

Barriers for Deconstruction and Reuse/Recycling of Construction Materials
in Germany

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1. BARRIERS FOR DECONSTRUCTION

1.1 Three major construction types in Germany

The three major building construction types presently found in Germany are listed in Table1 (Klauß et al., 2009):

Table 1: The three major construction types in Germany

Type	Vertical support structures	Horizontal support structures
1. Masonry (partly with reinforced concrete frames) and reinforced concrete (framed) ceilings	Masonry	Reinforced concrete
2. Masonry with timber framed ceiling	Masonry	Timber
3. Precast concrete slabs with reinforced concrete ceilings (especially in the eastern Parts of Germany)	Precast concrete	Reinforced concrete

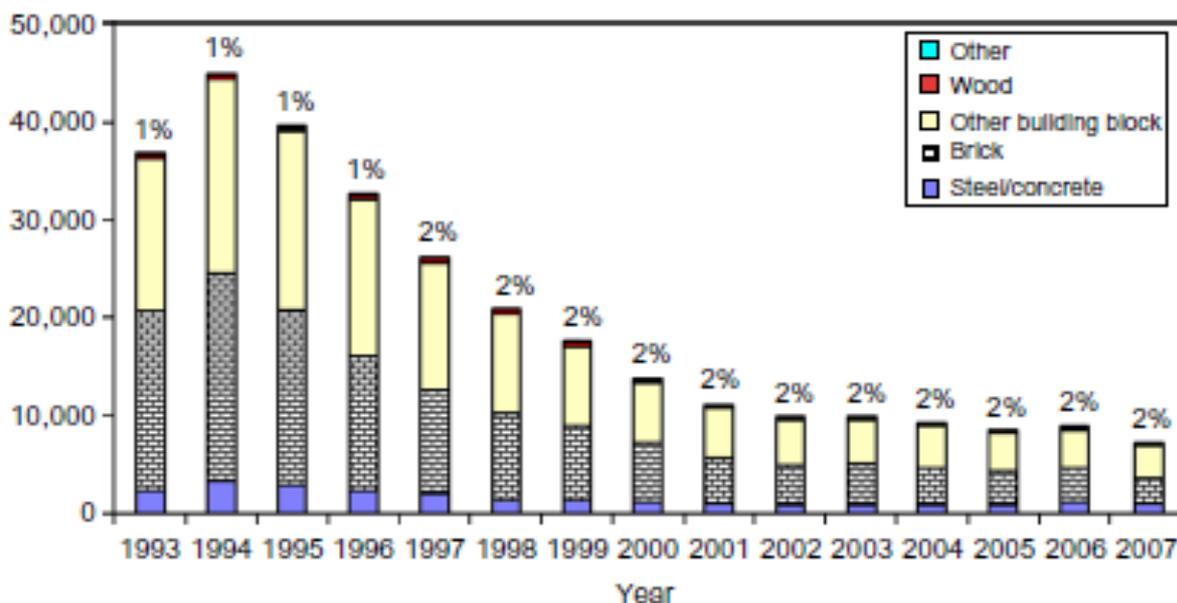


Figure 1: Major building construction types in Germany and the percentage of wood types thereof (Mahapatra et al, 2009)

Other common building construction types in Germany include timber frame, steel skeleton frame and precast reinforced concrete frame, noting that timber frame type construction represents only around 2% of all building permits issued in Germany up to 2007 (Figure 1).

1.2 Methods commonly used to remove buildings in Germany for each construction type

The methods commonly used to remove each of the three major construction types presently found in Germany vary depending on key variables including the *location*, the *building type and surrounding conditions* together with the *time* and *budget* allocated for demolition. Subject to assessment of these variables, the following four demolition methods can be used selectively as shown in Table 2 for each of the three major construction types as detailed in section 1 (cf. Rentz et al, 1994; DIN 18007, 2000):

Table 2: Suitability of various demolition methods for each of the three major construction types in Germany

Construction type with respect to table 1	Types of demolition methods			
	<i>Removal (with hand tools)</i>	<i>Ebbing (top down removal with grabber or gripper)</i>	<i>Pressing (horizontal pressure from outside with excavator or bulldozer)</i>	<i>Blasting (tumbling building down through use of explosives)</i>
Type 1	√	√	√	√
Type 2	√	√	X	X
Type 3	√	X	X	X

Often a mixture of these methods is employed. The selection and combination of demolition methods depend on local conditions, such as space constraints, specifications on material separation and reusability of demolition waste as well as legal conditions in terms of national and local limited values for noise, dust and vibrations with respect to environmental and health protection.

For instance the combination, manual removal combined with machine ebbing, is used for projects, where high quality materials that attract premium EUR/t rates for recycling can be economically recovered using more expensive manual labour methods. The lower value C&D materials are demolished as a heterogeneous mass via lower cost automated methods for subsequent sorting and designations, as reuse, recycle or landfill items.

1.3 Barriers for deconstruction to make better use of the C&D waste in Germany

The major barriers for deconstruction in the German market that prevent the property development industry from making better use of the C&D waste include:

- Existing buildings are not designed for dismantling;
- Major components within these buildings have not been designed for disassembly;
- Suitable machines for deconstructing existing buildings often do not yet exist;
- Disposal costs for demolition waste are often very low offering no financial penalty;
- Deconstruction of existing buildings by focussing on a high level of material separation often takes additional time;

- Building codes and/or materials standards often make the reuse of C&D waste difficult;
- Uncertain cost factors for the deconstruction process of existing buildings;
- Lack of standardised “best practice” for deconstruction in the demolition industry;
- Hazardous materials such as lead, asbestos and PCBs in pre-1980’s buildings;
- Lack of quantitative case studies to show economic, environmental and social benefits.

Whilst architects and engineers in Germany are now starting to design new buildings for future deconstruction (BMVBS, 2011), the problem remains with deconstruction of existing building stock particularly with regards to the contamination and heterogeneity of C&D waste. Accordingly, government, academic institutions and industry associations in Germany are currently focusing their efforts on development of technical, policy and other solutions to support the advancement of “sustainable” deconstruction, which includes the reuse of recycled material as well as design for deconstruction in the future (BMVBS, 2011; DIN 15643, 2011, DGNB, 2012).

1.4 Strategies to overcome these barriers in Germany – technical, political and other

The main **political** strategy that has been developed to overcome some of the barriers in Germany with respect to making better use of C&D waste is the Federal “Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal” (KrW-/AbfG). It aims to ensure, as far as possible, avoidance and recovery of C&D waste through waste producers and the property developers in case of deconstruction, and contains basic principles for waste management and closed loop recycling strategies. It provides a waste management hierarchy and states, that the first goal of waste management must be waste prevention and avoidance. If prevention is not possible, the composition of waste must be improved in order to permit reuse or recycling (KrW-/AbfG, 2012). With respect to this issue, the ordinance about waste treatment (NachwV, 2006) reinforces the KrW-/AbfG. Tariffs for disposal of C&D waste vary locally across Germany.

There are several **technical** strategies in Germany that have also been developed to overcome some of these barriers. Technical standards are set, such as the ATV DIN 18459, which covers, amongst other general and contracting issues regarding all kinds of construction work, the extraction, storage and transportation of deconstruction materials and components based on the European Waste Catalogue (EWC) (Sunke and Schultmann, 2008). As mentioned above, government, academic institutions and industry associations in Germany are currently developing technical solutions, such as building certification systems to support the advancement of “sustainable” deconstruction, which includes the reuse of recycled material as well as design for deconstruction in the future (BMVBS, 2011; 2011, DGNB, 2012). There is also a work instruction for the recycling of C&D wastes as well as the use of recycled materials in federal buildings (BMVBS, 2008).

Furthermore, research projects, such as the study of “best practice” methods for deconstruction and recycling of C&D waste by the French-German Institut of Technology (DFIU) in conjunction with various industry association partners, support political efforts to overcome barriers with respect to making better use of C&D waste. Here studies have been undertaken to compare the cost, time and percentage to landfill impacts of various deconstruction methods such as selective dismantling versus manual sorting of C&D waste after conventional demolition as shown in Figure 2 (Schultmann and Rentz, 2002):

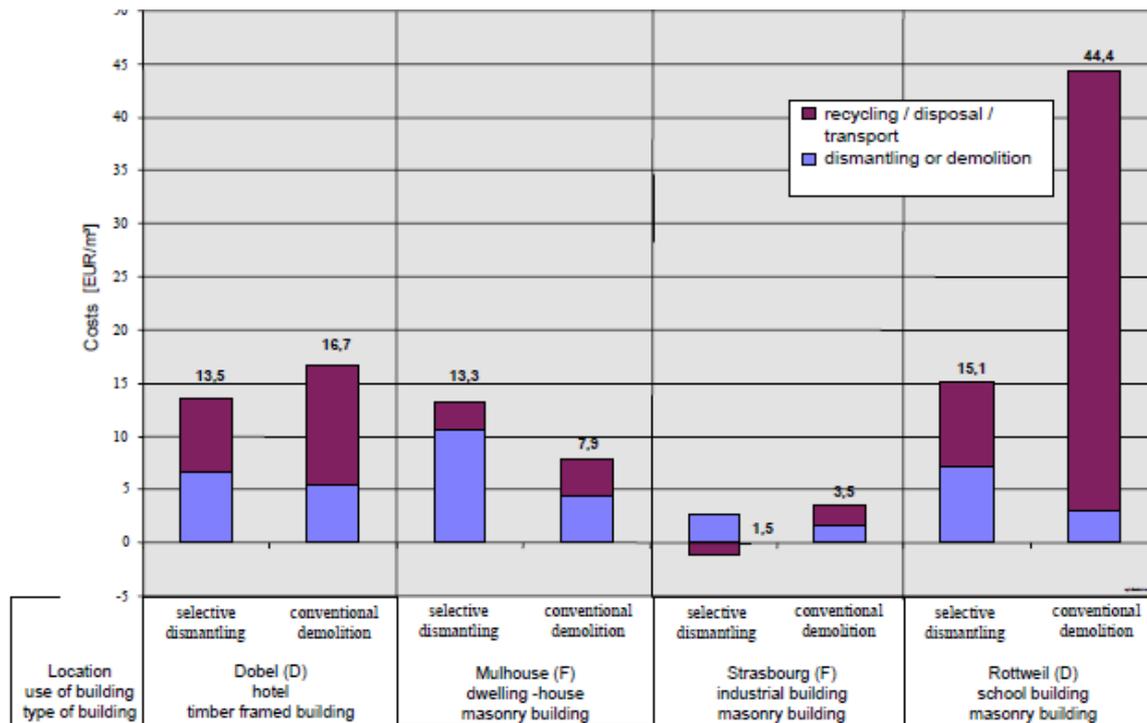


Figure 2: Sample study of various deconstruction methods (Schultmann and Rentz, 2002)

Depending on the disposal costs and recycling income opportunities in the region where the building is situated, the additional personnel costs for selective dismantling may outweigh the landfill disposal and raw material cost offsets plus the income received from local recycling of C&D materials thus favouring post demolition sorting of C&D materials (Schultmann, 1998). Studies of recycling methods for C&D waste have also been undertaken, which show that whilst the air flow separation methods as used in the majority of German recycling facilities have lower operating costs, the more expensive water based separation systems result in higher recovery rates from mixed C&D waste, as shown in Figure 3 (Hanisch, 1998).

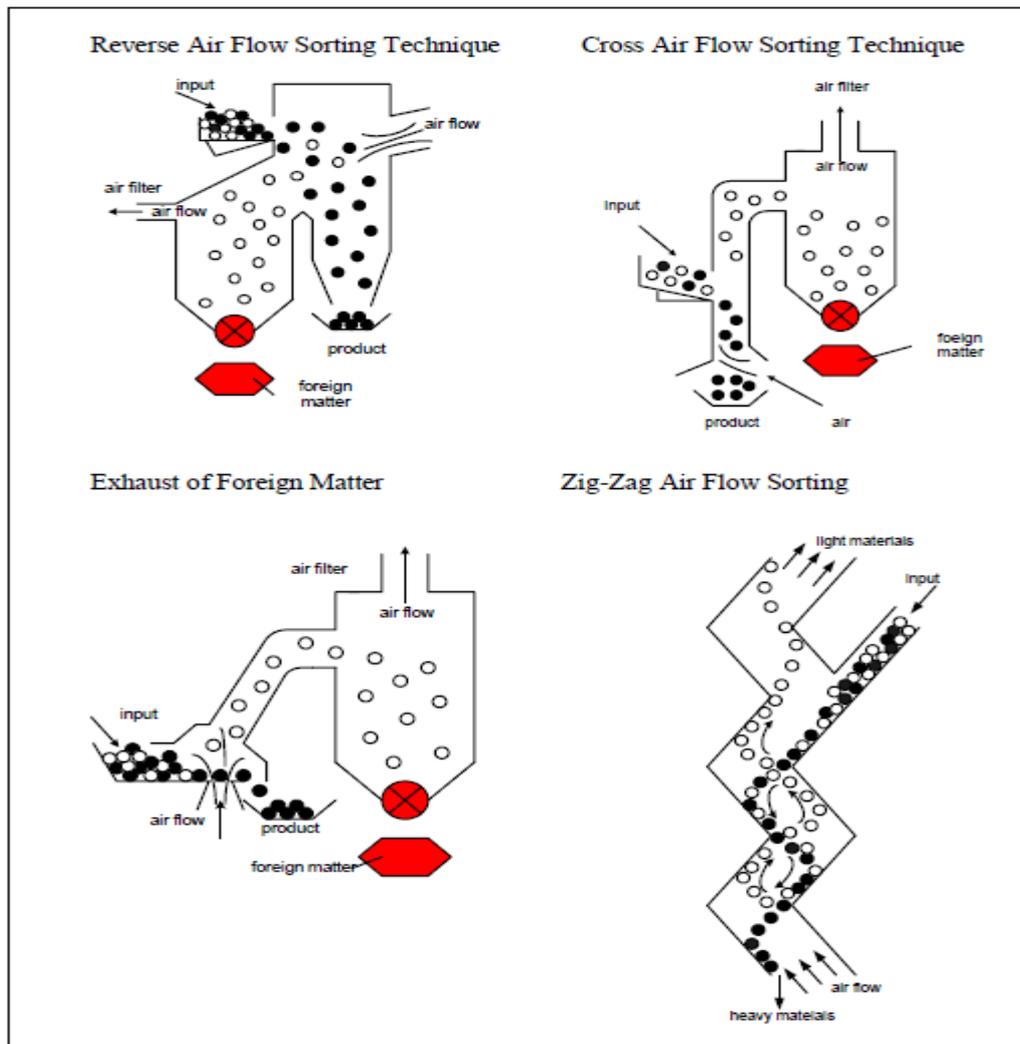


Figure 3: Sample study of air flow based C&D waste separation systems (Hanisch, 1998)

Other strategies in Germany that are being developed to overcome remaining barriers to making better use of C&D waste include the research and development of **systems supporting sustainable deconstruction already in the deconstruction planning phase**. For instance, the French-German Institute for Environmental Research (DFIU) at the Karlsruhe Institute of Technology (KIT) does research together with the Institute for Technology and Management in Construction (TMB) at the KIT, the “Fachgruppe Bauliches Recycling” at the Brandenburg University of Technology Cottbus (BTU) and two industrial partners with respect to a sustainable deconstruction approach built on common technical strategies by adding environmental metric measurements, such as noise, dust, vibration and hazardous materials, at new case study sites for integration with computer based decision support and an optimisation tool (DFIU, 2012). The objective of this research project, which is funded by the “Deutsche Bundesstiftung Umwelt” (DBU), is to develop an enhanced software tool and a sustainable deconstruction protocol that supports the engineer as well as the deconstruction company in the first instance in minimising any potential negative environmental and human impacts through the deconstruction process during the deconstruction planning phase.

References

ATV DIN (German Institute for Standardization) 18459 (2006): VOB Vergabe- und Vertragsordnung für Bauleistungen - Teil C: Allgemeine Technische Vertragsbedingungen für Bauleistungen (ATV) - Abbruch- und Rückbauarbeiten. Status 2006-10.

BMVBS (Federal Ministry of Transport, Building and Urban Development) (2011): Bewertungssystem Nachhaltiges Bauen (BNB) Neubau Büro- und Verwaltungsgebäude – Technische Qualität – Technische Ausführung – Rückbau, Trennung und Verwertung. Version 2011_1. Online available: http://www.nachhaltigesbauen.de/fileadmin/pdf/BNB_Steckbriefe_Buero_Neubau/aktuell/BNB_BN_414.pdf, accessed on 28.07.2012.

BMVBS (Federal Ministry of Transport, Building and Urban Development) (2008): Arbeitshilfen zum Umgang mit Bau- und Abbruchabfällen sowie zum Einsatz von Recycling- Baustoffen auf Liegenschaften des Bundes – Arbeitshilfe Recycling. Online available under: <http://www.arbeitshilfen-recycling.de/index0.html>, accessed on 29.07.2012.

DFIU (French-German Institute for Environmental Research) (2012): Minimierung von Umweltbelastungen beim Abbruch von Hoch-/Tiefbauten und Schaffung hochwertiger Recyclingmöglichkeiten für Materialien aus Gebäudeabbruch (1. Phase). Research project. Project description (*in German*) online available: http://www.iip.kit.edu/773_1715.php, accessed on 27.07.2012.

DGNB. 2011. DGNB Certificate Online available under: <http://www.dgnb.de/dgnb-system/en/>, accessed on 28.07.2012.

DIN (German Institute for Standardization) EN 15643 (2011): Sustainability of construction works – Sustainability assessment of buildings. Status 2011-2.

DIN (German Institute for Standardization) 18007 (2000): Abbrucharbeiten - Begriffe, Verfahren, Anwendungsbereiche. Status 2000-05.

Hanisch, J. (1998): Aktueller Stand der Bauabfallsortierung. In: Aufbereitungs-Technik, Vol. 39, 1998, No. 10, pp. 485/492.

Klauß, S.; Kirchhof, W.; Gissel, J. (2009): Katalog regionaltypischer Materialien im Gebäudebestand mit Bezug auf die Baualtersklassen und Ableitung typischer Bauteilaufbauten. ZBU, Kassel, October, 2009.

KrW-/AbfG () (2012): Gesetz zur Förderung der Kreislaufwirtschaft und Sicherung der umweltverträglichen Bewirtschaftung von Abfällen (Kreislaufwirtschaftsgesetz). Date of execution, 24.02.2012.

Mahapatra, K., Gustavsson, L. and Hemstrom, K. (2012): Multi-storey wood-frame buildings in Germany, Sweden and the UK. In: Construction Innovation: Information, Process, Management, Vol 12, 2012, No. 1 pp. 62-85.

NachwV (2006): Verordnung über die Nachweisführung bei der Entsorgung von Abfällen (Nachweisverordnung). Date of execution, 20.10.2006. Latest revision, 24.02.2012.

Rentz, o.; Ruch, M.; Nicolai, M.; Spengler, T., Schultmann, F. (1994): Selectiver Rückbau und Recycling von Gebäuden. Landsberg, ecomed Verlagsgesellschaft, 1994.

Schultmann, F. (1998): Kreislaufführung von Baustoffen, stoffflußbasiertes Projektmanagement für die operative Demontage- und Recyclingplanung von Gebäuden. Erich Schmidt Verlag (Reihe Baurecht und Bautechnik), Berlin, 1998.

Schultmann, F.; Rentz, O. (2002): Scheduling of deconstruction projects unter resource constrains. In: Construction Management and Economics, Vol. 20, 2002, No. 5, pp.391-401.

Sunke, N.; Schultmann, F. (2008): Waste management in Germany. In: CIB Report, Construction Materials Stewardship in Selected Countries, 2008.

2. Barrier for Reuse and Recycle

2.1 The top five C&D wastes in Germany

The top five C&D wastes in Germany consist of excavated earth, demolition debris, road construction waste, construction waste and cement construction material.

Table 3 shows the relative composition of C&D waste and the status of recycling in 2004. As shown, most recycled C&D waste is demolition waste and road scarification (Sunke and Schultmann, 2008).

Table 3: C&D Waste Composition and Recycling in Germany, 2004 (Sunke and Schultmann, 2008, cf. Li et al. 2012)

Waste type	Total C&D waste production		Amount of waste recycled
	million tons	%	million tons
Demolition waste	50.5	25.2%	31.1
Road scarification	19.7	9.8%	18.4
Construction waste	1.9	0.9%	0.1
Cement	0.3	0.2%	-
Total (without excavation)	72.4	36.1%	49.6
Waste from excavation	128.3	63.9%	9.1
Total	200.7	100%	58.7

With regards to the overall treatment of C&D waste in Germany, most of the recovered waste was dealt with by “treatment for recovery” and “energy recovery” is largely avoided, as shown in Table 4 for 2008. For disposal, most waste went to landfill, followed by “treatment for disposal”. Only a small part of the waste was incinerated, which resulted in an overall recovery rate of 88% (Federal Statistical Office, 2010).

Table 4: C&D waste balance in Germany in 2008 (units '000 tonnes) (Federal Statistical Office, 2010, cf. Li et al. 2012)

		C&D waste	Hazardous waste	Non-hazardous waste
Total		200 517	8 489	192 028
Disposal		24 024	3 713	20 311
Of which	Landfill	22 577	2 671	19 906
	Incineration	154	50	104
	Treatment for disposal	1 293	992	301
Recovery		176 494	4 777	171 717
Of which	Energy recovery	824	201	623
	Treatment for recovery	175 670	4 576	171 094
Recovery rate %		88	56	89

2.2 Other C&D wastes in Germany for universal concern

A total of approximately 8.5 million tonnes of “hazardous” C&D waste was generated in Germany in 2008, which included materials of universal concern, such as asbestos and plastic sealants containing PCB’s. These materials are classified under codes 17 06 05 and 17 09 02 respectively in the integrated European Waste Catalogue (EWC) (Figure 4), which came into force in 1999 via the national ordinance EAKV.

[17 BUILDING AND DEMOLITION WASTES (INCLUDING EXCAVATION OF CONTAMINATED LOCATIONS)]
17 01 concrete, brick, tiles and ceramic(s)
17 01 01 Concrete
17 01 02 Bricks
17 01 03 Tiles, bricks and ceramic(s)
17 01 06 * Mixtures of, or fractions of concrete, bricks, tiles and ceramic(s), containing dangerous material
17 01 07 Mixtures of concrete, bricks, tiles and ceramic(s) with exception of those that fall under 17 01 06
17 02 Wood, Glass and Plastic
17 02 01 Wood
17 02 02 Glass
17 02 03 Plastic
17 02 04 * Glass, plastic and wood contaminated by dangerous materials
17 03 Bitumen mixtures, Coaltar and Tar containing products
17 03 01 * Coal tar contaminated bitumen mixtures
17 03 02 Bitumen mixtures with exception of those under 17 03 01
17 03 03 * Coal tar and tar containing products
17 04 Metals (including alloys)
17 04 01 Copper, bronze, brass
17 04 02 Aluminum
17 04 03 Lead
17 04 04 Zinc
17 04 05 Iron and steel
17 04 06 Tin
17 04 07 Mixed metals
17 04 09 * Metal waste contaminated by dangerous materials
17 04 10 * Cables contaminated by oil, coal tar or other dangerous materials
17 04 11 Cables with exception of those, under 17 04 10
17 05 Soil (including excavation of contaminated locations), stones and waste
17 05 03 * Soil and stones containing dangerous materials
17 05 04 Soil and stones with exception that covered by 17 05 03
17 05 05 * Waste containing dangerous materials
17 05 06 Waste with exception of that under 17 05 05
17 05 07 * Track ballasts containing dangerous materials
17 05 08 Track ballasts with exception of that under 17 05 07
17 06 Damming material and asbestos contaminated building materials
17 06 01 *Damming material containing asbestos
17 06 03 *Other damming material, which consists
17 06 04 Damming material with exception of those under 17 06 01 and 17 06 03
17 06 05 *Asbestos contaminated building materials
17 08 Gypsum based building materials
17 08 01 * Gypsum based material contaminated by dangerous materials
17 08 02 Gypsum based building materials with exception of those under 17 08 01
17 09 Other building and demolition wastes
17 09 01 * Building and demolition wastes containing mercury
17 09 02 * Building and demolition wastes containing PCB (e.g. PCB contaminated sealants, PCB contaminated floor mats on resin base, PCB contaminated insulating glazings, PCB contaminated condensers)
17 09 03 *Other building and demolition wastes (including mixed wastes), the dangerous materials contained
17 09 04 Mixed building and demolition wastes with exception of those falling under 17 09 01, 17 09 02 and 17 09 03
(* denotes waste requiring special examination or monitoring)

Figure 4: European Waste Catalogue showing asbestos and PCB codes (EAKV, 1999)

Whilst it is difficult to obtain data on the amount of asbestos containing C&D waste in Germany, the amount of C&D waste containing PCB’s was estimated at 0.02 million tonnes based on 2006 data contained in the report “Waste Accounting in Germany – Possibilities and Limits” (Federal Statistical Office, 2011).

2.3 Recycle ratio of C&D waste in Germany

The C&D waste recovery rate in Germany is one of the highest in the world. In 2006, the recovery rate of C&D waste was 70% or 51 million tons (Federal Ministry for the Environment, 2006), which well exceeded the targets set for EU member states (Commission, 2010a). The individual

recycle rates for the top five C&D wastes in Germany range from 0% to a maximum of 93% as shown in Table 5 (Sunke and Schultmann, 2008):

Table 5: Recovery rates by C&D waste type in Germany (Sunke and Schultmann, 2008)

Waste type	Recovery rate (%)
Excavation waste (i.e. earth)	7
Demolition waste (i.e. bricks, concrete, steel etc)	62
Road scarification (i.e. bitumen)	93
Construction materials (i.e. packaging, off-cuts etc.)	5
Cement (i.e. leftovers from batch mixes)	0

The recovery rate for hazardous materials such as PCB's has been estimated at 49% with other materials of universal concern such as asbestos having a 0% recovery rate as it is normally disposed of in clearly marked landfill areas (Federal Statistical Office, 2011).

2.4 Products produced in Germany from C&D waste

A detailed study of potential products that can be produced from C&D waste has been undertaken for the demolition waste category, as shown in Table 6 (Leal et al, 2006).

Table 6: Demolition waste reuse and recycling options in Germany (Leal et al, 2006)

Demolition waste type	Reuse options	Recycling options
Concrete	Prefabricated items & concrete blocks can be reused directly with little processing	Can be crushed and ground to aggregate or sorted and used as fill
Brick	Can be reused directly after considerable time is taken to sort and clean suitable bricks	Can be crushed and ground to aggregate or sorted and used as fill
Wood	Solid elements can be reused directly in structural applications	Shredding for use as mulch or in engineered wood products and pelletisation for use as fuel
Steel	Some elements such as roofing sheets can be reused directly subject to condition	Shredding for use in place of gravel fill or smelting to replace use of new ore
Aluminum	Rarely reused directly as aluminum is often designed for one time use only	Commonly melted in rotary furnaces under a layer of liquid melting salt, refined and cast
Plastics	Rarely reused directly as plastic is often designed for one time use only	Plastic tubes, PVC floor mats and windows are melted to form new PVC roofing sheets
Tiles	Can be directly reused when free of dangerous materials and damage	Crushed with brick and concrete to be used as fill in place of gravel
Mixed excavation waste	Soil mixed with foundations can generally be reused on site as backfill for sand and gravel pits	Treated for contamination and sorted for use as backfill or as road base

2.5 Barriers for reuse and recycling of C&D waste in Germany – technical, political and other strategies to overcome these barriers

Most C&D waste recycled in Germany is from demolition work without much recovery from new construction waste, as shown in Table 5. One of the barriers to achieving this is the lack of specific laws relating to the reduction of the use of landfill sites for non-recycled C&D waste. As these landfill sites take up more land resources and impose risks on the environment, it is therefore necessary for the German government to employ **political** strategies to overcome this barrier, such

as the establishment of relevant legislations enforcing the reduction of new construction waste being sent to landfill (Li et al., 2012).

Another barrier is the lack of specific regulations on manufacturers' responsibility for waste minimisation in the German construction industry. The products produced by manufacturers, transported to construction sites and used in buildings contribute to waste problems and environmental impact, if the products cannot be recovered or degraded. It is therefore necessary for the German government to adopt additional **political** strategies to overcome this barrier such as regulations and policies on C&D waste minimisation from the perspective of the construction material manufacturer. Higher standards for material design and product stewardship need to be established for construction material manufacturers so as to encourage them to take up their responsibilities for waste minimisation in construction projects.

Technical strategies to help overcome these barriers could include research regarding innovation in packaging production for construction materials in order to minimise waste and facilitate ease of recovery. The government needs to establish R&D incentive measures for technological innovation in construction material packaging so as to minimise waste and increase reuse and recycling, similar to what has been done in the German automotive component industry since 1995 when suppliers were made responsible for recovery of their packaging materials from the auto manufacturer. This leads for instance to the development of the reusable, collapsible auto component package, as shown in Figure 5 (Bylinsky and Moore, 1995).



Figure 5: Example of reusable, collapsible auto industry component packaging (Bylinsky and Moore, 1995)

Other possible strategies to overcome these barriers to greater reuse and recycling of C&D waste in Germany include **financial incentives** from the government for the recovery of waste generated from construction processes. The construction industry client needs to be financially motivated to incorporate waste management as part of the project delivery process. Project teams who successfully achieve high waste recovery rates also need to be rewarded financially and the lessons learned need to be shared via case studies. Waste management companies also need to be provided with financial incentives to encourage the adoption of new technologies to improve the effectiveness of waste recycling processes. (Li et al., 2012).

References

Bylinsky, G.; Moore, A.H. (1995): Manufacturing for reuse: Fortune, Vol 131, 1995, No. 2 pp. 102-112.

EAKV (1999): Verordnung zur Einführung des Europäischen Abfallkatalogs (EAK-Verordnung), vom 13.09.1996, Bundesgesetzblatt I S. 1428-1446.

Federal Ministry for the Environment (2006): Waste Management in Germany 2006. Online available under: http://www.bmu.de/english/waste_management/doc/3446.php. Accessed: 13.08.2012, updated 03.2006.

Federal Statistical Office, 2010: Environment - Waste Balance 2008. Federal Statistical Office. Wiesbaden, 2010.

Federal Statistical Office (2011): Waste accounting in Germany – Possibilities and Limits. Final Report February 2011. Federal Statistical Office - Environment, Environmental-Economic Accounting Group.

Leal, W.; Schultz, C.; Gottwald, J.; Weisleder, S.; Nasser, D. (2006): Construction and Demolition Waste Management in Germany, in: EU-Asia Pro Eco II B Post-Tsunami Programme Report, October 2006, pp. 23-55.

Li, M.; Kühlen, A.; Yang, J.; Schultmann, F. (2012): Improvement of statutory framework for construction and demolition waste management exemplified by Germany and Australia. Issued at the Urban Environment Symposium, in Karlsruhe, 16.-19.09.2012.

Sunke, N.; Schultmann, F. (2008): Waste management in Germany. In: CIB Report, Construction Materials Stewardship in Selected Countries, 2008.