of primary aggregates. In this respect, developments such as AggRegain (www.aggregain.org.uk), managed by the Waste and Resources

Action Programme (WRAP, www.wrap.org.uk) become increasingly important in demonstrating the performance and supply potential of recycled material (a summary of AggRegain and WRAP is given in Box 2.5). So too does the development of protocols to guide various industry players (such as project managers, designers etc) through the minefield of evolving standards and recycled material opportunities.

Box 2.6

WRAP (the Waste & Resources Action Programme)

WRAP is a not-for-profit company supported by funding from DEFRA, the DTI and the devolved administrations of Scotland, Wales and Northern Ireland. It is working to promote sustainable waste management by creating stable and efficient markets for recycled materials and products

AggRegain

Funded through the Aggregates Levy Sustainability Fund, AggRegain has been established by WRAP (the Waste and Resources Action Programme) to provide a 'one-stop' source of practical information on the use of recycled and secondary aggregates. It is a free service, designed to assist anyone interested in specifying, purchasing or supplying these types of products.

There are numerous recommendations on how to make industry more sustainable in the UK with respect to resource and waste management. Procurement guidance is an area where there are, increasingly, requirements for government departments to ensure that their tendering processes put pressure on potential contractors to demonstrate their environmental credentials. Approaches described in this report continue this process by providing information on methodologies and technological advances to encourage the displacement of primary materials by so-called waste materials. In doing so we also encourage the use of low carbon emission construction methodologies. The drivers are therefore powerful and require government support. However, rather than simply following Dutch and German models, for example, this report recommends that the UK learns from overseas experience, but puts in place the processes which suit the local context. Three main recommendations are proposed as a result:

- A requirement for the planning process to include recycled material content in new builds – as encouraged by standards introduced through the Construction Products Directive
- A requirement for the planning notification process to ensure that contractors adopt a resource efficiency protocol for demolition material.
- A requirement for all government (local & national) departments to tender construction and demolition projects on the basis of a Demolition or Construction Protocol. These would detail a minimum set of criteria for bids to consider, with respect to resource and waste management.

Section 3

Demolition Case Studies: *Identifying The Requirements Of A Protocol*

3.1 Objective

This section describes a number of projects where consultation took place to discuss the approach chosen for the management of demolition material. In considering the perceived opportunities and barriers it is possible to identify the areas where project teams require more information. This section therefore describes how demolition material is typically managed and identifies the areas where guidance, through a Demolition Protocol, is required.

3.2 Scope Of Demolition Projects Considered

The potential for using C&DW as a high value material in the construction of new buildings has been demonstrated in a variety of projects. An example of this is BRE's Environmental Building where the material from a 12-storey office block in central London was used as coarse aggregate in over 1500m³ of concrete supplied for foundations, floor slabs, structural columns and waffle floors (Collins, R., 1998). Similarly, Wessex Water's new 11,000m² headquarters building demonstrates the use of Recycled Concrete aggregate (RCA) in structural concrete (Wessex Water, 2000). The proportion of coarse aggregate replaced by Recycled Concrete Aggregate (RCA) was limited to 40%. In this example railway sleepers were used to obtain 20mm crushed concrete. These examples demonstrate the potential for demolition recycle. However, such uses are still rare despite the potential. As a result, and to develop an understanding of the requirements of a demolition protocol, a number of very different demolition case studies were looked at.

These projects were located in a wide variety of geographical locations, stretching from the rural landscape of Oban in the Highlands of Scotland, to the densely populated South East of England. In consulting with the teams responsible for these projects it was possible to identify the issues which prevent or promote the use of recycled demolition material as a substitute for primary materials. A number of the demolition projects consulted are now summarised, divided into different categories on the basis of the material management option chosen or likely to be chosen. It should be noted that the management options described are based on the information provided by the project teams at the time of the consultation and may not therefore represent the final option chosen. Descriptions of the categories used to describe the options involved in the case studies are given in Box 3.1.

Box 3.1 Categories Of Material Management

Demolition & Landfill Disposal

This typically refers to projects where there is little evidence of market opportunities being considered for the demolition material and where the predominant management option discussed is landfill.

Demolition & Low - Medium Value End-Uses

This generally refers to projects where the management options for demolition material include “standard” approaches involving the use of recycled C&DW as type II sub-base in roads, general fill etc.

The case study descriptions given below are followed by a summary of barriers and opportunities. This summary describes the issues and drivers influencing the different members of a project team and reflects consultations on a number of projects.

3.3 Demolition & Landfill Disposal

3.3.1 Dunstaffnage Marine Laboratory, Oban

The laboratory is located a couple of miles outside of Oban. The project requires the demolition of a sizeable part of the existing building followed by construction on the same site of a larger facility. Discussions with the project team revealed concerns about recycling the demolition material on site because of the remoteness of the area and the potential cost of recycling i.e. the cost of using specialist machinery when there are local quarries nearby (Ennstone Thistle). As a result, the likely outcome was that the demolition material would be landfilled at the local Shanks site.

3.3.2 Rottenrow Maternity Hospital, Glasgow

Located on Strathclyde University’s campus in Glasgow, the hospital building was sold to the university and demolished in the latter part of 2002. The consultation took place after the appointment of the project team and after an initial short-list of demolition contractors was drawn up – with initial bids submitted. There were a number of concerns expressed by the project team with respect to a putting in place a process which, it was considered, would complicate the project management. As a result, a “traditional” demolition approach was adopted, with a standard soft strip and demolition process which resulted in very little material segregation. Future discussions did not reveal any plans for recycling of the demolition material.

3.3.3 High Rise Towers, Waltham Forest

English Partnership expressed interest in discussions to investigate the potential for recycling demolition material from two Leytonstone towers in Waltham Forest (Cathall Estate) and using the material in the subsequent redevelopment. Beyond using some of the demolition material to infill parts of the site, there had been little consideration until now about to use the remainder of the material. Dearle-Henderson, the project managers, initiated a project team meeting to discuss the potential for using the demolition material. BS8500, a British Standard for concrete, was discussed with respect to describing the opportunities for using recycled aggregate in a number of concrete applications. The designers believed that there was insufficient time to understand the full implications of doing so, having experienced difficulties with recycled demolition material in the past. It was felt that beyond using the material as a fill, significant quantities of material would be landfilled.

3.4 Demolition & Low Value End-Uses

3.4.1 The Granary Buildings, Glasgow

These buildings represent the largest clay brick constructions in Europe (anecdotal information), being demolished to make way for the initial phase of the Glasgow Harbour development. The project team identified that one of the main opportunities for demolition material was to potentially infill Yorkhill Quay. This would require 150 000m³ of material, with the Granary buildings providing 75 000m³. The waste from the granary at the time of consultation was being crushed to 6F2 (attempts to achieve Type 1 were less successful). Discussions were held with Arup, the civil engineers for the site infrastructure, to explore the potential for using recycled demolition material in aspects of the new infrastructure. A significant project objective was to save costs by keeping and using demolition material on site – the main use of such material, apart from infilling the quay, would involve the production of capping material 6F2 for use in road construction around the new development.

3.4.2 Channel Tunnel Rail Link

The Channel Tunnel Rail Link represents one of the UK's most significant construction and demolition projects, involving the construction of new track, bridges, stations etc to connect with various parts of existing UK infrastructure. Waste management at the various sites has been carefully monitored and recycling infrastructure provided adjacent to temporary railhead facilities at Kings Cross Station – including crushers and screeners -

to allow the transportation of C&DW by rail. Generally speaking, material is crushed to produce a hard core for use as a fill material, or transported to landfill sites outside London. An innovative aspect of the demolition included a contractual requirement to salvage bricks, however, due to limited demand this reclamation process has met with limited success.



Fig. 3.1. Aerial View Of Construction Work On The CTRL Project

3.5 Consultations – Identifying The Requirements Of A Protocol

Consultations with project teams for demolition and construction work invariably resulted in the identification of many questions which needed to be answered before further progress could be made on adopting new and different approaches to material management. Some frequently asked questions, with responses are detailed below:

Q: What are the cost benefits of using recycled demolition material as a replacement for primary aggregates in new buildings?

A: Awareness of the potential technical opportunities for using recycled aggregates in high performance applications has been growing in recent years. However, there is little information available on the potential cost benefits of such use in new buildings. With the Aggregate Levy of 2002 adding £1.60 to each tonne of primary material, together with the landfill tax (£2/tonne for inert waste, £14 for active waste), the attractiveness of using recycled materials is undoubtedly increasing.

Q: How can the quality of demolition material be assessed and what testing is required?

A: Technological progress means that the waste processing industry is increasingly developing plant to manage the physical contamination (wood, plastic etc) associated with recycled aggregates. However, the number of innovative plant is limited and currently insufficient to cope with the potential capacity. Physical contamination is the result of a material segregation

process, or soft strip, which leaves undesired materials. With respect to this, there is limited understanding of how much segregation is required to prevent physical contamination reducing the value and potential uses of recycled demolition material. Guidance which indicates the point to which segregation should be carried out would therefore be valuable. This protocol provides bills of material for a number of building types. This allows an estimate to be made of how much segregation is required to remove contaminants and therefore to allow recycled demolition material to be specified in high performance applications (such as concrete).

In addition, there is limited awareness of the potential for chemical contamination of demolition materials and with uncertainty comes barriers. Guidance, as described by Risk Assessments in this protocol, allows an assessment of buildings and their potential chemical contamination. Such guidance could indicate where testing is and is not required.

Q: How do standards allow demolition material to be used?

A: Standards and technical guidance to assist in the process of specifying recycled aggregates have been evolving for some time now. In particular the Construction Products Directive has resulted in the introduction of standards for aggregates and concrete. The new standards endorse the use of recycled aggregates in many high value applications for example, in high strength structural concrete. The protocol describes the opportunities and relates these to procedures which identify the potential of buildings (for demolition) to supply high performance materials, as well as to identify where these can be used in new constructions.

Q: What is involved in specifying recycled demolition material in new building components?

A: There is historical and continued reluctance on the part of designers to specify recycled materials in new builds. The basis for some of these concerns is the uncertainty of supply and *knowing what you are going to get*. For projects where the project team is managing both the demolition and subsequent new build, this uncertainty can be significantly diminished by following the procedures laid out in this protocol.

An approach considered for aspects of constructing Terminal 5 can also be considered – where efforts were made to investigate the potential of identified demolitions to provide suitable recycled aggregate. However, if circumstances would not permit such an approach it is recommended that relationships be created with recognised recycled aggregate suppliers, where such suppliers can demonstrate that the procedures in the protocol are being followed.

Various digests and standards identify the potential for designers to specify quantities of Recycled Aggregate (RA) or Recycled Concrete Aggregate (RCA). However, the process of managing such materials may appear complicated with respect to being able to identify where the RA or RCA can be specified. This process can be facilitated by specifying in the Bill of Materials those components which can and should be constructed using= recycled demolition material. The information from this Bill of Materials can then be aggregated in a Material Schedule, providing an overall recycled material content for any new building.

Q: How is professional indemnity and liability affected by specifying recycled materials?

A: This has been described as a *non-issue* by one insurance company. Liability is dependent on the designer following appropriate standards and using appropriate engineering principles. The insurance industry will provide cover on this basis and not on the basis of whether primary or recycled aggregates are used in a design.

Q: How should a contract be set up to maximise the potential of demolition materials?

The process of doing this may appear tortuous to project teams where consideration of new applications for recycled aggregates is unknown territory and an area which has been relatively unimportant. However, this protocol provides guidance on a number of contractual aspects which provide an improved opportunity to recover maximum value from demolition material.



Section 4

Adapting The Planning System To Improve Resource Efficiency

4.1 Objective

This section describes a number of ways in which the planning system can be adapted to improve resource efficiency for demolition. Currently, there is no link between the resource available in existing buildings earmarked for demolition and the procurement process for new build. This section describes a number of ways in which the planning system can drive more sustainable approaches to the demolition of buildings forming part of the redevelopment process, with respect to material recovery, as well as describing mechanisms which lead to the specification of demolition recyclate in the new build.

4.2 Introduction

The current planning framework for demolition is discussed in Section 2 of the Protocol Report. In this section mechanisms are described which allow the planning system to support more efficient resource management methodologies for demolition. In effect the most effective mechanisms to drive change will be through:

1. Regional Spatial Strategies
2. Local Development Plans
3. Supplementary Guidance
4. Section 75 (Scotland) & Section 106 (England & Wales) Agreements
5. Planning conditions



The context for improving resource efficiency has already been discussed in previous sections and Figure 4.1 highlights one of the main issues to be dealt with in carrying out demolition work. i.e. the lack of planning to produce segregated material streams. Without such planning, the resource potential of a building is unlikely to be realised.

4.3 The Development Of Planning Policy To Support Sustainable Demolition and Construction

Planning Policies to support more sustainable resource use have been developed and are evolving with respect to guidance for the provision of minerals and waste management (as described in Section 2 of this protocol). There are few examples of guidance with respect to influencing the procurement and specification of recycled materials. At a local level this does exist in fragments across the UK, for example, Brent Council has produced supplementary planning guidance on Sustainable Design and Construction. To implement the broad strategic goals of mineral planning and waste management, planning has the potential to play a key part by controlling the way in which elements of the construction industry are managed

The Office of the Deputy Prime Minister report *"Controlling the Environmental Effects of Recycled and Secondary Aggregates Production - Good Practice Guidance"* describes complementary measures to encourage recycling (Chapter 14, <http://www.planning.odpm.gov.uk/recycled/practice/16.htm>). In addition to the identification of sites in development plans, the report describes how local authorities can institute various complementary measures to support recycling and secondary aggregates production:

- Preparation of waste management strategies
- Maintaining a public register of recycled aggregates operators and sources of recycled/secondary aggregates
- Initiatives to improve segregation of waste at source
- Measures to improve perceptions of the suitability of recycled and secondary aggregates for use in construction, for example through local authority specifications
- Joint ventures with mineral/waste operators
- Inclusion of informatives in planning permission decision letters, which describe the opportunities for recycling construction and demolition waste material and the benefits of doing this
- Operating an annual award scheme for well managed sites

The above points all make reference to developing best practice, however these are very much geared towards a voluntary style approach and may, in reality, have little weight. The change in behaviour associated with achieving resource efficiency between demolition and new build will however require the development of overarching policy which has the power to ensure more cohesive (not fragmented) and sustainable approaches. Voluntary programmes, rather than acting the driver, could be used to complement the development of more prescriptive planning policy. The following sections therefore discuss the potential of planning to influence resource efficient processes for demolition and construction procurement.

4.4 Innovative Planning & Resource Efficiency Models

Effectively, the planning system can drive two processes:

- The procurement of material in the new build
- The methodology required to demolish a building.

The result is a stimulation of demand for recycle and an increase in the supply of materials to meet this demand. The mechanisms at play are summarised in Figure 4.2 below.

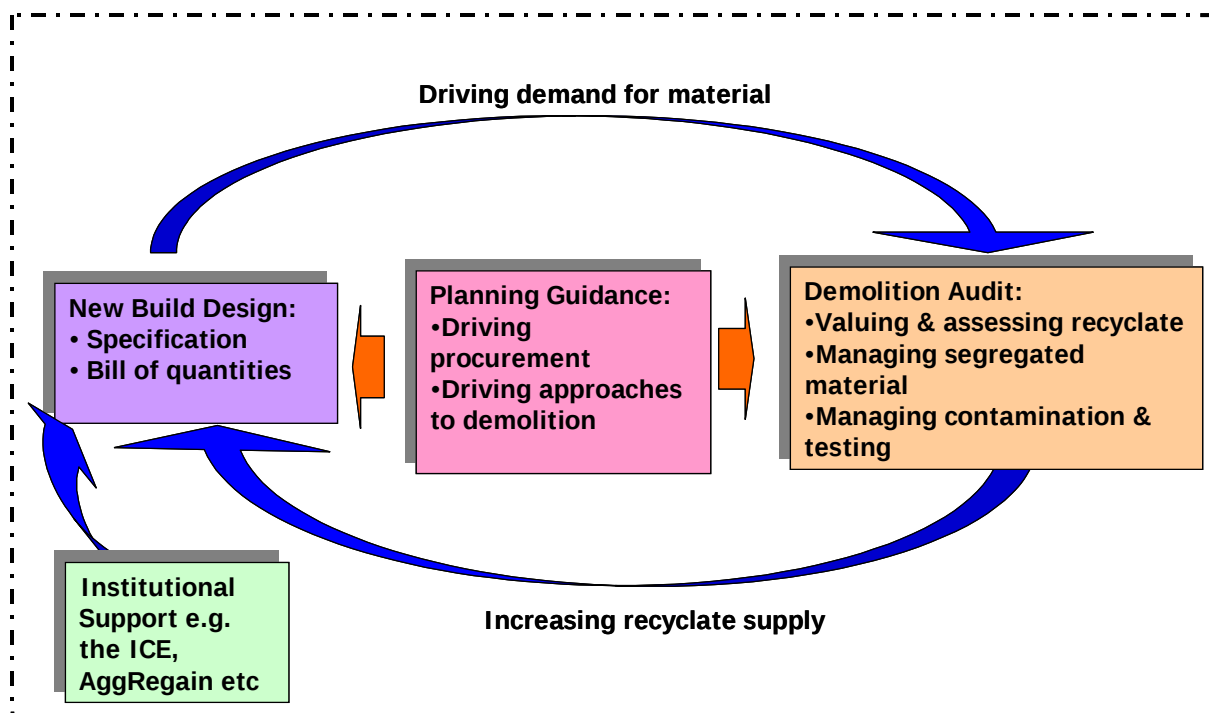


Figure 4.2 Planning & Resource Efficiency Model For Demolition & The New Build

The protocol requires a Bill of Quantities (BOQ) to be produced via a demolition audit, with potential applications, tonnages and percentages of recycling/reuse opportunities detailed. The audit allows the creation of a recovery index which effectively describes the percentage of the demolition material which can be recycled. Driven by the planning process, the resource model described above requires that the recovery index and background information are submitted by the project team before consent is given for the demolition to proceed. This process is described in some detail in **Section 5, Demolition Audit**.

The next stage then depends on whether the project team is directly responsible for the construction of a new build on the site of the demolition. If so, the team must demonstrate that the recovery index of the new build falls within a range

which is linked to the previous building on the site. If the new build project is independent of prior demolition work the recovery index must then be within a defined range for the type of building being constructed. Figure 4.3 shows, from a resource efficiency perspective, how the various stages in the development of a project are linked.

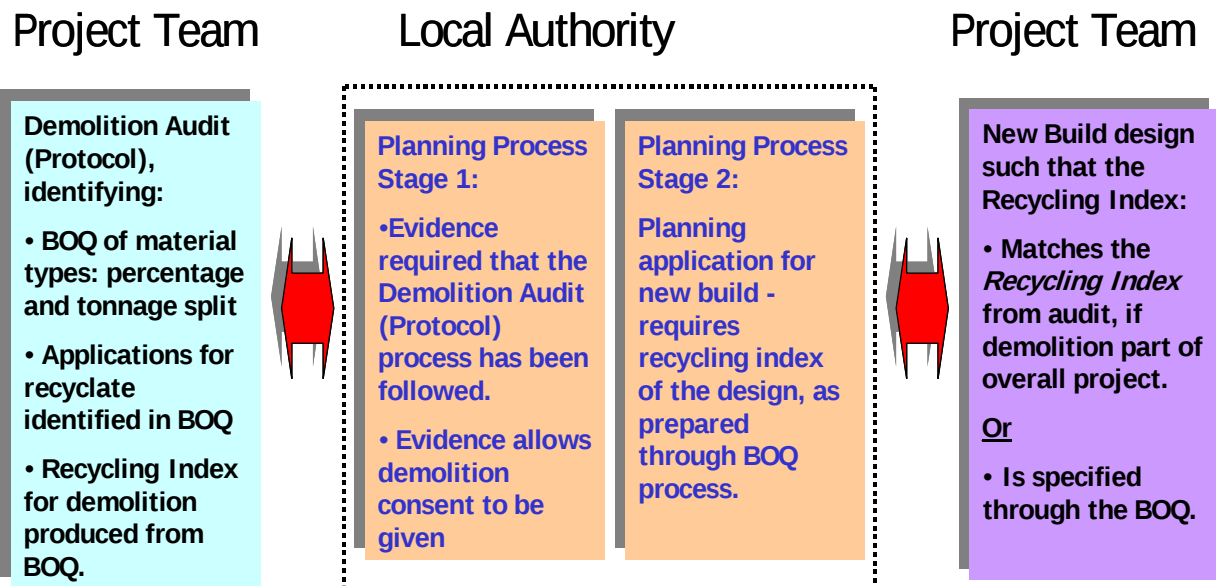


Figure 4.3. Linking The Project Stages In The Resource Efficiency Model

The New Build Recovery Index is produced from the new build Bill of Quantities, which is summarised in a Material Schedule Summary. In this document the opportunities for using recycled material are detailed and the content, as a percentage of the overall building tonnage, is produced. This is described in much more detail in **Section 7, Standards & New Build Opportunities**.

4.5 A Planning Structure For Sustainability

The planning process can work from the top down to effect change. The Planning & Compulsory Procurement Bill (due for Royal Assent in April 2004) for England & Wales requires ***Regional Spatial Strategies*** which have waste and minerals sections. These sections could emphasise that Demolition Waste/Recyclate should be specified and procured in the new build. Local Development Plans would then have to be prepared in accordance with these spatial strategies, with supplementary planning guidance, conditions & agreements used as the implementation mechanisms. Obligations from such planning mechanisms could then ensure that the project team has to provide the Demolition Recovery Index (DRI) and New Build Recovery Index (NBRI),

with the associated tonnages of material. The planning process could then make the provision of this information a requirement before consent is given for demolition, where it is part of an overall redevelopment project, to proceed.

4.6 Supplementary Planning Guidance & Conditions

Supplementary Planning Guidance (SPG) provides the opportunity for local authorities to set out in detail how the policies of the local plan will work and is therefore key for the implementation of overarching planning policies, particularly with respect to sustainability, waste and minerals management. Appropriate weight will be accorded to SPG when determining planning applications, on the basis of the consultation process involved and the subsequent adoption as council policy. Depending on the nature of the guidance, this consultation process may sometimes take place in a targeted way, with key organisations consulted (other opportunities to comment may, for example be via on-line sources such as council websites). Alternatively, the consultation process may include the whole community, but this will depend either on the nature of the guidance or the policy of the council.

The local plan and SPG provide details of where, what and how development proposals should proceed, with the SPG providing a negotiating tool for the provision of improved development proposals. As such the SPG could provide detailed design guidance for the provision of demolition recycle in new build proposals. The processes required, which in the early days of the protocol will be novel and unknown, can be put across to applicants via a pre-application pack (which includes this protocol). An example of how this could work is that the local authority includes this pack with the application forms, with on-line guidance provided where necessary. Scoring criteria would then be laid out to assist the applicant in his/her considerations of material use for the new build.

A material consideration of the planning condition would then be the sustainability score of the applicants proposal, with the application either rejected or approved with conditions related to the use of demolition recycle in the new build.

4.7 Planning Agreements

Commonly referred to as Section 106 (England & Wales) or 75 (Scotland) agreements, *Planning Agreements* allow local authorities to put conditions on the development of land. A simplified example of the range of powers is described in Scottish Planning Policy 1 (SPP1), where section 55 (on Planning Agreements) states that:

“If considered by the planning authority to be necessary or expedient, the agreement may contain incidental or consequential provision, including financial ones.”

Although vague in terms of specific functions, there is potential to explore the opportunities presented by such agreements, where project teams / developers can be required to produce DRIs & NBRI and require the specification of recycled materials in new builds. Box 4.1 indicates how Planning Agreements are currently used by local authorities.

Box 4.1 Examples of Some Applications Of Planning Agreements

- Secure affordable housing
- To secure transport improvements including Green Transport Plans
- For the restoration of land and landscaping
- To control the phasing of development
- To secure community facilities
- To maintain open spaces
- For sustainable urban drainage

Current legislation on the use of planning agreements is set out in the following:

- Section 75 of the Town and Country Planning (Scotland) Act 1997
- Section 106 of the Town and Country Planning (England & Wales) Act 1994

The potential for planning agreements to influence demolition will be reinforced at local authority level by the existence of other related planning policies, either reflected through Development Plans (statutory) or Supplementary Guidance (non-statutory). Existing guidance, for example with policies promoting *Sustainable Development* and waste/resource efficiency, will provide the underpinning basis for establishing a planning agreement to control demolition and new builds in this respect. The agreements in this context therefore serve to implement existing local authority policy and obligations. Examples of how these obligations are defined is given in Box 4.2.

Box 4.1 Section 106 Of The Town & Country Planning (England & Wales) Act 1994 - Planning Obligations

Any person interested in land in the area of a local planning authority may, by agreement or otherwise, enter into an obligation (referred to in this section and sections 106A and 106B as "a planning obligation"), enforceable to the extent mentioned in sub-section (3):-

- (a) Restricting the development or use of the land in any specified way;
- (b) Requiring specified operations or activities to be carried out in, on, under or over the land;
- (c) Requiring the land to be used in any specified way; or
- (d) Requiring a sum or sums to be paid to the authority on a specified date or dates or periodically.

4.8 Adapted Planning Systems To Drive Resource Efficiency

It should be noted that where redevelopment involves demolition as the first stage in the process, the planning authority will require that the planning application is prepared to include the scope of works for both the new build and demolition phase. As described in Section 2 of this Protocol Report, where demolition takes place in isolation, prior approval only needs to be sought if the building is, for example, a dwelling house or attached to a dwelling house (there are other examples involving conservation areas etc). As a result, using the methodologies described in sections 5 & 6, to produce the NBRI and DRI, supplementary guidance, conditions and agreements etc can be produced to require very different behaviour regarding the management of demolition material, including the potential for specifying and procuring demolition recycle in the new build.

A planning process for managing redevelopment, which involves demolition followed by a new build, is now described. The initial driver is the requirement for the developer to produce the *Demolition Recovery Index* (DRI), with an agreed demolition methodology, **plus** the *New Build Recovery Index* (NBRI), with an agreed percentage of demolition material specified in the new build. As detailed in Section 6, "*Standards & Specifying Demolition Recyclate In The New Build*", standards have evolved to such an extent that planning authorities can realistically require that recovered (recycled/reclaimed) materials be specified in increasing applications within the new build. Production of the Demolition Recovery Index (DRI) could follow an agreed demolition methodology which results in a requirement for material segregation practices and demonstration, through certificates/receipts that material has been sold to a material reprocessor. The various steps involved in the process are now summarised in Figure 4.4.

It should be noted that the models shown in Figures 4.2 and 4.3 describe a macro (overall) approach to achieving resource efficiency in demolition and the new build. The micro (detailed) processes required to make this happen will be driven through Supplementary Planning Guidance & Conditions and/or Planning Agreements), requiring developers to manage demolition and the new build using more innovative approaches.

Redevelopment: Demolition Plus New Build

The required steps:

1. The Planning Authority requires the production of the New Build Recovery Index, from the developer, for: concrete components, building and project (building + infrastructure)
2. Planning authority requires production of the Demolition Recovery Index (DRI) along with a methodology for waste/material management – see opposite
3. Where the tonnage of allowable recovered materials, as identified from the NBRI, is less than the tonnage of demolition recyclate produced (from the DRI), the developer must procure recyclate in quantities which satisfy the full potential demand (the NBRI) for recovered materials in the new build. Evidence of material purchase/use must be available.
4. Additional demolition recyclate must then be specified in any infrastructure works, in accordance with the potential for specifying demolition recyclate in the scope of works – as identified in the Project Recovery Index.
5. Where the tonnage of allowable recovered materials, as identified from the NBRI, is more than the tonnage of demolition recyclate produced (from the DRI), the full quantity of demolition recyclate must be purchased for

The Demolition Methodology

The required steps:

1. The Planning Authority requires the production of the Demolition Recovery Index.
2. The developer produces a material recovery plan which states the proposed level of recovery, segregation and markets for demolition recyclate.
3. Where the proposed level of material recovery is significantly less than the DRI, the onus is on the developer to provide reasons for the departure.
4. The authority, in consultation with the developer, negotiates the final level of material recovery.
5. Material transfer notes will identify the management option for material taken off site.
6. The developer must be able to provide evidence that the negotiated material recovery target has been achieved.

Figure 4.4 Step By Step Process Of How Planning Can Produce Resource Efficiency

4.9 Material Credit Scheme

Where the process of adopting the required percentage of re-used or recycled materials is difficult, perhaps due to the local market conditions, developers could be offered the opportunity to purchase material credits from new developments that have exceeded the guidance levels for recycled material content. This system of trading material credits would reflect the tradeable permit system currently being proposed for the collection of municipal wastes in the UK, where local authorities are given permits specifying the tonnages of waste which can be landfilled. Those local authorities unable to limit the tonnage of waste sent to landfill, in accordance with the permits allocated, could then have the option of purchasing credits from other more successful authorities. Although such a system may mean there are high & poor performance authorities, the overall result would be that the landfill diversion targets are met for the country as a whole. A Material Credit Scheme for development (construction and demolition) could work in the same way.



Section 5

Building Audit & Planning For Material Segregation

5.1 Objective

This section describes a number of project management approaches to demolition - to maximise the recovery of material for subsequent high value applications. The aim is to provide guidance which supports the decision-making processes of a project team – this includes the client, consulting engineers and demolition contractors.

This section does not describe a detailed approach for planning the demolition of specific buildings. The philosophy adopted in this protocol is that such methodologies are best developed by the practitioners – i.e. the demolition contractors.

This section instead complements the resource efficiency model, by providing a number of approaches for planning and auditing demolition projects which lead to segregated material and improved potential for specification in high value applications. In addition, the interface with planning authorities is summarised (described in more detail in the planning section) to allow a Recycling Index for demolition to be produced.

5.2 Planning For Segregation

In planning a demolition, a number of pressures influence how material can be managed:

- Space constraints around and near to the site
- Timescales i.e. the need for a fast-track project will impact on the potential for carrying out innovative approaches
- Financial incentive & markets
- Proximity to other properties such as residential, commercial buildings

The maximum benefit from material will be obtained if a building is taken apart methodically, with the processes geared to create waste streams of the following:

- Concrete - therefore producing Recycled Concrete Aggregate (RCA)
- Masonry (e.g. clay brick) – therefore producing Recycled Aggregate (RA)
- Steel – high reclaim value
- Non-ferrous metals such as copper, aluminium etc – high reclaim value
- Wood – structural timber has high reclaim value
- Plastic, such as PVC – a potential reclaimable material of the future (from a 2003 perspective)
- Glass – high recycling value
- Mixed streams of “*difficult*” items such as plaster board which reduce the value of the other waste streams

Note that materials such as asbestos are not discussed with respect to recovery or management because of the well-developed health and safety procedures already governing the management of such materials. However, a cost-benefit exercise is required to establish the viability of segregating materials to the extent described above. Segregating material into the above streams means that there is greater potential for subsequent use in high value applications, for example, in concrete. As discussed in the Section 7 (Standards) segregated material streams can be used as Recycled Concrete Aggregate (RCA) & Recycled Aggregate (RA) and specified in concrete (BS8500), adding value to the material. The potential, therefore, for using such aggregates in high value applications highlights the importance of segregating demolition material - either at source or afterwards using reprocessing plant.



Figure 5.1 Demolition & Segregation of Bricks (*Courtesy of Channel Tunnel Rail Link*)

A project team which does not recognise the potential value of demolition material may continue to develop methodologies which, in relation to material segregation, is limited in scope. For example, as described in Section 5 (Contamination) leaving plasterboard in place could potentially add cost to the process of producing RCA/RA. The material may require further processing, for example using an air fractionator, to separate out the contamination.

5.3 Building Audits & The Demolition Recovery Index

An audit allows the potential of a building to be properly assessed through the creation of a Bill of Quantities (BOQ), identifying the material/components in terms of the different headings described previously, with potential applications, tonnages and percentages of recycling/reuse opportunities detailed. The production of this BOQ will allow the project team to identify the full potential of the demolition material, by identifying where the material can be reused or remanufactured and recycled and the quantities available for this. In addition, as described in Section 1 of the Protocol: *Planning & Resource Efficiency*, this BOQ then supports the planning process which may

require the project team to produce a *Demolition Recovery Index (DRI)* before consent is given for demolition to proceed.

The purpose of the DRI is summarised below, the planning elements of which are described in more detail in Section 1 of the Protocol Report:

- Demonstrates that the project team's demolition methodology has identified the resource potential of the building.
- Allows a negotiated quantity/percentage of demolition material to be recovered - based on the DRI. With respect to negotiations with planning authorities, this can then be enforced by a Section 106 Agreement (England & Wales) or Section 75 Agreement (Scotland).
- Provides a monitoring system for planning authorities, which then allows an assessment to be made on the way that material has actually been managed. The project team may be required to issue copies of material recovery notes for the demolition - which demonstrate the quantity of material actually recovered.
- Drives resource efficiency, by linking the material resource potential of old buildings (for demolition) to the design and procurement of material for new builds.
- Provides planning authorities with a tool for specifying the percentage of reused/remanufactured/recycled material in new builds. If the new build is managed by the project team responsible for demolition, then the DRI for the old building is linked to the materials procured for the new build. The process for determining the New Build Recovery Index (NBRI) is described in Section 7.

Figure 5.2 below summarises where the audit fits into the resource efficiency model. This shows the links between demolition and new builds, as well as the relationship required of project teams and planning authorities.

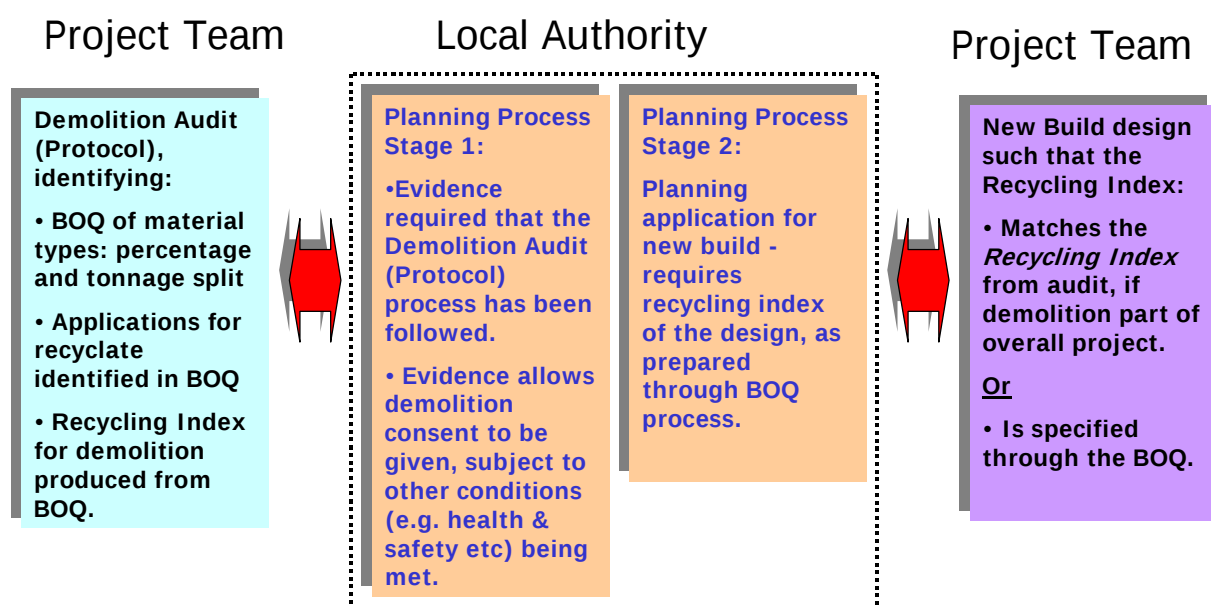


Figure 5.2. Resource Efficiency Model For Demolition Material

5.4 The Need For A Demolition Audit

One of the main non-technical barriers to sustainable construction involves failure in the flow of information on cost benefits for recycled demolition material and their potential for use in new builds. In demolition projects there is often limited information on the material composition of the building to be demolished and in particular of the options for recycling material and associated cost benefits. A resource efficiency model is described in Figure 5.3 below which describes a priority of applications for demolition material. The ranking provided of preferred options in the hierarchy is provided only as a guide and there may be circumstances where the relative rankings may change. It should be noted that remanufacture in this context refers to processing materials such as timber which can subsequently be reused in another timber application.

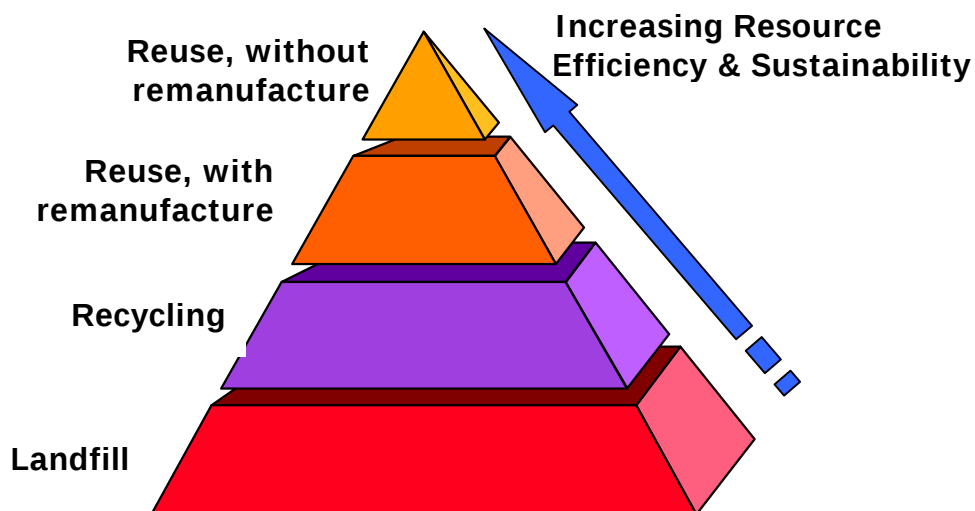


Figure 5.3 Resource Efficiency Hierarchy

A building which has completed its useful life is now as valuable a resource as a mineral deposit, if not more considering that it is frequently located close to or at the site of re-use. Demolishing a building without determining the nature and quantity of materials is therefore a process which is unlikely to be maximising the full potential of those resources. The common conception is that demolition is the end of a building project. However, it could often be the case that it is the start of a new building project, with the potential to supply raw materials. Demolition can therefore be integrated with a future works programme or at least be considered for use in other building projects. A pre-demolition audit can therefore form an important part of the overall project management process.

There is an opportunity for the project team (client group) to carry out an audit of sufficient detail to ascertain the composition of the building before the demolition project is put out to tender. In carrying out a pre-demolition audit several issues need to be considered.

- What is the opportunity and potential to reduce costs and improve the environmental status of the project?
- What is the technical and economic viability of putting the opportunities into practice?

The availability of more detailed information on building materials (for the property being demolished) can enable, as part of the tendering process, the option of quoting against a more detailed bill of materials. This can then present clearly to the client or project team the cost benefits of a more sustainable approach. Considerations will include an understanding of the time required to demolish the building - does this increase? Cost savings, if identified, can then be compared with any loss in revenue from delaying any new build on the site.

5.5 Developing The Bill Of Quantities

The Demolition Audit will result in the preparation of a detailed Bill Of Quantities. A significant opportunity is to organise the material into the following headings for the different building components:

- Concrete – structures, foundations, blockwork etc
- Non-concrete masonry – bricks, stone, tiles etc
- Metals (ferrous & non-ferrous) – copper, aluminium, steel
- Wood – flooring, roofing, furniture etc
- Glass – windows, partitions, furniture, doors
- Composite – MDF, plywood etc
- Hazardous / contaminants – asbestos, hydrocarbons etc

It should be noted that this protocol does not include hazardous material, which contractors must follow established Health and Safety procedures to manage. However, the above headings will allow an assessment of the recovery potential of demolition material. The recovery potential and obstacles to recovery are summarised in Table 5.1, where a description of the potential value for demolition recyclate is given. Further details on how to maximise the recovery potential of materials is described in Section 7. *Standards and Specifying Demolition Recyclate In The New Build.*

Table 5.1 Demolition Material - Recovery Potential & Obstacles

Material	Value	Potential Applications & Issues
Concrete	High	1. Re-use: blockwork, structures. 2. Recycling: a) Recycled Concrete Aggregate (RCA) in new concrete applications, or as a sub-base material in structural applications. b) Constituent in Recycled Aggregate (typically brick, stone, slate etc), again for concrete or engineering fill applications. 3. Use low and high strength concretes for RCA. However screed may shatter, with a high level of fines and should be excluded from RCA.
Non-concrete masonry	Medium	1. Re-use: brickwork, stone, slate 2. Recycling: a) Recycled Aggregate (RA) in concrete applications or as a sub-base material in structural applications. b) Engineering fill, for example below blinding concrete in wall foundations,
Metals	High	1. Re-use: steel beams in good condition have high market value. 2. Recycling: a) Highest value (per tonne) from aluminium and copper – strip cables, compress wires and bale for shipment to processor. b) Steel is the most significant tonnage – beams and reinforcement.
Woods	Medium	Reclaimed timber can be inspected and re-used, most likely in non-structural applications, however can be chipped and used in variety of recycled applications.
Glass	High	Glass is being procured in increasing applications, for example as an aggregate (sand), shot blasting, filtration for water treatment etc.

Table 5.2 provides a template for production of the demolition BOQ as described previously. The material types are broken down further into groups of easily recognisable components which will assist the completion of the table. This template is not intended to be exhaustive, but to cover in general terms the materials likely to be encountered. The demolition BOQ is different to a design BOQ for a new building, where the components must be defined with great accuracy. The level of information acquired in the demolition audit

needs to be of a sufficiently general nature for the information to be gathered in an economically effective time-scale yet provide sufficient information to allow the project team to provide a cost-effective tender price.

5.6 The Demolition Recovery Index

Once the BOQ is completed a Demolition Recovery Index (DRI), as described earlier is produced, as summarised in Table 5.3. The BOQ presented here has been completed to indicate how it should be used. The methodology for completion of the BOQ is described in the following box (note that Table 5.4 provides a glossary for some of the construction terms included in the BOQ).

Methodology For Arriving At The DRI

Recovery Potential Column: Describing the identified market for the material. The descriptions given in Table 5.2 describe one of the higher value opportunities.

Units: Refers to an estimate of the number of items. For example, 200 floorboards.

Tonnage: This will be produced from the estimate of the units (where appropriate) or experience.

Recovery Index: The figures given in Table 5.2 describe, in a scale of 0 to 1 (effectively a percentage), the potential for recovering (recycling/re-use) the material/components.

Recovered Tonnage: Multiplication of the tonnage by the recovery index. This gives the recovery potential of the building to be demolished.

The BOQ allows the different components of the demolition to be aggregated into more general categories of concrete, wood etc. This supports the process of identifying the potential value of demolition material by presenting material in groupings which reflect how material will actually be purchased. Table 5.5 summarises the outlets for the reuse (favoured) and recycling of material, or its disposal. As an example and, as mentioned before, recycling concrete and masonry enables the production of aggregates of various types. These aggregates can be used in a variety of applications, in both buildings and roads. With respect to the range of applications it is important to note that one component may have a number of different outlets – for example brickwork, where lime mortar bricks have the potential to be reused, while others may have to be recycled.

Table 5.2 Bill Of Quantities

	Recovery Potential	Units	Total Tonnage	Recovery Index	Recovered Tonnage
Concrete Components					
Blocks	RCA	100	10	100%	10
Ceiling soffits	RCA	20	10	100%	10
Floor slabs	RCA	40	40	100%	40
Foundations	RCA	N/A	200	100%	200
Kerbing, haunching	RCA	100	10	100%	10
Paving slabs	RCA	50	1	100%	1
Stair units	RCA	10	10	100%	10
Lintels	RCA	100	25	100%	25
Piles	RCA	20	50	100%	50
Beams	RCA	40	80	100%	80
Blinding	RCA	N/A	50	100%	50
Render	RCA	N/A	10	0	0
Terrazzo	RCA	N/A	10	100%	10
Mass Concrete	RCA	N/A	20	100%	20
Total			526		516
Non-concrete Masonry Components					
Clay bricks	RA		200	100%	200
Roofing tiles	RA		20	100%	20
Floor tiles	RA		5	100%	5
Paving stones	RA		3	100%	3
Stonework	RA		5	100%	5
Screed	Disposal	N/A	50	0	0
Total			283		233

Table 5.2 (Cont / ...) Bill Of Quantities

	Recovery Potential	Units	Total Tonnage	Recovery Index	Recovered Tonnage
Metals					
Structural steel	Reuse	40	20	100%	20
Reinforcement bar	Smelting		20	100%	20
Radiators	Smelting	100	2	100%	2
Wiring	Smelting	N/A	0.5	100%	0.5
Window frames	Smelting	50	0.5	100%	0.2
Pipework – supply, drainage etc	Smelting	N/A	2	100%	2
Lintels	Smelting	70	7	100%	7
Furniture (list)	Reuse / Smelting		1	100%	1
Total			53		53
Wood					
Doors	Re-use / chipping	20	2	100%	2
Floorboards	Re-use / chipping	500	10	100%	10
Joists	Re-use / chipping	100	2	100%	2
Window / door frames	Re-use / chipping	50	0.5	100%	0.5
Furniture (list)	Re-use / chipping		1	100%	1
Total			15.5		15.5
Glass					
Windows	RCA / RA	100	1	100%	1
Doors	RCA / RA	100	0.5	100%	0.5
Partitions	RCA / RA	50	0.25	100%	0.25
Furniture (list)	RCA / RA	10	0.1	100%	0.1
Total			1.85		1.85

Table 5.2 (Cont / ...) Bill Of Quantities

	Description	Units	Total	Recovery Index	Recovered Tonnage
Composites					
MDF	Chipping	100	1	100%	1
Plywood	Chipping	50	0.5	100%	0.5
Plasterboard	Disposal	100	1	0	0
Total			2.5		1.5
Plant					
Tanks	Smelting	10	5	100%	5
Pumps	Recondition / smelting	10	1	100%	1
Elevators	Recondition / smelting	2	5	100%	5
Machinery (list various)	Recondition / smelting	10	10	100%	10
Total			21		21
Architectural Features					
Mantle pieces	Reclaim	1	0.5	100%	0.5
Archways	Reclaim	2	2	100%	2
Columns	Reclaim	6	1	100%	1
Decorative masonry	Reclaim	50	2.5	100%	2.5
Total			6		6
Miscellaneous					
Bituminous materials	Recycling / sub-base		50	100%	50
Excavations – soils, aggregate etc	Recycling / soils		50	100%	50
Total			100		100

Table 5.2 (Cont / ...) Bill Of Quantities

	Recovery Potential	Units	Total	Recovery Index	Recovered Tonnage
Hazardous Material / Potential Contamination					
Asbestos, fire resistant panelling, insulation	Landfill	200	20	0	0
External wood fittings – creosote, fencing, pentachlorophenol	Landfill		5	0	0
Wood – lead, mercury based paint	Landfill		5	0	0
Storage tanks - Fuel, oil, gasoline*	Specialised recovery process	5	5	98%	4.9
Fluorescent lighting - mercury**	Specialised recovery process	100	0.5	98%	0.49
Veneers, laminated wood	Landfill		2	0	0
Total			37.5		5.39

Table 5.3 Demolition Recovery Index

Material	Total Tonnage	Recovered Tonnage
Concrete	526	516
Non-concrete masonry	283	233
Metals	53	53
Wood	30.5	30.5
Glass	1.85	1.85
Composites	2.5	1.5
Plant	21	21
Architectural Features	6	6
Miscellaneous	100	100
Hazardous / Potential Contamination	37.5	5.39
Total	2,122.70	968.24
Demolition Recovery Index	92 %	

5.7 Bill Of Quantities Glossary

The following table provides a definition for some of the construction materials described in the Bill of Quantities.

Table 5.4 Bill Of Quantity Definitions

Material	Application	Description
Render	Plastering - concrete	The base coat of plaster or sand cement coating applied externally
Blinding	Groundworks - concrete	Low strength concrete applied between sub-base layers and structural elements such as wall foundation and concrete slabs.
Screed	Flooring - concrete	A cementitious mixture, laid to a depth of 50-75mm over concrete flooring to provide a smooth floor finish. Screed typically has low load resistance.
Terrazzo	Flooring - concrete	A mixture of white cement and marble chippings/powder, laid wet then ground smooth. This is often seen in shop doorways but can also be used for work surfaces and basins

Table 5.4 (Cont / ...) Bill Of Quantity Definitions

Material	Application	Description
Joist	Flooring - wood	Structural member running horizontally and supporting a ceiling or floor
Blocks	Walls - concrete	Light or dense concrete blocks are generally used in masonry that is hidden such as within the inner skin of cavity work. They may, however, be used 'architecturally' in public buildings. Blocks most often measure 440 x 215mm, which is equivalent to 6 standard bricks. Lightweight blocks have insulation properties and are often made from aerated concrete where pulverised fuel ash is the aggregate. These are usually referred to as breeze blocks and common trade names include Theralite and Celcon. Harder concrete blocks may have hollow centres which can be filled with foam insulation. Very dense concrete is used in heavy load bearing blocks, which can be up to 225mm thick. These can be quite heavy to lift and require care when laying to avoid squeezing out the mortar
Lintel	Walls – concrete or steel	A concrete or steel beam positioned over doors or other openings to support the bricks/blocks above
Purlin	Roofing - wood	A horizontal roof member located part way up a rafter. The purpose of the purlin is to prevent the rafter from sagging under load and, in turn, the purlin may be supported by posts to transfer the purlin loads onto internal walls below and so to the foundations. This will prevent the outer walls from bearing all the roof loads.
Rafter	Roofing - wood	The structural member of a roof which supports the weathering materials underneath. It would still be called a rafter in a flat roof
Soffit	Ceilings – concrete, masonry etc	The undersurface of any part of a building such as the arch, eaves or cantilevered section

5.8 Using The Demolition Recovery Index

For the example shown in Table 5.2, the Demolition Recovery Index (DRI) is 92%, excluding other items which would be removed in the soft strip such as furniture and soft furnishings. The DRI indicates the potential of a demolition with respect to material recovery and in addition to indicating where cost savings can be made, provides planning authorities with a tool to ensure that project teams employ sustainable methodologies before consent for demolition is given. This is described in more detail in the Planning Section.

Table 5.5. Possible Outlets For Concrete & Masonry

Materials	Outlets (percentage possible in each group)					
	Reuse	Recycling				Waste
		Roads		Buildings		
		<i>Non-structural</i>	<i>Structural</i>	<i>Non-structural</i>	<i>Structural</i>	
Concrete						
Non-concrete masonry						
Brick						
Metals						
Glass						
Wood						
Bituminous material						

It may be sufficient to concentrate on the overall volume and mass of materials, focusing on what products have high value and suitable quality for deconstruction and reuse initially. After a BOQ has been prepared the recycling opportunities can then be assessed commercially.

It should be noted that BRE has developed the SMARTWaste tool. Waste arisings can be categorised by source, type, amount, cause and cost. This tool has been used in some audits and the information provided by the tool is very detailed. The tool has been developed as a time saving opportunity.

5.9 Steps Involved In Carrying Out An Audit

An effective process for carrying out a Building Audit is described in Figure 5.4 below:

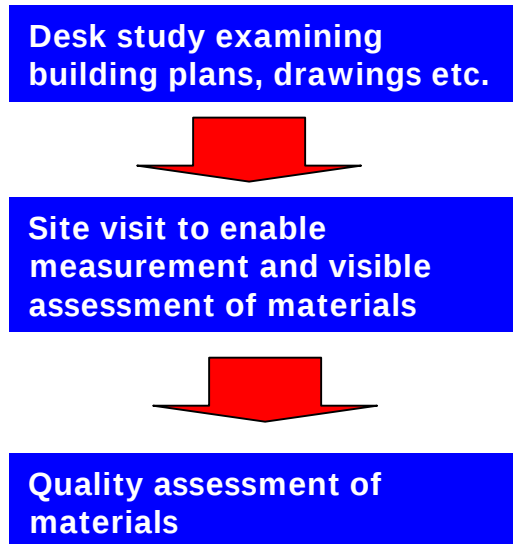


Figure 5.4 Steps For Carrying Out Demolition Audit

5.9.1 Initial Desk-Study Examining Building Plans, Drawings Etc

The level of detail obtained from building plans will vary with every building. Currently, these plans tend to be held for between 10 and 20 years by local planning authorities, with the detail varying for each authority. Most buildings being demolished are likely to be over 20 years of age so as the system currently stands such registers are unlikely to provide the required data for a demolition audit. If the building is of significant worth plans may be held in public records offices or in libraries. Architects and planners may also hold design plans that can be accessed. There is real value in knowing the date of construction, with respect to understanding which standards were used for key materials such as concrete, where the potential for chemical contamination can be more easily understood (see Section 5). In a similar vein, the potential for physical contamination can be understood by accessing BOQs which provide a detailed description of the materials which should be removed as part of the soft strip - to ensure that the value of the demolition material is optimised (see Section 5).

5.9.2 Site Visit To Enable Measurement And Visible Assessment Of Materials

This could be carried by the demolition contractor or a surveyor. Measurement of the building components could be done to ensure that the initial desk-based study is realistic and properly descriptive of the building in question.

5.9.3 Quality Assessment Of Materials

Materials assessed by an experienced contractor who knows the market and potential values.

5.10 Cost Benefit Analysis – Identification Of Technical And Economic Feasibility

The bottom line for choosing most demolition contracts is economics. To reuse and recycle materials from demolition sites it is generally necessary to take buildings apart in an ordered fashion, considering the segregation of material groupings where possible. This means that the actual labour cost for the demolition may increase increase.

Having obtained the initial Bill Of Quantities there needs to be consideration of technical issues such as the physical removal of components to make recycling and reuse possible. This may include the feasibility of removing steel beams intact or other larger components in their entirety. The cost benefits therefore need to be weighed up. Table 5.6 shows the elements to be considered when evaluating the management of materials from demolition. The income is dependent on the available local infrastructure and so will be different for every job. A simple table like this may enable the benefits of recycling to be visible for the client. It may also enable the tendering procedure to go forward in a more innovative way (as discussed later). With time the cost data which makes up Table 5.6 will become available on a number of case studies through data sources provided by AggRegain (WRAP's recycled aggregates programme, <http://www.aggregain.org.uk>).

Table 5.6 Cost Benefits Of Managing Demolition Materials

Material	Landfill			Reuse / Recovery			
	Cost (haulage, gate fee, tax etc)	Cost of demolition (labour, plant, etc)	Total cost	Reprocessing costs (inc. haulage etc)	Cost of demolition (labour, plant, etc)	Sales Price (market price for materials)	Total Costs
Concrete							
Masonry							
Reclaimed steel							
Timber							
Metals							
Glass							
Others							

The sales-price column is one which will vary significantly depending on the application being sought for the material. For example, market values for aggregate which can be specified in concrete mixes is significantly higher than applications such as engineering fills.

An additional column can be considered for the economic evaluation when the project team is responsible for a new build. Again, using the example of aggregates, the purchase price for primary aggregates can be compared with recycled, either produced on site or purchased from a reprocessor. It is worth noting that the Aggregate Levy introduced in 2002 has added £1.60 per tonne to the cost of primary material.

5.11 Contracts

5.11.1 Tendering Process

Most demolition contracts are tendered without detailed knowledge of the composition of the building being demolished. Typically, limited time and money is put into assessing the breakdown of materials and, as such, tenders issued on the basis of a limited audit (the more common approach) result in bids which are not as tailored to maximise material recovery value as could be. Materials are then removed in an unsegregated form, in as short a time as possible. Unless specialised material processing equipment is used there are even fewer possible end uses for the material. The main difference in bids will be the result of the time demands for removing the material from site. Time constraints will be the essence of the bid. However, it is also true that relatively little time is required to carry out an audit, in comparison with the overall timescales for negotiating demolition contracts and the subsequent new builds (if required).

5.11.2 Contract Types

Contracts for a demolition project are typically awarded on the basis of one of the following:

- Request for quotation
- Negotiated process
- Competitive tender

The client will often decide on the approach best suited to the complexities of the project and local circumstances. Often the more complex the job is, the more likely the contractual conditions will be negotiated.

Contractual arrangements will, by definition, impact on the management of the resource, i.e. demolition material. Separating/segregating materials *in situ* (at source) may be the more complex option with respect to planning issues and space constraints. *Ex situ* (away from the source) may result in the opportunity

to use more sophisticated reprocessing plant. It is therefore important for the project team to prepare a contractual framework on a *building-by-building* basis, where the ultimately beneficial process of producing segregated material is achieved. One approach is to employ an open-book system.

5.11.3 Open Book Contracts & Material Segregation

Open book systems are by no means uncommon across the construction and demolition industries. Such systems require the contractor and client to enter into what is a transparent materials management and recovery system. This involves an arrangement between the client and contractor where a list of materials capable of being recycled is included in the contract on the basis that:

- A price (credit) for the material is stated per tonne
- The actual tonnage obtained then allows a total value (credit) to be reclaimed on the demolition resource/material
- Material transfer documentation is provided by the recycling company to validate the actual amounts of material handled
- The resulting income is allocated to the client/contractor on the negotiated basis set out in the contract

The open-book approach has a number of advantages over more traditional approaches, where material is costed on a lump sum basis - either for straightforward removal from the site or for use as hardcore, piling mat, fill etc. The advantages can be summarised as follows:

- The client is involved in a more transparent negotiation which identifies the actual market value of materials
- Both client and contractor have an incentive to recover as much high quality (value) material as possible.
- A more disciplined, planned management approach is required

An addendum document may form a part of the tender, including the bill of quantities. This will quantify what can be reused or recycled (as in the Section 5.2) and invite bids from contractors quoting against this.

5.12 Risks

A number of risks could be associated with demolition methodologies requiring the preparation of detailed Bills of Quantities and the production of segregated material (for subsequent high value applications). A number of these risks are summarised below:

- Increased costs for the demolition process
- Lengthier timescales for demolition.
- Perceived risks associated with the quality of recycled materials.
- Added management complexity.

Each of the above risks is now discussed in turn with the exception of the quality issues which is comprehensively addressed in the Standards section.

5.12.1 Costs

It could be argued that increased costs are incurred through the additional man-hours required to plan and carry out demolition audits and material segregation processes. However, as presented in Table 5.6 there are a number of cost items to be considered in making an evaluation. In most UK urban environments, recycled aggregate costs are priced at a lower level than the equivalent primary material. Until the market is more clearly understood, cost comparative exercises should be carried out to ensure that the optimum material procurement strategy is being adopted.

An open book approach may therefore prove to be one which minimises the risk to the client - where ongoing cost savings are realised through material reuse/recycling. This may be a process best suited to more complex projects, allowing the client to ensure that the contractor maintains the desired outputs. Open book contracts also remove much of the risk to the demolition contractor as a result of the client agreeing the full price with any recycling benefits accrued being demonstrated and shared.

5.12.2 Timescales

The risk here concerns the lengthening of project timescales such that there is an impact from lost rents from subsequent redevelopment of the site. Again, cost benefit analysis will ensure that the optimum approach is adopted. However, it should be noted that the time required to carry out detailed building audits and introduce material segregation, if properly managed, will be relatively small compared to the timescales associated with setting up projects, going through the planning application process etc. Again, a professionally costed project will ensure that all the options are considered.

5.12.4 Management Complexity

Processes associated with auditing, open-book contracts and material segregation may appear complex. However, unfamiliarity with alternative approaches should not be a barrier to improving resource efficiency, which will ultimately not only produce environmental benefits through the expansion of recycled markets, but result in cost savings for clients. Those companies which embrace new approaches (involving a wider examination of market potential) will take an increasing market share as demand increases for more sustainable construction practices. The issues which appear to make demolition and construction projects more complex are greatly diminished when each contributing item is considered on its own. This is where the demolition protocol comes in - by providing the necessary guidance and background information. The following section supports this process by providing a straightforward approach to assessing the potential for carrying out material segregation on site.

5.13 A Site Design Guide For Material Segregation

Having identified the opportunities for obtaining segregated material, an understanding of the potential for the site, or an adjacent site, to manage the flow of materials and, potentially reprocessing plant needs to be developed. The following sections indicate a number of planning approaches to facilitate the project team in reaching a qualitative assessment of the potential for their site to cope with the space demands of managing segregated material.

5.14 Material Storage Space

The following illustrative diagram and accompanying table show the following for different building sizes (material volumes):

- Storage space required for demolition material as it is brought down
- Storage space required for segregated & reprocessed demolition material
- Space required for access & vehicle movements

This *Site Design Guide* describes the opportunities and constraints associated with source segregating material on site, as well as considering the potential advantages and disadvantages of bringing reprocessing facilities to the site e.g. crushers, screeners and handling equipment for reinforced concrete, steelwork etc.

The Guidance Document from the Office of the Deputy Prime Minister (ODPM) called *“Controlling the Environmental Effects of Recycled and Secondary Aggregates Production - Good Practice Guidance”*, refers to the size of site required for on-site crushing (Section 14.21). The minimum area needed to operate crushing and screening plant is described as being approximately 0.1ha i.e. 1,000 m² (e.g. approx 32 x 32 metres). The assumptions here are stated as being:

- Material is processed immediately
- There is no storage of waste or processed material on-site

For operations that involve the stockpiling of material, the Institute of Demolition Engineers¹ recommends a minimum site size of 1 ha (e.g. 100 x 100 metres). For smaller sites the ODPM’s guidance is described in the box below.

Consideration Of Environmental Impacts

ODPM guidance states that for a site of 1,000m² *“there is little scope for mitigating environmental effects such as noise and dust with a site this size”*. As such, it states that *“on-site aggregates recycling should be avoided in close proximity to sensitive receptors”*. This guidance should be referred to as part of the project planning process.

Figure 5.5, Site Space Diagram, demonstrates the space/area provisions which would need to be calculated before a decision could be made on the viability of segregating and processing material on-site. The diagram and associated tables are presented to highlight the planning provisions required of the demolition project team. Without undergoing a process of this nature, the demolition approach adopted will be one which has not considered the full potential of the building, site and materials.

¹ The Institute of Demolition Engineers. Recycling of Demolition Debris

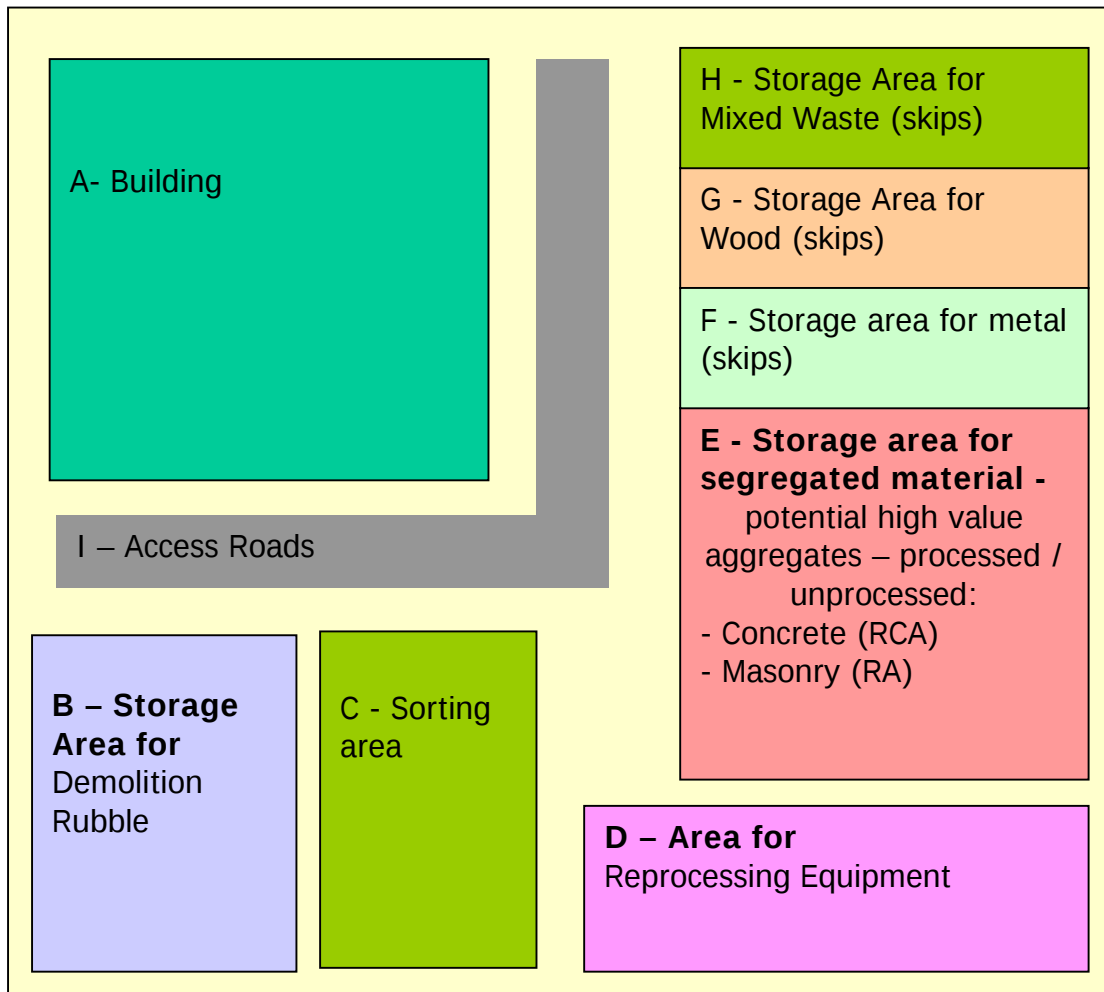


Figure 5.5 . Site Space Diagram

In conjunction with the Site Space Diagram a calculation is required to indicate the total amount (tonnage and volume) of materials to come from the demolition. Table 5.7 gives an indication of how this data could be compiled.

Table 5.7 Site Space Summary

Material & Equipment	Tonnage	Volume, m ³	Bulk volume, m ³	Area, m ²
High value aggregate				
Medium value aggregate				
Recyclable steel				
Recyclable hardwood				
Mixed waste				
Reprocessing equipment				
Access roads/areas	N/A	N/A	N/A	
Total				

However, material will in most cases be removed off site as quickly as possible. Depending on the daily throughput planned for material, storage areas can then be planned out for the site to facilitate the production of segregated material streams. A way of representing this is shown for indicative purposes in Table 5.8

Table 5.8 Determining Storage Space For Different Material Throughputs

Materials	Area Required For Throughputs Shown		
	100 tonnes	200 tonnes	500 tonnes
A – Building (inc foundations)	N/A	N/A	N/A
B - Demolition Rubble			
C – Sorting area			
D - Reprocessing equipment	N/A	N/A	N/A
E – Segregated RA / RCA			
F – Segregated Metal			
G – Segregated Wood			
H – Mixed waste			
Total			



Section 6

Building Audits & Managing Contamination

6.1 Objective

This section on “Managing Contamination” provides guidance to project teams, describing how the potential of buildings for demolition can be assessed with respect to both chemical and physical contamination.

With knowledge of the contamination potential of building components/types the project team can make an informed decision on how to develop a segregation strategy for materials produced from the demolition and hence promote a quality assured protocol. Producing segregated materials then optimises the potential for use in high performance applications.

6.2 The Impacts Of Contamination

Demolition material can be specified and used with the same confidence as primary materials in a variety of low and high value applications. One of the main barriers often quoted about recycled materials in general relates to quality. As a result, purchasers and specifiers require guidance on potential contamination associated with recycled materials and the testing required to prove conformance with British Standards. This section, in providing such guidance, identifies procedures to assess the nature of chemical and physical contamination in buildings. A number of different building types are considered as part of this process, identifying through the Bill of Quantities, the potential for different materials to act as a physical or chemical contaminant. In addition, flowcharts are presented which take the user through the process of identifying which parts of a building may have unacceptable levels of chemical contamination.

This section provides guidance on how to interpret the British Standards, describing straightforward methodologies to evaluate how the potential to segregate high quality material can be assessed against different contamination types. It also provides information to improve the awareness of chemical contamination, identifying situations or environments in which contaminants may pose a problem. Understanding how and why certain chemicals cause problems can be key to identifying when certain contaminants are likely to be problematic. This basic chemical knowledge can help reduce costs because fewer chemical tests may be needed, or problem areas identified and, instead of landfilling material, alternative more appropriate applications may be found.



Figure 6.1. Low level sulphate damage to bricks

6.3 Chemical Contamination Overview

Issues of chemical contamination addressed here are restricted mainly to the potential for specifying demolition recyclate in concrete products. There are four main chemical contaminants regarding concrete. They are alkali/silica, carbonate, chloride and sulphate. There are limits for each of these potential chemical contaminants in concrete and therefore it is important that these are considered to ensure that the material produced from demolition sites is uncontaminated and suitable for specification in high performance applications. However, the reality for some concrete applications is that there may not be a chemical testing requirement. This is the case, according to BS8500, if it can be demonstrated that the composition of the concrete from demolition is known and that it has not been contaminated by use. If testing is required, Table 6.1 indicates the range of tests possible, as specified in the standards. These standards state that:

“The necessity for testing and declaring all properties is limited to the particular application at end use or origin of the aggregate. When required the tests specified be carried out to determine the appropriate chemical content by mass.”

Table 6.1 Chemical Tests

Chemical Tests	13055 Lightweight Aggregates	12620 Aggregates in Concrete	13383 Armour- stone	13043 Bituminous Mixtures	Aggregates for Mortar 13139
Chlorides	✓				✓
Acid Soluble Sulphate	✓	✓			✓
Alkali					
Total Sulphur	✓	✓			✓
Loss on Ignition	✓				✓
Alkali – Silica Reactivity		✓			✓
Other Constituents		✓	✓		✓
Carbonate Content		✓			
Water soluble Constituents			✓		✓
Water Solubility				✓	
Water Susceptibility				✓	
Calcium hydroxide content				✓	

This section is therefore provided to identify when such tests may be required. The flowcharts shown in Figures 6.2 to 6.4 show risk assessment procedures which identify the potential for chemical contamination from different demolition material sources – with respect to their potential use in concrete products. These flowcharts identify the types of building components which are likely to be contaminated/uncontaminated and therefore identify the requirements with respect to testing.

Each of the flowcharts begins with a Historical Use risk assessment - the process for carrying out such assessments is described in the following section. With potentially contaminated and uncontaminated components identified, we can see that there will be advantages in choosing a demolition approach which results in materials being segregated.

6.4 Historical Use Risk Assessment

Table 6.2 can be used to identify which chemical contaminants are likely to occur in demolition materials as a result of a building's prior use. This information is important in terms of understanding the potential of the demolition material to meet required standards for use in concrete. There are several steps to be taken:

1. Determine former site uses and therefore building uses.
2. Use the table to identify the likely contaminants from the building by reading across each row.
3. If there are potential contaminants in the building carry out the flow chart process to determine where to segregate contaminated from uncontaminated material.

The list of former site uses is by no means exhaustive, but this indicative list does indicate those contaminants which would be likely to have a negative impact on the potential value of demolition material recovered. A number of other building uses are of course possible, but where contamination is considered to be unlikely these are excluded from the risk assessment table. Many non-industrial buildings will not have suffered from contamination during use, but may have contamination problems due to their location. For example, a block of flats located near the coast is likely to have a problem due to excessive chloride. External surfaces of such buildings should be segregated from internal components to maximise the latter's potential.

Note that contamination from metals, radioactive materials and hydrocarbons are not included in the table. If there is a perceived risk (from a human health viewpoint) from the site then tests for the above should also be carried out in accordance with Health & Safety procedures.

Table 6.2 Historical Building Use & Potential Contaminants

Historical Use	Likely Contaminants				
	Inorganic chemicals				pH
	SO ₄	Cl ⁻	CO ₃	ASR	
Building Type					
Airports	X	✓	✓	X	✓
Carparks	✓	✓	X	X	X
Ceramics works	✓	✓	✓	X	✓
Chemical works – paints	✓	X	X	✓	✓
Chemical works – cosmetics	✓	X	X	✓	✓
Chemical works – disinfectants	✓	✓	X	✓	✓
Chemical works – explosives	✓	✓	X	X	✓
Chemical works – fertiliser	✓	✓	✓	✓	✓
Chemical works – fine chemical	✓	✓	✓	X	-
Chemical works – sealants	✓	X	✓	✓	✓
Chemical works – organic chemicals	✓	X	✓	X	✓
Chemical works – soap manufacturer	X	X	X	X	✓
Dockyards	✓	✓	✓	X	-
Electronics	X	X	X	✓	
Engineering works	✓	✓	✓	X	✓

Table 6.2 Historical Building Use & Potential Contaminants

Historical Use	Likely Contaminants				
	Inorganic chemicals				pH
	SO ₄	Cl ⁻	CO ₃	ASR	
Building Type					
Gasworks	✓	X	✓	X	✓
Metal works	✓	X	✓	X	✓
Petrol Station	✓	✓	✓	X	✓
Power stations	✓	✓	✓	X	✓
Pulp and paper manufacturing works	✓	✓	✓	✓	✓
Sewage works	✓	✓	✓	✓	✓
Textile works and dye works	✓	✓	X	✓	✓

(Assessment of Risks to Human Health from Land Contamination, CLR8, DEFRA, 2002).

6.5 Chemical Contamination Risk Assessment

In many circumstances chemical tests on Recycled Aggregate (RA) will not need to be carried out due to the limitations placed on the exposure classes that this can be used in. It should also be noted that some materials are more likely to be contaminated than others. For example foundations in contact with sulphate contaminated groundwater, or exterior walls of houses adjacent to the sea will be contaminated with chloride. This means that there should be segregation of building materials into contaminated and “clean” which are therefore suitable for higher value applications. It is also worth noting that the age of the building, the standards that it was designed to and its use may all affect the types of chemical contaminants that may be present (if any).

A former industrial use of a building may indicate that there may be chemical contamination arising from heavy metals. In many cases heavy metal contamination will not pose a problem to the integrity of structures and should pose minimal health risks due to the heavy metals being bound up within the concrete. Tests for dangerous substances should be carried out as and when required. It should be noted that a database on dangerous substances for example radioactive substances, heavy metals and polyaromatic carbons is available via the construction web site on EUROPA (CREATE, accessed through <http://europa.eu.int>). It is also worth noting that a protocol looking at the effects of heavily contaminated building materials is being published by BRE and is scheduled to be published in 2004.

Table 6.3 below provides an illustration of a working tool for the project team to use when carrying out the risk assessment. After following the flowcharts, the table can be completed to provide a summary document of the testing requirements. Following on from this summary, data can then form a part of the *Building Audit* stage of this Protocol. Note that the table shown provides a list of building components which is far from exhaustive – these are shown here only for guidance purposes. In using the flowcharts, if the material has a low risk of contamination, “*LR*” should be entered. “*HR*” should be entered if there is a high risk of contamination and testing is required.

Immediately after the flowcharts there is a section which describes the reasoning behind the question and decision paths. Here, the issues associated with sulphate, carbonate and chlorides are described.

Table 6.3 Summary of Contamination Risk Assessment

Building Components	Sulphate	Carbonate	Chlorides	Alkaline Materials
Floor slabs				
Precast concrete slabs				
Soffits				
Lightweight Blockwork				
Dense Concrete Blockwork				
Artificial Stone Blockwork				
Columns				
Ground level or below level				
Ground beams				
Piles				
Ground floor slabs				
Retaining walls				
Basements				

Notes:

1. Where “*HR*” is entered in a column, this material is *likely* to require the chemical test shown.
2. Where “*LR*”, is entered in a column this material is *unlikely* to require the chemical test shown.

The risk assessment flow charts should be used to determine the necessary tests to be carried out -whether the end use of the materials is known or not. If these tests are not carried out then the potential value and applications of the demolition material recovered is immediately diminished. In some cases (dependent on the end use of the material) the tests may not be required at all.

6.6 Potential Chemical Contamination Issues

Understanding the conditions in which potential contaminants can cause problems can help to identify “potentially contaminated areas or materials”.

Chemical contaminants may be more problematic under certain conditions. Table 6.4 identifies situations when contaminants are more likely to be present, and looks at how common contaminants can be identified and problems with recycling minimised.

Table 6.4 Potential Chemical Contaminants, Problems & Identification

Sulphate	
Potential Problem	Identification of Problem
There are two main problems due to excessive sulphate in aggregates to be used in concrete applications. 1. Wet deposition of sulphates or sulphates present in the building materials (especially from gypsum) dissolve the calcium carbonate in the cement, which forms a crust of calcium sulphate. The sulphated layers are easily washed away resulting in the exposure of more stone (Swenson C., 2003. Concrete in Sulphate Environments CBD 136, Institute for Research in Construction, National Research Council, Canada). 2. Sulphate crystals can cause the concrete to expand and crack, resulting in displacement of walls and brickwork and deterioration of concrete floors and sub floors. Common causes of sulphate contamination arise from sulphate containing cements, buildings in contact with sulphate contaminated groundwater.	Identify cement cracking and concrete type used (see example picture at start of section). Buildings constructed with dense, impermeable concrete are less at risk.

Table 6.4 (Cont/...) Potential Chemical Contaminants, Problems & Identification

Chlorides	
Potential Problem	Identification of Problem
Chloride ions are very mobile and are able to move around in the pore water of the concrete. They can break down the protective alkaline layer that protects the steel, which exposes the steel to oxygen, which oxidises the steel to form rust. The volume of rust is approximately 10 times greater than the steel that has been converted. This causes the concrete to crack and result in spalling (concrete breaking away from section) and surfaces “delaminating”. Chloride contamination poses the biggest problems in marine environments or where road de-icers or chloride containing building materials have been used.	Assessment of the quality of workmanship should be undertaken, if the compaction of the concrete mixes is good, the joints aren't leaking and any saturation of concrete has not been prolonged. The risks are greatly minimised. Pre stressed and post tensioned concrete is more susceptible to chloride induced corrosion because it only requires 0.1% chloride (chloride by weight of cement), to initiate corrosion, however the threshold for reinforced concrete is 0.4%.
Carbonation	
Potential Problem	Identification of Problem
Concrete is alkaline, this provides a protective layer for the steel reinforcement by protecting them from the air in the pores of the concrete. The calcium in the rock reacts with carbon dioxide in the air to form calcium carbonates. This neutralises the pH of the concrete leading to the breakdown of the protective layer and resulting in the exposure of the steel reinforcements to air and causing corrosion. Dry conditions increase the rate of carbonation. Carbonation tends to be more of a problem in confined poorly vented areas.	Check for corrosion and spalling in confined areas.

Table 6.4 (Cont/...) Potential Chemical Contaminants, Problems & Identification

Alkali – Silica Reactions	
Potential Problem	Identification of Problem
ASR, is a chemical reaction which takes place within aggregate particles between the alkaline pore solution of the cement paste and silica containing parts of the aggregate particles. The large amount of hydroxyl ions present in the pore solution due to the high alkali concentration disrupt or dissolve the siliceous aggregate particles forming a product ("gel") that is able to combine with water. A gel will form that expands and causes the concrete to crack. As the concrete deteriorates, more water enters to fuel the reaction. This cycle continues until the concrete deteriorates past the point of serviceability. Factors that affect the rate and severity of ASR are: 1. Potential reactivity of the aggregate. 2. Alkali content of the cement. 3. Amount of water present in the concrete. 4. Number of wet / dry cycles. Material with high silica content can be used in applications of lower strength concrete in conjunction with some of the measures highlighted in the flow chart. Wet conditions can accelerate alkali-silica reactions if a high alkali cement has been used with reactive aggregates. Reactive aggregates contain a high siliceous content. Quarries containing rocks with a high siliceous content are well documented.	To minimise contamination due to the alkali-silica reaction within aggregates produced from a demolition site consider: <i>Is it possible to determine where the aggregates used in the building were sourced originally?</i> This will prove difficult - if so testing of the aggregate will be required. If there is high silica content in the material a low alkaline cement can be used - material therefore has potential to be used in structural applications. Where crumbling of concrete is visible & areas have experienced a large number of wet and dry cycles (e.g. the outer walls of a property) segregated material if it is suspected that silica content is significant. Used with the Risk Assessment flow charts the above points can ensure that material produced from demolition sites is uncontaminated and usable in applications of the highest value.

It is worth remembering that standards allow for limited levels of chemical contamination, provided these levels are within test limits or will not cause damage to the subsequent new build. Risk Assessment Flowcharts which allow consideration of buildings and their potential for contamination are now described.

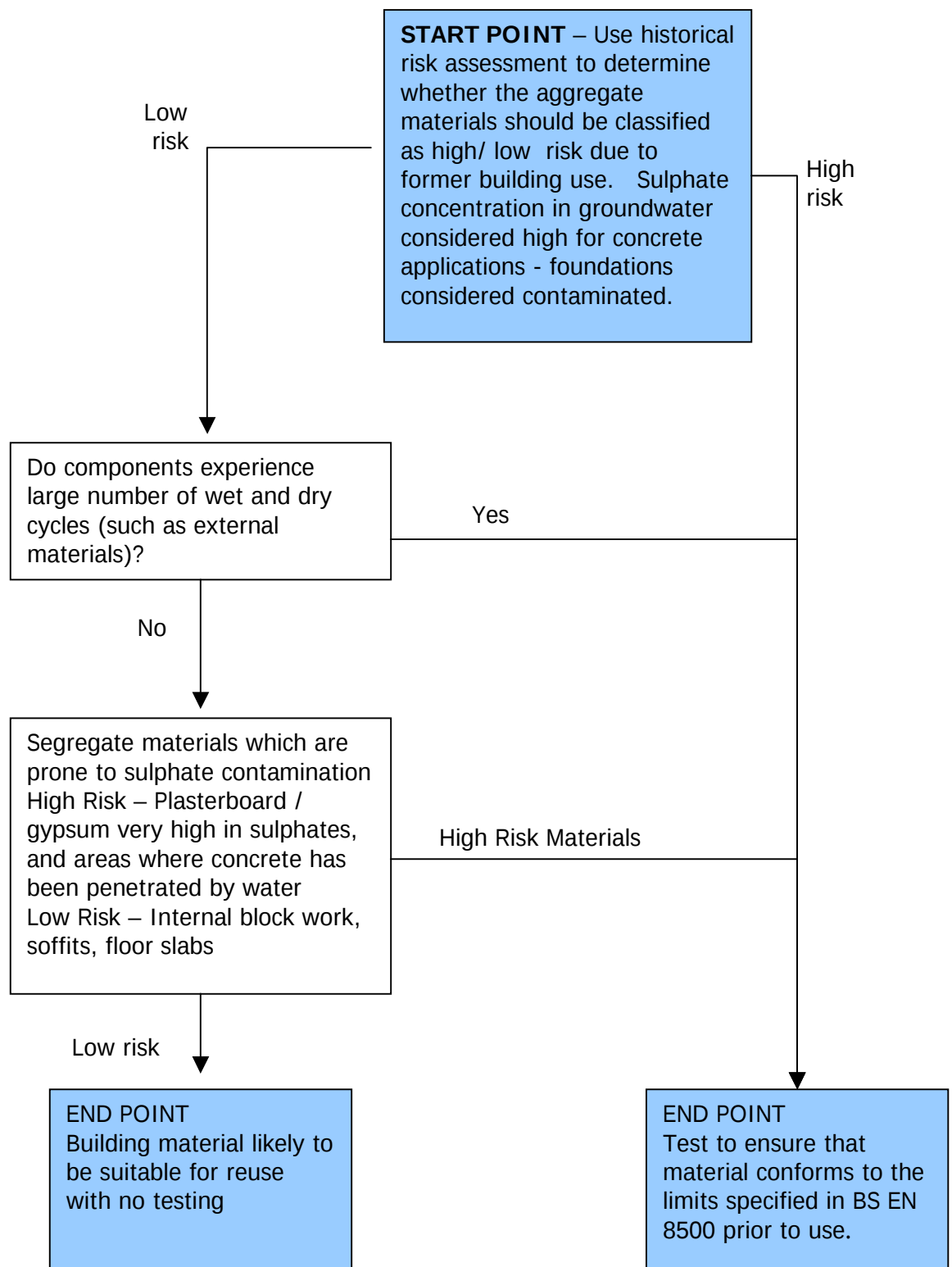


Figure 6.2 Risk Assessment Flowchart For Sulphate Contamination

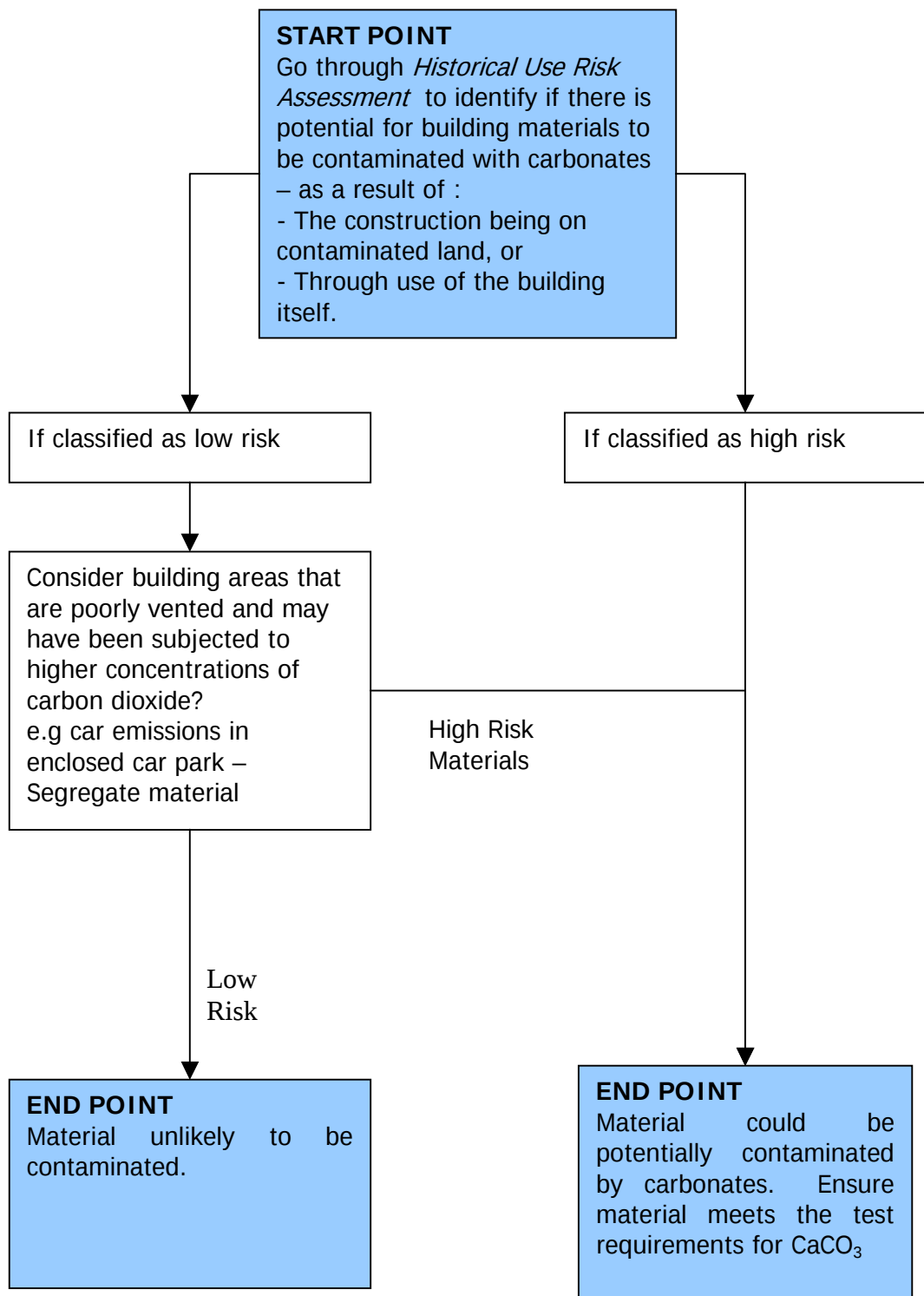


Figure 6.3 Risk Assessment Flowchart For Carbonate Contamination

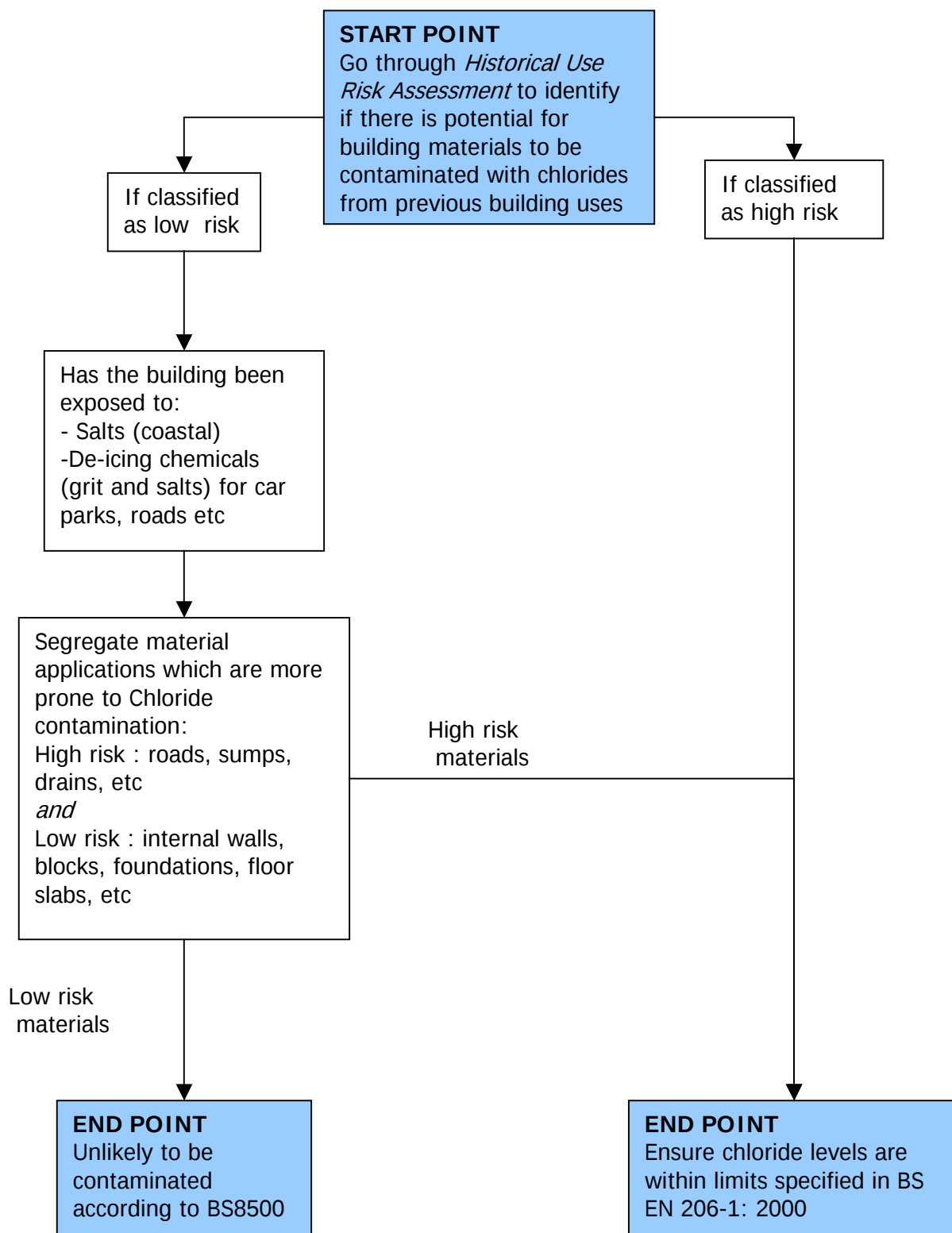


Figure 6.4 Risk Assessment Flowchart For Chloride Contamination

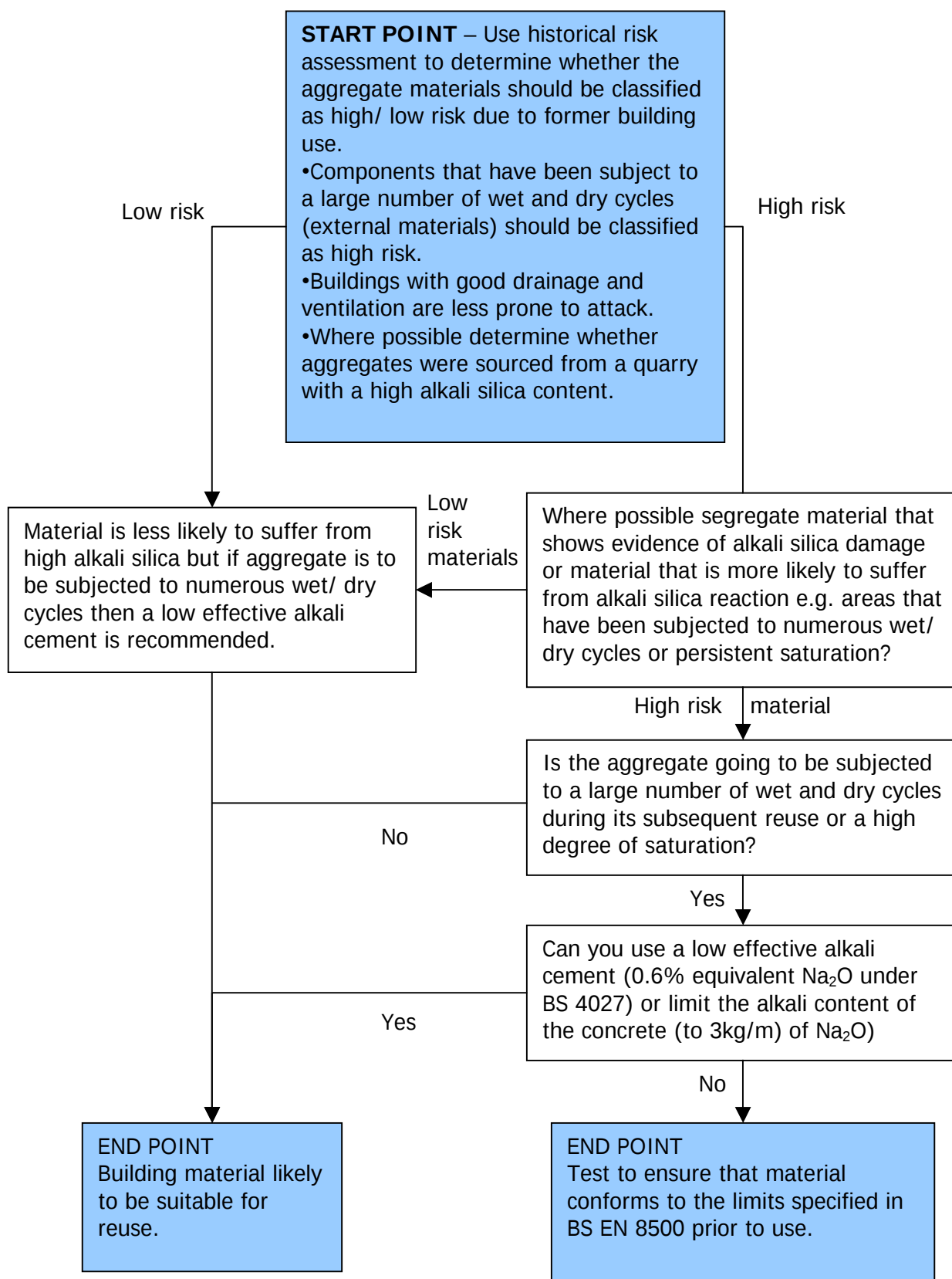


Figure 6.5 Risk Assessment Flowchart For ASR Potential Contamination

6.7 The Impacts Of Physical Contamination

The issues associated with physical contamination are different to those of chemical contamination. Approving recycled demolition material in applications such as road sub-bases has required the development of awareness with regards to the testing regime for permissible organic content, frost-heave performance etc. In new buildings and high performance applications, the physical contamination requirements of BS 8500 relate to maximum levels of fines, lightweight, material, asphalt, foreign material and acid soluble sulphate. The requirements of the standard are summarised in Table 6.5 below.

Table 6.5 BS 8500

Max Allowable Fractions (% mass)	RCA	RA
Masonry material	5	100
Fines	5	3
Lightweight material	0.5	1.0
Asphalt	5.0	10.0
Foreign material e.g. glass, plastic, metals	1.0	1.0
Acid-soluble sulphate (SO ₃)	1.0	1.0

This table then provides a basis for the physical segregation of demolition materials, if the market being pursued for such materials is their specification in concrete as an aggregate. The alternative (or complimentary to) to segregated materials is for the materials to be separated by sophisticated reprocessing plant, as described in Appendix B.

An example of an issue here could be one where the demolition methodology developed resulted in plasterboard being left in place. This could have a potentially negative impact on the potential for then specifying RCA/RA in concrete because the acid-sulphate (SO₃) level could exceed 1% - the maximum permissible level.

The ability to identify the level of physical contamination in a building allows the project team to plan a demolition approach which maximises the value of the material recovered. In other words, a soft strip and material segregation approach can be costed and the viability assessed. This section of the protocol aids this process by considering a number of currently existing buildings as examples of buildings for future demolition. Bills of Quantities were obtained for these buildings, which allow the potential contaminants to be identified.

A total of four different building types are considered here, as described below:

- Concrete Structure Office Building – 4 storey
- Traditional Masonry Residential Development – 4 storey
- Structural Steel Framed Office Development – 2 Storey
- Steel Framed Retail Development – Single Storey

Tables 6.6 and 6.7 below provide a summary of the building materials used in the construction of the Hydepark Street office in Glasgow¹ (completed 2000), and Campbell Street Healthcare Residential Development in Greenock. The different demolition materials which will ultimately arise from these buildings are grouped together in terms of high, low value etc. Note that the criteria for assigning these values is described in the Building Audit section. In presenting the data in this way we develop a profile of the potential for recycling and the contamination risks presented by specific materials. It can be seen from the tables that when the buildings are due for demolition there will be significant opportunities to recover material for recycling. Consider the following simplified process:

- Soft-strip to remove composite roofing, sanitary products, doors, window frames, suspended ceilings, raised floors, carpeting, furnishings, plant & machinery
- Soft strip to remove plasterboard/plaster
- Recyclable steel & hardwood segregated from material streams

The issues and opportunities associated with each building type are described after each of the tables. It should be noted that these Bills of Quantities describe the significant resource potential of buildings to substitute for primary materials in high value applications. These quantities also excluded soft furnishings which would be removed as part of the soft strip process (for example, carpeting).

¹ Information provided courtesy of Burro Happold, Glasgow

Table 6.6 Hydepark Street, Glasgow – 4 Storey, Concrete Framed Office

Material Composition	% Weight	Tonnes
High Value Aggregate: RCA	91.8%	2,581
Medium Value Aggregate: RA	0.7%	20
Recyclable Steel	5.9%	166
Recyclable Hardwood, Glass	0.1%	3
Potential Physical Contamination* - Softwood (0.2%) - Plasterboard / Plaster (1.1%) - Glass (0.1%)	1.5%	

* Does not include weight of composite roofing, sanitary products, doors, window frames, suspended ceilings, raised floors, carpeting.

Table 6.6 shows that 2,582 & 20 tonnes of material is available as RCA & RA respectively. Once the 166 tonnes of steel is removed, the quantity of contaminants is such that the requirements of BS 8500 can be met – for the production of RCA and RA. In fact, assuming that there are no issues with chemical contamination (as determined by following the risk assessments described previously) the full 2,602 tonnes of material could be used as RCA.

Table 6.7 Campbell Street, Greenock – 4 Floor, Traditional Masonry Residence

Material Composition	% Weight	Tonnes
High Value Aggregate: RCA	48.6%	1,052
Medium Value Aggregate: RA	38.4%	831
Recyclable Steel	0.7%	15
Potential Physical Contamination* Timber products (2.6%) Plasterboard, plaster, render (8.9%) Misc., including felt, glass etc (0.8%)	12.3%	266

* Does not include weight of composite roofing, sanitary products, doors, window frames, suspended ceilings, raised floors, carpeting.

1,052 & 831 tonnes of material are available as RCA & RA respectively. This building design includes significantly higher quantities of chipboard & plywood, as well as plasterboard, plaster, render etc. The soft strip and segregation process is likely to be costlier than the previous building to achieve material from site with contamination below the levels of the British Standard. However, having completed the material segregation process, there remains 1,898 tonnes of material with potential for high and medium value use.

Tables 6.7 and 6.8 present data for the other building types, demonstrating again that RCA is by far the most significant material arising.

Table 6.7 O Centre, Springhill - Steel Framed, Single Storey, Retail Development

Material Composition	% Weight	Tonnes
High Value Aggregate: RCA	72.6%	2,568
Medium Value Aggregate: RA	24.6%	871
Recyclable Reinforcing Steel	2.5%	87
Potential Physical Contamination - Fire Protection, Plasterboard	0.3%	11

Table 6.8 Satellite Workshop - Steel Framed, 2 Storey, Office Development

Material Composition	% Weight	Tonnes
High Value Aggregate: RCA	60.2%	1,462
Medium Value Aggregate: RA	29.8%	724
Recyclable Steel (Excluding Steel Frame)	1.7%	41
Potential Physical Contamination - Plasterboard, Plaster (6.4%) - Flooring / Ceiling System (0.97%) - Insulation (0.82%)	8.4%	203

The Bill of Quantities presented for the satellite workshop (Table 6.8) in particular describes significant levels of contamination from plasterboard. The requirements for material segregation processes are therefore presented clearly.

6.8 Physical Properties Compliance Testing

Table 6.8 shows the potential physical tests that the recycled aggregates may need to comply with, if required by the designer. The number of tests may vary depending upon the end use of the recycled aggregate and/ or the aggregate standard used. Guidance on when physical tests are required has not been covered by this protocol but clear guidelines are laid out within the standards. BS 8500 states that the RCA and RA should be sampled at a frequency sufficient to give enough data to demonstrate a compliant product. Providing information to the demolition contractor on the requirements at the outset of the project may influence the type of demolition equipment used. For example geometric requirements may influence the choice of crusher/ cruncher used to demolish the building (general information on the different equipment can be found in the Appendix).

Table 6.8 Physical Test Requirements For Aggregates Conforming To The New Aggregate Package.

	13055 Lightweight Aggregates	12620 Aggregates in Concrete	13383 Armour- stone	13043 Bituminous Mixtures	Aggregates for Mortar 13139
Particle Shape	✓				*
Aggregate Sizes	✓	✓			
Maximum masonry	✓	✓			
Maximum lightweight material	✓	✓			
Maximum Asphalt	✓	✓			
Foreign Material (<1%)	✓	✓			
Strength	✓	✓			
Exposure		✓			
Gradings	✓	✓	✓	✓	✓
Flakiness		✓		✓	
Crushed / Broken surfaces			✓	✓	
Shell Content		✓			✓
Fines Content	✓	✓		✓	✓
Fines Quality		✓		✓	*
Resistance to Abrasion				✓	
Angularity of fine Aggregate				✓	
Resistance to fragmentation		✓		✓	
Resistance to Wear		✓	✓	✓	
Resistance to breakage			✓		
Resistance to polishing		✓		✓	

Table 6.8 Physical Test Requirements For Aggregates Conforming To The New Aggregate Package.

	13055 Lightweight Aggregates	12620 Aggregates in Concrete	13383 Armour- stone	13043 Bituminous Mixtures	Aggregates for Mortar 13139
Surface Abrasion		✓		✓	
Aggregate Size					
Particle Size					
Particle Density	✓	✓	✓	✓	✓
Loose Bulk Density	✓				
Bulk Density		✓		✓	
% of Crushed Particles	✓				
Organic Contaminators					
Freeze/ Thaw	✓	✓	✓	✓	✓
Drying Shrinkage		✓			
Crushing Resistance	✓				
Resistance to Disintegration	✓				
Resistance to thermal Shock				✓	
Affintiy for bituminous binders				✓	
Delta ring and ball				✓	
Water Absorption	✓	✓	✓	✓	✓
Salt Crystallization			✓		
Water Content	✓			✓	
Temperature					
Compressive Strength					

6.9 Testing & The Quality Control Protocol For The Production Of Recycled Aggregates

6.9.1 Overview

The Quality Control Protocol provides suppliers with a procedure to control the quality of secondary and recycled aggregates for sale as construction materials, or as constituents in a product e.g. concrete or asphalt. It recommends minimum frequencies of inspection and testing and the aim is that it will allow suppliers to provide adequate assurance that their products conform to the relevant technical specifications or certified characteristics.

The protocol describes how:

“the producer of recycled aggregates should declare their use of this, or an equivalent, quality control protocol before making deliveries or at the tender negotiation stage”.

6.9.2 Inspection And Testing Regime Including Frequency And Methods Of Test For Finished Product

The protocol describes how inspection and testing regimes should be adjusted to suit the requirements of the finished product, the quality of incoming materials and the complexity of the processes involved. The main points are summarised below:

- Sampling of the processed product to be carried out in accordance with BS 812: Part 102.
- The minimum test frequencies shown in Table 6.9 below should be used.
- Products should be sampled and tested in accordance with the minimum test frequencies in order to provide sufficient data to demonstrate compliant product.
- The testing rates should be varied to ensure a controlled process.

The testing rate should be increased if the product is used in higher specification applications, e.g. Type 1 or concrete products.

Table 6.9. Quality Protocol Test Requirements

Property Description	Test Method BS812 / CEN	Min Test Frequency
Aggregate Composition Including Organics	Visual Sorting Of The Plus 10mm Fraction	1 per week
Bulk Density	BS 812 Part 2	1 per week
Grading	BS 812 Part 103	1 per week
Fines Content	BS 812 Part 103	1 per week
Particle Shape	BS 812 Part 105	2 per year

Section 7

Standards & Specifying Demolition Recyclate In The New Build

7.1 Objective

This section describes the opportunities presented by standards to specify recovered demolition material in the new build. This is presented for a number of materials, providing project teams with guidance which lays to rest many of the traditional obstacles and perceptions associated with recovered materials. There are significant opportunities for specifying recovered materials in high value application and this section aims to outline these for project teams, these teams consisting of the developer, project manager, designer/specifier and procurement personnel.

In addition, planning authorities are presented with a mechanism to ensure that a percentage of recovered material is specified in the new build. This is derived through the creation of the New Build Recovery Index (NBRI), which identifies the potential for new build components to include recovered materials.

7.2 Introduction

An important aspect of materials with reuse & recycling potential is that innovations in the waste management and recycling industries mean that the range of applications for remanufactured or reusable components is continually expanding. However, the use of materials in new buildings is tightly controlled by industry standards, which means that demolition materials must be produced and controlled such that they can be specified with confidence for the application in question.

This section identifies, through standards and specifications, potential higher performance applications for recycled material in building components. The materials considered here are:

- Concrete and masonry materials
- Glass
- Steel
- Timber

Particular emphasis is given to the recycling potential of concrete and masonry materials which produce the most significant tonnages by far of demolition material. Industry's perception of the potential of these material streams is evolving, with recycled aggregate (produced from concrete and masonry materials) increasingly specified in unbound applications i.e. where the material is crushed and screened to produce granular fills in a variety of applications. For example in the sub-bases of roads or as an engineering fill beneath buildings. This protocol gives particular consideration to how such recycled aggregate can be specified in high performance bound applications

such as concretes. Guidance contained in this section includes:

- Opportunities presented by standards
- Aggregates covered by the standards
- Advice on complying with the standards
- Responsibilities of producers and specifiers as outlined by BS 8500
- Design guide for recycled materials
- Specification guidance

It should be noted that the Waste and Resources Programme (WRAP) is developing markets for recycled glass, wood and concrete/masonry products. Additional information on each of these material streams can be found from the following programmes:

- ConGlassCrete: www.wrap.org.uk/conglasscrete
- RecycleWood: www.recycledwood.org.uk
- AggRegain: www.aggregain.org.uk

The introduction of the replacement Construction Products Directive standards and the aggregate levy (£1.60 per tonne of primary aggregate) have opened the door to a number of opportunities that until recently were not available. Where *Planning Guidance* for material recovery is absent, it is recommended that to maximise the potential now presented by the standards:

- A project team is chosen that has experience or is enthusiastic about using recovered materials, including recycled aggregates (this may need to be client led).
- The replacement CPD standards are used when possible (the replacement CPD standards will **have** to be used after June 2004).
- Demolition materials are viewed as a resource and not a waste.

7.3 Opportunities - Construction Products Directive

The development of new construction standards and specifications by CEN (*Comite Europeen de Normalisation*), through the Construction Products Directive (CPD) and published in Britain by the British Standards Institute (BSI), have been designed to provide a level playing field for all products across Europe. Many of the new standards make provisions for recycled aggregates and have moved away from the traditional recipe based formulas that prevented the former use of recycled materials in higher value applications.

The new standards endorse the use of **coarse** recycled aggregates in many high value applications, for example, in structural concrete. With the introduction of these replacement standards there should be no technical barriers to specifying the use of recycled aggregates by following the

guidance provided. The CPD standards cover all construction products, but this section concentrates on the increased possibilities for recycled aggregates.

Table 7.1 lists the new replacement standards and the existing standards. All of the following replacement standards allow the reuse of aggregates in high value applications. Where high value applications have been taken to mean aggregates that can be used for structural applications. Existing British standards will be withdrawn by 1 June 2004 at the latest. There will be a period of coexistence where both standards are current. This period of coexistence has been provided to allow producers time to sell old stock and provides time for both specifiers and producers to become familiar with the replacement standards. Note that the old standard will take precedence if there is conflict between the old and new – up to December 2003 only.

Table 7.1 Replacement Standards Related To Aggregates Introduced Through The CPD.

Existing Standard	Replacement Standard	Uses Of Recycled Aggregates Conforming To Replacement Standard
BS 882 Specification for aggregates from natural sources for concrete. Valid until 2003.	BS EN 12620 Aggregates in Concrete	• Structural concrete • Roads • Pavements • Precast concrete products.
BS 5328 Guide to specifying Concrete	Partially replaced by BS 8500 – 2 Specification for constituent materials and concrete - should be used in conjunction with BS EN 206 Concrete – Part 1: Specification, performance, production and conformity.	• Structures cast in situ • Precast structures and structural precast products for buildings and civil engineering structures.
BS 1199 & 1200 Specifications for building sands from natural sources.	BS 13139 Aggregates for Mortar	• Masonry mortar • Floor/screed mortar • Plastering mortar • Rendering of external walls • Special bedding materials • Repair mortar, Grouts

Table 7.1 (Cont / ...) : Replacement Standards Related To Aggregates Introduced Through The CPD.

Existing Standard	Replacement Standard	Uses Of Recycled Aggregates Conforming To Replacement Standard
BS 63-1, BS 63-2 Road Aggregates: specification for single sized aggregates for general purposes.	BS EN 13043 Aggregates for Bituminous mixtures and surface treatments for roads, airfields and other trafficked areas.	• Bituminous mixtures • Surface treatments for roads, airfields and other trafficked areas.
BS 3797: 1990 Specification for lightweight aggregates for masonry units and structural concrete.	BS EN 13055: Lightweight Aggregates- Part 1: Lightweight aggregates for concrete, mortar and grout.	• Buildings • Roads • Civil engineering works.
	BS EN 13383 Armourstone	• Protection for harbours • Kerbstones • Walling

A more detailed listing, as well as general information on all construction products can be obtained from the Office of the Deputy Prime Minister (ODPM), which details current standards and those in development. Table 7.2 outlines the timescales for the introduction of replacement standards.

Table 7.2 Dates of Compulsory use of Replacement Standards

Existing Standard	Replacement Standard	Available Date of replacement standard	Period of Co-Existence	Withdrawal date of existing standard
BS 882	BS EN 12620	18/ 9/ 02	1/ 7/ 03	1/ 6/ 04
BS 1199 & 1200.	BS 13139	8/ 05/ 02	1/ 03/ 03	1/ 06/ 04
BS 63-1, BS 63-2	BS EN 13043	11/ 09/ 02	1/ 07/ 03	1/ 06/ 04
BS 3797: 1990	BS EN 13055	8/ 05/ 02	1/ 03/ 03	1/ 06/ 04
	BS EN 13383	8/ 05/ 02	1/ 03/ 03	1/ 06/ 04

7.4. Demolition Recyclate: Concrete & Masonry

7.4.1 Materials Covered By BS 8500 – 2 & BS EN 206 – Part 1

BS 8500 covers the use of recycled and secondary aggregates conforming to BS 12620 and BS 13055 and only applies to coarse recycled aggregates. The full titles for the two parts of BS 8500 are:

- BS 8500 Concrete. Complementary British Standard to BS EN 206-1-Part 1. Method of specifying and guidance for the specifier
- BS 8500 Concrete. Complementary British Standard to BS EN 206-1 – Part 2. Specification for constituent materials and concrete

There are currently no standards for the use of fine Recycled Concrete Aggregate (RCA) or Recycled Aggregate (RA) for use in concrete. BS 882 covers composites of RCA or RA.

BS 8500 differentiates between RA and RCA. RA may consist of crushed and graded inorganic materials - concrete or masonry (concrete or masonry). The maximum masonry content of RCA is 5%. Due to improved performance aspects of RCA, this may be used for higher strength concrete in a wider range of exposure classes. Both RCA and RA have to meet the requirements shown in Table 6.3, which is reproduced from the standard.

Table 7.3 BS 8500 - Concrete, p8

Type of aggregate	Requirements					
	Maximum masonry content <i>Mass fraction %</i>	Maximum fines <i>Mass fraction %</i>	Maximum lightweight material <i>Mass fraction %</i>	Maximum asphalt <i>Mass fraction %</i>	Maximum foreign material e.g. glass, plastic, metals <i>Mass fraction %</i>	Maximum acid-soluble sulphate (SO ₃) <i>Mass fraction %</i>
RCA	5	5	0.5	5.0	1.0	1.0
RA	100	3	1.0	10.0	1.0	1.0
A - Where the material to be used is obtained by crushing hardened concrete of known composition that has not been contaminated by use, the only requirements are those for grading and maximum fines						
B - Material with a density less than 1,000 kg/m ³						

7.4.2 Applications Permitted By The Standards

The opportunities presented by BS 8500 are numerous for RCA, which may now be used in higher strength concrete of up to C40-50 strength. Examples of applications requiring such strength are foundations, load bearing walls and pre-cast concrete floor slabs. **Reinforced** concrete of strength RC25-50 can also contain up to 20% mass fraction of recycled concrete aggregates, provided that they have not been excluded by the specification. A greater percentage can be used if the specification permits.

The standards also provide greater opportunities for Recycled Aggregates (RA), which have traditionally been used for low value applications e.g. temporary roads, on-site landscaping and bulk fill. Recycled aggregates can be used for concrete of C16/20 strength concrete. Examples of concrete requiring strength of C16 are concrete blindings, concrete bedding & backing for kerbs and pipe-work supports and protection.

If chemical testing of the RCA & RA is required this should comply with the tests shown in Table 7.4. These tests require physical sorting of the aggregate sample and visual determination of the constituents present. Note that chemical testing is not required for RCA of a known composition – the only requirements relate to gradings and fines.

To identify the likely requirements for chemical testing, the Risk Assessment Flowcharts in Section 6 (Building Audits & Managing Contamination) should be referred to.

Table 7.4 Chemical Tests

Chemical Tests	13055 Lightweight Aggregates	12620 Aggregates in Concrete	13383 Armour- stone	13043 Bituminous Mixtures	Aggregates for Mortar 13139
Chlorides	✓				✓
Acid Soluble Sulphate	✓	✓			✓
Alkali					
Total Sulphur	✓	✓			✓
Loss on Ignition	✓				✓
Alkali – Silica Reactivity		✓			✓
Other Constituents		✓	✓		✓
Carbonate Content		✓			
Water soluble Constituents			✓		✓
Water Solubility				✓	
Water Susceptibility				✓	
Calcium hydroxide content				✓	

The report *Mix Design Specification for Low strength concretes containing Recycled and Secondary Aggregates* by Dr W.F. Price examined BS 8500 and concluded that the greatest opportunities for specifying recycled aggregates were in the specification of designated concrete mixes. Designated concrete mixes require strength testing and therefore the quality of the concrete can be confirmed. As mentioned before, BS 8500 allows specifiers to specify the use of RCA for use in such concrete to C40/50 strength.

An example of the possibilities provided by the replacement standards is shown in Table 7.5 for flooring - covered by BS 8204. BS 8204 covers concrete bases and cement-sand-leveling screed to receive in-situ flooring. Concrete is required for the sub-grade, sub-base and base of the structural slab.

Table 7.5: Requirements of BS 8204 and the Recycling Potential for Recycled Aggregates

BS 8204 Requirements	Potential for Recycled Aggregates
Lightweight aggregates should conform to BS 3797 (being replaced by BS EN 13055-1)	BS EN 13055 Permits the use of recycled aggregates.
Aggregates to be used in the concrete bases should conform to BS 12620 or be: “Aggregates of other types providing that they are suitable regarding strength, density, shrinkage, durability and surface finish of the base.”	BS EN 12620 permits the use of recycled aggregates.
Specifies that the aggregates should not contain any deleterious material in sufficient quantities to adversely affect the base or screed.	This section of the protocol provides guidance on how to predict and test for potential physical or chemical contaminants. Also illustrated is the potential contamination from specific building types, thereby highlighting the segregation requirements.
Minimum strengths for base slabs to receive flooring should be • C30 for slabs to receive direct application of flooring, or cement sand levelling screed. • C35 for slabs to receive high strength bonded or monolithic wearing screed.	BS 8500 limits the maximum strength class for RCA (unless of known composition) as C40/50 therefore it would be technically possible to use RCA. The maximum strength class for RA is C16/20. Therefore an alternative use would need to be found for RA.
Note: BS8500 limits the mass fraction of recycled concrete to 20% (unless the specification permits more) for reinforced concrete of strength RC 25-RC50.	

The Building Audit (section 5 of this Protocol) will help to determine the types of material present in a building earmarked for demolition. Knowledge of how standards affect the required quality of demolition materials – with respect to their specification in a defined end-use – allows the demolition technique to be planned and the degree of segregation to be understood. Alternatively, this may apply in the future if purchasing or planning conditions

evolve such that, for example, a minimum percentage of recycled material is specified in a new build. Examples of comparative performance and cost benefits from using RCA and RA in different applications can be found at WRAP's AggRegain website: www.aggregain.org.uk.

7.4.3 The Limitations

Guidance on the exposure classes recycled aggregates can be used for is provided in BS 8500, as duplicated in Tables 7.6 and 7.7 below.

Table 7.6 Exposure Classes for RCA and RA (BS 8500)

Type of Aggregate	Limitations on Use	
	Maximum strength class	Exposure classes ^b
RCA ^a	C40/50	X0, XC1, XC2, XC3, XC4, XF1, DC-1
RA	C16/20	X0, DC-1
^a Material obtained by crushing hardened concrete of known composition that has not been contaminated by use may be used in any strength class. ^b These aggregates may be used in other exposure classes provided it has been demonstrated that the resulting concrete is suitable for the intended environment, e.g. freeze/thaw resisting, sulphate-resisting, etc.		

Table 7.7 Definitions of Exposure Classes for RCA and RA (from BS 8500-1:2002)

Exposure class	Definition of Exposure Class
X0	For concrete without reinforcement or embedded metal: all exposures except where there is freeze/thaw, abrasion or chemical attack. For concrete with reinforcement or embedded metal: very dry.
XC1	Dry or permanently wet
XC2	Wet, rarely dry
XC3/ XC4	Moderate humidity or cyclic wet and dry
XF1	Moderate water saturation without de-icing agent
DC1	

Recycled aggregates may be used in more demanding exposure classes provided it can be shown that they are fit for purpose. Related to this, the Risk Assessment Flowcharts shown in Section 6 will assist the process of determining when testing is required.

7.4.4 Responsibilities Of Producer And Specifier

The responsibility for aggregates conforming to standards lies with the producer -according to BS8500. However, it is the specifier's responsibility to ensure that the materials specified are sufficient to carry out the job. Guidance on specifying concrete is provided in BS85000: 1 2002.

7.5 Demolition Recyclate: Glass

7.5.1 Technical Opportunities

The physical and chemical properties of glass result in a versatile material that can be easily recycled and used as an aggregate. It is estimated that the construction and demolition industries produce total flat glass arisings of between 2.2 – 2.4 million tonnes per year (*Recycled Glass Market Study and Standards Review, 2002, WRAP*).

Some of the benefits of recycled glass as an aggregate include:

- Zero water absorption resulting in increased durability of concrete.
- Reduced susceptibility to freeze/ thaw characteristics – therefore advantages in using recycled glass as an aggregate in the top surface layers.
- Greater hardness than natural aggregates
- Concrete flow properties can be improved by using glass. Therefore higher strength, lower water mixes can be obtained.
- Finely ground glass has pozzolanic properties contributing to the strength of concrete.

Many perceived barriers have been identified in the WRAP fact sheet *Building on Recycled Glass as an aggregate*. Solutions to the “barriers” have been compiled in the table below and provide some options to designers/ specifiers wishing to use glass in high value applications.

Table 7.8. Summary Of Barriers For Using Glass As An Aggregate

Barriers	Solutions
Standards are material specific	Replacement European aggregate standards are currently available. Details of the replacement performance based standards can be found in <i>Section 7.3 Construction Products Directive</i>
No accepted standards for glass in terms of its physical and chemical properties.	• Ensure compliance with (replacement) performance based standards. • Look to past uses – States in the USA have been using glass as recycled aggregates for many years. • Examine demonstration case studies (see www.aggregain.org.uk)

Table 7.8 (Cont / ...) Summary Of Barriers For Using Glass As An Aggregate

Barriers	Solutions
Larger glass aggregates (>5mm) have a high “flakiness index”. Generally a rounder shape is more workable than a flat shape.	- Crush glass below 5mm. - Use in applications that do not have a restriction on the flakiness index.
Increased potential for alkali silica reactions to occur. (The alkali silica reaction produces a gel that expands and can cause the concrete to crack).	- Use a fine sized glass aggregate (<2mm). Using a fine sized aggregate can have beneficial effects because the increased surface area results in a beneficial pozzolanic reaction. - Suppress the reaction with admixtures - Using low alkali cement. Further information on minimising the threat of alkali- silica reactions can be found in the BRE Digest <i>Alkali Silica Reaction in Concrete Digest 330</i>.

7.5.2 Purchasing Glass Aggregate

Currently, approximately 50,000 tonnes of glass is used in aggregate production (*Building on Recycled Glass as an aggregate, WRAP*). It is estimated that the number and range of applications will increase such that over 300,000 tonnes of recycled glass is used per year by 2006. There are currently a number of glass aggregate suppliers. Some of the key players are identified in Table 7.9 below, with an indication given of the types of products and applications currently on the market.

Table 7.9. Summary Of Key Glass Aggregate Suppliers

Supplier	Product	Applications	Benefits	Standard / Specification
Day Aggregates Held as a stock item at Greenwich, Brentford, Purley and Crawley	Recycled glass sand.	Block paving sand Free draining trench backfill Cable laying sand Asphalt sand	As per sand from natural sources.	Supplied and specified to BS 7533 Cat III. Manufactured to Specification Highways Works Clause 710 – Revision May 2001.

Table 7.9 (Cont / ...) Summary Of Key Glass Aggregate Suppliers

Supplier	Product	Applications	Benefits	Standard / Specification
RMC Contacts for purchasing glasphalt can be found on: http://www.rmcdirectory.co.uk/SearchResults.asp	Glasphalt Substitution of 30% of natural aggregates by glass.	Roadbase and basecourse mixes. Structural layers of the road.	Low absorption of moisture. Relatively hard. Non variable.	Clause 929 Specification for Highway Works and BS 4987 Coated macadam (asphalt concrete) for roads and other paved areas. Specification for constituent materials and for mixtures
Conway Concrete Products	20% replacement of sand by recycled glass.	For use in pre-cast concrete products		

7.5.3 Case Studies

London Remade has developed a number of eco sites. At the eco sites glass is processed and can be brought back by local councils. For example, Westminster City Council will be using recycled glass in the sub grades of the roads to help resurface Stratford Place.

Haverthwaite Road Resurfacing Trial Orpington, Bromley - Use of recycled Glass in the Surfacing layers of the road.

Used glass from an eco site set up by London Remade in the surfacing layers of the road. The asphalt produced contained 10% recycled glass. There are no changes to the laying of the asphalt. There are two main differences between glass asphalt and conventional asphalt. Glass asphalt contains little specks of white which produce a slight glint in sunlight. Glass asphalt is also not as firm as conventional asphalt; therefore initially glass asphalt is being used by Bromley council on smaller roads, which have a lower traffic holding.

http://www.londonremade.com/london_remade/download_files/Haverthwaite%20Road.doc

7.5.4 Ensuring That Glass Complies With The Standards

Many of the replacement standards detailed earlier in section 6.3 allow the use of materials that are fit for purpose and do not contain any deleterious materials that could cause adverse effects. Ensuring that the glass meets all requirements of the standard should ensure that the glass is fit for purpose.

In some cases the properties of glass may mean that choosing to specify it is technically favourable as well as environmentally friendly. A report carried out by Enviro for WRAP entitled *Recycled Glass Market Study and Standards Review* identified some of the key tests that glass would need to comply with to be used as an aggregate. These are listed below:

Table 7.10. Testing & Compliance For Use Of Glass As Recycled Aggregates

Test	Compliance
Grading	Should be able to meet the finer grading requirements using glass.
Flakiness	Should be no difficulty meeting the requirements using smaller sized glass particles.
Shell Content	Glass should not contain a significant shell content.
10% Fines	As stated
Sulphates	Should not be a problem for recycled glass aggregates.
Chlorides	May need to be tested. Chloride content for aggregates in concrete should not exceed 0.02% for pre stressed concrete.

7.6 Demolition Recyclate: Timber

7.6.1 Standards Where Barriers Apply

The *Wood Market Study – Standards Review* by BSI analysed 163 standards with respect to their position on providing barriers or encouraging the use of reclaimed wood. This concluded that 145 standards were neutral, 18 presented a barrier and none were considered to be positive.

The barriers used to identify if a standard prohibited the use of reclaimed/recycled wood are enclosed in the table below.

Table 7.11 Summary Of Barriers From Standards Prohibiting The Use of Reclaimed/Recycled Wood

Barrier	Reason
Performance	Strength grading treated wood may be costly, as paint may have to be removed prior to visual inspection.
Chemical Contamination	Unknown treatments may mean it is difficult to carry out chemical testing.
Species	Species of reclaimed wood may be unknown and difficult to establish.
Aesthetic	Colour or texture of reclaimed wood may not be suitable for intended end use.
Delivery Conditions	May stipulate certain requirements on delivery e.g. known origin etc.
Physical Contamination	Removal of rubble and/ or fasteners may add to the cost.

If none of the above barriers apply the standard is considered neutral with respect to specifying reclaimed wood.

The following standards place barriers on the specification of reclaimed wood. By identifying these, we also identify the standards which can be used with confidence to specify reclaimed wood.

Table 7.12 List Of Standards With Barriers For The Use of Reclaimed/Recycled Wood

Standard Number	Title	Barrier
BS 5268-5:1989	Structural Use of timber. Code of practice for the preservative treatment of structural timber	Species specific
BS EN 460: 1994	Durability of wood and wood based products. Natural durability of solid wood. Guide to the durability requirements for wood to be used in hazard classes.	Species specific
BS 373	Testing methods for small clear timber specimens	Requires that timber should be tested in green and seasoned condition.
BS 4978	Softwood visual strength grading	Specified method of strength grading is not possible on reclaimed wood.

Table 7.12 (Cont/...) List Of Standards With Barriers For The Use of Reclaimed/Recycled Wood

Standard Number	Title	Barrier
BS 5756	Hardwood visual strength grading	Requires visual grading.
BS 6446	Manufacturing specification for glued structural components	Specifies that the species or type and strength class shall be those specified in the design of the component.
BS EN 386	Performance and production requirements for glued laminated timber	Timber should be defined by its strength class or strength properties and to be strength graded against European standards.
BS EN 518	Structural timber visual strength grading	Visual strength grading of timber.
BS 5268 –2	Structural use of timber code of practice	Requires strength grading.
BS 5268 – 3	Trussed rafter roofs code of practice	Requires strength grading.
BS 5268 – 6.2	Timber frame walls code of practice, buildings other than dwellings	Requires strength grading.
BS 5268 – 7.1	Domestic floor joists	Requires strength grading.
BS 1297	Tongue and groove flooring softwood flooring specification	Species
BS 8000-5	Workmanship on building sites code of practice	Species, grade and preservative used should be shown on delivery.
BS EN 975-1	Hardwoods appearance grading	Appearance grading
BS EN 1611-1	Softwoods appearance grading	Appearance grading
BS EN 12246	Quality classification for pallets and packaging	Visual classification
BS 5977-2:1983	Lintels. Specification for prefabricated lintels	Performance, species
BS 6180: 1999	Barriers in and about buildings. Code of practice	Performance, species

Table 7.12 (Cont / ...) List Of Standards With Barriers For The Use of Reclaimed/Recycled Wood

Standard Number	Title	Barrier
BS 8004: 1986	Code of practice for foundation	Performance
BS 8103-3:1996	Structural design of low rise buildings. Code of practice for timber floors and roofs for housing	Performance
BS MA 402:1975	Specification for marine guard rails, stanchions, etc. Gates and portable guard retail sections for merchant ships (excluding passenger ships)	Aesthetics, Delivery
BS 476-23:1987	Fire tests on building materials and structures. Methods for determination of the contribution of components to the fire resistance of a structure.	Chemical
BS 585-1:1989	Wood stairs. Specification for stairs with closed risers for domestic use, including straight and winder flights and quarter- or half landings.	Aesthetics

7.6.2 Issues & Solutions For Specifying The Reuse Of Timber

Technically there are no limitations to reusing timber in non-structural applications. Very old timber (pre 1929) can be easily reused and is often stronger than newer timber because it has been slow grown (anecdotal information). However, the decision to reuse it is one a project team has to consider with limited guidance from existing standards.

Project teams will have to consider carefully the availability of suitable timber, a challenge which can be met in some circumstances by adopting a flexible approach with the specifications developed (where possible), as well as by identifying local sources of timber for reuse. For example, if the project team is responsible for a demolition and the subsequent rebuild then a building audit may help to identify quantities of suitable timber for reuse from the old building.

All timber except that which has been laminated can be chipped and recycled. The timber floors and joists can also be stripped out and reused or recycled. Potential issues that may need to be considered in the project planning process are shown in Table 7.13 below:

Table 7.13 Issues & Solutions For Specifying The Reuse Of Timber

Problem	Example Solution
Attachment of wood or multiple nails in timber	If possible, remove nails whilst material is still in position. Timber ends are more likely to contain multiple nails - these can be sawn off.
Timber Dimensions	Where possible design the new build around the existing timber beams.
Damaged timber beams	Standards may disallow the timber for future structural purposes, but the timber could be used for non-structural uses or recycled for chipboard.
Compliance with standards	There should be problem with reusing old wood, providing it can be shown to comply with the strength and visual requirements of the standards.
Contaminants due to preservatives	Segregate treated and untreated wood. Treated wood may be reused but there are health and safety issues that will need to be considered.

7.6.3 The Use Of Recycled Wood For Wood Based Panels

By specifying wood-based panels with a recycled material content, the demand is increased in the current limited market with added value created for another demolition recycle. The European Panel Federation Industry Standard entitled "The use of recycled wood for wood based panels" lists maximum permissible values for contaminants in wood based panels.

All timber except that which has been laminated can be chipped and recycled. The timber floors and joists can also be stripped out and reused or recycled.

In certain cases it may be possible to use an alternative standard that does not discriminate against the use of recycled wood, or find an alternative use for the timber e.g. Of the 67 standards focusing on wood based panels, none have been assessed as presenting a barrier to the specification of reclaimed and/or recycled wood. All of the standards assessed were classified as neutral.

WRAP have recently introduced a new service www.recyclewood.org.uk which allows businesses to identify local services and facilities available to recycle wood.

7.7 Demolition Recyclate: Metals

Once again present standards are limited with regards to identifying opportunities for the reuse of steel. However the manufacture of steel lends itself very easily to recycling. In America the Recycle steel organisation estimates that 64% of steel is recycled. In order to maximise the recycling and hence profitability it is important to dismantle the building properly in order to recoup as much steel as possible.

The sale of various metal components is a fundamental part of the profit margin of many demolition contractors. This is currently realised, without recourse to standards or specifications, through the following activities:

- Steel beams in good condition – sold intact to small scale contractors for reuse in local contracts
- Steel beams, warped/damaged – sold on to local reprocessors
- Copper wires – stripped from cables, baled and sold on to reprocessors
- Aluminium components – compacted, baled and sold on to reprocessors

7.8 Demolition Recyclate Content In New Buildings

7.8.1 Developing The New Build Recovery Index

Planning guidance is now being developed to require recycled material content in new builds. This section draws on the potential offered by the development of standards through the Construction Products Directive to describe the percentages of recovered material from demolition which can be specified and procured for new builds. This leads to the creation of a **New Build Recovery Index** as described in Figure 7.1. A recovery index can be created for particular aspects of the Bill of Quantities, for example concrete materials, infrastructure (roads, pavements etc), which then allows guidance or planning conditions to be applied to specific aspects of new developments. This could be particularly advantageous in the early days of using the model, where the process of managing new initiatives may be considered more straightforward if, for example, concrete was the only material where component design and material procurement should reflect the Recovery Index.

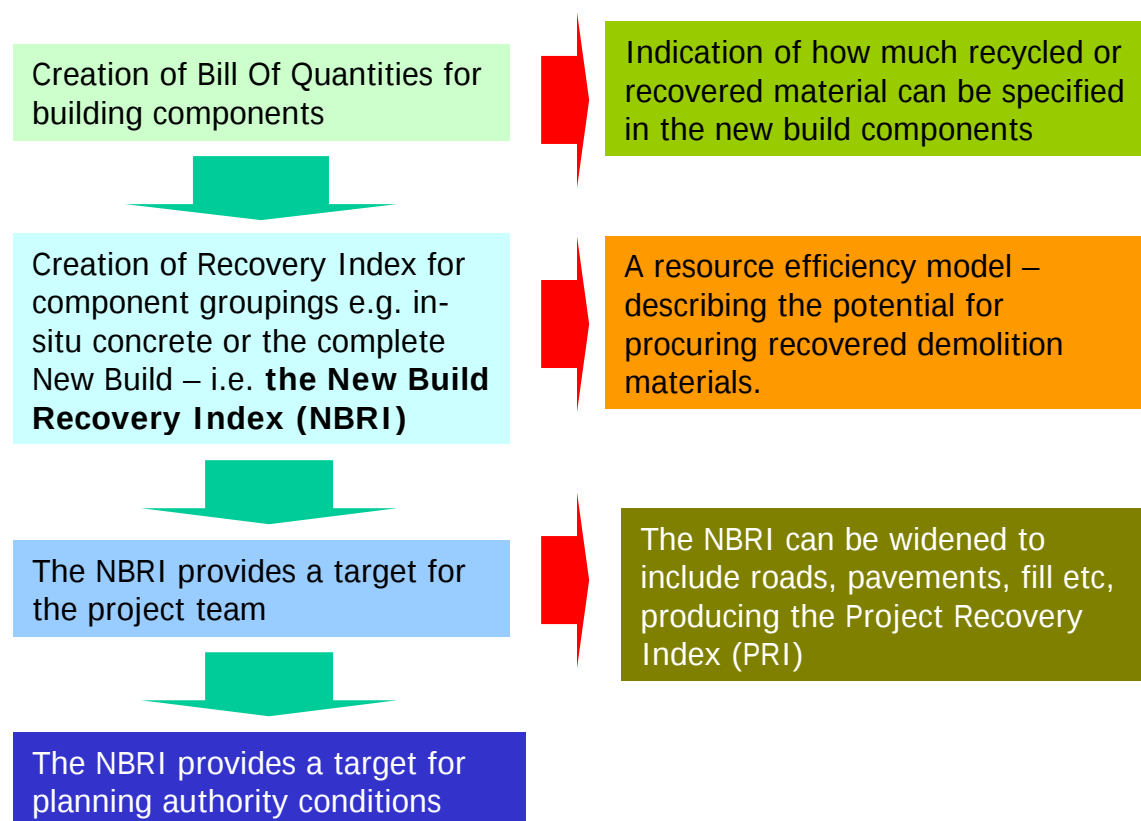


Figure 7.1. The Development of the New Build Recovery Index

With respect to concrete, its most significant constituent is aggregate. As described earlier there are no technical performance issues to prevent recycled aggregates from substituting for significant percentages of primary aggregates in many applications. However, in determining the percentage of recycled aggregate which can be specified - to then calculate the NBRI, the following must be considered:

- RCA & RA can only be specified as coarse aggregates – concrete consists of both coarse and fine aggregates.
- BS 8500 states that RCA can be specified for 20% of the coarse aggregate for reinforced applications. Any variation on this would require separate specification.

An indicative Bill of Quantities is presented in Table 7.16 for *In Situ Concrete / Large Precast Concrete*. The data from this detailed BOQ is then transferred to either the Summary BOQ (Table 7.17) or Material Schedule (Table 7.22). The summary shown in Table 7.17 then presents the data in a user friendly format which allows the New Build Recovery Index to be determined in a straightforward way. Three columns are presented in this table which summarise the potential for specifying recovered materials. This recovery potential is expressed in terms of what is currently possible, independent of the constraints from local markets and supplies. What is referred to here

is the potential only, a potential which will change over time as recovered materials markets evolve. The three columns are as follows:

- Reclaimed material allowed – for example, the percentage of bricks used which could be reclaimed –
- Recycled material allowed – the percentage of recycled materials which can be specified for the component in question. For example, glass and steel can consist of 100% recycled materials.
- Recovered material potential – this is the summation of the previous two columns.

Estimates for recovered (recycled/reclaimed) material content stated in the BOQ for a variety of materials on the basis described in table 7.14 below (not including aggregates).

Table 7.14. Potential For Material To Include Recovered Materials

Material	Recovery Potential & Rationale For Recovery
Bricks	Recovery potential 10%. Although depending on the building, this could be 100%, it is recognised that for the majority of cases this rate will not be practical where the mortar used comprises of Ordinary Portland Cement. Older buildings where lime based mortars were used would make the recovery process more straightforward.
Steel	Recycling potential of 100% from the electric arc furnace (EAF) process, which uses virtually 100 percent old steel to make new. products—such as structural beams, steel plates, and reinforcement bars-- whose major required characteristic is strength. For example, structural beams (The Steel Recycling Institute, http://www.recycle-steel.org/index2.html).
MDF Fibreboard	Recycling potential of 100% - can be produced from significant quantities of recycled wood and 100% is stated as the potential (as quoted by a number of “green” suppliers) – note that this figure will exclude the weight of adhesives.
Double-glazing	Recycling potential of 70% stated, conservatively. In some parts of Europe it is Government policy to insist on the use of recycled PVC in window profiles. Frame material can be wood, PVC, aluminium etc, all of which can be produced using recycled/reclaimed material (glass, of course, can be 100% recycled).
Hardwoods and softwoods	10% recovery potential is estimated, based on the potential to use reclaimed wood in non-structural components, e.g. doors, panelling etc.

This BOQ uses data for the Hyde Park Street building in Glasgow (data courtesy of Burro Happold) with a recovery index produced following the process described in Figure 7.1. To support the completion of this table, the percentages of recycled aggregate need to be stated. As a result, Table 7.15 presents data on the mix proportions for standardised prescribed concretes, which describes the proportion of aggregates.

Table 7.15a Mix Proportions For Standardised Prescribed Concretes

Standardised Prescribed Concrete	Constituent	Quantity or Proportion of Constituent			
		Max aggregate size 40 mm or 45 mm		Max aggregate size 20 mm or 22.4 mm	
		Class S2	Class S3	Class S2	Class S3
ST1	Cement or combination	200 kg	220 kg	230 kg	255 kg
	Total Aggregate	1,990 kg	1,930 kg	1,925 kg	1,860 kg

Source: Table 10 BS 8500 Part II

For indicative purposes, the Bill of Quantities shown in Table 7.16 is completed as a worked example with the aggregate data produced on the basis of the mix for ST1 concrete, class 2, as summarised below:

- Cement: 230 kg
- Total Aggregates: 1,925

The split of fine and coarse aggregates is shown in Table 7.15b:

Table 7.15b Mix Proportions for 32.5 Strength, ST2 Batched Cement

Quantities	Cement	Fine	Coarse	Total
Litres		50	75	
m ³		0.05	0.075	
kg	25	60	90	175
%	14%	34%	51%	100%

Source: Table 12 of BS 8500 Part II

As shown in the table, 51% of the concrete mix is coarse aggregate. This figure is used in the following BOQ, with 20% of this fraction resulting in the quantity of recycled aggregates which can be specified for reinforced concrete.

Table 7.16 In Situ Concrete / Large Precast Concrete BOQ & Recovery Index

Item	Volume (m3)	Total Material Weight (tonnes)	Coarse Aggregate Weight (tonnes)	Reclaimed Material Allowed %	Recycled Material Allowed %	Recovered Material Potential (tonnes)
Ground beams						
Generally	80	192	98	N/A	20%	20
Isolated foundations						
Generally	23	55	28	N/A	20%	6
Beds						
150 to 450 thick	74	178	91	N/A	20%	18
Slabs						
150 to 450 thick	650	1,560	796	N/A	20%	159
Walls						
150 to 450 thick	45	108	55	N/A	20%	11
Attached beams						
Generally	48	115	59	N/A	20%	12
Columns						
Generally	35	84	43	N/A	20%	9
Upstands						
Generally	3	7	4	N/A	20%	1
Sub-total		2,299	1,173			235
Blinding						
Not exceeding 150 thick	21	50	26	N/A	100%	26
Sub-total		50	26			26
Total		2,350	1,198			260

In Situ Concrete Recovery Index**11 %**

Table 7.17 Summary Bill of Quantities & New Build Recovery Index

	Volume (m3)	Total Material Weight (tonnes)	Coarse Aggregate Weight (tonnes)	Reclaimed Material Allowed %	Recycled Material Allowed %	Recovered Material Potential (tonnes)
1. IN-SITU CONCRETE						
BH E10:133	21	50	26	N/A	100%	26
BH E10:130	958	2,299	1,173	N/A	20%	235
2. CONCRETE ANCILLARIES						
Reinforcement Bars	20	154	79	N/A	20%	16
Cement-sand screed	30	68	N/A	N/A	0%	
3. PRECAST CONCRETE						
Units including stairs	10	25	13	N/A	20%	3
Lintels	2	5	3	N/A	20%	1
4. STRUCTURAL METALWORK						
Structural Steelwork	2	13	N/A	N/A	100%	13
5. TIMBER						
Hardwood	2.6	3.3	N/A	10%	N/A	0.3
Softwood	11	6	N/A	0%	0%	0
6. BRICKWORK & BLOCKWORK						
Engineering Brickwork	9	20	N/A	10%	N/A	2
Lightweight Blockwork (F10:350, 351)	220	132	67	N/A	100%	67
7. FINISHES						
Plasterboard / Plaster	18	30	N/A	N/A	0%	
Medium Density Fibreboard(MDF)	0.1	0.1	0	N/A	100%	0.1
8. MISC.						
Double Glazing	1.6	4.2	N/A		70%	3
9. Quantified Building Totals		2,810	1,360			365

New Build Recovery Index**13 %**

Table 7.18 Infrastructure & Ancillary BOQ & Recovery Index

Item	Volume (m3)	Total Material Weight (tonnes)	Coarse Aggregate Weight (tonnes)	Reclaimed Material Allowed %	Recycled Material Allowed %	Recovered Material Potential (tonnes)
CONCRETE ANCILLARIES						
Formwork - BH E20:610	5	4	N/A	100%	N/A	4
Formwork - BH E20:620	32	22	N/A	100%	N/A	22
Formwork - BH E20:630	43	30	N/A	100%	N/A	30
ROADS & PAVINGS						
Granular Material (Type 1)	208	396	N/A	N/A	100%	396
Dense Bitumen Macadam	120	289	N/A	N/A	100%	289
Rolled Asphalt	42	96	N/A	N/A	100%	96
Precast Concrete Kerbs	9	22	11	N/A	100%	11
Granite blocks	16	37	N/A	100%	N/A	37
EARTHWORKS						
Imported Topsoil	27	38	N/A	100%	N/A	38
Imported Other Material (6F1)	555	999	509	N/A	100%	509
Total		1,933				1,433
Infrastructure & Ancillary RI			74 %			

Table 7.19 Summary Of Recovery Potential

	Material Weight	Recovered Material Potential
Quantified Building Totals	2,810t	365t
Infrastructure & Ancillaries Totals	1,933t	1,433t
Project Totals	4,743t	1,798t
Project Recovery Index		38 %

In summary, the BOQs shown in the previous tables describe how the Recovery Index can be created for different elements of the new build:

- Material Component Recovery Index, e.g. concrete
- The New Build Recovery Index - summarised for all components
- The Project Recovery Index - for the new build plus support infrastructure such as roads

It is clear from the Recovery Indices produced, that infrastructure such as roads, present more opportunities with respect to the demand for material which can be met by demolition recycle. However, these applications are lower value than concrete applications where higher process will be paid for RCA.

A key aspect of any demolition and subsequent new build is to consider the relationship between the tonnage of material produced and the tonnages which can be specified in the new build. This is summarised in the example shown in Table 7.20 below. To enable a simplified comparison between the supply potential of the demolition and the demand from the new build, the example shown is produced on the basis that the demolition and new build type are identical designs. i.e. the comparison is made on the basis of the same materials arising from demolition as specified in the new build, with the BOQ for the Hydepark Street building being used once more.

Table 7.20

Demolition Arisings		New Build Demand (from BOQ)		
Overall Tonnage	Total Tonnage Of RA & RCA Produced	Max Tonnage Of RA & RCA Potentially Specified In The New Build	Max Tonnage Of RA & RCA Potentially Specified In The Infrastructure	Total Aggregate Demand
2,810t	1,153t	332t	1,377t	1,709t

These figures clearly demonstrate that demolition may be likely to produce more material, for example with respect to RA and RCA, than can be specified in the new build. However, consideration of the infrastructure material requirements demonstrates that all of the demolition material can be specified for applications on the new build site. With respect to cost savings, it would therefore make economic sense for RCA & RA to substitute for primary aggregates in concrete components of the new build (where the price differential is greatest), with the remaining material specified in the infrastructure.

7.8.2 Developing The Effectiveness Of The NBRI System

As described in Section 4, on “Adapting The Planning System To Improve Resource Efficiency” there is the opportunity for the planning system to require that recycled material content is procured for new buildings, using the NBRI as the basis for the actual percentage.

In such a scenario the planning system would introduce a new demand led process which then acts as a stimulus for increasing the use of demolition materials in higher value applications. This in turn would lead to increased supply of demolition recyclate, reducing the demand for primary aggregates and reducing the amount of demolition waste landfilled.

In summary, the Bill of Quantities (BOQ) is then starting point in the new build, as described previously, where the components making up the building are summarised. The approach in producing the NBRI will be supported through time by the development of typical building profiles covering a range of construction, loadings and building types as illustrated in Table 7.21 below:

Table 7.21 Development Of Material Profiles For Different Building Types

Construction	Loading	Building Type
Concrete framed	Light (Residential)	Low level (1 - 2 floors)
Steel framed	Medium (Commercial)	Medium level (3 - 10 floors)
Timber framed	Heavy (Industrial)	High level (10+ floors)

Bill of Quantity Summaries (using the main BOQ headings) or Material Schedules (see Table 7.22) held in the public domain would allow cross-referencing of the development type in question to a library of information (computer-based) providing typical ranges of recycled material specified in new building components. This data library would be built up from real case studies and theoretical examples. Planning policies driven by sustainable development targets could then have the background knowledge to support the process of influencing targets and decisions regarding the percentage of materials to be re-used or recycled in future developments.

A catalogue of material suppliers promoting the re-use or recycling of construction and demolition materials would further support the material schedule. This would allow designers access to information that would allow them to identify opportunities to specify the re-use or recycled materials. This function is one which may increasingly be supported by WRAP's AggRegain programme.

Note that a template for a Material Schedule is shown as an example in Table 7.21 (at the end of this section), structured on the headings set out in the Civil Engineering Standard Method of Measurement, 3rd Edition. This is shown as an example of an alternative approach to summarising the BOQ as shown earlier in Table 7.17. As building projects will form the focus of developments, benefits may be accrued from structuring the material schedule on the headings set out in the Standard Method Measurement of Building Works, 7th Edition.

A further advantage in requiring developers to compile and submit a Summary Bill of Quantities or Material Schedule is that this data will provide invaluable information if and when the building is scheduled for demolition. Access to a summary of the material composition in the building will improve the accuracy of the Demolition Audit stage.

7.8.3 Conclusions

The Recovery Indices described in this section indicate how project teams can design projects for improved resource efficiency, with significant cost savings as a result. The processes also guide the project team on how to achieve targets resulting from the planning application process which will increasingly demand the specification of recovered demolition materials in the new build.

Table 7.21 Material Schedule – Example Of Potential Framework

	TOTAL WEIGHT	RE-USE %	RECYCLE %	COMMENTS
EARTHWORKS				
Imported Topsoil				
Imported Rock				
Imported Other Material				
IN-SITU CONCRETE				
Designed Mix - C7.5				
Designed Mix - C10				
Designed Mix - C15				
Designed Mix - C20				
Designed Mix - C25				
Designed Mix - C30				
Designed Mix - C35				
Designed Mix - C40				
CONCRETE ANCILLARIES				
Formwork - Rough Finish				
Formwork - Fair Finish				
Reinforcement Bars				
Reinforcement Fabric				
PRECAST CONCRETE				
Slabs				
PIPEWORK				
Clay Pipes & Fittings				
Concrete Pipes & Fittings				
Iron / Steel Pipes & Fittings				
PVC Pipes & Fittings				
HDPE Pipes & Fittings				
MDPE Pipes & Fittings				
Manholes				
Gullies				
Ducts				
Pipe Bedding & Surround - Granular				
Pipe Bedding & Surround - Concrete				

Table 7.21 (Cont / ...) Material Schedule – Example Of Potential Framework

	TOTAL WEIGHT	RE-USE %	RECYCLE %	COMMENTS
STRUCTURAL METALWORK				
Structural Columns				
Structural Beams				
MISC METALWORK				
Stairways & Landings				
Cladding				
TIMBER				
Hardwood Decking				
Softwood Decking				
Hardwood Decking				
Softwood Decking				
ROADS & PAVINGS				
Granular Material (Type 1)				
Granular Material (Type 2)				
Dense Bitumen Macadam				
Rolled Ashphalt				
Precast Concrete Kerbs				
BRICKWORK & BLOCKWORK				
Common Brickwork				
Facing Brickwork				
Engineering Brickwork				
Lightweight Blockwork				
Dense Concrete Blockwork				
Artificial Stone Blockwork				
Ashlar Masonry				
Rubble Masonry				
MISCELLANEOUS				
Insulation				
Glazing				



Appendix A

List of Consultees

The preparation of this protocol has involved extensive consultation. A list of the consultees is shown below:

1. Arup
2. Babbie Group
3. Bechtel
4. BRBS (Netherlands)
5. Brent Council
6. Building Research Laboratory
7. Burro Happold
8. Calford Seadon
9. Cappagh Ltd
10. Carillion
11. Cleanaway
12. Copenhagen Municipal Authority
13. Cory Environmental
14. Countrywide
15. DAKOFA (Danish Waste Industry Association)
16. Dearle & Henderson
17. Demex (Danish Engineering Co.)
18. Department Of Trade & Industry (DTI)
19. Dil Green Architects
20. Dundee City Council
21. Dunstaffnage Marine Laboratory
22. English Partnership
23. Environment Agency
24. EPA, Denmark
25. FIR (International Recycling Federation, Netherlands)
26. Furniture Resource Centre

27. Glasgow City Council
28. Green Architecture Ltd
29. Halcrow
30. Health & Safety Executive
31. ICE Waste Board
32. Institute OF Demolition Engineers
33. Institution Of Civil Engineers
34. Laidlaw Scott
35. Laing Homes
36. Levitt Bernstein
37. London Remade
38. Ministry of the Environment (Netherlands)
39. Ministry of Transport (Netherlands)
40. MPM Capita
41. National Federation of Demolition Contractors
42. Office Of The Deputy Prime Minister (formerly the DTLR)
43. Ove Arup
44. Peabody Housing Association
45. Royal Town Planning Institute
46. Scottish Environment Protection Agency
47. Scottish Executive, Planning Department
48. Southwark Council
49. Strathclyde University
50. Symonds
51. Tayside Contracts
52. Theo Paow Denmark (Danish Reprocessor)
53. Tue Brix (Danish Demolition Contractor)
54. Viridis
55. VVAV (Dutch Waste Processing Association)
56. WH Malcolm
57. Whiteinch Demolition

Appendix B

Demolition & Material Processing Techniques

Objective

This section describes current and emerging technologies with respect to demolition and material processing technologies. This section aims to provide the project teams with information on pros and cons of various approaches, indicating processes which facilitate selective demolition (segregation) of buildings. Another objective involves highlighting the opportunities presented by state of the art processing plant - to demonstrate that on occasions where significant segregation of material has not been possible, there are still opportunities to extract recycled demolition materials which can be specified in high performance applications.

Demolition and Processing Equipment

When buildings and other structures were designed in the past little or no consideration was given to how these buildings and structures would be demolished. More recently building design has started to consider how the building may be taken apart in the future.

Buildings earmarked for demolition require a number of different technologies for the dismantling of structures. The demolition technique will be chosen depending on:

- Building type
- Building location
- Desired timescale of the works
- Health and safety issues

In turn the demolition method will determine the type of material produced from the building. There are then options on how to manage this material, with respect to reuse, recycling or disposal. For optimum sustainability the demolition process will result in the deconstruction of a building, with the reuse of as many of the materials as possible. If the reuse of materials is not possible, then recycling is the next preferred option, with the products being used in high value applications. Demolition technique and subsequent material processing will influence the applications that products can be used in.

Demolition Techniques

In this section a number of demolition techniques are considered. The processing equipment utilised to allow aggregates to be produced to specifications are also assessed.

A number of demolition techniques are shown in Table A.1 Blasting is used for rapid demolition of many buildings, especially high-rise. Unfortunately the limited soft strip process prior to such demolition often results in a high percentage of contaminants in the demolition material. This therefore makes it more difficult to obtain high value recycled product. As shown in Sections 5 & 6 the segregation of material (e.g. to obtain concrete) is desired to allow the production of recycled aggregates of a suitable quality for a range of high value applications.

More modern approaches using hydraulic shears and crusher / cutting devices mean that long arm cranes allow remote dismantling of buildings. This improves the health and safety aspect of demolition, but still allows excellent control over what materials are actually removed. The demolition of concrete structures by cutting or shearing enables reinforced concrete to be cut into blocks and removed by a crane in a manner which is the reverse of the construction process. The removal of internal metal components using high-speed heat torches or other cutting techniques enables a less mixed material to be produced. This increases the likelihood of the processed material meeting the required standards and suitable for higher value applications.

A project team which is informed on the wealth of demolition techniques can ensure that contractors are appointed who specialise in more sustainable and environmentally aware methodologies – and that the approaches involved make sense in the required time frames.

Table A.1 Demolition Techniques

Demolition Techniques		Location	General comments
Controlled Blasting	Mild explosives	Non-urban or controlled urban environment	A fast track/short time scale process that can be used on most building material types. The material produced from the blast is mixed and unsegregated leading to greater difficulty to produce 'clean materials'.
	High intensity explosives	As above except blast fence required.	
Hammering	Pneumatic	Any	A much slower process that is used mainly for the concrete basal structures. As these are often small, hand-held machines there is precision in the type of material that can be produced enabling greater recycling potential although not used very often due to health and safety issues or time.
	Hydraulic	Any	

Table A.1 (Cont / ...) Demolition Techniques

Demolition Techniques	Location	General comments
Crushing/cutting Jaw crushers (Figure 4.1) Munchers Hammer mill Vibratory plates	Any	A wide range of crusher or cutting devices are used to demolish a building. Depending on the building structure the material produced can be of one waste stream. The technique can be used at a relatively quick rate depending on the level of segregation that is desired. Many are used with long reach cranes allowing health and safety to be improved on site.
Hydraulic shear	Commonly used in urban environments where vibrations need to be kept to a minimum.	Used to dismantle concrete or masonry structure up to 0.6-0.8m thick. It has an ability to remove reinforcing steel also. Some modern cutting implements can be used to ensure large components can be removed intact – in particular large concrete lintels etc. – and so allow reuse of materials.
Concrete scabbling	Any	Use of mechanical device to remove contaminated material from hard surfaces by removing the top layer. This material is normally landfilled. This ensures that other material that is removed is not contaminated.
Pressure washing	Any	Usually used for decontamination – ensures that material produced from other demolition methods has a lower level of impurities than would otherwise.
Heat torch	Any	A variety of heat torches of differing temperature enable various metal components to be removed including I-beams. This is a good technique to use to ensure segregation of the metal for reuse or recycling.



Figure 7.1 Jaw Crusher With Long Reach Crane To Remove Upper Part Of Building.

The British Standard Code of Practice for Demolition (BS 6187:2000) is geared towards the health and safety issues regarding building dismantling. New super long-reach, robotic and remote controlled techniques are being utilised to allow accuracy of the demolition and ensure safety is optimised.

Selective dismantling requires additional planning with these non-labour intensive techniques and a balance between environmental benefit and health and safety needs to be established and considered by a project team in terms of cost.

To improve the potential outlets for demolition material there is a need to dismantle buildings in a way that allows materials to be reused & recycled if possible. Generally, building construction and time constraints mean that this happens only to a limited extent. However, there is an opportunity for project teams to gain cost benefits by putting additional effort into the planning processes to maximise material recovery value.

Most demolition arisings are in the form of concrete, brick or general masonry materials. There will of course also be timber, glass, metal and various other material streams. There is a range of aggregates to be produced from demolition material depending on the standards that the material meets. An important factor in aggregates meeting the standards is the quality of the material before processing and the percentage of contaminants it contains.

Processing And Production of Recycled Aggregates

Overview

The material recycling industry uses plant (most often in fixed *Recycling Facilities*) in order to process concrete and masonry demolition material. There are also many smaller mobile recycling facilities around the country. These can be utilised if there is sufficient space at the sites in question.

Most demolition material is brought to recycling facilities in a mixed form, as it often considered difficult to be segregated sufficiently (especially at urban sites where space is limited). It is also considered to be difficult to bring mobile plant onto sites for reprocessing - which further provides a disincentive to source segregate. The ideal scenario, from a recycling perspective, is to process materials on-site, already segregated

as standards require. . However, recycling rates are extremely high already in certain parts of the UK, with rates of up to 90% achieved in some areas. However, the applications for the recycled aggregates are still fairly limited, although in recent years the quantities being produced for road sub-bases.

Significantly increasing the recycled aggregate share of the concrete market requires a shift in the development of more innovative recycling plant or a change in behaviour resulting in the segregation of demolition material.

Processing Techniques

In general a processing plant will involve the following processes:

- Crushing and grinding
- Screening
- Materials sizing and combining

The requirements of the aggregate market are generally met by sizing material against a number of narrow particle sizes. Material is then supplied suitably blended. The aggregate then needs to meet the required standards for the application in which it is to be used.

A general procedure for the processing of demolition material into recycled aggregate is described below in Figure A.2.

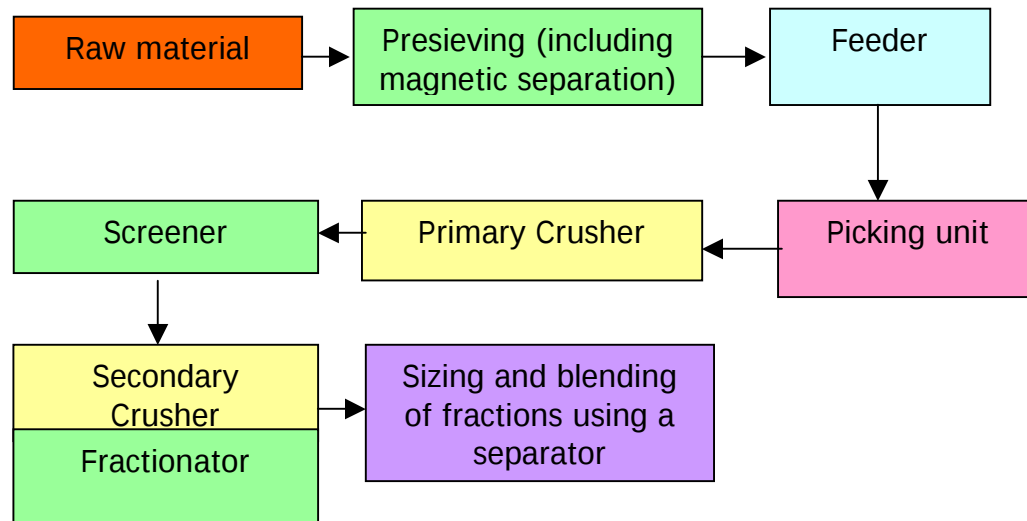
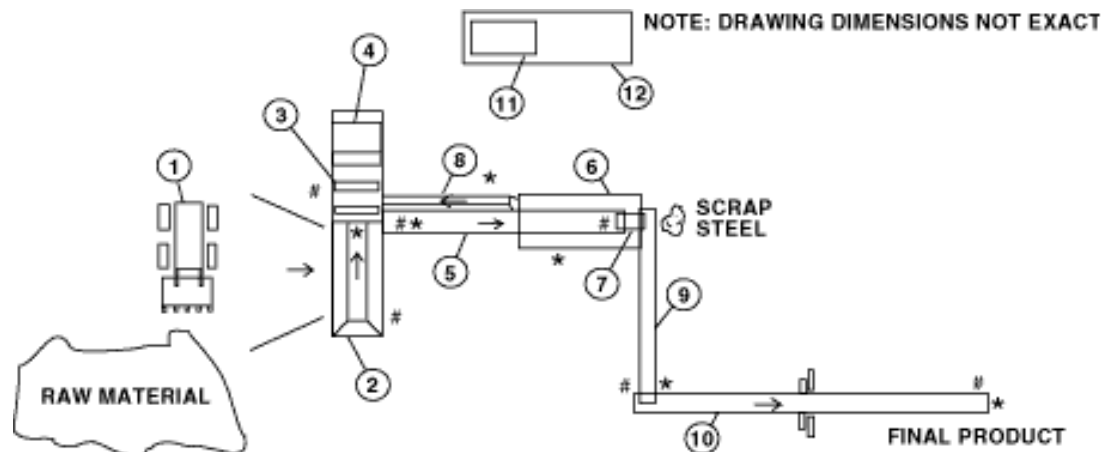


Figure A.2 Schematic Flow Chart Of Typical Processing Procedures

There is a wide variety of different crushers, screeners and separators. The procedure outlined in Figure A.2 is an example of what could be referred to as "*best practice*". This system is organised to ensure that screeners and crushers can be manipulated to provide a range of material with well-defined particle sizes, such as that specified in the Specification for Highway Works, Series 700 for drainage, or Type 1 material. However, the above system is significantly different from most approaches. Other recycling facilities may be more likely to follow the system described in Figure A.3 over the page.



- | | |
|---------------------------------------|------------------------------------|
| 1. Belt Magnet For Separating Steel | 6. Loader |
| 2. Crusher Return Conveyor | 7. Loading Hopper |
| 3. Product Transfer Conveyor | 8. Horizontal Shaft Impact Crusher |
| 4. Radial Stacker | 9. Diesel Engine To Drive Crusher |
| 5. Diesel Engine Generator In Trailer | 10. Screen Feed Conveyor |
| | 11. Screen |

Figure A.3 A Common Set-Up For Demolition Processing

In a fairly common process, the first step in the processing of material recovered from a demolition site (before it enters the crusher stage) is pre-sieving and separation (e.g. using picking belts) of as much extraneous and undesired material. These often require the use of manual labour to remove waste materials or wood, metals, etc. Vibrating feeders are often used, eliminating the need for intensive labour, but also producing material which is more likely to be contaminated. This process also ensures that a percentage of fines are removed before crushing. This provides more efficient working of the crushers. Using an impact crusher as a primary crusher with a variety of screeners and a jaw or impact crusher as a secondary crusher then a screener can produce a large variety of different aggregates.

Some Typical Recycled Products

Crushed Concrete

Type 1 and 2, 6F1 and 6F2 and capping and bulk fill grades

Crushed Asphalt

6F3, 50 and 75 mm graded

Glass Sand

Paving sand to BS7533

Demolition Hardcore

Crushed and graded or as a general fill

Separation Techniques

The biggest problem with demolition material as often produced is its mixed nature. There are a variety of techniques to segregate this. The two general classifications of the processes are either dry or wet. There are advantages and disadvantages to both processes. Wet plants do not have the dust problems associated with dry plants, however they are more expensive with respect to running costs and the complexities associated with the discharge of wastewater. Air separation may therefore be considered to be a more straightforward process to manage in the longer term and one which also produces a range of well fractioned materials.

The degree of separation is very dependent on the machine specification. There is limited difference in the quality of the material produced using either technique, although water based separation has been considered to produce a slightly better degree of separation. Conventional dry processing of recycling materials uses as its core the air classifier where separation occurs at relatively close sized fractions. Air speed is adjusted so that lighter material (such as wood, paper, or waste material) can be taken off first followed by disturbant materials with low bulk density and special particle shapes. Modern air classifiers (costing over £300 000) have been utilised providing excellent separation of materials. They can separate particle sizes into 5-10mm and 10-15mm allowing the production of aggregates meeting the highest specifications.

Water separation systems have the advantage of being able to separate concrete from brick. Besides providing a dust-proof surface, the separation of materials of density of $<2\text{g/cm}^3$ is possible. This can be done using a jig-technique. A pulsating water flow passes through a material mixture. Pulsation leads to stratification – the material ‘settling’ according to density. In addition, water separation is also useful for the separation of some polystyrene bonded concretes as well as being able to remove contaminants such as clay (by washing).

An important consideration involves future requirements for recycling plant. The growing market for high value applications for recycled aggregate means that separation technologies will be key for ensuring that contaminants are reduced to acceptable levels, as described in standards.

Size reduction equipment is divided into crushers, grinders, and cutting machines. Crushing follows the initial separation of material. Crushers do the heavy work of breaking large pieces of solid demolition material into smaller “lumps”. Generally a primary crusher will operate on demolition material, accepting most of what comes from site (after pre-sieving and hand-picking) and breaking it into 100 to 250 mm lumps. A secondary crusher then reduces these lumps into much smaller particles. Grinders can be used to reduce crushed feed to powder for some applications although these machines are not so common in recycling facilities. Cutters can produce particles of definite size and shape that are needed for some applications.

The profile for an ideal crusher is as follows:

- Have a large capacity.
- Require a small power input per unit of product.
- Yield a product of the single size distribution desired.

A cost-effective crushing plant is the result of careful machine selection, correct operation in accordance with changing conditions, and properly planned maintenance. If starting out on the process of choosing machinery, the key to selecting the most appropriate kit is to know what the crusher is expected to do. In other words, consider the following:

- The type of material to be crushed
- The size of the material, for example, slabs, columns, blockwork etc
- Quantities

Table A.2 describes typical crushers used in a recycling facility to produce a variety of aggregate materials. Suggestions are made on the questions which need to be answered. There is a large range of crushers within each crusher type and so for each plant specific questions need to be answered.

Note On Mobile Plant

Mobile plant is often used for the production of recycled aggregates. However, at the moment the quality of material produced generally fails to reach the standards set by stationary plant. A significant contribution to this reduced quality is the “fixed” nature of much of the required separation equipment (as described above). Mobile plant can be very cost effective by reducing transport costs associated with large quantities of material movement from a site.

Table A.2 Crusher Types

Crusher type	Costs	Capacity	Problems	Materials Processed and Output
Jaw crusher	£100 000 - £180 000	Best at <600 tonnes/hr (t/hr) Mobile crusher – 120-200t/hr	Wet fines clog the machine. They also have a low reduction ratio – 6:1	Input size – 0-700x450mm any demolition waste but best without intensely reinforced concrete Output size 0-200mm
Gyratory		1000t/hr mobile approx. – 220 – 360t/hr	Wet fines	Input size – 0-700x450mm any demolition waste but best without intensely reinforced concrete Output size 0-56mm
Impact (rotary or hammer)	£120 000	150-1000t/hr (faster than jaw) mobile – 80-360t/hr	Only suitable on material that has less than 15% silica.	Input size – smaller than gyratory and jaw 0-56mm

Impact crushers are generally preferred for the recycling of demolition material. An impact crusher can be used as the primary crusher. It shatters reinforced concrete leaving the tramp iron, rebar and mesh free to be separated (using an electromagnet). The impact crusher is often favoured because it can stand alone without a secondary crusher.

Advantages of an impact crusher:

- Shatters concrete leaving reinforcements easily recycled
- Has a large reduction ratio (30:1)
- A single pass can produce particle sizes suitable for Type 1
- Can cope with asphalt in the system

Disadvantages

- Not economical for materials with a high abrasion index
- Produces a large amount of fines
- More angular product than aggregates produced using a jaw crusher – a disadvantage in some applications
- Abrasive wear leads to costly replacement of parts

With respect to wear & tear, Barmac crushers operate on the principle of crushing rock against rock. They are therefore impacted in the same way and can be used in applications with very abrasive materials.

In considering the recycling potential of demolition material it is important to consider the building type. If there are basalt or quartzite facings on the building then these will be very difficult to break down using an impact crusher.



Figure A.4 Loading Of Aggregate Into A Secondary Crusher

Location, equipment selection and plant layout are critical to the efficiency of the recycling operation. A secondary gyratory crusher or a cone crusher is usually chosen as the next machine in the chain required to reach the desired product size. In a crushing plant, the size of material is reduced in each stage and has to be controlled by screens. Material must be directed to different parts of the plant by means of chutes, flap gates, feeders, and conveyors.

A screen is installed ahead of a crusher so that only the coarser material is fed to it. This means that the fine material is not fed into the crushing chamber, and the risk of packing is avoided. The amount of material fed is also reduced so that the capacity of the system is increased. A smaller quantity of material passes through the crusher, producing a lower wear cost per tonne.

There are various machine combinations for closed circuit crushing. A common way of combining a crusher and a screen is to install the screen after the crusher so that the screen oversize goes back to the crusher.

Typical example:

1. Initial impact crusher produces material – 125 – 75mm – then 3-way split screener – produces 600 type.
2. Secondary – SIZES?? – produce 800 series
3. Tertiary – air fractionation – produce very fine fractions – 5-10mm and 10-15mm. Type 700.

Future Advances In Processing Equipment And Techniques

Future demolition machines are likely to be quieter than ever before and equipment like hydraulic hammers, cutter-crushers and recycle crushing plants will benefit from reduced noise and improved dust suppression.

Having become extremely adept at dismantling structures built in the 1950s, 60s and 70s, contractors will also have to adapt to meet the very specific challenges posed by the modular construction structures of the 1980s up to the present day. Not only will this require the learning of new skills, it might also require the use of yet-to-be designed attachments, developed as much for manipulating and handling as for breaking and cutting. In the future, demolition contractors will have to become increasingly informed of new building designs, as these are increasingly conceived using more sustainable approaches.

The future is also likely to see more consideration of the workload balance between the initial soft strip and the physical structure dismantling. At present, the soft strip is a labour intensive process that can take up to five times as long as the real bulk of the demolition contract. It may be that the use of compact, sub-one tonne mini excavators and skid steer loaders equipped with specialist attachments are able to considerably reduce this timescale.

There are future challenges that lie ahead in the demolition of buildings using sustainable practices. Advances in technology need to be coupled with changes in management and consideration of the issues regarding reuse and recycling of demolition material.