

CONSTRUCTION MATERIALS STEWARDSHIP

The Status Quo in Selected Countries

CIB W115



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Edited by John B. Storey

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TABLE OF CONTENTS

Preface.....	4
Introduction: An International Overview of Construction Materials Stewardship.....	6
John Storey <i>Victoria University of Wellington, New Zealand</i>	
Germany.....	9
Nicole Sunke and Frank Schultmann <i>University of Siegen, Chair of Business Administration, Construction Management and Economics, Germany</i>	
1 STATUS QUO OF C&D WASTE RECOVERY IN GERMANY.....	9
2 CURRENT ACTIONS AND POTENTIALS.....	11
3 INITIATIVES.....	14
4 RENEWABLE ENERGY.....	15
5 CHALLENGES AND RESEARCH EFFORT.....	15
6 REFERENCES.....	16
7 ANNEX.....	16
Great Britain.....	18
Gillian Hobbs <i>Building Research Establishment, Great Britain</i>	
Japan.....	30
S. Nakajima <i>Building Research Institute, Tsukuba, Ibaraki, Japan</i>	
1 OUTLINE OF THE C&D WASTE.....	30
2 MATERIAL BALANCE.....	32
3 CONSTRUCTION WASTE RECYCLING LAW.....	35
4 ASSESSMENT OF RESOURCES AND MATEIALS IN ‘CASBEE’.....	36
5 OTHER LAWS AND SYSTEMS.....	36
6 REFERENCES.....	37
New Zealand.....	39
J.B. Storey <i>Victoria University of Wellington, Wellington, New Zealand</i>	
C. Keane <i>Victoria University of Wellington, Wellington, New Zealand</i>	
1 INTRODUCTION.....	39
2 EFFECTIVE MATERIALS USE.....	39
3 LIFE CYCLE COSTING.....	40
4 CONSTRUCTION WASTE.....	40
5 WASTE AS SOURCE.....	41
6 CLOSED LOOP RECYCLING.....	42
7 DECONSTRUCTION.....	42
8 TRANSFORMABLE AND ADAPTABLE BUILDINGS.....	43
9 WHOLE BUILDING REUSE.....	43
10 REGENERATION OF RENEWABLES RESOURCE BASE.....	45

11	IMPROVING UTILISATION OF USED CONSTRUCTION MATERIALS.....	45
12	BARRIERS AND SOLUTIONS.....	46
13	RESEARCH, INFORMATION, INITIATIVES, POLICY AND REGULATION.....	46
14	CONCLUSIONS.....	57
15	REFERENCES.....	58
Slovenia		59
L. Hanžič		
<i>Faculty of Civil Engineering, University of Maribor, Maribor, Slovenia</i>		
B. Jurič		
<i>Projekt d.d. Nova Gorica, Nova Gorica, Slovenia</i>		
<i>Faculty of Civil Engineering, University of Maribor, Maribor, Slovenia</i>		
1	INTRODUCTION.....	59
2	USE OF CONSTRUCTION MATERIALS.....	59
3	LEGISLATION.....	60
4	DECONSTRUCTION AND DEMOLITION TECHNIQUES.....	62
5	TREATMENT OF C&D WASTE MATERIALS.....	63
6	CONCLUSIONS.....	64
7	ACKNOWLEDGMENT.....	65
8	REFERENCES.....	66
Sweden.....		67
C. Thormark		
<i>Construction Management, Faculty of Engineering, Lund University, Sweden</i>		
1	INTRODUCTION.....	67
2	EFFECTIVE UTILISATION OF NEW AND EXISTING CONSTRUCTION MATERIALS.....	67
3	LIFE CYCLE COSTING AND MANAGEMENT.....	68
4	WASTE REDUCTION.....	68
5	CLOSED LOOP MATERIALS RECYCLING AND DECONSTRUCTION.....	69
6	WASTES AS RAW MATERIALS FOR MAKING CONSTRUCTION MATERIALS.....	70
7	DFD.....	70
8	PROMOTION OF MATERIALS AND COMPONENT REUSE.....	71
9	TOOLS AND TECHNIQUES.....	72
Switzerland.....		73
Holger Wallbaum		
Viola John		
Michael Büeler		
<i>ETH Zurich, Chair of Sustainable Construction, Institute for Construction Engineering and Management</i>		
<i>Department of Civil, Environmental and Geomatic Engineering, Switzerland</i>		
1	LEGAL STATUS AND STRUCTURE.....	73
2	STATISTICAL OVERVIEW.....	74
3	STRATEGIES AND CURRENT ACTIONS.....	76
4	OUTLOOK AND POTENTIAL.....	79
5	REFERENCES.....	79

The Netherlands.....	81
dr. Elma Durmisevic	
<i>Delft University of Technology, Faculty of Architecture Department of building technology</i>	
1 INTRODUCTION.....	81
2 STATE OF THE ART-IN THE NETHERLANDS.....	82
3 IFD BUILDINGS.....	84
4 WASTE PREVENTION BY DESIGN.....	85
5 CONCLUSIONS.....	88
6 REFERENCES.....	89
USA.....	90
A.R. Chini	
<i>University of Florida, Gainesville, Florida, USA</i>	
1 INTRODUCTION.....	90
2 RECYCLED AGGREGATE.....	92
3 ASPHALT ROOFING SHINGLES RECYCLING.....	92
4 WOOD RECYCLING.....	94
5 STEEL RECYCLING.....	95
6 DRYWALL RECYCLING.....	94
7 BRICK RECYCLING.....	95
8 PLASTICS RECYCLING.....	95
9 SUMMARY	95
10 ENVIRONMENTAL LAWS AFFECTING C&D DEBRIS.....	96
11 CONCLUSIONS AND RECOMMENDATIONS.....	98
12 REFERENCES.....	98

Preface

Working Commission 115 Construction Materials Stewardship of the International Council for Research and Innovation in Building Construction (CIB) was formed in September 2006. Its intention is to build on the work carried out in CIB Task Group 39 which operated from May 1999 to March 2005. TG 39 produced a series of five reports which culminated in CIB Publication 300 – Deconstruction and Materials Reuse and International Overview, which is a state-of-the art report on deconstruction and materials reuse in ten countries.

The purpose of new working commission is extend the work and achievements of TG39. The research to be undertaken by this working commission is more extensive in nature, scope, depth and coverage than the work undertaken covered by TG39. The status of a working commission acknowledges that research into construction materials stewardship is important in making a substantive contribution to progressing CIB's stated aims of promoting sustainable construction and development.

The mission of W115 is to drastically reduce the deployment and consumption of new, non-renewable construction materials, to replace non-renewable materials with renewable materials wherever possible, achieve equilibrium in the demand and production of renewable materials and ultimately to restore the renewable material resource base. To carry out these tasks in ways to maximise positive financial, social and environmental and ecological sustainability effects, impacts and outcomes.

Against this background the Commission's objectives are defined as:

1. Determine ways to utilise new and existing construction materials in the most effective and ecologically, environmentally, socially and financially responsible manner possible
2. Develop life cycle costing and management mechanisms for materials
3. Develop systems to mitigate and ultimately avoid construction material waste
4. Develop ways of using material wastes as raw materials for making construction materials
5. Develop methodologies for designing for closed loop materials use and for the effective recovery of materials and components from existing buildings
6. Develop design and construction methodologies for transformable and adaptable buildings and spaces to extend service life and so reduce overall construction material resource use
7. Establish strategies to promote whole building, component and materials reuse
8. Establish ways to regenerate the renewable materials resource base and improve the performance, availability and use of renewable construction materials
9. Establish methods and strategies to enhance utilisation of used construction materials
10. Establish what the barriers are to the sustainable use of building materials and devise methodologies to overcome these barriers.

11. Develop information and research outcomes that will contribute to and facilitate the establishment of policy and regulatory standards, initiatives and options aimed at reducing new materials deployment and consumption
12. Develop the necessary techniques and tools to support the foregoing objectives.

The first meetings of the commission members took place in conjunction with the CIB Co-sponsored Portugal SB07 in Lisbon in September 2007. A number of country reports were presented at that meeting. This publication includes those reports and a number of other reports received subsequent to that meeting. Nine countries are represented, Germany, Great Britain, Japan, New Zealand, Slovenia, Sweden, Switzerland, The Netherlands and the United States of America.

John Storey, Abdol Chini, Frank Schultmann,
W115 Coordinators

An International Overview of Construction Materials Stewardship

John Storey

Victoria University of Wellington, New Zealand

Since the turn of the century the world has undergone a significant change in its attitudes to sustainability. The primary focus of this shift has been related to the rapid increased incidence of extreme weather events resulting from climate change. The public now appears to accept that humanity is playing a significant role in creating rapid climate change and is looking to politicians and governments worldwide to take suitable action to mitigate effects and adapt our built environments, transport and industrial base; provided of course these measures do not reduce their standard of living.

Concurrently the notion of ‘peak oil’, for sometime regarded as a purely academic abstraction by most people, has been brought into sharp focus by recent large increases in the price of oil. Not only is this seen as a direct threat to living standards in the developed world but it has pushed whole populations in poorer countries below starvation levels. It is a stark reminder to us all that the world’s resources are finite and, in a surprisingly large number of cases, depletion is decades rather than centuries away. Yet the demand for resources is increasing exponentially, due to a combination of population growth, increased living standards and manufacturing regimes that encourage rapid redundancy and throw away end of life disposal. The focus on Climate Change, fossil fuel replacement and in some countries, water deficiencies, has tended to position material resource depletion as a tertiary priority for governments, public and most manufacturers. Yet the likelihood is that most conflicts in the 21st century will occur over resources and in particular resource security.

On an annual basis, the building sector absorbs somewhere between 40 and 50% of all material resources used on our planet. It also generates a similar proportion of solid ‘waste’. Most national and local governments still operate in a ‘use once and throw away’ mode. In this scenario the biggest issue is waste disposal and in particular how to prolong the life of landfills and ‘safely’ dispose of hazardous waste. Most ‘waste’ reduction measures in place internationally are still framed around these two issues.

While most national thinking remains firmly routed in this linear paradigm, some of the more advanced countries have begun to think in terms of cradle-to-the-grave responsibility in relation to product stewardship. This strategy still however presumes linear thinking and end-of-life disposal, even though in some cases it may involve deferred disposal through a series of down-cycling use phases. It remains a ‘green’ solution that is, making things less bad. Sustainability cannot be achieved by ‘green’ thinking and linear operational philosophies. Sustainability requires cyclic, closed-loop actions. But achieving sustainability remains a moving target related to time. This year’s targets will be overtaken by continued ‘throw away’ and even ‘green’ resource deployment, requiring ever higher targets to achieve sustainability of the whole system next year; and so on. Ultimately of course we should be aiming for restorative and regenerative resource deployment to bring back as many elements of the original resource base back to where we started at the dawn of the Industrial Age, which it is worth reminding ourselves is only 200 years ago.

Much thought has been put into achieving sustainable resource use and the effective deployment of resources, with the Rocky Mountain Institute’s book ‘Natural Capitalism’ and McDonough and Braungart’s treatise “Cradle to Cradle” being standout examples of publications that have reached a wide audience and espouse cyclic and closed loop paradigms and strategies. Ideas relating to international, intergenerational and interspecies equity, the shift from ‘green’ to triple bottom line ‘sustainability’ imperatives and more recently to restorative and regenerative thinking, have all played their part in this shift. There has been growing acceptance that the

planet's material resources are limited. It is clear that there is a need to carefully husband resources and use them in responsible ways that fulfil the stated intentions of achieving sustainable development.

Inevitably the way forward is going to be messy, with different countries, companies and individuals initiating and being involved in one, some or all the above operational modes and all advancing at the pace that their particular circumstances dictate. It is in this complex context that W115 – Construction Materials Stewardship is operating. Therefore, while it is tempting to focus only in the cyclic, sustainable or regenerative paradigm, it is likely to be most productive if the group is involved and shares information on leading edge thinking, ideas, initiatives and education on all of the, throw-away, green, sustainable and regenerative, levels of construction materials stewardship and right across the full strategy spectrum of reduce, reuse, repair, renew, recycle, recovery (energy) and residual management.

It is clear from the following reports just how far we need to go. Remarkably few countries have accurate figures for C+D waste generated. Most of the figures used are extrapolations from relatively meagre measurement data. There is not even an international consistency in the definition of what constitutes building waste and where the boundaries lie, for example, does it include the waste created during the original material acquisition, during manufacture, during delivery to site, material returned to the manufacturer from site as being damaged or below standard, excavated material, materials 'lost' on site and packaging? Not only do different countries include different materials and waste generated at different points in the lifecycle but different states and even different local government bodies within a nation use different definitions.

What does seem to emerge is that voluntary systems in this sphere have met with very limited success, apart from a few notable exceptions (The Netherlands and Denmark) and even here governments have found it necessary to introduce legislation to ensure equity and bring the rogue operators into line.

Almost all the legislation appears to relate to the linear processing of materials and material residues. Closed-loop action and initiatives seem to be primarily related to measures taken by forward looking individual companies who have embraced closed loop thinking as making good business sense.

Voluntary systems that are successful in promoting sustainable material stewardship measures are Building Assessment Systems. Version 2 of the LEED assessment system, for instance, awards up to 10 points (out of a total of 69) under the categories, storage and collection of recyclables, building reuse, construction waste management, resource reuse, recycled content and rapidly renewable materials with possible further points that could be awarded under innovation, certified wood and local materials categories.

There seems to be very few measures in place internationally to incentivise or promote the effective deployment of materials, the reuse of existing buildings, assemblies and materials and the desirable switch from a non-renewable to a renewable resource base. However a increasing number of governments have 'green' or sustainable preferred purchasing policies under development or in place. This is likely to make a big difference both in the materials and products purchased and in terms of the level of understand of what constitutes 'green' or sustainable products. Such a mechanism can also set increasingly demanding standards of construction material stewardship.

Education, knowledge and skills development specifically connected with construction materials stewardship appears to be sparse. It is well behind climate change and energy conservation and efficiency education which are themselves recognised as being inadequate in most countries.

It is clear that the concept of construction materials stewardship is still in its infancy and the objectives set by the working commission are extremely challenging. That CMS is not 'centre stage' in terms of government thinking can be regarded positively. Climate change and energy get most of the publicity and funding but they are also much more subject to fickle public and governmental scrutiny and political interference than construction materials stewardship, and that, most people would agree, is no bad thing.

Germany

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1 STATUS QUO OF C&D WASTE RECOVERY IN GERMANY

1.1 *Classification and composition of construction and demolition waste (C&D waste)*

The classification of C&D Waste in Germany is compliant with the European Waste Catalogue (EWC). The EWC groups construction and demolition waste in Section 17 00 00.

Five types of C&D Waste are differentiated:

1. Construction and demolition debris ('Bauschutt'): concrete, bricks, tiles and ceramics, mixtures of, or separate fractions of the aforementioned, except those containing dangerous substances
2. Road construction waste ('Strassenaufbruch'): bituminous mixtures except mixtures containing coal tar
3. Excavated earth ('Bodenaushub'): soil and stones, dredging spoil, track ballast, all excluding dangerous substances
4. Gypsum-based construction material ('Bauabfälle auf Gipsbasis'): gypsum-based construction materials except those containing dangerous substances
5. Construction waste ('Baustellenabfälle'):
 - a. wood, glass, plastic
 - b. copper, bronze, brass, aluminium, zinc, iron and steel, tin and mixed metal,
 - c. cables, except those containing dangerous substances, oil and tar
 - d. insulation materials, excluding those consisting of or containing dangerous substances
 - e. mixed C&D waste, except those containing mercury or PCBs

1.2 *C&D Waste Totals*

The 5th monitoring report of the *Working Group: Construction Recycling and Waste Management Industry* ('ARGE KWTB', 'Arbeitsgemeinschaft Kreislaufwirtschaftsträger Bau') conclude that the disposal of reusable C&D waste has decreased significantly in recent years. Currently only 10% of C&D debris are disposed of (1997: 50%) in Germany. On average, 218 million tonnes of mineral C&D waste was generated each year in the period from 1995 to 2005 of which to thirds was excavated earth and one third C&D debris, road construction waste, and construction waste, as shown in Figure 1.

Whilst excavated earth can be directly reused, approximately 70% of the remaining fractions have to be recycled in order to achieve further reuse, see Figures 2 and 3

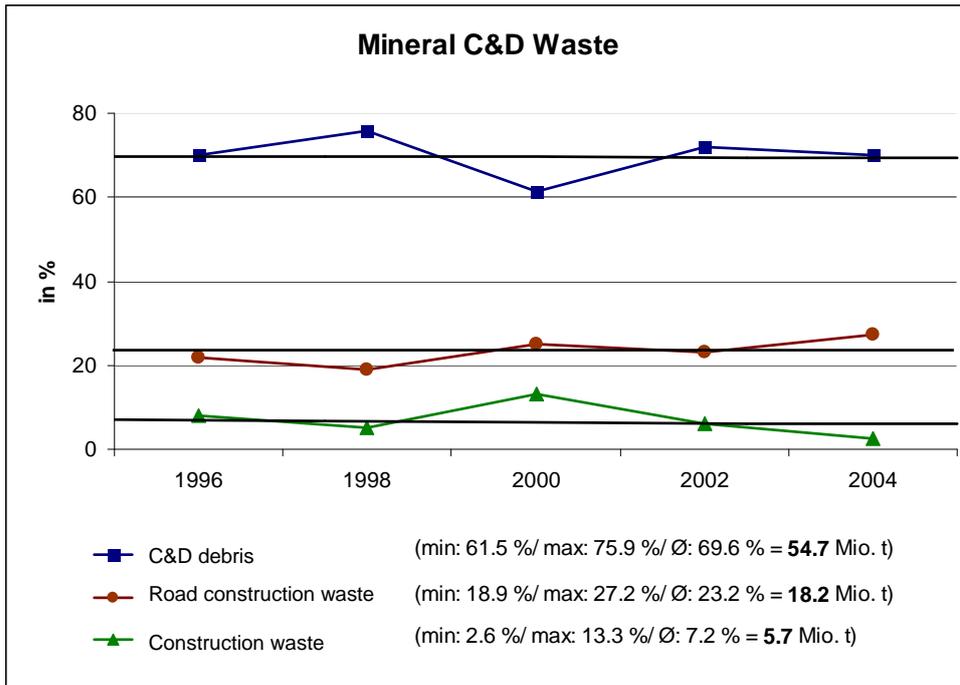


Figure 1. Accumulation of mineral C&D Waste in Germany – 10-year average (1995-2005).

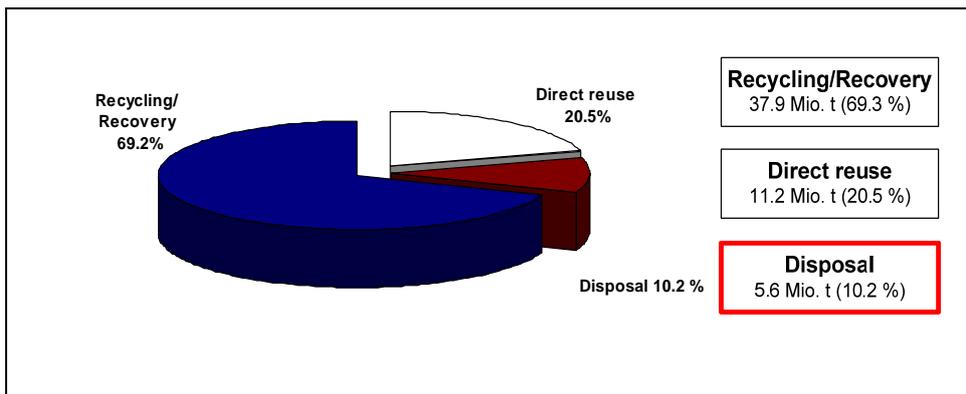


Figure 2. Disposition of construction and demolition waste (1995-2005).

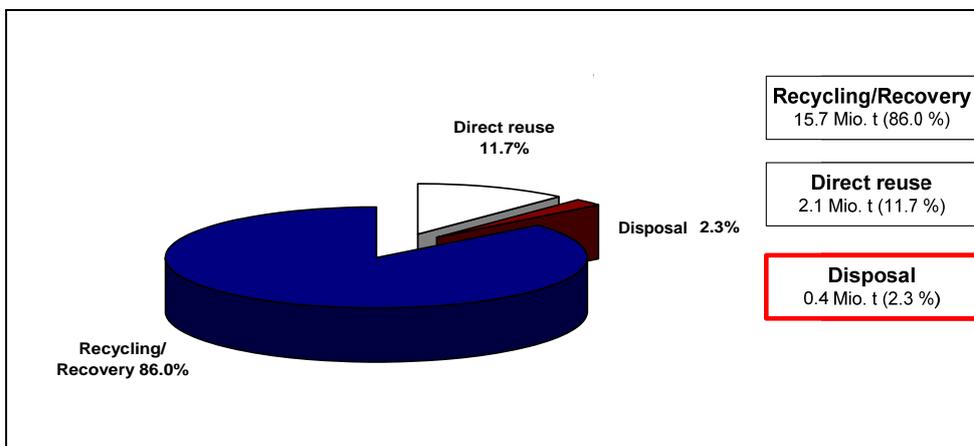


Figure 3. Disposition of road construction waste (1995-2005).

In 2004, C&D waste totalled 200.7 million tonnes which consisted of 128.3 million tonnes (63.9%) excavated earth and 72.4 million tonnes (36.1%) of construction and demolition debris, road construction waste, gypsum-based construction material, and construction waste.

In Germany, a decoupling of the accumulated C&D waste from construction investments can be observed. Hence, the market for mineral C&D waste has developed into a stand-alone market segment. 49.6 million of the 72.4 million tonnes of mineral C&D waste was recycled, which represents a recycling quota of 68.5%¹. Table 1 summarises the current state of C&D waste recovery in Germany.

C&D Waste	Recycling	Direct Reuse	Recovery quota - 10-year average (1995 - 2005)
C&D debris	69.3 % 37.9 million tonnes	20.5 % 11.2 million tonnes	89.8 %
Road construction waste	86.3 % 15.7 million tonnes	11.5 % 2.1 million tonnes	97.8 %
Construction waste	26.3 % 1.5 million tonnes	21.1 % 1.2 million tonnes	47.4 %

Table 1. Current state of C&D waste recovery (10-year average)²

Of the approximately 80 million tonnes of mineral C&D waste (C&D debris, road construction waste, construction waste, excluding excavated earth) accumulated during each year in the 10-year average, ca. 55 million tonnes were recycled, 15 million tonnes were directly reused, and approximately 10 million tonnes are still disposed of in landfills, although recovery options exist. Opportunities for recoverable C&D waste for resource preservation lie in the 15.6 million tonnes of excavated earth and 5.6 million tonnes C&D debris.

1.3 Accomplishments

The driving force behind the treatment of C&D waste in Germany is the *ARGE KWTB* (cf. section 1.2). This is a consortium of construction industry trade associations, e.g. The Central Association of the German Construction Industry ('Zentralverband des deutschen Baugewerbes (ZFB Zentralverband des deutschen Baugewerbes – ZFB') and Confederation of Recycling Construction Materials ('Bundesvereinigung Recycling-Baustoffe – BRB').

In 1996, the ARGE KWTB entered into a voluntary commitment with the Federal Environment Ministry for the Environment, Nature Conservation and Nuclear Safety, to achieve a 50% decrease in the amount of disposed of C&D waste in Germany. In 2005 the construction industry achieved their 10-year voluntary commitment for the 5th time with a long term recycling quota of 70.1% and a long term recovery quota of 88.7%.

2 CURRENT ACTIONS AND POTENTIALS

2.1 Laws and regulations

Legislation in the field of waste management has quite a long history in Germany. The *Law for the Prevention and Disposal of Waste* of 27th August 1986 outlined for the first time the principles for the transition from disposal to waste management. Accordingly to this law, the

¹ Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (2007) Selbstverpflichtung der Bauwirtschaft, <http://www.bmu.de/abfallwirtschaft/doc/3166.php>, 7 September 2007.

² 5th Monitoring Report 2004, ARGE KWTB, Arbeitsgemeinschaft Kreislaufwirtschaftsträger Bau

first aim must be the prevention of waste. If prevention is not possible, the composition of waste must be improved in order to permit reuse or recycling³.

In July 1994, the ‘*Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal*’, also known as the ‘Waste Avoidance, Recovery and Disposal Act’ or the ‘Closed Substance Cycle and Waste Management Act’ (‘Kreislaufwirtschafts- und Abfallgesetz - KrW-/AbfG’)⁴ was promulgated by the German parliament. This Act implements the European Council Directive 91/156/EEC of 18 March 1991 (revised Framework Directive on Waste, amending Council Directive 75/442 EEC) and of Council Directive 94/31/EC issued on 27 June 1994 that amended Directive 91/689/EEC on hazardous waste into national legislation. The waste avoidance, recovery and disposal act came into force two years after promulgation, on October 7th, 1996.

The act contains the basic principles of German waste management and closed-loop recycling strategies. Several principles for waste management were introduced, for example product responsibility and a new hierarchy for waste treatment.

The product responsibility clauses of the Waste Avoidance, Recovery and Disposal Act, assign responsibility for the waste arising from products to their producer.

The Act assigns a hierarchy for waste prevention:

- avoidance of waste is better than the recycling of waste,
- waste that cannot be prevented should be recovered, and
- landfill disposal of waste is only allowed when neither prevention nor recovery is feasible or economically reasonable.

In order to comply with the principle objectives, waste destined for recovery is to be separated and treated separately. (Art. 5 Krw-/AbfG). Art. 7, 23 and 24 KrW-/AbfG authorise the federal government to enact administrative orders and statutory ordinances with the aim of enforcing prevention and recovery to reduce contamination on wastes. The supplementary subsidiary regulations of the Recycling and Waste Management Act consist of various ordinances. These ordinances consist of regulations that restructure supervision under waste management law and align it with EU law and ordinances that create a basis for further devolution of supervision.

One of the major general administrative orders concerning construction and demolition waste is the Technical Instruction for Municipal Waste (‘TA Siedlungsabfall’)⁵ that is originally based on Art. 14 of the former Law on Prevention and Disposal of Waste (Abfallgesetz of 27th August 1986). The *German Technical Instruction for Municipal Waste* specifies the treatment and disposal of waste and deals with major waste streams, such as domestic waste and building and demolition waste. This administrative order deals with:

- the recycling of unavoidable waste
- reduction in the toxicity of waste
- ensuring that an environmentally friendly treatment or disposal of waste is maintained.

The Order requires that C&D waste should be collected, separated and prepared for recovery at source and that the responsible municipalities encourage the utilisation of mobile or semi-mobile recovery installations. It also contains requirements concerning the disposal of waste.

³ Schultmann, F. (2005) Deconstruction in Germany, in: Chini, A. (Ed.): Deconstruction and Materials Reuse – An International Overview, CIB Report 300 – Final Report of the Task Group 39 on Deconstruction

⁴ Gesetz zur Förderung der Kreislaufwirtschaft und Sicherung der umweltverträglichen Beseitigung von Abfällen (Kreislaufwirtschafts- und Abfallgesetz - KrW-/AbfG), 27 September 1994, Bundesgesetzblatt IS. 2705-2728.

⁵ Dritte Allgemeine Verwaltungsvorschrift zum Abfallgesetz (TA Siedlungsabfall) of 14 May 1993 (Beil. BAnz. Nr 99), Technische Anleitung zur Verwertung, Behandlung und sonstige Entsorgung von Siedlungsabfällen.

Fractions which do not meet the requirements set out in the TA. Siedlungsabfall will not be allowed to be land filled without further treatment.

The *federal states* (German Bundesländer) count on their own and *more specific laws and regulations on waste* ⁶. Some states have already introduced ordinances for demolition requiring organised dismantling and separation of waste on-site or at specialised treatment facilities. The municipalities or local authorities have further regulations such as demolition permits or dismantling ordinances. In some cities it is already compulsory to submit a deconstruction plan describing the phases of preparation, the method of deconstruction or demolition and giving detailed information on the recycling of the various materials, when demolition permits are required.

Furthermore, *DIN standards* have been issued in Germany regulating construction and deconstruction work. In November 2006, the ATV DIN 19459 ('Allgemeine technische Vertragsbedingungen') setting general standards for "demolition and deconstruction work" came into force. The ATV DIN 18459 is a supplement to the ATV DIN 18299 which regulates general and contracting issues regarding construction work of all kinds. In addition to the selective or complete deconstruction of construction work the ATV DIN 18459 also covers the extraction, storage and transportation of the deconstruction materials and components (classified according to the EWC).

Guidelines have been published by various authorities. For instance, the Guideline for Sustainable Construction ('Leitfaden Nachhaltiges Bauen'). This guideline addresses sustainable construction throughout the whole life cycle of buildings; i.e. the minimisation of energy and resource consumption as well as the reduction of negative environmental impacts. In particular it includes measures for:

- The reduction of energy consumption and operating resources
- The avoidance of transport costs for construction materials and components
- The use of renewable and recoverable construction materials and components



2.2 Federal support and incentives

The complex regulatory framework for waste management and waste management in construction of Germany, which has only briefly and by no means been comprehensively described above, is complimented by federal support programmes regarding the sound handling of construction materials and components as well as energy efficiency. One such programme is the *Insulation materials from renewable resources* ('Dämmstoffe aus nachwachsenden Rohstoffen') programme, summarized in Table 2.

⁶ E.g. Gesetz über die Vermeidung und Entsorgung von Abfällen und die Behandlung von Altlasten in Baden-Württemberg (Landesabfallgesetz-LAbfG), of 8 January 1990, Gesetzesblatt für Baden-Württemberg.

‘Insulation materials from renewable resources’ (Dämmstoffe aus nachwachsenden Rohstoffen)	
Aim	<ul style="list-style-type: none"> • Long term support of use of insulation material • manufactured from renewable resources from agriculture and forestry
Scope	<ul style="list-style-type: none"> • Government aid for purchase of insulation material for thermal and sound insulation • Supported resources, e.g. wool, flax, hemp or grain (www.naturdaemmstoffe.info)
Target group	<ul style="list-style-type: none"> • Owners, tenants, or property developer with German residence • Granted as governmental project aid
Aid	<ul style="list-style-type: none"> • Non-repayable grant • Currently: financial aid is provided at between 23 and 25 Euro per cubic metre of insulation material

Table 2. Government aid programme ‘Insulation materials from renewable resources’

2.3 Recommendations for action

Research projects concerning construction materials stewardship are funded by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Ministry of Economics and Technology (BMWI). These institutions grant research assistance for various initiatives for sustainable construction and materials management. One example is the sub-project "Identification of relevant substances and materials for a substance flow-oriented, resource-conserving waste management" within the project "Development of the closed cycle and waste management policy towards a sustainable substance flow and resources policy". The aim of this project was to identify relevant materials, and relevant areas in the life cycle, that offer the greatest potentials and the greatest options for reducing environmental impacts and conserving resources. Selected results for the concrete industry and residential buildings published in 2006 are given in table 3.

Concrete production	Raw material conservation: up to 10% (up to 16 Mt/a) from around 2010	Promotion and stronger establishment of concrete recycling in high-quality applications (aggregates for new concrete)
Residential buildings	Reduction in CO ₂ emissions: approx. 52% (approx. 110 Mt/a) between 2000 and 2025	Forced remediation of the often suboptimal housing stock in terms of energy efficiency (principal option)
Residential buildings	Reduction in the requirement for mineral resources: approx. 50% (approx. 80 Mt/a) between 2000 and 2025.	Extension of building lifetime by comprehensive refurbishment, pooling of apartments, lowering of unoccupied apartments and thus a restriction of new building volume to meet requirements, forced selective demolition of unused buildings.
Residential buildings	Reduction in land utilisation: from 31 ha/d to 5 ha/d, net housing and development land.	Forced exploitation of inner development potentials (e.g. derelict land), suitable density increases.
Residential buildings	Minimisation of the release of problematic substances (e.g. heavy metals, mineral fibres) during conversions and demolition.	Forcing and qualitative improvement in selective demolition and separate collection and recycling, removal of problematic and incompatible substances from the material cycles and their safe and hazardless disposal.

Table 3. Potentials and options for action⁷

3 INITIATIVES

Several initiatives regarding the circuitry of waste have been initiated by industry. Two major associations and various other organisations exist that focus on construction and demolition waste.

ARGE KWTB, Arbeitsgemeinschaft Kreislaufwirtschaftsträger Bau

– Construction Recycling and Waste Management Industry Working Group

⁷ Identification of Relevant Substances and Materials for a Substance Flow-Oriented Resource-Conserving Waste Management", Final project report, 25 May 2006, Darmstadt, issued by Öko-Institut e.V. – Institute for Applied Ecology (2006).

- Consortium of construction industry trade associations, e.g. Zentralverband des deutschen Baugewerbes (ZFB – Central Association of the German Construction Industry) and Bundesvereinigung Recycling-Baustoffe (BRB – Confederation of Recycling Construction Materials)

German Sustainable Building Council (GeSBC)

- Emerging Green building council within the World Green Building Council (World GBC)
- Formed in Germany to support and implement sustainable building & construction
- Aim of the association is the provision of a German certification system for buildings having special environmental properties and qualities
- <http://www.worldgbc.org/default.asp?id=183>

4 RENEWABLE ENERGY

Germany is innovative in the field of renewable energy. Considerable research effort as well as a series of governmental programs is directed towards the support of the use of renewable energy in the building construction sector and in energy efficient buildings. Well known examples are:

- Zero-Energy houses, low-energy houses, zero-waste houses
- Buildings Energy Pass
Starting in January 2006, energy transparency will be in accordance with EU guidelines via the ‘Buildings Energy Pass’. This will not only be mandatory for new buildings, but also for owners of existing buildings. The ‘Energy Pass’ gives renters and buyers comprehensive information about the energy needs of the particular property as well as their “energy-efficiency class”
- Incentives for photovoltaic and geothermal energy generation
- Draft of the directive on the use of renewable energy in buildings (‘Wärmegesetz’) in the federal state of Baden-Württemberg. The main features of this directive are:
 - 20% use of renewable energy for space and water heating required in new buildings
 - 10% use of renewable energy for space and water heating required in old buildings

5 CHALLENGES AND RESEARCH EFFORT

Currently Germany’s policy in environmental concerns is characterised by a strong focus on energy efficiency and renewable energy. The potential in Germany for the further successful and meaningful implementation of sustainable construction in Germany are high due to the following socio-economic prerequisites which present a strong basis for their application:

- High responsibility
- Availability of technical applications
- Thoroughness in work processes
- Preservation of values

Furthermore, Germany has successfully implemented construction materials recovery, with stable recovery percentages of 70% plus. Awareness for Construction Materials Stewardship has been created, governmental aid programmes exist and initiatives regarding recovery of C&D waste existed in the German construction industry for decades. Nevertheless, recycling of C&D waste is to some extent still performed in open-loop systems while closed-loop structures still have to be developed.

Germany has set out a strong political and research focus on energy efficiency of buildings and the use of renewable energy. It provides a strong basis for the development of innovative ideas

for cyclic C&D waste treatment, that address the available of technologies as well as the attitudes of its human capital.

Sophisticated approaches for environmental performance are, however, still limited. This refers to building environmental assessment tools like BREEAM or LEED, which are not widespread yet.

Future research for Germany may focus especially on the development of building assessment methods and the creation of awareness for energy efficiency and the use of renewable energies and for the application of environmentally sound construction materials and practices. Moreover, the configuration and efficient management of closed-loop systems for construction materials that aim at resource conservation remains work in progress.

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7 ANNEX

EWC Code	Description
BAUSCHUTT / CONSTRUCTION AND DEMOLITION DEBRIS	
17 01	concrete, bricks, tiles and ceramics
17 01 01	concrete
17 01 02	bricks
17 01 03	tiles and ceramics
17 01 06	mixtures of, or separate fractions of concrete, bricks, tiles and ceramics containing dangerous substances
17 01 07	mixtures of, or separate fractions of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06

Table 4. C&D wastes according to the EWC – C&D debris (European Commission 2002).

EWC Code	Description
STRASSENAUFBRUCH / ROAD CONSTRUCTION WASTE	
17 03	bituminous mixtures, coal tar and tarred products
17 03 01	bituminous mixtures containing coal tar
17 03 02	bituminous mixtures other than those mentioned in 17 03 01
17 03 03	coal tar and tarred products

Table 5. C&D wastes according to the EWC – Road construction waste (European Commission 2002).

EWC Code	Description
BODENAUSHUB / EXCAVATED EARTH	
17 05	soil (including excavated soil from contaminated sites), stones and dredging
	spoil
17 05 03	soil and stones containing dangerous substances
17 05 04	soil and stones other than those mentioned in 17 05 03
17 05 05	dredging spoil containing dangerous substances
17 05 06	dredging spoil other than those mentioned in 17 05 05
17 05 07	track ballast containing dangerous substances
17 05 08	track ballast other than those mentioned in 17 05 07

Table 6. C&D wastes according to the EWC – Excavated earth (European Commission 2002).

EWC Code	Description
BAUABFÄLLE AUF GIPSBASIS / GYPSUM-BASED CONSTRUCTION MATERIAL	
17 08	gypsum-based construction material
17 08 01	gypsum-based construction materials contaminated with dangerous substances
17 08 02	gypsum-based construction materials other than those mentioned in 17 08 01

Table 7. C&D wastes according to the EWC – Gypsum-based construction material (European Commission 2002).

EWC Code	Description
BAUSTELLENABFÄLLE / CONSTRUCTION WASTE	
17 02	wood, glass and plastic
17 02 01 - 03	Wood / glass / plastic
17 02 04	glass, plastic and wood containing or contaminated with dangerous substances
17 04	metals (including their alloys)
17 04 01 - 07	copper, bronze, brass / aluminium / lead / zinc / iron and steel / tin / mixed metals
17 04 09	metal waste contaminated with dangerous substances
17 04 10	cables containing oil, coal tar and other dangerous substances
17 04 11	cables other than those mentioned in 17 04 10
17 06	insulation materials and asbestos-containing construction materials
17 06 04	insulation materials other than those mentioned in 17 06 01 and 17 06 03 (insulation materials containing asbestos / other insulation materials consisting of or containing dangerous substances)
17 06 05	construction materials containing asbestos
17 09	other construction and demolition wastes
17 09 04	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03 (construction and demolition wastes containing mercury / PCB / (including mixed wastes) containing dangerous substances)

Table 8. C&D wastes according to the EWC – Construction waste (European Commission 2002).

Great Britain

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INTRODUCTION

This report is organised and ordered to outline the GB response to CIB Working Commission W115 Objectives.

Related Objective

1. Determine ways to utilise new and existing construction materials in the most effective and ecologically, environmentally, socially and financially responsible manner possible

This is a multifaceted requirement that means a hierarchical approach needs to be adopted when decision making. A possible approach in Great Britain is as follows:

Step 1 – Choose ‘A’ rated specifications

There is a well defined route to specifying construction elements that have lower environmental impacts. The Green Guide to Specification⁸ contains typical wall, roof, floor and other constructions listed against a simple environmental rating scale running from ‘A’ (good) to ‘C’ (poor). Twelve different environmental impacts are individually scored, together with an overall Summary Rating, information on recycling and typical costs. The Summary Ratings enable users to select materials and components on their overall environmental performance over the building’s life. This guide is currently being updated to expand the range of ratings and to be accessible from the internet.

Step 2 – Choose products within ‘A’ rated specifications that offer enhanced environmental performance

The Green Guide ratings are based upon standard products used within the specifications listed. It should be possible to identify products that perform better than average; for example, through comparison of Ecopoints/m² for flooring products. This data is derived through environmental profiles⁹.

Step 3 – Improved material resource efficiency of selected products

Extracting the LCA data for material resource issues will help identify products that offer:

- lower wastage rates
- lower/zero hazardous content
- higher levels of recycled content
- the greatest potential for reuse/recycling at end-of-life

If this data is not readily accessible then discussions with suppliers are required.

⁸ BRE Green Guide to Specification – progress on update downloadable from www.bre.co.uk/greenguide

⁹ BRE Environmental profiles methodology downloadable from www.bre.co.uk/envprofiles

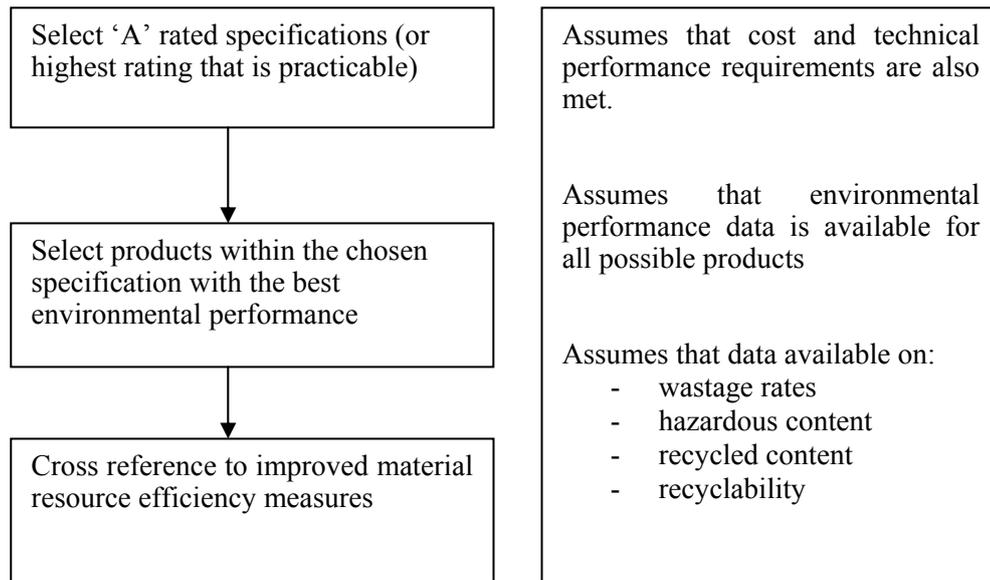


Fig 1. Possible decision making approach for product selection

Related Objective

2 Develop life cycle costing and management mechanisms for materials

Life cycle assessment (LCA) is basically the combined effect of single impacts as described in the table below. Therefore, it could be concluded that material resource efficiency measures will affect the LCA result in a positive or negative way. If the result is positive then these measures should be accelerated.

- in manufacture (including impacts from virgin and recycled inputs)
- in use in a building (taken over a typical building life and including maintenance and replacement)
- in demolition (the waste produced, allowing for recycling and reuse).
- Climate change – from CO₂ and other greenhouse gases especially associated with energy use
- Ozone depletion – from gases affecting the ozone layer
- Acidification – contribution to the formation of acid rain
- Consumption of minerals and water
- Emission of pollutants to air and water – including toxicity to humans and ecosystems
- Quantity of waste sent to disposal

Weighting these impacts provides an ‘Ecopoint’ rating – a single measure of overall impact.

Table 1 – Impacts considered in BRE’s LCA method – Environmental profiles¹⁰

This is fine in principle, if all products and processes have reported in terms of LCA and it is easy to extract the data relating to single impacts. It is difficult to see how LCA in the construction products field will drive forward material resource efficiency measures. This is partly due to incomplete LCA data, but also due to the weighting allocated to impacts.

Weighting of LCA data is the only way to derive a single metric, e.g. carbon equivalence or ‘ecopoints’. It is also an inherently subjective process. Climate change and the need to reduce

¹⁰ BRE Environmental profiles methodology downloadable from www.bre.co.uk/envprofiles

fossil fuel consumption has meant that related impacts attract a higher weighting than any other type of impact. In the absence of other drivers this would not be a problem, i.e. most of the focus would be on reducing energy with other issues only considered once this has been achieved. However, we are living in a world where multiple drivers operate including the need to reduce:

- waste to landfill
- consumption of materials
- contamination of the environment
- whole life costs
- local environmental/social impact

The current status of LCA does not reconcile all these needs sufficiently. As a consequence other mechanisms are being used to drive forward improvements in these areas. These include legislation, policy statements, minimum performance standards, and industry support and guidance.

Related Objective

3 Develop systems to mitigate and ultimately avoid construction material waste

Achieving significant waste reduction would require co-ordinated and concerted action across a fragmented supply chain. Key actions that would help achieve a waste reduction target include:

Commitments	Suggested Champion	Timescale	Purpose/ Links
Set baseline data for construction related waste	CRWP ¹¹	2008	Start process of improvement
Measure performance consistently in terms of waste reduction, reuse, recycling etc per company, sector, process and product	CRWP	Annual reporting	Measure levels of improvement
Extended producer responsibility for all key construction products OR industry agreed voluntary commitments	Defra ¹²	2010	Promote resource efficiency on a product basis, e.g. returnable packaging, eco-design
Supply chain commitments in place for all government procured projects	OGC ¹³	2009	Targets for waste reduction will only be met if the supply chain is committed to combined action
Relevant professional training/education to include modules on resource efficiency	CRWP	2010	Construction professionals educated to consider resource efficiency to be part of their future jobs e.g. designers
Strengthen the Code for Sustainable Homes to require significant waste reduction at levels 3 onwards	CLG ¹⁴	2008	Sets out requirements to reduce waste as part of overall standard
Recommendations			
Develop consistent method of measuring carbon impacts relating to waste and resources	CRWP	2008	Links to reducing overall environmental impact of construction through better decision making
Develop consistent method of measuring whole life cost impacts relating to waste and resources	CRWP	2008	Links to reducing overall cost of resources and waste through better decision making
Encourage the reduction of waste in	Defra	2008	Recycling has been promoted above

¹¹ Construction resources & waste platform – www.crwplatform.co.uk

¹² Department for Environment Food and Rural Affairs – www.defra.gov.uk

¹³ Office of Government Commerce - www.ogc.gov.uk

¹⁴ Department of Communities and Local Government – www.communities.gov.uk

preference to recycling

Encourage the reuse of products and materials in preference to recycling BMRA¹⁵ 2008

reduction and reuse. It is important to redress the balance

Recycling has been promoted above reduction and reuse. It is important to redress the balance

Related Objective

4 Develop ways of using material wastes as raw materials for making construction materials

This issue has been top of the agenda in GB with multiple organisations devoted to increasing the rate of recycling and providing routes for recyclate – the construction sector is a big target for recycled content owing to the huge mass of materials used each year. It is now important to refocus efforts on waste reduction and reuse.

Headline figures for construction products:

2005

Total value = £28 billion

Total mass = 376 million tonnes

Total recycled/secondary mass = 80 million tonnes (or 21%)

Previous data was collected in 1998¹⁶ using the much of same primary data source (Prodcom reports) but not the same methodology. Here the headline figures were:

1998

Total mass = 363 million tonnes

Total recycled/secondary mass = 65 million tonnes (or 18%)

Total reclaimed mass = 3 million tonnes

Related Objective

5 Develop methodologies for designing for closed loop materials use and for the effective recovery of materials and components from existing buildings

Pre-demolition audits use ‘SMARTAudit’ methodology¹⁷ and apply it to identify and target key demolition products (KDPs) generated from a demolition project.

Pre-demolition audits:

- Identify volumes of wastes so a company can plan ‘re-use, recycling and recovery’ activities prior to work starting.
- Are tailor-made for each demolition project. Available services include:
 - Identifying markets for recycled or recovered material
 - Identifying reclamation and re-use potential both on-site and off-site
 - Local and national material valuation
 - Segregation recommendations and
 - Environmental quantification based on BRE’s Environmental Profiling methodology.
- Increase material and labour efficiency, reduce waste and maximise profit.

¹⁵ Building Materials Reuse Association

¹⁶ The Construction industry mass balance: resource use, wastes and emissions. Biffaward & Viridis 2002

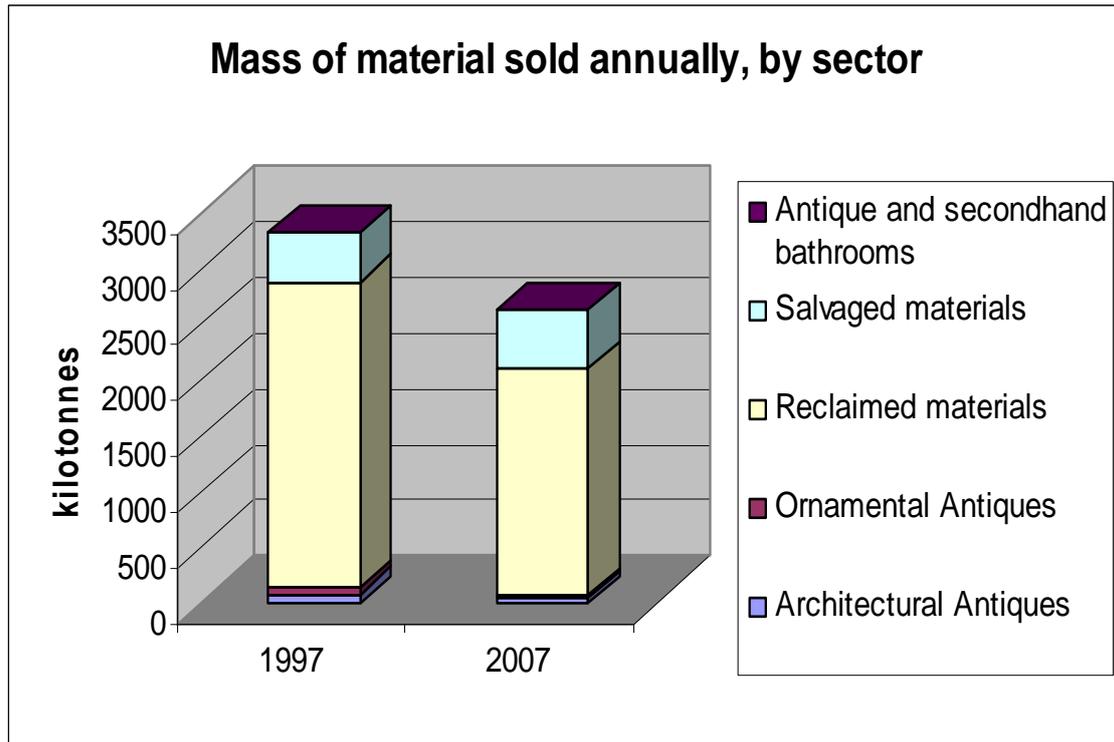
¹⁷ See www.smartwaste.co.uk

- Audits can provide data needed to apply the Demolition Protocol (a voluntary resource planning initiative).

Related Objective

7 Establish strategies to promote whole building, component and materials reuse

The news is not very encouraging on the reuse front in GB. There was anecdotal evidence which suggested the policy and support push on recycling had negatively affected reclamation, but this was difficult to prove. One of the evidence projects carried out this year involved an update survey of the reclamation industry. This last time this was carried out was in 1997, a comparison of the results is given in the chart below.



This represents a 700,000 tonne, or 21%, reduction in the reclamation of demolition products over 10 years.

Chart 1: Trends in reclamation¹⁸

One of the follow on tasks of the *Construction Resources & Waste Platform*¹⁹ for 2007/08 is to help improve the demand for reclaimed products in mainstream construction.

¹⁸ As determined by Salvo and the BigREc surveys of 1997 and 2007.

¹⁹ See www.crwplatform.co.uk

Related Objective

9 Establish methods and strategies to enhance utilisation of used construction materials

Support for the construction sector has been principally funded through Defra and its landfill tax recycling scheme – BREW – Business Resource Efficiency and Waste programme.

Defra is the lead Government Department with regards to environmental issues and is responsible for policy making in the fields of environmental protection, waste management and sustainable development. Defra also has responsibilities with regard to Producer responsibility, alongside the Department of Trade and Industry (DTI).

The BREW partners are key players in the drive towards resource efficiency in construction and have many roles and responsibilities ranging from key policy and strategy development, practical research, trials and assistance, training and market development for recycled materials. The construction sector has been recognised as a major improvement area and therefore has been identified as a priority for action.

In addition to national initiatives, many organisations within England operate at a regional level, in accordance with the 9 Regional Development Agency areas, therefore many projects have a local focus and results may not be easily accessible at the national level. There is a great deal of research work completed and ongoing, though it is not always apparent if and how the research findings have been applied in practice.

A BREW coherence group for construction has been established and includes all the relevant BREW delivery partners, co-ordinated by BRE through the Construction Waste & Resources Platform. The table below summarises BREW delivery bodies and their key activities relating to construction resource efficiency up to April 2008. From April 2008, BREW ceased to operate separately from Defra, resulting in a reduction/consolidation of business support activities. The government wide ‘business support simplification programme’ is continuing which will inevitably mean a reduction in the number of distinct business support delivery bodies.

Delivery body and web site address	Key activities
Carbon Trust www.carbontrust.co.uk	Low Carbon Building Accelerator Building Design Advice
DTI (now BERR – Department for Business, Enterprise & Regulatory Reform) www.berr.gov.uk	Resource Efficiency Knowledge Transfer Network Technology Programme (now managed by the Technology Strategy Board)
Environment Agency www.environment-agency.gov.uk	(Construction) Sector Plan Awareness campaign – Sitewise II Sustainable Design and Construction Hazardous waste advice – HAZRED Legislation advice - NetRegs
Envirowise www.envirowise.gov.uk	Guides for trade suppliers, packaging, designing for resource efficiency, Site Waste Management Plans Training for small builders, Site Waste Management Plans Resource Efficiency Clubs Supply Chain Partnerships, Case Studies Fast Track & Design Track visits Newsletter - BrickSandMortar
MTP (Market Transformation Programme) www.mtprog.com	Forward look and recommendations on resource efficiency improvements for: <ul style="list-style-type: none">- Modern Methods of Construction- Floor Coverings- Roofing membranes

- Insulation products
- Window systems
- Plasterboard (including further development of supply chain voluntary commitment to reduce/recycle)

NISP (National Industrial Symbiosis Programme) www.nisp.org.uk	Regional networks Workshops Linking companies from different sectors to identify and implement synergies to improve efficiency and use of materials Case studies
Regional Development Agencies	All 9 RDAs receive funding from BREW to co-ordinate resource efficiency and waste initiatives to meet the needs of business.
WRAP (Waste and Resources Action Programme) www.wrap.org.uk/construction	Waste minimisation and management Materials recycling Procuring recycled content AggRegain Website Construction web portal

Table 2: Overview of BREW delivery bodies and key activities

Many other organisations are tackling construction resource efficiency outside of the BREW partnership. The table below summarises key support activities relating to construction resource efficiency, outside of BREW.

Delivery body and web site address	Key activities
BRE (Building Research Establishment) www.bre.co.uk www.smartwaste.co.uk	National Construction Waste benchmarking project Reducing waste through refurbishment - T-ZERO Reducing construction product waste – Be Aware Waste auditing software – SMARTStart/Audit Recycling site locator – BREMAP On site help for sites – CoRE Recycled building products network BREEAM Construction Lean Improvement Programme
CIRIA (Construction Industry Research and Information Association) www.ciria.org.uk	Publications, Training Networks – Construction Productivity Network, Construction Industry Environmental Forum
TRADA www.trada.co.uk	Information and research relating to the specification and use of timber and wood products
Mass Balance www.massbalance.org	Biffaward funded reports using mass balance principles. Around 60 waste and materials studies based upon regions and sectors
Resource Efficiency Knowledge Transfer Network www.resource-efficiency.org	Enables exchange of information relating to resource efficiency. E- newsletters and other online support.
Constructing Excellence www.constructingexcellence.org	Construction products key performance indicators available from website
Remades	Generic name for organisations working to create markets for recycled materials. More detail available in Annex 2.
English Partnerships – Design for Manufacture www.designformanufacture.info	Measurement and reduction of waste of housing related to this programme. EP recently announced another programme of work – the Carbon Challenge.
SmartLIFE www.smartlife-project.net	Detailed waste measurement of 100 houses – 3 types of MMC and more traditional construction

Vinyl2010 www.vinyl2010.org	The European PVC industry's voluntary commitment to sustainability, subscribed to by 23,000 companies. Includes recycling of PVC through subsidised collection.
MINRES	Approach to improving the use and uptake of mineral wastes in construction products
Strategic Supply Chain Group www.sscf.info	Network of companies, public agencies and institutions who promote sustainable procurement. Produce tool and guidance and training events.
Resource Recovery Forum www.resourcesnotwaste.org	Network of organisations interested in resource efficiency. Comprehensive library

Table 3 - Overview of other delivery bodies and key activities

Related Objective

11 Develop information and research outcomes that will contribute to and facilitate the establishment of policy and regulatory standards, initiatives and options aimed at reducing new materials deployment and consumption

A great deal of policy and legislation is already/ or about to be in place to promote many of the objectives of WC115. It is important to support these policies whilst seeking to improve their impact through consultation and provision of user friendly tools to the construction sector – currently suffering from information overload in GB.

Driver	Issues	Effect on construction	
		2007	Predicted within 5 to 7 years
Waste Strategy for England 2007 Defra	Key objectives include: Creating less waste across the supply chain Close the loop through reuse and recycling Improve economics of the reuse and recycling sector Targets (under consultation include): Halve amount of C,D & E wastes going to landfill by 2012 Construction clients to include contractual requirements for measurement and improvement in half of construction projects over £1M in value by 2009 Government to achieve waste-neutral construction in its major construction projects by 2012	Developing policy and focus for the construction sector and its waste by providing clear targets, milestones and actions. Joined up thinking between industry and Government. Increased diversion of waste from landfill, focus on the supply chain and Government procurement	Joint working between Government and Industry Increased diversion from landfill, reduction in amount of waste arising, increased client requirements for resource efficiency Increased markets for reclaimed and recycled materials

Table 4. Issues arising from government policy in England

Driver	Issue	Effect on construction	
		2007	Predicted within 5 to 7 years
Packaging regulations	Companies are obliged to recover packaging waste	Construction industry must comply with the Producer Responsibility Obligations (Packaging Waste) Regulations if they have a turnover of more than £2 million & handle 50 tonnes of packaging waste per year	Work with supply chains and product manufacturers to reduce waste and ensure packaging is reusable/returnable
Landfill tax	Landfill tax for active waste is currently £24 per tonne (2007). From 1 April 2008 and until at least 2010-11, the standard rate of landfill tax will increase by £8 per tonne each year = doubling of landfill tax for active waste over the next 3 to 4 years	Increased costs for collection of waste from construction, refurbishment and demolition sites	Significantly increased costs to industry if producing waste and using waste management contractors. Incentives to reduce the amount of waste produced and recycle and recover more waste, making it economically beneficial to do so.
	Landfill tax for inactive waste of £2 per tonne. £2.50 per tonne from 1 April 2008.	Static tax cost for inert waste – collection costs affected by local markets	Static tax cost for inert waste – collection costs affected by local markets
Aggregate Levy	Aggregate Levy of £1.60 per tonne. £1.95 per tonne from 1 April 2008.	There is an economic incentive to use recycled materials and to minimise the use of primary aggregates so reducing environmental impacts. Encouragement of recycled and secondary aggregates being used in low grade applications.	Increased economic incentive to use recycled and secondary aggregates, including more on site re-use and more procurement/purchasing considerations. Better quality of supply of recycled and secondary aggregates, being used in high value applications.
Hazardous Waste (England and Wales) Regulations 2005	Pre-treatment of hazardous waste before landfill. Less landfills accepting hazardous waste. More waste materials defined as hazardous waste.	Increased costs of disposing of hazardous waste to landfill and requirement to establish what wastes are hazardous. If a site produces more than 200 kg per year, the company will have to register that site with the Environment Agency Engaging with the suppliers of products in terms of their hazardousness when disposed of is useful – this could encourage the use of non-hazardous materials. More contaminated sites treated in-situ to avoid removal and disposal costs.	Increased costs for removal of hazardous waste from construction and demolition sites. Encourage designers, contractors and subcontractors to use materials that are non-hazardous.

Table 5. Issues related to legislation and regulation in England

Driver	Issue	Effect on construction	
		2007	Predicted within 5 to 7 years
EU Thematic Strategy on Waste Prevention and Recycling	Prevention programmes and recycling targets for priority materials, including construction and demolition waste are being considered.	No current effect as the Strategy is currently being consulted on and developed.	Likely to require more waste from construction and demolition to be recycled and therefore systems put in place on and off site
	A revision of the Waste Framework Directive, including the definition of disposal and recovery and clarifying the extent of the waste definition	No effect at present, as still in the consultation stage.	There may be fewer requirements for waste management licensing and exemptions.
Possible Development of End of Life Building Directive (10 to 15 years)	Industry will have to bear responsibility for the houses they build, maintain and demolish and the waste generated at each stage	No effect at present	The construction industry will eventually have to design buildings and use products that can ultimately be re-used, recycled and recovered at the end of their life. Design for deconstruction and disassembly of products.

Table 6. Issues relating to EU legislation and regulation

Driver	Issue	Effect on construction	
		2007	Predicted within 5 to 7 years
Site Waste Management Plans (SWMPs)	Voluntary use of SWMPs for projects with a value over £200,000. SWMPs are compulsory from April 2008 for projects over £300,000	Encouragement to plan and manage their waste effectively on site; reduction in flytipping	Effective planning, monitoring and management of waste on site through the use of a SWMP; increased reduction in flytipping
Code for Sustainable Homes	Voluntary code to assist housebuilders to meet minimum environmental standards.	Require SWMP, see above. Some push towards best practice	Likely to be a mandatory standard by then and also to have been revised, e.g. targets will be set for waste generation

Table 7: Summary of the issues relating to best practice

The Code for Sustainable Homes (CSH) is a good example of a more integrated approach to improving the overall environmental performance of buildings. For new homes, a new standard has been developed that provide a framework for achieving ‘zero carbon’ new homes. CSH is

currently voluntary for private housing and mandatory for social housing. Using the planning system, it should be possible to ensure higher environmental performance levels are achieved by requiring all new housing in the local area to achieve a certain Code level. The levels are illustrated in the tables below:

Code Level 1 – above regulatory standards and a similar standard to BRE’s EcoHomes PASS level and the EST’s Good Practice Standard for energy efficiency
Code Level 2 – a similar standard to BRE’s EcoHomes GOOD level
Code Level 3 – a broadly similar standard to BRE’s EcoHomes VERY GOOD level and the EST’s Best Practice Standard for energy efficiency
Code Level 4 – Broadly set at current exemplary performance
Code Level 5 – Based on exemplary performance with high standards of energy and water efficiency
Code Level 6 – aspirational standard based on zero carbon emissions for the dwelling and high performance across all environmental categories

Before a dwelling can start to be awarded points under the Code it must achieve minimum standards in the following categories:

1) Carbon dioxide (CO₂) emissions resulting from operational energy consumption
Code Levels Minimum Percentage reduction in Dwelling Emission Rate Over Target
Emission rate (current building regs)
Level 1 * 10 %
Level 2 ** 18%
Level 3 *** 25%
Level 4 **** 44%
Level 5 ***** 100%
Level 6 ***** ‘Zero carbon home’

2) Potable Water Consumption (from WCs, showers and baths, taps and appliances, calculated using the Code Water Calculator)
Code Levels Minimum Potable water Consumption in litres per person per day
Level 1 * 120
Level 2 ** 120
Level 3 *** 105
Level 4 **** 105
Level 5 ***** 80
Level 6 ***** 80
3) Embodied impacts of construction Materials - single mandatory requirement
4) Surface Water Runoff - single mandatory requirement
5) Construction Site Waste Management - single mandatory requirement
6) Household Waste Storage Space and Facilities - single mandatory requirement

Related Objective

12 Develop the necessary techniques and tools to support the foregoing objectives

Data on waste arisings is fundamental to setting targets for waste reduction i.e. waste Benchmarks and Performance Indicators²⁰.

- BRE are carrying out a project funded by [Defra](#) to establish minimum reporting requirements for construction, refurbishment and demolition waste and to generate self-updating benchmarks for a set of performance indicators.

²⁰ For the purposes of this report ‘benchmark’ refers to the standard figure and ‘performance indicators’ refers to the metric/ unit of measurement. For example, 10 m³ waste/100m² floor area – the benchmark is 10 and the performance indicator is m³ waste/100m² floor area.

These performance indicators and benchmarks can then be used for:

- Setting of waste reduction targets
- Comparison of performance at a site, company, regional and national level
- Estimation of waste throughout a project
- Setting of contractual clauses/conditions for a project
- Site Waste Management Planning
- Support for planning applications
- Providing data for local and regional resource management planning

Project Type	m3 waste/100 m2 floor area
Civil Engineering	24.3
Commercial Offices	16.7
Commercial Retail	15.4
Education	12.5
Healthcare	15.0
Industrial Buildings	19.9
Leisure	13.8
Public Buildings	21.5
Residential	14.7
Average across project type	17.1

Table 8 Current construction waste benchmarks on 'SMARTWaste' *:

*Data from over 200 completed projects, these figures are based on actual volume (not bulk volume which includes void space). These benchmarks (using an Environmental Performance Indicator of m³ waste/100 m² floor area) were calculated in April 2008.

Site Waste Management Plans are now compulsory in England for any construction project costing more than £300,000. In April 2008, BRE launched a site waste management planning tool, 'SMARTWaste' that has web-based waste data reporting embedded into it²¹. This tool has been taken up widely by the UK construction industry to aid compliance with the Site Waste Management Plan regulations, with around 2000 companies registered by August 2008. Several companies outside the UK are also interested in using this system. This should be possible with a few changes to the system, such as country location, currency and translation of user guides (if required), take place.

²¹ www.smartwaste.co.uk

Japan

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The current state of material utilisation in the building industry in Japan is summarised in this report and related laws and systems are introduced. This report focuses on the following topics:

- (1) A summary of the C&D waste generated by the building industry.
- (2) The material balance of representative building materials.
- (3) An outline of the Construction Waste Recycling Law (2002).
- (4) An outline of the environmental assessment method 'CASBEE' (2004).
- (5) Other laws and systems.

1 OUTLINE OF THE C&D WASTE

Related Objective

11 Develop information and research outcomes that will contribute to and facilitate the establishment of policy and regulatory standards, initiatives and options aimed at reducing new materials deployment and consumption.

1.1 Summary

The Japanese Government has reported the status of C&D wastes every 5 years since 1995. The total weight of C&D waste was approximately 99 million tons in 1995 and it has been decreased to 77 million tons in 2005.

1.2 Amount of waste generated from engineering works and the building industry

The amount of the waste generated from engineering works and the building industry for the years 1995, 2000 and 2005 are summarised in Figure 1. The waste generated by public engineering works and building demolition activities are decreasing. Approximately sixty percent of the C&D waste was generated from engineering works with forty percent coming from the building industry.

1.3 Amount of recycled and land filled C&D waste

The amount of recycled and land filled C&D waste is summarized in figure 2. The recycle ratio

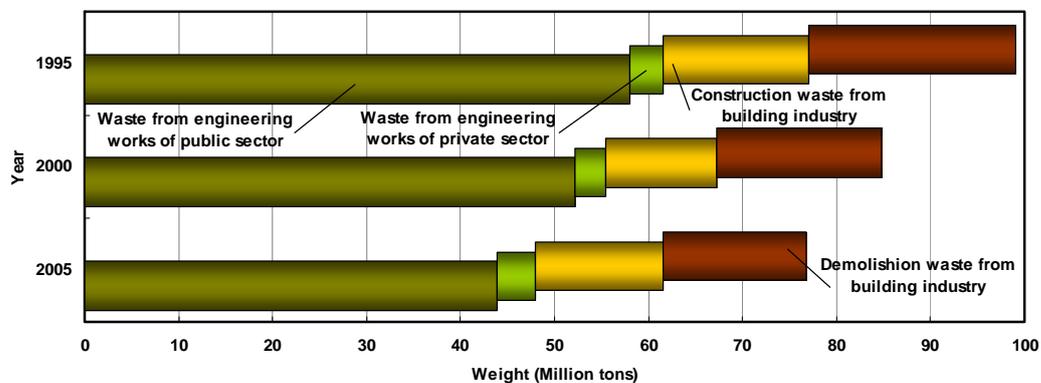


Figure 1 Amount of waste generated from engineering works and building sector

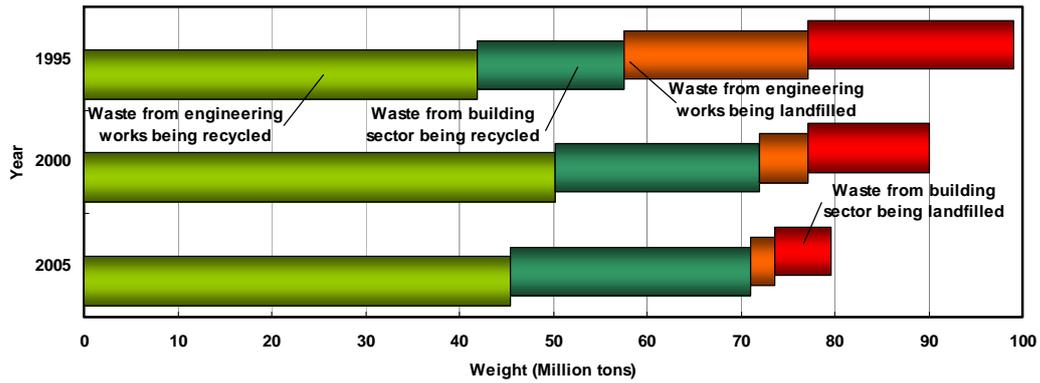


Figure 2 Amount of the recycled and land filled the C&D waste

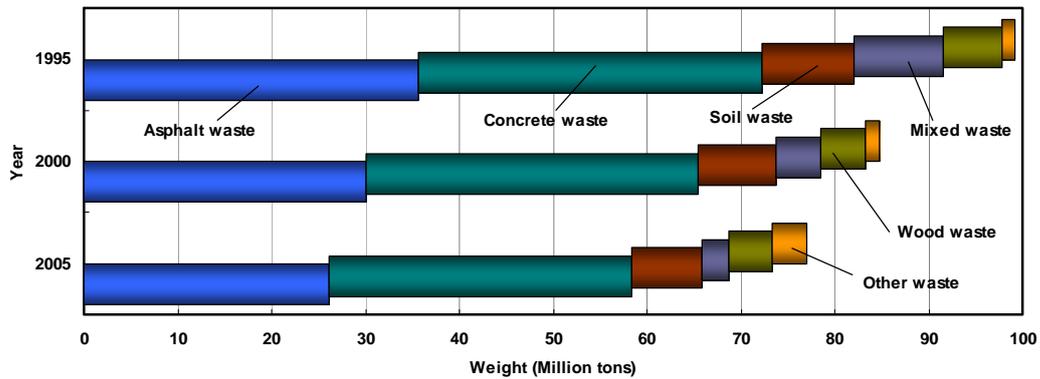


Figure 3 Type and amount of C&D waste

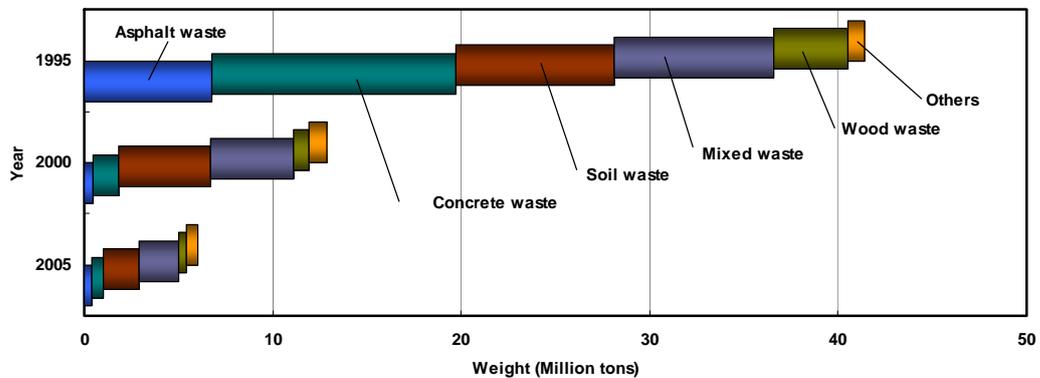


Figure 4 Amount of landfill waste.

of the whole C&D wastes was 58% in 1995 and 92% in 2005. The waste being recycled is increasing and the waste being landfill is decreasing.

1.4 Type and amount of C&D waste

The type and amount of the C&D waste are summarized in figure 3. 34% of the C&D waste was asphalt waste, 41% was concrete waste, 10% was soil waste, 4% was mixed waste and 6% was wooden waste in 2005. The amount of the mixed waste has dramatically decreased.

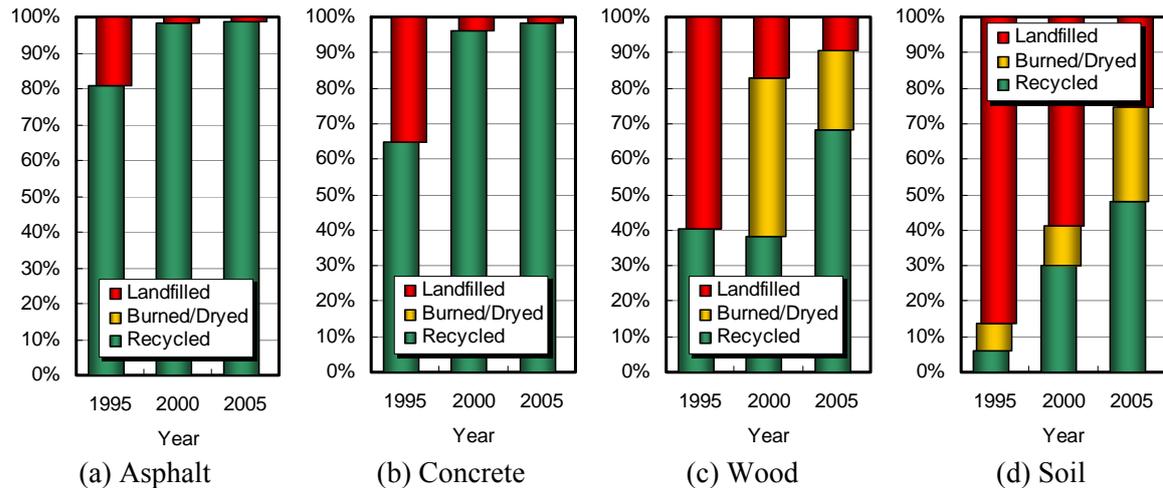


Figure 5 Recycling ratio of major individual C&D waste components.

1.5 Amount of the landfill waste

The types and amounts of the landfill waste are summarised in figure 4. The amount of land filled waste was 42 million tons in 1995 and 6 million tons in 2005. The amount of the landfill waste has drastically decreased.

1.6 Recycling ratio of the individual C&D waste

The recycling ratio of individual C&D waste components is summarised in figure 5. The recycling ratio of every type of waste was improved. For example the recycle ratio of asphalt waste was 80.8% in 1995 and 87.5% in 2005. The recycle ratio of concrete was 64.7% in 1995 and 98.1% in 2005. And the recycle ratio of wood waste was 40.3% in 1995 and 68.2% in 2005.

2 MATERIAL BALANCE

Related Objective

11 Develop information and research outcomes that will contribute to and facilitate the establishment of policy and regulatory standards, initiatives and options aimed at reducing new materials deployment and consumption.

2.1 Summary

The material balance of the representative construction materials were clarified by looking through the literatures and interviewing people in the industry (Yosida) (Japan Steel Association) (Nakajima). The material balances of concrete, steel, wooden products, gypsum board and particleboards/fibreboard in 2005 are summarised in this section. The material balances of these materials are illustrated in the same format so that each can be compared.

2.2 Material balance of concrete

The material balance of concrete is shown in Figure 6. The material flow is illustrated for four phases of the life cycle of materials “resource consumption”, “production”, “utilisation” and “disposal and storage”. The resource consumption was 750 million tons and the total weight of the concrete products was 670 million tons. Approximately 30% of the products were utilized to construct buildings or houses. The amount of waste generated was 50 million tons.

2.3 Material balance of steel

The material balance of steel is shown in Figure 7. 250 million tons of raw materials were consumed and one sixth of the raw materials were steel scraps. The total weight of the production was 100 million tons and approximately 60% was for domestic use. The amount of steel scraps generated was 35 million tons.

2.4 Material balance of wooden products

The material balance of wooden products is shown in Figure 8. The resource consumption was 35 million tons. Approximately 40% of the raw materials were logs and 60% was the imported wooden products. And approximately 40% of the logs were domestic. The self-support ratio of wooden products is approximately 20%. The total weight of the products was 30 million tons and 12 million tons of the products were utilized to construct buildings or houses. The amount of the waste generated was 9 million tons and the amount of the C&D waste was 5 million tons.

2.5 Material balance of gypsum board

The material balance of gypsum boards is shown in Figure 9. The total weight of raw materials consumed was 5 million tons and approximately 70% of the raw materials were industrial by-products. The total weight of the products was 4.2 million tons and approximately 90% of the products were used to construct buildings and houses. The amount of the waste was 1.1 million tons.

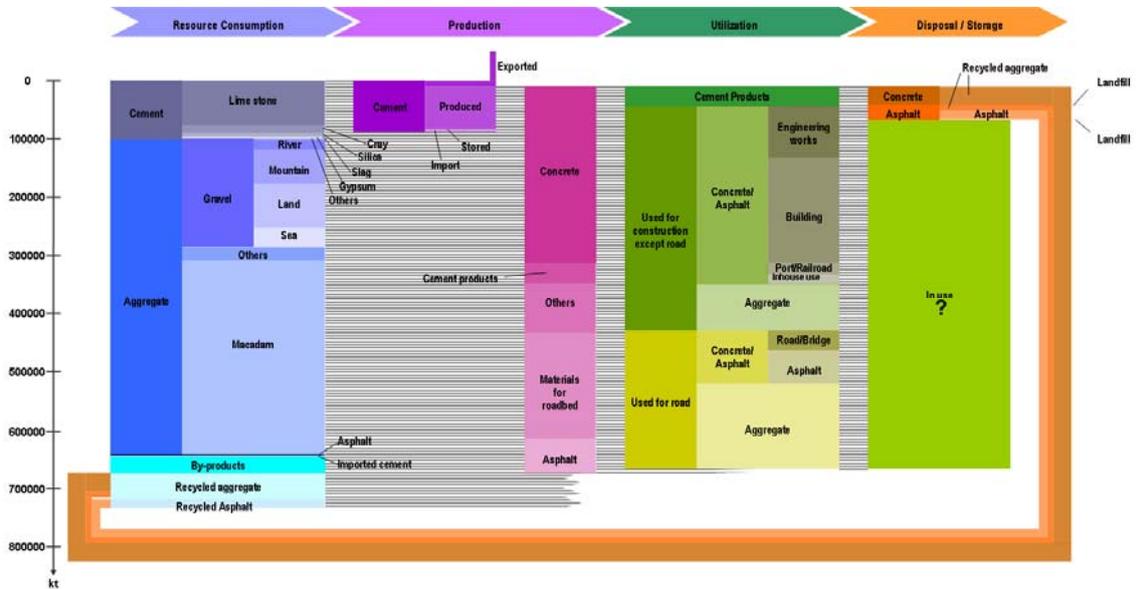


Figure 6 Material balance of concrete.

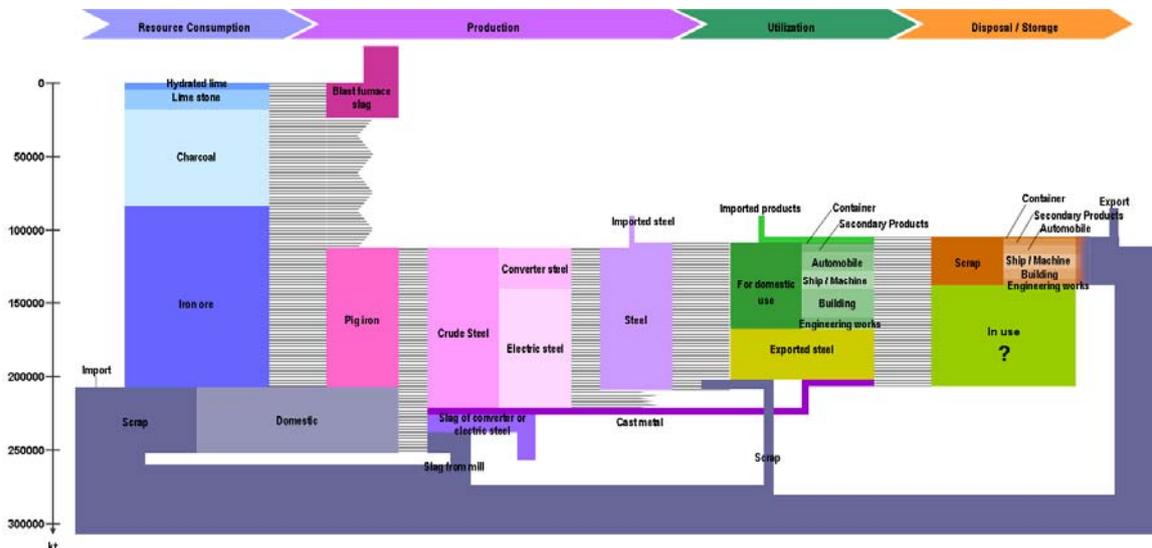


Figure 7 Material balance of steel.

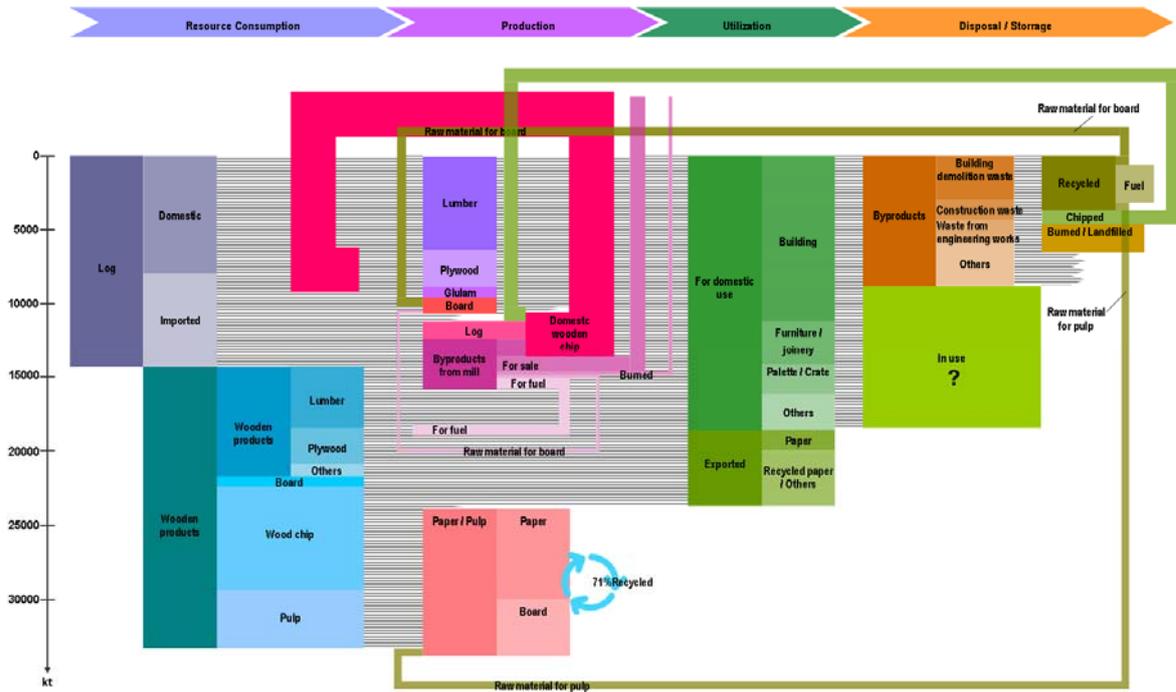


Figure 8 Material balance of wooden materials.

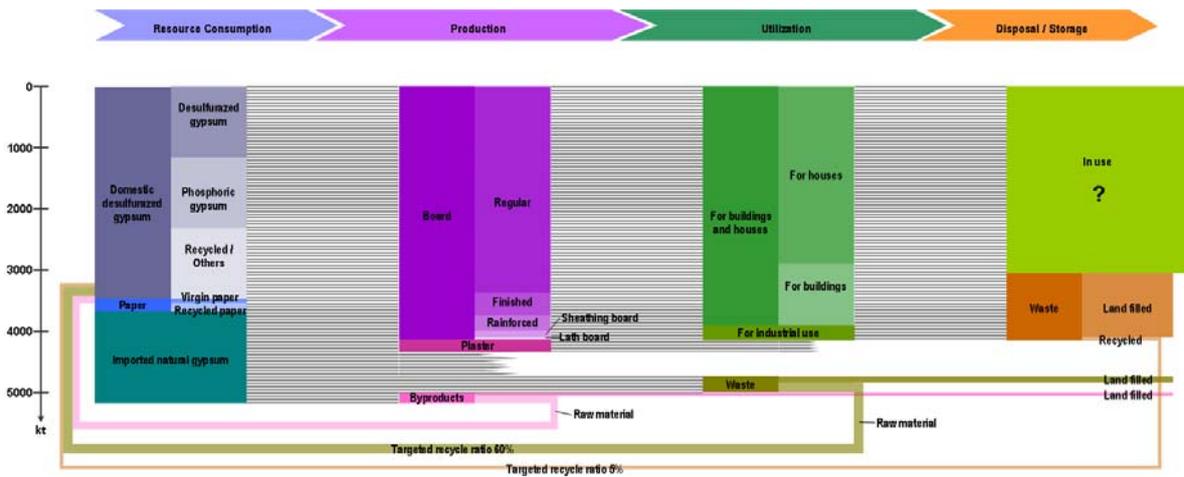


Figure 9 Material balance of gypsum boards.

2.5 Material balance of particle board and fibreboard

The material balance of particle board and fibreboard is shown in figure 10. The total weight of the raw materials consumed was 1.5 million tons and approximately 60% of the raw materials were the C&D waste. The total weight of the products was 1.3 million tons and approximately 50% of the products were used to construct buildings and houses.

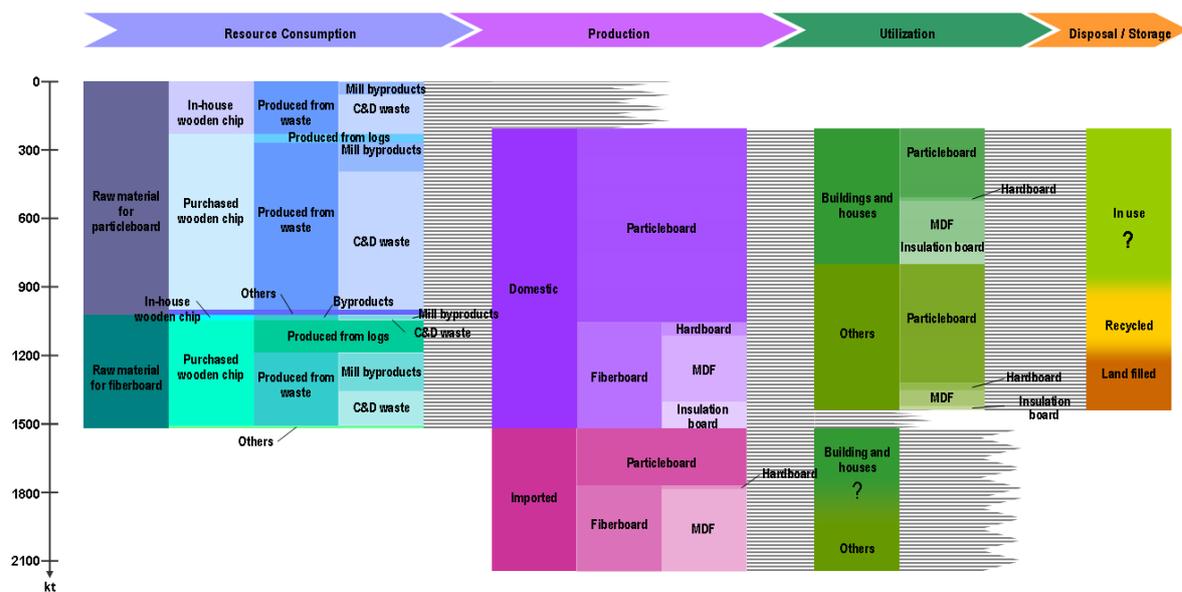


Figure 10 Material balance of particle boards and fiber boards.

3 CONSTRUCTION WASTE RECYCLING LAW

Related Objectives:

7. Establish strategies to promote whole building, component and materials reuse.
9. Establish methods and strategies to enhance utilization of used construction materials.

3.1 Summary

The construction waste recycling law was introduced to improve the recycling ratio of construction waste and to reduce burdens on future generations, (MLIT 2002). The law is roughly composed of five elements:

- (1) Requirement for selective dismantling and recycling.
- (2) Measures to promote selective dismantle and recycling
- (3) Measures to adjust the contract between the owners and the demolition contractor.
- (4) The establishment of a registration system for demolition contractors.
- (5) Measures to promote recycling and the use of recycled materials

3.2 Requirement for selective dismantling and recycling

Selective dismantling to recover specific materials such as concrete, asphalt and wood is required for buildings beyond a certain minimum size. It is expected that these requirements will be expanded and increased in the future.

3.3 Measures to promote selective dismantling and recycling

The owner of the building is required to present the scheduled for removal prior to demolition. And the results of dismantling and recycling should be reported at the end of the process.

3.4 Measures to adjust the contract between the owner and the demolition contractor

The contractor undertaking deconstruction must provide a plan for selective dismantling to the owner. The method of selective dismantling and the cost must be specified for the demolition/dismantling work.

3.5 *The establishment of a registration system for demolition contractors*

Contractors undertaking demolition/dismantling are required to be registered in that region. The demolition contractor must engage an engineer who manages the various technologies for demolition/deconstruction. Because the budget for demolition/deconstruction is typically small, it is not currently necessary to get the permission of the local government. It is therefore easy for an unqualified and unlicensed contractor to provide demolition services. This is one of the reasons why illegal dumping of waste occurs as well as the indiscriminate dismantling of structures.

3.6 *Measures to promote recycling and the use of recycled materials*

As the basic policy, the recycling and the reuse of construction materials are promoted by creating an action plan. Measures to promote recycling and the use of recycled materials should be taken in the cooperation of the owner.

4 ASSESSMENT OF RESOURCES AND MATERIALS IN 'CASBEE'

Related Objectives:

12. Develop the necessary techniques and tools to support the foregoing objectives.

4.1 'CASBEE'

'CASBEE' (Comprehensive Assessment System for Building Environment Efficiency) (Japan Sustainable Building Consortium) is an environmental labelling method for building, based on assessment of the performance of buildings. 'BEE' (Building Environmental Efficiency) was developed as a new indicator. The environmental performance of the building is labelled as B⁻, B⁺, A or S.

The assessment items of 'CASBEE' are "Quality of Building" and "Environmental Load". And the assessment item "Quality of Building" includes "Indoor Environment", "Quality of Service" and "Outdoor Environment on Site". And the assessment item "Environmental Load" includes "Energy", "Resources and Materials" and "Off-site Environment".

'BEE' is calculated by dividing "Quality of Building" by "Environmental Load". The 'CASBEE' result sheet is shown in Figure 11.

4.2 *Assessment of Resources and materials in 'CASBEE'*

The assessment item "Resources and Materials" in 'CASBEE' has sub-assessment items "Water Resource" and "Material of Low Environmental Load". The assessment item "Water Resource" has sub-assessment items "Water Saving" and "Rainwater & Grey Water". The assessment item "Material of Low Environmental Load" has sub-assessment items "Recycled Materials", "Timber from Sustainable Forestry", "Materials with Low Health Risks", "Reuse of Existing Buildings' Skeleton etc.", "Reusability of Components & Materials" and "Use of CFCs & Halons".

5 OTHER LAWS AND SYSTEMS

Related Objectives:

3. *Develop systems to mitigate and ultimately avoid construction material waste.*

5.1 *Green Products Purchase Law*

The Green Products Purchase Law requires the national government, the local government and the public sector to purchase green products. Products produced from recycled raw materials are regarded as green products.

5.2 'Eco-Mark' Approval System

'Eco-Mark' is an approval system organised by the Japan Environment Association. There are 49 categories including 7 categories related to construction materials and components. For example tiles and cement blocks, wooden boards, wooden products produced from wood harvested from sustainable forest, glasses etc. are listed.

6 REFERENCES

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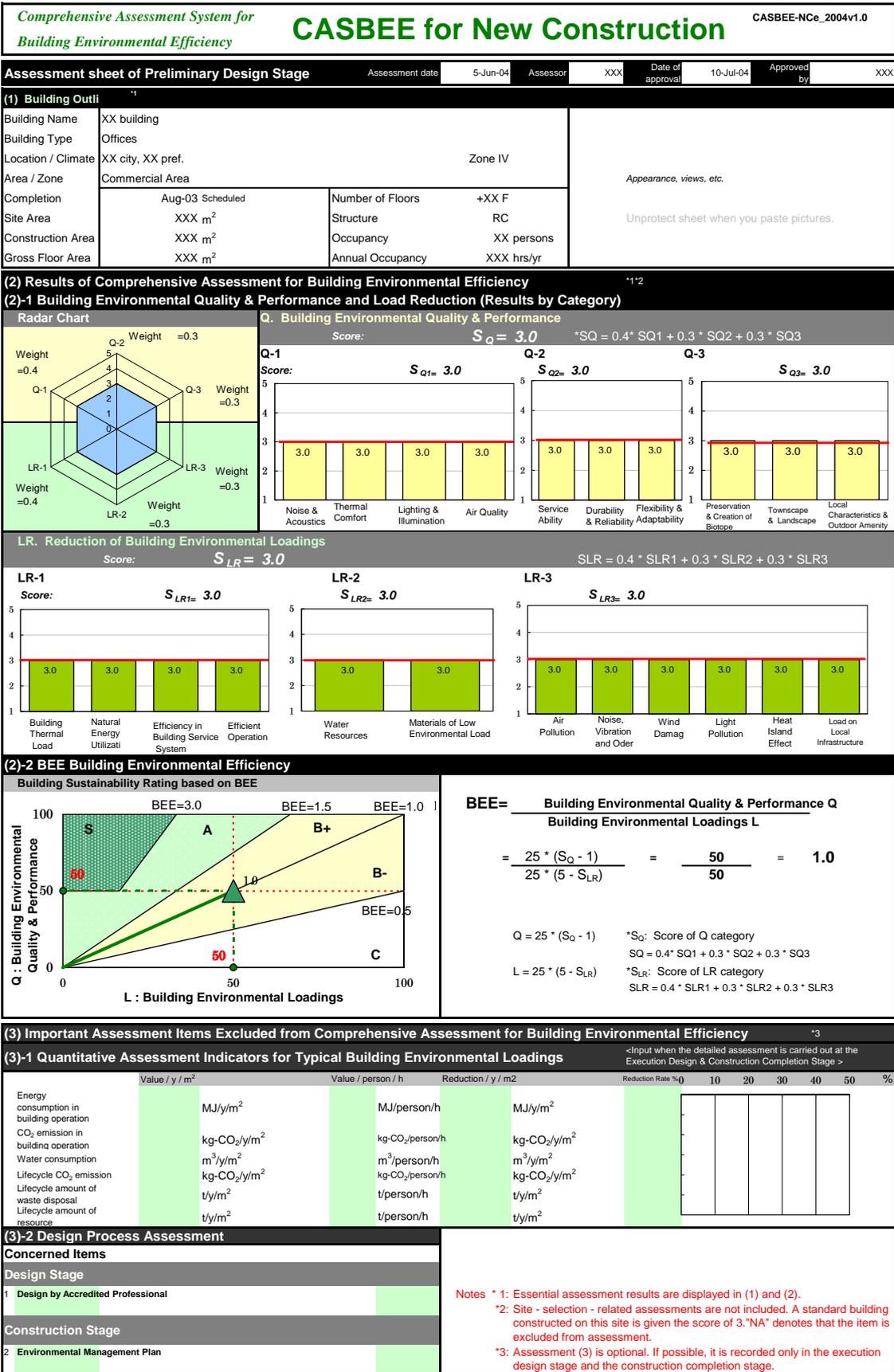


Figure 11 'CASBEE' Result sheet.

New Zealand

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ABSTRACT: The New Zealand Country Report deals with construction materials stewardship under the 12 Objective headings set out in the CIB W115 foundation document. There are a whole series of organisations and initiatives that relate to C+D waste reduction but the main preoccupation of these organisations is prolonging the active life of NZ's landfills. Very few organisations or individuals are interested or aware of the bigger picture. Central Government leads initiatives in this area but initiatives have to date been largely voluntary in nature and have garnered very patchy responses. Even if the most radical of these initiatives, the Waste Minimisation Bill which is currently before parliament passes into law, it still represents *cradle to grave* and 'green' thinking rather than a *closed-loop, cyclic, cradle-to-cradle, regenerative* response to resource depletion.

1 INTRODUCTION

1.1 *Previous Reporting*

Reference should be made to The State of Deconstruction in New Zealand report published in CIB publication 300 March 2005 for previous reporting on several aspects of the work being undertaken in the CIB W115 Construction Materials Stewardship Working Commission. Reference is made in the report to The New Zealand Waste Strategy – Towards Zero Waste and a Sustainable New Zealand published in March 2002 by the Ministry for the Environment - Manatu Mo Te Taiao. This remains the key reference document for Construction Materials Stewardship in New Zealand. It is available for reference, along with several other relevant documents on the MfE website www.mfe.govt.nz/publications. It should be noted that none of the publications deal solely with construction materials stewardship but in the Targets in the New Zealand Waste Strategy 2006: Review of Progress published in March 2007, C+D waste is finally been recognised as the largest solid waste stream contributor.

2 EFFECTIVE MATERIALS USE

2.1 *Related Objective*

1 Develop ways to utilise new and existing construction materials in the most effective ecologically, environmentally, socially and financially responsible manner possible

2.2 *New Zealand Situation*

There is currently no national strategy to utilise construction materials in an effective or responsible manner. Some individual companies have developed, or are developing strategies connected with material and product stewardship. These initiatives are primarily related to increasing financial profitability, with little consideration of other aspects of resource stewardship. A number of companies have carried out Life Cycle Analysis audits on their processes but these tend to be costly, time consuming and of uncertain value. This uncertainty arises out of the lack of NZ specific data which means, for example, that European energy mix data has to be used in NZ LCA audits. This varies considerably from the NZ condition and of

itself raises doubts as to the value of audit outcomes. There is also a lack of personnel with the skills to interpret and translate the derived LCA data into effective process actions.

3 LIFE CYCLE COSTING

Related Objective

2 Develop life cycle costing and management mechanisms for materials

3.1 NZ Situation

Requirements for the consideration of life cycle costing, materials durability and low maintenance are all incorporated in the Building Act (2004). Regulation is still being drafted around these considerations. Some research has been carried out by the Building Research Association of New Zealand (BRANZ) in these areas. Significant work has been carried out by Victoria University of Wellington School of Architecture's Centre for Building Performance Research on life cycle embodied energy and CO² equivalency using a specially developed hybrid system of data sourcing. This approach derives figures that are much more accurate than sector energy based figures.

No known work is currently being carried out in the area of management systems for materials. Central government is however working on a green preferential purchasing policy, although this has yet to be finalised or implemented. Once in place this should have a dramatic effect on the availability, cost and viability of 'green' products. Other government funded institutions such as universities and medical facilities along with local government will no doubt be encouraged to follow government lead in terms of its preferential purchasing policy. Together these organisations have massive purchasing programmes. It is likely that life cycle costing will be a part of the purchasing criteria.

4 CONSTRUCTION WASTE

4.1 Related Objective

3 Develop systems to mitigate and ultimately avoid construction material waste

4.2 NZ Situation

There are currently no known accurate figures for construction process waste in New Zealand, but the consensus figure is that it is approximately 8-10% of all non-prefabricated materials. This is the figure that Quantity Surveyors and Cost estimators use in their cost estimates. Added to this are costs associated with supply, cutting and fitting, discarding, tidying-up and disposal. The total building on-cost of construction waste is estimated at about 10%. Some of the more forward looking intelligently managed building companies have realised that they can either significantly increase profit or give themselves a competitive edge during tendering, if they can reduce construction waste.

Construction waste minimisation is one of the Principles incorporated in the Building Act (2004). Ahead of regulation, New Zealand's biggest building conglomerate, Fletcher Construction, have realised that reducing construction waste makes good business sense. They are already taking this issue seriously and insisting that their sub-contractors operate with equal diligence in this area. Increased use of prefabricated components, maximising use of sheeting

materials on-site, source separation, waste recovery and waste diversion are becoming standard practice within this organisation and these practices are gradually spreading to other construction companies. Pre-construction planning in conjunction with designers to create material modular size spaces and reduce construction waste and rising levels of prefabrication in construction both result in reduced construction waste. Post production waste associated with prefabrication is generally easier to recycle than on-site waste.

In the current building boom and without regulation, few companies have taken construction waste minimisation seriously but with the increasing likelihood of a significant market downturn and imminent regulation, it is expected that more attention will be paid to reducing construction waste in the immediate future.

There are considerable uncertainties surrounding the figures for C+D wastes currently available in New Zealand. Figures are reasonably accurate for controlled landfills and were estimated to be 820,560 tonnes in 2006. However figures for cleanfills, which take non-hazardous C+ D waste, are extrapolated from a small number of research programmes undertaken in locations in only three cities. These figures suggest that the amount of C+D waste sent to landfills is in the region of 2.700.000 – 3.700.000 tonnes based on averaged per capita values.

Similar levels of uncertainty surround the figures for the amount of C+D waste diverted from landfills and cleanfills. This is estimated to be approximately 1.000.000 tonnes but this figure has been derived from “direct contact with construction and demolition industry” rather than through direct measurement.

In many small communities C+D waste is not yet perceived as a problem and even in larger communities it is regarded as a landfill problem rather than a resource issue. Many communities simply do not have the volumes to make recycling commercially viable or the resources to carry out a comprehensive recycling programme. This situation may change when and if the Waste Minimisation Bill is enacted but the main effort initially is likely to be directed to urban centres.

5 WASTE AS SOURCE

5.1 Related Objective

4 Develop ways of using material wastes as raw materials for making construction materials.

5.2 New Zealand Situation

There is no legislation or systematic approach to using waste materials as raw materials for making construction materials in New Zealand. In this context utilising materials wastes is left to individual companies. Examples include:

‘Polystyrene Palace’ 100% recycling of bead polystyrene waste into a range of building insulation products (closed loop recycling)

‘Pacific Steel’, steel reinforcing bars that use 100% recycled steel (closed loop recycling)

‘Woolblock’ wool insulation that uses 100% production waste wool carpet clippings (uniform recycling)

‘Pink Batts’ fibreglass insulation that incorporates 80% window glass waste (uniform recycling)

‘Burgess Rubber’ floor tiles, made from recycled tyres (uniform recycling)

‘Pacific Plastics’, who take any plastic and extrude it into a range of low quality (down cycling >closed loop recycling)

6. CLOSED LOOP RECYCLING

6.1 Related Objective

5 Develop methodologies for closed loop materials use and for the effective recovery of materials and components from existing buildings.

6.2 NZ Situation

Many companies now practice closed loop recycling to process and pre-consumer wastes at various stages in the manufacturing and delivery processes. Post-consumer closed loop material recycling remains largely confined to metals. Steel is the dominant closed loop building material but aluminium, zinc, copper and lead are also recovered and reused in a closed loop manner. There are no facilities in New Zealand for reprocessing stainless steel and some aluminium alloys. These are collected and exported.

A small amount of closed loop recycling occurs through the incorporation of recovered materials into renovations. There is a single closed loop polystyrene reprocessing plant, Polystyrene Palace, but it struggles to survive in competition with new product plants.

Other recovered materials are usually made into different materials. This can be an up-cycling or down-cycling end use. Recovered native timber for instance is usually up-cycled whereas concrete aggregate is usually down-cycled. The closed-loop recycling of concrete aggregate for engineering grade concrete is particularly difficult due to the need for high levels of uniformity and high strength in concrete required to resist earthquake loadings in New Zealand.

7 DECONSTRUCTION

7.1 Related Objective

5 Develop methodologies for closed loop materials use and for the effective recovery of materials and components from existing buildings.

7.2 NZ Situation

With respect to the effective recovery of materials and components from existing buildings, otherwise known as deconstruction, reverse construction, disassembly or dismantling little has changed from the situation reported in ‘The State of Deconstruction in New Zealand’ section of CIB Publication 300 ‘Deconstruction and Material Reuse – An International Overview’, published in March 2005. There is however, an increasing awareness of the commercial opportunities presented by deconstruction by contractors, consultants and client organisations.

Nikau Contractors and Ward Demolition still dominate this market although a number of smaller players have entered the marketplace. Larger building contractors sometimes undertake deconstruction work themselves on large contracts, but generally lack the expertise to maximise the potential of the situation. Both Nikau and Ward have developed considerable expertise in deconstruction and in the on selling on the resources recovered. Both claim 80 – 95% resource recovery as standard. An increasing number of contracts undertaken yield recovery rates in excess of 90%. Both companies operate largely in the Auckland region although Nikau are willing and able to operate effectively in other parts of the country provided the contract is large enough. Both Nikau and Ward have developed specialise divisions within the umbrella company.²² Nikau specialise in dismantling and overseas sale of industrial process equipment to and the up-cycling of recovered material products such as native timber. Ward specialise in the design and manufacture of specialised deconstruction equipment.

²² See www.ward-demolition.co.nz and www.nikau.org for further information.

Some information on is provided on the REBRI website²³ on closed loop recycling and deconstruction but it is of a very general nature and is useful only as a brief introduction to the topics

8 TRANSFORMABLE AND ADAPTABLE BUILDINGS

8.1 *Related Objective*

6 Develop design and construction methodologies for transformable and adaptable buildings and spaces to extend service life and so reduce overall construction material resource use.

8.2 *NZ Situation*

No known work is currently being carried out in this area in New Zealand. Little has changed from the situation reported in CIB Publication 300.

9 WHOLE BUILDING REUSE

9.1 *Related Objective*

7 Establish strategies to promote whole building, component and materials reuse

9.2 *NZ Situation*

9.2.1 *Green Star*

The primary method to promote whole building, component and materials reuse is through the Green Star NZ building assessment scheme which is an offshoot of BREEAM/LEED/Australian Green Star suite of green building assessment systems. Currently this only applies to new and refurbished commercial buildings and has only been available for about one year. Further building typologies are under development.

Within Green Star there is a section on materials, which includes points for the re-use of existing facades and structures and rewards reduced wastage of fit-out materials as well as recycled content in concrete and steel.

9.2.2 *Government Initiatives*

In Wellington 60% of the big tenants and a significant proportion of the small tenants are in the public sector. Central Government has decided that as from the 1st July 2007 all new direct public service departments office lettings will be in 4 or 5 Green Star rated buildings and there is a strong likelihood that many other publicly funded organisations will follow suit.

The new NZ Building Code will define minimum ESD requirements, for both new and refurbishing or reconstructing buildings. The Building Act (2004) section 4(2)(n) mandates the need to facilitate the efficient and sustainable use in buildings of (i) materials and (ii) material conservation. This section of the Act also requires that consideration be given to low maintenance, improved durability and construction waste reduction.

No measures will be included for the promotion of whole building, component or materials reuse. Central government is however currently developing a 'green' preferential purchasing policy. The content of this policy remains unknown, at the time of writing. There is an

²³ REBRI = Resource Efficiency in Building and Related Industries. Website www.rebri.org.nz. The website contains wide ranging but fairly superficial information and advice concerning building related recycling in New Zealand.

opportunity here to include measures to promote materials reuse, most likely by giving preferential treatment to materials that incorporate recycled content.

There have been suggestions that Government could lead the way by insisting on a minimum amount of recycled content in its own new or refurbished buildings and government is not opposed to this idea but so far has done very little to implement such a policy.

9.2.3 Component reuse

Component reuse tends to be restricted to domestic situations, mainly to match the style of components already in use in existing buildings. Such components are often the 'cherry picked' elements that have high value to bulk. With timber framed domestic buildings it is relatively easy to cut out and reposition and reuse whole envelope sections and components and they are often extended and remodelled in this way.

9.2.4 Moving Buildings

Timber framed domestic buildings can be either moved complete or cut up into sections. Several companies specialize in this area of work. Travel distances of several hundred kilometres are not unknown. Older well-built homes containing original features and materials are highly valued and are often moved rather than being demolished. Older homes tend to be carefully disassembled and their components reused particularly the rare native timbers from which pre-1940s homes were built.

Rather more rarely whole commercial buildings have been moved. This tends to be over short distances and is usually to make way for a redevelopment project.

9.2.5 Whole Building Reuse

With a replacement rates of between 1.5 -2% across all building types, most of the buildings that we will use for at least the next 50 years and probably longer are already built. There are no policies in place in New Zealand to require the upgrading of these buildings. Regulations with regard to materials only come into force when buildings are renovated and even then the regulations tend only to apply to the parts of the building being renovated.

With commercial buildings, maximising financial return remains the principal imperative. Government is only likely to intervene if market imperatives are not leading to desired results. There seems to be a strong financial argument for refurbishing rather than building new and indeed in NZ very few new office buildings were constructed in the period 1989 to 2005. Although refurbishment largely related to cosmetic improvement combined with improvement in lighting and heating/cooling systems during this period. Façade and structural changes were and continue to be fairly rare so the vast majority of the original materials are retained in refurbished buildings.

Both developer/owners and realtors contacted in two studies carried out recently (Storey 2007a and Storey 2007b) found that there has been a very significant increase of interest in 'green' design over the last twelve to eighteen months and especially over the last six months. While attitudes may be changing in this sector it is too early to claim that such indications can be interpreted as a trend. This was thought to have been driven both by the firming up of government commitment to the 'greening' of the public sector and because several 'green' building exemplars can now be visited. Whether this interest in 'green buildings' extend to material stewardship remains to be seen.

A very high level of interest has been shown in the renovation of the new Department of Conservation's HQ building renovation. An increasing number of existing office building renovations, such as the one at 50 Customhouse Quay in Wellington, do feature ESD elements. Converted or upgraded apartment buildings often retain both the structure and façade which together contain a very high proportion of the original building materials

Some buildings lend themselves more easily to ESD upgrading than others. Office buildings built during the 1960s through to 1990 were underspecified, minimalist and in some cases incorporate shoddy construction. In many cases these buildings were regarded as having floor-to-floor heights that prohibit renovation to meet current office tenant expectations. It is this generation of buildings that were regarded as being most at risk of demolition. It is particularly interesting therefore, that a major refurbishment and enlargement of 1960's office building in central Auckland is currently underway. In this building, 21 Queen's Street, Auckland, the structure core configuration was retained but the heavy façade spandrel panels were replaced. This allowed several extra floors to be added without having to upgrade the structure.

Reasons for the very limited action currently taking place with respect to building reuse appear to include: lack of demand; owner inertia compounded by high occupancy rates and lack of certainty in the regulatory sector; the difficulties associated with upgrading in the primarily multiple-letting circumstances of the commercial rental market; lack of government incentives and the lack of recognition given to incremental ESD improvement of buildings within current building assessment systems. These attitudes and factors will need to be addressed if New Zealand is to make the best use of its existing commercial buildings.

10 REGENERATION OF RENEWABLES RESOURCE BASE

10.1 *Related Objective*

8 Establish ways to regenerate the renewable materials resource base and improve the performance, availability and use of renewable construction materials

10.2 *NZ Situation*

The only viable renewable material in New Zealand is plantation grown timber. About 31% of New Zealand is forested, with about 90% of this being in commercial plantations. About 85% of plantation timber is *Pinus radiata* (Monterey Pine) which is an exotic species first introduced into NZ in the 1890s. It has wide usage in the building industry but needs chemical treatment if exposed to water or weather. Its growth cycle for construction timber is about 28 years in New Zealand. Other species are grown for special purposes but all have longer growth cycles. NZ could respond relatively quickly to increased demand for timber products, should the financial climate permit. All plantations are 'sustainably' managed and are replanted as soon as timber is harvested. Native timbers tend to have very long growth cycles and are protected and only tiny amounts are released for use each year, usually to make artefacts of special cultural significance to Maori.

New Zealand used to have a thriving flax industry and research is currently underway to review the viability of reviving the commercialisation of this plant.

'SCION' is the major biomaterials research organisation in New Zealand. It operates internationally with partners in Australia and the USA. It is currently engaged in research and the commercialisation of a range of bioplastic products using timber cellulose as the feedstock. All of these products fall into one or other of the Cradle to Cradle philosophy of products either being nutrient or technical feedstocks in a closed loop recycling mode.

11 IMPROVING UTILISATION OF USED CONSTRUCTION MATERIALS

11.1 *Related Objective*

9 Establish methods and strategies to enhance utilisation of used construction materials

11.2 NZ Situation

A Waste Minimisation Bill is currently progressing through parliament. Part of this includes a Waste Levy which will be used to administer the system and provide for the raising of a contestable fund for waste minimisation initiatives.

The NZ government does not believe in the value of subsidies preferring instead to operate a combination of mandatory legislation, voluntary agreements, and contestable, project specific public good funding. This stance has been relaxed somewhat in relation to low income family housing but is otherwise in tact.

One of the main issues that hinder the reuse of building materials is the lack of adequate quality control mechanisms including the danger of contamination from unsuitable materials, and structural grading. It is hoped that one of the early projects paid for under the Waste Levy Fund is the development of a strategies to overcome these problems.

12 BARRIERS AND SOLUTIONS

12.1 Related Objective

10 Establish what the barriers are to the sustainable use of building materials and devise methodologies to overcome these barriers

12.2 NZ Situation

The barriers and possible solutions are covered in some depth in a paper entitled *Overcoming the Barriers to Deconstruction and Materials Reuse in New Zealand (Storey 2003)*, that appeared in CIB Publication 287. Little has changed in NZ in the intervening period with respect to materials reuse. Government has tried very hard to persuade industry and local authorities to develop appropriate waste minimisation measures, but has met with very limited and disparate responses. In 2006 they acknowledged defeat and officially adopted a private member's bill initiated by a Green Party member of parliament.

Many people in the building industry would argue that until the rules concerning C+D waste treatment and disposal are clarified it would be unwise to devise waste minimisation initiatives. Therefore change is most likely to occur as a consequence of and subsequent to, the passing of the Waste Minimisation Act that is currently before parliament.

13 RESEARCH, INFORMATION, INITIATIVES, POLICY AND REGULATION

13.1 Related Objective

11 Develop information and research outcomes that will contribute to and facilitate the establishment of policy and regulatory standards, initiatives and options aimed at reducing new materials deployment and consumption.

13.2 NZ Situation

13.2.1 Overview

Central government is taking the most proactive role across the broad spectrum of construction materials stewardship with leadership and the main initiatives and coming from the Ministry for the Environment. Other ministries such as the Department of Building and Housing, The Ministry of Economic Development, the Department of Conservation, the Ministry of Research into Science and Technology and the Ministry of Agriculture and Fisheries have all undertaken complimentary initiatives in their areas of special responsibility. Other organisations tend to

focus on particular aspects of construction materials stewardship. Local authorities tend to focus on programmes to minimise landfill waste. There is something of a general hiatus in many areas of construction materials stewardship until the Waste Minimisation Bill currently before parliament is passed into law because of the uncertainties concerning the legal framework, financial implications, coverage, reporting, baselines and technical requirements relating to waste minimisation that are still in flux. Whether this condition prevents action or is simply a convenient excuse for inaction by a number of stakeholder groups remains unclear.

13.2.2 Ministry for the Environment (MfE)

The Ministry is working on a number of initiatives to reduce C&D waste, in an attempt to implement its New Zealand Waste Strategy. These initiatives focus on providing tools and resources for the C&D industries, and promoting these tools to other industry sectors.

The Ministry C&D waste work programme currently includes:

- Increasing awareness of the Resource Efficiency in Building and Related Industries (REBRI) guidelines and promoting their use to the construction and demolition Industries
- Encouraging principles of resource efficiency in industry training qualifications (e.g. architecture, engineering and carpentry courses)
- Running workshops for large construction or demolition firms, based on the REBRI guidelines
- Developing case studies using the REBRI guidelines
- Stimulating market development for recovered C&D waste. A number of reports investigating market development have been written:
 - *Assessment of Markets for C&D waste (2004)*
 - *Review of Verification Programme Options (2004)*
- Facilitating an industry based steering group to oversee C&D waste reduction initiatives. This steering group is made up of industry representatives, and provides feedback on Ministry for the Environment initiatives
- Working to promote the recovery of C&D waste through resource recovery parks
- Investigating the possibility of using product stewardship to address some construction materials that contribute to the waste stream.
- Raising awareness - as C&D is a low profile waste stream work is underway to raise the awareness and understanding of issues facing C&D waste minimisation.

13.2.2.1 The New Zealand Waste Strategy 2002

This is a long term strategy whose central objectives are to help reduce waste, recover resources and better manage residual waste in New Zealand. It covers solid, liquid, gaseous and hazardous waste. C+D Waste is recognised as one waste category. The Ministry for the Environment prepared the strategy in partnership with Local Government. The Waste Strategy identifies a number of principles, policies and action programmes to achieve the vision towards zero waste and a sustainable New Zealand. One of the key targets of this strategy was that by December 2005 all territorial authorities would have instituted a measurement programme to identify existing construction and demolition waste quantities and set local targets for diversion from landfills. This target was not achieved and this failure undermines the primary target of achieving a 50% reduction in C&D waste by 2008 as there is no baseline to assess the success or failure of any initiative undertaken.

13.2.2.1.1 Voluntary Action

Actions laid down in The NZ Waste Strategy are voluntary and to date C&D waste reduction and diversion remains one of the secondary stream of targets in the NZ Waste Strategy, in that reduction is not expected to be achievable immediately. The Ministry has initiated a Waste

Management Planning project that will provide a base for this work to proceed in the near future. It is recognised that there are likely to be a number of sites that are not even recognised as disposal sites in some areas, due to the designations under which they were established. It is felt likely, that a waste-licensing scheme might be a suitable vehicle for establishing quantities in this sector, and this may require a national approach. When the Waste Minimisation Act is passed the situation is expected to change drastically, firstly because compliance will be mandatory and secondly because C&D waste is now recognised as the biggest solid waste stream. However until the Act is passed these expectations remain purely speculative. (<http://www.mfe.govt.nz/issues/waste/targets/index.html>)

13.2.2.1.2 Monitoring and measurement systems

Monitoring and measurement systems for construction and demolition wastes vary among territorial authorities. This is mainly because the amount of construction and demolition waste generated in any given area depends on the amount of economic activity. In general, high levels of construction and demolition waste are the result of high levels of economic growth and population increase. In many areas the volume of construction and demolition waste generated does not justify measurement. In other areas, the majority of construction and demolition waste is disposed of to local cleanfills, most of which are not council-owned. Some territorial authorities report some roadside construction waste is used in land reclamation by local farmers, but this is not measured. (MfE, 2007)

So far only ten territorial authorities have a formal monitoring system for construction and demolition waste. Of these, six have set local targets for the diversion of this type of waste. Figures for 2005 were provided by 16 territorial authorities, who collectively estimated that in their territories 224,581 tonnes of construction and demolition waste were sent to landfill in 2005. This is not sufficient to provide an adequate picture of the waste stream throughout New Zealand or to adequately determine progress against the 50 per cent reduction target (MfE, 2007)

13.2.2.1.3 Product Stewardship

Product stewardship schemes in NZ reflect *cradle to grave* linear, use and recycle or dump thinking, rather than *cradle to cradle*, cyclic, closed loop thinking. Schemes are aimed at reducing the environmental impacts of manufactured products. In effect in the operant product stewardship schemes, producers, brand owners, importers, retailers, consumers and other parties accept responsibility for the environmental effects of their products – from the time they are produced until they are disposed of. Product stewardship scheme participants take responsibility for the environmental effects of their products and take these costs into account when making decisions about the production, purchase and disposal of their products.

New Zealand already has a number of existing product stewardships schemes, all voluntary and industry-led, and would like to encourage more. The main benefit in these schemes is that manufacturers seek ways to achieve more efficient and responsible use of resources. At the very least, rather than dealing with the waste problem at the point the product is thrown away, these so called ‘Upstream’ initiatives (such as material selection, design changes, packaging choice and buying habits) can all help to make disposal – whether it be for reuse, recycling or landfill - much less of a problem.

Existing schemes in New Zealand focus on products including:

- packaging
- oil
- tyres
- paint

Work is currently underway to work with stakeholders involved in plasterboard and treated timber in order to develop schemes. (<http://www.mfe.govt.nz/issues/sustainable-industry/initiatives/product-stewardship/>)

Product stewardship also features strongly in the proposals set out in the Waste Minimisation Bill

13.2.2.2 Targets in the New Zealand Waste Strategy: 2006 Review of Progress (MfE, 2007)

This document was published by the Ministry in April 2007 to assess the progress made towards achieving the targets set out in New Zealand's Waste Strategy, to identify areas which require more work and prioritise further action. In this document contains the most accurate estimates for the amount of C + D waste available to date. The research was commissioned by MfE from Waste Not Consulting in 2006. However many of the derived figures are the result of intelligent analysis of available local data extrapolated into the national context.

The key findings were:

- Construction and demolition waste is the largest waste stream in New Zealand and is estimated to make up 50 per cent of all waste (<http://www.mfe.govt.nz/issues/waste/construction-demo/index.html>).
- Construction and demolition waste is estimated to comprise around 26 per cent of waste to landfill, or 820,560 tonnes in 2006.
- Construction and demolition waste makes up the majority of waste disposed of to cleanfill. This is estimated to be between 2.7 and 3.7 million tonnes in 2005, which is greater than the total volume of waste to landfill in New Zealand.
- An estimated one million tonnes of construction and demolition waste is diverted from landfills and cleanfills by industry. (MfE, 2007).

Efforts to reduce overall C&D waste has so far focused on the 'Big 3' waste materials - timber, plasterboard and concrete. It is estimated they make up the majority of C&D waste, including 81 per cent from construction sites (Paterson, 1997).

13.2.2.3. The C&D Waste Steering Group

This was established by the MfE and brings together stakeholders from throughout the building and waste industries to develop initiatives and input into government legislation.

13.2.2.4 A Guide to Sustainable Office Fitouts

A guide developed by the Ministry containing information specifically related to reducing waste during an office fitout.

13.2.3 REBRI

REBRI stands for Resource Efficiency in Building and Related Industries. It grew from a collaborative effort (called Project Construction + Demolition) between The Auckland Regional Council, BRANZ, the Auckland City Council (with some funding by the Ministry for the Environment). Beginning in 1995 this partnership has undertaken, research, demonstration projects, sorting trials, and a variety of other initiatives as well organising an industry advocacy group. (<http://www.rebri.org.nz/about/>)

Its purpose is to promote, advocate and assist resource efficiency measures in the building and related industries and their goal is to provide the resources to:

- reduce waste disposal costs
- save money on raw materials
- use materials more effectively
- reduce the environmental impact from landfill disposal

- assist industry, councils and the community to meet the New Zealand Waste Strategy target (<http://www.rebri.org.nz/>)

13.2.3.1 Guidelines

More recently, in 2003, the National Construction and Demolition Waste Reduction Project was set up, as a joint project between central government, local government and industry, to extend this initiative even further, with the aim of developing tools and helping industry, councils and the community to reduce C&D waste at landfills and cleanfills.

The deliverables of the project included:

- An assessment of existing markets for recycled and reusable materials from C&D waste and the development of regional market development strategies for Auckland, Waikato and Canterbury
- A review of current legislative tools available to local and regional government to regulate C&D waste and guidance notes on regulating waste management under the Local Government Act (1974) and (2002)
- Best practice guidelines for C&D recycling and reuse operators
- A waste tracking system for the chain of custody and processing of C&D materials within the resource recovery industry
- Best practice guidelines for five sectors: design and planning, construction, home renovation, building products and demolition
- A website (www.rebri.org.nz) as a C&D waste reduction information portal for industry, local government and the community.

(http://www.nsc.govt.nz/our_environment/Waste_Minimisation/Businesscare/Construction-demolition.htm)

13.2.3.2 Case Studies

Since the publishing of the guidelines the Ministry for the Environment and a number of local councils have sought to apply the guidelines to practical construction projects. The Ministry's process is to identify possible and interested projects. The Ministry then engages with the project coordinators and develops a memorandum of understanding regarding resource efficiency and waste minimisation during the project. The Ministry then contracts a consulting firm to provide expert advice on the REBRI guidelines, resource efficiency and waste minimisation practices to project contractors. (Inglis, 2007)

The main objectives for these case studies are to:

- Test the validity of the guidelines on a practical project
- Build capacity within project contractors (e.g. designers, construction companies) for resource efficiency and waste minimisation
- Raise awareness and build momentum for resource efficiency amongst construction companies, waste contractors and the wider community
- Build a business case for resource efficiency
- Minimise waste coming off a significant construction project

13.2.4 Waste Minimisation (Solids) Bill

The Waste Minimisation (Solids) Bill is intended to increase the volume and variety of material recovered from the waste streaming to landfills around NZ. This Bill puts in place provisions to enable households and businesses to decrease their waste disposal. It includes provision for a levy on industrial waste, sets targets for reducing waste in landfills and cleanfills, provides for producer responsibility programmes, and provides for public procurement programmes to spur the development of markets for products and services that result in waste reduction.

http://www.parliament.nz/en-NZ/PB/Legislation/Bills/c/c/e/00DBHOH_BILL7267_1-Waste-Minimisation-Solids-Bill.htm)

Waste Minimisation strategies proposed include:

- Creation of a Waste Minimisation Authority
- A Landfill Levy - increased disposal prices will encourage greater volumes to be recycled.
- The establishment of a contestable fund for initiatives financed from Levy money
- Landfill bans
- Product Stewardship - companies putting products on the NZ market will be encouraged to take responsibility for developing and delivering end-of-life solutions that reduce the risk of harm to the environment
- Producer responsibility regulation
- Waste management plans submission with consent applications

On 14 June 2006 the Waste Minimisation (Solids) Bill had its first reading in Parliament. The Bill has been referred to the Local Government and Environment Select Committee and is to be reported back to the House by 31 October 2007. The Bill is expected to receive its second reading in late 2007. (<http://www.mfe.govt.nz/issues/waste/waste-bill.html>)

13.2.5 Department of Building and Housing

The Department of Building and Housing is the government agency that is responsible for the regulation of the built environment in general and in particular the quality and performance of buildings.

13.2.5.1 The Building Act (2004)

The Act contains a series of purposes and principles which the Department of Building and Housing, and building consent authorities, have to take account of in their duties under the Act. These principles include:
the efficient and sustainable use of materials (including material conservation), and
the reduction of waste during the construction process.

These measures will be regulated under the NZ Building Code. These measures need to be congruent with instruments set out in the Waste Minimisation Bill and their framing has been delayed until the waste minimisation measures have been firmed-up. (<http://www.level.org.nz/material-use/minimising-waste/>)

13.2.5.2 'Smarter Homes' (website)

Smarter Homes has been created for the Ministry for the Environment by a team including the Consumers' Institute, Beacon Pathway Ltd, URS, Creo, and Victoria University with assistance from a number of other interested organisations. Ongoing funding is provided by the Department of Building and Housing

It exists to provide clear, independent, factual information about sustainable home design, building and lifestyle options. The site is aimed at home owners and renters, and at building and property professionals who want an overview of smart home and building issues. The site has a section dedicated to on-site waste minimisation and gives links to related industry information. (<http://www.smarterhomes.org.nz/help/about-smarter-homes/>)

13.2.6 BRANZ (Building Research Association of New Zealand)

BRANZ is the principle body undertaking building industry research in New Zealand. Construction materials stewardship has not been a particular priority of this organisation except through the REBRI scheme mentioned previously.

13.2.6.3 'Level' (website)

'Level' is the professional/industry equivalent to the 'Smarter Homes' website mentioned above. The information provided is complementary to that contained in the 'Smarter Homes' website and deals more with the 'how' rather than the 'why' of sustainability. As with the Smarter Homes webpage the main focus is on energy conservation and efficiency rather than on material stewardship which barely rates a mention. However this deficiency is recognised and is likely to be addressed in the future.

13.2.7 Govt³

Recently, 49 government or government financed organisation, including all 34 of the ministries and departments and Victoria University of Wellington, signed up to what is called the Govt³ compact. The '3' denotes incorporation of triple bottom line, (financial, social and environmental) sustainable thinking in a wide range of public service activities including buildings. This is a voluntary scheme, and signals a 'green' shift in attitudes within the public service. The Ministry for the Environment's Sustainable Industry Group provides leadership and co-ordination. Govt³ provides a mechanism to contribute to the creation of successful outcomes through an iterative process of learning from and work with other government departments.

The declared aims of the group are to undertake practical action, learn from and share knowledge with other participating agencies, link people together and provide technical information and case studies. (Storey, 2007)

The group has developed a set of guidelines containing information on reducing both C&D waste and general office waste.

Their actions have impacted in the following ways:

- The Department of Building and Housing: changes to the building code have emphasis on sustainability and deconstruction; building construction procurement policies with energy efficient and whole of life requirements; The REBRI programme that measured C&D waste on construction sites, identified alternate markets for materials and introduced site recovery and waste minimisation programmes in major centres.
- Transit NZ introduced sustainability policy in 2003, resulting in changes to the aggregate specifications that facilitate the use of recycled materials and alternate enhancement of lower specification aggregates to minimise waste and make economic use of local materials. (Fredricsen)

13.2.8 Resource Management Act

RMA issues continue to influence heavily, particularly transport and site operating hours, effects management, contaminated soils (real and perceived) and a general propensity to make simple things difficult.

13.2.9 Renewable Energy and Carbon reduction policies

These policies potentially impact the wood waste recovery to energy market, and should be positive if seen as carbon neutral.

<http://www.ioqnz.co.nz/uploads/The%20Changing%20Scene%20for%20Construction%20and%20Demolition%20Waste%20Rec.pdf>

13.2.10 SCION

SCION is a biotechnology research institute with a number of national and international partners. Once they develop laboratory solutions they undertake pilot commercialisation programmes and work with their partner organisations to bring them to the marketplace.



Their 'Waste 2 Gold' programme is of particular relevance in relation to construction materials stewardship.

13.2.10.1 Waste 2 Gold

Scion is developing a range of innovative solutions that mitigate environmental hazard waste, and create marketable products from waste. Opportunities to make savings on waste treatment and disposal can be made, along with increased profitability for businesses. In particular, this means significant improvements in the overall environmental sustainability and international competitiveness of a business.

SCION is pursuing a range of added-value options in the following areas:

- Using waste as a bio-processing feedstock;
- Combining waste with other materials for added value products;
- Recovering energy and chemicals from wastes and residues.

Three examples SCION is already working on are:

1. **Bugs to bio-plastics** – turning waste into biodegradable polymers using novel bacteria – a renewable substitute for existing petrochemical plastics.
2. **Waste to composites** – by mixing waste with other materials, such as plastics, resins and additives, Scion are creating a range of novel products, including controlled-release fertilisers, biodegradable plant pots, panels, and other moulded plastic products.
3. **Biomass to energy** –converting residues into biogas, liquid biofuels, or solid energy systems (e.g. wood pellets for heating systems).

(<http://www.scionresearch.com/the+waste+2+gold+project.aspx?PageContentID=1061>)

13.2.11 WasteMINZ

The Waste Management Institute of New Zealand (WasteMINZ) is a non-profit organisation that was formed in 1989 to promote sustainable waste management practices for the benefit of all New Zealanders. Their primary function is to provide a forum for presentation and dissemination of information and to act as a facilitator for the waste management industry in New Zealand.

The organisation accomplishes these goals by hosting an annual conference, conducting regular workshops and seminars, publishing a newsletter titled Waste Awareness, sector groups, sharing information, and providing networking opportunities for members. In addition, WasteMINZ works closely with other organisations that also have interests and goals in specialized areas within the waste management field.

The WasteMINZ also interacts with other similar waste management organisations at the international level, and is a national member of the International Solid Waste Association (ISWA). WasteMINZ hosted the ISWA World Congress in 1997. This event, which was held in Wellington, New Zealand, attracted numerous international delegates. (<http://www.wasteminz.org.nz/about.htm>)

13.2.12 Local Government Initiatives

A number of City Councils are at the adopting their own plans, targets and guidelines for reducing construction and demolition waste.

13.2.12.1 Waitakere City Council

Waitakere City Council has a strong focus on sustainable initiatives. They have a section on their website dedicated to Sustainable Construction and Demolition. It answers questions such as:

- *What can the industry do to be more sustainable?* Use REBRI guidelines, suggests ways to protect the environment while undertaking construction activities, Sustainable Building Cluster.
- *What can I do as a resident who is building or renovating to be more sustainable?* Contains practical advice for home owners about getting informed, contacting council for help, Sustainable Home Guidelines, Eco-Design Advisor Service, informing contractors.
- *Why are we worried about C&D waste?* NZ Waste Strategy Targets
- *The National C&D Waste Reduction Project - Creating the REBRI Guidelines*
- *Waitakere C&D Waste Reduction Projects - Earthsong Eco-Neighbourhood*

The Council have also created *The Sustainable Home Guidelines*, which contains information on “Avoiding Construction Waste.”

13.2.12.2 North Shore City Council (NSCC)

The NSCC have developed a Waste Minimisation Plan (2005). The Council were also actively involved in the Construction and Demolition Waste Reduction Project, which resulted in the REBRI guidelines and a number of other deliverables. The North Shore City Council REBRI project initiative, which started in May 2006, uses the resources and tools developed in the Construction and Demolition Waste Reduction Project which was completed in 2005.

13.2.12.3 Christchurch City Council

CCC have undertaken a number of C+D Waste related initiatives

- Waste Minimisation (Recycling) Directory
- Waste Minimisation Guide
- Target Sustainability
- TerraNova – Recovered Materials Foundation (dedicated to renewing resources through smart thinking and innovative solutions).

13.2.13 ‘Beacon Pathway Ltd’

‘Beacon’ is a major research initiative relating to sustainable homes. It is a joint venture between government and industry. Amongst other things they have produced a series of demonstration projects.

The ‘NOW Home’ series are collaborative, live research projects testing ways to make sustainable living available to most New Zealanders, and undertaken by Beacon Pathway Ltd.

The design uses the best practices, materials and knowledge available today to improve the comfort, affordability and overall efficiency of the house. Aims include:

- reducing the production of waste during construction, occupation and eventual demolition
- using materials made from renewable sources and requiring the lowest possible energy input for their manufacture.

As NOW Homes were constructed, the waste generated on the construction sites was sorted to find out how much waste had been recycled or reused and thereby diverted from the landfill. REBRI resources were used as a guideline for good waste management practice. Photographic records of the layout and location of the waste receptacles, as well as a daily photographic site record of the overall building progress was made.

Designs for two other demonstration home series are under development. The first of these, the 'THEN Home' programme, and relates to renovation of existing houses, while the second is a 'FUTURE Home' programme

13.2.14 Zero Waste New Zealand Trust

The Zero Waste New Zealand Trust is a charitable organisation dedicating its effort towards 'zero waste and a sustainable New Zealand'. Zero Waste New Zealand Limited is a waste minimisation consultancy which was established in 2005 as a charitable company to financially support the Zero Waste Trust. The Trust works to influence and encourage people in New Zealand and overseas to think of rubbish as a resource, and on actions that lead to a sustainable society. New Zealand is the first country in the world to have formally adopted Zero Waste.

Zero Waste encompasses:

- Cleaner production (using less resources, creating less pollution)
- Product redesign so that products can be taken apart, and instead of being disposed of, the parts reused, recycled or composted
- Promoting reusable and recycled products
- Recycling or resource recovery
- Composting
- Implementing legislation including levies (taxes) that lead to producers and consumers paying the true cost of resource consumption
- Helping communities achieve a local economy that operates efficiently, sustains good jobs and promotes self-reliance
- Employment creation
- Reducing spending on resources and waste management

13.2.15 Sustainable Building Network (SBN)

The Sustainable Business Network is a forum for businesses that are interested in sustainable development practice. They promote sustainable practice in New Zealand and support businesses on the path to becoming sustainable. SBN link businesses and provide a forum for the exchange of ideas and experiences. Their aim regarding environmental quality is to implement practices and procedures that go beyond compliance through the adoption of proactive strategies to restore and enhance the environment, in which we live, work and play.

The SBN is involved with organising Conferences and Workshops which deal with waste.

13.2.16 Education

13.2.16.1 Victoria University of Wellington

A number of staff at the Victoria University of Wellington have an interest and have been actively involved in CIB TG39 and subsequently CIB W115 since the 2001.

13.2.16.1.1 Arch 222: Sustainable Architecture – 'Making a Material from Waste'.

In addition to a series lectures in this course on resource stewardship students develop solutions to the construction and demolition waste problem in New Zealand through an assignment entitled 'Making a Material from Waste'. This assignment has been running for the past 9 years. Students are asked to find inventive and effective ways to use waste materials to produce new products. Key 'problem' wastes are identified including plasterboard, rubber tyres, specific plastics and timber off-cuts. Students are then challenged to create new and innovative building materials from this waste. This project is aimed at moving from a linear *cradle to grave*

mentality to a more cyclic, closed loop *cradle to cradle* approach to design which aims to reduce waste while addressing materials use in the built environment.

13.2.16.1.2 UNITEC (Institute of Technology), Auckland

The Waste Minimisation course at UNITEC can be taken on its own, as a Certificate of Proficiency, as part of the one-year Diploma of Environmental Technology, as part of the three-year Bachelor of Resource Management or as part of the four-year Bachelor of Engineering (Environmental).

The course covers:

- cleaner production systems
- life cycle analysis
- waste auditing
- quality and environmental management systems
- Maori cultural aspects relating to waste management and the environment

One of the features of the course is that students get "hands on" experience in working with organisations in helping them to reduce their waste production.

13.2.16.1.3 Auckland University of Technology

As part of the Bachelor of Applied Science, AUT offer a Level 7 (third year) paper in Natural Resource Management but this is not specifically targeted at C+D waste.

13.2.16.1.4 Extractive Industries Training Organisation (EXITO)

EXITO is the Industry Training Organisation (ITO) for Resource Recovery. Training covers recycling, Zero Waste and Resource Recovery theory, metal recycling, solid waste collection, processing and landfill.

Formed in 1996 by Government Statute, EXITO works with industry based experts; New Zealand Qualifications Authority (NZQA), Tertiary Education Commission (TEC) and training providers, to provide industry with work based training and career pathways.

During December 2006, February and March 2007 the EXITO national survey of the Construction and Demolition Waste Industry was conducted throughout New Zealand. The purpose of the survey was to obtain data and information to facilitate future EXITO policy decision-making and enable accurate planning for the training needs of those people entering or involved in the New Zealand construction and demolition waste industry. (EXITO, 2007)

13.2.17 Professional Institutes

A motion was passed at the 2003 Annual General Meeting of the New Zealand Institute of Architects confirming that "the NZIA demonstrates support for the principle of working towards achieving zero waste in our cities by directing Council to put in place a strategy to promote zero waste at all levels", <http://www.zerowaste.co.nz/default,242.sm>).

A series of executive and presidential appointments made since that time has resulted in sustainability being regarded as a low priority item and very little has happened within the NZIA over the last with regard to construction materials stewardship.

IPENZ (Institute of Professional Engineers of New Zealand) has now taken over the leadership role in all aspects of sustainability from the NZIA

13.2.17 Recycling Operators of New Zealand Inc. (RONZ)

RONZ is the national body that represents businesses working in the recovered materials and recycling industries. They are involved in local and national issues as an advocate and counsel. RONZ lobbies for and promotes recycling, resource efficiency and waste minimisation in New Zealand. The organisation seeks involvement with a wide range of operators and organisations throughout New Zealand in order that the common objectives for waste minimisation can be identified and targeted in the most sustainable and beneficial manner.

RONZ is represented on the 'C&D Forum', a 'think tank' that engages with all sectors which contribute to generating waste through construction or demolition; architects and designers, building materials companies, building industry organisations, town planners, demolition companies, waste hauliers and disposal companies, recyclers and all levels of government.

RONZ acts as an advocate for architects, designers and kitchen builders as well as local authorities to design for recycling systems and recyclables storage capacity; in homes, offices, commercial premises and factories.

(<http://www.ronz.org.nz/ROnZpage.aspx?pageId=59#Construction>)

13.2.18 New Zealand Waste Exchangers

A number of waste exchange programmes exist around the country. The National Waste Exchange Database, sponsored by WasteMINZ (<http://www.wasteminz.org.nz.htm>), is a free service available as a website portal. It lists waste quantities and availability for each region in New Zealand to help businesses find alternative disposal methods. The 'RENEW' Waste Exchange is a region-wide information exchange designed to help businesses find markets for their industrial by-products, surplus materials and waste. Through RENEW, waste generators can be matched with waste users and re-users.

14 CONCLUSIONS

There is no unified stewardship approach to materials use in New Zealand. As with many other sustainability initiatives central government is leading the way with strategy and policy initiatives. The Ministry for the Environment (Me) is the principal government agency operating in this field, although other government departments such as the Department of Building and Housing (DBH) are involved in particular aspects of materials stewardship. Local government is responsible for waste collection and disposal, construct and manage landfills, waste transfer stations, licence clean fills²⁴ and undertake local waste minimisation and diversion initiatives within their own area.

Action by central and local authorities is largely focused on waste reduction, diversion and management programmes, aimed at prolonging the lives of landfills. Waste minimisation initiatives have been undertaken on a voluntary basis and responses vary considerably between local authorities. Many local authorities promote the idea of waste minimisation and over 50% have declared an intention of achieving zero waste; but few have put systems in place to attain that objective. C+D waste management and minimisation has until recently been a low priority target for central government and most local authorities²⁵. This has been in part because until very recently C+D waste was only measured at landfill sites and was reported as 17% of the total solid waste stream whereas most disposal of C+D waste occurs at clean fill sites. In the most recent Me report (Me 2006) C+D waste going to landfills, clean fills and monofills²⁶ is taken into account and C+D waste is now acknowledged to comprise between 60 and 66% of the solid waste stream. This has already resulted in C+D waste management being assigned a much higher priority.

²⁴ Cleanfills are licensed disposal sites for non hazardous waste.

²⁵ Christchurch City Council is a notable exception to this rule

²⁶ Monofills are disposal sites for single non hazardous waste.

Currently the only mechanism available to local authorities for C+D waste mitigation is to set landfill charges at a sufficiently high level so that diversion becomes a financially attractive alternative to dumping. However, only between 18 and 23% of C+D waste goes to landfills, the rest goes to clean fills. These are largely privately owned and set their charges to attract rather than discourage dumping. An unintended consequence of local authorities setting their own landfill charges is that C+D waste is delivered to cheaper distant landfills rather than the nearest ones, with resultant additional fuel consumption, CO² emissions and traffic congestion from disposal vehicles.

It is clear that the voluntary regime of waste mitigation for C+D waste has been largely ineffectual and central government is beginning to regulate in this area. These initiatives are covered under Objective 11 section of this report. However the mindset in central and local government remains largely focused on waste minimisation rather than construction materials stewardship.

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Slovenia

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ABSTRACT: Slovenia is a small European country with limited natural resources and space available for waste disposal. Measurements of the reuse of construction materials are undertaken and this report analyses current use of construction materials in Slovenia, legislation and regulations dealing with construction and demolition (C&D) waste, most often used deconstruction techniques and types of treatment applied to C&D

1 INTRODUCTION

Slovenia is a central European country located between Austria, Hungary, Croatia and Italy. It became an independent republic in 1991 after the secession from Yugoslavia and joined European Union in 2004. Total surface area of Slovenia is 20,273 km² (RS, 2007a). Land utilization is given in Table 1. The population of Slovenia is approximately 2 million people and according to census 2002 51 % of residents live in urban areas (SI-Stat, 2007). Since Slovenia is a small country its natural resources are rather limited. Their exploitation is further restricted by highlands which cover 70 % of the territory (RS, 2007b) and the fact that dwellings are scattered all around the countryside. Hence, the reuse of materials is one of the essential elements of promoting sustainable development, especially in the field of built environment, where large amounts of materials are consumed.

Land utilisation (%)

Woods	Agriculture	Bare soil	Water	Urban areas	Infrastructure
66.0	27.8	1.5	0.7	2.8	1.1

Table 1. Land utilization in Slovenia (RS, 2007a).

The aim of this report is to present an up-to-date picture of deconstruction and construction materials reuse in Slovenia. It discusses the current use of construction materials, currently valid legislation and regulations, deconstruction techniques as well as the types of treatment applied to construction and demolition (C&D) waste.

2 USE OF CONSTRUCTION MATERIALS

The current consumption of construction materials is the basis for the development of a national strategy regarding the reuse of materials. The quantities of basic construction materials consumed in Slovenia in 2003 are presented in Table 2. The value given for aggregate includes aggregates used for concrete and asphalt production as well as for different unbound layers. Concrete, which has an annual consumption of approximately 1 metric tonne per person, is considered as the most significant construction material in Slovenia. It is used for construction of bridges, viaducts, tunnels and for industrial, trade and sports buildings, as well as for hospitals and other public objects. However, in road construction asphalt surfaces are predominantly used and there are no concrete surfaced highways in Slovenia. On one hand this is due to the fact that there was a strong demand in Slovenia to build the major east-west and north-south trunk routes, therefore large investments were made in road infrastructure and concrete pavements would increase the cost significantly. On the other hand the knowledge of

concrete pavements by the people who commission and build infrastructure rather limited. Due to this lack of knowledge the investments in suitable equipment and technology are quite small.

	Quantity (metric tonnes)	
	Total	Per person
Aggregate	13,000,000	6.5
Concrete	2,000,000	1.0
Asphalt	820,000	0.410
Cement	340,000	0.170
Clay bricks	160,000	0.080
Metals	85,000	0.043
Timber	39,000	0.020

Table 2. Consumption of basic construction materials in Slovenia in 2003 (RS, 2006).

There are two major categories of domestic buildings in Slovenia. The first category covers houses built by developers. The majority of the buildings in this category are apartment blocks and semi-detached or row houses where the predominant construction material is concrete with clay bricks being the second most popular choice. The majority of individual residential houses are built by house owners. It is very common in Slovenia that a family builds its own house. In this case the first preference is for clay bricks, although cellular concrete blocks are also used.

Only a minority of houses are prefabricated and these are most often made of plasterboards or plaster-cellulose fibre boards attached to metallic or timber frame. It is interesting to note that a number of timber buildings is negligible in a country which is predominantly (66 %) covered by woodland (RS, 2007a). It is not entirely clear why this is the case, especially as timber is a renewable resource, however a short discussion held with architecture students at *Faculty of Civil Engineering, University of Maribor* suggests that understanding of the mentality of Slovenian people may provide some explanation. Many residential houses are built by the family and are handed down from generation to generation. Hence, materials that are perceived as strong and durable such as concrete and bricks are favoured for construction of family homes.

Clay bricks are considered to be more natural material, whereas wood is considered to have short life time, to cause problems with moisture and fungus and to be of a high risk for fire. Although most of these are prejudices, they seem to be firmly set in Slovenian psyche. It should also be noted, that new houses are usually made with good thermal insulation, are equipped with central heating and durable materials for finishing layers are commonly used. As the result the cost of residential buildings is high.

From Table 2 it can be seen that the consumption of metals and timber for structural purposes is comparatively small. The major use of the metal is for steel reinforcement in concrete, whereas the use of timber is confined to roof structures, to concrete formwork and scaffolding planking.

3 LEGISLATION

The legal basis for C&D waste processing in Slovenia is defined by the *Law on Environment Protection*. The first version of this law was published in 1993 and it has been frequently updated since that time. The current version was published in 2006 (UL, 2006) and succeeded the previous one published in 2004. It complies with European Union (EU) directives and is based on the principles of sustainable development, integrity and cooperation. Under this law the government and its ministries are required to prepare a *National Environment Protection Programme* which is implemented through several action plans dealing with different aspects of environment protection. Ministries are also responsible for data collection and the development and management of a publicly accessible information system. Waste is classified in accordance

with the *European Waste Catalogue and Hazardous Waste List* (EPA, 2002). This classifies C&D wastes including excavated soil from contaminated sites into group 17.

In compliance with the above mentioned legislation the *Action Plan for C&D Waste Processing 2004-2008* (henceforth referred to as *Action Plan*, RS, 2004) is currently operational. Its aim is to establish a good system for collection and recycling of C&D debris. Preference is given to separation of waste at source and its reuse at the original demolition site, whereas recycling is considered as the second and disposal as the last option.

Alongside the preparation of the *Action Plan* the specific *Regulations for Processing Construction Waste* (UL, 2003) were issued in order to enforce the concepts included in the plan itself. Supervision of activities is devolved to the *National Environmental Agency* (ARSO), which is authorised to collect data and issue licences for waste collection and recycling. Processing of C&D waste is the responsibility of the building developers (not to the contractors) who are considered as the owners of the waste. Hence, it is the developers' interest to reuse waste at the construction site as otherwise they are obliged to bear the costs for recycling or disposal.

When old buildings are demolished, developers are obliged to submit a *Plan of Demolition Debris Processing* in order to get a *Construction Permit*. After the demolition a *Report of Demolition Debris Processing* must be produced. This report must contain all relevant documentation stating the quantities of debris and any treatment applied. In this way developers are obliged to hand waste over to registered collection or recycling stations and number of unregistered stations has consequently reduced significantly in the last year. However, this is a sort of an ideal situation and in practice it doesn't always work that way. The major problem is the lack of knowledge and competence of architects, structural engineers, developers, contractors and civil service.

Collection and recycling stations must be registered. Licences are issued by ARSO for a period of 5 or 10 years and specifically for one or more subclasses of C&D waste, as defined in Group 17 of the *European Waste Catalogue and Hazardous Waste List* (EPA, 2002). In order to obtain the licence, the station must possess at least one adequately arranged facility and must assure reuse or recycling. There are 36 collection and 46 recycling stations currently registered in Slovenia. However, they are not evenly distributed. The most critical area is the central region of Slovenia, where the capital city is located, as this region produces at least 30 % of the country's total C&D waste. Collection and recycling stations are obliged to report to ARSO annually. In spite of many problems that still exist, it is considered that significant progress has been made and that the aims of the *Action Plan* have been achieved to a considerable degree. Therefore it will be possible to set higher goals in the new action plan which will be prepared next year to cover the period from 2009 to 2013.

Disposal, which is considered as the last and undesirable option for C&D waste treatment, is regulated by the *Regulations for Waste Disposal* (UL, 2000a and UL, 2004). According to its *Appendix 2* it is possible to dispose of six groups of C&D waste in landfills for inert waste, namely concrete (classification number 17 01 01), bricks (17 01 02), tiles and ceramics (17 01 03), mixtures of concrete, bricks, tiles and ceramics (17 01 07), glass (17 02 02) and soil and stones (17 05 04). Classification numbers are given according to the *European Waste Catalogue* (EPA, 2002). If large amounts of C&D debris are about to be disposed in landfills for inert waste evaluation of their properties is required.

It should also be noted that in 2005 the *Association for Processing Construction Waste* was formed as a non-governmental organisation. This brings together people and companies involved in different stages and aspects of C&D waste treatment. The aim of the association is to educate its membership and disseminate information and knowledge as well as to detect problems and propose solutions regarding technical and legislative questions.

4 DECONSTRUCTION AND DEMOLITION TECHNIQUES

Deconstruction in Slovenia is not yet widely practiced however a certain amount of casual and unauthorised deconstruction and reclamation occurs in abandoned buildings, as people simply carry away elements which they find useful for their own purposes. This is not the kind of deconstruction that should be stimulated as it may result in the improper use of materials and final disposal in backyards or illegal pits.

The advantages of planned deconstruction become obvious only when environmental benefit is considered. Otherwise demolition is usually faster and cheaper unless the price for waste disposal is high. That means that regulations are required to initiate use of deconstruction techniques as discussed in the previous section of this report. Another factor that plays an important role is the market price of primary and used or recycled materials. Achievement of deconstruction is also strongly dependant on the understanding and skills of site engineers and foremen. Many site personnel are not well informed on this subject.

The review of the current levels of deconstruction in Slovenia shows, that due to relatively high prices of metals, buildings are often stripped of metallic parts prior to demolition. This includes the electric installation wires which are stripped of their insulation in-situ. As the awareness of harmful effects of asbestos is quite high and the legislation is very strict, elements containing asbestos are usually carefully removed. The use of asbestos is now prohibited, therefore such elements cannot be reused or recycled but are wrapped in plastic foil and deposited in such manner as to prevent interaction with the environment. Timber is also selectively removed and used as wood biomass.

Buildings made predominantly of concrete are stripped of other materials and demolished in a way which enables reclamation of steel reinforcement, collection of concrete and production of recycled aggregate. However, concrete recycling is usually not performed on construction site. This is due to the fact, that if the mobile recycling unit is to be stationed at the construction site special permission must be obtained and in order to obtain such permit an elaborate submission dealing with dust and noise emissions must be provided. This process is quite time consuming and generally concrete lumps are transported to recycling stations for treatment.

Buildings which are made of bricks combined with concrete or other materials are not selectively demolished and this type of waste is not very appropriate for recycling and further use. Fig. 1 gives an example of a construction site during demolition.



Figure 1. Example of a construction site during demolition.

5 TREATMENT OF C&D WASTE MATERIALS

According to the official statistics the amount of C&D waste produced annually in Slovenia in period from 2004 to 2006 was about 1.5 million tons (SI-Stat, 2007). In 2003 official statistics showed only 0.76 million tons (SI-Stat, 2007) but that was probably due to inefficient data collection at the time, in connection with a significant number of unregistered recycling plants. Due to the enforcement of the *Action Plan* the number of unregistered stations has decreased and data collection has become more accurate. As shown in Fig. 2 as much as 45 % of C&D waste is still disposed in landfills and this percentage does not show a decrease over time.

The amount of recycled waste is approximately 35 % and there is no increasing tendency. For data analysis purposes the 2003 results should not be used because data collection was insufficient at that time. It is interesting to observe that although the adopted strategy gives preference to the reuse of materials, official statistics do not separately record the amounts of reused materials. Observations suggest that, with the exception of excavated soil, the direct reuse of materials is negligible.

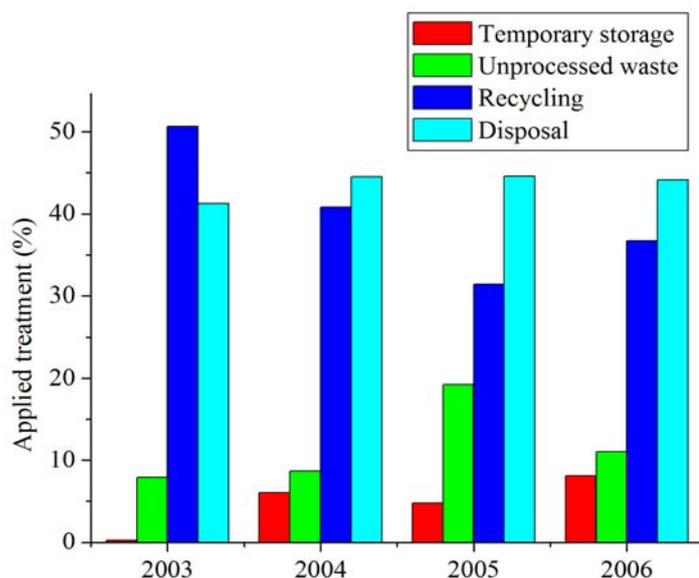


Figure 2. Treatment applied to C&D debris in Slovenia for years 2003 to 2006 (SI-Stat, 2007).

It was estimated that, for the *Action Plan* to succeed, there needed to be an active involvement of 25 to 30 biggest Slovenian construction companies who would establish their own collection and recycling facilities, preferably in a single location. In this way larger construction companies would process waste from their own construction sites. Quite a few of these companies have established their own facilities and two examples are given in Fig. 3. This has a positive effect not only on collection of waste and its recycling but also on the consumption of recycled materials.

Markets for recycled materials are not yet well established. This is connected to the lack of technical regulations and quality standards for recycled materials. Every material that is sold on the open market must be certified in accordance with the *Law on Construction Products* (UL, 2000b), which is based on *Construction Product Directives* (EU, 1989). In consequence this means that the product must bear the CE marking. As recycled materials significantly differ from primary materials they fail to fulfil the same standards and thus they cannot be traded. On the other hand the larger construction companies that recycle C&D waste from their construction sites tend to use their own recycled materials as they have a higher level of confidence if the origin of recycled material is known and (of course) in this way contractors

manage to reduce cost and increase their profit. The downside of such approach might be that inferior materials are used with negative effects on quality and durability unless adequate safeguards are in place.



Figure 3. Two examples of recycling centres for C&D waste in Slovenia.

A review of the reuse of construction materials listed in Table 2 shows that the most widespread reused material is asphalt, which is almost entirely used for the production of fresh asphalt mixtures. This is possible as technical regulations in this field are quite advanced and allow up to 10 % of pre-used asphalt to be added to fresh mixtures without additional testing.

Although there are no specific restrictions for the use of recycled aggregate in concrete such aggregate must conform to general standards for aggregates. As this usually cannot be achieved, recycled aggregates are rarely used for concrete mixtures and even then only when concrete for low grade applications is required. Thus, recycled aggregates are usually used for unbound layers. Reconsidered this situation would be worthwhile, particularly in the case of recycled aggregate sourced from high grade applications. Such concrete is made using good quality aggregate and the major portion of coarse recycled fractions actually consist of virgin aggregate. Hence, it makes little sense to use such aggregate for low grade applications in their second life cycle. Aggregates obtained from unbound layers and mixed debris or bricks are not adequate for concrete production and their re-use would be sensibly confined for unbound layers.

Metals are salvaged due to their high prices and handed over to metal industry, whereas the majority of timber is re-used as woody biomass, most often in municipally-owned district heating systems.

6 CONCLUSIONS

In the last four years Slovenia has made a significant progress in the field of processing C&D waste. However, a lot of work still remains to be done. Although good baselines have been set by legislation, it should not be forgotten that laws and regulations can become fully operational only if the people involved in the process develop a good comprehension of the problems to be addressed. Therefore it is recommended that significant efforts to educate architects, engineers and government personnel are made in order to carry out the following tasks:

- Architects:
 - design buildings which could be easily deconstructed
 - design building elements which could be produced with the minimum of waste and
 - select materials from renewable sources or materials which could be reused or easily recycled.
- Engineers:
 - assist architects in finding optimal solutions for tasks mentioned above

- design infrastructure in ways to facilitate deconstruct it at the end of its life cycle
- organise construction in such way to minimize construction waste
- apply deconstruction instead of demolition techniques and
- determine possible markets and applications for recycled materials.
- Central and local government:
 - set efficient administrative procedures to enforce concepts defined by legislation
 - in cooperation with engineers prepare standards and technical regulations for recycled materials
 - establish competent inspection services and
 - employ qualified personnel.

Since the emphasis of the above mentioned tasks is on education three Slovenian universities will have to face a challenge and consistently introduce the principles of sustainable development not only in their study programmes but in their everyday activities as well. In the mission statement only the oldest Slovenian university, namely the *University of Ljubljana* states that their objective is to train scientist and experts “capable of leading sustainable development, with a view to respecting the legacy of European Enlightenment and Humanism as well as human rights” (UN-Lj, 2008).

The recently established *University of Primorska* aims to “foster the transfer of academic knowledge and research achievements into practice” through taking responsibility for the economic growth and development of the nation and therefore implicitly to facilitate sustainable development (UN-P, 2008). The third university – *University of Maribor* is aiming for a transfer of knowledge into the Slovenian economy in order to assist business success on global markets (UN-Mb, 2008), which does not seem to involve a commitment to sustainable development.

Architecture and Civil Engineering programmes are offered only at the *University of Ljubljana* and the *University of Maribor*. An overview of subjects delivered in their programmes shows that in contradistinction to their mission statements specific subjects on sustainable development are taught out only at the *University of Maribor*. However, specific topics relating to construction materials stewardship, such as:

- design and construction of built environment which allow deconstruction
- deconstruction methods
- methods of reusing C&D waste materials
- possibilities to use municipal and industry waste in construction practice;
- management and economy of deconstruction and waste materials etc.

are not incorporated in suitable subjects in either University. This leads to the conclusion that the necessary major paradigm shift in the thinking of university leadership and teachers has not yet occurred.

A similar cerebral paradigm shift will also have to take place in the construction industry. The widespread current perception amongst understanding of practitioners is that waste originates at the end of the built environment life-cycle and emphasis is put on the reuse and recycling of waste. Due to this limited comprehension of the subject of construction materials stewardship architects and structural engineers who are involved in the design stage do not feel responsible for waste generation. As much of the waste generated could be avoided in the first place the “Reduce” principle needs to be addressed in the future during the education and continuing professional development of all design and construction professionals.

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Sweden

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1 INTRODUCTION

The environmental aspects of construction and demolition waste, C&DW, didn't significantly impinge on society until the early 1990s. While huge problems remain in this field, a lot has been achieved during the last fifteen years.

Based on information from regular waste enterprises, the amount of waste put to landfill in the year 2002 was 40% less than the 1994 figure. However, there is still no waste statistics in Sweden and it is therefore not possible to tell either the total amount of C&DW, nor how much is recycled. Some construction companies declare that today they put less than 10% of their waste to landfill, but it is assessed that in general about 50% of the total C&DW in Sweden is still put to landfill.

In Sweden, the most important issue in order to increase recycling is to sort out the environmental hazardous components from the waste. Therefore much effort has been directed to this issue.

This report gives a short overview and a state of the art regarding some of measures which have been taken in order to decrease the amount of C&DW and to improve the waste handling. The headlines connect to the objectives in the program for the CIB W115. In each section examples are given of projects, activities or initiatives in Sweden.

2 EFFECTIVE UTILISATION OF NEW AND EXISTING CONSTRUCTION MATERIALS

2.1 *Related Objective*

1 Determine ways for utilising new and existing construction materials in the most effective and ecologically, environmentally, socially and financially responsible manner possible

2.2 *Environmental building programme*

During the last ten years, several city communities have developed environmental building programmes for big building projects, where environmental aspects have been an important issue. One example is BO01 in Malmö which was a building fair for a neighbourhood with over 500 apartments mainly in multi apartment buildings. In 2007 one of these programmes was adopted by the Cecile Council ²⁷ as a model for building in Sweden.

The programme gives guidance for building materials, construction and demolition waste, household waste, water and sewer, energy, healthy building, building management and building user's aspects.

A tool for sustainable procurement has been developed, the Swedish Instrument for Ecologically Sustainable Procurement. Amongst other things, it contains environmental requirement specifications and related environmental information in criteria documents for the

²⁷ This is an association of around 30 organisations within the Swedish building and real estate sector. The history of the Ecocycle Council goes back to 1994 when the Swedish government through its "Ecocycle Commission" established informal contacts with a number of representatives of the building and property sector. To facilitate contacts with the Ecocycle Commission the representatives of the sector took the initiative to set up a network - the Ecocycle Council for the Building Sector. One of its first works was to investigate the main environmental impacts caused by the building sector.

goods and services that are most common purchased within the public sector. <http://www.eku.nu/eng/>

White-goods is, so far, only the only product group in the tool that is connected to buildings. However, new groupings are continuously being produced and the tool can be used as a model for building procurement.

2.3 Choice of material, environmental assessment of whole buildings

There are several systems and information sites available to enable material selection. A data base called BASTA has been developed for building materials and components which fulfil the requirements on chemical features set up by the Swedish regulation. The project was initiated by the building sector and was partly financed by EC's Life-fund. The work was carried out by persons from the big construction companies, the building material industry, architects, authorities, researchers etc. The work took about four years and the database was released in 2007. The database is intended to complement to other for material selection systems.

A number of environmental product declarations (EPDs), are presented on internet site run by the Swedish Environmental Management Council. <http://www.miljostyrning.se/eng/> The building product declaration is a Type II-declaration (the declaration and the information is provided up by the material producer) based on a model developed by the Ecocycle Council. There is an internet site where all declarations are presented.

There are also a number of other guides for the selection of sustainable building materials, as well as systems for environmental assessment of whole buildings.

3 LIFE CYCLE COSTING AND MANAGEMENT

3.1 Related Objective

2 Develop life cycle costing and management mechanisms for materials waste

3.2 LCC

Life Cycle Costing (LCC) is often used in Sweden for decisions regarding energy use, for example to choose the most energy efficient equipment, insulation standard etc. Future recycling is not included in current LCC-calculations.

4 WASTE REDUCTION

4.1 Related Objective

3 Develop systems to mitigate and ultimately avoid construction material waste

4.1 Goals and regulations

Timeline

- 2000 Tax on waste put into landfill is set at 28 €/ton.
- 2002 Combustible waste is not allowed to be put into landfills
Tax on waste put into landfills is increased by 10 %.
- 2003 Tax on waste put into landfills is increased 48% compared to year 2002.
- 2005 Compostable waste is not allowed to put into landfill.
The Building Council sets a goal for 2010 to reduce the amount of waste going to landfill at 50% compared to 1994.
- 2006 Tax on waste put into landfill is increased 74% compared to year 2002.

4.3 Demolition permit

Before demolition/deconstruction work starts, the developer must have a demolition permit from the city authority. To receive the permit, an investigation must be performed regarding hazardous components in the building as well as safety devices for dust, noise, working environment etc. The developer must also declare how all the waste will be sorted and handled. There are special requirements on environmentally hazardous waste.

4.4 Waste enterprises offers total control of C&D waste

Some waste enterprises have started to provide construction companies comprehensive solutions for C&D waste. The waste enterprise maps out the construction company's total waste flow. They make suggestions for how the waste should be sorted, handled and recycled and suggest routines for the waste collection.

The important advantage for the construction company is that it is a simple system, the waste handling is handled by waste specialists, and they have only one contact person at the waste enterprise. They also get continuously reports on the waste amount and the waste costs. This is important in order to improve their recycling and the quality of their environmental reports.

4.5 Waste fees

The costs have increased greatly during the last few years. Costs vary between different waste fractions; unsorted waste can for example be more than ten times higher than for wood. Both authorities and construction companies consider price to be a very important motivating force for increased sorting and recycling.

4.6 Education

There has been and are considerable efforts to educate all stakeholders within the building sector regarding waste handling. Issues that are focused on are, for example, environmental hazardous components in the waste, regulations, waste sorting, recycling possibilities, responsibilities etc. Also numerous brief and easy to understand brochures and booklets have been published, often directed to specific groups or focused on specific issues. This education is an important part of achieving progress in waste reduction and waste handling.

4.7 Industrialised building

Although industrialised building was not introduced with the intention of minimising waste, it tends to result in much lower on-site construction waste volumes. The waste produced at the manufacturing plant is generally clean, easily collected and can therefore usually be recycled.

5 CLOSED LOOP MATERIALS RECYCLING AND DECONSTRUCTION

5.1 Related Objective

5 Develop methodologies for designing closed loop materials use and for the effective recovery of materials and components from existing buildings

5.2 Integrated Reuse Research Project

The aim of an ongoing research project, is to produce a national overview of integrated reuse projects that have been realised. The question of why they have been realised will be addressed by an analysis of the conditions surrounding the project. Project drivers, triggers, enablers and constraints will be assessed and analysed. The knowledge gained in this project will benefit the process of constructing new buildings using the integrated reuse project concept. Furthermore, different government bodies will get a better picture of what is needed in order to promote integrated reuse projects, in terms of financial support, technological development and innovation.

6 WASTES AS RAW MATERIALS FOR MAKING CONSTRUCTION MATERIALS

6.1 Related Objective

4 Develop ways of using material wastes as raw materials for making construction materials.

6.2 Concrete, gypsum and mineral wool

Concrete is recycled by both general waste enterprises and enterprises specialised in concrete recycling. The produced materials are mainly used as road base but some is also used for new concrete.

Clean and dry gypsum board spillage can be crushed and used in new gypsum boards. New gypsum boards can consist of about 20% recycled gypsum. Already 2005 it was concluded that this recycling was economically beneficial due to the high landfill cost for gypsum. Several companies collect and crush gypsum waste.

Mineral wool wastage is also possible to recycle. There are some companies collect and tear mineral wool into loose wool, some with mobile equipment.

7 DfD

7.1 Related Objective

6 Develop design and construction methodologies for transformable and adaptable buildings and spaces to extend service life and so reduce overall construction material resource use

7.2 Survey of Swedish attitudes regarding Design for Disassembly and Recycling (DfD) in building construction

In Sweden the issue of design for disassembly and recycling (DfD), otherwise known as Design for Deconstruction, in building construction has just started. In order to get a picture of the attitudes to DfD, a series of interviews were undertaken with stakeholders connected to the building sector.

The questions asked were:

- How is your company/authority acting regarding DfD?
- What is, in your opinion, needed in order to introduce DfD in Building construction?
- What problems/constraints do you see for the different actors within the building sector?
- What knowledge is needed to introduce DfD in Building construction?
- Comments?

Interviews were held with construction companies, lean building construction companies, the Nordic eco-labelling of buildings, Ecocycle Council, Swedish National Board for Housing and Planning and the Swedish Environmental Protection Agency.

Most of those interviewed had a very positive attitude to the idea of DfD and considered it important to put the issue on the agenda. However, none of the informants had so far performed any DfD work connected to building construction or heard of any Swedish activities in this field. The lean building construction companies expressed great interest and considered DfD to be something that really would be worth developing. SIS eco-labelling of buildings had discussed the possibilities to include disassembly in the labelling but concluded that a method for evaluating disassembly first must be developed.

Several driving forces and constraints were identified by the interviewed stakeholder groups. The construction companies said that the Building Code is an obvious driving force. If economical benefits could be presented, they would of course also be important driving forces. Eco-labelling was also seen to be a strong driving force as DfD would be seen as a selling point, provide publicity and in the long run result in economic benefit.

As mentioned above, SIS eco-labelling of buildings are interested in including DfD in the labelling if assessment methods are available.

The Swedish National Board for Housing and Planning considered it as fully realistic to include DfD in the Swedish Building Code, providing that one can clearly identify either environmental or societal benefits from DfD. DfD could be expressed as a functional demand in the Code. They also expressed a positive attitude to a disassembly declaration, like a tax declaration of real property. It could be simple declaration defined say in only three levels.

The Ecocycle Council considered that it is now time to update the ten year old investigation of the main environmental impacts caused by the building sector. Based on the results from such investigation, the need of DfD can be evaluated.

The interviewees identified several areas where information would need to be provided. The need for Design guidelines were pointed out as being of special importance. This includes for example knowledge of the recycling processes for all building materials. What the environmental consequences of recycling are and what are the technical requirements, for examples, how do the various finishes on used on gypsum plasterboard affect the recycling process.

Some respondents pointed at the possibility that varying reasons for the call for moving a building (flooding caused by climate changes, unused buildings caused by decreased population etc) may result in the need for a variety of disassembly techniques and suggested that this possibility should be investigated.

Some stakeholders pointed out that there would be a the need to investigate the market for disassembled building products and the economical effects of DfD while others considered that there was a greater need to demonstrate the environmental benefits of DfD.

7.2 *Guideline*

A guide line for DfD is under development. The guide is directed at architects, engineers, developers etc in the building sector. It aims to introduce DfD, present the basic thinking of the concept and present guidelines for DfD.

8 PROMOTION OF MATERIALS AND COMPONENT REUSE

8.1 *Related Objective*

7 Establish strategies to promote whole building, component and materials reuse.

8.2 *Database for salvaged building components*

A database for second hand building components was established 1996 on the internet. There are thirteen depots spread over the country and each depot is responsible for putting their products in the database. The age, dimension, price, description and photo and region of each product is displayed. It is possible to search by type of product, location etc. The database has made it much easier to find and sell second hand products and so has increased material and product.

8.2 *Attitudes to moveable buildings*

A few surveys have been performed regarding people's attitudes towards movable buildings. An important finding is that movable buildings are often connected with bad and boring architecture. New and good design is considered to be the main challenge in order to increase the use of moveable buildings for example for day nurseries, schools etc.

8.3 Conditions and constraints for integrated reuse projects

An ongoing research programme aims at producing a national overview of completed integrated reuse projects. The question of why stakeholders have undertaken these projects will be addressed by an analysis of the conditions surrounding the project. Project drivers, triggers, enablers and constraints will be assessed and analysed. The knowledge gained in this project and earlier experience will benefit the process of constructing new buildings in Linköping using the integrated reuse project concept. Furthermore, different government bodies will get a better picture of what is needed in order to promote integrated reuse projects, in terms of financial support, technological development and innovation.

In some regions with surplus apartments, buildings have been disassembled and reassembled in regions where there is a great demand of apartments. Multi-apartment buildings have been reassembled as student apartments and row houses have been reassembled as row houses. A few companies have been started where moving buildings is their main business concept.

9 TOOLS AND TECHNIQUES

9.1 Related Objective

12 Develop the necessary techniques and tools to support the foregoing objectives

9.2 Data base on waste production

There are no definitive Swedish statistics on construction and building waste. Currently available information is based on assessments. Statistics Sweden is running a project to develop methods for data collection and develop a database.

Switzerland

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ABSTRACT: In Switzerland construction waste management is dealt with under regulations and guidelines based on the Environmental Protection Law. The legislation requires that waste is avoided or - if that is not possible - reused. Authorities can prescribe the reuse of waste if this is ecologically and economically reasonable. Standards regulate the waste management on building sites and the use of recycled material in construction. Approximately 11.1 million tons of construction waste is generated per year – excluding excavated earth. 84% is reused – either directly on construction site or after an appropriate treatment. The rest is disposed of on dumps or burned. Different tools are available for waste owners, waste disposition companies and waste-law executing authorities. One of them is the Disposition Guide. It consists of a central database listing all waste disposition systems and a web page that offers information about waste treatment.

1. LEGAL STATUS AND STRUCTURE

1.1 *Legal status*

Environmental protection in Switzerland is based on the Federal Constitution (Bundesverfassung [BV] 1999). In Article 73 and 74 the Constitution requires a sustainable handling of the environment. Harmful effects should be avoided and where this is not possible, the causer is responsible for resulting costs. Based on this article the government has issued numerous laws, regulations and guidelines. In addition private organizations issued standards, which also have an obligatory character.

1.1.1 *Laws*

In 1983 the Swiss parliament issued the Law for Environmental Protection (Umweltschutzgesetz [USG] 1983). The law contains the basic principles of waste management, without treating construction waste specifically. The law requires that waste should be avoided or reused as far as possible. The government can prescribe the reuse of waste if this is ecologically and economically reasonable. The cantons are responsible for the execution of the law.

1.1.2 *Regulations*

Numerous regulations relate to the Law for Environmental Protection. The major regulation in the field of waste management is the Technical Waste Regulation (Technische Verordnung über Abfälle [TVA] 1990). It requires the separation of construction waste on building sites. Waste has to be separated into the following categories: Unspoiled excavated earth, waste that can be disposed of in dumps without further treatment, inflammable waste and remaining waste. Excavated earth should be used for re-cultivation projects as far as possible, inflammable waste should be burned. Authorities can require waste owners to recycle their waste if this is ecologically reasonable, technically feasible and economically bearable. The federal states have to write a waste plan, which describes the state's waste management system.

1.1.3 *Guidelines*

The Federal Office for Environment FOEN has issued numerous guidelines aimed at standardising the way in which the federal states apply the regulations. The guidelines specify the national regulations and define quality requirements of waste to recycle. There is, for

example the Excavation Guideline (Aushubrichtlinie, BUWAL, 1999) and the Directive for Utilization of Mineral Waste Material (Richtlinie für die Verwertung mineralischer Bauabfälle, BAFU 3106, 2006).

1.1.4 Standards

The Swiss Engineer and Architect Association SIA and the Swiss Association of Road Building Experts VSS, regulate the waste management on building sites in their standards. These standards are mandatory. The associations require the creation of waste management plans in order to oblige the planners to implement waste management in the earliest planning and design phase (SIA 1993; VSS 1998). These standards also determine quality requirements for recycled construction materials. (SIA 1994)

1.2 Structure and responsibilities

Switzerland consists of 26 federal states all of which have their own constitution and federal laws. In the field of waste management, the national government is responsible for issuing laws while their execution is the responsibility of the states. Additionally the states and municipalities have their own more specific laws and regulations on waste management. The Federal Office for Environment FOEN tries to standardise the application by issuing numerous guidelines.

1.3 Classification

According to the SIA 430 (SIA 1993) construction and demolition waste is grouped into four different types:

1. Excavated Earth (“Aushub”)
2. Construction and demolition debris (“Bauschutt”) which is further differentiated into road construction waste (“Strassenaufbruch”), asphalt debris (“Ausbauasphalt”), concrete debris (“Betonabbruch”) and mixed debris (“Mischabbruch”)
3. Bulky construction waste (“Bausperrgut”)
4. Special waste (“Sonderabfälle”)

2 STATISTICAL OVERVIEW

2.1 Introduction

In the field of construction waste, no statistics have been made in the recent past. In 1998, the FOEN and the federal states assigned an engineering company to execute a calculation model on resulting construction waste between 1997 and 2010. The results have been published in 2001 by the FOEN (BUWAL 2001). In 2004 those results have been checked critically within the framework of a more general annual waste statistic (BAFU 2004). The examination showed that the construction waste amounts have not change much since 1997.

2.2 Swiss building stock

The following model calculation, is based on data from the Federal Statistical Office (Bundesamt für Statistik BFS, 2005) and displays material flow calculations for Switzerland. The Swiss building stock consists of 2.46 billion tons of embodied construction material, of which about two-thirds are stored in structural engineering stocks and one-third is stored in civil engineering stocks and other infrastructure buildings. The major material groups are concrete with approximately 1060 million tons and gravel/sand with 760 million tons.

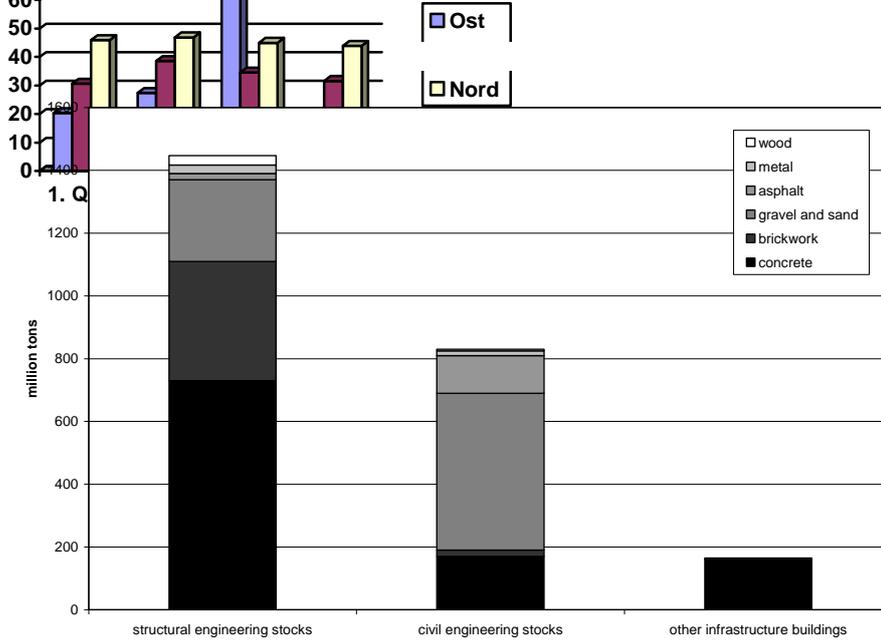


Figure 1: Estimated construction material stocks in structural and civil engineering and other infrastructure buildings (BFS 2005)

2.3 Construction waste and types of disposition

The embodied materials are the source of future construction waste. In 1997, 11.1 million tons of construction waste were produced by demolition, renewal and building of structures. Excavated earth is not included in those amounts.

Approximately 42% of construction waste is reused directly on the construction site. This amount consists exclusively of road construction debris and bitumen waste. Another 39% - mostly concrete, bitumen and mixed debris and gravel/sand - is reused after an appropriate treatment. This makes a total of 81% of reused waste. The remaining waste is either disposed of in landfills (approx. 1 million tons) or burned. Wood waste contributes two-thirds of the burnt s.

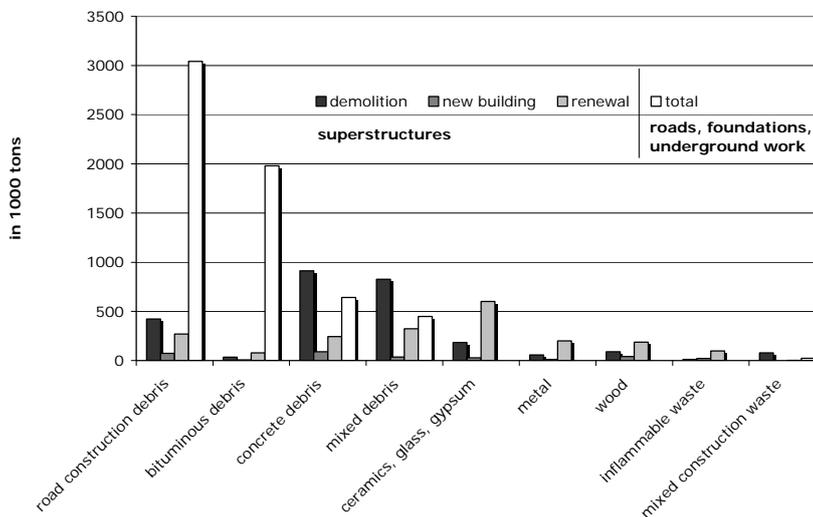


Figure 2: Construction waste in Switzerland 1997 (BUWAL 2001)

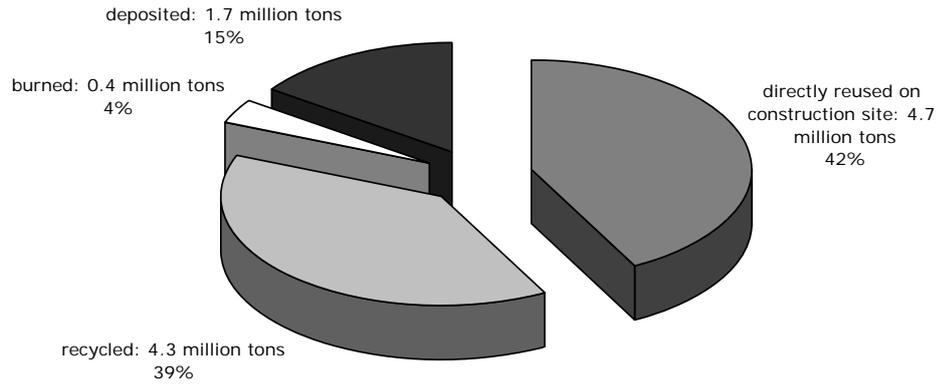


Figure 3: Disposition of construction waste in Switzerland 1997 (BUWAL 2001)

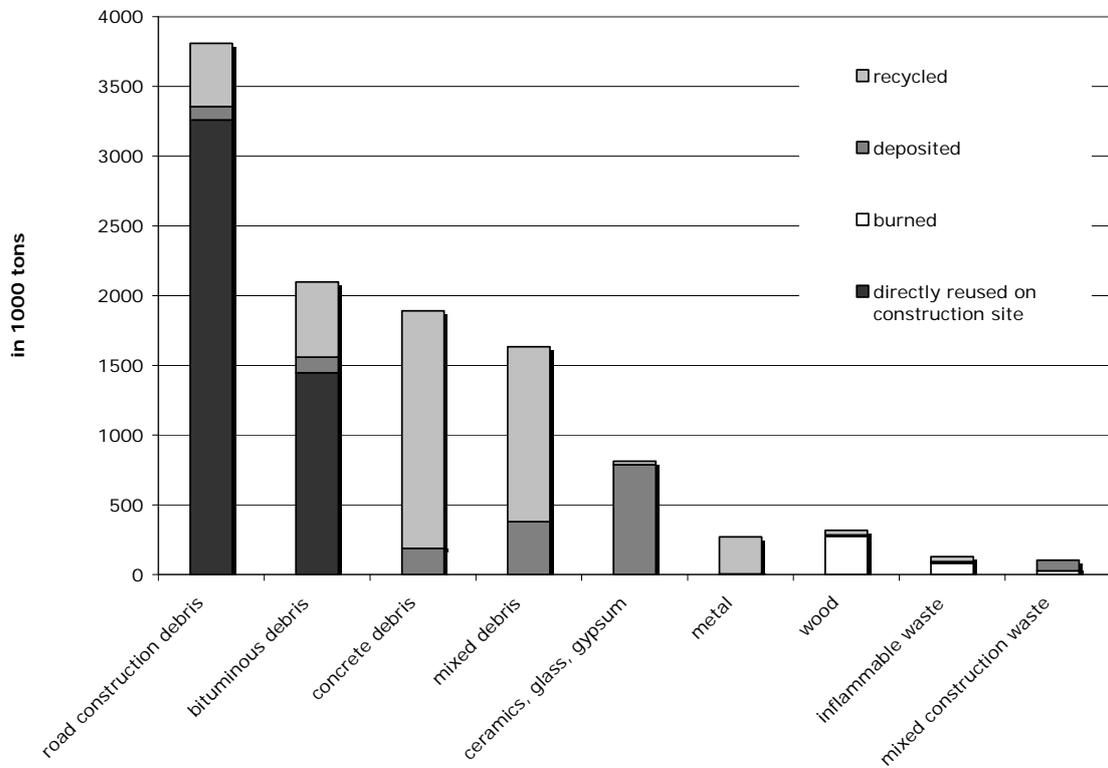


Figure 4: Disposition of construction waste types in Switzerland 1997 (BUWAL 2001)

3 STRATEGIES AND CURRENT ACTIONS

In Switzerland, there are several guidelines, recommendations, labelling systems and other tools that tackle the problem of construction waste management by way of building strategies, disposition strategies and reuse and recycling strategies.

3.1 Building strategies

3.1.1 SIA 112/1: Recommendations for sustainable building

The SIA 112/1 (SIA 2004) provides guidance that enables principal and planner to communicate possible tasks and objectives in sustainable building. It covers social, economic and ecological aspects of sustainability in building through defined criteria and objectives. Propositions and recommendations for the choice of appropriate construction materials are made:

- Use of available primary resources and a maximum use of secondary (reused or recycled) resources
- Use of materials with low embodied energy and low environmental impacts
- Avoiding materials which emit harmful substances
- Use of assemblies, techniques and devices that facilitate easy separation for reuse or recycling

3.1.2 SNARC: System for an environmental sustainability assessment of architecture projects

SNARC (SIA 2004) is a tool for assessing a project during an architecture competition. It is a systematic approach aimed at facilitating an impartial assessment of a project's fulfilment of environmental objectives. The evaluation criteria cover important aspects like resource demand and embodied energy in construction and flexibility for later refurbishment.

3.1.3 MINERGIE-EC

MINERGIE is a label for sustainable buildings in the Swiss cantons Bern and Zurich. It has been initiated in 1994 by the Association MINERGIE and is the most important energy-standard for low-energy buildings in Switzerland. In 2006, the MINERGIE-ECO standard has been added in cooperation with the Swiss association eco-bau. This Standard does not only cover aspects of energy-efficiency and thermal comfort, but also ecological aspects concerning the choice of construction materials and indoor environmental quality. In order to get a MINERGIE-ECO certificate, a building needs to fulfil a catalogue of criteria on the basis of the MINERGIE-standard and the SIA 112/1. The use of recycling concrete is mandatory.

3.1.4 Instruments for sustainability assessments: Survey and orientation aid (*Instrumente zur Nachhaltigkeitsbeurteilung: Bestandsaufnahme und Orientierungshilfe*)

This handbook has been published by the Swiss Federal Office for Spatial Development (Bundesamt für Raumentwicklung ARE) in 2004. It is a descriptive compendium of the multitude of instruments used for an assessment of sustainability in Switzerland, Austria and France. Its aim is to give designers guidance and orientation in their choice of an adequate evaluation-tool for sustainability and to help them to understand why this instrument will help them within a particular context.

3.1.5 'Eco-bau' requirements sustainable building ('Eco-bau' Vorgaben ökologisch Bauen)

'Eco-bau' is a common platform of the public building departments from federal, state, and city governments with recommendations for sustainable planning, building and maintaining of buildings and systems. Eco-bau offers checklists for sustainable material decisions. This information is also integrated in cost planning software as additional components. The aim of those additional components is to graphically represent ecologically advantageous performances. This helps planners to integrate considerations about sustainability in building projects and material decisions. The information given primarily directed towards designers assigned by the public building departments. (Eco-bau 2007) The requirements are already being used at many building departments, for example in the cantons of Zurich and Bern as well as in the City of Zurich (Amt für Hochbauten).

3.1.6 SIA 493: Declaration of ecological features of building products

The SIA 493 (SIA 1997) is not a standard but a recommendation issued by the SIA. It defines the ecologically relevant features that have to be declared for fourteen building product groups. It standardizes the terminology and the form of the declaration. The declaration grid implements the most important features on the production, the processing, the use and the disposal of a

building product. The recommendation aims at listing and standardizing valuation criteria. It is aimed at designers in building companies.

3.2 Disposal strategies

3.2.1 Disposal Guide (Entsorgungswegweiser)

The Disposal Guide was developed on behalf of the federal states, the FOEN, the ARV (Association of recycling companies) and the VBSA (Association of waste disposal companies). It has two primary components. The first is a database that lists waste disposal companies that fulfil the requirements set out in legal statutes. The second element consists of a website that offers a collection of leaflets, and guidelines on waste management and defines terms in the field of waste treatment. On the one hand, the Disposal Guide aims at standardising the federal states' execution. On the other hand, it aims to inform waste owners of simple and correct ways of treating their waste. So the Disposal Guide is aimed at the state authorities, waste owners and at managers of waste disposal systems. (Abfallinfo Schweiz GmbH 2006).

3.2.2 Multi dell concept (Mehrmuldenkonzept MMK)

The Mehrmuldenkonzept (MMK) (SBV 2001) was developed and published by the Association of Swiss Construction Entrepreneurs (SBV) based on the Technical Waste Regulation. It is an aid for site managers to correctly treat and separate waste on the construction site. The MMK defines different standardised contents of waste containers and ways of disposal. The MMK aims at facilitating quick and rational disposal ways within close proximity to the construction site. The MMK is aimed at managers who have to implement a waste management plan in accordance with the mandatory standards laid down.

3.3 Reuse and recycling strategies

3.3.1 AWEL Project: Gravel for generations (Kies für Generationen)

The Office for Waste, Water, Energy and Air (Amt für Abfall, Wasser, Energie und Luft AWEL) recently launched this project with the objective of encouraging the gravel, concrete and deconstruction industry to use mineral deconstruction material for high quality recycling concrete instead rather than sending it to the landfill. The project will be supported by the Association of the Swiss gravel and concrete industry (Fachverband der Schweizerischen Kies- und Betonindustrie FSKB)

3.3.2 Component network Switzerland (Bauteilnetz Schweiz)

Bauteilnetz Schweiz is a private association that promotes the reuse of building components. Founded in 1996, it has now over 60 members, 15 of whom work in component stock exchanges or component shops. The association's website is a platform for the selling and buying of components and for general information about waste management and recycling. Bauteilnetz Schweiz targets architects, construction companies and private buyers. According to the business report (Bauteilnetz Schweiz 2006) the sales of the involved companies amounted to two million Swiss francs in 2006, which corresponds to a volume of about 2600 tons of building components, which represents a ten fold growth from its first operational year, 1997. (Bauteilnetz Schweiz 2007)

3.3.3 KBOB Recommendation: Concrete with recycled aggregate (Beton aus recycelter Gesteinskörnung 2007/2):

The KBOB (Coordinator of the federal building and real estate agencies) (KBOB 2007) has published a leaflet on the use of recycled aggregate for the production of concrete. It contains information about the advantages of using recycling-concrete in building in order to motivate designers to use recycling-concrete instead of normal concrete

3.3.4 Leaflets of the ARV (*Merkblätter des ARV*)

The ARV, an association of companies in the field of excavation, demolition and construction material recycling has issued numerous leaflets. They summarise relevant laws, regulations and guidelines. The leaflets are addressed directly at the industry's companies with the intention of giving them an overview of the legal situation and what the associations offers. (ARV 2007)

4 OUTLOOK AND POTENTIAL

4.1 *Status Quo*

Although there are no special incentives of the government, most construction waste is reused – either directly on the construction site or after an appropriate treatment. This proves that reuse is technical possible and economically feasible. The basic conditions for sustainable waste management are favourable. Waste owners can find information about different ways of disposal easily and quickly. Designers who want to build with recycled materials can rely on numerous aids. Building with recycled materials is regulated in the standards. The execution of laws and regulations is relatively consistent from one federal state to another.

4.2 *Recommendations*

Today, there is still about 1 million tons of the total construction-waste being disposed of in landfill dumps. Mixed debris and concrete debris constitute the main part of this disposed waste.

Where possible, waste should be reused directly on the construction site. Where reuse is not possible, construction-waste should be recycled. In some fields, the recycling technology is already available and the recycled products are tested in practical application. Those material cycles should be aiming to become closed loop in order to prevent construction waste disposal entirely.

Basic conditions for considerations on sustainability are favourable. Society is becoming more and more conscious of environmental subjects. Builders should learn more about sustainable building technologies in order to raise pressure on building companies to use those technologies

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The Netherlands

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Abstract: The conventional way of construction, has become a burden to the dynamic and changing society of the 21st century. Developers and real estate managers warn that there is a miss-match between the existing building stock and the dynamic and changing demands with respect to the use of buildings and their systems. LUMC project in Leiden indicate that buildings in the health care sector reconstruct on average 10% of their footprint per year. Offices needs are under constant change and require flexible environments.

A report by the World Resource Institute projects 300% rise in material use as world population and economic activity increases over the next 50 years. The price of steel is rising. Raw materials supplies are gradually depleting and becoming increasingly expensive. Landfill sites are filling up, forcing increases in waste disposal taxes and making waste management exceptionally expensive.

Ultimately the physical impact of increasing building mass in industrialised nations and the developing world will become undeniable in 21st century.

It can be argued that existing construction methods are in large part responsible for the increase of the total life cycle costs of the building, material/energy use and waste production. If building practice does not evolve towards building methods that stimulate reuse and the recycling of buildings and its constituent parts (by for instance deconstruction) the gap between conventional approach to development of buildings and the key principles of sustainable design (such as, adaptability to the user needs, cost reduction, conservation of natural resources, energy saving, waste reduction etc.) would increase considerably.

In order to find a balance between the efficient use of materials, changing user demands and increasing life cycle costs a different approach to building design and construction is needed. Such an approach might focus on the long-term performance of building structures and materials.

An attempt at such an approach is a Dutch Government programme called IFD (Industrial, Flexible and Demountable) Buildings.

The aim of the programme was to introduce flexible building concepts by the use of industrially produced demountable systems.

This report will examine the potential for broader implementation of the IFD design and construction approach.

1 INTRODUCTION

The exponential increase in population and contemporaneous increase in standard of living for many, will mean that the demand for essential goods & services (transportation, cars, planes, but also housing, materials, water, food) will increase by at least a factor 2 in the next few decades (Natalis, 2007). Many scientists speculate that if 9 billion people have a western life style we would need 6 Earth's to provide the necessary resources to sustain such a population (figure 1). In many fields the limits of what Earth can sustain have already been reached. If the need to support an additional 3 billion people and effect of increased per capita consumption is added it is clear that there is only one option: we need better and sustainable solutions to treat material resources (Natalis 2007).

If the building sector is to respond to this challenge building sector it needs to provide buildings that are smart, transformable and adaptable and that their structures can be utilised as a resource pool for a new construction.



Figure1: The consequences of the increase of the resource consumption

The fundamental questions are:

- Why not design building structures for remanufacturing and reconfiguration in place of demolition and down-cycling?
- Why not design buildings and systems that can serve multiple purposes?
- Why not reduce energy and material consumption by considering buildings as resource pools for a new construction?
- Why not consider waste and demolition as a design error?

2 STATE OF THE ART-IN THE NETHERLANDS

The economic contribution of the Dutch construction industry is 5.1% yet the Dutch building industry has accounts for 25% in road transport, 35% of the national waste production and 43% of the national energy consumption and CO₂ emissions

Construction and demolition waste in the Netherlands has increased from 19 Mton in 2000 to 24.967Mton in 2003. (table 1)

Whilst 23.977Mton of construction and demolition waste out of 24.967Mton generated most ended up in useful application in a form of material reuse which is associated with down-cycling of materials. 90% of demolition and construction waste in the Netherlands is being down-cycled for use as road base. There is also an imbalance between the contribution of the Dutch Industry to the GNP and the level of material exploitation.

The construction industry generates 5% of GNP whilst it exploits 50% of material resources. Even though the Earth has its limits when it comes to its resources it is evident that the construction industry, which is the biggest consumer of the Earth's resources, is dependent on inefficient production methods and processes which do not enable closed-loop recycling of building materials. Basically building construction is optimised to provide answers to short term

problems (initial use concept) after which materials are dumped or down-cycled to a lower level application.

Afval in Nederland per doelgroep (2004)

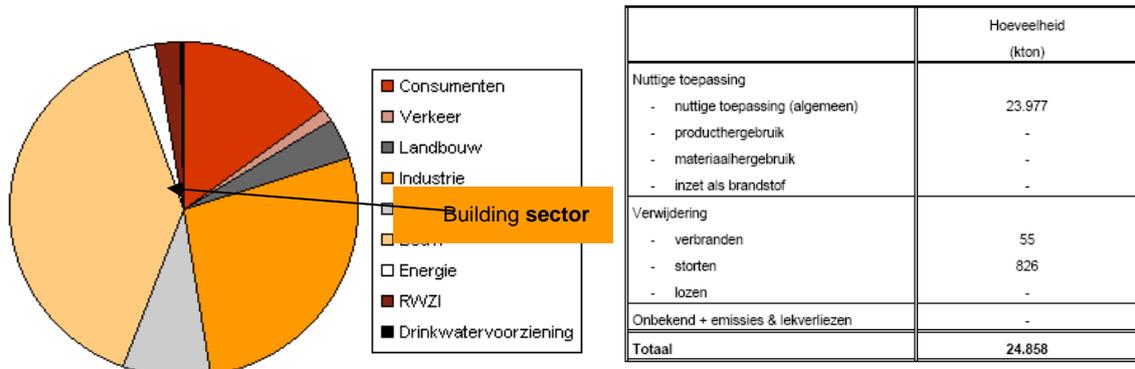


Table 1: Waste in the Netherlands per sector (2004)

Another disproportionate effect, related to the current building process, is one of invested capital. Buildings are made of materials that have different durability from 5-50+ years. Yet according to the centre for building statistics in the Netherlands CBS, Dutch families are moving on average every 10 years. (Keyner, 2006). Considering the conventional building practice that does not support material and systems recovery, basically all buyers of building materials and thus buildings loose, at the certain point a great deal of their initial investment.

year	Average building costs euro's/m3
1995	158
1996	162
1997	169
1998	174
1999	182
2000	190
2001	207
2002	224
2003	232
2004	232
2005	234
2006	236

Table 2: Increase of the construction costs per year in the Netherlands (CSB 2007)

This loss is growing bigger with continuously increasing building costs (Table 2). Building costs are going up at double the increases in market value. According to the Centre for Building Statistics in the Netherlands (CSB) the reason for the enormous increase of the construction costs lay in the increased cost of the loans and material. CBS predicts that construction costs will continue to go up in coming years and that one can expect a serious shortage of the labour.

In order to stimulate construction industry to develop alternative construction methods that will address issues of material efficiency by remanufacturing, reuse and customization of industry Dutch Ministry of Economic Affairs and Housing has initiated IFD (Industrial, Flexible and Demountable) building programme.

Development of industrial, flexible and demountable building systems results in significant cost savings because these systems could be easily adapted and remanufactured. As such the IFD approach can bridge the gap between the construction methods /user requirements and environmental responsiveness.

3 IFD BUILDINGS

IFD stands for Industrial, Flexible and Demountable building approach. As a part of this programme about 90 concepts have been developed in the past 9 years. A number of developers, manufacturers and contractors that are interested in industrialised flexible, demountable building concepts that are more targeted to the end user is growing. Some of these are developing companies to implement particular designs. ERA, which developed a concept called Personal Housing,(IFD 2000). HBG adopted the Smart House designed by Robert Winkel (IFD 2000). Zondag Bouwgroep developed the “gewilde wonen” based on the concept of C. Weber. Nijhuis developed Trento, etc.

Industrialised in the IFD concept means an Open system assembled from prefabricated components. It is about introducing a manufacturing model in building assembly so that building components can be easier replaced or reused.

Flexible in the IFD concept is a set performance parameters aimed at meeting client needs for the building during its technical life span.

Demountable in the IFD concept is a set of strategic performance parameters of the building system that aim to enable disassembly and recovery of building materials for reuse, reconfiguration or recycling.

The aim of IFD buildings is to upgrade the industrialisation of housing by involving users in project development from the beginning of the developing process. The evaluation of IFD projects indicate that often, once the owner/user has made a choice about the house form and design, technical systems are put in place which do not support adaptability, replacement or reuse of building components. In other words most of these customised building systems do not offer a freedom of choice to the second user/owner of the house. However, considering the trend of increase of changes in the buildings in general, coupled with increase in construction costs and negative environmental impact, one can expect that measures to facilitate transformation and recovery of building materials will be integrated into the next generation of IFD customised housing concepts.

This trend can be recognised in the fact that IFD has reacted very positively to individual development of flexible systems, where disassembly and replacement of components has been considered as a priority during system development. Systems worth mentioning are floor and electrical systems, as they have solved some problems of the fixed integration between structure and services. Some of these are Corus Star-Frame floor, Infra+floor, Wing+floor, Kabelweg system, KISS system and many others. (figure 2).

3.1 ‘Smarthouse’

Recently built family ‘Smarthouse’ system houses in the Netherlands exemplify designs where IFD principles have been applied.

3.1.1 Flexibility Strategy

The ‘Smarthouse’ system has the following flexibility aspects: exchangeability of façade, roof, partitioning walls, installations, extendibility of the structure, and spatial flexibility. The load bearing structure of the “Smarthouse” is made of steel. Façade, roof, floor and separation walls are sequentially assembled into structure and each system could be replaced without interference to others. Installations are distributed through the hollow floor what makes functional flexibility possible.

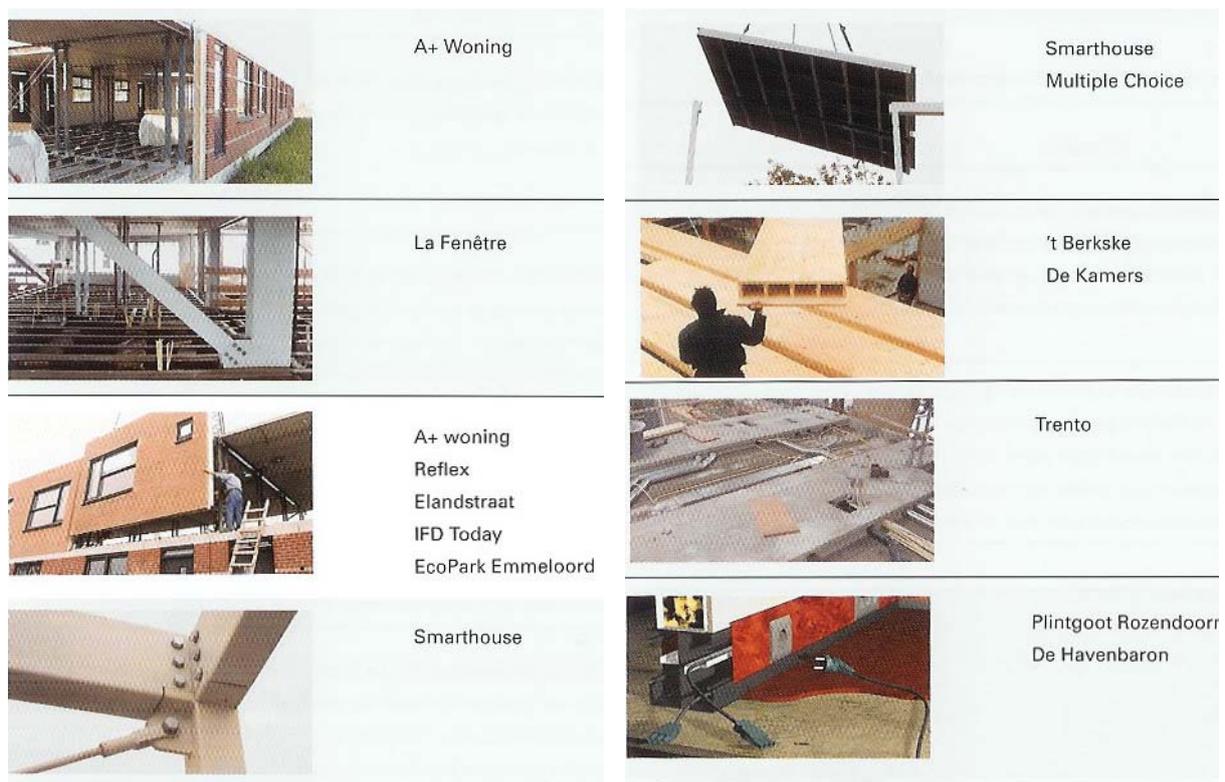


Figure 2: systems developed within IFD program

3.1.2 Dismantling Strategy

The weight of 'Smarthouse' is 25,000 kg including the weight of load bearing structure (5000-8000kg). This is one fifth of one conventional house (Winkel 1999). Bearing in mind that the components are made in factories and then transported to the assembly sites, it would be possible to transport fully assembled 'Smarthouse' housing units, to site as its weight does not reach the maximal weight that could be transported on one truck (35.000 kg.). All parts of the 'Smarthouse' can be dismantled to the single component (figure 3). The possibility of returning the components to the manufacturer for reintroduction into the production and building process is being considered

3.1.3 Recycling Strategy

Most of the steel components could be easily reintroduced into the building process as a half product. Compared with material recycling, half product reuse saves much more energy. The partitioning walls are constructed with gypsum boards that are finished with recycled paper and waste products. All boards will be reintroduced into the production process.

4 WASTE PREVENTION BY DESIGN

Experience with IFD projects has shown that the real problem of sustainable construction does not lie in product development itself but in development of an integrated design concept that makes use of flexible, industrial, and demountable systems. In other words, a systematic integration of issues from changing use scenarios to the manufacturing of products, which would support the use scenarios, would be needed in order to see IFD as a viable alternative to the way we built today.

The possibility of disassembling a component during transformation of the layout, or being able to remove the component for maintenance or repair, makes the building and its components reusable and extends their life cycle use. This integrates Industrial, Flexible and Demountable parameters into one sustainable building concept.

The requirement for high disassembly potential in a building and its systems/components introduces a three dimensional-transformational concept to building design. This 3D effect encompasses spatial, structural and material transformation. (Durmisevic 2006) (Figure 3). Such a concept takes account of material recovery during spatial transformation, system/component reconfiguration/reuse during structural transformation and material up-cycling during material transformation. The key to each dimension of transformation within the building and ultimately towards a completely “transformable” building, is disassembly. A three dimensional-transformational strategy requires a customised production technique that increases building flexibility in layout, technical solutions, components and finishes.

With this in mind the new target for innovation in construction is to increase the transformational capacity of buildings on three levels of construction:

- Building level – ensures continuity in the utilisation of the building through spatial adaptability,
- System level - ensures continuity in the use of systems and components through replace-ability, reuse and recover of building components
- Material level - ensures continuity in the effective disposition of the materials through reuse and up-cycling of building materials (figure 3).

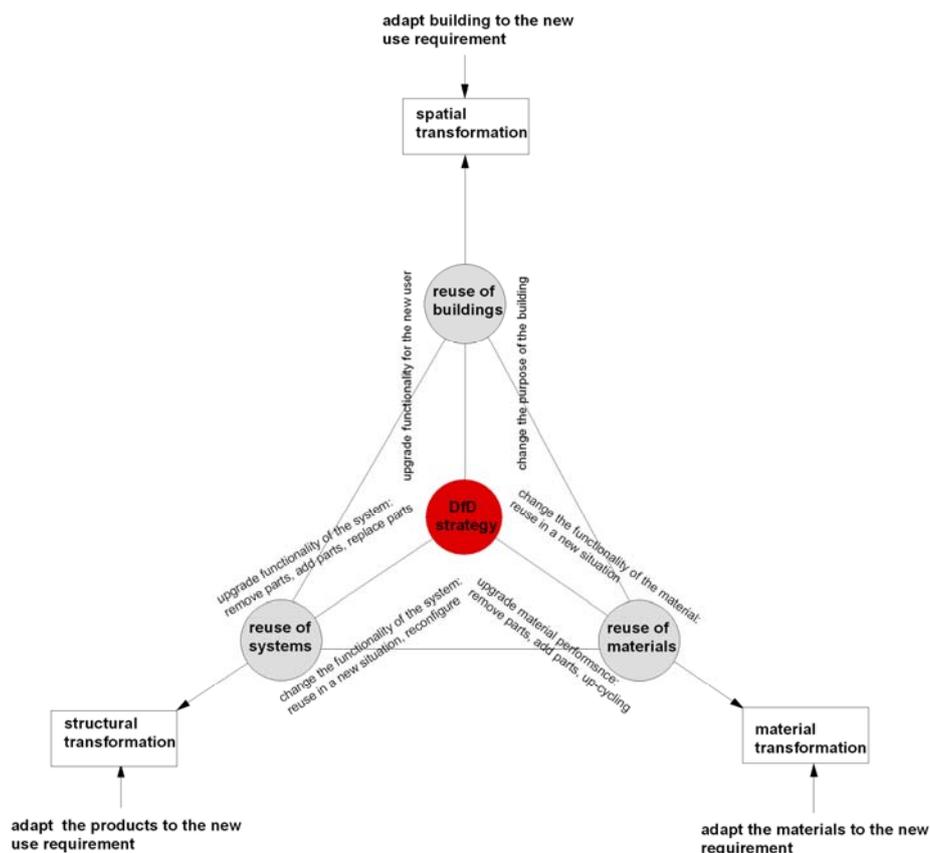


Figure 3: Three dimensional transformational concept

In such way, development of Transformable Industrial Buildings(TIB) integrates issues from spatial adaptability and flexibility of building systems to material efficiency and energy saving. It can also integrate concepts from “function neutral buildings”, “customisation of housing” and “zero energy buildings” to “supply driven design”, “reuse” and “cradle to cradle”.

There are a number of initiatives at the moment as a follow up of IFD programme that aim to increase Transformation capacity of buildings and systems such as; construction of a Housing project in Amsterdam “SOLIDS”, development of a flexible concept for high-rise housing together with architects Ken Yeang, development of building system that would be rented instead of sold and many others. Some of these cases will be discussed in further text.

4.1 Het Oosten ‘SOLIDS’

‘Solids’ is an experimental project initiated, by the biggest housing corporation in Amsterdam and is currently under construction. The main concept of the ‘solids’ building system is to create a high quality envelope and services for the apartment building (mix of social housing). The envelope of the building is fixed and should last at least 200 years. The building itself has an open building plan with vertical cores at 8m centres. The minimum rental space is 90m². First users of the building can indicate how many m² they would like to rent. The housing corporation will locate separation walls between the apartments once the configuration of the floor plan is confirmed. Separation walls can be moved to another location when needed. Layout of the apartments is totally free and can be customised by the tenants. The housing corporation can provide infill system for the apartments but infill systems could be provided by the users them self’s as well.



Figure 4: SOLIDS - possible scenarios for the use of the apartment building

4.2 Waste prevention by industrial production with a new business model - Qbiz system

Research indicates that manufacturers will compete in the future not based on the ability to make specific products, but on their competence to develop products customized to specific customer needs. This approach supports mass customization while taking into account environmental issues. Under these Circumstances the building industry will have to focus on approaching the end user by making steps towards mass customization, and by rethinking its position. One example of such an approach is development of Qbiz system in the Netherlands. The system is a combination of prefabricated 3D unit and 2D elements.



Figure 5: Qbis system – company’s business model is based on renting of materials (variation of flexible and demountable system)

3D modular unit contains the main installation network and forms a stability core of the structure. This module is seen as an aorta of the building that services other elements of the building. Building elements as columns, floor, façade, partitioning walls etc. are flexible and removable. All materials in the system are rented to the users of the building. At the moment that façade or any other part of the building structure needs to be replaced or upgraded. The company takes materials/systems back and brings them into a remanufacturing process or uses them in another building.

5 CONCLUSIONS

A general switch is needed from design and construction of buildings as finished products to life cycle design approach where performance of building and its materials is considered through each life cycle phase of building and its materials. One of key tasks of the follow up on IFD program is to transform design and construction process into processes that will address material recover and systems reconfiguration so that materials and elements can be used for different purposes and that building can be seen as a material resource pool for the new construction.

The focus of the further development should be around a business model that recognizes buildings and material as valuable long-term assets. The main question that needs to be answered is; can’t we think of a new way of design and construction that can allow easy

adaptation of buildings to the changing use concepts by reconfiguring its structure and components and reusing the component and materials in a new configuration?

Such approach could provide integrated solutions that will address adaptability, building costs and negative environmental impact at the same time.

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USA

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ABSTRACT: The US Environmental Protection Agency (EPA) has estimated that total waste generated from construction, renovation and demolition of buildings, roads, bridges, and dams was 295 million metric tons (MMT) in 2003. The National Demolition Association (NDA) estimates that approximately 86 MMT of this material are building demolition debris. The NDS estimates that the demolition industry currently recycles approximately forty percent of the waste generated on its project sites. Nearly all building materials have the potential for reuse following their initial useful life. Although reuse possibilities are available for building materials following demolition, deconstruction maximizes this potential because it allows these materials to be recovered with the least possible amount of damage. Additionally, the organisational nature of deconstruction involves sorting separate materials, which further facilitates reuse opportunities. Wood, steel, concrete, asphalt roofing, brick, plastics, and drywall all have high reuse potential. This report evaluates the existing practice of C&D waste management in the USA and recommends suggestions for increasing construction materials reuse. The national and local environmental regulations affecting C&D debris are discussed and recycling goals and mandates for several states are presented. The report found that the future of recycled materials will be driven by higher landfill costs, greater product acceptance, and government recycling mandates. Favourable in-service experience with recycled materials and development of specifications and guidelines for their use are necessary for recycled materials acceptance. A sustainable recycling material industry requires sufficient raw materials, favourable transportation distances, product acceptance and limited landfill space.

1 INTRODUCTION

The demolition of building structures produces enormous amounts of materials that in most countries results in a significant waste stream. Construction and Demolition waste (C&D) includes waste from the construction, renovation, and removal of buildings, from the construction and demolition of roads, bridges, and other non-building structures, and from the clearing of rocks, trees, and dirt. The US Environmental Protection Agency (EPA) has estimated that total waste generated from construction, renovation and demolition of buildings, roads, bridges, and dams was 295 million metric tonnes (MMT) in 2003 (RCRA, 2004). EPA is in the process of updating the report it published in 1996 on C&D building related debris based on the 2003 data. This report will be published by the end of 2008. Building related C&D waste was estimated to be 143.3 million metric tonnes in 2000 (Chini, 2005). This estimate was achieved by multiplying number of buildings being constructed or demolished by amounts of waste estimated to be generated per square foot. Renovation figures were derived from estimates of consumer and business spending on specific remodelling and renovation activities (see Table 1). Franklin and Associates (1998) estimates that 35 to 45 percent of this debris is sent to Municipal Solid Waste (MSW) landfills or unpermitted landfills and 20 to 30 percent is reused or recycled (see Table 2).

	Residential	Non-residential	Totals
Construction	8.8 (14%)	6.0 (7%)	14.8 (10%)
Renovation	34.5 (56%)	30.2 (37%)	64.7 (45%)
Demolition	17.9 (30%)	45.9 (56%)	63.8 (45%)
Totals	61.2 (43%)	82.1 (57%)	143.3

Table 1 Summary of estimated building-related C&D debris generation, 2000
(Million Metric Tonnes)

	C&D Landfills (40%)	MSW/Unpermitted Landfills (35%)	Recovered (25%)	Total (100%)
Residential				
demolition	7.2	6.3	4.5	18.0
renovation	13.7	12.1	8.6	34.4
construction	3.5	3.1	2.2	8.8
Non-Residential				
demolition	18.4	16.1	11.5	46.0
renovation	12.1	10.4	7.6	30.1
construction	2.4	2.2	1.4	6.0
Total	57.3	50.2	35.8	143.3

Table 2 Estimated quantities of materials bound for C&D landfills, MSW and unpermitted landfills, or recovery (Million Metric Tonnes).

Deconstruction may be defined as the disassembly of structures for the purpose of reusing components and building materials. The primary intent is to divert the maximum amount of building materials from the waste stream. Top priority is placed on the direct reuse of materials in new or existing structures. Immediate reuse allows the materials to retain their current economic value.

The next desirable option for waste is to recycle. In a perfect world, the term recycling would describe a process in which raw materials achieve an endless useful life. Each conversion for reuse of the material would have future reuse possibilities designed in. It is true that nothing can be used forever. The passing of time eventually renders all materials useless. However, the concept of an endless useful life potential for raw materials is achievable. ‘Closed-loop’ recycling should be the end goal of the recycling industry in order to maximise the usefulness of virgin materials and minimise the necessity to extract them.

Currently, the recycling of materials frequently does not allow for future use of the material after the initial conversion. When timber extracted from deconstruction or demolition site is ground into mulch for landscaping, the useful life of the material is extended and that quantity of virgin materials is preserved. However, the possibility for future use after that is virtually eliminated. Processes such as this, which we usually call recycling, are not actually recycling at all. The process of reducing a raw material’s quality, potential for future uses, and economic value, is called down-cycling. The process of reusing a material for similar uses, thus maintaining the possibility for reuse again later, is recycling. The process of increasing the material’s quality, potential for future use, and economic value is called up-cycling.

Nearly all building materials have the potential for reuse following their initial useful life. Although reuse possibilities are available for building materials following demolition, deconstruction maximizes this potential because it allows these materials to be recovered with the least possible amount of damage and contamination. Additionally, the organizational nature of deconstruction involves sorting separate materials, which further facilitates reuse opportunities. Wood, steel, concrete, asphalt roofing shingles, brick, plastics, and drywall all have high reuse potential. A close-up of each of these materials follows.

2 RECYCLED AGGREGATE

Recycled aggregate is produced by crushing concrete and asphalt pavement to reclaim the aggregate. The primary market for recycled aggregate is road base. More than 91 MMT of worn-out asphalt pavements are recovered annually. About 80 percent of the recovered material

is currently recycled, and the remaining 20% is landfilled. One-third of the recycled material is used as aggregates for new asphalt hot mixes and the remaining two-thirds is used as road base (Kelly, 1998).

Total building related and infrastructural C&D waste concrete generated annually in US is estimated to be about 182 MMT (Sandler, 2003). It is estimated that about 50 percent (91 MMT) of waste concrete is recycled annually into usable aggregates. This is roughly 5 percent of 1.8 billion metric tons total aggregates market. The rest is supplied by virgin aggregates from natural sources. An estimated 68 per cent of aggregate recycled from concrete is used as road base and the remainder is used for new concrete (6 percent), asphalt hot mixes (9 percent), and low value products like general fill (Deal, 1997). The low usage rate of recycled concrete aggregate (RCA) in new concrete and asphalt hot mixes (15 percent) compared to the higher usage rates in lower valued products is related to real and perceived quality issues. Many State agencies have allowed use of RCA mostly as road base materials but not for high-quality uses such as road surfacing.

Concrete can be recycled by hauling the concrete debris to a permanent recycling facility for crushing and screening or it can be crushed and screened at the demolition site where the aggregate is reused when it is processed. The latter approach is preferred because it reduces transportation costs and energy use due to hauling materials. Some States convert existing worn-out concrete roads to rubble-in-place. The old concrete surface is broken up and compacted, and asphalt pavement is placed over the enhanced base.

For concrete recycling to be profitable, transportation costs need to be kept low, which forces the market to be urban oriented. The availability of feedstock for recycling plants depends on the amount of demolition taking place, which is much higher within older, larger cities. Recycling concrete plants often have the opportunity to charge a fee for accepting concrete debris, especially where fees for depositing materials into landfills are high. This added revenue can compensate for a lower market price for recycled aggregate products.

The future of recycled aggregates will be driven by higher landfill costs, greater product acceptance, government recycling mandates, and a large stock of existing roads and buildings to be demolished. Favourable in-service experience with recycled aggregates and development of specifications and guidelines for their use are necessary for recycled aggregate acceptance. A sustainable recycling aggregate industry requires sufficient raw materials, favourable transportation distances, product acceptance and limited landfill space.

3 ASPHALT ROOFING SHINGLES RECYCLING

Shingles in the waste stream are tear-offs from re-roof jobs, demolition debris, tabs that are cut out to shape the new shingles for assembly, and discarded new shingles that did not meet quality standards. Asphalt shingle scrap can be used in asphalt pavement, aggregate base and sub-base, cold patch for potholes, and new roofing. In U.S., approximately 10 MMT of waste asphalt roofing shingles (ARS) are generated per year. Re-roofing jobs account for 9 MMT and manufacturing scrap generates another 1 MMT (CIWMB, Shingles).

ARS are made of asphalt cement (19 to 36 percent), mineral filler (limestone, silica - 8 to 40 percent), mineral granules (ceramic-coated natural rock - 20 to 38 percent), and felt backing (organic or fibreglass - 2 to 15 percent). Between 1963 and 1977, three of the largest shingle manufacturers used asbestos in their fibre mat of their shingles. The average asbestos content was 2 percent in 1963 and 0.00016 per cent in 1973. Due to the practice of covering a worn out roof with new shingles, there may continue to be a very small amount of asbestos in the shingle waste stream until about 2016 (some shingles last up to 20 years). Although only a small percentage of shingle production over a limited number of years involved asbestos, asbestos-containing roofing materials is a potential hazard that recyclers must face (NAHB, 2007).

Scraps produced during the manufacturing process has a uniform content, whereas tear-off waste may consist of varying compositions and has been exposed to ultraviolet sunlight. Many State departments of transportation have specifications that allow the use of recycled shingles in pavement materials. Some do not allow the use of tear-off scrap because of potential asbestos-content and content and condition variability.

The factors that affect roofer's disposal choices between recycling yards and landfills are transportation costs and disposal fees. Recyclers typically charge about \$30 per ton to cover processing costs. The differential between the recycler's charge and the landfill tip fee must be large enough to provide an economic incentive to roofers to avoid landfill disposal.

4 WOOD RECYCLING

According to Falk and McKeever (2004) an estimated 25.2 MMT of demolition waste and 10.5 MMT of construction waste for total of 35.7 MMT of C&D waste wood was generated in 2002. Their study also concluded that about 18.4 MMT or approximately 50% of the generated waste was recoverable. With the exception of scrap steel, wood products have the highest recoverability level of any building materials. This is due to the large amount of recoverable wood in the deconstruction and demolition market. Additionally, the ways in which wood can be reused are numerous. Wood products can be recycled for direct reuse in similar applications, they can be down-cycled into mulch, or they can be up-cycled into more valuable items, such as custom cabinetry or furniture.

Many wood products can be recovered and reused directly, with little or no processing necessary. Currently, recovered structural timbers are in high demand in the United States because of their lack of availability from any other source. Virgin stocks were overexploited during the years of heavy logging and have yet to recover. People value the timbers for their aesthetic quality and historical significance. Additionally, dimension framing lumber can be recovered and reused as is. The market for recycled dimension lumber is still a fledgling industry. The reuse applications for recovered lumber are currently limited due to a lack of standardized grading requirements. This should change with the establishment of grading requirements. Once the structural uses of recovered dimension lumber are established, the demand will increase exponentially. Reusing recovered wood products in similar applications extends the lifecycle of the product because it maintains the potential for further recycling down the line.

Wood products can be up-cycled into more valuable products. This is often the ideal situation because it maintains the recyclability of the product while increasing its economic potential. An example of up-cycling wood products includes the conversion of recovered framing lumber into custom cabinetry, furniture, or wood flooring.

Down-cycling of wood products involves decreasing the future recyclability and economic potential of the wood. For example, one option for wood waste is to use it as a feedstock for engineered wood products such as, particle boards or oriented strand boards. Sometimes scrap wood from demolition is sent through a grinder and turned into mulch. This eliminates the possibility of further recycling of the wood at a later date and diminishes its economic value. The markets for down-cycled wood products include mulch, fibres for manufacturing, animal bedding, and biomass.

Down-cycling of wood products should be the last option when considering reuse possibilities because it degrades the material. However, down-cycling is an important alternative in the recycling industry. Many used wood products have no available reuse options. Down-cycling this wood serves to divert it from the waste stream and create supply for the mulch, biomass, and animal bedding markets.

Wood treated with copper chrome arsenate (CCA) for preservation against insects may need to be managed using alternative methods. The use of CCA treated wood products in residential applications has been banned by the EPA and regulations are being developed for the handling of treated wood and its disposal.

5 STEEL RECYCLING

The North American steel industry is far ahead of any other building material industry in its use of recycling to conserve raw materials and creates economic opportunity. “Each year, steel recycling saves the energy equivalent to electrically power about one-fifth of the households in the United States for one year and every ton of steel recycled saves 2,500 pounds of iron ore, 1,400 pounds of coal, and 120 pounds of limestone” (Steel Recycling Institute). The steel industry’s overall recycling rate is nearly 75%. This includes the recycling of cans, automobiles, appliances, construction materials, and many other steel products. All new steel products contain recycled steel. In 2005, almost 70 MMT of steel were recycled or exported for recycling (Steel Recycling Institute).

There are two processes for making steel. The Basic Oxygen Furnace process, which is used to produce the steel needed for packaging, car bodies, appliances and steel framing, used a minimum of 31% recycled steel in 2005. The Electric Arc Furnace process, which is used to produce steel shapes such as railroad ties and bridge spans, used nearly 95% recycled steel (Steel Recycling Institute). According to the Steel Recycling Institute 97.5 percent of structural beams and plates and 65 percent of reinforcing steel were recycled in 2005.

6 DRYWALL RECYCLING

Drywall, also referred to as gypsum board is the principal material used in the U.S. for interior applications. It is made of a sheet of gypsum covered on both sides with a paper facing and a paperboard backing. The U.S. produces about 13.7 MMT of new drywall per year. Most drywall waste is generated from renovation (10 MMT), new construction (1.5 MMT), demolition (0.9 MMT), and manufacturing (0.3 MMT) (Sandler, 2003).

Scrap gypsum drywall is currently being recycled in several applications including:

- The manufacture of new drywall
- Use as an ingredient in the production of cement
- Application to soils and crops to improve soil drainage and plant growth
- A major ingredient in the production of fertilizer products
- An additive to composting operations

In recent years, scrap drywall from new construction is separated and processed at the project site using a mobile grinder and used as a soil amendment or a plant nutrient. This approach may be feasible when the soils and grass species show a benefit from the application of gypsum. This recycling technique offers a potential economic benefit when the cost to process and land apply the ground drywall at the construction site is less than the cost to store, haul and dispose of the drywall.

The presence of gypsum drywall in landfills has been linked to the production of hydrogen sulphide (H₂S). H₂S has a foul, rotten-egg odour that has caused numerous complaints at landfills around in U.S. and Canada. As a result, several communities in Canada do not accept drywall at landfills and, several locations in U.S. are considering placing restrictions on the amount of drywall that may be land disposed.

Despite its successful use in many locations, most drywall is still disposed of in landfills due to challenges in collection and separation and low landfill disposal fees (CMRA, Drywall).

7 BRICK RECYCLING

The preferred method of recycling used bricks is to remove them undamaged and reuse them directly. The only current method used commercially to enable used bricks to be made suitable for reuse in their original form involves cleaning the old mortar from the bricks by hand. A small blunt hand axe can be used to knock the mortar from the bricks. The problem with this is that it is extremely difficult to remove modern Portland cement based mortar from bricks using the technique described above. Thus only old bricks are generally cleaned and recycled by this method. There are however, studies in progress involving the use of pressure waves to break the bond between the mortar and the bricks. This may become a viable solution and create more brick recycling opportunities in the near future.

There are currently studies ongoing concerning the use of crushed brick in road base. The results have been inconclusive to this point.

8 PLASTICS RECYCLING

According to the 2000 State of Plastics Recycling, nearly 1700 companies handling and reclaiming post-consumer plastics were in business in 1999. This was nearly six times greater than the 300 companies in business in 1986. The primary market for recycled PET bottles continues to be fibre for carpet and textiles and the primary market for recycled HDPE is bottles. However, a recently updated *Recycled Plastics Products Source Book* lists over 1,300 plastic products from recycled content, including waterproof paper products and plastic lumber for structural applications. New ASTM (American Society for Testing and Materials) standards are paving the way for plastic lumber that could be used in framing, railroad ties, and marine pilings (State of Plastics Recycling). The use of recycled plastics for such applications could mean longer life and less maintenance, which translated to lower cost over the life of the product.

There is however a need to increase the reuse and recycling rates for plastics, which are currently much lower than other major construction materials steel, concrete, and wood. The construction industry uses 60 per cent of global PVC, which is difficult to recycle and can contaminate recycling of other commonly recycled plastics. There was only a 1.7% increase in the pounds of plastic collected in 2005 (0.96 MMT) compared with that of 2004 (0.87 MMT) (State of Plastics Recycling).

9 SUMMARY

Table 3 summarizes estimated waste due to building and infrastructure related construction and demolition as well as municipal solid waste. The table also shows estimated weight of recovered materials. As Table 3 shows only concrete and steel have a recovery rate of 50 per cent or above. The recovery rate for other materials is not significant, but it is increasing due to rising cost of landfilling waste, stringent new government regulations, and a steady growing concern for the environment. Many demolition contactors are integrating recycling as a side business. According to one estimate in 2005, there were about 3500 C&D recycling facilities in USA (Taylor, 2005).

Material	Building C&D Waste	Infrastructure C& D Waste	Steel Products	Municipal Solid Waste	Re-covered
Concrete	55	127	-	-	91
Wood	36	-	-	27	10
Drywall	13	-	-	-	2
Roofing	10	-	-	-	NA
Steel	9	12	59	13	70
Bricks	4	-	-	-	NA
Plastics	4	-	-	24.3	1

Table 3 C&D waste generation and recovery (MMT)
(NA: the recovered weight is Not Available)

According to the National Demolition Association (NDA) only four materials – concrete, metal, high quality lumber and wood have current market value. NDA suggests that the federal government establish specifications and purchasing guidelines for each recovered material; take a leading role in promoting the development of new technologies and processes that will produce durable, economical, high quality recycled products; provide tax incentives for end users of the recycled products; and develop national inspection standards for recycling facilities (The NDS Report, 2004).

The future of recycled materials will be driven by higher landfill costs, greater product acceptance, and government recycling mandates. Favourable in-service experience with recycled materials and development of specifications and guidelines for their use are necessary for recycled materials acceptance. A sustainable recycling material industry requires sufficient raw materials, favourable transportation distances, product acceptance and limited landfill space.

10 ENVIRONMENTAL LAWS AFFECTING C&D DEBRIS

According to the U.S. Environmental Protection Agency (EPA), construction and demolition (C&D) debris can consist of three types of waste: (1) Inert or nonhazardous waste; (2) hazardous waste as regulated by the EPA under the Resource Conservation and Recovery Act (RCRA); and (3) items that contain hazardous components that might be regulated by some states.

C&D debris is not federally regulated, except to the extent that solid waste landfills must follow a few basic standards outlined in the Federal Register at 40 CFR Part 257. States, therefore, have the primary role in defining and regulating the management of C&D debris.

Wastes are defined as hazardous by EPA if they are specifically named on one of four lists of hazardous wastes or if they exhibit one of four characteristics: ignitability, corrosively, reactivity, or toxicity. Typical examples of C&D wastes that are considered hazardous according to EPA's definition are:

- C&D debris containing mercury: fluorescent lamps, thermostat probes, old paint
- Lead-based paint debris: woodwork, siding, window and doors painted before 1978

- Asbestos debris: Insulation, resilient floor covering, siding shingles, roofing products, and cement products made with asbestos before 1977

A large fraction of C&D debris generated in the United States ends up in C&D landfills. Since much of this waste stream is inert, states do not require these landfills to provide all of the same environmental protections as those licensed to receive municipal solid waste. Therefore, C&D landfills generally have lower tipping fees and handle a large amount of the C&D debris generated in the United States. Most states regulate C&D debris, although programmes vary widely. Some states require liners or leachate collection systems, a few require both and others require neither.

Many states have active programmes that encourage C&D waste recycling. Examples of the range of state activities and programmes are given below (CICA Center, 2008).

Vermont. Each year, waste from new construction, renovation and demolition projects generates over 20 percent of Vermont's trash. That adds up to 90,000 tons of construction and demolition waste (C&D) which ends up in landfills each year. Vermont has some of the highest waste disposal costs in the country. Fees range between \$65.00 to over \$100.00 per ton and it's not expected to get any cheaper. Vermont has created a Construction Waste Reduction website that describes a range of resources to help prevent and reduce waste during construction, renovation, deconstruction, and demolition and save money in the process.

Minnesota. MN posts an abundance of information and links to other resources on their C&D Waste: Reduce, Reuse and Recycle website, including a recycler's directory. The Minnesota Sustainable Design Guide provides strategies for the diversion of 80% of demolition debris and 75% of construction waste (both by volume) from landfills through salvage, recycling and/or recovery. (<http://www.pca.state.mn.us/oea/greenbuilding/waste.cfm>)

California: CA identifies reuse and recycling of C&D materials as one component of a larger holistic practice called 'Sustainable or green building construction'. Among other resources, there is C&D Debris Recyclers web based database to search for recycling facilities by material. (<http://www.ciwmb.ca.gov/ConDemo/Recyclers/RecyclerSearch.aspx>)

Illinois. The IL C&D debris website provides a general understanding of the statutory and regulatory requirements governing construction and demolition debris and offers advice on recycling. (<http://www.epa.state.il.us/small-business/construction-debris/>)

Iowa. Iowa DNR has established a very useful C&D recycling website with links to many state and national resources, including a directory of Recycling Businesses. (<http://www.iowadnr.com/waste/recycling/cnd.html>)

Ohio. Ohio publishes an on-line C&D directory to enhance the recycling of construction and demolition debris (C&DD) materials in Ohio. This directory is intended to serve as a reference for construction contractors, remodelers, and demolition contractors who are interested in establishing a waste reduction programme for their business. (<http://www.epa.state.oh.us/ocapp/p2/recyc/debris.html>)

Maryland. Maryland House Bill 1157 directs local governments to enact laws or regulations that require an owner of a building or structure to arrange for a salvage period before demolishing the building or structure. A local jurisdiction must establish laws or regulations relating to the timing and length of salvage periods, access to the building or structure for the salvage or deconstruction crews, minimum qualifications for the salvage or deconstruction crews and the assumption of liability by the salvage or deconstruction crews for their work. A

demolition permit cannot be issued unless these requirements are met (Maryland House Bill, 2004).

Several cities and counties have established regulations that require a minimum recycling rate for C&D waste.

Chicago. Chicago recently adopted an ordinance requiring a certain percentage of construction and demolition waste to be recycled — 25 percent for projects that had a permit issued in 2007, and 50 percent if the permit is issued in 2008 (Martin, 2007).

Portland. In Oregon, the city of Portland requires a 75 per cent recycling rate on all C&D projects exceeding \$50,000. In addition to \$24 per metric ton tipping fee, a \$38 per metric ton tax is imposed on all landfill debris (Taylor, 2005).

Sonoma County. In Sonoma County, California C&D waste loads that have not been sorted for recyclables must pay a 25 percent surcharge for the county to handle resorting.

11 CONCLUSIONS AND RECOMMENDATIONS

Demand for construction materials will continue to rise over the next few decades, as the world population increases and the global economy continues to expand. The first objective for management of waste and materials should be to reduce the overall volumes of all wastes that need to be disposed of. The second objective is to reduce the amount of materials used to make products by increasing the useful life of products as well as reuse/recycling of materials and products. In a market economy, decisions involving which resources are used are primarily driven by economic forces. Therefore, the most effective ways for achieving these goals are to use economic incentives to promote efficient resource use and minimize waste generation. These include waste generation fees and credits to reward purchase of products that rely on recycled materials.

Developing more efficient recycling technologies and developing markets for recycled materials or products are essential for the recycling industry to flourish. Government should also play a role through government purchasing programmes that increase demand for products with recycled content. President Clinton's decision to move the Federal Government towards increased use of recycled paper had a major impact in use of recycled paper across the economy as other large entities followed the Federal Government. Public education to enhance awareness of sustainability issues is an important factor in accepting products with recycled content. As the National Demolition Association suggests the federal government should establish specifications and purchasing guidelines for each recovered material; take a leading role in promoting the development of new technologies and processes that will produce durable, economical, high quality recycled products; provide tax incentives for end users of the recycled products; and develop national inspection standards for recycling facilities.

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INTERNATIONAL COUNCIL FOR RESEARCH AND INNOVATION IN BUILDING AND CONSTRUCTION

CIB's mission is to serve its members through encouraging and facilitating international cooperation and information exchange in building and construction research and innovation. CIB is engaged in the scientific, technical, economic and social domains related to building and construction, supporting improvements in the building process and the performance of the built environment.

CIB Membership offers:

- international networking between academia, R&D organisations and industry
- participation in local and international CIB conferences, symposia and seminars
- CIB special publications and conference proceedings
- R&D collaboration

Membership: CIB currently numbers over 400 members originating in some 70 countries, with very different backgrounds: major public or semi-public organisations, research institutes, universities and technical schools, documentation centres, firms, contractors, etc. CIB members include most of the major national laboratories and leading universities around the world in building and construction.

Working Commissions and Task Groups: CIB Members participate in over 50 Working Commissions and Task Groups, undertaking collaborative R&D activities organised around:

- construction materials and technologies
- indoor environment
- design of buildings and of the built environment
- organisation, management and economics
- legal and procurement practices

Networking: The CIB provides a platform for academia, R&D organisations and industry to network together, as well as a network to decision makers, government institution and other building and construction institutions and organisations. The CIB network is respected for its thought-leadership, information and knowledge.

The CIB has formal and informal relationships with, amongst others: the United Nations Environmental Programme (UNEP); the European Commission; the European Network of Building Research Institutes (ENBRI); the International Initiative for Sustainable Built Environment (IISBE), the International Organization for Standardization (ISO); the International Labour Organization (ILO), International Energy Agency (IEA); International Associations of Civil Engineering, including ECCS, fib, IABSE, IASS and RILEM.

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- International Symposium on Water Supply and Drainage for Buildings (W062)
- Organisation and Management of Construction (W065)
- Durability of Building Materials and Components (W080, RILEM & ISO)
- Quality and Safety on Construction Sites (W099)
- Construction in Developing Countries (W107)
- Sustainable Buildings regional and global triennial conference series (CIB, IISBE & UNEP)
- Revaluing Construction
- International Construction Client's Forum

CIB Commissions (August 2008)

- TG49 Architectural Engineering
- TG53 Postgraduate Research Training in Building and Construction
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- TG57 Industrialisation in Construction
- TG58 Clients and Construction Innovation
- TG59 People in Construction
- TG61 Benchmarking Construction Performance Data
- TG62 Built Environment Complexity
- TG63 Disasters and the Built Environment
- TG64 Leadership in Construction
- TG65 Small Firms in Construction
- TG66 Energy and the Built Environment
- TG67 Statutory Adjudication in Construction
- TG68 Construction Mediation
- TG69 Green Buildings and the Law
- TG70 Sustainable Design of Tall Buildings
- TG71 Research and Innovation Transfer
- TG72 Public Private Partnership
- W014 Fire
- W018 Timber Structures
- W023 Wall Structures
- W040 Heat and Moisture Transfer in Buildings
- W051 Acoustics
- W055 Building Economics
- W056 Sandwich Panels
- W062 Water Supply and Drainage
- W065 Organisation and Management of Construction
- W069 Housing Sociology
- W070 Facilities Management and Maintenance
- W077 Indoor Climate
- W078 Information Technology for Construction
- W080 Prediction of Service Life of Building Materials and Components
- W083 Roofing Materials and Systems
- W084 Building Comfortable Environments for All
- W086 Building Pathology
- W089 Building Research and Education
- W092 Procurement Systems
- W096 Architectural Management
- W098 Intelligent & Responsive Buildings
- W099 Safety and Health on Construction Sites
- W101 Spatial Planning and Infrastructure Development
- W102 Information and Knowledge Management in Building
- W104 Open Building Implementation
- W107 Construction in Developing Countries
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PAGE 1



INTERNATIONAL COUNCIL FOR RESEARCH AND INNOVATION IN BUILDING AND CONSTRUCTION

Publications: The CIB produces a wide range of special publications, conference proceedings, etc., most of which are available to CIB Members via the CIB home pages. The CIB network also provides access to the publications of its more than 400 Members.



Recent CIB publications include:

- Guide and Bibliography to Service Life and Durability Research for Buildings and Components (CIB 295)
- Performance Based Methods for Service Life Prediction (CIB 294)
- Performance Criteria of Buildings for Health and Comfort (CIB 292)
- Performance Based Building 1st International State-of-the-Art Report (CIB 291)
- Proceedings of the CIB-CTBUH Conference on Tall Buildings: Strategies for Performance in the Aftermath of the World Trade Centre (CIB 290)
- Condition Assessment of Roofs (CIB 289)
- Proceedings from the 3rd International Postgraduate Research Conference in the Built and Human Environment
- Proceedings of the 5th International Conference on Performance-Based Codes and Fire Safety Design Methods
- Proceedings of the 29th International Symposium on Water Supply and Drainage for Buildings
- Agenda 21 for Sustainable Development in Developing Countries

R&D Collaboration: The CIB provides an active platform for international collaborative R&D between academia, R&D organisations and industry.

Publications arising from recent collaborative R&D activities include:

- Agenda 21 for Sustainable Construction
- Agenda 21 for Sustainable Construction in Developing Countries
- The Construction Sector System Approach: An International Framework (CIB 293)
- Red Man, Green Man: A Review of the Use of Performance Indicators for Urban Sustainability (CIB 286a)
- Benchmarking of Labour-Intensive Construction Activities: Lean Construction and Fundamental Principles of Working Management (CIB 276)
- Guide and Bibliography to Service Life and Durability Research for Buildings and Components (CIB 295)
- Performance-Based Building Regulatory Systems (CIB 299)
- Design for Deconstruction and Materials Reuse (CIB 272)
- Value Through Design (CIB 280)



An example of a recent major CIB collaborative activity is the Thematic Network PeBBu Performance Based Building: a four-year programme that included 50 member organisations, that was coordinated by CIB and that was funded through the European Commission Fifth Framework Programme.

Themes: The main thrust of CIB activities takes place through a network of around 50 Working Commissions and Task Groups, organised around four CIB Priority Themes:

- Sustainable Construction
- Clients and Users
- Revaluing Construction
- Integrated Design Solutions

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FM1	Fee level	10526	11052	11605	11837
FM2	Fee level	7018	7369	7738	7892
FM3	Fee level	2413	2534	2661	2715
AM1	Fee level	1213	1274	1338	1364
AM2	Fee level	851	936	1030	1133
IM	Fee level	241	253	266	271

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