Construction Waste Reduction around the World

Publication 364
W115 - Construction Materials Stewardship

International Council
for Research and Innovation
in Building and Construction

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CIB Publication 364

Working Commission W115
Construction Materials Stewardship

Edited by

Gilli Hobbs
Director of Construction Resource Efficiency
Building Research Establishment
Watford, UK

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Foreword

Working Commission 115 (W115) 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 (TG 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 edited by Abdol Chini.

The purpose of this new working commission is to extend the work and achievements of TG39. The research to be undertaken by W115 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 and to replace them with renewable ones whenever possible.

The first meeting of the commission members took place in conjunction with SB07- International Conference on Sustainable Construction - in Lisbon, Portugal in September 2007. The commission's first publication (CIB Publication 318), "*Construction Materials Stewardship – The Status Quo in Selected Countries*," edited by John Storey, includes the reports presented at this meeting and a number of other reports received subsequent to the meeting. Nine counties were represented, Germany, Japan, New Zealand, Slovenia, Sweden, Switzerland, The Netherlands, United Kingdom, and the United States of America.

The third annual meeting of W115 was in conjunction with the Construction Materials Stewardship Conference at the University of Twente in Enschede, The Netherlands in June 2009. The commission's second publication (CIB Publication 323) titled, "*Lifecycle Design of Buildings, Systems and Materials*," edited by Elma Durmisevic, is the Proceedings of this conference and includes twenty two fully reviewed papers presented at the conference.

This report is the third product of W115 and provides an overview of construction waste reduction activities across the world through a series of country reports from Canada, Germany, Israel, Japan, Norway, Singapore, Slovenia, Switzerland, Turkey, UK, and USA. The W115 coordinators would like to acknowledge the major contributions made by Gilli Hobbs in developing the template for the country reports and bringing them together into a single report. Special thanks to the authors of the country reports for their time and efforts in collecting the needed data and writing the report.

In this time of economic uncertainty and constraint, the need to conserve resources and reduce costs has never been greater. This report provides a valuable insight into the progress being made towards Construction Materials Stewardship and how we could all improve further into the future.

Abdol Chini, Frank Schultmann, and John Storey
W115 Coordinators

Introduction

This report has been produced by the CIB working commission 115 – Construction Materials Stewardship. It is intended to provide an overview of construction waste reduction activities across the world through a series of country reports.

A template was produced and sent to W115 members for completion. This included sections on the following:

1. Current national statistics
2. Benchmark Data
3. Policies, strategies and legislation
4. Guidance documents/ reports linked to construction waste reduction
5. Exemplars, case studies

The completed reports are the main content of this publication.

About CIB W115 – Construction Materials Stewardship[1]

This Commission aims to:

· Drastically reduce the deployment and consumption of new non-renewable construction materials, to replace non-renewable materials with renewable ones whenever possible, to achieve equilibrium in the demand and supply of renewable materials and ultimately to restore the renewable resource base

· Carry out these tasks in ways to maximize positive financial, social and environmental and ecological sustainability effects, impacts and outcomes.

Against this background the Commission's Objectives are to:

· Determine ways to utilise new and existing construction materials in the most effective and ecologically, environmentally, socially and economic manner possible

· Develop life cycle costing and management mechanisms for materials

· Develop systems to mitigate and ultimately avoid construction material waste

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

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

· Establish strategies to promote whole buildings, components and materials re-use

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

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

· Establish what the barriers are to the sustainable use of building materials and devise methodologies to overcome those barriers

· 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

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

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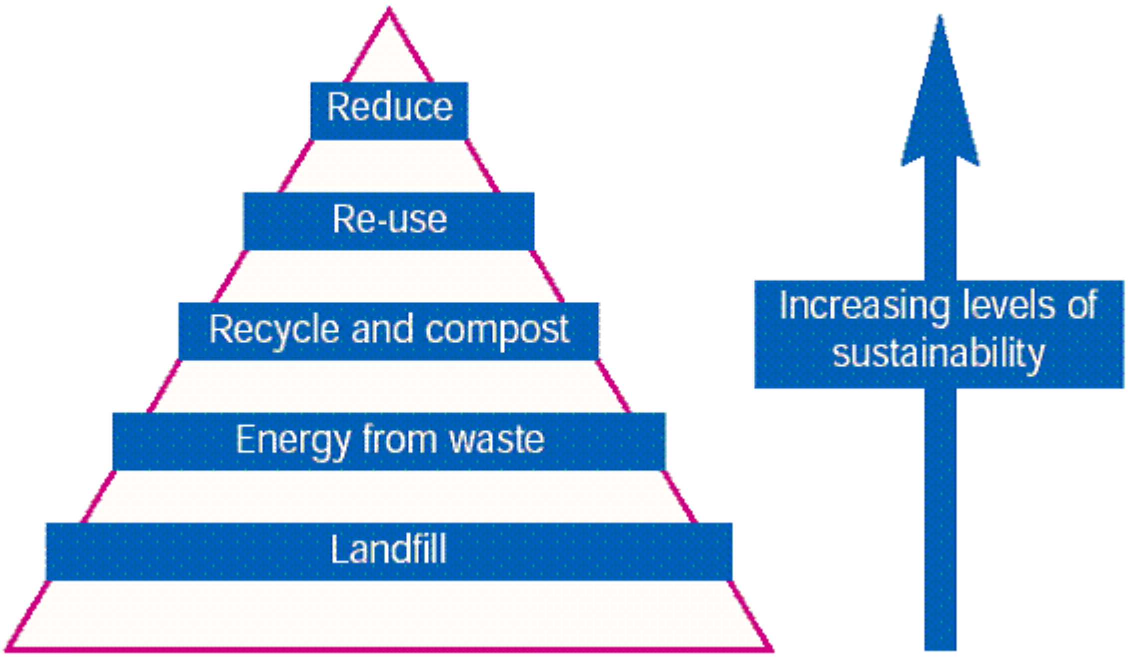
[1] You can find more information on the activities of CIB W115 at www.cibw115.org

About construction waste reduction

A key objective in many countries is to decouple the generation of waste from economic growth. It has been the case for many years that the amount of waste produced increases with economic prosperity. One reason for this is that the cost of materials reduces in comparison with the cost of labour, so it becomes ‘cheaper’ to waste materials rather than invest more time in using materials efficiently. However, the cost of waste is typically underestimated in both economic and environmental terms. Waste reduction is also difficult to measure, in order to make compelling business cases to change practices or products.

Waste reduction (also called prevention or minimisation) has been at the top of the waste hierarchy for many years (as illustrated in Figure 1), but has been typically overlooked in both business resource efficiency support and government policy. Although a great deal of focus has been on recycling and energy from waste, more attention is now being placed upon waste prevention, for example in the EU.

Figure 1: Waste hierarchy



In the EU, the emphasis of the revised Waste Framework Directive has shifted from being mainly about preventing pollution from waste, to one where preventing waste in the first place is on equal footing. The 5 step waste hierarchy means that future decisions on waste policy, management and developing infrastructure will be expected to take into account the hierarchy, which prioritises in the following order: prevention, preparing for reuse, recycling, recovery and then disposal as the final option.

In most countries, construction waste accounts for a significant proportion of the overall wastes arising. Although it is still the case that many countries lack good data in this area which is a key step in knowing where to prioritise waste reduction. Other activities that can promote waste reduction include:

- Benchmarks for waste production linked to construction activity, for example typical wastage rates of a product or material. This enables targets to be set for improvement and waste reduction can then be measured.
- Understanding the composition and causes of waste. This enables actions to reduce waste to be identified and prioritised.
- Understanding the financial cost of waste: The overall cost of waste is a combination of the cost of materials wasted, labour to produce waste & clear it up, plus the cost of disposal or recovery.
- Understanding the environmental cost of waste: This includes the environmental impacts associated with manufacturing and distributing the wasted products, e.g. embodied energy, which is usually far greater than the subsequent impacts associated with managing the waste material, especially if it is reused.
- Landfill tax or bans: Have the effect of increasing the cost of waste management, which in turn increases the focus companies may have on preventing waste.
- Voluntary commitments and agreements: Can lead to pan sector and supply chain improvements.
- Supply chain partnerships: Can promote less wasteful practices such as precut materials, return of excess product and packaging, standardisation of stock.
- Green Building standards to include credits for waste reduction and/or minimum performance requirements relating to waste generation.

On an international basis, a G8 Meeting was held in Kobe in May 2008. The meeting adopted 3R as a main objective of the meeting as well as climate change. It is unclear if this will have much impact on construction resource efficiency across the G8 nations. The Kobe 3R action plan has 3 main goals with many associated actions, a selection of which are included below[2]:
Goal 1: Prioritize 3Rs Policies and Improve Resource Productivity

- Share the importance of the spirit of mottainai[3], minimize associated life cycle environmental impacts.
- National governments to measure the environmental and economic effects of 3Rs-related activities from a life cycle approach.
- Improve Resource Productivity (indicator of tonnes resources used relative to GDP) and Set Targets
- 3Rs and Greenhouse Gas Emission Reductions e.g. waste as alternative sources of energy to fossil fuel resources, organic materials in uses such as animal feed, composting, fermentation, and energy recovery.
- Promote and create a market for 3Rs-related Products e.g. by encouraging research and development, certification and standards, promote the development of more eco-efficient products through green public procurement and other policy measures.

Goal 2: Establishment of an International Sound Material-Cycle Society

- To achieve sustainable resource circulation on a global scale, place high priority on the promotion of environmentally sound management of re-usable and recyclable resources within each country.
- Share information and cooperate internationally on mechanisms to support proper international resource circulation such as eco-labelling, certification schemes, or traceability technologies.

[2] Kobe 3R action plan 2008. http://www.basel.int/meetings/cop/cop9/docs/i43e.pdf.
[3] Mottainai is a Japanese concept meaning that it is a shame for something to go to waste without having made use of its potential in full.

Goal 3: Collaborate for 3Rs Capacity Development in Developing Countries

- Collaborate to improve 3Rs capacity in developing countries by helping to develop databases, information sharing and monitoring mechanisms
- Promote Technology Transfer, Information Sharing and Environmental Education

This report provides an international perspective and along with the other activities of CIBW115 – Construction Materials Stewardship shares these goals, especially in sharing information and co-operating internationally.

Acknowledgements

Many members of CIBW115 contributed valuable information through their country reports and commented on the report in its draft form. Their contact details are given in each section and on the member's page of the CIB website.

Canada (with a focus on Ontario)

Contributed by:
Dr Mark Gorgolewski
Professor, Department of Architectural Science
Ryerson University, Toronto

1. Introduction

Environment Canada estimates that Canada's Construction, Renovation and Demolition (CRD) sector generates 11 million tonnes of solid waste each year (this is believed to include road and bridge building waste which constitutes a significant part of this waste). Most of this "waste" is managed as garbage and is landfilled. Estimates indicate that CRD wastes contribute approximately 20-25% of landfill by volume. Detailed information on the composition of this waste stream is patchy with a few local surveys. Some reports have assumed US percentages for waste composition. In the absence of clear and consistent characterization of CRD waste, or regulations, the tracking and reporting of CRD waste activities is not clearly assigned. Thus, generation and diversion data collection between jurisdictions and sectors are often estimates.

Recent interest at the federal level in Canada has focussed on the impact of waste and landfilling on Greenhouse Gas (GHG) emissions. Under the Action Plan 2000 on Climate Change studies were commissioned to assess the impact of waste reduction strategies on greenhouse gas emissions, including CRD waste (see Section 6).

1.1. Federal/Provincial/Municipal jurisdictions

The Canadian Environmental Protection Act (EPA), places only the transport of hazardous waste between provincial and international borders as a federal responsibility. Typically CRD wastes are not characterized as hazardous and are not generally subject to any federal regulations. At present, the Government of Canada lists a number of statutes that compel federal government departments to utilize sustainable best practices regarding source separation and diversion of CRD wastes. However, the responsibility to manage and track CRD wastes is dealt with at the provincial and territorial level.

Provincial and territorial regulations specific to managing CRD wastes vary considerably and are also not consistently enforced. Recording and verifying the generation, disposal and diversion of CRD Waste is inconsistent due to variations in requirements of each province, seasonality, climate, and urban renewal activity. The data that is collected is often difficult to compare in the absence of an established or common definition.CRD waste generation rates are also affected by inconsistent measurement practices. In some cases, waste is recorded before materials are diverted for reuse and recycling, while in others, only material which is disposed of in landfills is measured. Furthermore, CRD waste recovery definitions also vary: reuse and recycling are generally considered, but in some cases waste-to-energy as well as inert/clean fill disposal are counted as recovery. To facilitate consistent and accurate tracking and measurement of CRD wastes, a consistent and detailed definition needs to be adopted.
In addition to provincial regulations, municipalities often implement regulations to manage or control CRD waste management practices at the local level including by-laws that ban the landfilling of specific CRD material (e.g. drywall).

2. Current national statistics

Quantified data on CRD waste produced and diverted at a national level in Canada is provided by Statistics Canada through a bi-annual survey that applies to residential, business and government sectors. Defined as demolition, land clearing and construction waste, the survey's most recent results report a 22% diversion rate nationwide (see Tables 1 and 2 below).

Statistics Canada figures are based on the waste treated by the waste management industry. Any waste diversion activities that occurred without using services of the waste management industry are not included. So any wastes that are managed directly between a waste generator and a next user are not recorded. This is likely to occur most significantly in the case of large projects which have enough recyclable material to manage their wastes directly and with a potential second user directly available. An example of this is the redevelopment of Pearson Airport Terminal 1 in Toronto, where about 200,000 tonnes of concrete from the demolition was crushed on-site for reuse for new road construction[4]. This diversion activity occurred on site and was therefore never processed by the waste industry. Similarly, but on a smaller scale the many individual components extracted from renovation or demolition projects that are offered for resale at ReStores (see section 5.3 below) are also not counted. The waste generation and diversion figures miss these materials streams.

Table 1: Disposal of waste — by source and by province and territory[5]

Province	Residential sources		Non-residential sources		All sources	
(Tonnes)	2004	2006	2004	2006	2004	2006
Newfoundland and Labrador	228,004	227,618	172,044	180,110	400,048	407,728
Prince Edward Island	n/a	n/a	n/a	n/a	n/a	n/a
Nova Scotia	179,262	169,337	220,705	232,333	399,967	401,670
New Brunswick	208,120	216,357	234,053	233,881	442,173	450,238
Quebec 3	2,209,000	2,183,788	4,245,000	4,624,653	6,454,000	6,808,440
Ontario	3,489,917	3,705,235	6,319,347	6,732,545	9,809,264	10,437,780
Manitoba	450,658	455,304	477,459	568,968	928,117	1,024,272
Saskatchewan	279,420	296,062	515,513	537,691	794,933	833,753
Alberta	943,420	973,683	2,133,890	2,846,189	3,077,311	3,819,872
British Columbia	919,323	956,968	1,848,335	1,960,113	2,767,657	2,917,080
Yukon Territory, NWT & Nunavut	n/a	n/a	n/a	n/a	n/a	n/a

4 RIS International Ltd. (2005). The Private Sector IC&I Waste Management System in Ontario.
http://solidwastemag.com/PostedDocuments/PDFs/2005/AprMay/ICIPrivateSectorWasteStudy.pdf

5 Statistics Canada, Environment Accounts and Statistics Division, CANSIM table 153-0041.
http://www.statcan.gc.ca/pub/16f0023x/2006001/5212379-eng.htm

Canada	*8,961,583*	*9,238,376*	*16,265,183*	*18,010,801*	*25,226,766*	*27,249,178*

Table 2: Diversion of waste by province and territory[6]

Province	Total Materials diverted		Diverted materials per capita		Diversion rate	
	2004	2006	2004	2006	2004	2006
	(tonnes)		(percent)		(percent)	
Newfoundland and Labrador	35,308	30,385	68	60	8.1	6.9
Prince Edward Island	n/a	n/a	n/a	n/a	34	37.8
Nova Scotia	239,845	275,983	256	295	37.5	40.7
New Brunswick	139,262	252,174	185	337	24	35.9
Quebec 1	2,130,100	2,456,300	282	321	24.8	26.5
Ontario	2,414,552	2,396,856	194	189	19.8	18.7
Manitoba	157,490	152,799	135	130	14.5	13
Saskatchewan	114,182	106,868	115	108	12.6	11.4
Alberta	620,080	652,637	193	194	16.8	14.6
British Columbia	1,209,216	1,366,191	288	316	30.4	31.9
Yukon Territory, NWT & Nunavut	n/a	n/a	n/a	n/a	11.9	15.9
Canada	*7,112,735*	*7,749,030*	*222*	*237*	*22*	*22*

Table 3: Quantity of total waste materials generated, by source and by province & territory, 2002[7]

Province	Residential sources	Industrial, commercial institutional	Construction & demolition sources	All sources
		(Tonnes)		
Newfoundland and Labrador	231,291	n/a	n/a	414,979
Prince Edward Island	n/a	n/a	n/a	n/a
Nova Scotia	252,012	n/a	n/a	558,918
New Brunswick	256,190	216,432	63,941	536,563
Quebec	3,471,000	3,196,000	619,800	7,286,800
Ontario	4,388,239	6,514,191	1,158,701	12,061,131
Manitoba	494,535	566,750	86,151	1,147,436
Saskatchewan	321,069	n/a	n/a	941,731

[6] Statistics Canada, Environment Accounts and Statistics Division, CANSIM table 153-0042. http://www.statcan.gc.ca/pub/16f0023x/2006001/5212387-eng.htm

[7] Statistics Canada –Waste Management Industry Survey : Business and Government Sectors, 2002 http://www.statcan.gc.ca/pub/16f0023x/16f0023x2002001-eng.pdf

Province	Residential sources	Industrial, commercial institutional	Construction & demolition sources	All sources
		(Tonnes)		
Alberta	1,159,697	1,642,843	677,395	3,479,935
British Columbia	1,354,177	1,933,387	562,457	3,850,021
Yukon Territory, NWT & Nunavut	n/a	n/a	n/a	n/a
Total	*12,008,338*	*15,075,307*	*3,371,880*	*30,455,524*

Waste from Residential sources, Industrial, Commercial and Institutional sources (ICI) and Construction and Demolition sources is compared by province for 2002 in Table 3. CRD waste forms about 11% of the total measured waste. Table 4 indicates the amount of each waste stream that is diverted for recycling. The overall CRD recycling rate for Canada is about 16% although this varies considerably from over 34% in Quebec to only about 5% in Alberta.

Table 4: Materials Prepared for Recycling, by Source , by Province & Territory, 2002[8]

Province	Residential sources	Industrial, commercial institutional sources	Construction & demolition sources	All sources
		tonnes		
Newfoundland and Labrador	15,073	n/a	n/a	383,861
Prince Edward Island	n/a	n/a	n/a	n/a
Nova Scotia	82,363	n/a	n/a	169,724
New Brunswick	52,685	61,620	8,653	122,957
Quebec	595,000	935,000	213,000	1,743,000
Ontario	949,830	1,320,952	144,716	2,415,498
Manitoba	81,923	160,796	8,161	250,880
Saskatchewan	42,376	n/a	n/a	146,607
Alberta	293,300	262,537	33,805	589,642
British Columbia	417,403	586,719	100,999	1,105,121
Yukon Territory, NWT & Nunavut	n/a	n/a	n/a	n/a
Total	*2,553,134*	*3,511,308*	*536,345*	*6,619,794*

Waste categorisation studies have been carried out in some provinces and the results vary considerably. Table 5 provides mass and percentage figures for 2002 in Ontario while Table 6 provides comparisons of winter and summer seasonal figures for Alberta. The percentages vary considerably.

8 Statistics Canada – Catalogue no. 16F0023XIE Waste Management Industry Survey : Business and Government Sectors, 2002
http://www.statcan.gc.ca/pub/16f0023x/16f0023x2002001-eng.pdf

Table 5: Projected tonnage of CRD waste disposed in Ontario 2002[9]

Materials	Total Tonnes	%
Wood	310,778.00	31%
Ferrous	8,257.00	1%
Non ferrous	27,643.00	3%
Drywall	111,385.00	11%
Concrete	167,988.00	17%
Asphalt	79,053.00	8%
Paper	12,060.00	1%
Others	296,820.00	29%
Total	*1,013,984.00*	*100%*

Table 6: Summary of CRD categorisation based on survey of Alberta CRD waste stream (2000 data)[10]

	Mass Percentage Basis		
Waste Category	**Annual**	**Summer**	**Winter**
Wood	19%	17%	23%
Metal	12%	12%	13%
Drywall	6%	5%	7%
Roofing products	13%	11%	16%
Concrete	8%	9%	8%
Asphalt	8%	9%	5%
Brick	5%	5%	4%
Other	29%	32%	24%
Total	*100%*	*100%*	*100%*

Table 7 indicates comparative CRD waste generation from urban and rural sources. In absolute figures the urban waste streams dominate due to higher construction activity. However, it seems that proportionally a greater amount of demolition waste is generated in rural areas.

[9] An analysis of resource recovery opportunities in Canada and the projection of greenhouse gas emissions implications, NRCan 2006.

[10] Construction, Renovation and Demolition (CRD) Waste Characterization Study, CH2M Gore & Storrie Limited, Published by Alberta Construction, Renovation, And Demolition (CRD) Waste Advisory Committee, 2000. http://www3.gov.ab.ca/env/waste/aow/crd/publications/CRD_Report_All.pdf

Table 7: Seasonal waste generation by CRD sector based on audit of Alberta waste stream (2000 data)[11]

	Winter			Summer		
Landfill Type	**Construction**	**Renovation**	**Demolition**	**Construction**	**Renovation**	**Demolition**
Urban	67%	28%	5%	65%	26%	9%
Rural	31%	44%	25%	33%	29%	38%
Overall	*64%*	*29%*	*7%*	*63%*	*26%*	*11%*

3. Policies, strategies and legislation

CRD waste management regulations vary considerably by province and territory. This section will focus primarily on data from the province of Ontario, which is the most populous and generates the most CRD waste of all the Canadian provinces.

3.1 Ontario's 3Rs Regulations

In 2004 the Government of Ontario set a goal to divert 60 per cent of Ontario's waste by the end of 2008 (up from 28% in 2002) through the 3R's (Reduce, Reuse, and Recycle implemented as part of the Waste diversion Act 2002). This aims to reduce the impact on natural resources from waste disposal and to reduce the utilization of landfills in Ontario. Ontario generated over 12 million tonnes of solid waste in 2006, of which about 1.2 million tonnes were generated from the construction renovation & demolition (CRD) sector. Unfortunately, the 60% diversion goal has not as yet been achieved – residential waste diversion is up considerably to about 40% in 2010 but industrial diversion (including construction and demolition) has been more difficult to improve and appears to have gone down. The Province of Quebec also set waste diversion targets for 2008. These varied by material: 60% for most residential materials, 60-90% for IC&I materials, and 60% for construction and demolition materials.

There are two key pieces of legislation in Ontario affecting CRD waste: the Ontario Environmental Protection Act (EPA) and the Building Code Act (BCA). The EPA identifies what is considered waste and then specifies how it should be handled, while the BCA permits, under specific circumstances, the use of used or recycled materials in a building or renovation project.

Under the EPA, in 1994 the Ontario Ministry of the Environment (MOE) passed the 3Rs Regulations that affect the construction & demolition industry. Both regulations 102/94 and 103/94 are applicable to construction and demolition projects consisting of one or more buildings with a floor area greater than 2,000 m².

Regulation 102/94 requires that the waste audit be conducted and the work plan completed before the beginning of the CRD project, as follows:

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[11] Construction, Renovation and Demolition (CRD) Waste Characterization Study, CH2M Gore & Storrie Limited, Published by Alberta Construction, Renovation, And Demolition (CRD) Waste Advisory Committee, 2000. http://www3.gov.ab.ca/env/waste/aow/crd/publications/CRD_Report_All.pdf

- conduct an audit of the waste that will be generated by the project and prepare a written waste audit report;
- based on the audit, prepare a written waste reduction plan that includes source separation (recycling) programs for materials such as wood, steel, concrete and bricks before the project begins;
- implement the waste reduction work plan;
- include measures for communicating the plan to workers at the project site;
- retain a copy of the audit and work plan documents on file for five years from completion of the project.

Regulation 103/94 requires source separation (recycling) programs for specified wastes:

- implement a source separation program for the reusable and recyclable materials listed in Regulation 102/94;
- specify facilities that are sufficient for the collection, sorting, handling and storage of these materials;
- communicate the source separation program and its successes to employees, patrons, and tenants;
- make reasonable effort to ensure that the separated waste is reused or recycled.

Material to be recycled by establishments designated under Ontario's 3Rs Regulations include: cardboard, brick, concrete, drywall (gypsum board), steel and wood.

Various reports have commented on a consistent lack of enforcement of CRD waste management regulations in Ontario. Inspections by the Ministry of Environment in 2006 revealed that more than 90 per cent of industrial, commercial and institutional (ICI) groups were out of compliance with the Ontario Regulation 102/94 and 103/94[12] and a 2010 reort by the Auditor General states that "the Ministry has little assurance that the regulations are being complied with" [13]. Although a waste audit and plan must be prepared there is no requirement to submit it anywhere and non-compliance does not lead to any financial penalty. There is a lack of awareness of the regulations, an ineffective inspection process, and lack of information. Conversely the Ontario Waste Management Association (the association that represents private-sector waste management companies), estimates that the cost of disposing waste in a landfill is about 40% lower than the cost of recycling, creating disincentives to recycle.

However, the recent focus on waste diversion resulting from the 60% diversion target in Ontario (and Quebec), and the increased concerns about waste disposal, as well as the impact the sustainable building concerns and the LEED green building rating have led to more efforts at enforcement. At this stage it is unclear what affect this is having.

The situation in other Canadian provinces varies. Some provinces have little or no regulations regarding CRD waste management. Others such as British Columbia and Nova Scotia have higher ICI waste diversion rates than Ontario due to more creative diversion programs. Both

[12] Baker, B. (2007, March 17). ICI: clean up your act; Michigan move to ban Ontario trash worrisome. Daily Commercial News
http://dcnonl.com/article/id20429&search_term=ICI%20clean%20up%20your%20act

[13] 2010 Auditor General's Report, Section 3.09, p. 213 http://69.164.72.173/en/reports_en/en10/309en10.pdf

have implemented varying bans on some recyclable materials. Gypsum for example is banned from all landfills in British Columbia (and recently also in the Ottawa municipal region). Since the mid-1990s Nova Scotia's landfills cannot legally accept recyclable materials. The legislation requires ICI waste generators to separate recyclable materials from all other waste. This include a ban on CRD waste in regular municipal landfills. In Nova Scotia CRD waste must go to a licensed CRD yard for recycling and what cannot be recycled must go to a special landfill.

3.2 Green building rating systems

The Leadership in Energy and Environmental Design LEED green building rating administered in Canada by the Canada Green Building Council (CaGBC) has had considerable impact on construction practise[14]. LEED was developed to provide an agreed standard for what constitutes "sustainable building" and to transform existing building markets so that sustainable design, construction and operation become mainstream practices. LEED Canada NC 2009 offers a third-party certification process whereby points are collected within five environmental performance categories. A total of 110 points are available. One of these categories "Materials and Resources" includes several credits worth 14 points that are aimed at waste reduction. These include:

- The **Building Reuse credit** (Materials & Resources, credit 1) offers up to four points for extending the life of existing buildings thus conserving materials that would have been used for a new building. To score one point, a minimum 55% of the main portion of the building structure and shell should remain in place. More points are available if a greater proportion is reused.
- The **Construction Waste Management credit** (Materials & Resources, credit 2) aims to address the large volume of construction waste generated. One or two points are available for diverting 50% or 75% of the weight (or volume) of construction, demolition and land clearing debris from landfill disposal.
- The **Resource Reuse credit** (Materials & Resources, credit 3) aims to extend the life cycle of building components by specifying salvaged, reused or refurbished components. This saves the resources needed to produce new components. One or two points are available if 5% or 10% of the total value of building materials comes from reused sources.
- The **Recycled Content credit** (Materials & Resources, credit 4) aims to increase demand for building materials such as steel that incorporate recycled content. LEED Canada differentiates between post consumer waste and post industrial waste. One point is available if the sum of the post-consumer recycled content plus one half of the post-industrial recycled content constitutes at least 10% of the total value of material for the project. A further point is available if these proportions are doubled.

Other green rating tools in use in Canada include Geen Globes which is an web based alternative to LEED, with many similar characteristics, that is sometimes used for smaller buildings. The Building Office Managers Association (BOMA) have adopted a revised version of GreenGlobes as their BOMA Best program that has had a considerable impact on existing commercial office space and includes some requirements for waste management. Toronto City has developed its own standard called the Toronto Green Development

[14] LEED (Leadership in Energy and Environmental Design), Canada Green Building Council www.cagbc.org

Standard that is now a requirement for all new larger buildings in the city. It is based on similar criteria to LEED and also addresses waste issues. In the housing sector a version of LEED for Homes has been adopted but has so far had limited impact. Other housing ratings such as R2000 and Energy Star focus more on operational energy use.

In recent years the Living Building Challenge has attracted considerable attention, although so far a very small numbers of buildings have achieved the standard. This is an attempt to define an environmentally neutral building, and includes criteria such as net zero energy and water. One of the requirements is for 80% to 100% diversion rates for all waste depending on the material.

4. Guidance documents/ reports linked to construction waste reduction

There are several sources of information and resource materials available for reducing CRD waste in Canada. Additional information is often drawn from the US. Much of this is in the form of guidance documents, case studies, best practices models, and model specifications and contracts. Considerable work is being done to increase awareness of the CRD waste issue, but the extent of progress being made is, at present, unclear.

- Reducing Construction Waste in the Ontario Residential Construction Industry, Teresa Janine Paul, Habitat Associates with the Ontario Home Builders' Association, 1997
  http://www3.gov.ab.ca/env/waste/aow/crd/publications/OHBA-Sustainability_In_Practice.pdf

- Let's Climb Another Molehill - An Examination of Construction, Demolition and Renovation (CRD) Waste Diversion in Canada and Associated Greenhouse Gas Emission Impacts, The Recycling Council of Ontario (RCO), 2005
  www.rco.on.ca/What-We-Do/Projects/Detail/?bo=WhatWeDo&id=23

- CaGBC, LEED Canada NC 2009 Green Building Rating System, Canada Green Building Council, Ottawa, 2009.
  www.cagbc.com

- Ontario's 60% Waste Diversion Goal- A Discussion Paper, Ontario Ministry of the Environment, 2004
  www.ene.gov.on.ca/envision/land/wda/bluebox/60percent.htm

- Old to New – Design guide for salvaged materials in new construction, Paul Kernan, published by the Greater Vancouver Regional District, Vancouver, 2002.
  www.gvrd.bc.ca/buildsmart/

- The Design for Reuse Primer was recently published in North America focussing on how to design with salvaged components.
  http://www.designforreuse.org/Design_for_Reuse/default.htm

- A Best Practices Guide To Solid Waste Reduction: A guide document providing an overview of federal, provincial and municipal waste guidelines and the CCA's Waste Management Code of Practice. CCA 81 – 2001, Canada Construction Association, 2001
  www.cca-acc.com/documents/ccalist_e.asp

- Construction, Renovation and Demolition (CRD) Waste Characterization Study, CH2M Gore & Storrie Limited, Published by Alberta Construction, Renovation, And Demolition (CRD) Waste Advisory Committee, 2000 http://www3.gov.ab.ca/env/waste/aow/crd/publications/CRD_Report_All.pdf

- Demolition, Land Clearing & Construction Waste Management Toolkit, Buildsmart, Greater Vancouver Regional District, 2008 www.metrovancouver.org/about/publications/Publications/dlctoolkit08web1.pdf

- A Guide to Source Separation of Recyclable Materials for Industrial, Commercial and Institutional Sectors and Multi-Unit Residential Buildings As Required under Ontario Regulation 103/94, Ontario Ministry of the Environment, 2007 www.ene.gov.on.ca/en/publications/forms/index.php#AuditandReduction

- Construction and Demolition Industry: Understanding the 3Rs Regulations Ontario Ministry of the Environment, 2007 www.ene.gov.on.ca/en/publications/forms/index.php#AuditandReduction

5. Exemplars and case studies

5.1 Molehill Tool [15]

The Recycling Council of Ontario developed a Molehill Tool for managers and operators involved in CRD activity job sites to help facilitate the integration of waste reduction planning and execution. This was based on 15 case study sites. The tool is meant to enable the user to apply waste reduction theory into practical use. The Molehill Tool possesses 5 distinct steps: planning, commitment, execution, evaluation, and repetition. The intention is to develop a site guide for builders.

5.2 Metro Vancouver [16]

MetroVancouver includes 24 municipalities in the Vancouver area, and has been quite actively pursuing CRD diversion opportunities. A Metro Vancouver Business Services Program provides assistance in reducing and recycling waste generated on CRD sites. This includes on-site technical assistance, presentations, workshops and information guides. The program also provides recycling and salvage depots for CRD waste and directories for local hauling companies.

Several reusable building supply companies that sell reusable building materials have started up in the area in response to these initiatives.

5.3 Habitat for Humanity Re-stores

Habitat for Humanity ReStores are building supply stores that accept and resell quality new and used building materials. They generate funds to support Habitat's building programs,

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[15] Let's Climb Another Molehill - An Examination of Construction, Demolition and Renovation (CRD) Waste Diversion in Canada and Associated Greenhouse Gas Emission Impacts, The Recycling Council of Ontario (RCO), 2005, chapter 7

[16] http://www.metrovancouver.org/buildsmart/Pages/default.aspx

while reducing the amount of useful materials and components that go to landfill. Typically components are donated by builders and demolition companies for resale. They include components such as windows, doors, kitchen units, flooring, heritage components, timber, and light fittings. Other salvage companies are beginning to market reused construction components as the demand increases.

5.4 Reuse of components

There are a number of well documented buildings in Canada that use significant amounts of salvaged components in their construction, illustrating the benefits of this approach. In particular the Mountain Equipment Coop (MEC), a well-established outdoor sports retail company has constructed several of its stores using large amounts of salvaged materials. The MEC project in Ottawa and Winnipeg are good examples of how a building structure can be taken down and key components reused in creating another building on the same site, significantly reducing the need for new materials, and potentially leading to environmental and cost benefits. The site for the Ottawa MEC store was previously occupied by a 40-year-old former grocery store that was not suitable for reuse. The components were carefully dismantled and catalogued, and a new building was designed around the available salvaged components. About seventy-five per cent of the existing building was incorporated into the new building.

Figure 1: Mountain Equipment Coop in Ottawa featuring many salvaged components

A similar approach was used by architects, Busby and Associates (now Perkins and Will Canada) for the new City of Vancouver Materials Testing Lab. They collected and catalogued salvaged materials available from recently demolished warehouse buildings for use in the new building, reducing waste and use of new resources. Approximately three-quarters of the building's structure and fabric consists of salvaged and recycled materials.

5.5 Construction Resource Initiatives Council

The Construction Resource Initiatives Council was established in Canada in 2011 as a non-profit building industry led organization aimed at improving diversion rates of construction and demolition waste currently being landfilled, and ultimately supporting, developing and implementing initiatives, moving the building industry towards a zero waste vision. The organisation emerged from several initiatives in the Ottawa region, specifically targeting a improvement in drywall recycling rates. Through research and informal consultation, the group’s scope has been expanded to include all construction and demolition resources.

6. Design for Deconstruction and Adaptability

Interest in Design for Deconstruction (DfD) and Design for Adaptability (DfA) is being driven by an increasing awareness that we need to get more use out of the resources invested into buildings, and reduce waste generated. There is a growing awareness that we need to developed cyclical systems so that resources are kept in use and not discarded. So, with DfA the intention is make buildings more adaptable and flexible so that they last a long time and evolve over their lifetime with changing needs. DfD facilitates the easy deconstruction of a building at the end of its life in such a way that maintains the useful and economic value of many of its components and materials.

The Canadian Standards Association has proposed a new standard for Deconstruction of Buildings (CSA Z783) which aims to improve the capacity of the industry to conserve resources and reduce greenhouse gas emissions and waste. It suggests minimum requirements to efficiently deconstruct existing buildings and highlights methods and processes to direct salvaged materials and components into useful and economically beneficial applications. A second CSA document, CSA Z782: Guideline for design for disassembly and adaptability in buildings (DfD/A) is aimed more at designers and highlights how to consider deconstruction issues in the design phase in the same way that designers consider construction issues. This document lists 14 principles for designers to follow, including versatility, convertibility and expandability.

7. Global warming implications

According to Environment Canada, disposal of solid waste on land is estimated to have contributed to approximately three percent of Canada's annual greenhouse gas (GHG) emissions of 731 million tonnes (Mt) of carbon dioxide equivalent (CO_2e) per year in 2002. In Ontario the figure is 3.4% of provincial greenhouse gas emissions and 8.7% in Quebec (Environment Canada, 2006), considering only landfill emissions and not including upstream emissions. This occurs from the production of methane from anaerobic decomposition of wastes. Assuming that about 21% of solid waste disposed in landfills in Canada is CRD waste it can be inferred that landfilling CRD waste could contribute as much as 4.6 Mt CO_2e annually to Canada's GHG emissions.

In 2005 the Recycling Council of Ontario engaged the Athena Institute to estimate the greenhouse gas savings associated with various CRD materials diverted from landfill based on a series of case studies[17]. The Athena Institute drew on its extensive Canadian regional life cycle inventory (LCI) databases and its software tool *Environmental Impact Estimator* (EIE), to develop the associated greenhouse gas savings estimates for the various modes of diversion from landfill. From twelve case studies, seven were chosen for assessment and the results are reported in Table 8. The study considered recycling and reuse separately, as these are not equivalent in their effect on greenhouse gas emissions savings. Reuse generally displaces the production of an actual finished alternative product, and the resultant greenhouse gas emissions of that product. Recycling typically avoids the use of a raw material in the manufacture of a product. For example, reuse of a whole steel frame building or elements such as whole beams and columns may offset the production of new steel-frame

[17] Let's Climb Another Molehill - An Examination of Construction, Demolition and Renovation (CRD) Waste Diversion in Canada and Associated Greenhouse Gas Emission Impacts, The Recycling Council of Ontario (RCO), 2005, Chapter 4.

components. However, recycling of steel means the steel goes back to the mill to be melted down for production of new steel which generally requires more energy. Similarly, concrete frame buildings can be entirely reused saving on the production of new concrete, or the concrete can be crushed and down-cycled, but this usually only displaces some of the primary aggregate and not the concrete (which includes cement). Reuse will generally lead to considerably more significant greenhouse gas reductions, as can be seen in Table 8.

This study summarised that the overall recycling and reuse initiatives saved 1,073,563 kg of carbon dioxide equivalent (CO_2e), or 4.8 kg of CO_2e per tonne of diverted CRD waste. The material contribution to net greenhouse gas savings was as follows: concrete (69%), vinyl windows (13%), steel (12%), asphalt (4%), with all the remaining materials amounting to 2%. The concrete was very significant due to three sites reporting concrete reuse which was attributed to the reuse of a building. Due to the greater benefit of reuse, this strategy accounted for 85% of the greenhouse gas savings across the seven sites assessed.

Table 8: Greenhouse Gas Savings by Site and Material Type [18]

Case study #	Material	Quantity (tonnes)	Diversion method	Substitutes for or avoids	GHG/ unit (kg)	Net GHG savings (kg)
1	gyproc	7.47	recycled	raw gypsum	24	179
5	gyproc	2.11	recycled	raw gypsum	24	51
7	steel stall	1.36	reused	hot-rolled sheet	1,862	2,532
	asphalt	16.36	reused	asphalt	111	1,816
	clay brick	51.14	reused	clay brick	2.48	7,440
	concrete	3005	reused	concrete	170	295,800
9	vinyl windows	3.11	reused	vinyl windows	122	139,080
11	concrete	8,965	recycled	aggregate	3.44	26,357
	structural steel	54.82	recycled	virgin steel	820	44,952
	rebar	97	recycled	virgin steel	820	79,540
	copper	6.1	recycled	virgin copper	1600	9,760
	wood	257.52	recycled	Animal bedding	11	2,833
13	concrete	4600	reused	concrete	170	415,820
	asphalt	385.5	reused	asphalt	111	42,791
14	wood	4	reused	wood	68	272
	steel cladding	2	reused	galv. steel	1,965	3,930
	concrete	2.1	reused	concrete	195	410
	Total				*1,073,563*	

[18] Let's Climb Another Molehill - An Examination of Construction, Demolition and Renovation (CRD) Waste Diversion in Canada and Associated Greenhouse Gas Emission Impacts, The Recycling Council of Ontario (RCO), 2005, Chapter 4.

Germany

Contributed by:
Frank Schultmann and Anna Kühlen
Institute for Industrial Production (IIP), French-German Institute for Environmental Research, Karlsruhe Institute of Technology (KIT)
Karlsruhe

1. National statistics

Amount and type of the total construction and demolition waste disposal in Germany in 2006:

No.	Waste type	Total waste disposal	Thereof		
			Disposed where produced	Delivered	
				Inland	Abroad
		1000 tonnes			
17	**Construction and demolition waste (including excavation of contaminated sites)**	**22 162.3**	**1 483.7**	**20 509.1**	**169.5**
170101	Concrete	294.8	49.8	245.0	-
170102	Bricks	218.6	32.8	185.8	-
170103	Tiles, bricks and ceramics	39.0	11.6	27.3	-
170106	Mixtures of or separated fractions of concrete, bricks, tiles and ceramics, including dangerous materials	458.1	80.6	377.5	-
170107	Mixtures of concrete, bricks, tiles and ceramics, excluding those listed in 17 01 06	3 487.2	209.5	3 277.7	-
170201	Wood	4.0	-	4.0	-
170202	Glass	9.9	0.2	9.7	-
170203	Plastics	2.4	0.0	2.3	-
170204	Glass, Plastics, wood, including dangerous materials or contaminated by dangerous materials	2.0	0.1	1.9	-
170301	Carbonaceous bitumen mixtures	474.6	5.7	468.9	-
170302	Bitumen mixtures excluded those listed in 17 03 01	3749	235.2	139.8	-
170303	Carbonaceous-tarry and tarry products	75.7	1.5	74.1	0.1
170407	Mixed metals	0.1	-	0.1	-

170409	Metal waste, contaminated by dangerous materials	0.2	-	0.2	0.0
170503	Earth and rocks, including dangerous materials	1 097.8	118.0	913.8	66.0
170504	Earth and rocks, excluding those listed in 17 05 03	14 416.4	682.5	13 698.0	35.9
170505	Excavated material, including dangerous materials	18.1	0.1	18.0	-
170506	Excavated material, excluding those listed in 17 05 05	167.1	0.6	166.5	-
170507	Track ballast, including dangerous materials	24.2	0.8	21.7	1.8
170508	Track ballast, excluding those listed in 17 05 07	38.1	21.4	16.7	-
170601	Insulating material, including asbestos	14.8	0.2	4.8	9.8
170603	Other insulating material, existing of dangerous materials or including such materials	68.9	1.9	65.9	1.1
170604	Insulating materials, excluding those listed in 17 06 01 and 17 06 03	33.7	2.2	31.5	-
170605	Asbestos construction materials	354.5	3.7	304.4	46.4
170801	Construction materials of cement, contaminated by dangerous materials	0.8	-	0.8	-
170802	Construction materials of cement, excluding those listed in 17 08 01	117.8	0.1	113.4	4.3
170901	Construction and demolition waste, including quicksilver	0.1	-	0.1	-
170902	Construction and demolition waste, including PCB (e.g. sealing compound, flooring, insulating glazing, condenser with PBC, flooring with resin	3.6	0.0	3.0	0.6
170903	Other construction and demolition waste (including mixed waste), including dangerous materials	22.0	12.2	6.4	3.4
170904	Mixed construction and demolition waste, excluding those listed in 17 09 01, 17 09 02 and 17 09 03	342.9	12.9	329.9	0.0

The table below lists the total construction and demolition waste production and the amount of recycled waste in 2000 and 2004.

Waste type	Total construction and demolition waste production [million tonnes]		Total construction and demolition waste production [%]	Amount of waste recycled [million tonnes]
Year	**2000**	**2004**	**(2004)**	**(2004)**
Demolition waste	52.1	50.5	25.2%	31.1
Road scarification	16.6	19.7	9.8%	18.4
Construction waste	4.3	1.9	0.9%	0.1
Cement	-	0.3	0.2%	-
Total (without excavation)	**73.0**	**72.4**	**36.1%**	**49.6**
Waste from excavation	?	128.3	63.9%	9.1
Total	**?**	**200.7**	**100%**	**58.7**

2. Policies, strategies and legislation

Negotiated Agreement of the ARGE KWTB

Regarding the treatment of construction and demolition (C&D) waste the ARGE KWTB (Arbeitsgemeinschaft Kreislaufwirtschaftsträger Bau − Construction Recycling and Waste Management Industry Working Group), a consortium of construction industry trade associations, e.g. The Central Association of the German Construction Industry (ZFB Zentralverband des deutschen Baugewerbes – ZFB') and Confederation of Recycling Construction Materials ('Bundesvereinigung Recycling-Baustoffe – BRB'), entered into a voluntary commitment with the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, to achieve a 50% reduction in the amount of landfilled 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%.

Waste Avoidance, Recovery and Avoidance Act

On October 7th, 1996 the Waste Avoidance, Recovery and Disposal Act (Kreislaufwirtschafts- und Abfallgesetz - KrW-/AbfG) came into force. The Act is strongly connected to the European guidelines 75/442/EWG. It contains the basic principles of German waste management and closed-loop recycling strategies. 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.

Organic waste

Since the Disposal Act in 2004, landfilling of organic, active waste is prohibited.

Recycling of mineral waste

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the representatives of the federal states are developing a regulation of alternative construction material for the recycling of mineral waste.

Integration of European guidelines into German law

Since 1999 the German government has developed a 'strategy for the future of disposal of waste from human settlements' ('Ziel 2020'), with a goal to recover all municipal waste completely by 2020, so that landfilling of municipal waste is no longer necessary. In relation to this, the federal environment agency is considering if this concept can be transferred to other waste materials, such as mineral waste and biological waste treatment residuals, as an essential contribution to the European strategy regarding waste recycling and avoidance. The European directives on waste and repealing certain directives (2008/98/EG) are not yet transferred into the national German law, but the transposition expected soon. For example, national legal changes are planned regarding the waste hierarchy.

The Certification of the German Sustainable Building Council (DGNB-Sealing)

The DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen) was formed in Germany to support and implement sustainable building & construction. The association plans together with the Federal Ministry of Transport, Building and Urban Affairs (Bundesministerium für Verkehr, Bau und Stadtentwicklung - BMVBS) the provision of a German certification system for buildings having special environmental properties and qualities. As the whole life cycle of a building is relevant for the award with this certification, minimal waste production is one important aspect that needs to be considered.

3. Guidance documents

Guideline for Sustainable Construction

The Guideline for Sustainable Construction ('Leitfaden Nachhaltiges Bauen') 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. http://www.bmvbs.de/cae/servlet/contentblob/46918/publicationFile/10715/leitfaden-nachhaltiges-bauen-nicht-barrierefrei.pdf

DIN Standards

In November 2006, the ATV DIN 19459 ('Allgemeine Technische Vertragsbedingungen'), setting general standards for "demolition and deconstruction work", came into force.

Other relevant German guidelines, relevant to the reduction of waste, are listed:

1. Demolition of residential and administrative buildings – guideline
   (Abbruch von Wohn- und Verwaltungsgebäuden – Handlungsanleitung)

Regional office for ecology in Baden-Württemberg

2. Guideline for sustainable construction of public buildings
(Leitfaden nachhaltiges Bauen bei Bundesbauten)
Federal Ministry of Transport, Buildings and Urban Affairs

3. Development of methodologies for the assessment of contamination of building materials before deconstruction
(Entwicklung von Verfahren zur Beurteilung der Kontaminierung der Baustoffe vor dem Abbruch)
German committee for reinforced concrete

4. Guideline for measurement and recycling planning of buildings to be demolished
(Leitfaden für die Erfassung und Verwertung der Materialien eines Abbruchobjektes)
German committee for reinforced concrete

5. Recycling guideline
(Arbeitshilfen Recyling)
Federal Ministry of Transport, Buildings and Urban Affairs

6. Environmentally advantageous and low cost treatment of demolition waste
(Umweltgerechter und kostensparender Umgang mit Bauabfällen)
Central association of the German construction industry

Related links:

Federal Ministry of Transport, Buildings and Urban Affairs
www.bmvbs.de/

Regional office for ecology in Baden-Württemberg
www.um.baden-wuerttemberg.de/servlet/is/1538/

German committee for reinforced concrete
www.dafstb.de/

Central association of the German construction industry:
www.zdb.de/

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
www.bmu.de/

Israel

Contributed by:
Gil Peled – Architect, Initiator of Eco-Challenges
Jerusalem

1. Current national statistics

The total construction, demolition, refurbishment and excavation waste in Israel is estimated at 7.5 million tons annually. About 3.5 million tons are construction and refurbishment waste from residential and industrial buildings, not including infrastructures. Excavation and soil totals some 3 million tons annually. About 3 million tons of waste are treated through recycling plants or to authorized landfills, with the rest, an estimated 1.5 million tons, still being discarded in open spaces and along roadsides. **(1)** (2)

This situation is one of the most serious environmental problems facing the country; however it has also presented a great opportunity for progress over the last few years. In 2008 already, 1 million tons of recycled waste was reused in the construction industry and there is a growing understanding by stakeholders of the importance and benefits which can be gained from waste reduction and recycling. (2)

Waste generating activity (2009)	**Amount (tons)**
Refurbishment (residential)	1,928,028
Construction (residential & industrial)	1,570,200
Total	3,498,228

Waste treatment activity (2009)	**Amount (tons)**
Recycled waste	1,483,231
Landfill & infrastructures	675,666 & 396,580
Total	2,555,477

An exact national breakdown is currently not available as there is no one method applied for calculating the waste amounts. The quantities are either based on statistical data relating to waste generation per person in the various administrative districts or are based on data collected by single operators of landfill sites and recycling plants.

(1) Israel Environment Bulletin Vol. 31, Publication of the Israel Ministry of Environmental Protection

(2) As communicated by Uri Tal, coordinator of solid waste treatment, Ministry of Environmental Protection, 9 / 2010

2. Benchmark Data

A study on residential construction waste for the Ministry of Environmental Protection has found that: (3)

- 36% of construction waste includes non-inert materials, such as plastic, aluminium and gypsum.
- 64% of the construction waste can be recycled (12% paper, 8% iron, 44% inert materials)
- Residential construction generates approximately 20 tons of waste per 100 m^2 of built space.

Estimates for demolition waste per 100 m^2 built space are as follows: (4) (3; 5)

Residential buildings: 50 tons, industrial buildings: 6 tons, parking facilities: 3 tons.

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(3) Baum H., Katz A., Composition of Waste Generated on Residential Construction Sites, The Technion - Israel Institute of Technology, 2004

(4) Northern District Master Plan for Dry Waste, 2005

(5) ibid 3

3. Policies, strategies and legislation

Nationwide policies and strategies

Efforts on reducing construction waste are focused on establishing authorized disposal and recycling facilities as well as on promoting use of recycled construction debris in building projects and infrastructure.

The Government has proposed action on local and national levels including:

- Establishing authorized landfill sites for dry waste.
- Setting up permanent and on-site recycling plants for construction waste.
- Establishing transfer stations for construction waste in local authorities.
- Developing reuse technologies for construction and recycled waste.
- Cleaning up and rehabilitating polluted open areas.
- Advancing municipal bylaws on construction waste.
- Operating national enforcement and inspection, stepping up enforcement.
- Imposing responsibility on local authorities for construction waste transport and disposal.
- Financing aid to local authorities for recycling plants and transfer stations.
- Creating funding for private entrepreneurs for recycling projects.
- Setting up standards for use of recycled construction waste (through the Israel Standards Institute).

The implementation plan formulated by the Ministry of the Environmental Protection includes:

- Stopping the illegal disposal of waste and ensuring that it reaches regulated sites, such as abandoned quarries.
- Advancing alternatives to landfills, including recycling and reuse of different waste components such as stone, concrete, wood and glass.

An amendment to the National Master Plan for Solid Waste Disposal (NP16) delegates responsibility for the designation of such sites to the District Planning Committees, to expedite approval for new disposal sites. The country's six administrative districts have also prepared regional master plans for dry waste.

Local planning committees require building permit holders to transfer their construction waste to an authorized site. For home renovations building permits are not required and attempts to regulate this area include making renovators and building contractors comply with business licensing conditions.

A major challenge in implementing these policies is getting all the stakeholders of the waste generating chain involved in waste reduction as well as moving the economic market forces to work towards waste reduction. (6) (7)

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(6) ibid 1
(7) Israel Ministry for Environmental Protection website on construction and demolition waste http://www.sviva.gov.il

Legislation

Legislation is on national and local levels, including municipalities, local planning committees and building permit holders:

The Municipal Law – lays the responsibility for the treatment of waste in a municipal area on the local authority and its head.

The Clean Observation Law (1984) - determines that the head of a local authority must declare a site for disposal of dry waste and notify its residents.

The Planning and Building Regulations (1998) - Local planning committees apply mandatory conditions for waste disposal in building permits.

The Planning and Building Regulations (2002) - Building permit holders for additions and renovations must prove compliance with conditions.

The Planning and Building Regulations (2006) - Mandatory compliance with the National Master Plan for Solid Waste Disposal (NP 16).

Israel Standard 1886 (2010) Standard for aggregates and infill materials which requires use of at least 20% of recycled building waste.

4. Guidance documents/ reports linked to construction waste reduction

The National Master Plan for Solid Waste Disposal (NP 16) - Designates waste disposal sites. (Hebrew)

District Master Plans for Waste – including solid waste and construction waste (Northern, Haifa, Central, Tel-Aviv, Jerusalem, and Southern districts) (Hebrew)

Various guidance documents of the Ministry of Environmental Protection and the Ministry of Defence (use of aggregates for infrastructure, roads etc.) (Hebrew)

Baum H., Katz A., Composition of Waste Generated on Residential Construction Sites, The Technion - Israel Institute of Technology, 2004. (Hebrew) (8) (9)

(8) ibid 7
(9) ibid 2

5. Exemplars, case studies

Exemplars

Waste breakdown in Tel-Aviv district (10)

Waste generating activity	Amount (tons)	Percentage
Refurbishment	184,000	42.44%
Construction	128,843	29.59%
Demolition	121,815	27.97%
Total	435,458	100%

Noteworthy is that the waste generated in the Tel-Aviv district is generally higher than the national average and that the main source of building waste is from refurbishment which is more difficult to regulate.

Tel-Aviv Centre, a re-source of waste. Photo: Gil Peled

(10) The Tel Aviv District Master Plan for Construction Waste, 2007

Residential refurbishment waste

A survey on residential refurbishment waste carried out by the Jerusalem Eco-Housing Pilot Project (Eco-Challenges) has found that: [11]

- Every complete refurbishment of apartments of 50 m^2 has generated waste totalling an average of 12 m^3 (about 2 skips).
- Most waste consists of tiles, gravel and concrete bricks, followed by fittings, wooden / aluminium openings, glass, PVC shutters & pipes, wiring, iron & steel.
- On-site reuse of construction waste possible for paths out of crushed bricks. Other reused waste includes wooden pallets and tyres and gravel for roof insulation.

Demolition waste reused for roof insulation
Photos: Gil Peled

Skip of refurbishment waste at pilot project

(11) Survey at the Jerusalem Eco-Housing Pilot Project, Eco-Challenges, 2010

Case studies

The Jerusalem Waste Treatment Master Plan (12)

The plan deals with the treatment of construction, demolition and excavation waste which is discarded illegally throughout the city, in open spaces, along the municipal seam line and the Old City Basin, taking into account their historic, religious and touristic values. Budget and implementation is distributed between the Ministry of Environmental Protection, The Israel Lands Administration, The Nature and Parks Authority and the Jerusalem Municipality. The Master Plan aims to develop a system for the management and treatment of waste, from 'cradle to grave'.

The Plan estimates the annual waste production in the Jerusalem region as:

- Up to 198,000 tons of construction and demolition waste.
- Up to 2 million tons of excavation material.
- Less than 10% of construction & demolition waste reaches approved sites.

The Plan includes:

- Prevention by means of education and information in Hebrew and Arabic.
- Enforcing existing laws and regulations; monitoring and inspection.
- Establishing infrastructures and rehabilitating disturbed sites.
- Encouraging contractors to crush excavation waste generated by projects.
- Establishing two transfer stations for the sorting, crushing and reuse of construction waste.
- Setting up a response team with the Israel Police and the Green Police.

Specific solutions include:

- Consideration of the topography to reduce excavation waste and use of it on site.
- Reduction at the source for example with prefabricated elements.
- On-site sorting and recycling.
- Monitoring skips of refurbishing waste.
- Easing access to transfer stations and authorized landfills.

Illegal demolition waste with asbestos content Photo: Gil Peled

(12) The Jerusalem Waste Treatment Master Plan 2006

Hiriya waste landfill site (13) (14) (15)

Hiriya is a former waste dump located southeast of Tel Aviv, near Ben-Gurion International Airport. The site was used as a landfill between 1952-1998, and was an environmental hazard known for its pollution, odour and flocks of birds endangering the safety of aircraft.

The waste mountain reached a height of 60 meters, and spread over an area of 450,000m², with a volume of 16 million cubic meters of waste. In 1998 the Hiriya landfill was finally closed.

Hiriya currently houses the largest waste transfer station in the Middle East. Each day, some 800 garbage trucks deposit 3,000 tons of household waste and garden trimmings, and 400 more trucks bring approximately 1,500 tons of construction waste from 18 local municipalities in the Dan Metropolitan Area. Three recycling plants operate at the foot of the mound, including a plant for grinding building waste into gravel and treatment of construction waste (100,000 tons annually). Additional plants recycle dry organic matter into mulch, and sort ordinary household waste through pools of water. The biological treatment facility handles a hundred tons of waste a day. The organic components are broken down to produce biogas and electricity. Seventy gas wells have been drilled to collect the methane gas trapped in the landfill. The plant generates all the electricity required by the site and sells the excess to the Israel Electric Corporation.

In 2004, an international architectural competition was held and Prof. Architect Peter Latz was chosen to design the rehabilitation of the mountain. In 2007 the Israeli government approved the creation of the Ayalon Park, the largest "green lung" of the Dan Metropolitan Area incorporating the Hiryia site, to which visitors can come to enjoy the green landscape with its natural surroundings including woodlands, fields, streams, and lakes.

Image of waste mound and park. Photo source: www.israelidesign.org.il

(13) Hiriya Website www.hiriya.co.il (see also www.ayalon-park.org.il)
(14) www.en.wikipedia.org/wiki/**Hiriya**
(15) "Islands in the Urban Stream" Conference Israeli Design Center, Mediatheque Holon on Thursday, April 30th 2009.

Jaffa Slope Park (16) (17) (18)

The Jaffa Slope was a landfill on the beach used from 1975 for construction waste disposal. Public opposition followed by a ruling of the Supreme Court forced the Tel-Aviv-Yafo Municipality to cease dumping construction waste in 1998. However, until 2003 it was still used illegally. This disturbed site created a boundary between the neighborhoods of Jaffa and its natural shoreline. In addition to polluting the area, the site also became notorious for its criminal activity. The site eventually presented an opportunity for new large scale landscape rehabilitation. Landscape architects Braudo-Maoz were commissioned for its design. The 200 dunam[19] park was opened in April 2010.

The basic idea was to re-open the site to the public through rehabilitation and to restore its natural place along the Tel Aviv coastline. The park stretches about 1km along the shoreline and about 300 meters inland and it is approximately 15m above water level. Local residents, as well as representatives of various environmental protection groups, participated in the design process of the park. For its execution, large-scale work has been carried out. Some 1,275,000 metric tons of construction waste dumped on this site over the years, slowly transformed into a long boardwalk with paths to the nearby neighborhoods and to the beach.

All the recycled materials were used for construction purposes mostly on the site itself. Some of the waste mounds were flattened to restore views of the sea and to enable easier access to it. The site now includes three higher observation points, an open air amphitheater, as well as a beach promenade. Several walking and cycling paths as well as sports facilities make it a popular recreation space. Emphasis was given to shaded areas and use of local, indigenous plant species. The works were carried out by the Tel-Aviv municipal construction company.

Aerial view of park along the coast. Photo source: www.israelidesign.org.il

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(16) ibid 15
(17) Tel-Aviv Municipality Website, www.tel-aviv.gov.il/
(18) Wikipedia he.wikipedia.org/wiki/מדרון_יפו

Rehabilitation of abandoned quarries (19) (20)

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19 A dunam is 1,000 square metres (10,764 sq ft) (Wikipedia April 2011)

Nationwide there are about 2000 abandoned quarries. Many of them have become illegal construction waste dumps creating further environmental hazards including the polluting of ground water sources. In 1978 the Quarries Rehabilitation Fund was set up, with a joint ministerial management committee including representatives from the Ministries of National Infrastructures, Environmental Protection, Finance, Interior, Industry and Commerce as well as from the National Parks and Nature Authority and Israel Land Authority.

Over 200 rehabilitation projects have been completed and some 50 projects are ongoing. Initial rehabilitation includes eliminating health and safety hazards as well as removing junk and garbage. Thereafter detailed rehabilitation plans are prepared for various new uses for the quarries such as for industrial areas, public parks, water reservoirs and cemeteries.

A recently approved plan includes the rehabilitation of the Bareket Quarry as a cemetery for the Dan Metropolitan Area, solving an acute need for a new large-scale cemetery in the centre of the country. The plan was commissioned by the Israel Land authority and designed by Ponger-Sagiv Architects. The quarry with an area of 300 dunams and a depth of some 50 meters, will house 270,000 burial crypts and graves, thereby becoming the largest cemetery of its kind in Israel. It will supply burial demand for about 30 years and will spare other valuable lands for nature reserves and other uses. Crushed demolition waste will be used extensively as infill. In an adjacent quarry a plant was set up for crushing and treating construction waste with an annual capacity of 150,000 tons.

Model of the Bareket cemetery. Photo source: www.green-dense-burial.com

(19) The Quarries Rehabilitation Fund website www.mine-rec.mni.gov.il
(20) The author of this report was part of the design team of Ponger-Sagiv architects, including this project.

Ecological Community Gardens

One of the first community gardens in Israel, of over 240 nationwide, is the Bustan Brodi Ecological Community Garden in Jerusalem. This grassroots initiative was led by concerned, environmentally-conscious residents. With much care, determination and dedication, they transformed a derelict site into a thriving community garden. The site, of some 1,000m2, was originally designated for a public building, but left abandoned for many years with remains of construction waste and concrete leftovers from constuction of the buildings flanking this site. The residents planted several local fruit trees, herbs and vegetables in keeping with the seven biblical species.

Recently, thanks to a generous donation, the garden was renovated and upgraded according to plans by the author, based on a brief created with participation of the residents. The design and execution posed many challenges and opportunities: The construction waste, comprising concrete leftovers, was crushed on site and reused for drainage of the compost area to reduce soil contamination. Top soil was removed to a mimimum depth and then reused in the rammed-earth paving, thereby eliminating excavation waste. Border stones out of recyled concrete waste were used to outline the paths and leaf-shaped gathering areas. Paths and gathering areas were kept at the level of the existing surrounding terrain to facilitate natural waterflow and drainage, as well as retaining the ecological corridors for the small animals inhabiting the site.

This project has created a successful precedent for on-site reduction and elimination of excavation and construction wastes in future community gardens, adjacent to construction sites in Jerusalem and beyond.


Bustan Brodi Ecological Community Garden. Architect Gil Peled Photo: Peled

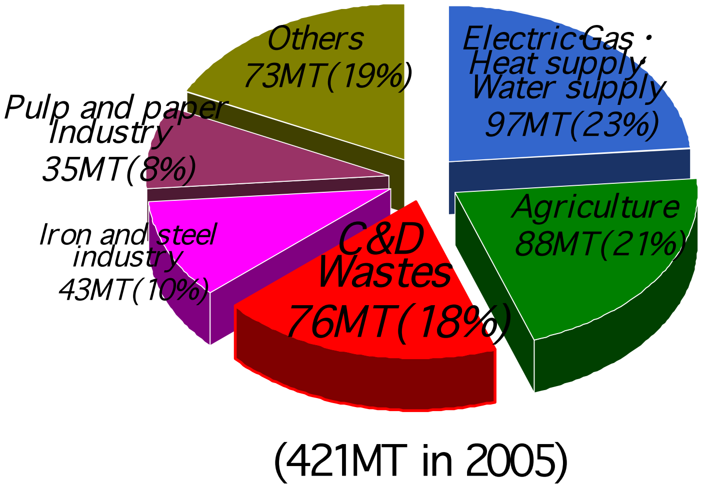
Japan

Contributed by:
Shiro Nakajima Ph.D
Dept. of Building Materials and Components, Building Research Institute

1. National statistics

Almost 20% of industrial waste is generated from the construction sector (see figure 1). Also, 18 % of landfilled waste is from the construction sector, around 7 MT in 2003. Landfill availability for industrial waste is thought to be very limited, it was estimated in 2003 that final disposal sites would only be able to accept industrial waste for another 6 years. However, these sites were still operating in 2010.

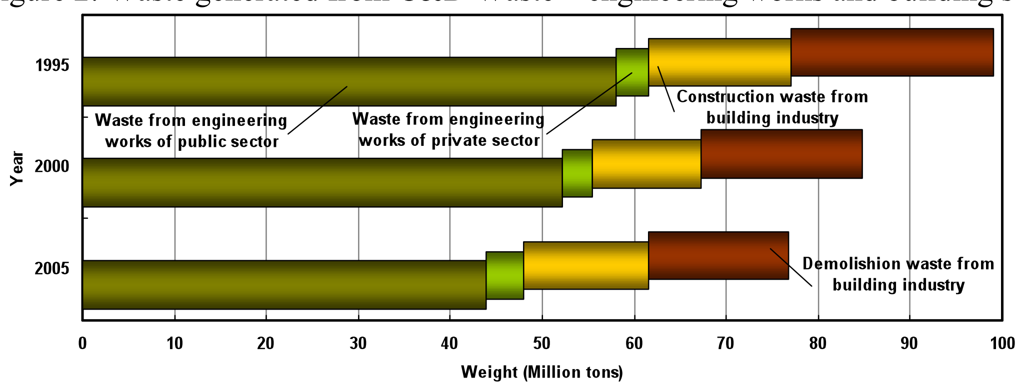
Figure 1: Industrial waste production in 2005



The Japanese Government reports the status of C&D waste every 5 years (from 1995). The total weight of the C&D waste was approximately 99 million tons in 1995 and it decreased to 77 million tons in 2005.

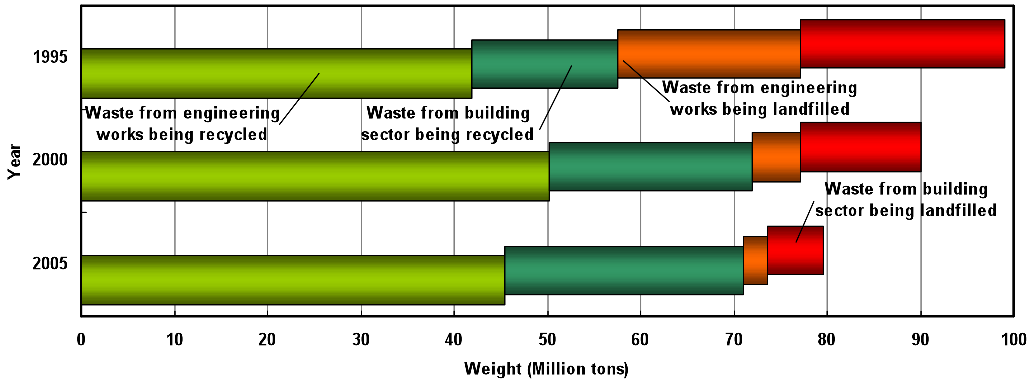
The amount of the waste generated from the engineering works and the building industry for the year 1995, 2000 and 2005 is summarized in figure 2. The waste generated from the public engineering works and building demolition activities are decreasing. Approximately 60% of the C&D waste was generated from the engineering works, and 40% of that was generated from the building industry.

Figure 2: Waste generated from C&D Waste – engineering works and building sector



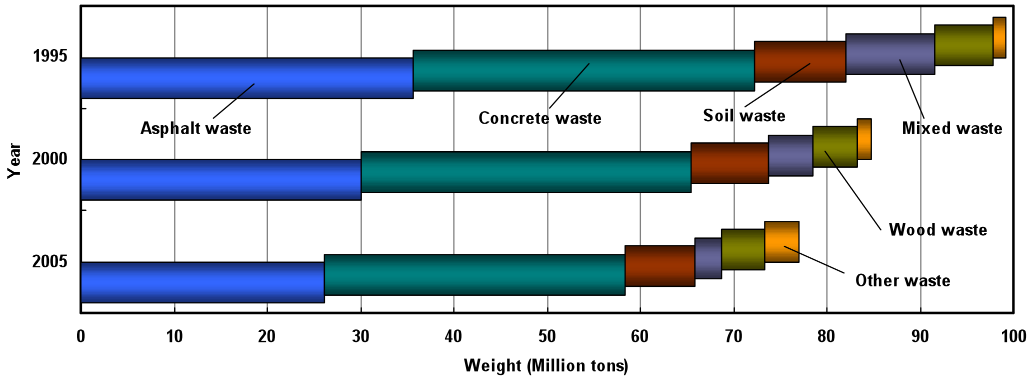
The amount of recycled and landfilled C&D waste is summarized in figure 3. The recycling rate for all C&D waste was 58% in 1995 and 92% in 2005. The waste being recycled is increasing and the waste being landfilled is decreasing.

Figure 3: Amount of recycled and land filled C&D waste



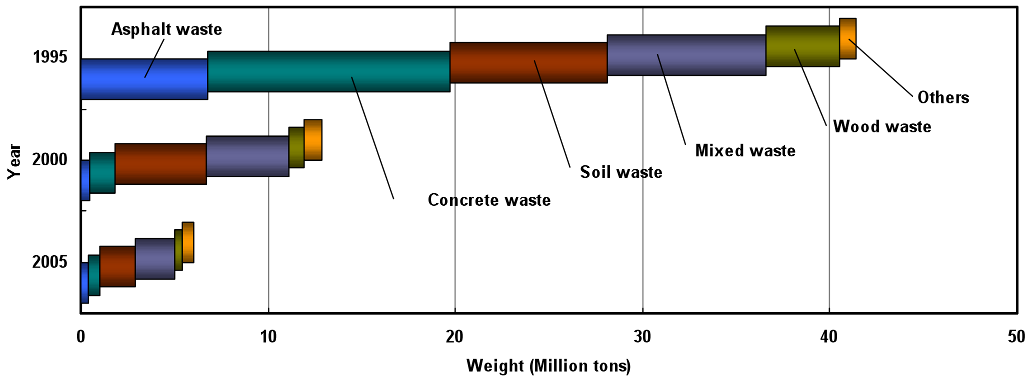
The type and amount of the C&D waste is summarized in figure 4. In 2005, 34% of the C&D waste was asphalt waste, 41% was concrete waste, 10% was soil waste, 4% was mixed waste and 6% was wood waste. The amount of mixed waste has decreased significantly.

Figure 4: Type and amount of the C&D waste



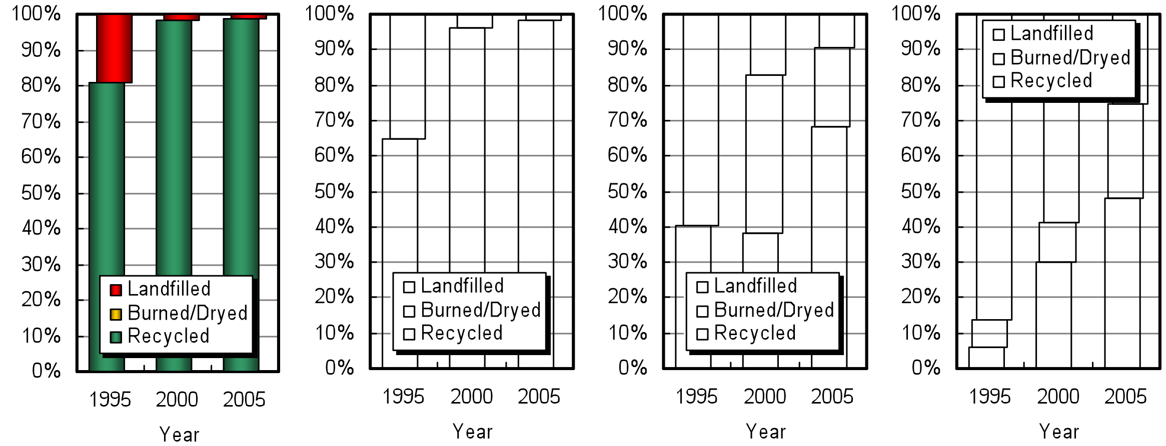
The type and amount of landfilled waste is summarized in figure 5. The amount of the landfilled waste was 42 million tons in 1995 and 6 million tons in 2005, it has decreased significantly.

Figure 5: Amount of the landfilled waste.



The recycling rates for the individual C&D waste are summarized in figure 6. The recycling rates for all waste types have been improved since 1995. For example, the recycling rate of asphalt waste was 80.8% in 1995 and 97.5% in 2005, concrete was 64.7% in 1995 and 98.1% in 2005, and wood waste was 40.3% in 1995 and 68.2% in 2005.

Figure 6: Recycling rates for the individual C&D waste



(a) Asphalt *(b) Concrete* *(c) Wood* *(d) Soil*

The 2010 statistics for C&D waste are expected to be issued in late 2010.

Benchmarks relating to the typical amount of C&D waste arisings are not produced by the government. However, the following organizations have produced benchmark data:
- The Building Research Institute.
- The National Institute for Land Infrastructure Management.
- Architectural Institute of Japan.
- Some Universities.

2. Policies, strategies and legislation

The Construction Materials Recycling Act was enforced in 2004. A summary of the accompanying Guideline is given below:

Construction Materials Recycling Act

-- A Ministerial Ordinance for Ministry of Land, Infrastructure and Transport, dated 5th of March, 2002. This ordinance shall come into force on 30th of May, 2004.

Interpretation and the fundamental guideline of this Act

This fundamental policy details the requirements for the effective and efficient use of building materials for building work and proper waste management.

Basic objectives

(1) To separate building materials into specific materials and to recycle specific building material wastes

(2) Waste prevention and proper waste management

Roles and responsibilities

Manufacturers of building materials are required:

- to develop and manufacture new building materials which decrease non-recyclable materials;
- to disclose the nature of the materials when used as building materials;
- to decrease waste production and facilitate the process of deconstruction and recycling by avoiding materials that are difficult to recycle at post demolition stage

Planners and designers are required to consider the effective deconstruction of the building; and choose building materials that facilitate recycling the building material wastes, in an efficient, effective and cost effective way. Material selection should also avoid building materials containing hazardous substances as these are difficult to recycle. Clients are responsible for ensuring that waste is reduced, and demolished buildings are separated into materials for recycling. Main contractors are responsible for ensuring any subcontractors will reduce waste and separate building materials for recycling. All contractors are required to properly implement and facilitate such actions as the restriction of the occurrence of waste building materials, dismantlement, and recycling of the waste building materials through construction method, proper choice of building materials, and development of construction technology. Waste contractors are required to enforce the recycling of building material wastes. The Government is required to encourage research and development, data provision, dissemination of good practice, and provide funding to support the restriction of the occurrence of waste building materials, dismantlement, and recycling of the waste building materials. Municipalities are required to take necessary measures in collaboration with government policy.

Dismantlement (deconstruction), and recycling of the waste building materials.

Due to the varying nature of buildings, deconstruction must be implemented carefully with the right building method according to the building, utilising appropriate skills, techniques and equipment. Those working in deconstruction/demolition are required to have knowledge and higher skills. Materials should be reused or recycled on site if possible. The cost of deconstruction should be minimised through promoting technological development, collaboration with others and the development of suitable facilities. The availability of recycling sites varies regionally and this needs to be understood.

Waste reduction

Everyone involved in producing building waste should play an active part and collaborate with others to restrict building material wastes. Buildings should be properly maintained and renovated to prolong their life. Those who manufacture building materials are required to precut building materials, and enable the maintenance of building materials which have potential of increased durability and renovation. The designer is required to strive for improved durability of the framework of structure, as well as to promote long-term use through correct maintenance and renovation. The client should consider the long-term durability within the technically and financially viable range. In addition, the client is required to restrict difficult to recycle building materials, and employ a construction method that promotes the reuse of building materials at end of life, whilst striving to build a highly durable architecture. The client particularly is required to promote the recyclability of concrete-type frame structures. The Government will require waste prevention when acting as a client. Municipalities are required to develop local measures that align with government policy.

Setting targets for the recycling of specific building material wastes
The recycling of specific building materials is to be promoted over the next decade, especially when taking into account regional variations in recycling infrastructure. The recycling rates by 2010 (the weight of recycled versus that of specific building material wastes occurring at the construction site), is listed in the table below:

Concrete (including reinforced)	95%
Timber	
Asphalt concrete	

Achieving these recycling rates will require
1. Adequate facilities for recycling
2. Development of technology to reduce costs of recycling
3. Increase use of recycled products and materials

This will be supported through taxes and loans. Municipalities should take measures to develop adequate recycling infrastructure for specific building material wastes in each region. Specific guidance provided for each of concrete (recycled aggregates and sands), wood waste (panel board production, fuel, mulch), asphalt concrete (hot & cold mix recycling, road sub-base, capping etc). Other materials such as plastics and plasterboard should also be focussed upon in terms of technological and financial development to promote recycling.

Promoting the use of recycled materials
Materials and products separated for recycling need to have end uses. This requires the development of good quality recycled products that are safe and durable. There are a variety of roles for relevant people. Manufacturers of building materials should try to increase the recycled content of their products. Designers need to design in the use of reclaimed and recycled building materials. This should be reinforced through the procurement of building materials. Contractors should also maximise the use of recycled products and materials. Waste and recycling contractors need to produce stable and good quality recycled materials. The Government shall encourage research and development, provision of guidance and case studies, quality standards, and standardization necessary for the promotion of recycled materials. Municipalities are required to develop local measures that align with government policy. The Government should also lead by example in public procurement (in line with law No. 100, 2000).

Specifically, in the procurement of recycled aggregates regardless of the cost, providing they are fit for purpose and produced within 40 km from the relevant site, except for the cases when by-products occurred at construction sites take precedence. In procurement of road materials where heated asphalt mixture is available through recycling asphalt concrete, within 40 km and 1.5 hours transport from the relevant site, a principle to use the heated asphalt mixture no matter of cost, regardless of cost, providing they are fit for purpose. In terms of timber formwork (shuttering), we shall promote using recycled wooden boards. Also promoted for use in publicly procured projects is mulch (derived from building waste).

Separate dismantling of specific building material wastes for preserving environment
A greater understanding of the best ways to recycle building materials will be developed. This includes energy for waste, impact on the environment and associated emissions. Everyone in the supply chain should consider the environment and co-operate to achieve the

best outcome. This includes applying life cycle assessment across each stage of the dismantling and recycling (or disposal) process).

Promotion of dismantlement of specific building materials and recycling
A greater understanding of the costs and benefits relating to the dismantlement and recycling of specific building material wastes should be developed. Everyone in the supply chain should co-operate to achieve the best outcome. The Government should provide web-based resources relating to guidance and location of suitable recycling facilities.

Hazardous materials
Hazardous wastes must be dealt with correctly, in line with existing legislation such as Waste Disposal Act, Clean Air Act, Act on Special Measures against Dioxins, Occupational Safety and Hygiene Act. In particular, measures to prevent CFCs or asbestos from escaping into the environment need to be implemented. Guideline includes specific guidance on the incidence and control of CFCs in refrigeration applications (considered too difficult to retrieve from insulation), asbestos, and wood treated with CCA.

3. Guidance documents and tools

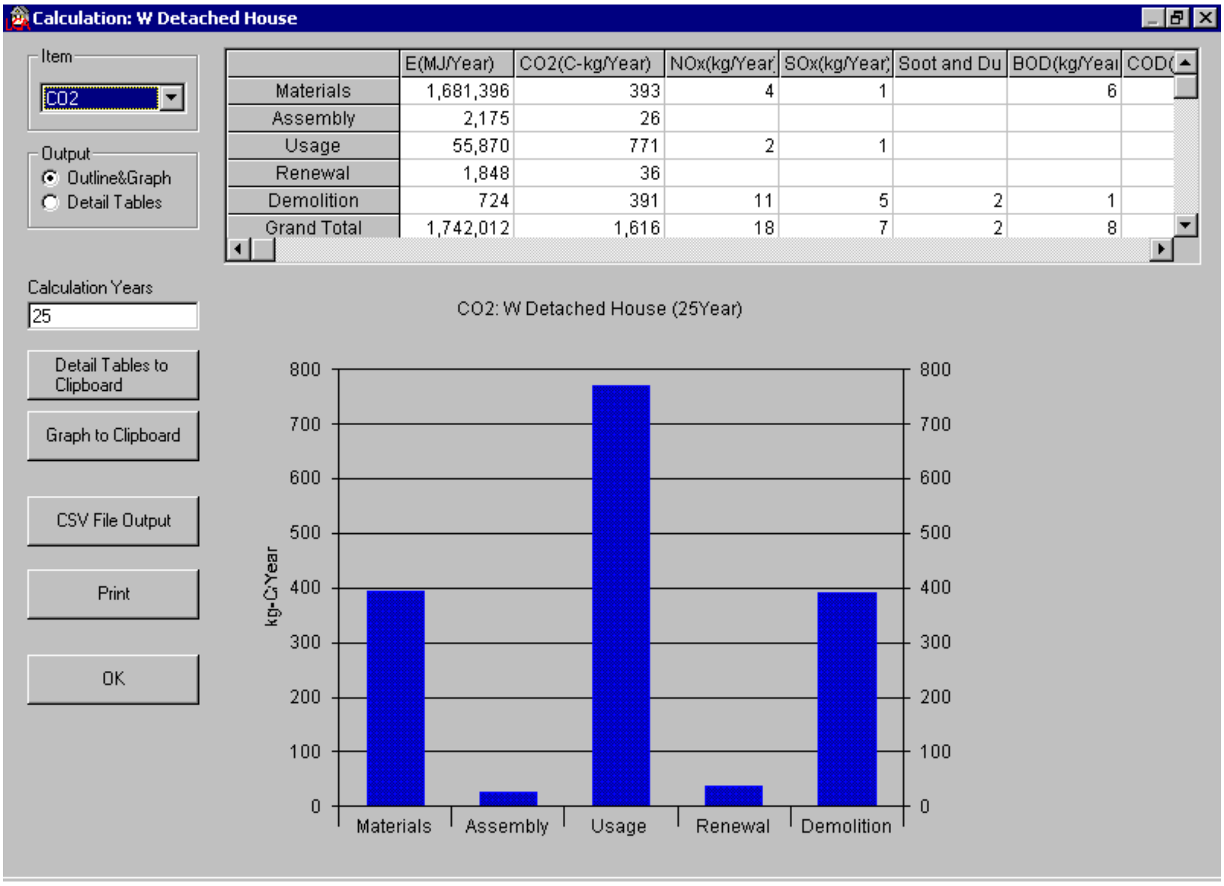
CASBEE
CASBEE (Comprehensive Assessment System for Building Environment Efficiency) is an environmental labelling method for buildings. BEE (Building Environmental Efficiency) was developed as a new indicator. The environmental performance of the building is labelled as B-, B+, A and S. The assessment categories of CASBEE are “Quality of Building” and “Environmental Load”. “Quality of Building” includes “Indoor Environment”, “Quality of Service” and “Outdoor Environment on Site”. “Environmental Load” includes “Energy”, “Resources and Materials” and “Off-site Environment”. BEE is calculated by dividing “Quality of Building” with Environmental Load”.

The sub categories relating to “Resources and Materials” in CASBEE are “Water Resource” and “Material of Low Environmental Load”. “Material of Low Environmental Load” has sub categories of “Recycled Materials”, “Timber from Sustainable Forestry”, “Materials with Low Health Risks”, “Reuse of Existing Building”, “Reusability of Components & Materials” and “Use of CFCs & Halons”. See Figure 8 for indicative results.

BEAT
BEAT (Building Environment Assessment Tool) is a life cycle assessment system that calculates environmental impacts related with homes and offices. BEAT is a tool to help designers of buildings to decrease environmental impacts, to be used by ordinary building designers who are not familiar with life cycle assessment and environmental effects of buildings.

BEAT considers the entire life cycle of houses and office buildings. The life cycle of building is divided into five stages, production and transport of building materials and components, assembling on construction site, using or living in the building, renewal and renovation, and demolition. The results displaying window of BEAT-HOUSE is shown in figure 7. BEAT was developed by the Building Research Institute and the National Institute for Land Infrastructure Management.

Figure 7: Results displaying window of BEAT-HOUSE



AJI LCA-TOOL

AIJ (Architectural Institute of Japan) has its own building assessment tool. The tool was developed in 1997 and is revised every 4 years. The AIJ LCA-TOOL includes environmental impact factors such as CO2, CFCs, NOx, SOx, Resource Consumption and C&D. See figure 9 for indicative results.

C&D Assessment Tool

NILM (National Institute for Land Infrastructure Management) has developed a C&D waste assessment tool. The type and amount of C&D waste for a certain project can be calculated for the following four scenarios.

Scenario I: Separation to the level required by The Construction Materials Recycling Act
Scenario II: Scenario I plus separation into valuable resources and normal-level separation
Scenario III: Scenario II plus separation of materials which is assigned by The Waste Disposal and Public Cleaning Law or materials with well developed disposal systems that are currently available
Scenario IV: Full separation (assuming that a disposal facility using an as-yet-unavailable technology is constructed)

Figure 8: Result presenting sheet of CASBEE

Comprehensive Assessment System for Building Environmental Efficiency

CASBEE for New Construction

CASBEE-NCe_2004v1.0

Assessment sheet of Preliminary Design Stage | Assessment date: 5-Jun-04 | Assessor: XXX | Date of approval: 10-Jul-04 | Approved by: XXX

(1) Building Outli *1

Building Name	XX building		
Building Type	Offices		
Location / Climate	XX city, XX pref.	Zone IV	
Area / Zone	Commercial Area		
Completion	Aug-03 Scheduled	Number of Floors	+XX F
Site Area	XXX m^2	Structure	RC
Construction Area	XXX m^2	Occupancy	XX persons
Gross Floor Area	XXX m^2	Annual Occupancy	XXX hrs/yr

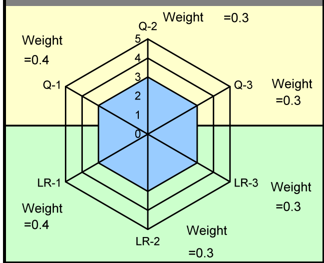
Appearance, views, etc.

Unprotect sheet when you paste pictures.

(2) Results of Comprehensive Assessment for Building Environmental Efficiency *1*2

(2)-1 Building Environmental Quality & Performance and Load Reduction (Results by Category)

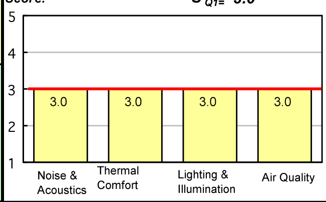
Radar Chart



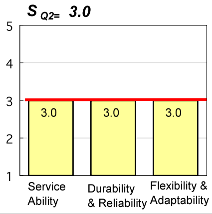
Q. Building Environmental Quality & Performance

Score: $S_Q = 3.0$ *SQ = 0.4* SQ1 + 0.3 * SQ2 + 0.3 * SQ3

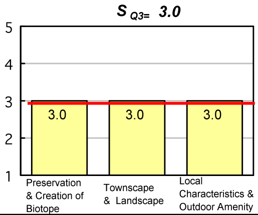
Q-1 *Score:* $S_{Q1} = 3.0$



Q-2 $S_{Q2} = 3.0$



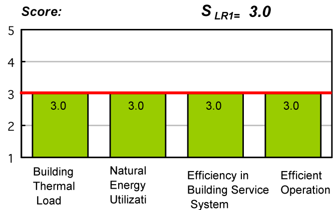
Q-3 $S_{Q3} = 3.0$



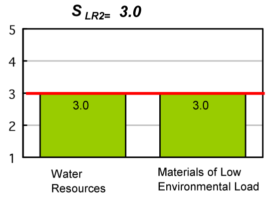
LR. Reduction of Building Environmental Loadings

Score: $S_{LR} = 3.0$ SLR = 0.4 * SLR1 + 0.3 * SLR2 + 0.3 * SLR3

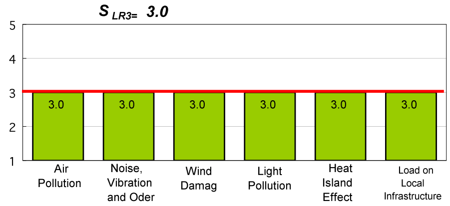
LR-1 *Score:* $S_{LR1} = 3.0$



LR-2 $S_{LR2} = 3.0$

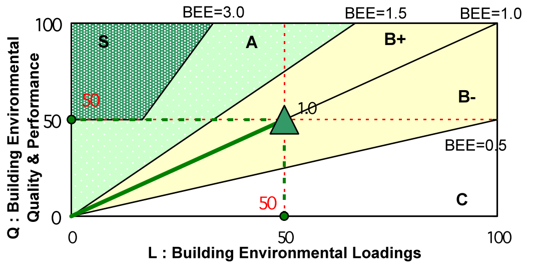


LR-3 $S_{LR3} = 3.0$



(2)-2 BEE Building Environmental Efficiency

Building Sustainability Rating based on BEE



$$BEE = \frac{\text{Building Environmental Quality \& Performance Q}}{\text{Building Environmental Loadings L}} = \frac{25 * (S_Q - 1)}{25 * (5 - S_{LR})} = \frac{50}{50} = 1.0$$

$Q = 25 * (S_Q - 1)$ *S_Q: Score of Q category

SQ = 0.4* SQ1 + 0.3 * SQ2 + 0.3 * SQ3

$L = 25 * (5 - S_{LR})$ *S_{LR}: Score of LR category

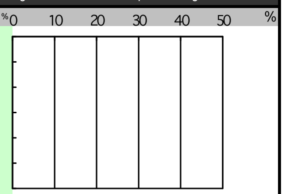
SLR = 0.4 * SLR1 + 0.3 * SLR2 + 0.3 * SLR3

(3) Important Assessment Items Excluded from Comprehensive Assessment for Building Environmental Efficiency *3

(3)-1 Quantitative Assessment Indicators for Typical Building Environmental Loadings

<Input when the detailed assessment is carried out at the Execution Design & Construction Completion Stage >

	Value / y / m^2		Value / person / h		Reduction / y / m2		Reduction Rate %
Energy consumption in building operation		MJ/y/m^2		MJ/person/h		MJ/y/m^2	
CO_2 emission in building operation		kg-CO_2/y/m^2		kg-CO_2/person/h		kg-CO_2/y/m^2	
Water consumption		m^3/y/m^2		m^3/person/h		m^3/y/m^2	
Lifecycle CO_2 emission		kg-CO_2/y/m^2		kg-CO_2/person/h		kg-CO_2/y/m^2	
Lifecycle amount of waste disposal		t/y/m^2		t/person/h		t/y/m^2	
Lifecycle amount of resource		t/y/m^2		t/person/h		t/y/m^2	



(3)-2 Design Process Assessment

Concerned Items

Design Stage

1 Design by Accredited Professional

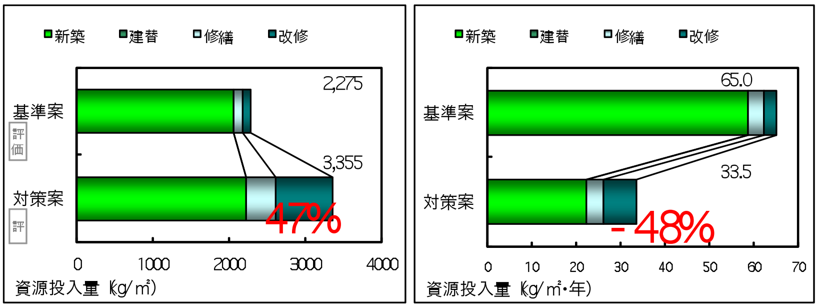
Construction Stage

2 Environmental Management Plan

Notes *1: Essential assessment results are displayed in (1) and (2).

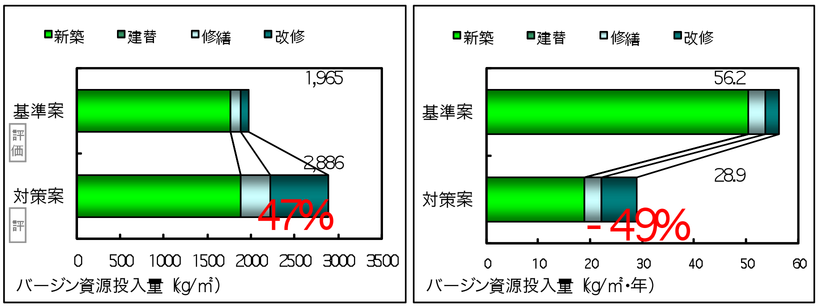
*2: Site - selection - related assessments are not included. A standard building constructed on this site is given the score of 3."NA" denotes that the item is excluded from assessment.

*3: Assessment (3) is optional. If possible, it is recorded only in the execution design stage and the construction completion stage.



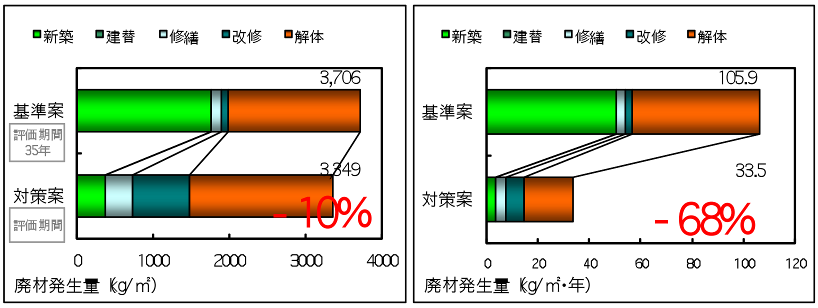
(1) Resource consumption.

Upper: Benchmark
Lower: With countermeasures



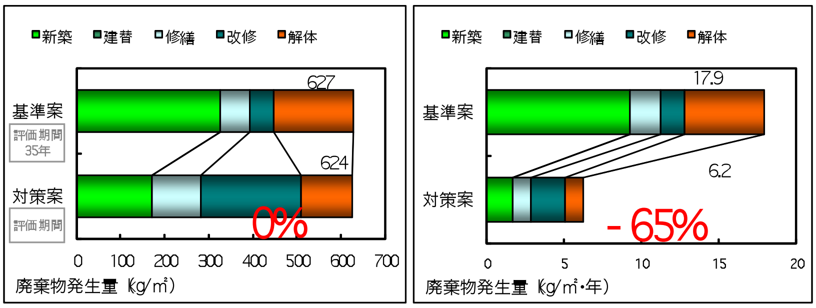
(2) Virgin resource consumption.

Upper: Benchmark
Lower: With countermeasures



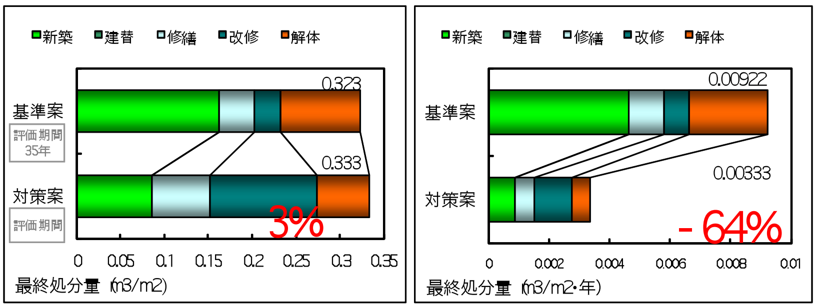
(3) Dismantled material.

Upper: Benchmark
Lower: With countermeasures



(4) Waste.

Upper: Benchmark
Lower: With countermeasures

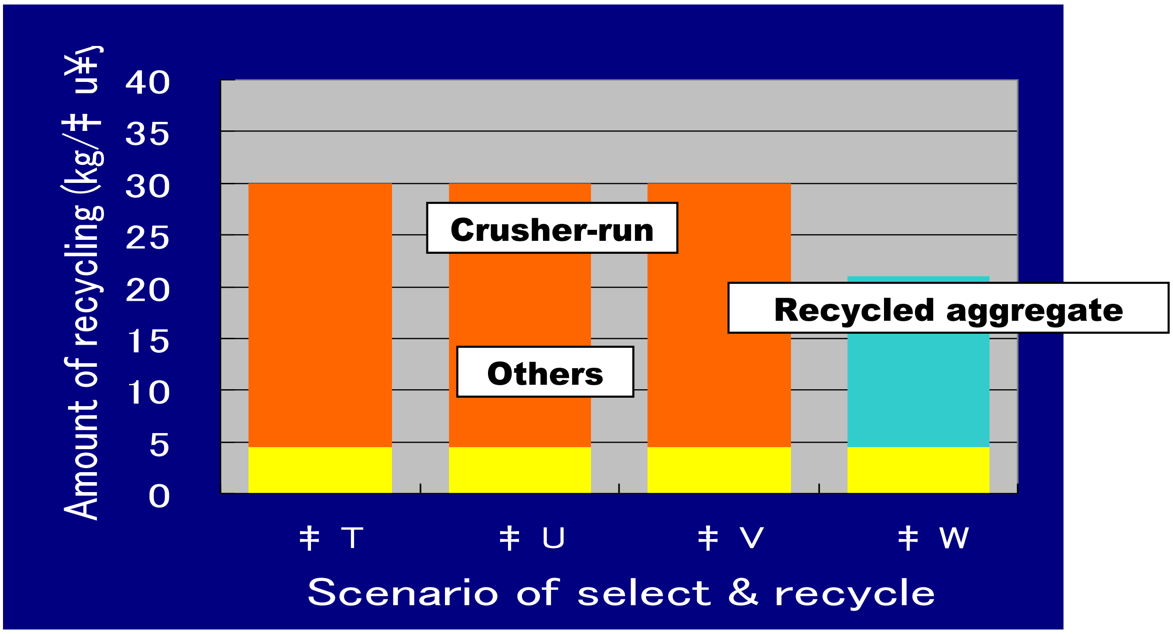


(5) Final disposal waste.

Upper: Benchmark
Lower: With countermeasures

Figure 9: Results displaying window of AIJ LCA-TOOL

Figure 10: gives an example of the calculated results



Norway

Contributed by:
Anne Sigrid Nordby.
Architect & Post Doctorate with NTNU - Department of Product Design

Reviewed by: Rolf André Bohne, Associate Professor, NTNU
Department of Civil and Transport Engineering, Building and Material Technology

1. National Statistics

Around 1.24 million tonnes of waste was generated by building activities in Norway in 2004[20]. Heavy building materials, mainly bricks and concrete, constituted about half the total generated amounts.

Waste from construction, rehabilitation (refurbishment) and demolition of buildings constitutes about 14% of the total waste amounts generated annually in Norway. This is mostly uncontaminated and can be disposed of at landfills or reused without special environmental considerations. Some building materials do however contain hazardous substances, which must be properly treated.

44% of the building related waste in 2004 came from rehabilitation activities, with Demolition accounting for 36% of the total waste amounts. Heavy building materials, mainly bricks and concrete, constituted about half the total waste amounts.

Slightly more than 7000 tonnes of hazardous waste were generated from building activities in 2004. This is, however, a conservative estimate. Some of the waste that has been registered as polluted heavy building materials should perhaps have been included in the hazardous waste category. The amounts of plastic, paper and glass may also be underestimated in the statistics, as some of these materials are "hidden" in the mixed waste category. Mixed waste constituted 23% of the total waste amounts from building activities in 2004.

There is considered to be a high degree of uncertainty in the data, especially given that the estimate in 1998 was 1.54 million tonnes, while the estimate reduced to 0.94 million tonnes in 2001. Generated amounts are estimated on basis of waste factors developed from waste reports from building projects in Oslo municipality, combined with structural statistics of constructed and demolished buildings and investments in rehabilitation.

Table 1 provides a breakdown of waste amounts from construction, rehabilitation and demolition of buildings in 2004.

[20] SSB Statistics Norway, 27 April 2006. www.ssb.no/english/subjects/01/05/avfbygganl_en/

Table 1 - Waste amounts from construction, rehabilitation and demolition of buildings in 2004 (tonnes)

Waste types	Construction	Rehabilitation	Demolition	Total
Wood	63 354	103 814	48 430	215 598
Paper and cardboard	2 320	575	5	2 900
Plastic	1 900	465	18	2 383
Glass	60	927	330	1 317
Metals	5 963	22 527	18 421	46 911
Electrical waste	438	1 926	1 003	3 367
Hazardous waste	783	4 620	1 800	7 203
Asbestos	-	3 773	944	4 716
Impregnated wood	516	216	421	1 152
Other hazardous waste	268	631	436	1 334
Polluted bricks and concrete	-	14 278	22 595	36 874
Bricks and concrete and other heavy building materials	48 873	228 028	322 841	599 742
Mixed waste	93 012	151 333	35 612	279 957
Other waste	25 408	15 929	1 543	42 880
Total (tonnes)	**242 110**	**544 422**	**452 599**	**1 239 131**

Table 2 provides a breakdown of treatment routes for this waste in 2004.

Table 2 - Breakdown of disposal routes

Waste types	Total	Material recovery	Incineration with energy recovery	Biological treatment	Landfill cover	Landfill	Sorting	Other disposal	Disposed/ treated outside waste plants
Wood	215 598	10 592	150 298	12 701	2 295	43	-	2 216	37 452
Paper, cardboard	2 900	2 807	93	-	-	-	-	-	-
Plastic	2 383	2 262	114	-	-	7	-	-	-
Glass	1 317	1 250	-	-	16	46	-	4	-
Metals	46 911	35 050	-	-	-	-	1 007	16	10 838
Electrical waste	3 367	2 626	4	-	-	17	371	349	-
Hazardous waste	7 203	200	1 766	13	-	5 223	-	-	-
Polluted bricks and concrete	36 874	-	-	-	-	-	-	-	36 874
Bricks, concrete, heavy materials	599 742	61 459	-	-	46 925	39 734	-	41 528	410 097
Mixed waste	279 957	973	41 557	3	577	223 316	12 463	1 068	-
Other waste	42 880	15 403	7 094	2 150	58	13 744	1 263	3 168	-
Total	*1 239 132*	*132 623*	*200 925*	*14 868*	*49 871*	*282 131*	*15 104*	*48 349*	*495 261*

2. Policies, strategies and legislation

Substitution duty (2007)

Hazardous building materials must be replaced with less hazardous alternatives if possible. Norwegian legislation relating to the substitution principle puts an obligation on business and industry to replace hazardous chemicals with less hazardous chemicals, provided that this does not lead to unreasonable costs or inconvenience. The Government is reinforcing the substitution principle by informing importers and distributors that they are expected to apply the substitution principle and consider alternatives to products that contain hazardous substances

Waste plans (2008)

Waste disposal plans and depollution descriptions need to be sent to the municipality for approval. The municipality ensures that the plans for handling and disposal of construction waste comply with the relevant requirements. Permission to start the project, as needed under the Planning and Building Act, is not being given until the waste disposal plan and depollution description have been approved. These are mandatory in all communities and require a minimum of 60% source separation of construction related waste. Municipalities can also set higher demands.

The producer of waste has to deliver a final report to the municipality. This report describes the disposal of construction waste generated in connection with the project. The report includes documentation of quantities of waste delivered for recycling or to a legal landfill. If the quantities of waste or the means of disposal substantially deviate from what has been planned, the reason for this has to be specifically argued and documented.

Organic waste (2009)

Landfilling of biodegradable waste is now prohibited, including materials such as waste wood. The statistics from 2004 indicate that at least 17% of the waste stream would fall into this category, probably more when including the biodegradable fraction of the mixed waste category. However, this is estimated to be mostly incinerated with energy recovery.

3. Guidance documents relating to construction waste reduction

1. *National Action Plan for Building & Construction waste 2 (Byggenærings Landsforening BNL, 2007), available at:*
   www.byggemiljo.no/getfile.php/Filer/Publikasjoner/NHP2 kortversjon m forside.pdf

2. *Design-guide for reuse and recycling (Leland 2008), available at:* www.byggemiljo.no/article.php?articleID=499&categoryID=6

3. PhD-thesis, NTNU: *Eco-efficiency and Performance Strategies in Construction and Demolition Waste Recycling Systems* (Bohne 2005), available at: http://ntnu.diva-portal.org/smash/record.jsf?pid=diva2:125234

4. PhD-thesis, NTNU: *Salvageability of building materials: Reasons, criteria and consequences regarding architectural design that facilitate reuse and recycling (Nordby 2009),* available at*:* http://ntnu.diva-portal.org/smash/record.jsf?pid=diva2:225736

Singapore

Contributed by:
Dr Edward Anggadjaja
Assistant Director
Building and Construction Authority

Low Giau Leong
Senior Research Officer
Building and Construction Authority

Ms Bek Jun Hui
Senior Research Officer
Building and Construction Authority

1. Current national statistics

Background
Singapore is a small city state sited on about 700 km^2 of land, supporting a population of about 5 million people. With one of the highest population densities in the world but practically no natural resources, the development of the city has to be undertaken in a sustainable manner to ensure a first-rate living environment not only for current, but also future generations of Singaporeans. The building and construction sector, being one of the key drivers of Singapore's economy (19.8% growth in 2009), will be at forefront of the national sustainable development effort.

Demolition Waste

Demolition waste quantities in the last three years (see Figure 1) showed that there are significant quantities of construction and demolition waste (C&D waste) from which quality recycled concrete aggregates (RCA) could be recycled. Based on these data, an average of 1.19 million tons of C&D waste could potentially be recycled each year. Figure 2 shows that of the estimated 1.01 million tons of demolition waste generated in 2010, concrete waste makes up about 66% (or 0.67 million tons) of demolition waste. As the total aggregate content of concrete is about 75% per unit volume, this means 0.5 million tons of RCA could be potentially reclaimed for reuse yearly.

Figure 1 - Demolition Waste Quantities from 2008 to 2010

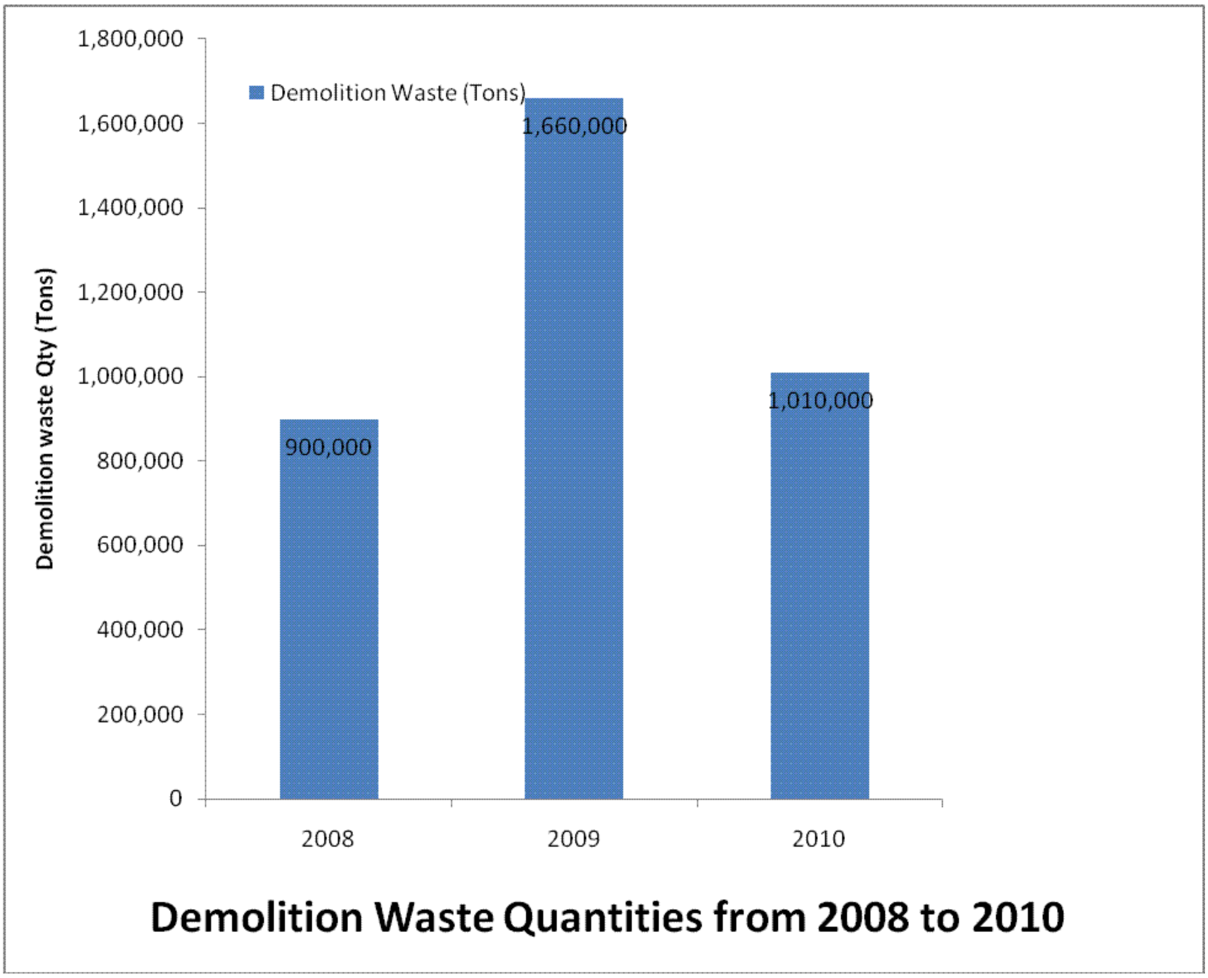


Figure 2 - Composition of Demolition Waste from Projects in 2010

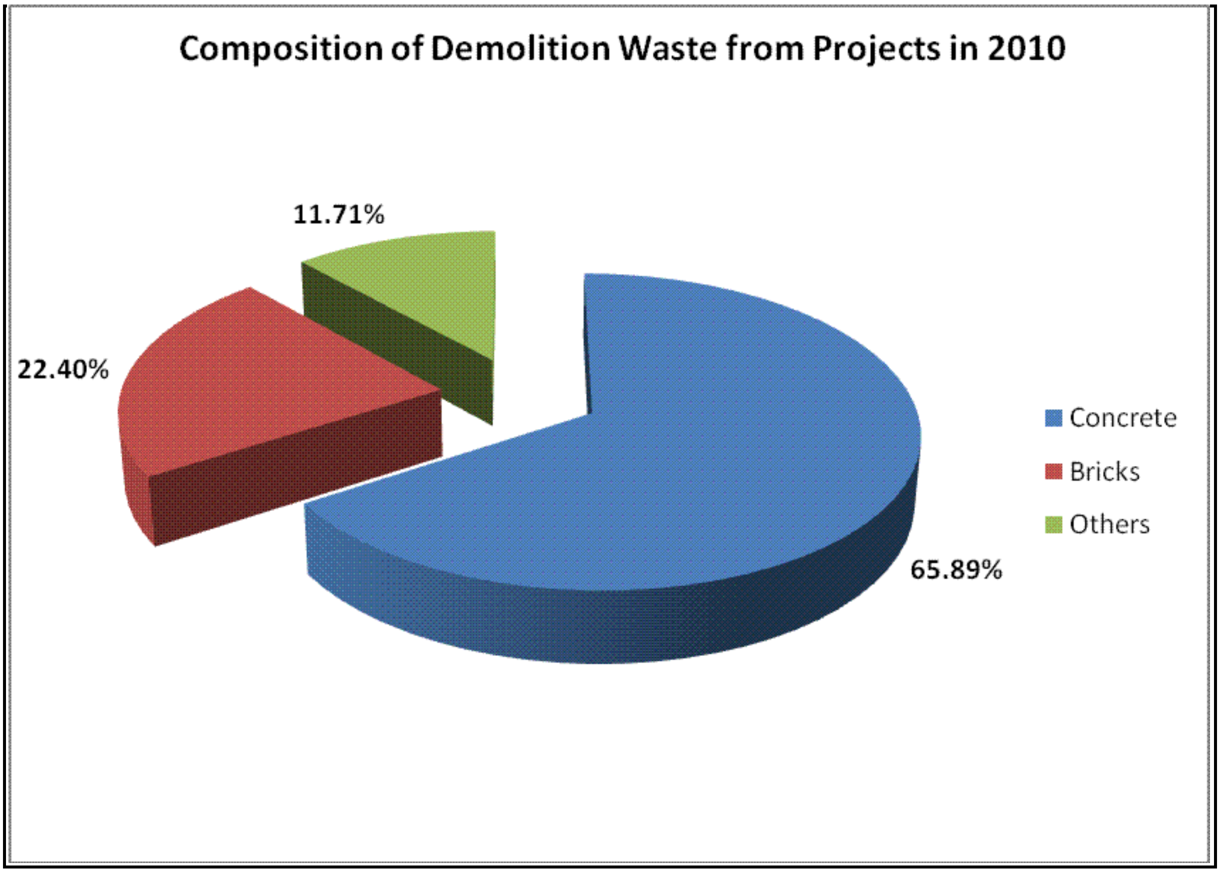
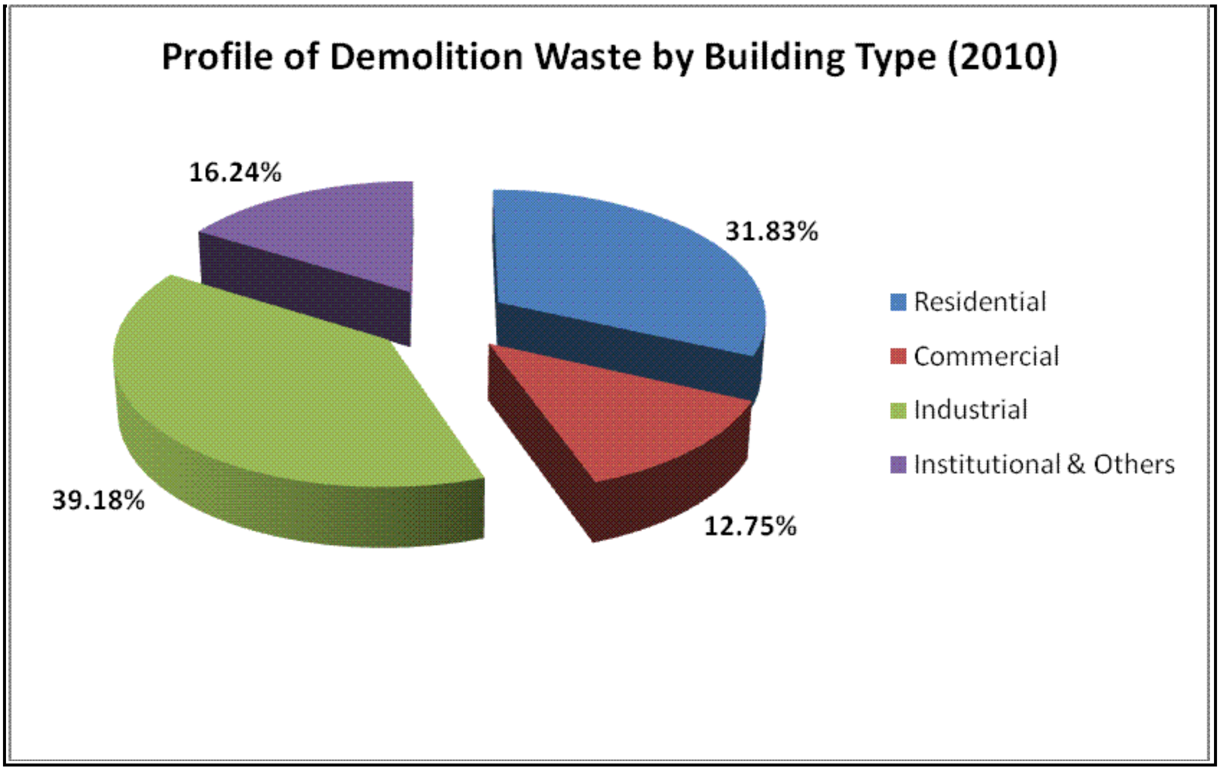


Figure 3 - Profile of Demolition Waste by Building Type



2. Benchmark Data

Benchmark at Design Stage

Benchmarking of construction-related waste does not necessarily take place downstream at the construction stage. It is also equally important to establish benchmarks at the upstream design stage to measure the extent to which sustainable construction is being adopted on a project basis.

Concrete Usage Index (CUI)

A concrete usage index called CUI was introduced by the Building and Construction Authority (BCA) of Singapore as part of the BCA Green Mark Scheme, a locally developed green building rating system for the tropics. The CUI is calculated based on the ratio between volume of concrete used against the total constructed floor area of the building. Different indices are set for residential and non-residential building projects to provide as benchmarks for efficient usage of concrete. These benchmarks are useful for waste prevention and waste minimisation that could otherwise have been generated due to excessive use of concrete in construction projects. The CUI calculation and a worked example taken from the Code of Environmental Sustainability adopted in Singapore are shown in Figure 4.

Figure 4 - Concrete Usage Index (CUI)

3-1(a) Up to 4 points are allocated to encourage more efficient concrete usage for building components based on the percentage reduction in the prescribed Concrete Usage Index (CUI) limit.

Note : *Concrete Usage Index* (CUI) is an indicator of the amount of concrete used to construct the superstructure which includes both the structural and non-structural elements. CUI does not include the concrete used for external works and sub-structural works such as basements and foundations. CUI is defined as the volume of concrete in cubic metres needed to cast a square metre of constructed floor area. It is expressed as:

$$\text{Concrete Usage Index} = \frac{\text{Concrete Volume in } m^3}{\text{Constructed Floor Area in } m^2}$$

Table 3-1(a) CUI Limit for Residential Building

CATEGORY	Concrete Usage Index (CUI) limit (m^3/m^2)
Residential (15 storey & below)	0.55
Residential (above 15 storey)	0.60

Worked Example 3-1(a)

Proposed development comprises a 15 storey residential block with a basement carpark and the following details :

Concrete usage for the superstructure	Constructed floor areas
For 1st storey = 587 m^3 From 2nd to 15th storey = 5400 m^3 (including roof level)	For 1st storey = 1000 m^2 From 2nd to 15th storey = 14000 m^2 (including roof level)
Therefore, Total concrete usage = 5987 m^3	Therefore, Total constructed floor area = 15000m^2

Note : The concrete usage for foundation and two basements are not required to be included.

$$\text{Concrete Usage Index CUI} = \frac{5987}{15000} = 0.4\ m^3/m^2$$

For residential buildings ≤ 15 storey, the CUI limit = 0.55

% reduction in CUI = (0.55-0.4)/(0.55) = 27 %

Points scored = 0.1 x (27%)= 2.7 points

3. Policies, strategies and legislation

Sustainable Construction Master Plan

The Building and Construction Authority (BCA), together with industry associations and major government agencies, formulated the Sustainable Construction Master Plans in 2008 to reduce the use of natural materials in building projects. Five strategic thrusts shown in Table 1 have been identified to drive the industry towards sustainable construction. Besides reducing the impact of construction activities on the environment through a closed-loop zero-waste construction approach, the Sustainable Construction Master Plan also mitigates impact on limited landfill capacity with a view of working towards zero landfill.

In Singapore's context, Sustainable Construction focuses on the adoption of materials and products in buildings and construction that will consume less natural resources and increase the reusability of such materials and products for the same or similar purpose. Two key focus areas of sustainable construction in Singapore are efficient design to optimise use of natural materials, and waste minimization, reuse and recycling.

Table 1: Five Strategic Thrusts of Sustainable Construction Master Plan

	Efficient Design to Optimise Use of Natural Materials	Recycling and Use of Sustainable Materials
Strategic Thrust 1	Government taking the lead in adopting sustainable construction	
Strategic Thrust 2	Promoting sustainable construction in private sector	
Strategic Thrust 3	Building industry capabilities	
Strategic Thrust 4	Strategic profiling and raising awareness to generate sustained demand	
Strategic Thrust 5	Setting minimum standards through legislative requirements	

STRATEGIC THRUST 1: Government taking the lead in adopting sustainable construction

The Government will continue to lead the way forward in environmental sustainability through adoption of green procurement practices for public sector developments. In general, the public sector projects accounts for about 30-40% of the total construction demand in Singapore. All new public sector buildings and those undergoing major retrofitting works are required to achieve the highest Green Mark accolade, i.e. the Green Mark Platinum Award. Besides new buildings, Government is also committed to have all existing buildings owned by government agencies to attain the Green Mark Gold Plus standard by 2020.

It is also important for government agencies to take the lead in championing sustainable construction practices in their projects and showcase these efforts to the industry. For example, the major public housing developer, the Housing & Development Board (HDB), specifies the use of recycled aggregates for non-structural concrete elements in their projects. The Land Transport Authority (LTA) has also piloted a trial test on the use of Incineration Bottom Ash (IBA) as alternative materials in road construction (Figure 5).

Figure 5: Use of Incineration Bottom Ash in road construction
(from Straits' Times, 19 Mar 2009)

STRATEGIC THRUST 2: Promoting sustainable construction in the private sector

Promotion of sustainable construction in the private sector is mainly being done through BCA's Green Mark Scheme via adoption of the Code for Environmental Sustainability of Buildings. The Green Mark Scheme is a locally-developed green building rating system to evaluate a building for its environmental impact and performance. Since April 2008, the Green Mark Certified rating has been legislated as the minimum mandatory standard for all building works with a gross floor area of 2,000 m^2 or more. In 2009, the government has also set higher Green Mark standards, such as the Green Mark Platinum or Green Mark Gold Plus Award as land sales conditions for selected new growth areas.

To further encourage private developers to achieve outstanding design, quality and sustainability objectives in their projects, BCA and the Urban Redevelopment Authority (URA) has introduced the Green Mark Gross Floor Area (GM GFA) Incentive Scheme in 2009. The scheme will grant developments that achieve either the Green Mark Platinum or Green Mark Gold Plus Award with additional gross floor area over and above the Master Plan Gross Plot Ratio control. For instance, developments that obtained the Green Mark Platinum rating will earn an additional gross floor area up to 2% of the individual development's total gross floor area, subject to a cap of 5,000 m^2.

BCA also worked with Singapore Green Building Council (SGBC) to launch the SGBC Green Building Product Certification Scheme for recycled Materials during the inaugural SGBC Green Building Conference in Sept 2010. Developers adopting these green building products in their projects will be awarded GM points under GM version 4.

STRATEGIC THRUST 3: Building industry capabilities

The government recognises the need to build up industry competencies and capabilities as a basis for the industry stakeholders to integrate such practices into their design and construction processes. In 2006, the government established a S$20 million Green Mark Incentive Scheme For New Buildings (GMIS-NB). The scheme offers cash incentives to private developers, building owners and project consultants whose new developments with a gross floor area of at least 2,000 m^2 achieves a Green Mark Gold rating or higher. In 2009, BCA unveiled a S$100 million Green Mark Incentive Schemes For Existing Buildings (GMIS-EB) to jump-start the ‘greening’ of existing buildings in the private sector.

For research and development, a S$50 million “Research Fund for the Built Environment” was launched in 2007 to kick-start R&D efforts in sustainable development. To further accelerate adoption of sustainable construction practices and technologies, a S$15 million Sustainable Construction Capability Development Fund was established in 2010 to build up the capabilities of the industry. A comprehensive training framework has also been put in place to nurture a core group of green building professionals. Some 20,000 green specialists at the PMET (Professional, Manager, Executive and Technician) level are expected to be trained over the next 10 years in the development, design, construction, operation and maintenance of green buildings.

STRATEGIC THRUST 4: Strategic profiling and raising awareness to generate sustained demand

BCA has always been proactive in raising awareness. Locally, BCA organises various workshops, seminars and conference such as the International Solid Waste Association (ISWA) World Congress in Nov 2008, Seminar on Innovations in the Design & Construction of steel and composite structures in 2009, a 2-day workshop on Material recycling for sustainable construction in 2010, and most recently, the Sustainable Construction Seminar 2011.

On the international platform, BCA also participated actively in established events such as AsiaConstruct, Sustainable Building Conference (SB10) and the Working Commission W115 on Construction Materials Stewardship under the International Council for Research and Innovation in Building and Construction (CIB). To review and further enhance our Sustainable Construction efforts, BCA formed an International Panel of Experts (IPE) in April 2009, which comprised 4 renowned experts from UK, USA and Austria, with the participation of 2 local experts from the academia.

In addition, BCA also organised the inaugural Singapore Green Building Week since October 2009 to profile Singapore as a hub for green building development in the region. The event featured the International Green Building Conference (IGBC) that showcased Singapore’s achievement in shaping a sustainable built environment and engaged foreign experts to share their experiences in green building with the industry. The Singapore’s first Zero Energy Building was also launched and much international awareness was generated through Singapore’s iconic Green Mark projects.

STRATEGIC THRUST 5: Setting minimum standards through legislative requirements

Legislative requirements remain fundamental in determining the advancement of new methods and materials. In 2008, BCA required all demolition contractors to declare the estimated quantity of demolition waste, as part of the conditions of the permit to commence demolition work. Further in 2008, BCA adopted the local equivalent of BS EN 12620: Specification for Aggregates for Concrete, which has provisions for the use of manufactured and recycled concrete aggregates. The recognition of the new Standard is crucial for providing guidelines to the industry on the performance of new construction materials from non-natural sources.

To encourage recovery of higher quality recycled materials, a Demolition Protocol for Resource Recovery was incorporated into the local Code of Practice for Demolition or SS 557 since 2010. The Demolition Protocol is a set of procedures on how demolition wastes should be managed on-site to maximise resource recovery for beneficial reuse and recycling. It aims to produce cleaner demolition waste to a quality acceptable for waste recyclers to produce high quality Recycled Concrete Aggregates (RCA). The protocol consists of the following:

- **Pre-Demolition Audit**

Pre-Demolition Audit enables the quantity of recyclable and non-recyclable materials such as concrete and bricks respectively to be identified on different parts of a building. The level of material segregation and the required demolition sequence are pre-determined before the actual demolition for better planning and on-site management. Resource recovery target is also established.

- **Sequential Demolition**

The demolition process is separated into phases in which individual materials are carefully dismantled one step at a time and salvaged for reuse and recycling. The wastes generated in each dismantling stage should be of similar type and nature such that contamination by non-recyclable items can be significantly reduced. The sequence of demolition is principally carried out in reverse order to the construction process.

- **On-site Sorting**

For demolition wastes to have meaningful applications, it is vital that the wastes are properly managed and stored separately on site to avoid cross-contamination of wastes. Once the demolition wastes have been properly separated, they can be channelled to appropriate recycling facilities for further processing into useable products.

Legislation on Construction and Demolition Waste

Singapore has elaborate laws on waste and its management including C&D waste. The major statutes are found on the Environmental Public Health (Amendment) Act 2008 by the National Environment Agency (NEA) to minimize and recycle waste as necessary to be sustainable. For example, there is a compulsory requirement for waste to be carted from sites by registered waste contractors. There are also rules on illegal disposal of waste, and littering or soiling of the streets from trucks carrying materials. Active promotion of waste recycling, coupled with stringent environmental regulations enforced by NEA is currently practiced. Moreover, waste minimization guidebook was established and enforced. The guidebook help in sequential development and implementation of a waste minimization plan for construction sites facility. The guidebook steps include management's commitment, selection of waste minimization committee, conducting a waste audit, determination of the true costs of waste, developing waste reduction options, assessment of scope of savings and rank options, developing waste minimization plan and implementation and plan improvement.

Code for Environmental Sustainability

The Code for Environmental Sustainability sets out the minimum environmental sustainability standard for buildings. It includes the Green Mark assessment criteria and scoring methodology for determining the environmental performance of a building development.

Sustainable Construction is one of the Green Mark assessment criteria under the Code for Environmental Sustainability. Sustainable Construction refers to the adoption of building designs, construction practices and materials that are environmentally friendly and sustainable.

Tables 2(a) and 2(b) of the Code for Environmental Sustainability show the assessment criteria under two different building categories: Residential (R) & Non-Residential Buildings (NR). In the tables below, Part 3: Environmental Protection contains sections that encourage the adoption of building design, construction practices and materials that are environmentally friendly and sustainable.

Currently, the implementation of Environmental management programmes (including the monitoring & setting of targets to minimize energy use, water use and construction waste) is a Sustainable Construction elective under the BCA Green Mark Scheme. For the demolition of buildings which are at least 6 storeys high, BCA encourages the preparation and submission of detailed deconstruction plans and site waste management plans to ensure that waste is minimized and recycled as much as possible.

Table 2(a) - Framework and Point Allocations for Residential Building Criteria

cations - BCA Green Mark for Residential Buildings (Version RB/4.0)

Category	Point Allocations
Related Requirements	
: Energy Efficiency	
1 Thermal Performance of Building Envelope – RETV	15
2 Naturally Ventilated Design and Air-Conditioning System	22
3 Daylighting	6
4 Artificial Lighting	10
5 Ventilation in Carparks	6
6 Lifts	1
7 Energy Efficient Features	7
8 Renewable Energy	20
ory Score for Part 1 – Energy Efficiency	87 (Max)
Green Requirements	
: Water Efficiency	
1 Water Efficient Fittings	10
2 Water Usage Monitoring	1
3 Irrigation System and Landscaping	3
ory Score for Part 2 – Water Efficiency	14
: Environmental Protection	
1 Sustainable Construction	10
2 Sustainable Products	8
3 Greenery Provision	8
4 Environmental Management Practice	8
5 Green Transport	4
6 Stormwater Management	3
ory Score for Part 3 – Environmental Protection	41
: Indoor Environmental Quality	
1 Noise Level	1
2 Indoor Air Pollutants	2
3 Waste Disposal	1
4 Indoor Air Quality in Wet Areas	2
ory Score for Part 4 – Indoor Environmental Quality	6
: Other Green Features	
1 Green Features & Innovations	7
ory Score for Part 5 – Other Green Features	7
Green Mark Score :	155 (Max)

Table 2(b) – Framework and Point Allocations for Non-Residential Building Criteria

Point Allocations - BCA Green Mark for New Non-Residential Buildings (Version NRB/4.0

	Category		Point Allocations
(I)	Energy Related Requirements		
Minimum 30 points	Part 1 : Energy Efficiency		
	NRB 1-1 Thermal Performance of Building Envelope - ETTV	Section (A) Applicable to air-con areas	12
	NRB 1-2 Air-Conditioning System		30
	Sub-Total (A) – NRB 1-1 to 1-2		42
	NRB 1-3 Building Envelope – Design/Thermal Parameter	Section (B) Applicable to non air-con areas excluding carparks and common areas	35
	NRB 1-4 Natural Ventilation / Mechanical Ventilation		20
	Sub-Total (B) – NRB 1-3 to 1-4		55
	NRB 1-5 Daylighting	Section (C) Generally applicable to all areas	6
	NRB 1-6 Artificial Lighting		12
	NRB 1-7 Ventilation in Carparks		4
	NRB 1-8 Ventilation in Common Areas		5
	NRB 1-9 Lifts and Escalators		2
	NRB 1-10 Energy Efficient Practices & Features		12
	NRB 1-11 Renewable Energy		20
	Sub-Total (C) – NRB 1-5 to 1-11		61
	Category Score for Part 1 – Energy Efficiency Prorate Subtotal (A) + Prorate Subtotal (B) + Prorate Subtotal (C)		116 (Max)
(II)	Other Green Requirements		
Minimum 20 points	Part 2 : Water Efficiency		
	NRB 2-1 Water Efficient Fittings		10
	NRB 2-2 Water Usage and Leak Detection		2
	NRB 2-3 Irrigation System and Landscaping		3
	NRB 2-4 Water Consumption of Cooling Towers		2
	Category Score for Part 2 – Water Efficiency		17
	Part 3 : Environmental Protection		
	NRB 3-1 Sustainable Construction		10
	NRB 3-2 Sustainable Products		8
	NRB 3-3 Greenery Provision		8
	NRB 3-4 Environmental Management Practice		7
	NRB 3-5 Green Transport		4
	NRB 3-6 Refrigerants		2
	NRB 3-7 Stormwater Management		3
	Category Score for Part 3 – Environmental Protection		42
	Part 4 : Indoor Environmental Quality		
	NRB 4-1 Thermal Comfort		1
	NRB 4-2 Noise Level		1
	NRB 4-3 Indoor Air Pollutants		2
	NRB 4-4 Indoor Air Quality (IAQ) Management		2
	NRB 4-5 High Frequency Ballasts		2
	Category Score for Part 4 – Indoor Environmental Quality		8
	Part 5 : Other Green Features		
	NRB 5-1 Green Features & Innovations		7
	Category Score for Part 5 – Other Green Features		7
		Green Mark Score :	190 (Max)

Table 2(a)(i) - Residential Building

onmental Protection	Green Mark Points
inable Construction cycling and the adoption of building ruction practices and materials that are y friendly and sustainable. tainable and Recycled Materials Cements with approved industrial by (such as Ground Granulated nace Slag (GGBS), silica fume, fly ash) ce Ordinary Portland Cement (OPC) by 10% by mass for superstructural works.	1 point
d Concrete Aggregates (RCA) and Copper Slag (WCS) from approved to replace coarse and fine aggregates ncrete production of main building s. tructural building elements, the use of RCA be limited to maximum 10% replacement by fine aggregates respectively or as approved authorities.	Extent of Coverage : The total quantity used (in tonnage) for replacement of coarse or fine aggregates must not be less than the minimum usage requirement that is [0.03 x Gross Floor Area (GFA in m²)] 2 points for the use of RCA to replace coarse aggregates 2 points for the use of WCS to replace fine aggregates Where the total quantity used (in tonnage) for replacement of coarse or fine aggregates is at least two times (2x) that of the minimum usage requirement. 4 points for the use of RCA 4 points for the use of WCS (Up to 5 points for RB 3-1(a)(i) & (a)(ii))
Jsage Index (CUI) designs with efficient use of concrete for nponents. *uirement:* *under this criterion:* *d^Plus ≥ 3 points* *tinum ≥ 5 points*	Project CUI (m^3/m^2) / Points Allocation: ≤ 0.70 – 1 ≤ 0.60 – 2 ≤ 0.50 – 3 ≤ 0.40 – 4 ≤ 0.35 – 5
onmental Management Practice adoption of environmental friendly g construction and building operation.	
effective environmental management es including monitoring and setting of minimise energy use, water use and on waste.	1 point
er that has good track records in the f sustainable, environmentally friendly derate practices during construction such en and Gracious Builder Award.	1 point
uality assessed under the Construction sessment System (CONQUAS) and rk Scheme.	1 point each (Up to 2 points)
, main builder, M & E consultant and hat are ISO 14000 certified.	0.25 point for each firm (Up to 1 point)
am comprises Certified Green Mark (GMM), Certified Green Mark Facilities (GMFM) and Certified Green Mark al (GMP).	0.5 point for certified GMM 0.5 point for certified GMFM 1 point for certified GMP (Up to 1 point)
f building users' guide with details of the ntal friendly facilities and features within g and their functionalities in achieving led environmental performance during peration.	1 point
f facilities or recycling bins at each block pment for collection and storage of ecyclable waste such as paper, glass,	1 point

Table 2(b)(i) – Non-Residential Building

Part 3 – Environmental Protection	Green Mark Points
NRB 3-1 Sustainable Construction Encourage recycling and the adoption of building designs, construction practices and materials that are environmentally friendly and sustainable (a) Use of Sustainable and Recycled Materials (i) Green Cements with approved industrial by-product (such as Ground Granulated Blastfurnace Slag (GGBS), silica fume, fly ash) to replace Ordinary Portland Cement (OPC) by at least 10% by mass for superstructural works.	1 point
(ii) Recycled Concrete Aggregates (RCA) and Washed Copper Slag (WCS) from approved sources to replace coarse and fine aggregates for concrete production of main building elements. Note (7) : For structural building elements, the use of RCA and WCS shall be limited to maximum 10% replacement by mass of coarse/fine aggregates respectively or as approved by the relevant authorities.	Extent of Coverage : The total quantity used (in tonnage) for replacement of the coarse or fine aggregates must not be less than the minimum usage requirement that is [0.03 x Gross Floor Area (GFA in m²)] 2 points for the use of RCA to replace coarse aggregates 2 points for the use of WCS to replace fine aggregates Where the total quantity used (in tonnage) for replacement of coarse or fine aggregates is at least two times (2x) that of the minimum usage requirement. 4 points for the use of RCA 4 points for the use of WCS (Up to 5 points for NRB 3-1(a)(i) and (a)(ii))
(b) Concrete Usage Index (CUI) Encourage designs with efficient use of concrete for building components. *Prerequisite Requirement:* *Minimum points to be scored under this criterion:* *Green Mark Gold^Plus ≥ 3 points* *Green Mark Platinum ≥ 5 points*	Project CUI (m^3/m^2) / Points Allocation: ≤ 0.70 – 1 point ≤ 0.60 – 2 points ≤ 0.50 – 3 points ≤ 0.40 – 4 points ≤ 0.35 – 5 points
NRB 3-4 Environmental Management Practice Encourage the adoption of environmental friendly practices during construction and building operation.	
(a) Implement effective environmental friendly programmes including monitoring and setting targets to minimise energy use, water use and construction waste.	1 point
(b) Main builder that has good track records in the adoption of sustainable, environmentally friendly and considerate practices during construction such as the Green and Gracious Builder Award.	1 point
(c) Building quality assessed under the Construction Quality Assessment System (CONQUAS).	1 point
(d) Developer, main builder, M & E consultant and architect that are ISO 14000 certified.	0.25 point for each firm (Up to 1 point)
(e) Project team comprises Certified Green Mark Manager (GMM), Green Mark Facilities Manager (GMFM) and Green Mark Professional (GMP).	0.5 point for certified GMM 0.5 point for certified GMFM 1 point for certified GMP (Up to 1 point)
(f) Provision of building users' guide which should include details of the environmental friendly facilities and features within the building and their functionalities in achieving the intended environmental performance during building operation.	1 point
(g) Provision of facilities or recycling bins for collection and storage of different recyclable waste such as paper, glass, plastic food waste etc.	1 point

4. Guidance documents/ reports linked to construction waste reduction

The Green and Gracious Builder Award was introduced in 2009 by the Building and Construction Authority, Singapore to raise environmental consciousness and professionalism of builders. It recognizes progressive builders who adopt environmentally friendly practices and minimize the effects of construction for people living near the worksite. Builders are rated on their performance in adopting best practices in construction site management. The original 2-tier rating system was expanded to 4-tier in 2010 to encourage more builders to adopt such best practices.

The scheme strongly supports BCA's efforts to promote sustainability, environmental protection and considerate practices by our builders during the construction phase of development, including construction waste reduction initiatives.

The GGBS is based on good international practices and was conceived in consultation with industry players. The Scheme has the following key features:-
a. Focus on ***both green and gracious aspects*** which have high impact on the public to provide recognition of their efforts and achievements;
b. Start on a ***voluntary basis*** to encourage builders to take ownership;
c. Apply at ***company level*** to encourage builders to implement best practices on their sites ***consistently***; and,
d. Adopt a ***tiered rating system*** to quantify performance and enable differentiation of performance achievement among builders to encourage continual improvement.
Firms are assessed on their construction projects in the following areas:
a. **Green (50 points):** To encourage environmentally friendly best practices such as use of recycled materials, reduction in energy and water consumption on site, and on-site waste minimization.
b. **Gracious (40 points):** To encourage gracious best practices which address the public needs and concerns, such as enhanced communications, consideration for public accessibility, mitigating noise and vibrations, minimizing, if not eradicating disturbance in the vicinity and neighbourhood.
c. **Innovation (10 points):** To recognize firms which have adopted innovative solutions or technologies to address environmental concerns, site challenges, productivity and/or minimize the concerns of the public.

In addition, **Bonus points of up to 5 points** could be given to recognize outstanding achievements by the firms, such as relevant construction industry awards obtained and the number of Green Mark projects which the firm has carried out.

Four-tier rating system	
Category	**Score**
Star	Above 90
Excellent	76-90
Merit	61-75
Certified	50-60

<u>Assessment Criteria for Green and Gracious Builders Scheme</u>

<u>Summary of Assessment Criteria</u>

Criteria	Points Available
(A) Green Practices	**50**
❖ Company Policy	5
❖ Materials (Reduce/ Reuse/ Recycle)	19
❖ Energy	12
❖ Environmental/ Water	9
❖ Housekeeping & Air Quality	5
(B) Gracious Practices	**40**
❖ Company Policy	4
❖ Accessibility	4
❖ Public Safety	7
❖ Noise & Vibration	9
❖ Communications	7
❖ Workforce Management	9
(C) Innovation	**10**
Total	**100**
Plus: Bonus Points	5
Total Possible Points	**105**

GREEN PRACTICES (50%)

GREEN PRACTICES		**Total: 50**
Company Policy		**Subtotal: 5**
Procedure/ Planning	Does the builder have procedures to inculcate and raise awareness of green practices to all level of staff? i.e. a) Management and Professionals b) Site Supervisors c) Workers	2 pts
	Has the builder set specific goals and KPIs to address the various factors: a) Reduce/ Reuse/ Recycle b) Energy c) Environmental/ Water d) Housekeeping & Air Quality	2 pts
Practices	Does the builder include "Green" as one of the considerations when selecting its suppliers and subcontractors?	1 pt
Reduce/ Reuse/ Recycle		**Subtotal: 19**
Procedure/ Planning	Has the builder put in place procedures or measures to encourage recycling or reduction of construction waste and office waste?	3 pts
	Is there a monitoring system of wastage on site?	1 pt
KPI	Performance rating of waste on site a) Concrete Wastage b) Rebar Wastage c) Waste Disposal Cost – proxy to amount of waste generated	4 pts
Technology	Is there any use of systems and technology to reduce waste: a) Formwork systems to reduce use of Timber (2 pts) b) Platform systems (to reduce use of scaffolding) (2 pts) c) Use alternative methods or systems to reduce masonry work (2 pts)	6 pts
Practices	Are there use of recycled and sustainable materials for non-structural applications? (e.g. cement replacements, aggregate replacements, etc)	5 pts

GREEN PRACTICES		**Total: 50**
Energy		**Subtotal: 12**
Procedure/ Planning	Is there a monitoring system for energy consumption on site?	1 pt
KPI	Performance Rating of energy consumption. KPIs include a) Electricity consumption (For sites using AC Power) b) Diesel consumption (For sites using Diesel Generators)	3 pts
Technology	Is there any use of energy-saving/ efficient or "Green Label" appliances, equipment and/or devices? (both site and office environment)	4 pts
	Is there use of alternative energy/fuels (e.g. solar for site office, biodiesel for construction plant)?	2 pts
Practices	Do the sites use AC grid power supply instead of diesel generators?	2 pts
Environmental/ Water		**Subtotal: 9**
Procedure/ Planning	Is there a monitoring system of water on site?	1 pt
KPI	Performance Rating of water consumption	2 pts
	Performance Rating of Total Suspended Solids (TSS) Readings	2 pts
Technology	Does the builder have water saving or recycling equipment or devices (both site and office) to conserve water usage? E.g. Equipment to treat and recycle water for non-portable/ construction use?	3 pts
Practices	Does the builder use environmentally friendly products (e.g. pesticides, cleaning products, etc) for its office and sites?	1 pt
Housekeeping & Air Quality		**Subtotal: 5**
Procedure/ Planning	Are there any in-house procedures to encourage good housekeeping in construction sites?	1 pt
	Has the builder adopted measures to address dust generated from material storage and vehicles?	1 pt
	Has the builder adopted measures to address rubbish and refuse accumulation and collection?	1 pt
Practices	Are there any planned regular maintenance of construction	1 pt

	vehicles and machinery to reduce emission rates?	
	Does the builder appoint a designated site personnel or controller to oversee housekeeping and cleanliness on site?	1 pt

GRACIOUS PRACTICES (40%)

GRACIOUS PRACTICES		**Total: 40**
Company Policy		**Subtotal: 4**
Procedure/ Planning	Does the builder have an established policy to adopt gracious practices? Is the plan endorsed by top management?	2 pts
	Does the builder have procedures to inculcate and raise awareness of gracious best practices to all levels of staff? i.e. a) Management and Professionals b) Site supervisory c) Workers	1 pt
	Does the builder have procedures in place to address (with regards to gracious practices): a) Continual improvement and feedback to management and site staff b) Communicating such procedures and requirements to suppliers and subcontractors	1 pt
Accessibility		**Subtotal: 4**
Practices	Are the site accesses well signed? Is the access/ entry into site generally clean and unobstructed?	1 pt
	Has consideration been given to accessibility wheelchairs (e.g. use of temporary ramps)?	1 pt
	Does the builder adopted measures to address possible causes of traffic obstruction?	1 pt
	Has the builder put in efforts to ensure sufficient and good signages around the construction site (For both motorists and pedestrians?)	1 pt
Public Safety		**Subtotal: 7**
Practices	Does the site provide covered walkways around site (for passageways which are used heavily by general public)?	1 pt
	Are the hoarding and walkways sufficiently designed, well maintained and in good condition?	1 pt

	Do the sites provide full-height safety netting and catch platform to mitigate risk of falling debris?	1 pt
	Has consideration been given to the provision of footpaths? E.g. 1) Is the width of the footpath/ passageways sufficient to cater for pedestrian volume/ demand? 2) Is there provision of alternate footpath when the existing footpath or walkway is being used for the construction works?	1 pt
	Are vehicular barriers provided for passageways located close or next to roads? (Public safety)	1 pt
	Is site safety information made clear to visitors on site? (Safety information could include the dos and don'ts on site, fire safety evacuation information, etc)	1 pt
	Are there comprehensive assessment and monitoring of surrounding buildings?	1 pt
Noise & Vibration		**Subtotal: 9**
Procedure/ Planning	Does the builder set specific goals and KPIs to address the various factors: a) Noise b) Vibrations	1 pt
	Does builder have procedures and standards to manage the piling subcontractors in terms of noise and vibrations?	1 pt
	Are there any efforts done to minimize noise disturbance through careful scheduling of noisy activities?	2 pts
	Has the builder put in place operational procedures to mitigate noise and vibrations? a) Any efforts carried out to plan and locate noise source (e.g. vehicles, generators, etc) away from residents? b) Any procedures to ensure that construction plant & machinery are properly maintained? (e.g. fasten loose panels, replace defective silencers, etc) c) Any efforts to train workers to handle materials carefully to reduce impact noise?	1 pt
	Does the builder have procedures, measures and/or rules to mitigate issues arising from night and/or weekend construction works (where applicable)	1 pt
Technology	Is there any use of measures or alternative construction	2 pts

	methods/ machines to address noise and vibrations?	
Practices	Does the builder install noise and vibration meters both on and off site? (E.g. at neighbouring property/building)	1 pt
Communications		**Subtotal: 7**
Procedure/ Planning	Does the builder have a policy on public communications to residents/ tenants (businesses) / town councils around construction site?	1 pt
Practices	Does the builder send out letters to neighbouring residents to inform of key milestones or major works?	1.5 pt
	Is there a designated hotline for public to call? Do the banner and posters contain the hotline number?	1 pt
	Are the banners and posters clearly visible to public?	0.5 pt
	Does the site have a designated person to handle complaints and feedback and to coordinate with the project staff to improve the site activities?	1 pt
	Does the builder have guidelines and documents on the handling of feedback cases?	1 pt
	Does the builder adopt measures or procedures to minimise security concerns of neighbouring residents? Examples may include: 1) Encouraging workers participate in the "Workers on Watch (WOW) programme administered by SPF 2) Out of office security arrangements in place to mitigate security concerns when the site is not in operation.	1 pt
Workforce Management		**Subtotal: 9**
Practices	Are site personnel and sub-contractors familarised with the Award and what this means?	1 pt
	Does the company show consideration and provide welfare to the workers?	3 pts
	Does the builder have a system to manage their workers? Examples may include: 1) Briefing of workers on dos and don'ts in and around site (e.g. behavior around site, no loitering in public spaces)? 2) Setting up of disciplinary procedures. 3) Instructions clearly presented to workers, e.g. through handbooks.	2 pts

	Has the builder achieved safety results better than the industrial average (based on AFR and ASR statistics)?	1 pt
	Does the builder have procedures, measures and/or rules to enhance on-site living conditions and mitigate issues which may arise from on-site housing (where applicable)	2 pts

INNOVATION (10%) AND BONUS POINTS (5%)

OTHERS	**Total: 10**
Innovation	
Has the builder adopted procedures or innovative use of technology and/or special construction methods to address environmental concerns, site challenges and/or minimize the concerns of the public?	10 pts

BONUS POINTS	**Total: 5**
Awards	
Has the builder received recognition and/or awards (both public and private sector) in recognition of its outstanding performance/ achievements? 1) No. of completed projects certified under Green Mark Gold Plus and above 2) Awards (2 points per environmental related awards, 1 point for other awards)	Up to 5 pts

5. Exemplars, case studies

The following sections highlight two of the latest development projects in Singapore that have successfully adopted sustainability principles.

Case Study – Samwoh Eco-Green Building

The Samwoh Eco-Green Building (Figure 6) is the first 3-storey office building in South East Asia to be constructed using concrete with RCA beyond code limits for structural concrete. It was a joint project between Samwoh Corporation, BCA and Nanyang Technological University, and funded by the MND Research Fund for the Built Environment, to conduct a full-scale evaluation on the use of various percentages of recycled concrete aggregates in structural concrete for building structures.

Figure 6 - Samwoh Eco-Green Building

Currently the use of RCA from construction and demolition wastes in structural concrete at low percentages (10-20%) is already allowed in Singapore. It is also important to highlight that construction and demolition wastes in Singapore generally comes from relatively clean concrete structures with practically no variability in aggregate type since granite is the main type of coarse aggregate used. Figure 7 illustrates the processes involved in the production of RCA from construction and demolition wastes. In this building project, the first, second and third levels were constructed with Grade 40 concrete using 30%, 50% and 100% RCA respectively.

Another unique feature of the building was the use of fibre-optic sensors embedded in the columns to monitor the long-term structural performance of the concrete. The long term monitoring data obtained from the building will be useful for in-depth structural analysis and the formulation of future specifications on the use of RCA for structural concrete. Finally, the results can be used to build confidence of industry stakeholders on the use of RCA and for policymakers to consider increasing the limit of percentage replacement of RCA for structural concrete going forward. The Samwoh Eco-Green Building has also achieved the highest green building rating, the BCA Green Mark Platinum, due to extensive use of other green and sustainable features.

Figure 7 - Processing of C&D Waste into RCA

Case Study – Tampines Concourse

The Tampines Concourse Building shown in Figure 8, held the distinction as being the first carbon-neutral building in Singapore and it has also achieved the BCA Green Mark Gold Plus Award in 2009. Designed and built with environmental sustainability in mind, the 15 years leasehold building offers a total of 105,000 square feet of eco-friendly office space across 3 storeies.

The carbon neutrality of the development or net zero carbon emission was achieved through a mix of internal and external reductions. Internal reductions were the carbon emission savings from actions within the organization including construction materials and processes, and building operations. External reduction known as 'carbon offsets' was achieved by purchasing an amount of CO_2 equivalent saved from an accredited project overseas. In the first phase, the developer had off-set the construction and estimated first year of tenancy carbon emissions which totalled about 6,750 tonnes of CO_2 emissions[21]. The sustainable features used in the project are highlighted below.

- **Designed for Energy Efficiency**

It is the first building in Asia that utilizes a pre-cooled mechanical ventilation system for indoor cooling. Coupled with facade greening area of 2,504m^2 and green roof system of 1,921m^2, these vertical and horizontal greenery helps to mitigate solar heat gain in the building. The building also optimized the daylight penetration at atrium and lift lobbies with natural day-lighting system via specially-designed light shaft and sun pipes. Lastly, the

[21] The estimated emissions have been measured in compliance with the internationally recognized Green house Gas Protocol criteria as defined by the World Business Council for Sustainable Development and the World Resource Institute (WBCSD/WRI Protocol). By complimenting internal reductions with external ones, the building is able to reach net zero carbon today.

installation of photocell sensors at every floor automatically regulates use of artificial lighting on overcast days. The energy savings for entire building is estimated to be over 620,000 kWh per year.

- **Designed for Water Efficiency**

The project is the first office building in Singapore to be fully fitted with waterless urinals and water-efficient fittings in all toilets to reduce potable water usage and operational costs. Nano-coating was applied on waterless urinals for deodorisation and sterilisation and ease of maintenance. The water savings from these environmentally friendly features is approximately 280m^3 per year

- **Designed for Sustainable Construction**

The building was designed to promote conservation of natural resources. Green concrete was used for both structural and non-structural building components, through a mix combination of washed spent copper slag, recycled concrete aggregates and ground granulated blast furnace slag (GGBS). Zero potable water usage was also achieved during construction due to the use of rainwater recycling and waste water treatment system.

- **Designed for High Indoor Environmental Quality**

To achieve a high indoor environmental quality, non-chemical anti-termite treatment was used to prevent subterranean termite attack together with low VOC paints for all internal walls and ceilings to improve occupational health and comfort of building's users.

Figure 8 - Tampines Concourse

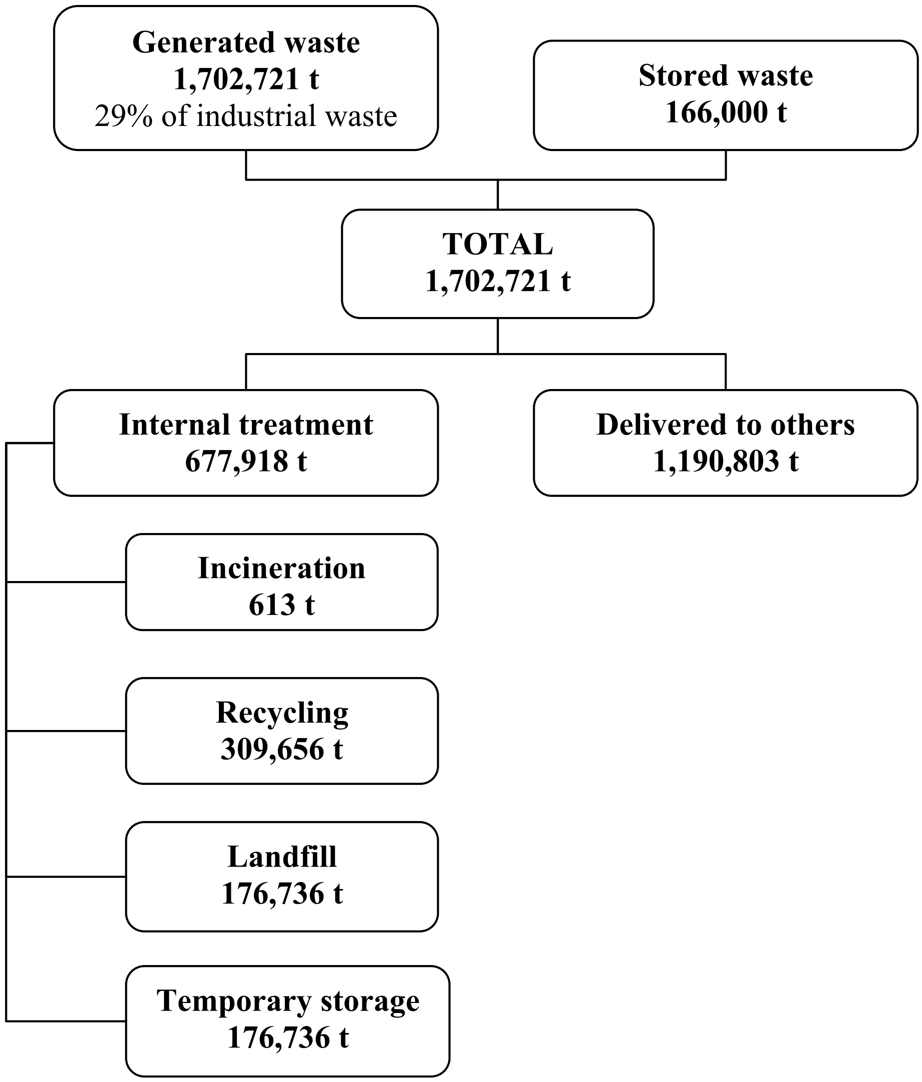
Slovenia

Contributed by:
Lucija Hanzic, University of Maribor
Faculty of Civil Engineering, Slovenia

1. Country statistics

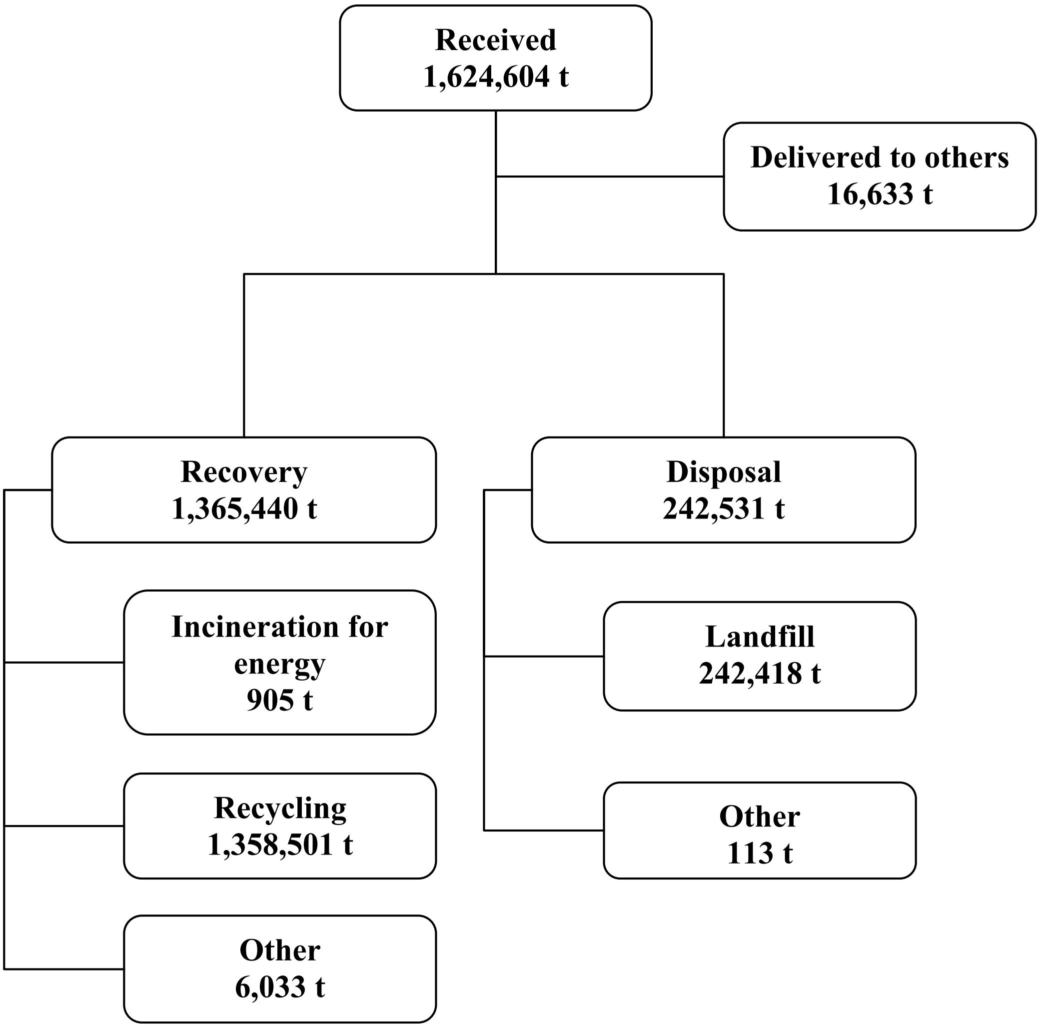
Quantities of waste generated within construction sector in 2008 are given in Figure 1.

Figure 1: Waste generated within construction sector in 2008 and its treatment



There are currently 26 authorised facilities for collection and/or recycling of construction waste in Slovenia. Processing of waste in these facilities is shown in Figure 2.

Figure 2: Treatment of waste collected by authorised facilities



Investments and current expenditure for environment protection are divided into the following categories:

- Protection of air and climate,
- Waste water management,
- Waste management,
- Protection and remediation of soil, ground water and surface water,
- Noise and vibration abatement,
- Protection of biodiversity and landscape and
- Other.

Data on investments and current expenditure for environmental protection are given in Table 1, whereas in Table 2 these values are given per capita. The population of Slovenia in 2008 was around 2.026 million.

Table 1: Gross investments and current expenditure for all environment protection actions and separately for waste management (WM) in 2008

	Gross investments €1000	Current expenditure €1000
Total	270,829	346,597
Total by construction industry	1,865	5,449
Total for WM	84,023	228,350
Total for WM by construction industry	98	2,896

Table 2: Gross investments and current expenditure per capita for all environment protection actions and separately for waste management (WM) in 2008

	Gross investments €	Current expenditure €
Total	133.67	171.07
Total by construction industry	0.92	2.69
Total for WM	41.47	112.71
Total for WM by construction industry	0.05	1.43

2. Policies, strategies and legislation

The Republic of Slovenia as a member of European Union implements EU policy through its national legislation. The main law governing environmental protection and thus construction waste management is:
The Environment Protection Act, OJ RS 41/2004
Amendments: OJ RS 20/2006, OJ RS 70/2008, OJ RS 108/2009
Original title: Zakon o varstvu okolja

The act lays the basis for the national strategy on environment protection stated including:

Resolution on national environment protection programme, OJ RS 2/2006
Original title: Resolucija o nacionalnem programu varstva okolja 2005 – 2012

The Resolution points out the need to reduce consumption and exploitation of natural resources. In relation to construction waste it sets the following goals:

- source separation and collection of waste materials (at least 30%),
- recycling and use of recycled materials (at least 40%),
- incineration of timber and energy recovery,
- reuse of about 30% of excavated soil,
- use of the construction waste and excavated soil that remains after processing, in quantities of 20% and 50% respectively,
- disposal of no more than 10% of construction waste and no more than 20% of excavated soil in non-hazardous waste landfill,
- reduce the excavation of mineral raw materials for construction purposes from about 8 t per capita to about 5.5 t per capita,

- registration of buildings with more than 1000 kg of materials containing weakly bonded asbestos and
- safe removal and disposal of asbestos containing materials.

The Environment Protection Act is implemented through a set of rules that are dealing with specific areas of environment protection. Most important in construction industry are:

Rules on waste management, OJ RS 34/2008
Original title: Uredba o ravnanju z odpadki

Rules on waste incineration, OJ RS 68/2008
Amendment: OJ RS 41/2009
Original title: Uredba o seziganju odpadkov

Rules on landfill waste tipping, OJ RS 32/2006
Amendments: OJ RS 98/2007, OJ RS 62/2008, OJ RS 53/2009
Original title: Uredba o odlaganju odpadkov na odlagaliscih

Rules on waste management from construction industry, OJ RS RS 34/2008
Original title: Uredba o ravnanju z odpadki, ki nastanejo pri gradbenih delih

Rules on soil encumbrance due to waste disposal, OJ RS 34/2008
Original title: Uredba o obremenjevanju tal z vnasanjem odpadkov

Rules on asbestos waste, OJ RS 34/2008
Original title: Uredba o ravnanju z odpadki, ki vsebujejo azbest

Rules on removal of materials containing asbestos during reconstruction, demolition and maintenance works
OJ RS 60/2006
Original title: Uredba o pogojih, pod katerimi se lahko pri rekonstrukciji ali odstranitvi objektov in pri vzdrzevalnih delih na objektih, instalacijah ali napravah odstranjujejo materiali, ki vsebujejo azbest

Rules on the handover of asbestos-cement construction products to municipal landfill and determination of maximum disposal cost
OJ RS 97/2006
Original title: Uredba o prevzemanju odpadnih azbestcementnih gradbenih izdelkov na odlagaliscih komunalnih odpadkov in o dolocitvi najvisje cene njihovega odlaganja

Rules on management of waste from mining industry and exploitation of mineral raw materials, OJ RS 43/2008
Original title: Uredba o ravnanju z odpadki iz rudarskih in drugih dejavnosti izkoriscanja mineralnih surovin

Rules on environmental tax for environment pollution due to waste disposal
OJ RS 129/2004
Amendments: OJ RS 68/2005, OJ RS 28/2006, OJ RS 132/2006, OJ RS 71/2007, OJ RS 85/2008
Original title: Uredba o okoljski dajatvi za onesnazevanje okolja zaradi odlaganja odpadkov

Switzerland

Contributed by:
Karin Treyer, MSc Student in Ecological Systems Design
Prof. Dr.-Ing. Holger Wallbaum Chair of Sustainable Construction, ETH Zurich

Assisted by:
Robin Quartier, Federal Office for the Environment
Stefan Rubli, "Wertstoffboerse", specialist in construction waste
Bruno Suter, Swiss Association on excavation earth, deconstruction and recycling (ARV)

1. National overview

Switzerland is a small, democratic non-EU country. Legislation provides a good basis for laws and regulations concerning construction waste, e.g. with the technical waste ordinance or with the guidelines for excavation or mineral waste material. Currently, 80% of the estimated 15 MT of construction waste per year is recycled (excluding excavation earth which amounts to 60-80 MT). However, the federal structure with 26 cantons complicates execution of laws and hinders a thorough overview on construction waste amounts emerging. As a result, projections were made in order to get an idea about flows and stocks in Swiss construction. Mainly mineral materials were considered, along with wood and metals.

Actual stocks of materials in structures

Swiss constructions hold a stock of estimated 2,823 MT or 1,470 Mm^3 of construction materials, growing with about 60 MT per year. The most widely used materials in house building are concrete and bricks (65.4 % in volume or 79.4 % in weight), whereas gravel and sand dominate civil engineering (69.9 % in volume or 68.9 % in weight).

Current National Statistics

Cantons have to work out a general strategy on waste according to the TVA. However, as there is no obligation to declare construction waste quantities and types for awarding authorities or (mainly privatised) waste processing companies, data on construction waste have been collected only roughly or not at all in the past. Transportation of waste between cantons is currently made but is not managed, this is compounded by the fact the sector is mostly privatised. As a result, data used in this report have mostly been modelled; data for the future have to be seen as theoretical reference points. Simulations are very important to understand the situation today and in the future. Problematic trends can be recognised and countermeasures can be taken early.

Switzerland and its building activities in general

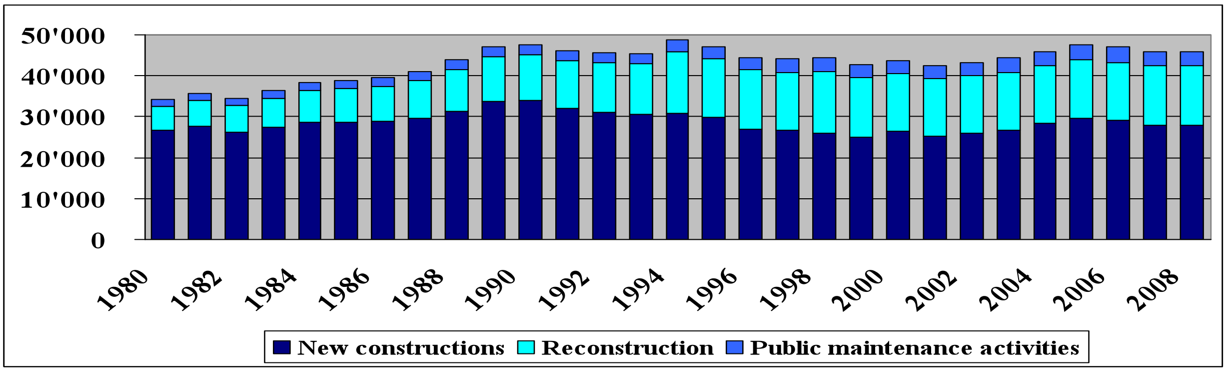
As mentioned above, the Swiss Confederation consists of 26 states named cantons and 2636 communes, which are the smallest political units in Switzerland. The democratic organized country extends over an area of 41,277 km2 with a population of 7,604,467 persons (2009 estimate). The population density, calculated considering only the habitable area, accounted for 246.9 persons/km^2 in 2007 [FSO 2009b]. The growth rate estimation amounts to 0.276% for the year 2009.

The GDP (PPP)[22] of Switzerland is estimated to be around $314.437 billions in 2009, which results in $42,948.461 per capita [IMF 2009].

The national organisation of construction publishes a "barometer for the business activities" each quarter year. Business ratios for planning and constructing are listed as well as the ratios for different industries. Please consult the homepage of "bauenschweiz" for further information (http://www.bauenschweiz.ch/Statistik.6.0.html - in German or French).

All expenses in the building sector as per working sector between 1980 and 2008 are shown in Figure 1. Prices in Mio CHF are standardized for the year 2000.

Figure 1: Expenses in the building sector as per working sector, 1980 – 2008 in Mio CHF, normalised to the year 2000 [FSO 2009a].



Higher expenses indicate higher construction activities in the respective years. There has been a period of raising construction activities between 1980 and 1990, bringing expenses from 34,198 Mio CHF to 47,588 Mio CHF. After that, expenses have levelled off at about 44,000 Mio CHF. It is interesting to note that highest expenses result from new construction activities, whereas we will see in chapter 0 that there is least construction waste emerging from these activities.

The actual financial crisis did not affect the constructing sector heavily: The federal government supported the economy with economy activities packages, whereas the first two focussed on the construction sector. Table 1 shows current figures in the construction sector.

[22] Gross Domestic Product at Purchasing Power Parity. Using a PPP basis is arguably more useful when comparing differences in living standards on the whole between nations because PPP takes into account the relative cost of living and the inflation rates of different countries, rather than just a nominal gross domestic product (GDP) comparison Wikipedia 2009. *Purchasing Power Parity.* Wikipedia - The free encyclopedia.

Table 1: Construction expenditures in 2008 as to type of work and type and category of construction in Mio CHF [FSO 2009a].

Type and category of construction	New constructions		Reconstruction, enlargement, demolition		Public maintenance activities	
	Investments 2008		Investments 2008		Investments 2008	
	in Mio. Fr.	Change to prior year in %	in Mio. Fr.	Change to prior year in %	in Mio. Fr.	Change to prior year in %
Total	**32,474**	**3.9%**	**16,791**	**3.6%**	**4,161**	**8.1%**
Total civil engineering	5,730	7.7%	4,186	11.5%	2,717	12.1%
Traffic and communication	4,470	8.0%	2,963	14.0%	-	-
Residual civil engineering	1,260	6.7%	1,223	5.9%	-	-
Total house building	26,744	3.1%	12,605	1.2%	1,443	1.3%
Residential building	18,757	1.6%	5,227	3.0%	-	-
Industry, business, services	5,095	12.3%	3,901	-6.1	-	-
Residual house building	2,892	-1.1%	3,477	7.9	-	-

Out of the total of 53,426 Mio CHF, new construction holds most expenditure with 61%, especially in house building (66% of all construction activities). Public maintenance activities account for only 8%. Expenses in new traffic and communication constructions are expected to decrease in support of reconstruction, enlargement and demolition since the national grid is more or less planned and finished. This fact can be confirmed with the increase of 14% of investments in reconstruction, enlargement and demolition of traffic and communication constructions. Public maintenance activities don't cost much because only small activities such as new coating or snow clearance are included in this category. About 2/3 of the investments are made by private awarding authorities, the other 1/3 by public awarding authorities (calculated for normed figures to the year 2000). This fact is important to know which stakeholders are influencing which sectors most.

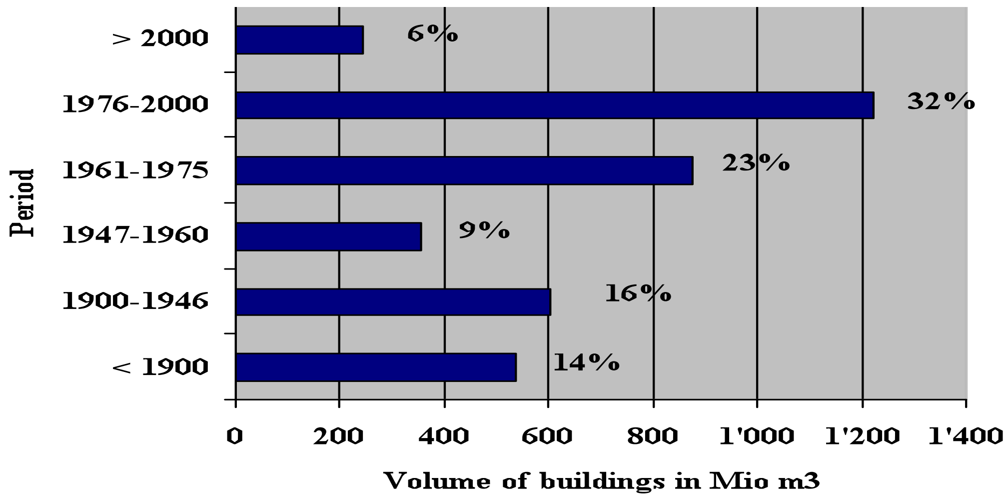
Flows and stocks

This section describes general volume stocks in house building. Existing networks and constructions were compiled for civil engineering. After that, flows and stocks are concretized for different materials.

Stocks in constructions

In 2007, there were 168 t of construction materials stocked per habitant. As we will see in the next chapter, the construction period has a great influence on the type of materials incorporated and therefore for waste management. The following figure shows the inventory volume in Mm3 of Swiss buildings in different time periods. Please note that data represent the whole building volume, including not only materials but also room volume. The periods

are chosen according to the building techniques used, e.g. bricking, building with concrete and bad insulation, or well-insulated buildings with flat roofs.
Figure 2: Inventory volume in Swiss house building in Mm3 [FOEN 2008c]



Nearly 40 % of the building volume has been built after the year 1975. 14 % in volume of buildings are still older than more than hundred years. In general, old buildings are rather to find in rural regions. Periods of intensive construction took place between 1961 and 1975 with nearly 60 Mm3 new constructions per year; this continued between 1976 and 2000 with nearly 50 Mm3 of new constructions per year. For the years 2005 and 2006, 40 Mm3 of new constructed volume per year are estimated. In future, this figure is estimated to even out at about 30 Mm3 [FOEN 2008c].

According to the FOEN modellings, one third of inventory volume is incorporated in apartment buildings; together with detached houses, this percentage is near 50%. Besides, industrial buildings make up nearly 20% of the building substance. The remaining part consists out of service buildings, agricultural buildings and diverse constructions [FOEN 2008c].

The field in civil engineering is large. It comprises:
- Traffic: Roads, railways, trams, metro, ski lifts, funiculars etc.
- Telecommunication
- Energy supply
- Water supply and waste water
- Other: barrages, linings, military infrastructure

The following description gives an (incomplete) overview on existing and planned underground constructions in Switzerland. Detailed material stocks are modelled in [FSO 2005] and [FOEN 2008c].

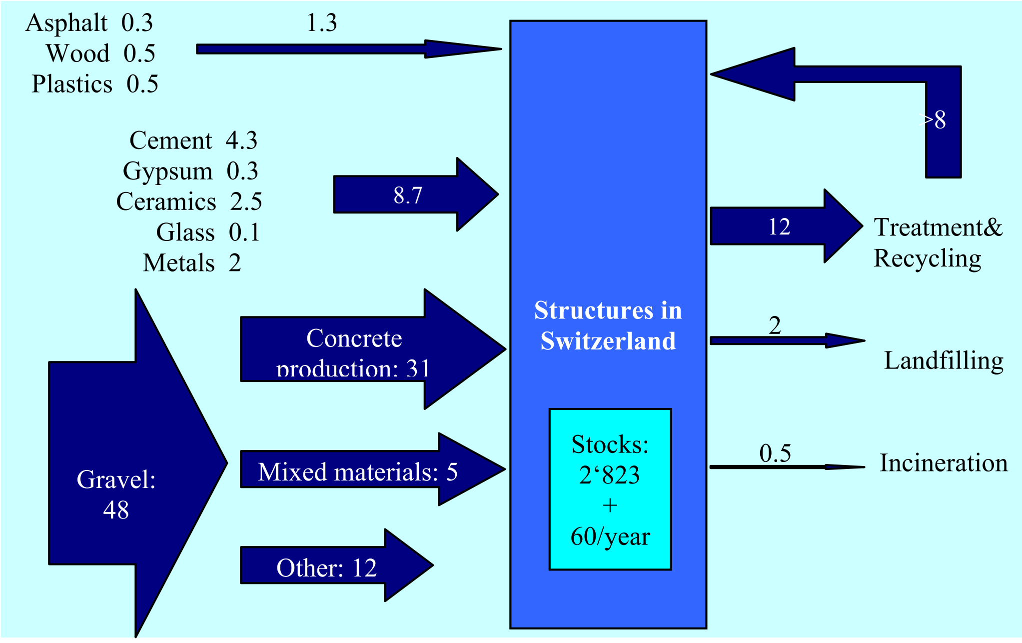
Table 2: Compilation of existent and planned underground constructions in Switzerland

Type of construction	Description
National roads 1)	1763.6 km of national roads are in line (2007), which are 93.2% of the total planned length of roadway. The missing 129.9 km are intended to be finished within the next 15 years
Other roads 2)	69,606 km existing (2007)
Road tunnels 1)	National roads: 120 km; planned are 290 km in total
Railways 2), 3)	Line length 5'107 km (2007); track length 12,079 km (2004) [FOEN 2008c]. Railway lines haven't been changing considerably between 1996 and 2007. The national project "AlpTransit" adds three long and several small tunnels to the lines (details see www.neat.ch): - The world's longest railway tunnel with 57 km (Gotthard-Basistunnel), opening planned for 2017. Total tunnel length (emergency galleries etc. included) is 153.5 km. - The world's third longest railway tunnel with 34.6 km (Lötschberg-Basistunnel) since June 2007; total lengths 91.8 km. - Ceneri-Basistunnel 15.4 km (opening planned for 2019)
Sewerage 4)	47,000 km public sewers, 40,000 km private sewers
Drinking water supply 3)	Estimated 54,124 km of water lines
Gas 3)	16,811 km without distributing lines
Energy	Estimations reaching from 77,495 km to 335,000 km after different models3). The FSO gives a total cable length of 267,269 km 5).
Communication	Fiber optic cable network
Other	Barrages linings, military constructions

Sources: 1) [ASTRA 2008] 2) [FSO 2009c] 3) [FOEN 2008c] 4) [Eawag 2009] 5) [FSO 2007]

Flows and stocks of construction materials

Figure 3 shows approximate and estimated material flows and stocks in Switzerland. Materials such as electrical equipment, furniture, insulation or packaging have been neglected. Still, there are about 60 MT of construction materials used per year in Switzerland. Arrows are not proportional to the respective values. This figure is an aggregation of Figure 4, Figure 10 and Table 6. The 60 MT of new stock per year correspond to about 35 Mm3, what is approximately consistent with data in Figure 2. Data are from the years 2001 to 2008.
Figure 3: Estimated material flows in construction engineering in MT. Adapted from [FOEN 2008c].



Gravel is the greatest flow going into the built volumes of Switzerland and ten to 500 times higher than those from other considerable materials. The estimation can be concretised with estimations by the Swiss Association of gravel and concrete industry FSKB (see chapter 0) in 2007, where 48 MT (28 Mm3) of gravel have been discharged. Out of these, about 65% in weight have been used for concrete production (discharge of 31 MT) and 10% in weight for mixed material (5 MT). The remaining 25% have been transformed into different materials [FSKB 2008b].

Switzerland holds only some mineral resources. Many materials used in building are imported. Swiss aggregate input (gravel/sand) can cover 80% of needed amount. For concrete, Switzerland nearly doesn't have to import this material. Gravel stocks in Switzerland are huge and the theoretical time horizon of exploitation hundreds to thousand years. Though, finiteness of the resources is a discussion point because of rising interest conflicts with gravel exploitation such as growing settlements, nature and ground water protection areas. As a result, the amount of gravel being available for exploitation reduces from 100% (gravel stock) to about 20% [Kündig, *et al.* 1997]. It has to be noted that the situation differs from region to region. Resulting to these conditions, the FSKB has presented its recycling strategy[23] in October 2009.

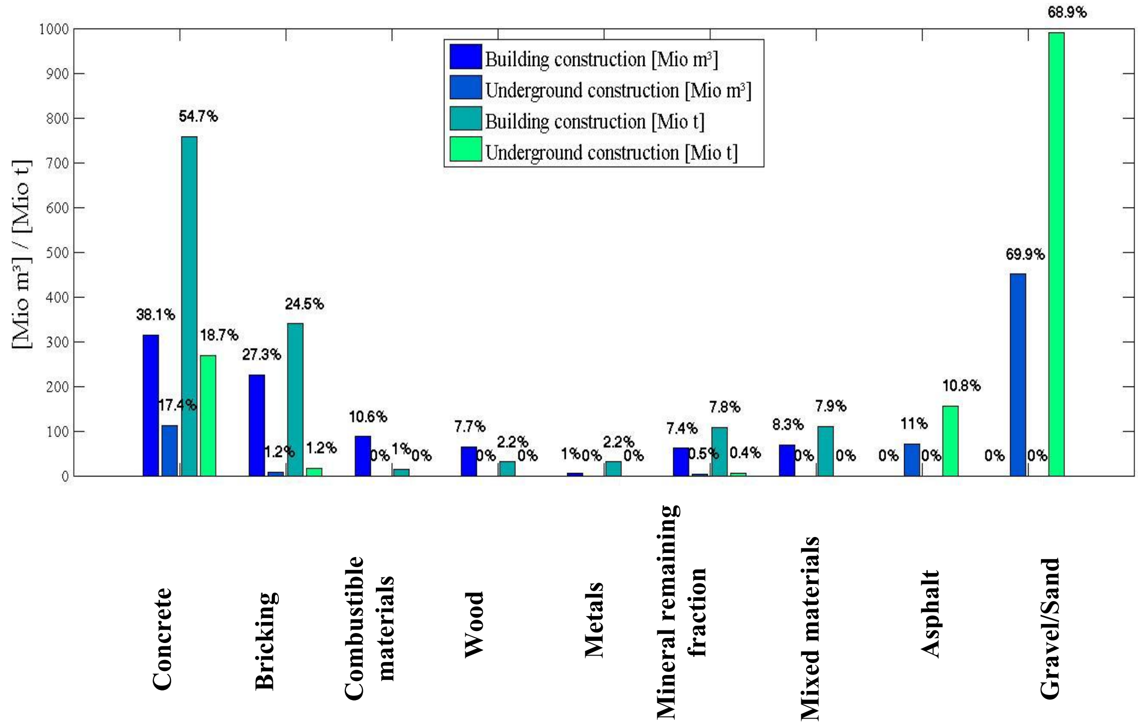
In contrast to the aggregates, nearly all metals and many other products for construction are imported. This is the case for a high amount of wooden products, too. However, Swiss forests hold a certain capability to be exploited better.

[23] Main issues of this strategy are:
1. FSKB advocates for the closure of material cycles.
2. It assists recycling, conditioning and application of rock construction materials.
3. FSKB supports entrepreneurs in environmental friendly recycling and removal of the manufactured products.
4. The aim is not to make a difference any more between primary and secondary construction materials, but to speak about construction materials meeting the norms.
5. FSKB is the contact for the whole industry sector in the matter of gravel, concrete and recycling.

About 80% of outflowing materials are recycled. Remaining materials go to landfills or incineration plants.

The mentioned, materials are used differently in building and civil engineering. **Error! Reference source not found.** contains three types of information about material stocks in building and civil engineering: First, it lists different materials such as concrete, bricking or asphalt. In addition, it shows how many Mm3 and MT of the relative material are stocked in building or in civil engineering. Lastly, percentages represent the percentage of the respective material in the whole stock of materials. The totals of stocked materials are 1470 Mm3 or 2823 MT respectively [FOEN 2008c]. This number is in accordance with an another literature source with a total stock of 2460 MT [FSO 2005].

Figure 4: Stocks in Swiss construction expressed in Mm3 and MT [FOEN 2008c].



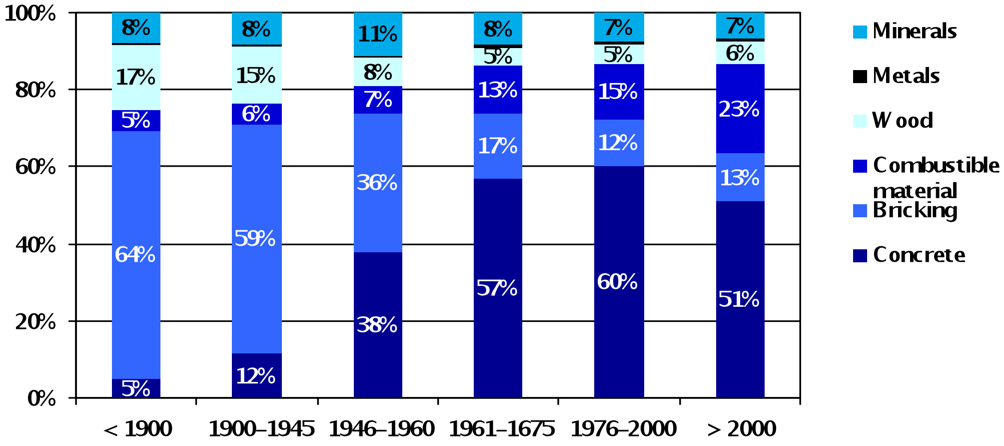
About 56 % in volume of all materials are stocked in house buildings (mainly concrete and bricks), another 44 % in volume in civil engineering (mainly gravel/sand). For weight percentages, this ration is about 50:50. It is evident that percentages and amounts vary much when expressed in volume or in weight. For example, concrete volume makes up nearly 40% of the total volume stocked in buildings, whereas it approaches 55% when expressed in weight. Similarly, 56 % in volume of all materials are stocked in the whole Swiss building structure in contrast to 49 % in weight. It is important to check if percentages are expressed by volume or by weight.

Concrete and gravel/sand make the biggest part of materials stocked in constructions. Altogether, concrete and brickwork/gravel and sand build up to 80 % in weight in houses and nearly 90 % in weight in construction engineering. This can be explained by their extensive use in supporting building elements (ceiling, wall and fundament) and in road construction. It is interesting to see further on in chapter 2 the relation of the quantity of material used to its recycling quantity.

Even if other materials than the above mentioned are taken into account, about 90 % in weight of a house building is made out of concrete, mortar and cement, bricks, rock, wood, ferrous metals and gypsum – i.e. mainly mineral materials.

In chapter 0, we took a look on the age of Swiss buildings and there was mentioned that this has a big influence on the material composition of the particular buildings. Figure 5 shows the volume percentages of materials stocked in buildings as to each time period. Road construction waste and asphalt (e.g. from access roads) are neglected.

Figure 5: Typical material composition of Swiss buildings in different years of completion; in % in volume [FOEN 2008c].



Knowing the trends in using materials is essential for waste planning as they represent the materials to deal with today and in the future. There can clearly be seen that *bricking* has been replaced by *concrete*. The latter will probably remain between 50-60 % in volume. Another scenario is that wood will replace a part of the concrete. Although *wood* is often mentioned as a good construction material because of its great availability and convenient characteristics, in practice, the portion of wood in buildings has steadily been reducing in the last century. In view of economics, there are many arguments against using pure wood for constructions, e.g. intensive care, or low return today. Wood will only have a successful future in house building if used in combination with other materials. Considering actual forest management in Switzerland, a more intensive use of wood would be desirable. Today, only about 53% of usable wood is exploited, the leftover is capital lying down [FOEN 2007][24].

Burnable materials[25] have steadily been increasing. On the first view, this may seem negative because the material is "lost" as a consequence for further cycles. However, incineration energy is used for district heat or production of electricity. Further on, landfill space is saved this way.

Metals are very low in Figure 5. They are very dense and therefore do not count much in volume based calculations. However, as we will see in Figure 8, results change when expressing metals in weight percentages.

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[24] Please see chapter 0 for a discussion about effects of Swiss forest exploitation on the CO_2 issue.
[25] Such as insulations, plastics, textiles, paper, packaging

Having a look now at civil engineering, we have seen before that gravel and sand are dominating materials in this sector. Figure 6 illustrates this.

Figure 6: Material composition of typical civil engineering in % in volume [FOEN 2008c].

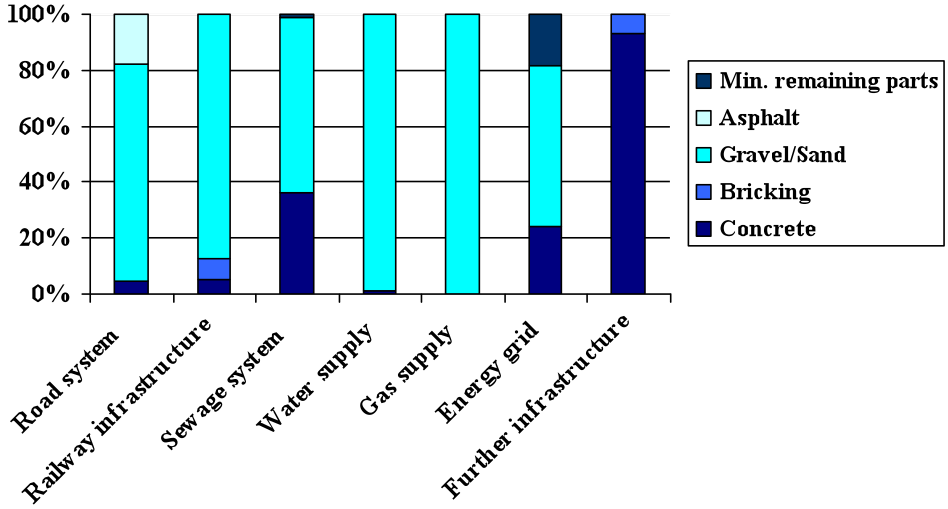


Figure 6 does not reveal anything unexpected. Besides gravel and sand, concrete is used in high amounts. Further infrastructure implies barrages and linings which are made of concrete.

61% of all materials are used in road infrastructure. Sewage works and other infrastructure still account for 12% each. Railway infrastructure and water supply count for 7% each, whereas the energy grid and gas supply only take 2% and 1% respectively.

1.1.3 Demolition rates

In order to estimate waste flows originating from constructions, renewal and demolition rates are helpful.

Demolition rates in house building have steadily been rising in the last years. However, modelled rates differ quite a lot. Newest estimations begin with a value of 0.177% in 1997, are estimated to 0.216% today (2009), and model the rate to reach 0.26% in 2018 [FOEN 2008c]. In contrast, modelling from 2001 estimate a demolition rate of 0.26% in 1997, rising to 0.41% in 2010 [FOEN 2001]. Based on these figures, models going further predict a demolition rate of 0.8% in 2050 [Brunner, *et al.* 2006], [Wallbaum et al. 2009], [Wallbaum et al. 2010].

Demolition activities are of great importance in view of trends in construction waste. There are three essential drivers in the growth of demolition activities:

a) Building age: More than half of the demolition volume stems from constructions made before the year 1945. However, it seems that renewal activities not only depend on technical service life of building parts, but also on the economically useful life.
b) Building type: Industrial buildings are used for a shorter time than residential buildings.
c) Location type: About 42% of the demolition volumes have their origin in urban regions (out of them, more than 50% are industrial buildings. [FOEN 2008c]

The demolition rate does not change much in civil engineering. Based on data from [FOEN 2001], a demolition rate remaining at constant 0.3% has been modelled by [Brunner, *et al.* 2006]

In this chapter, an overview on Swiss construction activities as well as on flows and stock estimates was established. Switzerland is a small country and space for construction activities as well as for landfills is scarce. A peak in house building was reached between 1961 and 1975 with 60 Mm3 (115 MT) of new constructions per year on average. But still, new constructions hold most expenditure, especially in house building. Swiss underground constructions are mainly built or planned; the demolition rate will remain more or less constant in future.

Gravel is the most used material in construction engineering. Gravel stocks in Switzerland are huge, but exploitability is lowered by different constraints. Besides gravel, concrete is the most important construction material. In house building, its fraction has been rising over the last century. The two materials are dominating civil engineering, too. More than half of all materials are stocked in road networks.

We will now focus on waste emerging from the construction sector.

Legislation and legal binding guidelines/standards
This chapter intends to give an overview on construction waste related laws and standards in Switzerland. After a short description of the legal structure, underlying laws for handling construction waste are presented. Coincidentally, some notions will be clarified with the help of definitions given in laws, regulations and standards. A short discussion on possibilities of the federal state to influence construction waste handling will be hold in the end of this chapter. In this sections, parts of the CIB report 318 (section Switzerland) have been restated [CIB 2008].

Switzerland consists of 26 federal states named "cantons" all of which have their own constitution, parliament, government and courts. The political system is therefore decentralised with a lively direct democracy. The National Government consists of the bicameral parliament (legislative), the Federal Council (executive) and the Federal Court (judicial). Switzerland does not belong to the European Union (EU), but has signed many agreements with the EU and its states. The National Government is responsible for issuing laws while their execution lies in the responsibility of the cantons. Additionally the states and municipalities have their own more specific laws and regulations on waste management, whereas national law has more power than these laws. The Federal Office for the Environment FOEN tries to standardise the application by issuing numerous guidelines. In addition private organizations such as the Swiss Association of Engineers and Architects (SIA) issued standards, which partly have an obligatory character.

Legislation
In this section, a short description of the current laws concerning construction waste management and important articles is given. Please consult the annex for the wording of the mentioned articles in the Swiss legislation (several parts only in German). Swiss laws and regulations are available in the four national languages[26] on www.admin.ch in the classified compilation of federal legislation. Please note that selected legal texts exist in English.
Legal status

[26] German, French, Italian, Romansh

Environmental protection in Switzerland is based on the Federal Constitution of the Swiss Confederation (Bundesverfassung BV, 1999[27]). In Articles 73 and 74, the Constitution requires a sustainable handling of the environment (principle of sustainability). Harmful effects shall be avoided (precautionary principle) and where this is not possible, the causer is responsible for resulting costs (costs-by-cause principle or polluter pays principle). Based on these articles the government has issued numerous laws, regulations and guidelines [BV 1999].

Laws

The Swiss parliament issued the Law for Environmental Protection in 1983 (Umweltschutzgesetz USG). The law contains the basic principles of waste management, without treating construction waste specifically. Article 30 requires that waste should be avoided or reused as far as possible. As to articles 30a to 30d, the government is allowed to prohibit or confine waste-causing products, to require suitable recycling from producers or to prescribe the reuse of waste if this is ecologically and economically reasonable [USG 1983]. For example, there has been discussed the idea of constraining exploitation of gravel in order to foster the use of secondary construction materials. However, this is not a primary interest of the gravel sector and additionally, the Federal Constitution guarantees commercial freedom of action. This example shows that there would be a certain potential to change something by the politics, but that it is very hard to reconcile the different statements.

Regulations

Numerous regulations relate to the Law for Environmental Protection. The major regulation in the field of waste management is the Technical Ordinance on Waste (Technische Verordnung über Abfälle TVA, 1990). Article 9 deals with construction waste; it requires the separation of the latter on building sites into the following categories:

a. Unpolluted excavated material and soil
b. Waste which can be deposited on a landfill for inert materials without further treatment
c. Burnable waste as wood, paper, cardboard or plastics
d. Other waste

Excavated material and soil should be as far as possible used for remediation projects (article 16) provided that it is pollution free according to article 3 paragraph 7. Burnable waste should be burned in appropriate waste incineration plants if it is not possible to exploit it further (articles 11 and 16). Authorities can require waste owners to recycle their waste if this is ecologically reasonable, technically feasible and economically bearable (Article 12). Article 15 obliges the cantons to write a waste plan describing the canton's waste management system and to issue statistics on yearly waste quantities [TVA 1990]. This task is done well in the field of municipal waste, but there are big gaps in the management of construction waste. Mainly, this is due to two reasons: Firstly, construction waste is handled mainly by privatised companies and there are no obligations for declaration of waste on construction sites or for plants receiving those materials. Secondly, waste flows between cantons as well as waste types are multiple and difficult to observe. These facts make it difficult for the authorities to observe the path of construction waste.

The TVA is subject to a revision. Technique has evolved much, shortage of disposal sites is a problem and the amount of construction waste will rise. Concerning construction

[27] Originally, it was established in 1848; a thoroughly revised version became effective in 1999.

engineering, the aim of the revision is to enhance capture and handling of construction waste flows. For the details about the revision see reference [FOEN 2008a]. The revised TVA will come into force at the earliest in 2011.

The regulation on the transport of waste (Verordnung über den Verkehr mit Abfällen VeVa, 2005) aims to guarantee the delivery of waste only to appropriate dumping enterprises. It focuses on special waste and other waste being liable to control defined in article 2. In construction waste management, this could be waste containing asbestos or contaminated excavated material [VeVa 2005].

Other regulations which concern excavated earth are the regulation on contaminated area sites (Altlastenverordnung AltlV) and the regulation on the charge for the remediation of contaminated area sites (Verordnung über die Abgabe zur Sanierung von Altlasten VASA) [AltlV 1998, VASA 2008].

For building products there exist a law and a regulation (Bundesgesetz and Bundesverordnung über Bauprodukte) [BauPG 1999, BaupV 2000]. Though, they don't implicate principles on sustainable design of building products, such as separability or pollutants. It seems that there would be room for improvement for construction waste avoidance if these legislation texts would be revised.

The next revision of the regulation for the reduction of risks when handling particular specific hazardous chemicals (Chemikalien-Risikoreduktions-Verordnung ChemRRV, 2005, SR 814.81) will implicate a prohibition of new bitumen containing road surfaces and PAH parts in the upper layers of roads [Stadt Zürich 2007].

The regulation on encumbrances on the soil (Verordnung über Belastungen des Bodens, 1998, SR 814.12) requires the careful treatment of excavated soil in article 7 so that it can be reused again as soil [VBBo 1998]. Please note that the VBBo only concerns the soil layers with plants growing in it, in contrast to the Excavation Guideline presented next.

Guidelines
The Federal Office for Environment FOEN has issued numerous guidelines which aim to standardise the way in which the cantons apply the regulations. The guidelines specify the national regulations and define quality requirements of waste to recycle [CIB 2008].
The most important Guidelines for construction waste handling are the Directive for Utilization of Mineral Waste Material (Richtlinie für die Verwertung mineralischer Bauabfälle, 2006), the Excavation Guideline (Aushubrichtlinie, 1999) and the Guideline for the Utilization of excavated earth (Wegleitung zur Verwertung von ausgehobenem Boden, 2001). Excavation material forms the biggest waste flow in Switzerland; additionally, there will take place big railway tunnel projects ("AlpTransit") in the next years. In 2007 already, the third longest railway tunnel of the world was inaugurated. A revision of the Excavation Guideline is planned to be made as soon as the revised TVA comes into effect.

Standards
The Swiss Association of Engineers and Architects SIA (Schweizerischer Verband für Ingenieure und Architekten) and the Swiss Association of Road and Transportation Experts VSS (Schweizerischer Verband der Strassen- und Verkehrsfachleute) regulate the waste management on building sites in many standards. According to the Swiss Association for Standardization SNV (Schweizerische Normenvereinigung), a standard is generally speaking

a recommendation and its application is voluntary. However, there are a number of standards which are mandatory because they are referred to by legislators or authorities laws or decrees [SNV 2009].

For economic people it is essential to gain safeness through reliable standards so that they consider the application of recycled materials in their constructions. The appendix shows a compilation of the current standards concerning sustainable construction and construction waste.

The most important standards in view of construction waste reduction are:
- SIA 112/1, SIA 162/4, SIA 430
- SN 640 141 to 144, SN 670 062

Notions as to the guidelines and standards:
According to the Excavation Guideline, the Guideline for the Utilization of Mineral Waste Material and SIA 430, construction and demolition waste is grouped into four different types as follows:

Excavated material ("Aushubmaterial") is all material coming from the activities of excavation, quarrying and spoil (Aushub, Abbruch, Abraum). It stems from soil horizon C (parent rock material). Excavated material is denoted "not contaminated" when no anthropogenic change of the natural chemical or substantial composition can be identified. The material can therefore be reused or landfilled without constraints. If excavated earth is denoted as "tolerable" or "contaminated", it has to be treated according to the TVA [FOEN 1999].

This term is used as a synonyme for mineral construction waste and is therefore set in the guideline for the utilization of mineral waste [FOEN 2006]. This kind of waste has to contain at least 90 % in weight of materials similar to rock. Construction and demolition debris is further differentiated into:
- *Road construction waste* ("Strassenaufbruch"): This includes material generated by breaking open or milling of uncombined layers of foundations or base and binder courses. This waste is constituted out of road planings (top layer as waste) and road base waste (lower layer waste).
- *Asphalt waste* ("Ausbauasphalt"): Asphalt waste is obtained through cold milling or through breaking open of bituminous layers.
- *Concrete waste* ("Betonabbruch"): Breaking down or milling of reinforced or non-reinforced concrete constructions or coatings results in concrete waste.
- *Mixed C&D waste* ("Mischabbruch"): As the name implies, this is a mixture of mineral construction waste stemming from massive building elements such as concrete or bricking.

Bulky construction waste ("Bausperrgut") is other construction waste which can't be allocated to the above groups, e.g. wood, metals or plastics. These should be separated into reusable and non-reusable waste [SIA430 1993].

Special waste ("Sonderabfälle") has properties which can become dangerous when handled without care. As a result, it has to undergo special treatment and is subject to the VeVa mentioned above [SIA430 1993].

Discussion

Many legal texts and important guidelines concerning construction waste exist already. However, the execution and elaboration lies in the hands of the cantonal governments, which makes it difficult to establish an overview. Today, it is difficult to get thorough information on the many different action modes, guidelines, and customs in the particular cantons. This is last but not least due to different space availability and mentality. The fact that Switzerland has four official languages does not enhance communication and efforts for standardization.

A government has several instruments to govern sustainable construction engineering. For example:

a) it can accord licences for gravel exploitation (and therefore resort to resources scarcity if wished);
b) prices for gravel or landfilling can be raised;
c) it can establish quality specifications for materials;
d) it can serve as exemplar;
e) it could establish financial incentives for recycling of materials.

Most of these instruments are (at least partly) applied in Switzerland. In future, it is important to review and discuss them periodically in order to adapt to changing circumstances.

Standards are very important to establish the same basis for all companies. However, it is crucial that they are widely accepted by people out of the sector and that they are adaptive in practice. As to the Swiss Association of Gravel and Concrete Industry FSKB (Fachverband der Schweizerischen Kies- und Betonindustrie) this is not guaranteed today in the case of rock construction materials [FSKB 2008c]. Round tables with all affected stakeholders should be hold from time to time in order to check differences in expectations and ideas. Standards, guidelines as well as laws are today sometimes used by the public authorities to refer back to them in calls for tenders and to favour those implementing sustainable criteria. This way, they can serve as exemplars for sustainable construction and sustainable construction waste handling.

After this short overview on legislation in Switzerland concerning construction waste, there will now be presented the country and its construction activities.

2. Benchmark data

More than 3/4 of total waste produced in Switzerland originates from construction engineering. It emerges in all life cycle stages of a construction. The title of this report is "Construction Waste in Switzerland", or, if expanded, "Construction Related Waste in Switzerland". However, it would be impossible to consider all waste being generated – e.g. when producing metals or carpets abroad or when considering all materials replaced in renewal activities.

Data on construction waste are available mainly for the biggest flows of materials in terms of volume and quantity, e.g. gravel, concrete, asphalt or bricking. Sure enough, compared to other materials used (mainly in house building), such as ceramics, electricity installation, floorings or carpets, the above mentioned account for much higher amounts in volume and weight. However, in many constructions, the "small" materials hold a certain importance and should not be neglected. As data for those materials are hardly available, this leads unavoidably to a certain selection bias in this context. Still, the materials above go into each building and don't have a long life time. In the end, sustainable handling of construction (waste) materials has to incorporate all flows in construction!

Please note that there are no thorough statistics on construction waste in Switzerland. Data listed here mainly originates from modelling done by engineering consultants for the FOEN, once between 1998 and 2001 and newly modelled in 2008. These figures therefore have to be taken as indicative. Out of the modelling in 2001, a publication resulted [FOEN 2001], whereas the latest data has not been published [FOEN 2008c]. Whenever possible, data from 2008 has been used.

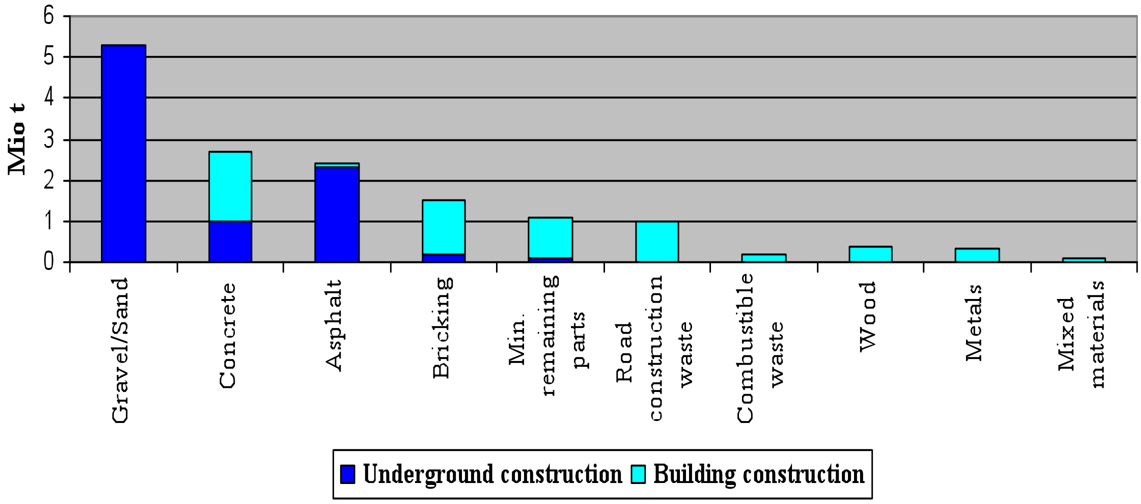
Waste types

This section deals with the waste which is emerging in construction engineering and the treatments that are possible in Switzerland. As in the previous chapters, the materials mainly dealt with are mineral materials. Firstly, these are the materials most used in construction in view of quantity and volume. Secondly, Swiss modelling in recent years focussed on these materials and therefore most data are available in this group.

The first modelling of construction waste in 2001 estimated a annual amount of 11 MT of construction waste in Switzerland. Because of higher demolition activities, they modelled this figure to increase by 40% in house building and by 3% in civil engineering (up to 14.5 Mio. t per year) until 2010 [FOEN 2001]. Latest estimates give a value of about 15 MT of waste per year, which is about three times more than municipal waste produced per year [FOEN 2008c]. In these figures, the excavation material is not included. The amount of the latter is estimated to be 60-80 MT [FSO 2005]. The rise in construction waste since 1997 is more or less due to the house building sector. In civil engineering, the infrastructure is mainly built so that activities in the future will mostly consist in waste-poor maintenance work.

Figure 7 shows results of latest waste modelling in Switzerland by the FOEN. Note: There is 0.13 MT of asphalt waste from house building, which is difficult to identify in the figure.

Figure 7: Annual outputs of waste materials in Swiss construction engineering [FOEN 2008c]



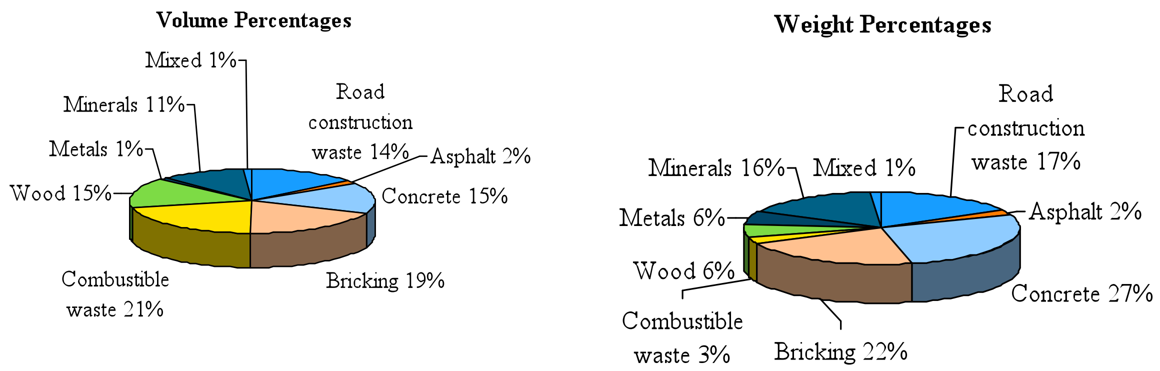
60% by weight (about 9 MT) of waste originates from civil engineering, and 40% by weight (6 MT) from house building. Gravel and sand waste emerge only in civil engineering. Additionally to this 5.3 MT, there is about 2 MT of gravel sludge produced by gravel washing. This sludge is used as fertilizer in agriculture [KIWE-Ca 2009].

It is apparent that material diversity is much higher in house building than in civil engineering. 60% by weight of civil engineering waste is gravel and sand, whereas the biggest percentage in house building is 27% by weight of concrete waste. This diversity makes waste separation and recycling more difficult. As a result, recycling is much more advanced in civil engineering than in house building.

Even if about 70 to 80% of house building waste is mineral based, there are more types of materials than in civil engineering.

Until now, percentages didn't differ much when calculated in weight respectively volume. This time, it is worth to have a look on both.

Figure 8: Volume and weight percentages of building waste types in Switzerland for 2008 [FOEN 2008c].

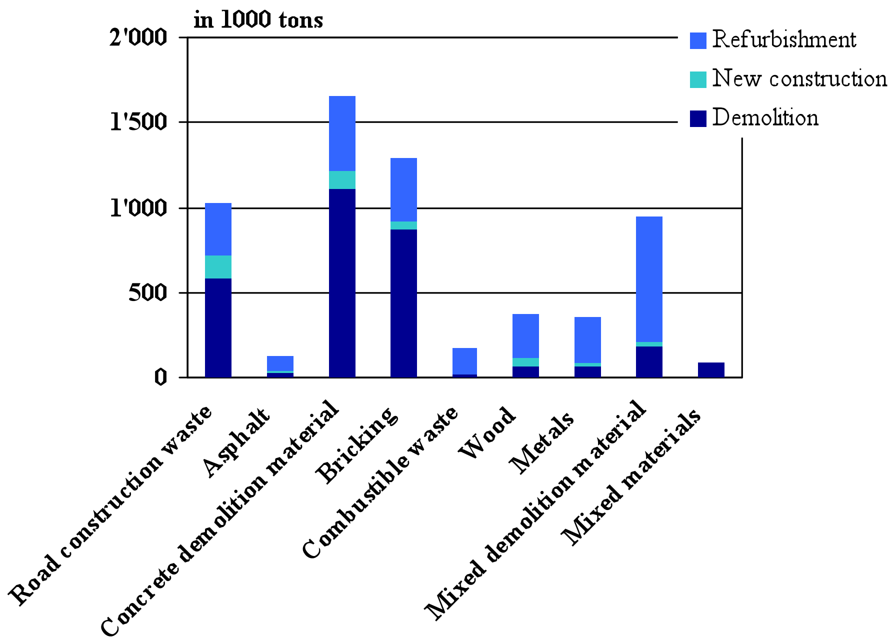


The total volume is 4.5 Mm3; total waste weight is 6 MT. It is obvious that percentages depend on the densities of materials. The biggest differences exist for combustibles, wood, metals and concrete. When considering waste, its amounts and treatment methods, it is therefore crucial to consider the way of expressing the figures.

At this point, it is interesting to look back to Figure 5. Buildings demolished today have an age of about 50 to 100 years. When not taking into account road construction waste and asphalt in the calculations for volume percentages in Figure 8, data corresponds well to building composition between 1900 and 1960.

The following figure shows the origin of the remnants according to demolition, refurbishment or new construction. The waste streams generated by new construction are very small compared to about 93 % in volume of the waste stemming from demolition (41 % in volume) and refurbishment (52 % in volume).

Figure 9: Origin of house building waste: Refurbishment, new construction, demolition (in 1000 tons) [FOEN 2008c].



Concrete and bricking stem mainly from demolition activities, whereas the main waste from refurbishment consists out of mixed demolition material and bricking. For burnable waste, wood and metals, the main waste source is refurbishment, too.

In civil engineering, more than 50% of the waste is produced in the sector of road construction. About one fourth originates from activities related to railway and water supply infrastructure. As a result, more than 90% of the waste consists out of gravel/sand, asphalt and concrete:

Table 3: Construction waste material types and amounts in civil engineering [FOEN 2008c].

Material	MT	Percent
Gravel/Sand	5.17	60%
Asphalt	2.33	26%
Concrete	0.99	11%
Bricking	0.17	2%
Mineral remaining fraction	0.08	1%
Total	8.74	100%

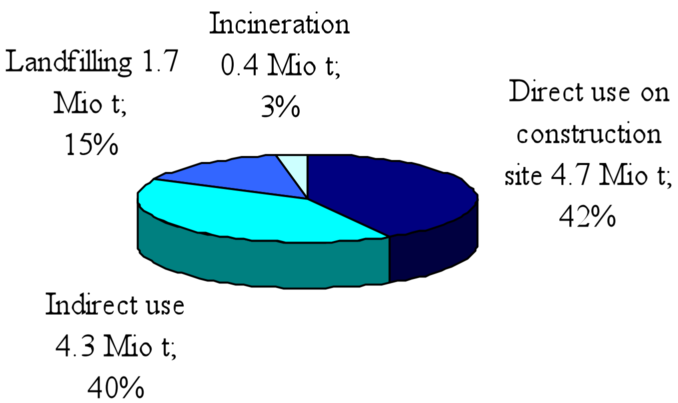
Recycling methods are well known and well-proven for these materials and widely accepted. The total volume of waste is not supposed to rise much in the future (see chapter 0). Furthermore, [Brunner*, et al.* 2006] estimates a constant demolition rate of about 0.3% between 1990 and 2050. Other materials in civil engineering not considered here are e.g. steel, polyethylene, or other plastics.

After we have seen that many different waste types arise, chapter 0 will present ways of disposal and recycling commonly used in Switzerland.

Disposal methods

In the past, the majority of mineral demolition material was disposed of in landfills and therefore consider the life *cycle*. Primary resources, especially gravel, were strained more and more with rising building activities and new ways of waste treatment were established. Figure 10 shows the different disposal routes of construction waste in 1997 with an estimated total of 11.1 MT of construction waste (see also p. 23).

Figure 10: Disposal routes of construction waste 1997 [FOEN 2001].



Most of the waste is directly used on the construction site – this is mainly possible in civil engineering. Indirect use can be recycling or another appropriate treatment and use. The percentage of landfilled material is still quite high, but should be reducing due to new regulations and efforts for reuse of materials. Incineration takes mainly place for wood. For civil engineering, some more detailed data was available on Table 4.

Table 4: Use of waste materials in civil engineering [FOEN 2008c].

Material	Arisings (t/a)	Recycling and disposal [%]	Direct use on site [%]
Concrete	993,461	97%	3%
Bricking	173,356	100%	0%
Gravel/Sand	5,273,210	35%	55%
Asphalt	2,331,099	50%	50%
Mineral leftovers	78,633	100%	0%
Total	***8,849,760***	***54%***	***46%***

More than 50% of gravel and sand and asphalt respectively are used directly on the construction site. For example, about ¼ of the asphalt is directly reprocessed by hot processing; the other ¼ is used as replacement for gravel [Kampag]. Problems arising when recycling asphalt will be discussed in section 0.

Direct use of waste materials on the construction site is mainly practiced in civil engineering, e.g. with hot processing of asphalt or reuse of gravel.

Indirect use mainly means recycling or another appropriate treatment. Chapter 0 will explain the exact ways of recycling and use with the main materials concrete, mixed C&D waste, asphalt and gravel sand.

The estimated amount of landfilled construction waste in 1997 was 1.7 MT. About 50 % in weight (0.8 MT) were landfilled in form of mineral debris (glass, ceramic, gypsum etc.). Materials such as road construction waste, concrete and mixed C&D waste constitute the remaining parts [FOEN 2001]. Latest figures of mineral debris are much higher: About 1.5 MT of mineral remainings are generated per year out of which a big part is landfilled. A change of this proceeding should be activated with the rise of landfilling costs of mineral waste by about 10% in 2008 [FOEN 2008c].

According to the report on waste economy 2008 written by the federal state, about 80% of disposed waste (mainly construction waste) goes into landfills for inert materials. There exist big differences in landfill space capacities between the cantons. There are cantons where landfill space is not an issue, there are others which report scarcity of space e.g. for excavation material. Though, there is no thorough overview on capacities of the existing landfills today and in the future. It is hoped that the new tax for landfills for inert materials as well as a new regulation on inert materials (VASA) will help to collect the amount of waste deposited there (besides mitigating landfilling, naturally).

Further on, the coordination of landfill capacities should be consolidated between cantons and regions [FOEN 2008c].

In Switzerland, all burnable waste which can't be exploited must be burned in appropriate plants. This business is dominated by municipal waste incineration plants. Some burnable waste is used for cement production. In 2006, 375,412 tons (50 kg per resident) of construction waste were burned in waste incineration plants [FOEN 2008c]. In this case, figures are well-known and exact. About two thirds of the burned construction waste consist out of wood [FOEN 2001].

All plants in Switzerland currently use technologies to produce electricity or district heat.

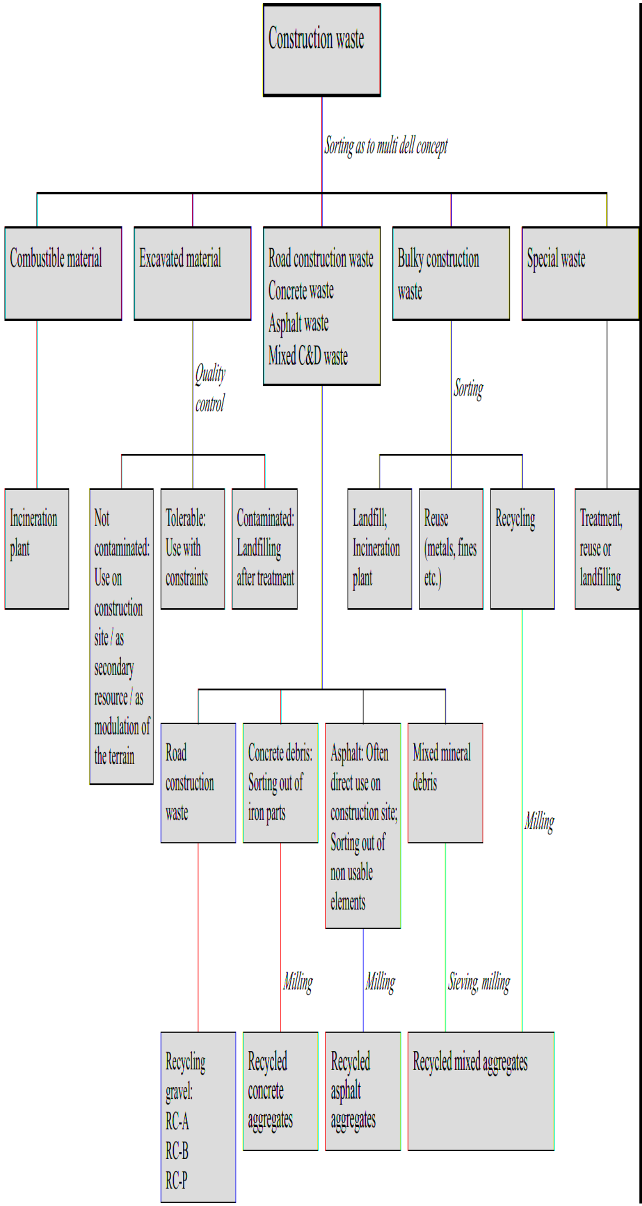
Total special waste forms about 6% of waste generated in Switzerland [FOEN 2008c].
In 2007, mineral special waste formed 36% (521,924 tons) of total special waste treated in Switzerland. Nearly 100% of this mineral waste was construction materials. 83% is contaminated excavation material (which builds the biggest special waste portion), the remaining fractions are problematic construction waste (e.g. contaminated demolition materials) and asphalt waste with a PAH content higher than 20,000 mg/kg. Treatment covers disposal, incineration, biological treatment or recycling/conditioning [FOEN 2009].

Materials
This chapter will provide an overview on the main recycling materials produced in Switzerland and their environmental influence. Challenges of recycling ways and obstacles in practice will be explained.

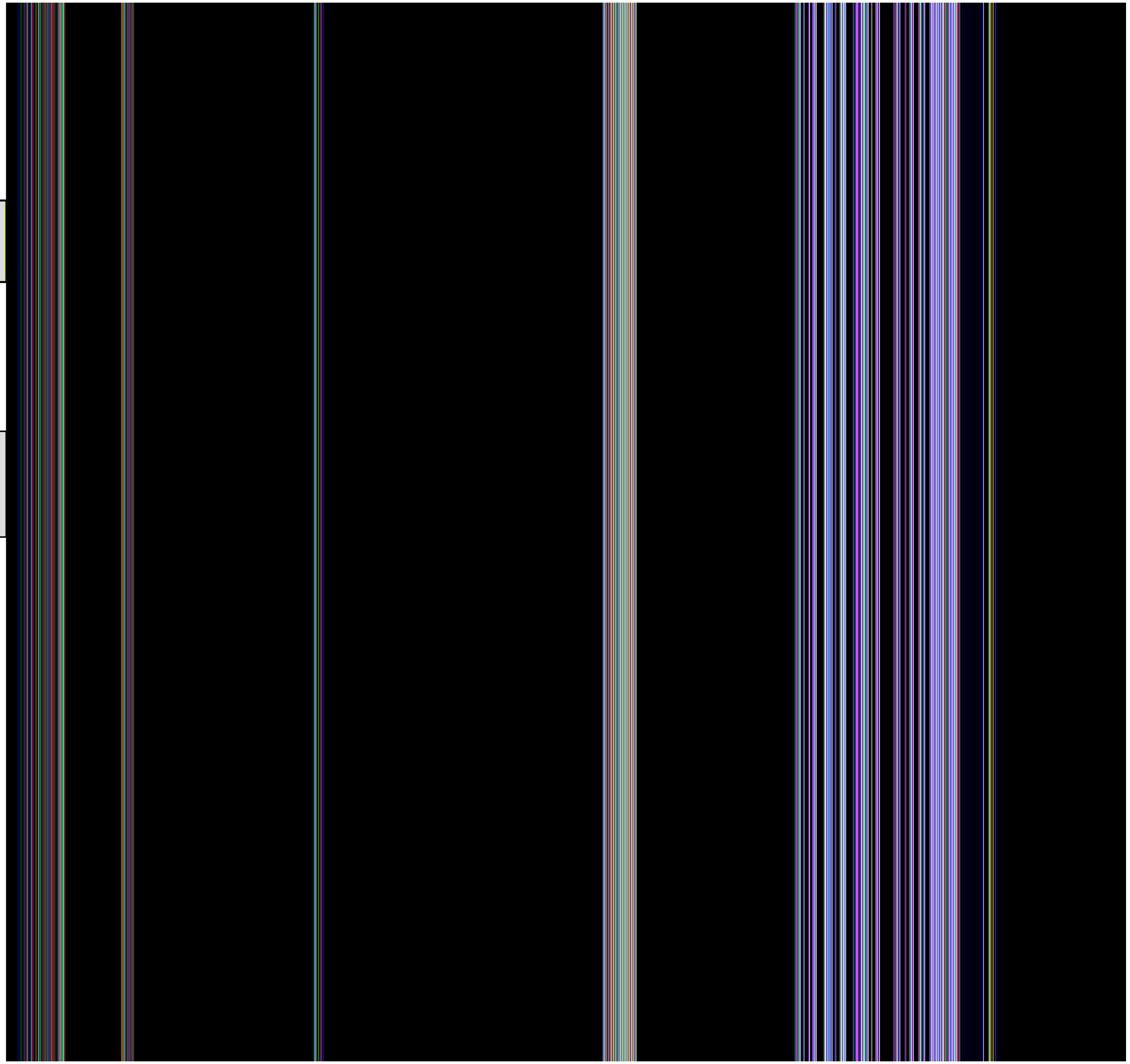
Recycling has to be an issue in Switzerland (as well as in other countries, naturally); this for its diverse positive effects such as reducing the use of primary resources or sparing use of landfill space. An economically viable recycling route could further minimise illegal dumping. Demolition activities are likely to increase because of shortage of building land and a move towards more energy efficient buildings. Governmental requirements can help to guide waste use towards a higher recycling rate – but there also has to be taken into consideration that more stringent laws and standards can interfere recycling efforts. However, there are many unsolved life cycle aspects for most of materials used, mainly in the building sector.

The main recycling ways and products
The diagram on the following page gives an overview on treatment ways of construction waste and their main products in Switzerland. It compiles information of the Guideline for the Utilization of Mineral Waste Material, the Excavation Guideline and the multi dell concept.

Diagram overleaf: Treatment ways of construction waste and main recycling products in Switzerland according to the official guidelines and concepts [FOEN 1999, FOEN 2006, SBV]



Construction waste
Sorting as to multi dell concept
Combustible material
Excavated material
Road construction waste
Concrete waste
Asphalt waste
Mixed C&D waste
Bulky construction waste
Special waste
Quality control
Sorting
Incineration plant
Not contaminated: Use on construction site / as secondary resource / as modulation of the terrain
Tolerable: Use with constraints
Contaminated: Landfilling after treatment
Landfill; Incineration plant
Reuse (metals, fines etc.)
Recycling
Treatment, reuse or landfilling
Road construction waste
Concrete debris: Sorting out of iron parts
Asphalt: Often direct use on construction site; Sorting out of non usable elements
Mixed mineral debris
Milling
Milling
Milling
Sieving, milling
Recycling gravel:
RC-A
RC-B
RC-P
Recycled concrete aggregates
Recycled asphalt aggregates
Recycled mixed aggregates



Directly on the construction sites, the materials are separated as to the widely accepted multi dell concept. Disposal methods include direct use on construction site, indirect use, landfilling and incineration. We can see that there are six main recycling materials dealt with in Switzerland: three granules and three recycling gravel types. Their allowed composition is defined by the guideline for mineral construction waste by the FOEN. A summary is shown in Table 5. If the above mentioned materials are not recycled into granules, they are often crushed and used as alternative for gravel/sand in civil engineering.

Table 5: Quality standards for the six mineral recycling materials [FOEN 2006].

Waste category / Secondary material	Asphalt	Gravel/Sand	Concrete demolition	Mixed demolition	Impurities
Recycled asphalt aggregates	90	10	2		0.3[28]
RC gravel sand P	4	95	4	1	0.3
RC gravel sand A	20	80	4	1	0.3
RC gravel sand B	4	80	20	1	0.3
Recycled concrete aggregates	3[29]	95		2	0.3
Recycled mixed aggregates	3	97			0.3 without gypsum + 1% gypsum

Reading example: Recycled asphalt aggregates have to contain at least 90% of asphalt. Further percentages of materials have to be fulfilled approximately.

The Swiss Association on excavation earth, deconstruction and recycling (ARV) collects data from its members with the help of inspections. Latest sales volumes of recycled materials are presented in Table 6 [ARV 2009]. Please note that (a) there are a few cantons in which there are no inspections made and (b) only materials complying with the official quality guidelines are captured. Additionally, the FSKB estimates a total sales volume of 5 MT of recycling material per year for its members [FSKB 2009]. Materials directly reused on the construction site are not included. As a result of these conditions, the data are implicitly to be taken as approximate values and do not represent the whole business market!

[28] Recycled asphalt aggregates being used with hot processing musn't contain impurities.
[29] Recycled concrete aggregates being added to classified concrete musn't contain asphalt.

Table 6: Sales volumes of recycling materials as to ARV and FSKB in 2006 and 2007

RC-Material	Sales volume 2006 in MT	Sales volume 2007 in MT
Recycled concrete aggregates	0.868	0.865
Recycled asphalt aggregates	0.399	0.360
Recycled mixed aggregates	0.346	0.390
Total granules	***1.613***	***1.615***
Recycling gravel	1.025	0.968
Diverse	0.483	0.399
Total ARV	**3.122**	**2.984**
Recycling materials FSKB	Ca. 5	Ca. 5
Total recycling materials	**8.122**	**7.984**

The sales volume in 2007 is slightly less than in 2006: 7.948 MT vs. 8.122 MT. Given the quite big uncertainty, this is not taken as relevant; all the more that in the whole, secondary products on the market have steadily been rising in the last years. Furthermore, one should consider that there are stockpiles of certain materials, especially of recycled mixed aggregates and Recycled asphalt aggregates.

A similar listing has been shown in [VSS 2002]. There was given a total of 5.4 MT of recycling material by the ARV, therefore being much higher than the 3 MT in 2006 and 2007. Investigations resulted in the supposition that these data probably have been estimated including materials not following the quality guidelines.

According to Mr Suter, executive of ARV, data of ARV and FSKB account for about 70% to 80% of all recycled materials in the construction sector. The total amount of discharge of recycled materials can be estimated to be 13 MT per year. This is higher than the mentioned 9 MT in Figure 4; one has always to consider that all data are estimations. Given the total need of about 60 MT of construction materials in the Swiss market, recycling materials can cover about 20% of the need, even if the recycling rate is at 80% today. It has further to be taken into account that, for example, 125% of input material may be required to reach 100% of usable material [Gellenkemper*, et al.* 2004]. This means that even if a rate of 100% recycling would be reached, only about ¼ of the total construction materials market could be provided with secondary materials. For example, as to [Lichtensteiger 1997], the percentage of recycled material in the whole stock of Swiss buildings is lower than 1%. Please note that these calculations can differ much from material to material. The input of secondary gravel for example is estimated to be at about 10% of total gravel demand [FSKB 2008a].

The allowed use of the six secondary construction materials is defined by the guideline for mineral construction waste as follows in Figure 7. Construction waste for recycling is present in unbound (e.g. excavation rock), hydraulic bound (e.g. concrete) or bituminous bound (e.g. asphalt) form.

Table 7: Allowed use of the six recycling materials as to the guideline for mineral based construction waste. Grey: Use not allowed [FOEN 2006].

Recycling material / Use possibilities	Use in unbound form		Use in bound form	
	Without coating	With coating	Hydraulic bound	Bituminous bound
Recycled asphalt aggregates	[30]	[31]		
Recycling gravel sand P				
Recycling gravel sand A				
Recycling gravel sand B				
Recycled concrete aggregates				
Mixed C&D waste granules				

These constraints are based on environmental and technological considerations. For example, leaching of possible pollutants wants to be avoided by the prohibition of use without coating for four of the materials. Even if these constraints are still functional as to [Hoffmann and Dr.Jacobs 2007] they will need constantly customisation in view of allowed contaminations. A new revision of the guideline will be made after the new TVA has been established.

The appendix contains a table out of the Swiss Norm SN 670 062 on secondary construction materials, their composition, their application areas and environmental constrictions (in German). The use in unbound form is mainly an application in civil engineering. Roads and squares are underlayed with basal material, or there are made backfills of dams or replenishments of gravel pits and construction sites. Bituminous bound material is used as coatings. The study mentioned before [VSS 2002] presented percentages for each of these classifications: 53% of all recycling materials are used without coating, 6% with coating. Products going into concrete production or coverings account for about 20% each.

All of these six materials are mainly offered in similar forms as gravel and therefore hold a substitutional function for gravel. In many cases, the material is not bound, which could include a higher risk of leaching of pollutors. However, [VSS 2002] claims that this would only be the case at illegal backfills. Backfilling with unconditioned construction waste mustn't be done in Switzerland. This is basically widely accepted and done; however, the

[30] Use is possible under the condition that the layer thickness amounts to a maximum of 7 cm and if the recycled asphalt aggregates are milled.
[31] Use is possible only if used as road sub-base and base material under a bituminous coating.

study mentioned before claims that there have to be a certain amount of material illegally dumped or backfilled. It says that this can be supposed as a result of mass balances.

Some of the waste materials are discussed in the following parts. On the one side, these are important materials in view of needed amounts, furthermore there are presented materials with a great potential for recycling in future and finally, the discussion will be hold on an exemplary case for a material not mentioned until now in this report.

Concrete

Concrete is a mixture of aggregate (gravel), water, cement, additives and other chemical admixtures. The definition of recycling concrete as to SN EN 206-1 (2000) includes a minimum of 25 % in weight of recycled concrete aggregates and/or recycled mixed aggregates [SNV 2000]. Secondary concrete can therefore be made out of concrete demolition, mixed mineral debris or asphalt. In Switzerland, recycled asphalt conrete and concrete made of concrete are widely accepted. In contrast, secondary material out of mixed C&D waste still does not have a good reputation on the market due to strongly unsteady properties (see section below). Another issue is that life cycle assessments (LCA's) have shown the secondary concrete does not improve environmental impacts (especially for CO_2 emissions) much if at all, so that this incentive drops out for companies ("greener" products/production). The crucial points for CO_2 emissions in (recycling) concrete production are the type and amount of cement. Furthermore, type and distance of transport have a big influence on environmental performance [Kytzia 2009, TUM 2006]. A positive result of those LCA's proves the durability of recycling concrete to be as high as of primary material. Furthermore, the use of waste as resource helps to protect valuable soil resources.

On the economic side, the price for recycling concrete is equal or higher than the one for primary concrete. However, on the long term, secondary materials could become cheaper than primary materials, depending on technologies and fees for waste conditioning or landfilling. All in all, [Dosho 2008] concludes that encouragement of the use of recycled aggregate concrete needs to secure a good balance between (a) safety and quality, (b) environmental impact, and (c) cost effectiveness.

Recycled mixed aggregates

As a special case of concrete raw material, recycled mixed aggregates are presented in this section. Recycled mixed aggregates can be made out of bricking and/or out of mixed mineral materials. As long as materials can't be separated in a proper way, recycled mixed aggregates would ostensibly be a very good solution to prevent landfilling. However, only estimated 20% of bricking and mixed mineral waste is recycled. Even if there are other unrecorded uses, a big amount of these materials is still landfilled.

Recycled mixed aggregates are not well accepted in the industry because of several properties listed below [Hoffmann 2005]:

- Gypsum, fine materials or other materials are not desirable in recycled mixed aggregates, but today can't be avoided in many cases.
- Composition of the granules fluctuates much and therefore the properties of the material.
- Because of a high amount of non-cubic aggregates, cavity is higher and therefore the need of cement increases. The same is valid for water absorption.
- The more mixed mineral debris, the lower is the modulus of elasticity. As compressive resistance remains the same, a higher distortion results.
- Shrinking is twice as high as for primary gravel.

It is recognized that lean concrete will be the place for recycled mixed aggregates. It can be introduced at many places on the construction site without problems. Examples for this (and for other types of recycling concrete, too) are given in two brochures by the canton of Geneva [GE 2009]. In order to transfer the current knowledge to the regarding persons and to overcome prejudices, the project “gravel for generations” has been started.

Another discussion point concerns possible pollutants in mixed mineral material and their behaviour. In Switzerland, a study was accomplished about pollutants in secondary construction material in general [VSS 2002].

Secondary construction materials do not contain many pollutants; additionally, most of them are inorganic. Indeed, concentrations of chemicals are higher in recycled mixed aggregates than in other secondary materials. The authors claim that high quality requirements for all secondary materials would ensure security for human beings and the environment. This way, accumulation of pollutants such as nitrogen compounds or chromium in ground water is avoided.

Asphalt
About 50% of asphalt waste is used directly on site, e.g. by a procedure using heat; the other 50% are recycled into recycled asphalt aggregates or landfilled. However, there are hold some discussions about the recycling of asphalt: A total of about 6 MT pavements contains tar, which corresponds to about 5% of the total embedded asphalt [ARV 2008]. Abrasion of material comprising PAH can trigger health problems.

Today, materials with more than 20,000 mg PAH per kg binding agent are allowed only to be used with restrictions and current policy works suggests to sort out and eliminate the tar-containing fraction [FOEN 2008c]. In contrast to this, the industry claims that there exist methods for a safe reuse of these materials [Killer 2008]. Even so, the next revision of the ChemRRV will probably implicate a prohibition of new bitumen containing road surfaces and PAK parts in the upper layers of roads [Stadt Zürich 2007]. The binding material shall be taken out of the cycle by incineration.

Excavation material
Excavation material is generated in high amounts, contaminated (only 5-10%) or pollution-free. As there is no obligation to capture the amount, only estimations can serve as lead. Today, estimations give figures around 40 to 60 Mm^3 per year, and given that big projects and high construction activity are expected, this figure will rise in the next years. Today, the material is mainly used for backfilling or reclamation of gravel pits or construction sites. The remaining parts are used in another form or are landfilled.

Depending on the canton’s space availabilities, scarcity of landfill space will become an urgent problem. Today already, materials are transported over big distances with lorries. The current TVA revision will deal with this problem. Materials with good construction properties can be used as construction materials, but for the remaining parts, solutions for in-situ or other use of excavation have to be established. A study accomplished by the Hochschule für Technik, Rapperswil was ordered by the FOEN [FOEN 2008b]. The study compiled examples of sustainable in-situ use of excavation materials in landscape forming. Identified problems concerned the quality of the remaining excavation material, space constraints and interim storage. Furthermore, it concluded that it was easier to reuse excavation material at big construction sites than at smaller ones. From the economic side of view, avoidance of landfill fees brings significant cost savings. Unfortunately, legal general conditions restrict the reuse of even uncontaminated excavation material.

Wood

Wood represents about 6% of all materials used in house building. A big advantage of this natural renewable resource is that there is nearly no waste arising because at each processing phase there are products which can be used for energy production or for chipboard for example. Furthermore, the specific properties of wood are advantageous to others, such as a low weight, very good insulation properties or high bearing strength. As a result, wood can be used for insulations, for supporting parts or for siding. In Switzerland, construction wooden waste is mainly incinerated. Often the material is treated with chemicals which hinder (re-) use of it. There are already many solutions to wood use without chemicals, which brings the further advantage of a better indoor air quality. An adept placement of wooden material, adequate time for painting or a good room climate is only some of appropriate employment strategies.

Today, Swiss forests are not exploited well. Only 4 Mm3 out of 7.5 Mm3 economical harvestable woods are taken out of the forests. In view of CO_2 savings and emissions, a study by the FOEN shows that it would be beneficial for Switzerland to exploit its timber resources better.

The study estimates a saving of 0.7 t CO_2 per m^3 of wood substituting another material out of which 0.3t is saved in Switzerland. Additionally, wood can be led to an energetic use and therefore contribute to additional savings of 0.6 t [FOEN 2007]. Not least, wood use in construction can therefore contribute to reaching the Kyoto goals and is an important actor in climate change discussions. Long transport to import materials can be mitigated when using wood of regional forests in construction.

Materials out of poly vinyl chloride (PVC)

Substitution for the many other materials used in construction engineering, there shall be presented the material PVC. It is a popular material due to its properties, but also due to its relative low grey energy [eco-devis 2002] and has more and more been used in the construction sector in the last decades. Therefore, there can be expected a certain amount of PVC materials emerging from demolition activities over the next decades.

For example, 85,000 t of crude PVC and 94,000 t of finished products such as windows, tubes, floorings have been imported in 2007, out of which about ¾ are sold in the construction sector [PVCH 2009], this means there were about 134,000 t of PVC materials used in constructions in 2007.

Even if incineration of PVC waste is environmentally unproblematic, a recycling is desirable given that PVC is based on to 43% on crude oil. However, there have to be considered the environmentally relevant ingredients.

There has recently started a recycling system in Switzerland to recycle PVC pipes emerging at demolition activities so that they do not go to the incineration plant [PVCH 2009]. Additionally to the take back of PVC pipes, there exists a joint venture for recycling of PVC flooring (www.arpschweiz.ch).

Discussion
The previous two chapters showed types and amounts of waste, its treatment and the most important secondary materials and their use.

Whilst recycling is very well known and established in civil engineering, the diversity and therefore complexity of materials is much higher in house building. Besides the "big" categories such as bricking or concrete, there are many other incorporated in a building – unfortunately often in compounds and treated with chemicals, what makes them impossible to separate (or impossible to do this economically) and problematic in view of pollutants.

Still, selective demolition could be a solution to the big flow of house building waste today incinerated or landfilled. There have already been made many tests on how this can be done and if it is economically feasible [EU 1999, Mesch and Baumann 2003, Roussat*, et al.* 2009, Wien 2004]. Results say that this method is highly positive for waste management and treatment. Costs vary much from case to case, so it cannot be said that selective demolition is sustainable in each case from the economical point of view. However, it is highly recommended to consider this type of demolition in deliberations. In Switzerland, gutting is made in many demolition activities, i.e. wooden parts, metals, floorings, plastics etc. are taken out as far as possible before tearing down the building envelope. Unfortunately, a possible reuse of elements such as windows, doors, heaters is often difficult because of fast developing technologies.

Waste materials coming from house building are seen to have contaminants and impurities. These prejudices have to be eliminated where solutions have already been found.

3. Strategies, guidance documents

This chapter presents main strategies or guidance documents which could mitigate construction waste. At the beginning, the Sustainable Development Strategy of the Swiss federal government is introduced. Strategies are then divided into building strategies concerning design problems; reuse and recycling strategies to decrease disposal or incineration; and disposal strategies which aim at abating incentives for landfilling. After this, important Swiss associations in the recycling of construction material industry are shortly presented, followed by an overview on available Life Cycle Assessment (LCA) instruments.

Sustainable Development Strategy, Switzerland
The Swiss Federal Council adopted the first Sustainable Development Strategy (SDS) in 1997 and established the second one in 2002. After a revision in 2007, Switzerland is now working on the action plan 2008-2011.

The guidelines are rooted in the Swiss Federal Constitution as well as in reference documents and strategies issued by the United Nations, the OECD and the EU.
In order to establish close links between legislative planning and the SDS, the Federal Council has derived eight key strategic priority challenges that form the basis of its action on sustainable development[32]. An Interdepartmental Sustainable Development Committee aims to significantly intensify the assessment and optimization of political projects from the

[32] These strategies refer to: Climate change and natural hazards; Energy; Spatial development and transport; Economy, production and consumption; Use of natural resources; Social cohesion, demography and migration; Public health, sport and the promotion of physical exercise; Global developmental and environmental challenges; Fiscal policy; Education, research and innovation; Culture

viewpoint of sustainable development, as well as monitoring (MONET) and controlling over the course of the current action plan. The MONET system of national indicators offers in-depth insights into sustainable development in Switzerland. Meanwhile, synthetic indicators such as the ecological footprint provide an appropriate basis for more general statements and for international comparisons.

Out of the measures portfolio, measures 4-1 (Integrated Product Policy) and 4-2 (Sustainable Building), each covering several sub-measures, have importance in view of sustainable construction. They are listed in the appendix [ARE 2009].

In the course of the SDS, a new regulation on the management of immovables and the logistics of the federal state came into effect in January 2009, following principles of the strategy (Verordnung über das Immobilienmangement und die Logistik des Bundes VILB). Life cycle costing should be taken into account as well as sustainable thinking (articles 2 and 9) [VILB 2009].

Please consult the following links of the government for further information (documents to some extent available in English):

- http://www.are.admin.ch/themen/nachhaltig/index.html?lang=en
- http://www.bfs.admin.ch/bfs/portal/en/index/themen/21.html

Building strategies

Eco-bau requirements for sustainable building www.ecobau.ch (d/f)

'Eco-bau' is a common platform of the public building departments from federal, cantonal, and city governments with recommendations for sustainable planning, building and maintaining of buildings and systems. Eco-bau offers checklists and other instruments for sustainable material decisions, mainly for tenders. For example, information is integrated in a cost planning software named eco-devis as additional component. 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. 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) [CIB 2008].

SNARC (SIA D 0200)

SNARC stands for "System for an environmental sustainability assessment of architecture projects". It can be downloaded on www.ecobau.ch (d/f).
It 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 ten evaluation criteria cover important aspects like resource demand and embodied energy in construction and flexibility for later refurbishment. The evaluation is made with the help of graphs and information in tables, e.g. on energy use in giga joules [CIB 2008].

Grey energy of buildings (SIA 2032)
A new leaflet (2008) aims to include grey energy considerations in the same manner as energy use during the use phase. Basics for project oriented ratings are established as well as standards for the calculation of the grey energy of buildings [SIA 2008].

Reuse and recycling strategies
"Disposal marker" - www.abfall.ch (d/f/it)
The disposal directory or "marker" is a web page on disposal questions established by the cantons, the FOEN, ARV and VBSA
It provides a compilation of relevant information on waste management in Switzerland in general and in the different cantons. The reader can find e.g. waste purchasers in a certain region, information on waste groups such as construction, industrial and business waste, legislation information or seminars. The website is available in German, French and Italian.

Multi Dell Concept
The Multi Dell Concept (Mehrmuldenkonzept MMK) 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. It aims at facilitating quick and rational disposal ways within close proximity to the construction site. Target group are managers who have to implement a waste management plan in accordance with the mandatory standards laid down [CIB 2008, SBV]. Please consult the appendix for further information on the concept.

Disposal strategies
Landfill taxes
There are mainly three reasons for raising taxes on landfilling:
1) Landfill volume is a scarce resource in Switzerland as the country is very small and mountainous. The price for landfill space can e.g. be up to twice as high as for gravel and the opening of new landfills related to many discussions.
2) Taxes raise the incentive for recycling all types of mineral waste.
3) Taxes provide information about the amount of materials disposed off in the landfills

The federal government has introduced two new landfilling taxes in recent time: One in 2008, which raised the landfilling costs of mineral waste by about 10%; and one in the beginning of 2009 charging inert materials with a new tax.

Associations and organisations - www.arv.ch
There are several associations focussing on (construction) waste treatment in Switzerland. First of all, the Swiss Association on Excavated Earth, Deconstruction and Recycling ARV (Aushub-, Rückbau – und Recycling-Verband) has to be mentioned. This association has been founded in 1990 and acts for its members in the whole country. Interests of the industry of construction waste recycling are represented towards the federal state, cantonal authorities, expert panels or the public. The ARV aims at enhancing acceptance of secondary construction materials and tries to establish solutions being in line with the market. The idea of life cycles is a core element of the association. Consistent standards and quality demands in the whole country of Switzerland shall establish a fair basis for every company. Periodical inspections ensure control and should lead to enhancements.

The Association of Operators of Swiss Waste Treatment Facilities VBSA (Verband der Betreiber Schweizerischer Abfallverwertungsanlagen), www.vbsa.ch, pools operating companies of different waste treatment technologies - such as sorting, incineration or landfilling. Most enterprises treating municipal waste are members of the association; the participation of construction waste recyclers is much smaller. The VBSA aims at a sustainable waste management and has a decisive influence on Swiss waste politics.

The Swiss Association of Gravel and Concrete Industry FSKB (Fachverband der Schweizerischen Kies- und Betonindustrie), www.fskb.ch,
is the most important player in the field of gravel and concrete market. In this position, it holds stewardship for the use of recycling products, too. Main interests are to represent concerns of the industry in politics and to support expertise of its members. Inspections and advanced trainings enhance the further development.

The Swiss Center for Rationalisation of Construction CRB (Schweizerische Zentralstelle für Baurationalisierung), www.crb.ch, is supported by three associations:

- BSA – Federation of Swiss Architects
- SIA – Swiss Association of Engineers and Architects
- SBV – Swiss Association of Builders

The CRB receives orders from the Swiss construction industry to develop standards for planning, construction and maintenance of constructions. Efficient information flows between all stakeholders in construction engineering shall be achieved.
Until today, the center has not focussed on sustainability and recycling of waste. Given the broad target public, such activities could have a certain influence on sustainable construction and construction waste handling.

AWEL Project: Gravel for generations (Kies für Generationen)
The project "Gravel for generations" was initiated by the department for wastes, water, energy and air (AWEL) in the canton Zurich. Its aim is to support the construction industry in recycling of "waste" construction materials to high quality materials, recognizing that such materials still have a bad reputation. With targeted communication strategies, prejudices should be reduced amongst all stakeholders and the significance of deconstruction materials in the gravel market be enhanced. This "outsourcing" of the deconstruction materials is made in order to hand over the responsibility of production and products to the competence of the industry and its associations. Out of this, an organisation supported by the industry itself is aimed to be launched. It could serve as binding communication platform for knowledge, supply and quality insurance in the market [AWEL 2007, Stadt Zürich 2007].

On the 24th of March 2010, a national symposium on secondary construction materials has been organised. National acting associations such as the ARV and FSKB support the symposium. Future challenges will include getting more associations, companies and cantons on board in order to expand the idea of a sustainable gravel use.

LCA tools for buildings
LCA (Life Cycle Assessments) can give valuable hints on the environmental effects of products or services. In a recent article by Haapio&Viitaniemi [Haapio and Viitaniemi 2008], an analysis of the differences between existing tools is made. Current examples of LCA-based building assessments and design tools are OGIP (CH), Eco-Quantum (NL), Equer (F),

Envest (GB), BECOSE (Finland), ECOSOFT (A), ESCALE (F), Sima-Pro (NL), LEGEP (DE).

In Switzerland, a list of ecological indicators for various construction (and other) materials has been developed. Data are representing Swiss averages and are based mainly on the ecoinvent Database. This list is a basis for various Swiss building assessment tools such as the "electronic constructional element catalogue" or the Software "LTE Ogip" [Empa 2009]. Recently KBOB, as coordination platform for governmental building owners, together with many private companies from the material and construction industry launched a project to expand and update life cycle inventory data for construction materials and products. Theses data should be part of the ecoinvent data base 3.0 that should be available by the end of 2011.

A rough calculation of ecological impacts of specific components can be made with the help of a "checklist for components" (Bauteilkatalog). Calculations integrate production phase, renewal and deposition of the materials over a building lifetime of 100 years. Impacts are shown for environmental burdens, grey energy and greenhouse effect. You can find more details on www.bauteilkatalog.ch (d/f)

4. Examples, case studies

This chapter shows selected examples where construction resources use and waste are or have been significantly reduced or where there are made attempts aiming at this.

MINERGIE-ECO ® - www.minergie.ch (d/f/i/e)

MINERGIE® and MINERGIE-P® are labels for sustainable buildings. MINERGIE has been initiated in 1994 and today is the most important and widely accepted 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 health and building material aspects concerning the choice of construction materials and indoor environmental quality.

In order to get a MINERGIE-ECO® or MINERGIE-P-ECO® certificate, a building needs to fulfil a catalogue of criteria on the basis of the MINERGIE®- or the MINERGIE-P® standard [CIB 2008]. Today, there are 14,217 buildings certified with the MINERGIE® standard, 481 with MINERGIE-P®, 54 with MINERGIE-ECO® and 61 with MINERGIE-P-ECO® - most of them in Switzerland, some in bordering countries (updates of these figures on the website). It can be claimed that at the moment MINERGIE-ECO® leads to the most sustainable way of building constructing in Switzerland. For example, the use of recycling concrete is mandatory and there is put focus on separable and locally produced materials. Taking into account the whole life cycle costing, buildings as to this label are cheaper in most of the cases. However, a building implementing all points demanded has higher costs of about 20% than a building considering basic regulations at the beginning of its life. This can be an obstacle to choose MINERGIE-ECO®.

Initiatives on the internet

There have been made several attempts to establish routes for construction waste handling on the internet. However, none of these was really successful. Reasons are amongst other different standards in the cantons or the difficulty of obtaining the attention of enough users. Today, there are for example two routes on the internet:

- www.bauteilnetz.ch, which is run by the “Swiss network of building elements”. The offered materials can be picked up in several cities.
- www.abfallboerse-schweiz.ch intends to establish a neutral and professional management in the recycling and disposal market. It aims at bringing the residues in a most profitable manner to new recycling or disposal processes. Please note that this company is not only oriented towards construction waste.

It is important to bring current knowledge on environmental protection and standards to the people on the construction site. www.baupunktumwelt.ch is a training program for (young) people which does not only focus on construction waste handling, but also on other environmental issues of construction.

Canton of Zurich
Today already, 90% of all mineral construction waste is recycled in the canton of Zurich. The canton of Zurich can be introduced as a positive example of efforts in construction waste mitigation. A strong focus is put on seeing waste materials as resources and the aim is to close the cycle of mineral construction material: waste economy should change into a resource economy. The project “Gravel for generations” has been initiated by the cantonal department for waste, water, energy and air. In 2007, the building management published a waste and resources management plan for the period 2007 to 2010 [AWEL 2007][33]. In the construction sector, future measures should aim at activating and involving the construction industry as far as possible.

Canton of Basel-Land
The department for energy and environmental protection of the canton of Basel-Land has initiated several projects for waste prevention in general between 1994 and 2000. One of it dealt with waste emerging from new construction activities. Goals of the project were on the one hand to check different possibilities of waste prevention and sustainable handling of resources on the basis of a tangible construction project. On the other hand, the results should enable the cantonal authorities to factor in sustainable aspects in their future projects. Economic, ecologic and social points were considered and evaluated and they have shown that despite the quite narrow constraints, many enhancements can be considered. Furthermore, it could be shown which planning phases and questions were most important in order to mitigate resource need of the construction and emerging of waste in phases later on in its life cycle [BL 2009].

Ecomat-GE, Canton of Geneva
The canton of Geneva has launched the project “Ecomat-GE” in 2006 uniting people from the industry with the aim of testing and documenting usability of secondary construction materials. As result, two brochures show in a practical manner which secondary materials can be used the best way in construction project [GE 2009]. Knowledge and experience should be transferred this way.

Swissbau 2010: Sustainability and energy efficiency
From the 12th to the 16th of January 2010, the biggest construction exhibition of Switzerland will take place. The goal is to take into account the whole value-added process of an immovable so that structures, processes and companies of construction and immovable

[33] Such a report has already been written for the period 2002 to 2006.

economy establish a better network. At Swissbau 2010, sustainable construction and energy efficiency are the main themes. Three special shows underline this intention. Links to the exhibition in general and to one of the special shows for sustainability: www.swissbau.ch and www.globalbuilding.ch

Discussion
Treatment of the main construction waste materials is well advanced in Switzerland with a total recycling rate of about 80%. It seems that a further reduction of primary gravel use can only take place when the growth rate of new constructions will decrease. This process is sometimes called "from stock growth to stock management" or "from waste management to resource management".

However, it has to be recognised that the recycling rate is much lower in house building than in civil engineering. Material diversity and therefore the recycling or reuse challenges are huge when examining a building. A next step to make (building) construction waste more sustainable would be to identify appropriate materials and (new) technologies for treatment. Recycling of PVC materials is one positive example for this. It shows that considerable knowledge is already there; efforts to bring it to the respective people should be intensified. Sadly enough, helpful web pages such as www.ecobau.ch are not used by many planners and clients, even if it provides useful information to mitigate construction waste.

Bottom up or top down, this is a well-known question when thinking about implementing sustainability. There have to be used both approaches in order to speed up new treatment ways of construction waste and to avoid waste in construction design. This process is still very slow in Switzerland, so that future work should concentrate on identifying important boosters to accelerating it. On the one hand, authorities can serve as exemplars or can point out the importance of sustainability. They can be supported by an adequate legal frame and decreed laws e.g. to prohibit landfilling of certain materials. Though, as to my opinion, laws and regulations can't be the most important drivers of sustainable construction waste handling. Possibilities to bypass them are large in this industry. However, they are very important in order to give signalling effects, to start discussions on the topic and to lead waste handling in defined direction. [Lichtensteiger 2006] even suggests incorporating structures as resource users and resource donors in regional and national cadastres.

Today, the awareness for sustainable construction waste handling and sustainable construction is very low among planners, clients and other people. Like in other sectors, information about these topics should be brought to the population (don't forget that 2/3 of all investments in construction engineering are made by private awarding authorities). Ideally, this would establish a certain force on planners and raise the willingness to include life cycle costing into calculations for a new structure or in refurbishment works.
Companies do what is profitable, this is how reality works. An important instrument in this view is Life Cycle Costing – a way of looking at a product's life cycle taking into account external and extra costs, e.g. emerging for renewal of material parts. This is also what could convince private people to include sustainable considerations when planning a building. However, high costs at the beginning of a building's life can be an obstacle to include all sustainable thoughts. Financial support by the cantons (which is today already partly given) could help to mitigate this problem.

Furthermore, planners have to be reached in a much broader manner. Apparently, in Switzerland today only very few architects take construction waste handling into their considerations. Admittedly, complexity of construction materials is high and many other points have to be thought of in planning. In addition, recycling construction materials or well-separable materials are not always available in a reasonable distance. This fact was also recognised when buildings were made following the MINERGIE-ECO® guidelines: All in all, it can't always be claimed that such a building is more sustainable than another, this e.g.

using concrete from the factory 500 m away. Due to today's circumstances, it can't be consequent in sustainable thinking in the whole. But such buildings show possibilities and can therefore have a signalling effect for the future.

Furthermore, supply driven architecture[34], architecture with component modules or intelligent buildings design[35] could have a significant influence on construction waste emergence in the future.

Discussion about construction waste has two levels: Firstly, there is the construction waste emerging today and in the next few years. These are materials which were used many years ago. Intensified selective demolition could e.g. help to maximize construction waste reuse and recycling. Secondly, there is the issue of construction materials used today in order to avoid waste in future. Within this second level, there are again two time spans to consider: Construction materials incorporated for 50 to 100 years; and materials with a much shorter lifetime and renewable rate.

Financial incentives for companies can be made by the government by increasing the price for primary resources and for disposal (landfilling, incineration plant). Furthermore, resources could be brought to shortage by establishing confinements for cheap imports or by limiting gravel excavation authorisations. In spite of such possibilities, secondary resources will not be cheaper than primary resources in the short term. Acceptance for this should be build up. Only if secondary construction materials are fostered, if they are broadly accepted, and if new market areas are established, a quite fast development in resources management can be achieved.

Federalism complicates communication between the cantons and the federal government and makes execution of the laws unclear. Additionally, the four languages spoken in Switzerland can hinder a free interexchange of information between people from the industry. As a result, it should be further tried to bring together cantonal experiences and people from different (language) regions.

[34] Supply Driven Architecture is architecture in which the availability of reusable components forms an explicit factor in the design process and in the decision making of architects [Twente 2009. *Supply Driven Architecture.* Power Point Presentation, University of Twente, NL]

[35] Design which allows different uses of a building, e.g. a new set-up of the rooms after some years.

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Turkey

Contributed by:
Soofia Tahira Elias-Ozkan, BArch, MS, PhD.
Associate Professor of Architecture and Director Building Science Graduate Program, Department of Architecture, Middle East Technical University, Ankara

1. Current national statistics

Statistics related to material specific waste are not available; however, those related to waste produced by the manufacturing sector are published as overall figures. According to the Turkish Statistics Institute the industrial sector produced 20 million tons of waste in the year 2004; of this amount 8% was recycled, 47% was dumped and 45% was sold or given away free of cost.

According to the guidelines prepared by the Ministry of Environment and Forestry, C&D waste constitutes 13 to 29% of the urban solid waste by volume and by weight. This amount is produced during the construction, renovation, repairs and demolition works carried out on residential / commercial buildings, roads and bridges. The proportions of inert or active aggregate is not known, neither is the specific activity which generated the waste.

2. Benchmark Data

Material	Process	Waste %
Portland Cement	production, transportation and storage	5 to 6%
White Cement	production, transportation and storage	10%
Mosaic chips	storage and transportation	2%
Brick	storage and transportation	8 to 10%
Roof tiles	storage and transportation	3 to 4%
Steel	production and construction	10 to 11 %

Source: Ankara Chamber of Trade and Industries for 2010

3. Policies, strategies and legislation

Policies and legislation to reduce waste in general and C&D waste were finalized in 2004 to comply with the EU Directives. National targets to reduce construction waste, wastage rates, tax on waste production are not available.

The legislation for Excavation, Construction and Demolition Waste Control (Hafriyat Toprağı, İnşaat ve Yıkıntı Atıkların kontrolu) was promulgated under Directive No. 25406 on 18.03.2004. It was prepared in accordance with the Environmental Law No 4856 section 8, 11 and 12; and the legislation for the Organisation and Duties of the Ministry of Environment and Forestry (Çevre ve Orman Bakanlığı Teşkilat ve Görevleri Hakkında Kanunun) Law No. 4856, section 9, sub-sections (d), (h), (o), (p) and (s).

The aim of this legislation, consisting of 48 sections, is outline the technical and administrative issues as well as the rules and regulations to be followed in taking care of the

Excavation, Construction and Demolition waste without harming the environment through the following steps:
• reduction at source,
• collection,
• temporary accumulation,
• transportation,
• reuse, recycle, and
• appropriate disposal.

The General Principles to be adopted are:
• To minimize the waste production at source,
• To re-use or recycle the excavated soil and construction and demolition waste,
• To prevent mixing of the excavated soil and construction and demolition waste,
• To separate the waste at source and selective demolition (deconstruct)
• Waste producers are responsible for the cost of waste disposal
• Individuals, departments and organisations in charge of the waste management are responsible for taking necessary precautions.

A very comprehensive Waste Management Action Plan for the period 2008 to 2012 was prepared by the General Directorate of Environmental Management of the Ministry of Environment and Forestry and was announced in May 2008. This 295 page document was produced in compliance with the EU Directives and it covers in detail the policies and legislation; types of wastes; relevant statistics; and the waste management strategies to be adopted. The latter are enumerated in the following order of preference:

1. Prevention
2. Reduction at source
3. Reuse
4. Recycle
5. Pre-treatment (including burning)
6. Appropriate disposal.

The categories of wastes dealt with here are: domestic waste; hazardous waste; medical (hospital) waste; packaging (plastics, paper, glass and metal); waste oil and used cooking oil; and batteries and cells. However, there is no mention of strategies for C&D waste management.

4. Guidance documents/ reports linked to construction waste reduction

Guidance documents/ reports linked to construction waste reduction are available from the official website of the Ministry of Environment and Forestry:
http://www.atikyonetimi.cevreorman.gov.tr/life/klavuzlar.htm

One such document is: "C&D Waste Management (Insaat /Yikinti Atiklari Yonetimi)", which was prepared by Prof. Dr Mustafa Ozturk, Deputy Director of the Ministry of Environment and Forestry, in 2005. The guidelines set down in this document are intended to help the municipalities to reduce, reuse and recycle C&D waste.

5. Exemplars, case studies

Not available for C&D waste

References:

- Waste Management Action Plan: 2008 - 2012 (Atık Yönetimi Eylem Planı 2008-2012); by the General Directorate of Environmental Management of the Ministry of Environment and Forestry, May 2008.

- Kose, H.O., S. Ayaz & B.Koroglu, Waste Management in Türkiye: Evaluation of National Policies and Results of Implementations – Performance Inspection Report. Turkish Ministry of Audits; January 2007.

- Turkmen, U., Management of Municipal Waste and Excavation, Construction and Demolition Waste, Department of Waste Management in the General Directorate of Environmental Management of the Ministry of Environment and Forestry, Afyon Karahisar, 06 March 2010.

- Öztürk, M. C&D Waste Management (Insaat /Yikinti Ttiklari Yonetimi), Ministry of Environment and Forestry, Ankara, 2005.

- Ankara Chamber of Trade and Industry webpage for material wastage benchmarks www.atso.org.tr/download/1/fire-ve-**zayiat**-oranlari.html

- http://www.atikyonetimi.cevreorman.gov.tr/istatistikler/istatistik.htm

- http://www.atikyonetimi.cevreorman.gov.tr/sunuslar.htm
- http://www.cevreonline.com/atik2/atikyonnedir.htm
- http://www.kenttemizlik.com/index.php?s=geridonusum
- http://www.golcukhaber.com.tr/haber/kati-atik-yonetim-plani-basariyla-suruyor-1607.htm

- http://www.cevreonline.com/atik2/hafriyat.htm
- http://www.organize.com.tr/liste.asp
- http://www.canyikimcilik.com/index.php?option=com_content&task=view&id=16&Itemid=32

- http://tuikapp.tuik.gov.tr/DIESS/SiniflamaSatirListeAction.do?surumId=4&kod=37.20&ustKod=37.20&seviye=4&detay=E&turId=1&turAdi=%201.%20Faaliyet%20S%C4%B1n%C4%B1flamalar%C4%B1&satirId=1634266

- http://www.resmi-gazete.org/y%C4%B1k%C4%B1m/

- http://www.aydin-bld.gov.tr/belediyemiz/yonetmelikler/139-hir-temizlie-kattoplanmasakliyesi-depolanmas-haskk-ymelik

United Kingdom

Contributed by:
Gilli Hobbs
Director of Resource Efficiency
Building Research Establishment
Watford, UK

1. Current statistics

Waste generation in the UK has reduced overall, from around 325 million tonnes in 2004 to 288 million tonnes in 2008, as shown in Figure 1. . This represents a decrease of over 11%. Evidence of waste reduction could indicate that a key objective of decoupling waste production from economic growth is being progressed. Although the economic downturn may have influenced the 2008 figures, the 2006 figures were also showing an overall reduction and this was a period or economic growth. The figures for 2010 are due to be published in July 2012.

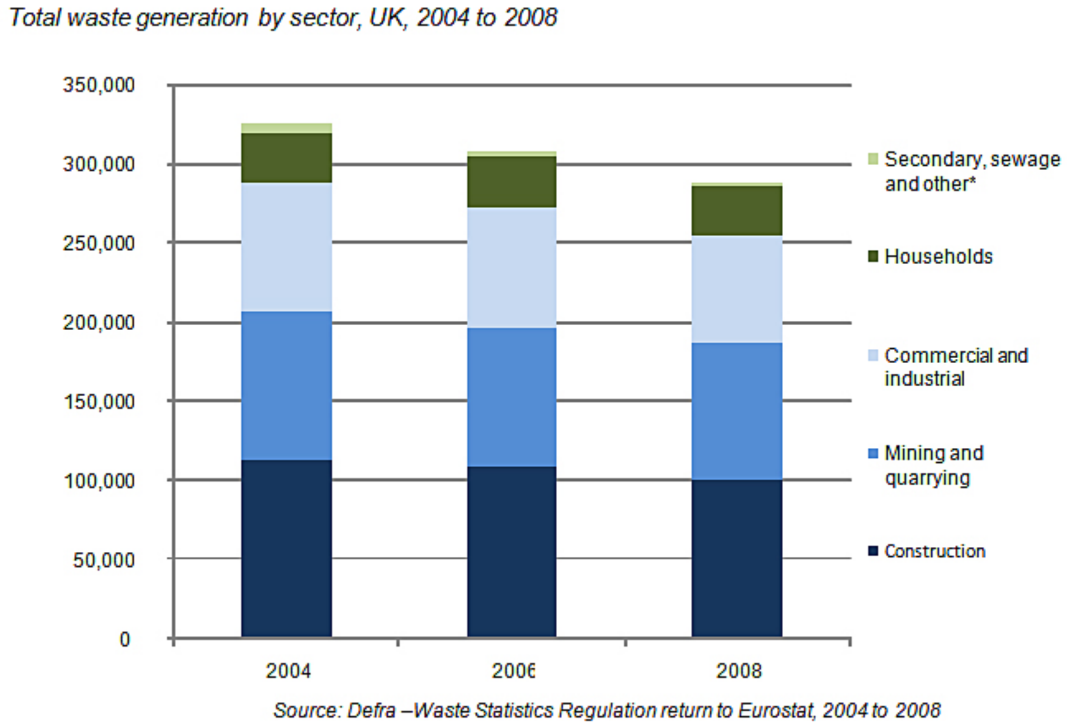

Figure 1: Overall waste arising in the UK 2004-2008.

Construction still represents the largest contributing sector to waste generation in the UK, at 101 million tonnes in 2008, closely followed by mining & quarrying waste at 86 million tonnes. Since much of the mining and quarrying is linked to the production of construction products and materials, such as sand and aggregates, it can be seen that the impact of construction activities in the production of waste in the UK is very significant compared to any other industry or household waste.

However, the focus of waste policy in the UK is not especially targeted at construction related waste, largely because the amount of construction waste being landfilled has reduced greatly over the last few years.

Figure 2 illustrates this shift towards recycling most construction waste. Between 1999 and 2008 the proportion of construction and demolition waste recycled increased from 35 per cent to 61 per cent.

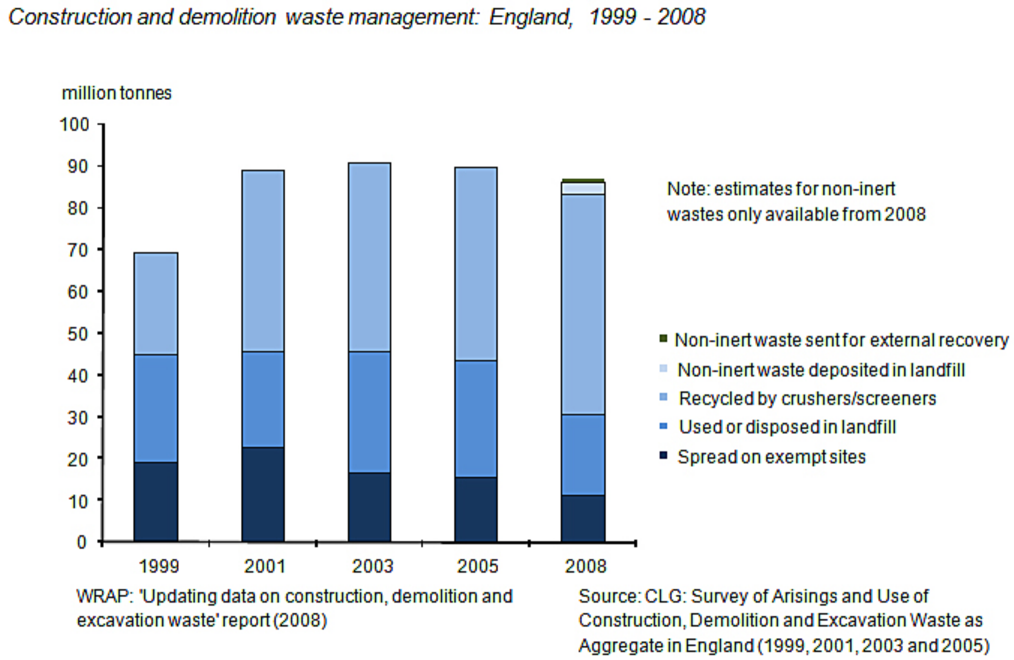

Figure 2: Construction and Demolition waste management (England only) 1999-2008.

Since 2008, it has been important to have better data in relation to the amount of construction, demolition & excavation (CD&E) waste being landfilled. This is mainly due to the national target in place to halve the amount of CD&E waste being landfilled in 2012 compared to 2008. Therefore an industry and government stakeholder group, called the Sustainable Construction Task Group – waste sub group, have developed a methodology to consistently measure against this target in absolute terms and relative to construction activity. To date, figures for 2008 and 2009 have been developed, as summarised below:

2008
Absolute: Amount of CD&E waste landfilled – 12.55 million tonnes
Relative: 133 tonnes of CD&E waste landfilled per £ million construction output

2009
Absolute: Amount of CD&E waste landfilled - 9.69 million tonnes (a decrease of 23%)
Relative: 116 tonnes of CD&E waste landfilled per £ million construction output (a decrease of 13%)

It should be noted that a large amount of inert material is needed to restore old quarries and provide engineering material to construct and maintain landfill sites during operation, such as daily cover material. Construction related waste is used for these applications in preference to

[36] CD&E Waste: The 2008 baseline of CD&E waste to landfill in England. Prepared by Katherine Adams on behalf of the Strategic Forum. 2009 data from unpublished report.

importing new materials. Accordingly, this material is not considered to have been disposed of at landfill as it has a beneficial use.

Looking forward, national statistics are likely to be linked to the EU target, as defined in the revised Waste Framework Directive, of a minimum 70% recycling of construction and demolition waste by 2020.

2. Benchmark Data

The benchmarks shown in this report are derived from data from completed projects on the SMARTWaste Plan[37]. This is a web-based tool developed to ensure compliance with Site Waste Management Plan Regulations 2008.

The benchmarks are based on completed ***new build*** construction projects. The benchmarks are also based on the construction phase only and do not include demolition, excavation or groundworks waste, i.e. waste entered on SMARTWaste Plan that arises from groundworks or excavation and all soil waste has been excluded. Benchmarks for refurbishment and demolition projects will be developed in the future as more of these projects are completed.

Data obtained from completed projects was subject to a number of logical and statistical tests, to ensure that the data used to produce the key performance indicators (KPI) is valid.

For projects that passed these logical tests, a count of the number of plausible results, the average, standard deviation and median of the results was obtained.

The benchmarks shown in this report are as follows:

- Table 1 shows the average m^3 of waste per $100m^2$ of floor area and the average m^3 of waste per £100K of project value for different project types. The number of projects used to calculate the benchmarks is also shown.
- Table 2 shows the average tonnes of waste per $100m^2$ of floor area and the average tonnes of waste per £100K of project value for different project types. The number of projects used to calculate the benchmarks is also shown.

[37] www.smartwaste.co.uk

Table 1: Waste Benchmark Data by Project Type

(New Build Only, Volume projects, Projects completed by end May 2011)

Project Type	Number of projects data relates to	Average $m^3/100m^2$	Number of projects data relates to	Average m^3/£100K
Residential	441	19.7	429	12.5
Public Buildings	38	25.4	42	11.5
Leisure	54	19.0	51	11.7
Industrial Buildings	35	16.3	36	11.4
Healthcare	77	17.2	74	10.1
Education	242	23.1	247	11.2
Commercial Other	8	12.5	7	10.0
Commercial Offices	45	20.9	43	10.1
Commercial Retail	123	22.1	126	18.1
Total number of projects	**1063**		**1055**	

Table 2: Waste Benchmark Data by Project Type

(New Build Only, Tonnage projects, Projects completed by end May 2011)

Project Type	Number of projects data relates to	Average Tonnes/$100m^2$	Number of projects data relates to	Average Tonnes/£100K
Residential	146	27.0	145	13.7
Public Buildings	22	29.0	22	13.8
Leisure	9	26.8	8	3.1
Industrial Buildings	15	14.3	16	16.1
Healthcare	20	16.1	18	11.2
Education	62	35.3	64	18.2
Commercial Other	2	8.9	2	5.7
Commercial Offices	13	17.9	12	7.5
Commercial Retail	71	36.3	72	15.5
Total number of projects	**360**		**299**	

Benchmarks are also produced related to different categories of waste, as illustrated in Table 3.

Table 3: Waste Benchmark Data - $m^3/100m^2$ by product for different project types (New Build Only, Volume projects, Projects completed by end May 2011)

Description	Commercial Retail	Residential
Bricks	0.763	1.698
Tiles and Ceramics	0.122	0.169
Concrete	1.69	1.487
Inert	1.281	3.235
Insulation	0.366	0.63
Metals	1.171	0.357
Packaging	1.426	1.85
Gypsum	0.74	1.387
Binders	0.107	0.102
Plastics	0.389	0.717
Timber	1.85	2.8
Floor coverings (soft)	0.057	0.049
Electrical and electronic equipment	0.064	0.056
Furniture	0.13	0.024
Canteen/office/adhoc	0.615	0.591
Liquids	0.1	0.021
Oils	0	0.001
Asphalt and tar	0.074	0.193
Hazardous	0.13	0.379
Other	0.837	0.513
Mixed	10.226	3.487
Total	**22.14**	**19.74**

These benchmarks are usefully applied in many ways, such as:

- Setting targets for waste reduction and monitoring progress
- Measuring and improving environmental performance of a building, such as credits for waste reduction within overall sustainable building standards
- Prioritising waste reduction actions linked to particular construction type and product groups
- Predicting the amount of waste likely to arise during construction, for example as required under Site Waste Planning Regulations 2008.
- Modelling waste arisings on a local, regional or national level to ensure appropriate and sufficient facilities exist to recover waste materials.

3. Policies, strategies and legislation

Policy and regulatory changes, alongside multiple ongoing consultations, have also been changing the framework against which resource efficiency improvements are set. Some of the key developments that are influencing resource efficiency, or could do so in the future, include:

1. Escalating landfill tax. From April 2011, this stood at £56/tonne for active waste. It will continue to escalate each year by £8/tonne until at least 2014 when the rate will be £80/tonne. Landfill tax has been extremely effective at diverting waste away from landfill into increasing recycling and recovery routes. As the rate increases, so does the financial viability of sorting, collecting, transporting and processing for reuse, recycling and other recovery.

2. Environmental Permitting[38] came into force April 2010, and those who required a waste management license previously should have transferred over to the single, simplified permitting regime. The point at which a waste 'handling' activity requires an Environmental Permit was also changed. These are called 'exemptions'[39] and were widely used in tandem with the old waste management licensing system by the construction sector. The new exemptions can still be used by the construction sector to carry out reuse, recycling and use of recycled materials, though the maximum amounts that can be processed using an exemption have decreased considerably for some areas; typically where old exemptions have been abused in the past.

3. The Environment Agency & WRAP Quality protocol project[40] has looked at, over the last few years, a variety of waste materials. The project establishes if and how a waste can be fully recovered and turned into one or more alternative, quality products. This then constitutes 'end-of-waste- criteria, as defined in the revised Waste Framework Directive 2008. The materials for which protocols are developed or underway includes flat glass, aggregates from inert waste, and gypsum from plasterboard.

4. Site Waste Management Plans came into force in England, April 2008 for projects exceeding £300k in value. They have had a significant impact in raising awareness of waste generated by the construction process, particularly in the period before construction starts where the amounts, types and destination of wastes have to be predicted and written down. Many in the contracting sector have gone far beyond legal compliance and are thus benefiting from improvements in resource efficiency.

5. The Code for Sustainable Homes (CSH) is an environmental assessment method for rating and certifying the performance of new homes. It is a national standard for use in the design and construction of new homes with a view to encouraging continuous improvement in sustainable home building. The Code became operational in April 2007 in England, and having a Code rating for new build homes mandatory, from 1st May 2008. This mandatory requirement came into effect for all developments where a local

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[38] The Environmental Permitting (England and Wales) Regulations 2007 & The Environmental Permitting (England and Wales) Regulations 2010.

[39] Detailed guidance on all new exemptions can be downloaded from www.environment-agency.gov.uk/business/topics/permitting/32322.aspx (apart from those regulated by local authorities)

[40] Download documents and monitor progress at www.environment-agency.gov.uk/business/topics/waste/32154.aspx

authority received the building notice, initial notice or full plans application after 1st May 2008. By end 2010, all new homes in England had to be a minimum of Code Level 3.

The credit for construction site waste management is known as WAS 2. Currently there are additional credits that can be achieved for demonstrating waste reduction and diversion of waste from landfill.

The Strategy for Sustainable Construction[41] was published 2008. This joint industry & government strategy provided a foundation for much of the work undertaken. There were a number of actions and deliverables specified, in this strategy, to contribute to an overarching target of halving waste to landfill (see Table 4).

Table 4 summary of targets and actions relevant to the construction sector:

Actions & Deliverables	**Timescale & progress**
Construction Waste Commitment: individual organisations commit to waste to landfill targets at company level.	*Formal Launch in September 2008, then ongoing* Progress: over 500 signed up by 2011, reporting portal established and link from SMARTWaste Plan in place.
Develop guidance on waste reduction for small builders.	*By 2009* Progress: Guidance produced and on WRAP's website. 'Reducing your construction waste Guidance for small and medium sized contractors'
Sector resource efficiency plans prepared and implemented by trade associations.	*Three begun by end 2008* Progress: Actions plans/ resource efficiency plans completed for the construction sector as a whole, flooring, joinery and pallets Insulation action plan underway.
Setting an overall target of diversion of demolition waste from landfill.	*By 2009* Progress: NFDC Action Plan and Target for Demolition waste published March 2010.
Extension of Plasterboard Voluntary Agreement to rest of the supply chain.	*By 2009* Progress: Plasterboard Sustainability Partnership formed Agreements completed for contractors 2008, included in NFDC demolition action plan 2010, in draft form for end-of-life/recycling.
20% reduction in construction packaging waste.	*By 2012* Progress: Packaging Action Plan nearing completion (Summer 2011)
Pilot product roadmaps to assess impacts of products across the full product lifecycle, to identify and prioritise any particular problems and solutions for improving sustainability.	Progress: Sustainability Action plans for windows and plasterboard completed in 2010

As it can be seen from this table, there has been a great deal of work undertaken linked to voluntary agreement, as industry Action Plans. This reflects the recent policy drive to move away from regulation, where appropriate, towards more voluntary agreements that are signed up to be the relevant industry organisations. The recent review of waste policy in England[42] recognises the industry led improvements in the construction sector and refers to the

[41] Strategy for Sustainable Construction. HM Govt & Strategic Forum for Construction June 2008
[42] Government Review of Waste Policy in England 2011

Sustainable Construction Task Group Action Plan[43] as highlighting where further actions need to be made.

6. Guidance documents and tools

Designing Out Waste: A Design Team Guide For Buildings
This document provides information on the key principles that designers can use during the design process and how these principles can be applied to projects to maximise opportunities to Design out Waste. The concepts and information presented apply to all professionals who partake in the design process including construction clients, architects, engineers, design teams and contractors. This guidance should be read in conjunction with other WRAP (Waste & Resources Action Programme) documents relating to efficient use of materials in construction.
http://www.wrap.org.uk/downloads/19279-02_Design_Guide_online_pdf_version.89ea2330.7167.pdf

The WRAP Net Waste Tool calculates the waste arising on a construction project, shows how to improve recycled content and quantifies the overall Net Waste for the project.

WRAP also produced RIBA accredited CPD literature[44] relating to designing out waste, to be used in conjunction with their Designing Out Waste Tool, in 2009/10. Associated training and workshops have also been developed. This work has led to the development of five key principles that design teams can use during the design process to reduce waste:
Design for Reuse and Recovery;
Design for Off Site Construction;
Design for Materials Optimisation;
Design for Waste Efficient Procurement; and
Design for Deconstruction and Flexibility.

Lastly, WRAP has produced web-based guidance on Waste Minimisation, Waste Management, Recycled Content and Regeneration[45]. By selecting the appropriate button according to activity and role, a user is able to discover the opportunities available.

True Cost of Waste Calculator[46]
This web-based tool provides a fuller cost of waste, environmentally and financially. The environmental cost includes the embodied carbon of the products and materials that have been wasted, along with the impacts associated with disposal or recycling, such as transport impacts. The true financial costs include the cost of the product or material being wasted, along with the cost of labour to handle the waste and cost of disposal or recycling. The objective of this tool is to highlight the true cost of waste, against which benefits of waste reduction can be compared. This provides a significantly more compelling business case and accurate assessment of environment benefit compared to considering waste disposal costs and impacts alone.

[43] www.strategicforum.org.uk/waste.shtml. An Action Plan for halving construction, demolition and excavation waste going to landfill, June 2011.
[44] Designing Out Waste: A Design Team Guide and Designing out Waste tool. WRAP 2010
[45] www.wrap.org.uk/construction/tools_and_guidance/achieving_resource_efficiency/index.html
[46] www.wastecalculator.co.uk

Category	Tonnes			Cost of waste (£)				
	Total Material Quantity	Wasted Material Quantity	Wastage rate Embodied Carbon	Material Cost	Wasted material cost	Labour cost	True Cost of mixed waste 40% void	True Cost of segregated waste 40% void
Bricks	-	-	-	-	-	-	-	-
Tiles and Ceramics	1	0	0.1	1,744	140	1	142	141
Concrete	16	1	0.3	7,613	381	10	402	395
Inert	-	-	-	-	-	-	-	-
Insulation	2	0	0.1	1,217	64	69	218	-
Metals	0	0	0	0	0	0	0	0
Gypsum	1	0	0	148	11	2	16	-
Binders	-	-	-	-	-	-	-	-
Plastics	-	-	-	-	-	-	-	-
Floor coverings (soft)	-	-	-	-	-	-	-	-
Asphalt and tar	-	-	-	-	-	-	-	-
Total:	20	1	0.5	10,722	596	83	779	683

BREEAM[47]

BREEAM is the world's foremost environmental assessment method and rating system for buildings, with 200,000 buildings with certified BREEAM assessment ratings and over a million registered for assessment since it was first launched in 1990.

BREEAM sets the standard for best practice in sustainable building design, construction and operation and has become one of the most comprehensive and widely recognised measures of a building's environmental performance. The measures used represent a broad range of categories and criteria from energy to ecology. They include aspects related to energy and water use, the internal environment (health and well-being), pollution, transport, materials, waste, ecology and management processes.

The data obtained from SMARTWaste projects has been used to develop waste reduction credits in BREEAM. In the latest version (2011), up to three credits are available when non-hazardous construction waste (excluding demolition and excavation waste) meets or exceeds the following resource efficiency benchmarks:

BREEAM credits	Amount of waste generated per 100m2 (gross internal floor area)	
	m3	**tonnes**
One credit	≤13.3	≤11.1
Two credits	≤7.5	≤6.5
Three credits	≤3.4	≤3.2
Exemplary Level	≤1.6	≤1.9

Only one credit is available for diversion of waste from landfill, thus reflecting waste reduction as having the higher priority.

47 www.breeam.org

BeAware
The Technology Strategy Board part funded Be Aware[48] project published its findings in 2009. Led by BRE and the Construction Products Association, with 14 other partners, the project's aim was to reduce resource use for any given construction product across its life cycle. The approach of getting all the relevant stakeholders in the supply chain together to focus on improving resource efficiency for a product group was a key output from this project, leading the way for the resource efficiency plans, as summarised above.

7. Exemplars, case studies

Kier Group – Plasterboard waste reduction:
Kier adopted several strategies at the Ipswich Hospital, Suffolk development[49]. These included using the design expertise of their dry-lining installer and supplier Knauf Drywall, reducing the number of layers of plasterboard required and limiting the types of board needed to three. Rationalising the number of board types simplified installation for the dry lining teams, reducing the scope for error and therefore wastage. Drawings were also colour coded to assist the dry lining teams. Also, a board was manufactured to specifically match the 3 m room height, eliminating a horizontal joint below the ceiling.

WRAP have produced a number of case studies focussed on waste reduction, these include:

- Designing out waste on a school project[50]. Here the top waste saving opportunities were 1) off site pre-engineering of walls using a cross-laminated timber system, and 2) avoiding the use of paint by leaving structural elements as finishes.
- Assessing the costs and benefits of reducing waste in construction trade packages[51]. Significant savings were highlighted through targeting good practice wastage rates for the components offering the biggest savings in the value of materials wasted.
- Assessing the costs and benefits of reducing waste in Refurbishment of a small retail unit[52]. This concludes that whoever takes the risk for the supply of materials will get the cost savings. This is normally the trade contractor, or the main contractor for bulk products such as aggregates. The extent of waste is rarely reconciled with the original order, meaning that trade contractors often do not know how much waste is costing. To convert this reduction in waste into a reduction in price (for the contractor or client), the trade contractor will need to 1) include a reduced wastage rate in their tender (for more competitive pricing on a lump sum tender); or 2) procure less materials, therefore save money, and share this up the supply chain (open book tender).

[48] Download sector reports on Modern Methods of Construction, Polymers, Precast Concrete and Timber Windows from www.bre.co.uk/page.jsp?id=707
[49] Kier Green Apple Awards 2007 Plasterboard or Plasterbarred?
[50] www.wrap.org.uk/downloads/Holy_Trinity_School_design_case_study_-_AG.0f036048.9691.pdf

[51] www.wrap.org.uk/downloads/Brick_block_trade_package_CBA.53ecadac.7003.pdf
[52] www.wrap.org.uk/downloads/Small_retail_refurb_CBA.f3c91a8f.7009.pdf

United States of America

Contributed by:
Abdol Chini and Nippun Goyal
Rinker School of Building Construction
University of Florida
Gainesville, Florida

1. Current National Statistics

Each year, the construction industry contributes a large amount of waste to the municipal solid waste stream (MSW). Quantifying this annual waste production is an inexact science. The most thorough attempt to estimate the total tonnage of Construction and Demolition (C&D) waste was made by Franklin Associates in 1998 when they published their report for the Environmental Protection Agency (EPA). This report provided a reasonable estimate of tonnage of C&D waste generated by residential and non-residential demolition, renovation and construction for the year 1996 (Franklin, 1998). Chini and Bruening estimated the tons of C&D waste produced during the year 2000 by utilizing the U.S. Census information for the year 2000 combined with research statistics taken directly from the Franklin Associates Report (Chini and Bruening, 2005). EPA updated the report for the 2003 C&D waste statistics and published it in 2009 (EPA, 2009).

Tables 1-3 show the total C&D waste generated for the year 1996, 2000, and 2003, respectively, and Figures 1-3 are graphical representation of residential, non-residential and total wastes generated in these years.

Table 1 Estimated C&D waste generation, 1996 (million metric ton) **- (***Franklin, 1998)*

	Residential		**Non-residential**		**Totals**	
	Million Metric tons	**Percent**	**Million Metric tons**	**Percent**	**Million Metric tons**	**Percent**
Construction	5.8	11%	3.81	6%	9.79	8%
Renovation	28.93	55%	25.40	36%	54.34	44%
Demolition	17.87	34%	40.91	58%	58.78	48%
Totals	52.79	100%	70.21	100%	**122.92**	100%
Percent	43%		57%		100%	

Table 2 Estimated C&D waste generation, 2000 (million metric ton) - (Chini and Bruening, 2005)

	Residential		**Non-residential**		**Totals**	
	Million Metric tons	**Percent**	**Million Metric tons**	**Percent**	**Million Metric tons**	**Percent**
Construction	8.79	14%	5.99	7%	14.79	10%
Renovation	34.50	56%	30.19	37%	64.69	45%
Demolition	17.89	30%	45.89	56%	63.79	45%
Totals	61.19	100%	82.10	100%	**143.24**	100%

Percent	43%		57%		100%	

Table 3 Estimated C&D waste generation, 2003 (million metric ton)- (EPA, 2009)

	Residential		**Non-residential**		**Totals**	
	Million Metric tons	**Percent**	**Million Metric tons**	**Percent**	**Million Metric tons**	**Percent**
Construction	9.07	15%	4.53	5%	13.60	9%
Renovation	34.47	57%	29.93	32%	64.41	42%
Demolition	17.23	28%	58.96	63%	76.20	49%
Totals	60.78	100%	93.44	100%	**154.22**	100%
Percent	39%		61%		100%	

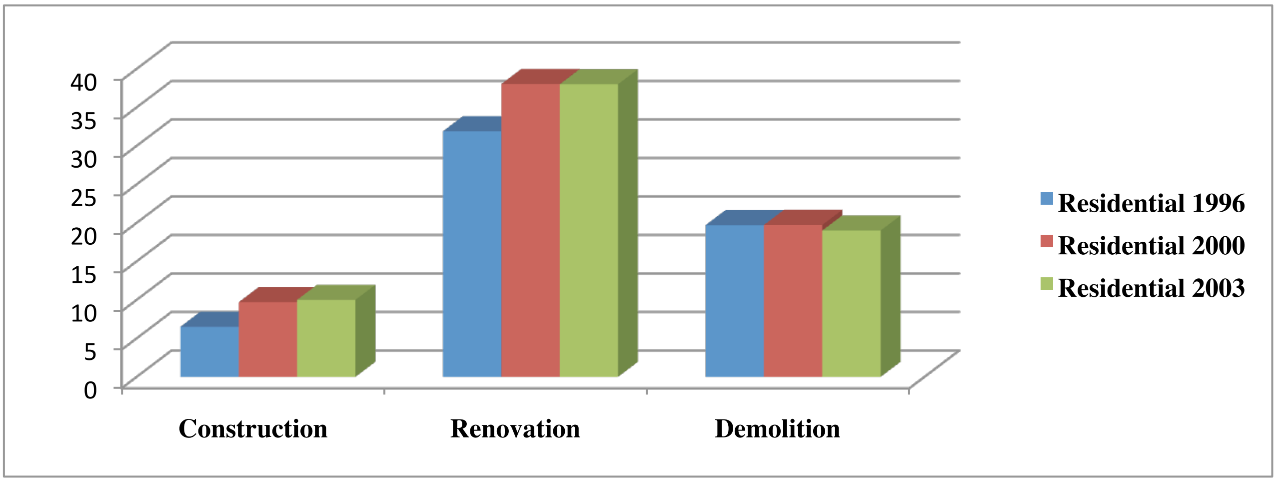


Figure 1 Residential C&D waste in MMT (1996 vs 2000 vs 2003)

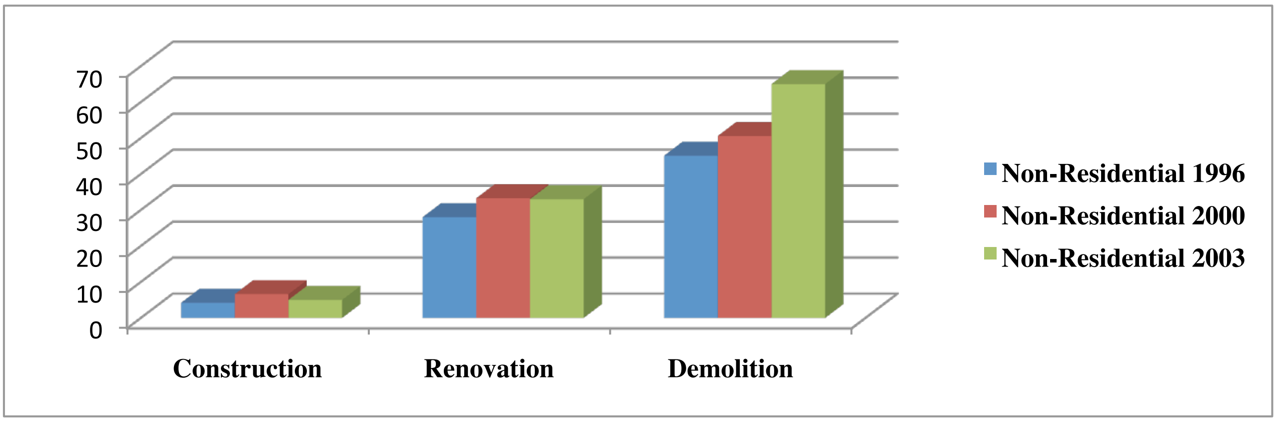


Figure 2 Non-residential C&D waste in MMT (1996 vs 2000 vs 2003)

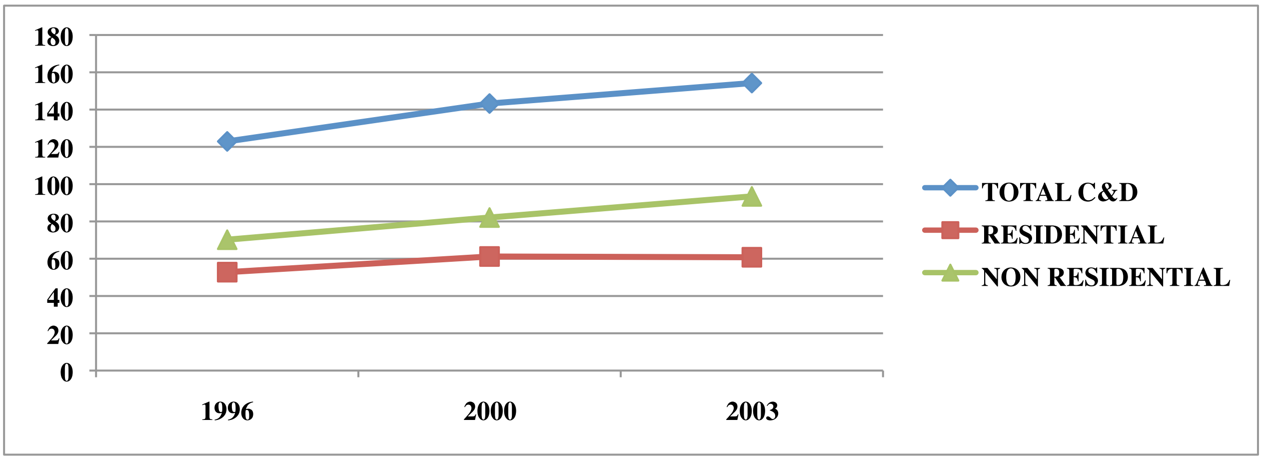


Figure 3 Total C&D generated in USA in last decade, MMT

Franklin Associate data shown above assumes a value for C&D waste generated per unit area of buildings and uses that value to calculate the total C&D waste generation based on the annual volume of construction. The report uses 21.5 Kg/m^2 of waste generation for residential and 19.5 Kg/m^2 for non-residential construction in their calculations. These numbers coincide with other reports that a 187 m^2 house produces 3,630 Kg of debris. Demolition wastes were estimated based on 550 Kg/m^2 for residential and 850 Kg/m^2 for non-residential buildings. These numbers will be used later in this report to establish benchmarks for better, good and standard practices for waste generation on a site depending on Residential or Non- Residential building.

A different approach is to calculate the total C&D waste based on population. Table 4 shows the waste collected from various landfills throughout U.S. The collected data has been divided into three categories: a) C&D disposed (excluding recycled materials, b) C&D generated (including recycled materials), and c) C&D generated as a percentage of total MSW (30%). Based on the population of a region and the waste generated, one can find the waste per capita per day using the following formula:

$$\text{Waste in Kilogram per capita per day} = \frac{\text{Waste in MMT x 1000}}{\text{Population x 365}}$$

As illustrated in Table 4, the C&D waste generation rate per capita per day ranges from 0.64 to 1.46 kilograms. Considering a recycling rate of 25% the average generation rate for the first category may be estimated to be: 0.90 / 0.75 = 1.20 kg per capita.

Overall average per capita per day may be calculated as follows:

(1.20 + 1.02 + 0.99) / 3 = 1.07 Kg per capita per day

Using the average per capita rate of 1.07 kilograms and U.S. population the total waste generated in each particular year can be calculated:

1. Total waste generated in 1996
   Population of U.S. in 1996 – 266,490,000
   Total C&D Waste generated in 1996 **= 104.08 MMT**

2. Total waste generated in 2000
   Population of U.S. in 2000 – 281,421,906
   Total C&D Waste generated in 2000 **= 109.90 MMT**

3. Total waste generated in 2003
   Population of U.S. in 2004 – 294,043,000
   Total C&D Waste generated in 2004 **= 114.84 MMT**

4. Total waste generated in 2010
   Population of U.S. in 2010 – 308,400,408
   Total C&D Waste generated in 2008 = **120.45 MMT**

Estimated total C&D waste generation in 1996, 2000, and 2003 using per capita method above are between 15 to 25% less than C&D waste calculated based on annual volume of building construction used by Franklin and Associates. It is important to note that the per capita method is not directly influenced by volume of construction in any year.

Table 4 Waste generated per capita per day based on collected landfill data

REGION	**C&D WASTE (MMT)**	**POPULATION**	**YEAR**	**PER CAPITA (Kg)**
C&D Waste (excl. recycled)				
Massachusetts	1,977,000	6,467,915	2007	0.84
Vermont	192,750	621,270	2008	0.85
Wisconsin	1,364,053	5,364,000	2001	0.70
Delaware	453,946	853,476	2006	1.46
California	8,732,074	35,484,453	2003	0.67
AVERAGE	**12,719,823**	**48,791,114**		**0.90**
C&D Waste (incl. recycled)				
Florida	3,750,000	16,047,246	2000	0.64
King County, WA	774,000	1,750,000	2001	1.21
New Hampshire	388,073	1,314,895	2006	0.81
Chicago	1,484,610	2,853,114	2007	1.43
AVERAGE	**6,396,683**	**21,965,255**		**1.02**
C&D Waste (30% of MSW)				
New York	9,000,000	18,755,900	1998	1.31
Pennsylvania	2,820,000	12,245,672	1998	0.63
New Jersey	2,340,000	8,287,419	1998	0.77
Ohio	3,600,000	11,311,536	1998	0.87
New Hampshire	390,000	1,205,940	1998	0.89
Maryland	1,950,000	5,204,464	1998	1.03
Virginia	3,600,000	6,900,918	1998	1.43
AVERAGE	**23,700,000**	**63,911,849**		**0.99**

2. Benchmark

Based on the data from various sources throughout U.S. summarized in previous section one can establish benchmarks for better, good and current practices for waste generation on a site for residential or non-residential buildings. Again, two approaches have been recommended, one based on waste per unit area of building under construction or demolition and the other based on weight per capita per year. The Franklin and Associates data of 21.5 Kg/m^2 of waste generation for residential and 19.5 Kg/m^2 for non-residential construction were used as current practice waste per unit area of building. Similarly for demolitions waste the Franklin and Associates estimate of 550 Kg/m^2 for residential and 850 Kg/m^2 for non-residential buildings were adopted as current practices. Reducing the current practice numbers by 25% is considered to be a good practice and any waste reduction beyond that is a better practice.

Benchmark for the second approach is based on weight per capita per year. The average per capita rate of 1.07 Kg per day or 390 Kg per year is used as the current practice. Reducing the current practice rate by 25% is considered to be a good practice and any waste reduction beyond 25% is a good practice. Tables 5 and 6 show these benchmarks. The second approach will give large communities such as counties and local municipalities a more practical number to compare with as it applies to the total population of a particular county or state.

Table 5 Benchmarks of Kg/m^2 for current, good and better practices

		BETTER PRACTICE	GOOD PRACTICE	CURRENT PRACTICE
RESIDENTIAL	Construction	< 16	16-21	22
	Demolition	< 410	410-540	550
NON- RESIDENTIAL	Construction	< 15	15-19	20
	Demolition	< 640	640-840	850

Table 6 Benchmarks of Kg per Capita per year for current, good and better practices

	BETTER PRACTICE	GOOD PRACTICE	CURRENT PRACTICE
C&D WASTE PER CAPITA PER YEAR	< 290	290 - 380	390

3. Policies, Strategies and Legislation

<u>Policies</u>

Although the federal government has largely avoided any effort to set construction and demolition waste recycling rate targets, many states and smaller jurisdictions have active programs that encourage construction and demolition waste recycling.

1. In Portland, Oregon the city requires job-site recycling of rubble (concrete/asphalt), land-clearing debris, corrugated cardboard, metals and wood on all construction and demolition projects with a permit value exceeding $50,000. This is accomplished by requiring a complete site plan prior to permit issuance.

(SOURCE: http://www.portlandonline.com/bps/index.cfm?c=41683&a=110862, VISITED ON 09/28/2009)

2. "In the state of Massachusetts, MASSDEP (Massachusetts Department of Environmental Protection) amended 310 CMR 19.017 to add asphalt pavement, brick, concrete, metal and wood to the list of items prohibited from disposal, transfer for disposal, or contracting for disposal. The disposal bans on these materials were effective July 1, 2006".

   (SOURCE: http://www.mass.gov/dep/recycle/solid/wastebans.htm, VISITED ON 09/10/2009)

3. In California, recycling facilities that accept more than 158 metric tons per day C&D waste are required to recycle at least 60% of their loads in order to obtain a solid waste permit. Increased regulation can cause C&D tipping fees to rise, which can result in increased C&D recycling.

   (SOURCE: http://www.hgac.com/community/waste/management/construction/documents/C_and_D_Report.pdf, VISITED ON 10/12/2009)

4. In 1999 city of Atherton in California passed an ordinance that requires all construction, renovation and demolition projects to divert fifty percent of waste from landfills. Within the city, all buildings slated for demolition are made available for deconstruction.

   (SOURCE: http://www.ciwmb.ca.gov/lglibrary/innovations/CnDRecycle/Planning.htm , VISITED ON 09/12/2009)

5. Deposits-

- In the town of Atherton in California permits for construction or demolition require a deposit of $50 per ton of waste to be generated. This deposit will be refunded once the job and related resource recovery are complete.
- Similarly in San Jose, California, demolition contractors must pay a deposit based on the square footage of their project in order to receive a city building permit. The deposit is refunded if the contractor can demonstrate that the C&D waste was taken to a city-certified recovery facility.
- In the city of Cotati in California, a $200 deposit is required that will be refunded after proof of reuse, recycling, or attempts thereof. According to the Alameda County Waste Management Authority (ACWMA) model ordinance, a deposit of the lesser of 3 percent of total project cost or $10,000 is required.

  (SOURCE: http://www.ciwmb.ca.gov/lglibrary/innovations/CnDRecycle/Planning.htm , VISITED ON 09/10/2009)

6. "In Ohio, a state law prohibits local governments from including C&D debris and other non-MSW in solid waste franchises"

   (SOURCE: http://www.recyclecddebris.com/rCDd/Handbook, VISITED ON 10/08/2009).

7. In Florida, 75 % recycling goals is established for all counties by 2020, and a certain amount of C&D waste is allowed to count toward those goals.

   (SOURCE: http://www.dep.state.fl.us/waste/recyclinggoal75/default.htm)

8. In Orange County, North Caroline, an ordinance was passed in 2002 which requires the recycling of specific materials along with plans for an additional C&D landfill. In

addition, people requesting building permits are required to apply for a "Recyclable Material Permit" that requires the permit holder to state what types of waste they anticipate generating and how they will manage that C&D waste.
(SOURCE: http://www.fac.unc.edu/OWRRGuidelines/Forms/RMPermitApplication.pdf, VISITED ON 09/17/2009)

9. "The town of Los Altos Hills, California recently eased the permitting process for deconstruction projects. When a deconstruction contract is attached to the permit application, permit fees are waived. Moreover the new building plans move to the front of the approval queue".
(SOURCE: http://www.uic.edu/depts/ovcr/iesp/research/deltareport.pdf, VISITED ON 09/17/2009)

10. In Illinois, *Illinois Sustainable Technology Center* provides a guide entitled, "Illinois Construction and Demolition Debris Reuse/Recycling Options and Contacts," which help builders find viable sources for recycling construction waste, establish job-site recycling programs, and identify waste recycling firms that offer unique construction contracts.
(SOURCE: http://www.uic.edu/depts/ovcr/iesp/research/deltareport.pdf, VISITED ON 09/18/2009)

Strategies

In order to reach to the range of 290 to 380 Kg per capita per year (good practice) there are various steps which should be taken by both the states and the local governments. Some of these steps have already been implemented in few regions.

1. There should be a mandatory recycling policy of selected materials when the cost of project exceeds certain value. For example: In Chicago, a construction and demolition ordinance was passed by the City Council in 2005, which states that projects subject to this law "shall be required to recycle or reuse construction or demolition debris produced on site as part of construction or demolition activities".
(SOURCE: http://www.uic.edu/depts/ovcr/iesp/research/deltareport.pdf, VISITED ON 10/08/2009)

2. A waste management plan should be submitted which indicates the estimated volume or weight of C&D waste to be generated on the project along with the maximum volume or weight of such materials that can feasibly be diverted via reuse or recycling.

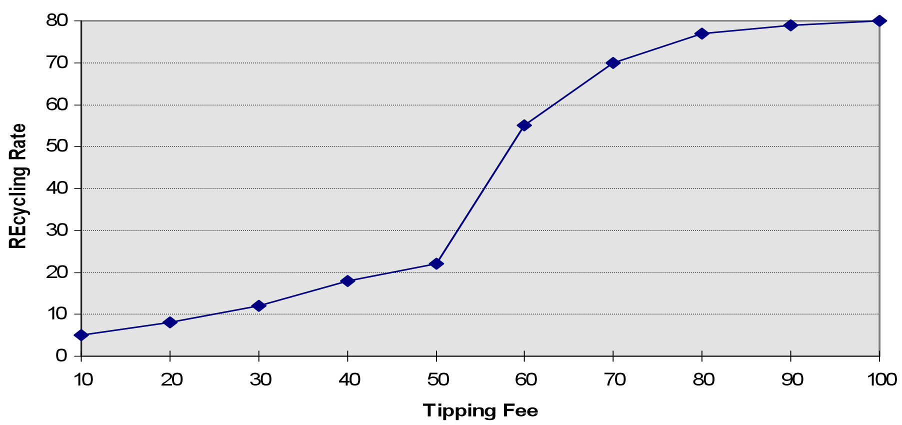
3. Deconstruction Permitting should be offered that allows for the additional time that deconstruction requires and reduces fees relative to those charged for demolition permits. Permit fees could be calibrated to the amount of materials recovered.
(SOURCE: http://www.uic.edu/depts/ovcr/iesp/research/deltareport.pdf, VISITED ON 10/08/2009)

4. Tax incentives should be provided to businesses that recycle.

5. Use of standard dimensions in the building design will help reduce on-site C&D waste.
(SOURCE: http://www.recyclecddebris.com/rCDd/Handbook, 10/08/2009)

6. Increase the tipping fee for disposal of C&D waste would encourage recycling and reuse. The following figure shows recycling rate (in percentage) as a function of tipping fee (in dollar/ton).

Tipping Fees vs. Recycling Rates



7. The Sustainable Development Policy could require one or more activities related to deconstruction or reuse, much in the same way that it currently requires a green roof for certain projects.
(SOURCE: http://www.uic.edu/depts/ovcr/iesp/research/deltareport.pdf, VISITED ON 10/08/2009)

8. More Green Building programs should be implemented and more points should be offered under Green Permitting/Green Building programs for deconstruction and reuse.

9. Decriminalize the salvaging of building materials from demolition sites and maintain an open market for C&D waste material.

10. Support reuse centers by providing below market rents on publicly owned warehouse space or selling public space to reuse stores for below-market value. These entities could also publicize the work of reuse centers (for example, distributing information about them at mortgage closings).

11. "State or federal tax credits could be offered for donation of building materials resulting from deconstruction in order to address the lack of a financial incentive for tax-exempt building owners – who are not eligible for the tax deduction for donated materials – to deconstruct their buildings. Secondary markets for tax credits exist so that recipients who do not pay income taxes, such as non-profits, can sell them to investors who could benefit from the credit. As an example, a Chicago company that manufactures rooftop solar systems has set up a process for transferring tax credits for tax-exempt buyers of solar systems to investors who can make use of the credit".
(SOURCE: http://www.uic.edu/depts/ovcr/iesp/research/deltareport.pdf, VISITED ON 10/08/2009)

12. Increase awareness of deconstruction techniques by carrying out training and Internet web sites that advertise the organizations and businesses involved in building material recovery and reuse.
(SOURCE: http://www.uic.edu/depts/ovcr/iesp/research/deltareport.pdf, VISITED ON 10/08/2009)

13. Leadership in Energy and Environmental Design (LEED) Green Building Rating System offers 14 point under Materials and Resources.

- Prerequisite 1 Storage and Collection of Recyclables Required

- Credit 1.1 Building Reuse—Maintain Existing Walls, Floors and Roof 1-3
- Credit 1.2 Building Reuse—Maintain Existing Interior Nonstructural Elements 1
- Credit 2 Construction Waste Management 1-2
- Credit 3 Materials Reuse 1-2
- Credit 4 Recycled Content 1-2
- Credit 5 Regional Materials 1-2
- Credit 6 Rapidly Renewable Materials 1
- Credit 7 Certified Wood 1

14. U.S. Green Building Council's LEED rating system can be upgraded. The standards should focus on even greater emphasis on reuse. The standards could be further strengthened by prioritizing reuse over recycling. It could offer more points for reuse. Currently LEED-NC offers just one point for reusing building materials. Moreover, the reuse section of the LEED standards for new construction and major renovations could be strengthened to include a percentage of reused materials above the current 5 to 10 percent. Additionally, USGBC can be an important partner in providing information and resources on reuse.

15. New building should be designed for disassembly and modular construction. For example: "According to Boston Consulting Group (2008), modular construction can reduce waste by 25 percent or more. In modular construction, building components are assembled off-site resulting in reduced waste in the construction process due to building to standard sizes, increasing recycling and reuse, reducing packaging and designing for deconstruction".
(SOURCE: http://www.uic.edu/depts/ovcr/iesp/research/deltareport.pdf, VISITED ON 10/08/2009)

16. Sales tax exemptions should be provided for recycling equipment i.e. on-site grinding equipment and recycled construction materials.
(SOURCE: http://www.recyclecddebris.com/rCDd/Handbook, VISITED ON 10/08/2009)

17. State and Local government should fund various research projects working on C&D waste issues and opportunities.

"Examples of C&D materials management projects funded at the state level:

- In 2002, the South Central Iowa Solid Waste Agency received a grant/loan from the Iowa Department of Natural Resources for construction of an Environmental Education Center. This project included the use of "green" construction materials and practices, as well as a study on construction waste to determine the composition of the waste generated and to assess the quantity potentially diverted from the landfill.

- In 2004, the North Carolina Division of Pollution Prevention and Environmental Assistance (DPPEA) awarded $25,000 to New Hanover County to implement a C&D debris recycling program at the county's landfill.

- The State of Hawaii Department of Business, Economic Development and Tourism provided funding to two construction operations on Maui—the Pukalani Golf Estates and the Front Street Affordable Housing Project—to track the production and disposal of waste materials. The 2003 final report was used by the County of Maui Recycling Section to develop a County Handbook for C&D Recycling.

- To encourage deconstruction practices, the California Integrated Waste Management Board granted up to $100,000 in 2000 to local governments to provide deconstruction training; demonstrate effective deconstruction technologies; establish deconstruction award and recognition programs; and develop deconstruction guidelines, case studies, and other educational materials.

- The Vermont Agency of Natural Resources established a grant program specifically for C&D related activities, such as researching new markets, new business planning, and job-site waste reduction activities. The development of this grant program was a direct result of the adoption of the Vermont Revised Solid Waste Management Plan in 2001 which identified critical solid waste management issues facing the state including C&D debris.

- The Florida Department of Environmental Protection provides grants to local governments and businesses to improve C&D materials recycling (funded at $4 million in fiscal year 2000-2001), particularly drywall and roofing materials".

(SOURCE: http://www.epa.gov/waste/conserve/rrr/imr/cdm/grants.htm, VISITED ON 09/18/2009)

4. Guidance documents and tools

Tools which will contribute in waste reduction throughout USA:

a. Construction and Demolition Waste Stream Composition Calculator

The Construction and Demolition (C&D) Waste Stream Composition Calculator is an analysis tool which run on Microsoft Excel sheet that can be used to evaluate the material composition of the disposed C&D waste stream. This calculator is designed to be used in conjunction with the C&D visual characterization method guide.

When data is properly entered into the calculator, it can provide a statistical estimate of the composition of a given C&D waste stream. The calculator does this by taking the estimated volume percentage of each material type in a sample load, and combining it with the total volume of the sample load, to arrive at a volume for the material type. This volume is then converted to a weight, using the standardized volume-to-weight conversion factors. The individual weights of each material type are summed across all samples and divided by the total weight of all samples to arrive at an average percentage of each material type, by weight, in the C&D waste stream.

(DOWNLOAD LINK: http://www.ciwmb.ca.gov/WASTECHAR/Calculator/Default.htm#Important

Estimated Composition by Weight for All Loads

Category	Total	Subcategory	Percent
Paper	**0.0%**		
		Unwaxed OCC	0.0%
		RC Paper	0.0%
Plastic	**0.0%**		
		Non-bag Film	0.0%
		Polystyrene Packaging	0.0%
		Rigid Plastic	0.0%
		RC Plastic	0.0%
Metal	**0.0%**		
		Major Appliances	0.0%
		HVAC Ducting	0.0%
		Other Ferrous & Non-Ferrous	0.0%
		RC Metal	0.0%
Organic	**0.0%**		
		Prunings, Trimmings, Branches, Stumps	0.0%
		RC Organic	0.0%
Carpet	**0.0%**		
		Carpet	0.0%
		Carpet Padding	0.0%
		RC Carpet	0.0%
Aggregates & Dirt	**0.0%**		
		Dirt, Sand, Soil	0.0%
		Concrete	0.0%
		Asphalt Paving	0.0%
		Brick, Ceramic, Porcelain	0.0%
		Rock, Gravel	0.0%
		RC Aggregates & Dirt	0.0%
Roofing	**0.0%**		
		Roofing	0.0%
		RC Roofing	0.0%
Insulation	**0.0%**		
		Insulation	0.0%
		RC Insulation	0.0%
Wood	**0.0%**		
		Clean Recyclable Lumber, Pallets, Crates	0.0%
		Other Untreated & Recyclable Wood	0.0%
		Painted, Stained, Treated Wood	0.0%
		RC Wood	0.0%
Gypsum	**0.0%**		
		Clean Gypsum Board	0.0%
		Painted Gypsum Board	0.0%
		RC Gypsum	0.0%
Misc. C&D	**0.0%**		
Glass	**0.0%**		
Electronics	**0.0%**		
HHW	**0.0%**		
Special	**0.0%**		
Mixed Residue	**0.0%**		
TOTAL	**0.0%**		

b. **Recycling Economics Worksheet**

Recycling Economic worksheet is another calculator which works on Microsoft Excel sheet and can be used to determine the cost-effectiveness of plan for recycling and reusing materials. Sample of Recycling Economics worksheet is shown below

DOWNLOAD LINK: http://your.kingcounty.gov/solidwaste/greenbuilding/construction-recycling/cost-effectiveness.asp

Recycling Economic Worksheet sample:

(1) Cost of recycling

Material	Tons/ Yards	Tip Fee	Subtotal 1	Loads	Hauling Fee	Subtotal 2	Months	Container Rental	Subtotal 3	Total Cost
Asphalt	600	$ -	$ -	0	$ -	$ -	0	$ -	$ -	$ -
(recycled onsite)										
Wood	24	$ 25.00	$ 600.00	12	$ 37.50	$ 450.00	3	$ 30.00	$ 90.00	$ 1,140.00
Cardboard	3	$ (39.00)	$ (117.00)	1	$ 37.50	$ 37.50	4	$ 30.00	$ 120.00	$ 40.50
Drywall	14	$ 45.00	$ 630.00	2	$ 50.00	$ 100.00	2	$ 30.00	$ 60.00	$ 790.00
			$ -			$ -			$ -	$ -
			$ -			$ -			$ -	$ -
			$ -			$ -			$ -	$ -
			$ -			$ -			$ -	$ -
			$ -			$ -			$ -	$ -
Totals			$ 1,113.00			$ 587.50			$ 270.00	$ 1,970.50

(2) Cost of not recycling

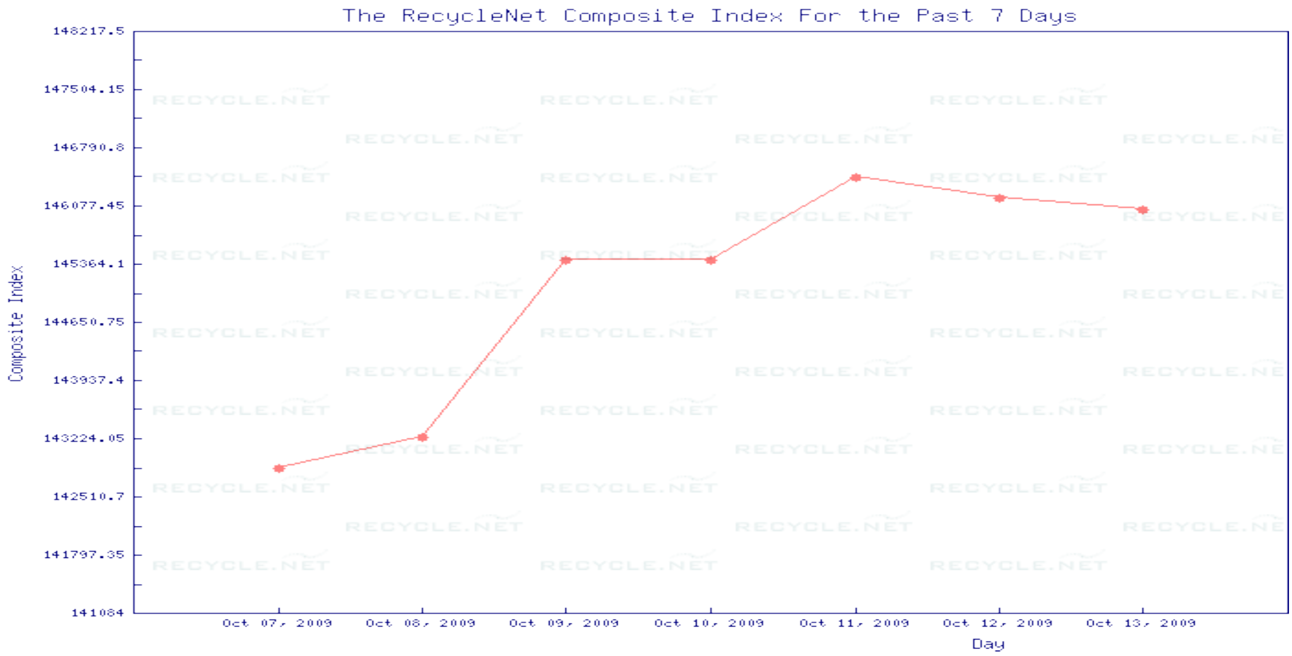
Material	Tons or Yards	Tip Fee	Subtotal 1	# Loads	Hauling Fee	Subtotal 2	# of Months	Container Rental	Subtotal 3	Total Cost
Garbage	641	$ 70.63	$45,273.83	6	$ 54.12	$ 324.72	6	$ 30.00	$ 180.00	$45,778.55

(3) Savings

Cost of Not Recycling	Cost of Recycling	**Total Savings**
$ 45,778.55	$ 1,970.50	**$ 43,808.05**

c. The Recycle Net Composite Index

"The RecycleNet Composite Index was established as a tool to track market trends for recyclable commodities. The index consists of a weighted basket of recyclable commodities that includes benchmark grades of scrap metals, waste paper, scrap glass and recycled plastic. The RecycleNet Composite Index is updated each day before noon EST and displays a snapshot of 5 viewpoints of current market trends (a view over the past 7 days, 30 days, 90 days 1 year & 2 years). The Index tracks 7 days per week although transaction activity on the weekends is typically lighter and it may not be uncommon to see no change reflected in the index". *WEBSITE: http://www.scrapindex.com/composite/7daygraph.html*



5. Case Study

a. State Offices at Butterfield Way, Sacramento, CA

The site work construction phase for the California Franchise Tax Board's State Offices at Butterfield Way realized tremendous financial benefits from recycling C&D debris. This led the project team to an extremely high 99.6% (by weight) C&D waste diversion rate for this phase. Sixty-nine percent of this waste (over 13,605 metric tons) was recycled, stored and reutilized on-site by the contractors saving $104,000. These savings resulted from eliminated tipping fees, and a reduction in road base and landscape mulch materials the project would have needed to purchase.

The Butterfield site included a former industrial site composed of over 20 acres of old asphalt parking lots, as well as concrete, trees and vegetation. The new construction will include 80,000 square meter of new office buildings, a central plant, warehouse and new parking areas.

Among the sustainable site features of this facility are landscaped bio-swales using mulch from recycled green waste that naturally cleanses storm water runoff from parking areas prior to its return to storm drains. Table below provides a summary of quantities and costs, including savings resulting from recycling efforts during the site work phase.

Description	Wood/ Green Waste	Concrete	Asphaltic Concrete	Misc. Const. & Land Clearing	TOTALS
C&D Waste (cubic yards)	1,200	2,500	8,200	364	12,264
Equiv. Metric Tons	270	4,500	14,760	83	19,612
Recycled On-Site	100%	20%	84%	0%	69.20%
Recycled Off-Site	0%	80%	16%	0%	30.40%
Total Recycled by Weight	100%	100%	100%	0%	99.60%
On-Site Recycling Cost	$15,000	$4,269	$158,319	$0	$177,588
Off-Site Recycling Cost	$0	$6,820	$16,693	$0	$23,513
Landfill Costs	$0	$0	$0	$3,396	$3,396
Avoided Material Costs	$11,880	$14,000	$192,864	$0	$218,744
Net C&D Recycling & Disposal Cost	$3,120	$2,911	$17,852	$3,396	$14,247
Potential 100% Disposal Costs	$12,000	$17,500	$57,400	$3,396	$90,296
Total Recycling (Savings)	$8,880	$20,411	$75,252	$0	$104,543

- “The cost to recycle green waste on-site equated to ~$13.6 per cubic meter. The cost to purchase and transport new woodchip mulch was ~$10.5 / cubic meter, and the avoided cost to dispose of this debris offsite equated to $11/ cubic meter. This equated to an incremental savings of $8/ cubic meter for onsite recycled green waste, totaling savings of $8,880.

- The combined cost to crush & recycle concrete on-site (20%) was ~$9.34/ cubic meter. The cost to crush & recycle concrete offsite equated to $3.7/ cubic meter. The cost to dispose of concrete waste would have been ~$4.3/ cubic meter for clean concrete and $7.6/ cubic meter for "semi-clean" concrete (<30% dirt).

- The cost to purchase aggregate base was approximately $30.6/ cubic meter. The C&D concrete waste on this project was "semi-clean". This equated to an incremental savings of $28.9/ cubic meter for on-site recycling of concrete debris and $3.9/ cubic meter for off-site recycling of concrete debris, totaling savings of $20,411.

- The combined cost to crush & recycle asphaltic concrete (AC) on-site (84%) was ~$25.75/ cubic meter. The cost to crush & recycle AC offsite equated to $13.9/ cubic meter. The cost to dispose of AC waste would have been ~$4.3/ cubic meter for clean AC and $7.6/ cubic meter for "semi-clean" AC (<30% dirt).

- The cost to purchase aggregate base was approximately $30.6/ cubic meter. The C&D AC waste on this project was "semi-clean". This equated to an incremental savings of $12.5/ cubic meter for on-site recycled AC debris and an incremental costs of $6.26/ cubic meter for off-site recycled AC debris, totaling savings of $75,252".
  SOURCE: CALIFORNIA INTERGRATED WASTE MANAGEMENT BOARD
  http://www.ciwmb.ca.gov/ConDemo/CaseStudies/DGSDiversion.pdf

b. MIT Media Lab, Cambridge, Massachusetts

W.K. MacNamara Demolition Co. of Waltham was the lead contractor for the demolition of the Media Lab of the Massachusetts Institute of Technology (MIT). The Media Lab was comprised of two buildings, located in a congested urban area. McNamara recycled 4,098 metric tons of material and disposed of 175 metric tons of mixed construction and demolition waste, for a total waste reduction rate of 96 percent.

Cost Savings: **$17,684**
Project: Commercial Demolition 4,366 sq. meter.
Recycled: 4,519 Tons of Material: Asphalt, Brick, Concrete, Timbers, Ceiling Tiles, and Doors.
Total Waste Reduction**: 96%**
(SOURCE: www.mass.gov/dep/**recycle**/reduce/cd**mit**.pdf, VISITED ON 10/12/2009)

c. Orange County North Carolina

In Orange County, North Carolina, an ordinance was passed in 2002 which requires the recycling of specific materials along with plans for an additional C&D landfill. In addition, people requesting building permits are required to apply for a "Recyclable Material Permit". This ordinance, while making specific demands on the business community, won broad-based support because of the new C&D landfill commitment. Ordinance resulted in decreased tipping fee revenues. The reduced revenue has been partially offset by sales of recyclable material, for the Solid Waste Management Department, which operates the Orange County landfill and the county's recycling programs. The important impact on the C&D waste stream was the significant reduction in waste and the increase in the recycling of material, as shown below.

	FY 2001 / 2002	FY 2002 / 2003
Disposed (at solid waste facility)	25,150 Metric tons	17,310 Metric tons
Disposed (elsewhere)	6,668 Metric tons	6,380 Metric tons
Subtotal	**31,818 Metric tons**	**23,690 Metric tons** (26% reduction)
Recycled (at solid waste facility)	996 Metric tons	3003 Metric tons
Recycled (elsewhere)	0 tons	6,034 Metric tons
Subtotal	**996 Metric tons**	**9037 Metric tons** (9-fold increase)

(SOURCE: http://www.recyclecddebris.com/rCDd/Handbook, VISITED ON 10/08/2009)

d. Port of Oakland

The Youth Employment Partnership to dismantle the Port of Oakland's Building 733. The large warehouse yielded 136,800 board meters of mainly old-growth Douglas fir.

The total expense to deconstruct- **$330,000**
Income from salvaged lumber**-$280,000**
Net cost was $50,000.
Demolition bid: **$150,000**. (Urban Ecologist, Number 2, 1997).
(SOURCE:http://www.crra.com/rrarc/publications/Deconstruction.pdf, VISITED ON 10/11/2009)

e. San Francisco's Presidio

Beyond Waste and *San Francisco Community Recyclers* deconstructed Building 901 at San Francisco's Presidio. The structure came down in one month, yielding 20,117 board meter of old growth Douglas fir and Port Orford cedar for salvage.

Total deconstructing expense (including labor, equipment, and administrative costs), was **$53,000**.
Income from the salvaged wood - **$43,660**
Net cost of deconstruction-$9,340
Demolition bid - **$16,800**

(SOURCE:http://www.crra.com/rrarc/publications/Deconstruction.pdf, VISITED ON 10/11/2009)

f. Executive Hills Deconstruction & Demolition Project, IOWA

Description	Metric Tons	Materials
Building Contents Recycled & Reused	8.2	Books, notebooks, copy machine, security safe, 75 air conditioning units
Building Materials Reused	388	Deconstruction materials (dimensional lumber, plywood sheathing, concrete block, brick, etc.), fixtures, cabinets
Building Materials Abated & Recycled	0.18	Fluorescent tubes and ballasts
Building Materials Recycled	234	Shingles, insulation, concrete
Total tons recycled/reused	**630**	**$20,800.00 in estimated project savings**

SOURCE: http://www.iowadnr.gov/waste/recycling/files/iowacase.pdf , VISITED ON 10/19/2009

References

Chini, A.R. and Bruening, S. 2005, Deconstruction and Materials Reuse in the United States, in Deconstruction and Materials Reuse – An International Overview, CIB Publication 300.

EPA (2003) Estimating 2003 Building Related Construction and Demolition Materials Amount, http://www.epa.gov/osw/conserve/rrr/imr/cdm/pubs/cd-meas.pdf (visited 2010, October 20)

Franklin and Associates, LTD (1998) Characterization of Municipal Solid Waste in the United States, Report No. EPA530-R-98-007, http://www.epa.gov/osw/nonhaz/municipal/pubs/msw97rpt.pdf (visited 2010, October 20)

Discussion

Contributed by:
Gilli Hobbs
Director of Resource Efficiency
Building Research Establishment
Watford, UK

Looking through the country reports, there are common themes and issues that arise across the globe, mostly developed independently in each country. However, there are also many differences in terms of the level of importance placed upon reducing this wastestream and the priorities in each country depending upon the supply chain phase, material type and type of construction.

Waste reduction tends to be a late arrival in policy and industry objectives related to Construction and Demolition Waste management and Sustainable building. A generic approach over time towards waste reduction could be as follows:

- All waste is managed in such a way as to prevent pollution and harm to human health
- Standards emerge relating to green or sustainable buildings, initially focussed on energy efficiency
- Landfill is undesirable for recyclable materials leading to a focus on recycling and energy recovery of waste
- Green building standards include wider measures such as recycling, recycled content
- Improved evidence on waste amounts, composition and causes
- Waste reduction is brought to the forefront of waste policy with related policy measures and business support focussed on waste reduction
- Waste reduction targets and methods of measurement are included in Green building standards
- Supply chains and sectors work in partnership to identify and implement waste reduction actions
- Ideally, waste production related to construction activity will start to decline – currently no country (that has reported) seems to have reached this point.

Policies that influence a focus on waste prevention include:

1. Understanding the wastestream: Amount generated and characterisation of waste – who is responsible for collecting this information – regional or national, government or industry. If policy is not developed at a national/federal level than there is likely to be inconsistencies within the same country in terms of data provision, taxes and incentives to reduce waste, and other policies designed to discourage waste production and landfilling.
2. Definition of waste and levels of management – the definition of waste can be a grey area across the world. Even where it has been set out in policy there are often different interpretations that can result. For example, the EU Waste Framework Directive definition of waste effectively counts any product or material that has been discarded by the holder to be a waste. As soon as the product or material is deemed waste then the legislation relating to environmental permitting and the transport of waste needs to be considered.
3. Site waste management plans, waste reduction plans, and permits linked to these are commonplace around the world, for example in Canada. However, as noted in this

country report, the enforcement of such plans is key to their widespread implementation and effectiveness.

4. Deposits linked to amount of waste likely to be generated as adopted in some US towns. The deposit is returned upon proof of management of waste in accordance with local requirements.

Waste reduction and recycling have a strong link to other impact areas such as greenhouse gas emissions e.g. methane from landfill, which can raise the profile of C&D waste, typically a significant component of wastes generated and wastes landfilled in most countries. Therefore, understanding the carbon impact of this waste is important to raising its profile/ encouraging further action at a policy level, as is the case in Canada.

A construction waste specific policy covering all aspects of waste prevention, reuse and recycling can help focus efforts very effectively, as demonstrated in the report from Japan relating to the Construction Materials Recycling Act of 2004. There have been dramatic improvements in the amount of material diverted from landfill since its implementation. It is less clear whether the requirements relating to waste reduction are having a similar effect owing to the lack of benchmark data against which to assess waste reduction, although the Act recognised the need to have improved evidence through further research and development. Examples of waste prevention measures include the Government requiring waste reduction in projects where they are the client, such as greater use of precut materials and increasing the overall durability of the building and its components. Encouraging the use of pre-fabricated building elements is also part of policy in Israel

Aside from policies focussed on waste prevention, Green Building standards can have a major influence on prioritising waste reduction on a construction project. For example, LEED, as used widely in Canada and the US have credits relating to 'extending the life of a building'; and BREEAM, as used widely in the UK have waste reduction credits linked to construction waste generation benchmarks.

There are many tools being used in various countries to assist in the evaluation, management and promotion of improved resource use in construction. They can be at the holistic level, whereby the overall life cycle impact of a structure or process is being assessed, and the resource and waste impact forms part of this evaluation, such as those used in Japan. Alternatively, tools such as the Molehill Tool in Canada, the True Cost of Waste Calculator in the UK, and the Construction and Demolition Waste Stream Composition Calculator in the US focus on the construction waste impact.

High level sector agreements such as the negotiated Agreement of the ARGE KWTB in Germany which was negotiated by key construction related trade association can be very effective at providing a common goal for the whole industry. An alternative, or complementary, approach could be to devise a set of objectives that can be applied at a site level, such as the Green and Gracious Builders Scheme in Singapore.

Collecting data via the waste management contractors, e.g. annual returns, is not a particularly good way to assess waste arising. Any waste not dealt with through licensed facilities, e.g. reuse of products, would not be captured, and the amount of waste produced is not related to construction activity.
There are some interesting methods described for looking at resource use related to construction, for example the Concrete Usage Index described in the Singapore report. This

essentially links concrete use to floor area, whereby excessive concrete use can be identified when compared to the average. The results are linked to the BCA Green Mark Scheme, a green standard, to encourage lower concrete consumption. Similarly, the benchmarks developed through the SMARTWaste system in the UK have been able to define levels of good and best practice in terms of waste production linked to floor area, which are then linked to the BREEAM sustainable building standard.

Resource use indicators have also been set at a national level, such as Slovenia where there is a policy to reduce the excavation of mineral raw materials for construction purposes from about 8 t per capita to about 5.5 t per capita. It will be interesting to see if this benchmark is measured to assess progress towards the target, and also what policies or activities have been put into place to promote such progress. In the report from Turkey, typical wastage rates for key construction materials, such as cement, are presented. Wastage rates can be a very effective way of measuring waste production and setting targets for subsequent reduction. This information can be used to drive improvements through the supply chain of a particular product group, especially when linked to overall environmental impact. Many product groups compete on a material level, such as plastic versus timber, and are keen to reduce the generic environmental impact attributed to the product group. Reducing wastage rates leads to an equivalent reduction in overall environmental impact.

Where it is difficult to gather data on a national level it can be useful to develop an indicator for extrapolation based upon waste produced per head of population, as defined in the USA report.

Waste reduction in refurbishment is an important area. As indicated in the Israel report, refurbishment waste can be greater than construction waste but is also more difficult to regulate through building permits and other similar policy instruments. This is reinforced in the Norway report where refurbishment waste is estimated to be the largest wastestream, when compared to construction and demolition waste. This suggests that a focus for waste reduction should be typical refurbishment activities and the products typically used. For example, insulation materials, kitchens and bathrooms in the residential sector; flooring and other fit-out materials in the non-residential sector. However, the information available relating to typical refurbishment waste composition is even more limited than for construction and demolition waste.

By contrast, construction waste production can be very low, for example less than 10% in Switzerland. Where this is the case, a focus on reducing waste from new build construction might not be the best priority for action. This emphasises the need to have good data on various levels to understand where priorities lie and where the biggest impact reduction can be made through waste reduction.

Waste reduction opportunities in demolition are obviously limited by the fact that the demolition process is in essence a waste production process. Avoidance of demolition through refurbishment or façade retention are examples of waste reduction. Reuse of materials from demolition into the new build could also be considered waste avoidance as these materials effectively do not become a waste.

Another way to categorise data is to consider the construction sector. This would typically be residential, non-residential and civil engineering/infrastructure/ public works. Large scale public works, such as major tunnelling works, can have the effect of skewing results year to year. Waste avoidance in large scale public works will be mainly linked to minimising excavation, landscaping and reuse of materials on-site or close to site, and soil remediation to facilitate the retention of contaminated material on-site rather than importing material.

Waste prevention through the reduction of hazardous substances is another area that is often overlooked. Some countries, such as Norway, actively apply a substitution principle whereby hazardous materials must be substituted for less hazardous materials where it is practicable to do so. There will always be a degree of subjectivity over what constitutes ‘practicable’ but it is often the case that manufacturers will continue to use the same feedstock unless challenged to consider an alternative solution. Once it becomes apparent that there may be a competitive advantage to substituting feedstock then it is a case of applying basic cost benefit analysis to determine the likelihood of substitution occurring without legislative intervention.

Exemplars and case studies focussed on waste reduction are few and far between, perhaps due to the difficulty in measuring success. The UK report suggests that it is easier to look at a particular product group, such as plasterboard, to be able to compare wastage rates across a number of sites linked to proactive steps taken to reduce waste.

There is still confusion between waste reduction and reuse or recycling of waste once produced, as evidenced by the wide ranging content of many of the country reports. Maybe this is symptomatic of the desire to report progress in some way, even if it is not necessarily linked to preventing waste production.

However, the country reports show an increasing realisation and move towards waste reduction as satisfying multiple drivers of reducing costs, environmental impacts, landfill and conserving finite resources. It remains unclear as to whether any country has achieved this goal yet.

Appendices

Appendix for Switzerland report

Legislation articles

Articles in German are available in French and Italian, too. However, they have not officially been translated into English.

The Federal Constitution of the Swiss Confederation

Art. 73 Sustainable Development

The Confederation and the Cantons shall endeavour to achieve a balanced and sustainable relationship between nature and its capacity to renew itself and the demands placed on it by the population.

Art. 74 Protection of the environment

1 The Confederation shall legislate on the protection of the population and its natural environment against damage or nuisance.

2 It shall ensure that such damage or nuisance is avoided. The costs of avoiding or eliminating such damage or nuisance shall be borne by those responsible for causing it.

3 The Cantons shall be responsible for the implementation of the relevant federal regulations, except where the law reserves this duty for the Confederation.

Act for Environmental Protection (USG)

Chapter 4: Waste; Section 1: Avoidance and Disposal of Waste

Art. 30 Principles

1 The production of waste should be avoided wherever possible.

2 Waste must be recycled wherever possible.

3 Waste must be disposed of in an environmentally compatible way and, insofar as this is possible and reasonable, within Switzerland.

Art. 30a Avoidance

The Federal Council may:

a. prohibit the putting into circulation of products intended for once-only, short-term use if the benefits of such use do not justify the harm to the environment that they cause;

b. prohibit the use of substances and organisms that considerably hamper disposal or the disposal of which may represent a danger to the environment;

c. require manufacturers to avoid production waste where there is no known environmentally compatible process for its disposal.

Art. 30b Collection

1 The Federal Council may require certain types of waste that are suitable for recycling or that need special treatment to be handed over separately for disposal.

2 It may require those who put products into circulation that are suitable for recycling or need special treatment:

   a. to take such products back after use;

   b. to charge a minimum deposit and to refund this when the product is returned.

3 It may arrange for the establishment of a deposit compensation fund and specifically require:

   a. those who put products into circulation on which deposits are paid to pay any surplus from the deposit charges into the compensation fund;

b. the surplus to be used to cover losses from refunding deposits and to encourage the return of products on which deposits are paid.

Art. 30c Treatment

1 Waste intended for placing in a landfill must be treated so that it contains as little organic bound carbon as possible and is as insoluble as possible in water.

2 Waste must not be burned other than in incineration plants; the foregoing does not apply to the burning of natural forest, field and garden waste provided that this causes no excessive emissions.

3 The Federal Council may issue further regulations on treatment for specific types of waste.

Art. 30d Recycling

The Federal Council may:

a. require certain types of waste to be recycled if this is economically feasible and harms the environment less than other forms of disposal and the manufacture of new products;

b. restrict the use of substances and products for certain purposes if this will promote the sale of equivalent products made from recycled waste without significant loss of quality or additional cost.

Technical Ordinance on Waste (TVA)

Art. 3 Begriffe

[…]

7 Aushub-, Abraum- und Ausbruchmaterial gilt als unverschmutzt, wenn:

a. die in ihm enthaltenen Stoffe die Grenzwerte gemäss Anhang 3 nicht überschreiten oder eine Überschreitung nicht auf menschliche Tätigkeiten zurückzuführen ist; und

b. es keine Fremdstoffe wie Siedlungsabfälle, Grünabfälle oder Bauabfälle enthält.

Art. 9 Construction waste

1 Any person carrying out building or demolition work shall not mix special waste with other waste and shall separate the other waste on the building site as follows:

a. unpolluted excavated material and soil;

b. waste which can be deposited on a landfill for inert materials without further treatment;

c. burnable waste as wood, paper, cardboard and plastics;

d. other waste.

1bis As far as the separation on the building site is not possible due to working conditions, he may separate them elsewhere.2

2 The authority may require a more extensive separation, if by this measure waste fractions can be recovered.

Art. 10 Prohibition to mix

Holders of waste shall not mix it with other waste nor with additives if this is primarily intended to reduce the pollutant level of the waste by dilution, in order to meet regulations concerning supply, recovering or depositing.

Art. 11 Obligation to incinerate

The Cantons shall ensure that municipal waste, sewage sludge, combustible fractions of construction waste and other burnable waste are incinerated in suitable plants as far as they cannot be recovered. Also permitted is an environmentally sound treatment with other thermal processes.

Art. 12 Obligation to recover

1 The authority may oblige owners of industrial, commercial or service undertakings to:

a. determine whether ways of recovering their waste already exist or could be set up and

b. inform the authority of the results of their investigations.

2 It may transfer the obligations laid down in Paragraph 1 to the owners of waste treatment facilities which accept numerous small quantities of the same type of waste.

3 It may demand from the owners of waste to provide for the recovery of specific types of waste if:

a. the recovering is technically feasible and economically viable;

b. the environmental impact will be smaller compared to disposal and new production.

Art. 15 Register of waste

1 Every year, the Cantons shall draw up a register of the quantities of waste generated within their territory. It shall be broken down according to the different types of waste, municipalities, waste treatment plants, and type of treatment, notably, recovery, incineration, deposition on landfills and temporary storage.

2 They shall respectively send a copy to the Federal Office of Environment, Forests and Landscape (Federal Office).

Art. 16 Waste management planning

3 The following principles shall apply when drawing up waste management plans:

a. Waste shall be recovered as far as possible, provided that the environmental impact is smaller than disposal and new production;

b. Waste which is not recovered shall, as much as possible, be treated so that it can be deposited on a landfill for inert materials or for stabilized residues:

c. Municipal waste, sewage sludge and combustible fractions of construction waste and other burnable waste which are not recovered shall be incinerated (Art 11).

d. Unpolluted excavated material and spoil shall be used for recultivation;

e. Waste shall be transported by rail if this is economically viable and the environmental impact is smaller than other means of transport.

Regulation on the transport of waste (VeVa)

Art. 2 Abfallverzeichnis

1 Das Eidgenössische Departement für Umwelt, Verkehr, Energie und Kommunikation (UVEK) erlässt eine Verordnung mit einem Abfallverzeichnis. Es berücksichtigt dabei das Abfallverzeichnis der Europäischen Gemeinschaft4.

2 Es bezeichnet im Abfallverzeichnis als:

a. *Sonderabfälle:* Abfälle, deren umweltverträgliche Entsorgung auf Grund ihrer Zusammensetzung, ihrer chemisch-physikalischen oder ihrer biologischen Eigenschaften auch im Inlandverkehr umfassende besondere technische und organisatorische Massnahmen erfordert;

b. *andere kontrollpflichtige Abfälle:* Abfälle, deren umweltverträgliche Entsorgung auf Grund ihrer Zusammensetzung, ihrer chemisch-physikalischen oder ihrer biologischen Eigenschaften auch im Inlandverkehr beschränkte besondere technische und organisatorische Massnahmen erfordert.

Regulation on encumbrances on the soil VBBo:

Art. 7 Umgang mit ausgehobenem Boden

1 Wer Boden aushebt, muss damit so umgehen, dass dieser wieder als Boden verwendet werden kann.

2 Wird ausgehobener Boden wieder als Boden verwendet (z. B. für Rekultivierungen oder Terrainveränderungen), so muss er so aufgebracht werden, dass:

a. die Fruchtbarkeit des vorhandenen und die des aufgebrachten Bodens durch physikalische Belastungen höchstens kurzfristig beeinträchtigt werden;

b. der vorhandene Boden chemisch nicht zusätzlich belastet wird.

VILB

Art. 2 Strategische Ziele

[…]

2 Im Bereich des Immobilienmanagements verfolgt er die folgenden strategischen Ziele:

a. Konzentration der Unterbringung von Organisationseinheiten der Bundesverwaltung in polyvalenten Objekten angemessener Grösse, die, soweit dies wirtschaftlich ist, im Eigentum des Bundes stehen;

b. Schaffung und Befolgung nachhaltiger Standards bezüglich Planung, Bau, Einrichtung, Bewirtschaftung, Betrieb und Rückbau; zur Unterstützung dieses Ziels führt die Bundesverwaltung ein Ressourcen- und Umweltmanagement durch.

Art. 9 Steuerung des Immobilienmanagements

[…]

f. *Nachhaltige Entwicklung:* Sie berücksichtigen in allen Phasen des Immobilienmanagements in ausgewogener Weise die wirtschaftliche Leistungsfähigkeit, die ökologische Verantwortung und die gesellschaftlichen Bedürfnisse. Massgebend sind dabei die Empfehlungen «Nachhaltiges Bauen» der Koordinationskonferenz der Bau- und Liegenschaftsorgane der öffentlichen Bauherren (KBOB).

Important standards and documentations concerning construction waste

All standards can be ordered via www.sia.ch (de/f) and www.vss.ch (de/f)
Editions with a "D" belong to the documentation serial of SIA. These documentations conciliate ongoing technical findings of professional groups and practical experiences.

Standard (Year)	Title	Short description
Building standards		
SIA 112/1 (2005)	Sustainable construction – house building	The SIA 112/1 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 (Translation taken out of [CIB 2008])
SIA D 0200 (2004)	SNARC, System for an environmental sustainability assessment of architecture projects	This 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. (Translation taken out of [CIB 2008])
SIA D 0152 (1998)	Comparison of instruments for ecological construction – guidance for planners	This is a compilation of Swiss and other instruments concerning ecological construction engineering. A big part of the standard consists out of case studies. The planner shall be supported in the choice of appropriate instruments. The disadvantage of this documentation is its age.
SIA D 0164 (2000)	Criteria for sustainable constructions	This is a clear guide for basics, decisions and education for sustainable house building. With the help of a criteria catalogue, buildings can be checked on their sustainability by principals and planners. Equal strengths are put on the three pillars economy, ecology and society.
SIA D 0137	Check lists for ecological planning and construction with suitable energy considerations	This standard covers important aspects on the following points: - Residential estate, surrounding, traffic - Energy, water, air - Construction materials - Domestic engineering - Economy
SIA 2032	Grey energy of buildings	This documentation shall contribute to an integral view on a buildings energy use. The calculation method is standardised so that everybody will use the same data basis in order to ensure comparability. As second point, the documentation wants to make planners aware of the issue of grey energy.
SIA D 0167	Planning and	This documentation shows in which phase of construction

Standard (Year)	Title	Short description
(2001)	constructing with architecture fitting into the landscape	landscape issues have to be taken into account. It is not orientated towards construction waste; but naturally a construction fitting into the landscape can avoid much excavation material landfilled.
Disposal, reuse and recycling standards		
SIA 430 (1994)	Disposal of construction wastes	This important standard defines material groups and fractions and their ways of disposal. See chapters 0 and 0 for details.
SIA 162/4 (1994)	Recycling concrete	This standard deals with ecological and practicable use of parts of debris. It aims at encouraging the use of recycling granules and recycling aggregates as replacement for primary gravel resources. Furthermore, the standard describes quality demands for cement, additives and other.
SIA 493 (1998)	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 [CIB 2008].
SN 640 141-144	Standards by the VSS on the conditioning of asphalt (141), road construction waste (142), concrete demolition material (143) and mixed demolition material (144)	These standards are based on the guideline for utilization of mineral waste material. They present the possible use, stocking, treatment, quality demands and environmental impacts. The aim is to ensure a high-quality use of secondary construction materials with an optimal knowledge on material specific properties.
SN 670 062	Recycling; general	This norm concerns mineral construction waste (debris) and concretizes its use in road construction.

Sustainable Development Strategy

Relevant measures for sustainable building and construction waste:

Measure 4-1: Integrated Product Policy (IPP)

(1) *Public sourcing* – Sustainable purchasing praxis of the state
(2) *Private consumption* – sensitisation of consumers
(3) *Life Cycle Analysis* / methodology of the thinking in lifecycles
(4) *Product standards and product labelling* in order to enforce and foster environmental and social standards
(5) *Sustainable material management* – strategies aiming for the reduction of resources use and environmental burdens.

Measure 4-2: Sustainable Building

(1) *Sustainable strategy on immovable belonging to the federal state:* Cooperation with the syndicate of private professional building contractors. The strategy will be based on the "Compendium on sustainable immovable management" being published in the end of 2009 by the coordination group of construction and property of the federal state (KBOB).
(2) *Influence of public building contractors as purchasers*: One third of yearly construction investments are made by the public authorities. Therefore, these constructions should serve as role models.
(3) *Influence of the state on building relevant programs*: Existing programs on sustainable building shall be synchronised and new programs shall be initiated if necessary
(4) *Exertion of influence on regulations and standards in the construction field*: Relevant standards will be established respecting all important stakeholders.
(5) *Enforcement of the network in sustainable building in Switzerland:* Constructors, economy and research should work together.

Multi Dell Concept, further explanations

The building industry has widely accepted a concept of waste separation in four different dells.

Dell 1: Separated materials	**Dell 2: Mixed mineral debris**	**Dell 3: Burnable waste**	**Dell 4: Bulky goods**
Inert materials (excavation earth, road construction waste, asphalt, concrete demolition); Metals	Mixed mineral fraction, not combustible (ceramics, gypsum, natural	Burnable materials which can't be reused/recycled (wood, plastics, insulations etc.)	Mixed waste of the other dells

Dell 4 is more costly for removal than the others. Special waste mustn't be disposed off in these dells.

The dells are then brought to regional sorting plants, where the materials are sorted out manually or with machines. After that, the materials go to the different treatment ways.

Standards on use of construction bulky waste (d/f)

SN 670062, Tab. 1: Normen über die Verwertung von Bauschutt: Stoffliche Zusammensetzung und Einsatzbereiche der Sekundärbaustoffe [VSS 1998].

Compilation of all mentioned links

All links have been accessed on the 6th of December 2009.

Webpage (languages available[53])	Keywords
http://www.are.admin.ch/themen/nachhaltig/00262/00528/index.html?lang=en (d/f/i/e)	Swiss Strategy for Sustainable Development
www.abfall.ch (d/f/i)	"Disposal marker"
www.abfallboerse-schweiz.ch (d/f/e)	Bourse for waste materials
www.admin.ch (d/f/i/e)	Official webpage of the Federal Government of Switzerland
www.are.admin.ch/themen/nachhaltig/index.html?lang=en (d/f/i/e)	Sustainable Development Strategy of the Swiss Federal Government
www.arpschweiz.ch (d/f)	Take back system for PVC tubes
www.arv.ch (d/f)	Swiss Association on Excavated Earth, Deconstruction and Recycling
www.bauenschweiz.ch/Statistik.6.0.html (d/f)	Quarterly business ratios for planning and constructing
www.baupunktumwelt.ch (d)	Training program
www.bauteilkatalog.ch (d/f)	Includes an instrument for calculations of ecological impacts of specific construction components
www.bauteilnetz.ch (d/f)	Contains a bourse for construction waste material
www.bfs.admin.ch/bfs/portal/en/index/themen/21.html (d/f/i/e)	Sustainable Development Strategy of the Swiss Federal Government. MONET indicator system.
www.cibworld.nl/ (e)	Homepage of the International Council for Research and Innovation in Building and Construction
www.crb.ch (d/f/i)	Swiss Center for Rationalisation of Construction
www.ecobau.ch (d/f)	Platform with many recommendations for sustainable planning, building and maintaining of buildings and systems
www.fskb.ch (d/f/i)	Swiss Association of Gravel and Concrete Industry
www.globalbuilding.ch (d)	Special exhibition on sustainable construction at Swissbau 2010
www.minergie.ch (d/f/i/e)	Label for sustainable buildings
www.neat.ch (d/f/i/e)	Railway tunnel project
www.swissbau.ch (d/f/i/e)	Exhibition on construction
www.uni-siegen.de/fb10/subdomains/cibw115/ (e)	Homepage of Working Group 115 of CIB on Construction Materials Stewardship
www.vbsa.ch (d/f/i)	Association of Operators of Swiss Waste Treatment Facilities

[53] d = German; f = French; i = Italian; e = English

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TG77 Health and the Built Environment
TG79 Building Regulations and Control in the face of Climate Change
W115 Construction Materials Stewardship
W116 Smart and Sustainable Built Environments

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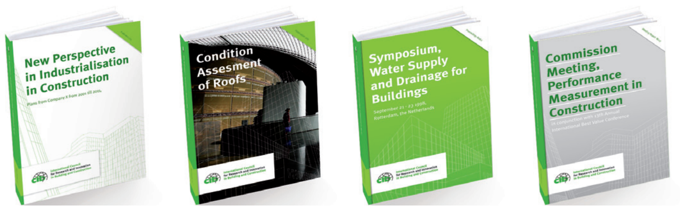

Examples of recent CIB Publications are:
- Green Buildings and the Law
- Culture in International Construction
- Proceedings of Sustainable Building 2010 Conferences

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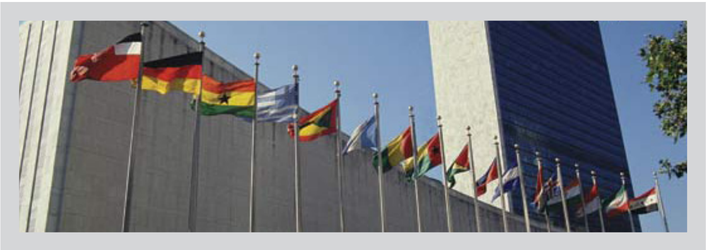

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CIB General Secretariat
Kruisplein 25-G
3014 DB Rotterdam
The Netherlands
Phone: +31-10-4110240
E-mail: secretariat@cibworld.nl
www.cibworld.nl

CIB Task Groups and Working Commissions		Priority Themes: SC	RC	IDDS	Areas of Scientific Interest: GEN	BT: BCT	BT: BPh	BBE: DB	BBE: BE	BP: MOE	BP: LPP
TG59	People in Construction										
TG63	Disasters and the Built Environment										
TG66	Energy and the Built Environment										
TG67	Statutory Adjudication in Construction										
TG68	Construction Mediation										
TG72	Public Private Partnership										
TG73	R&D Programs in Construction										
TG74	New Production and Business Models in Construction										
TG75	Engineering Studies on Traditional Constructions										
TG76	Recognising Innovation in Construction										
TG77	Health and the Built Environment										
TG78	Informality and Emergence in Construction										
TG79	Building Regulations and Control in the Face of Climate Change										
TG80	Legal and Regulatory Aspects of BIM										
TG81	Global Construction Data										
TG82	Marketing in Construction										
TG83	e-Business in Construction										
TG84	Construction Reform										
TG85	R&D Investment and Impact										
W014	Fire Safety										
W018	Timber Structures										
W023	Wall Structures										
W040	Heat and Moisture Transfer in Buildings										
W051	Acoustics										
W055	Construction Industry Economics										
W056	Sandwich Panels										
W062	Water Supply and Drainage										
W065	Organisation and Management of Construction										
W069	Housing Sociology										
W070	Facilities Management and Maintenance										
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	Education in the Built Environment										
W092	Procurement Systems										
W096	Architectural Management										
W098	Intelligent and Responsive Buildings										
W099	Safety and Health in Construction										
W101	Spatial Planning and Infrastructure Development										
W102	Information and Knowledge Management in Building										
W104	Open Building Implementation										
W107	Construction in Developing Countries										
W108	Climate Change and the Built Environment										
W110	Informal Settlements and Affordable Housing										
W111	Usability of Workplaces										
W112	Culture in Construction										
W113	Law and Dispute Resolution										
W114	Earthquake Engineering and Buildings										
W115	Construction Materials Stewardship										
W116	Smart and Sustainable Built Environments										
W117	Performance Measurement in Construction										
W118	Clients and Users in Construction										
W119	Customised Industrial Construction										

Extend of Involvement of Task Groups and Working Commissions

- (grey) Activities and Outcome of this Task Group or Working Commission may be of special importance to the respective Theme or Area
- (green) Activities and Outcome of this Task Group or Working Commission in principle always are of special importance to the respective Theme or Area

Abbreviations of defined Themes and Areas

Themes	
SC	Sustainable Construction
RC	Revaluing Construction
IDDS	Integrated Design and Delivery Solutions

Areas of Scientific Interest	
GEN	General issues: Innovation, Regulation, Information, Education
BT	BUILDING TECHNIQUE
BCT	Building and Construction Technologies
BPh	Building Physics
BBE	BUILDINGS AND THE BUILT ENVIRONMENT
DB	Design of Buildings
BE	Built Environment
BP	BUILDING PROCESS
MOE	Management, Organisation and Economics
LPP	Legal and Procurement Practices

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CIB General Secretariat
Kruisplein 25-G
3014 DB Rotterdam
E-mail: secretariat@cibworld.nl
www.cibworld.nl

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