16. Processing and UtilisationII
Construction Waste + Scrap Wood

Types of Construction Waste

- Building rubble
- Excavation
- Roadway rubble
- Construction site waste

EWC-No.	Waste Terminology
17	Construction and demolition rubble (including excavation of polluted sites)
17 01	Concrete, bricks, tiles, and ceramics
17 02	Wood, glass, and plastic
17 03	Bitumen mixtures, coal tar, and tar-containing products
17 04	Metals (including alloys)
17 05	Soil (including excavation of polluted sites), stones, and dredged material
17 06	Insulating material and asbestos-containing building materials
17 08	Building materials on gypsum basis
17 09	Other building and demolition waste

These 4-digit groups are subdivided into 6-digit categories, among others into not particularly harmful waste (nbüA) and particularly hazardous waste (büA), for instance for Group 17 01:

17 01 01	nbüA	Concrete
17 01 02	nbüA	Tiles
17 01 03	nbüA	Tiles, bricks, and ceramics
17 01 06	büA	Mixtures or separate fractions of concrete, bricks, tiles, and ceramics which contain hazardous substances
17 01 07	nbüA	Mixtures of concrete, bricks, tiles, and ceramics except those subsumed under 17 01 06

In the recycling practice, the classification of construction waste is done according to substance and origin. At least the following Waste Key Numbers are relevant.

Soil excavation without pollutant load
170504

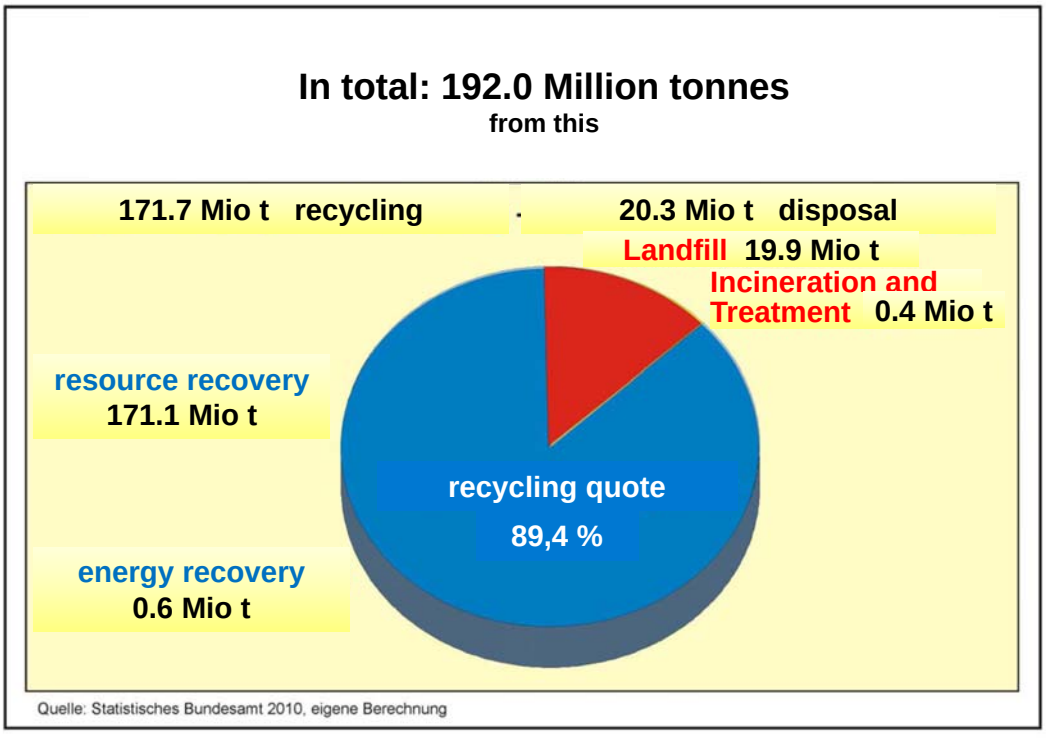
Roadway rubble from asphalt
170302
Roadway rubble from tar-containing asphalt
170301
Roadway rubble from concrete
170101

Building construction
170101, 170102, 171003, 170104
from concrete
from brickwork

Construction site waste
170701

construction and demolition waste 2008

(incl. road construction waste, harmless)



Technical instructions on produced from construction waste are more and more included in technical rules and regulations

Road construction

Directives on the quality control of mineral substances in road construction (RG Min-StB 93); Issue 1993/996

Leaflet on the re-use of concrete from road surfaces; Issue 1998

Technical Test Procedure for mineral materials in road construction (TP Min-StB) 1999; Issue 1999

Technical delivery terms for mineral materials in road construction TL Min StB 2000); Issue 2000

Directives on the environment-friendly application of industrial by-products and recycling building materials in road construction RuA-StB 01); Issue 2001

Road Construction

Leaflet on the re-use of mineral building materials as recycling building materials in road construction (M RC); Issue 2002

Leaflet on the re-use of bituminous lining material in road construction using bitumen emulsions; Issue 1993

Leaflet on the application of asphalt granulate (M VAG); Issue 2000

Directives on the environment-friendly utilisation of lining material with typical tar/bitumen components and on the utilisation of lining asphalt in road construction (RuVA-StB 01); Issue 2001

Leaflet on the application of lining asphalt and bitumous roadway rubble in substrata with hydraulic binding agents; Issue 2002

Construction Engineering

DAfStb Building Material Recycling Directive, Parts 1 and 2, German Committee for Reinforced Concrete, Berlin 1998

DIN 4226-100, Aggregates of concrete and mortar, Part 100: Recycling Aggregates, DIN, German Institute for Standardisation, registered society, Beuth-Verlag, Berlin 2002

Amounts and Disposal of Construction Waste

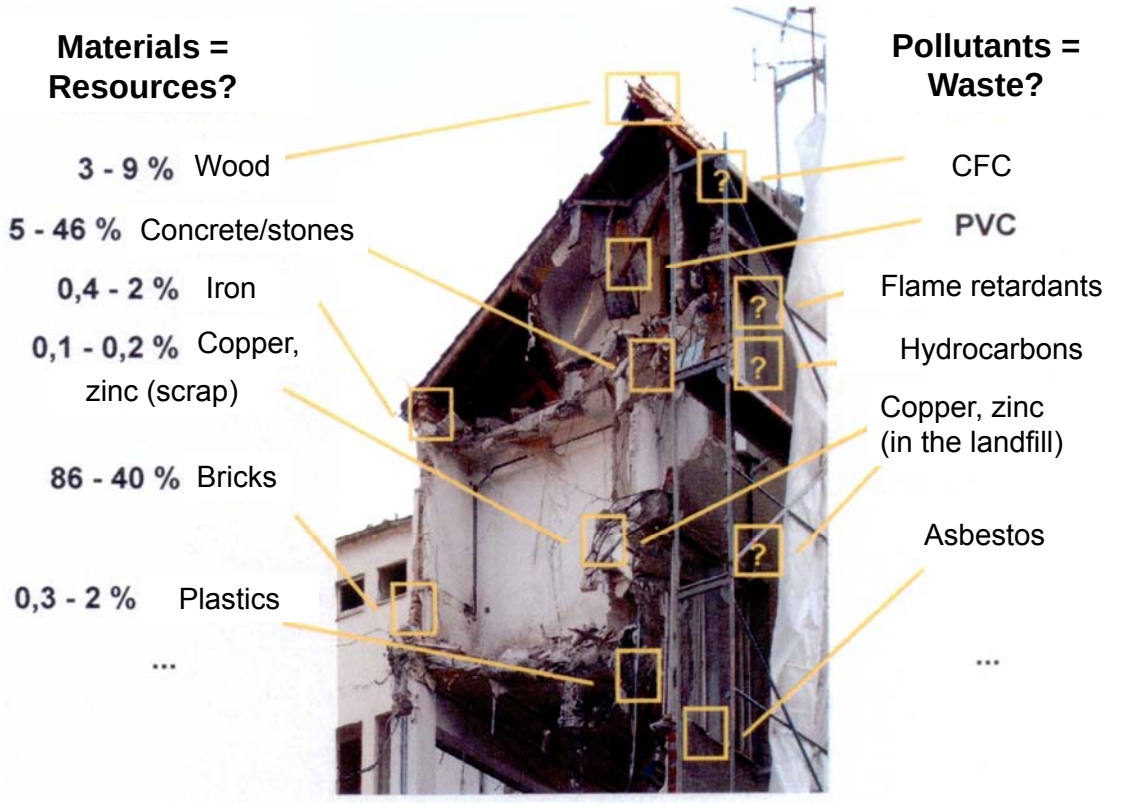
Excavation 1670 kg / P·a
Building rubble 700 kg / P·a

Roadway rubble 215 kg / P·a
Construction waste amounts ≈ Municipals wast amounts· factor 5 to 10

	1990	1996	1996	1998	2002	2004
Waste amounts in the building industry without internal utilisation on building sites, e.g. excavation and refilling in/under road surfaces, of which:	132,7	220,0		205	189	200,7
excavation		136,8		128,0	115,7	128,3
building rubble		58,1		58,5	52,1	50,5
roadway rubble		17,6		14,6	16,6	19,7
construction site waste		6,5		4,0	4,3	1,9
construction timber and demolition wood		1,0				
building rubble hard plaster based					0,3	0,3
of which disposed:	119,4	147 (66%)				142 (70%)
• disposed on soil and construction waste landfill	113,1					
• disposed on public landfills for municipal waste	4,9					
– other disposal; recultivation of mining areas	1,4	61				

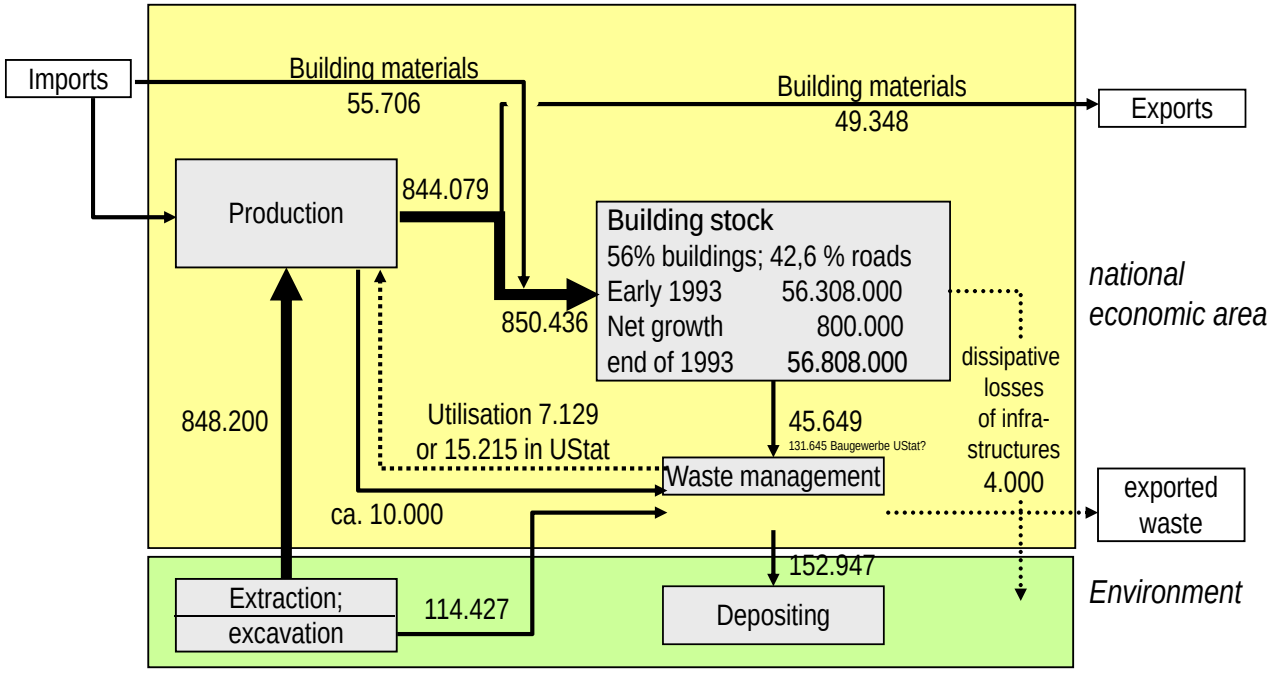
	1990	1996 disposed	1996 utilised (rate)			2004 disposed	2004 utilised (rate)
Excavation		123,5	13,3 (10%)			119,2	9,1 (7%)
Building rubble		17,4	40,7 (70%)			19,4	31,1 (62%)
Roadway rubble		2,6	14,0 (80%)			1,3	18,4 (93%)
Construction site waste		2,92	3,5 (55%)			1,8	0,1 (5,3%)
Construction timber and demolition wood		??	??			0,28	0,0

Repository Building



Mass Flow Balance for Building Materials/Construction Waste 1000 Mg

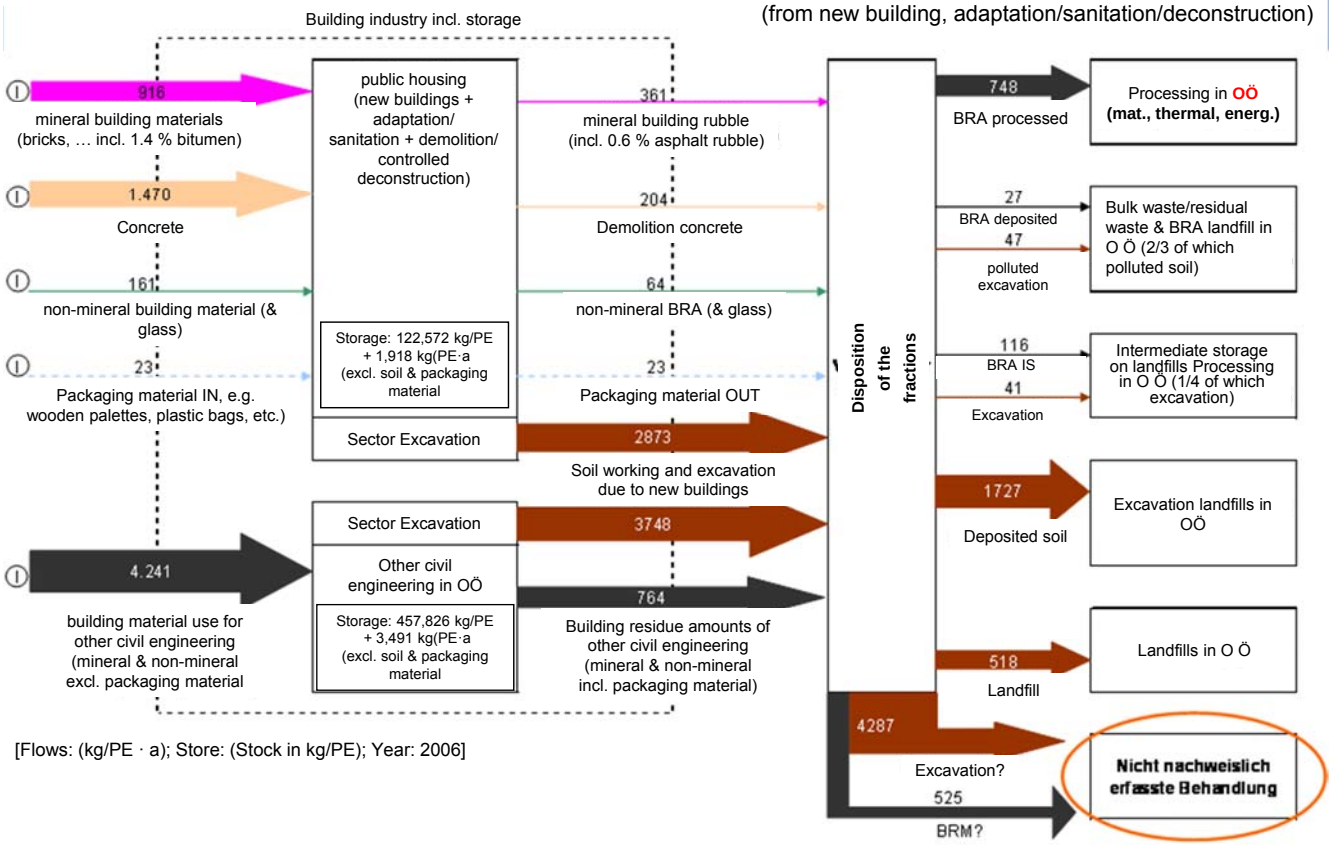
nach Gallenkemper et al., KA 1999



in D 1993

Building material use (for new buildings, adaptation/sanitation

Building residue amounts
(from new building, adaptation/sanitation/deconstruction)



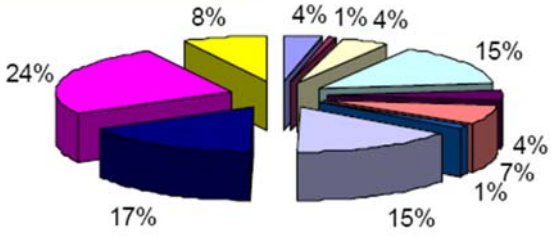
[Flows: (kg/PE · a); Store: (Stock in kg/PE); Year: 2006]

Amounts and utilisation ways of construction ways in 1999

	Amounts	Utilisation	
	[Mio t/a]	[Mio t/a]	[%]
Lining asphalt	15	15	100
Roadway rubble	28	27	96
Building rubble	45	29	64
Mixed building waste	12	4	33

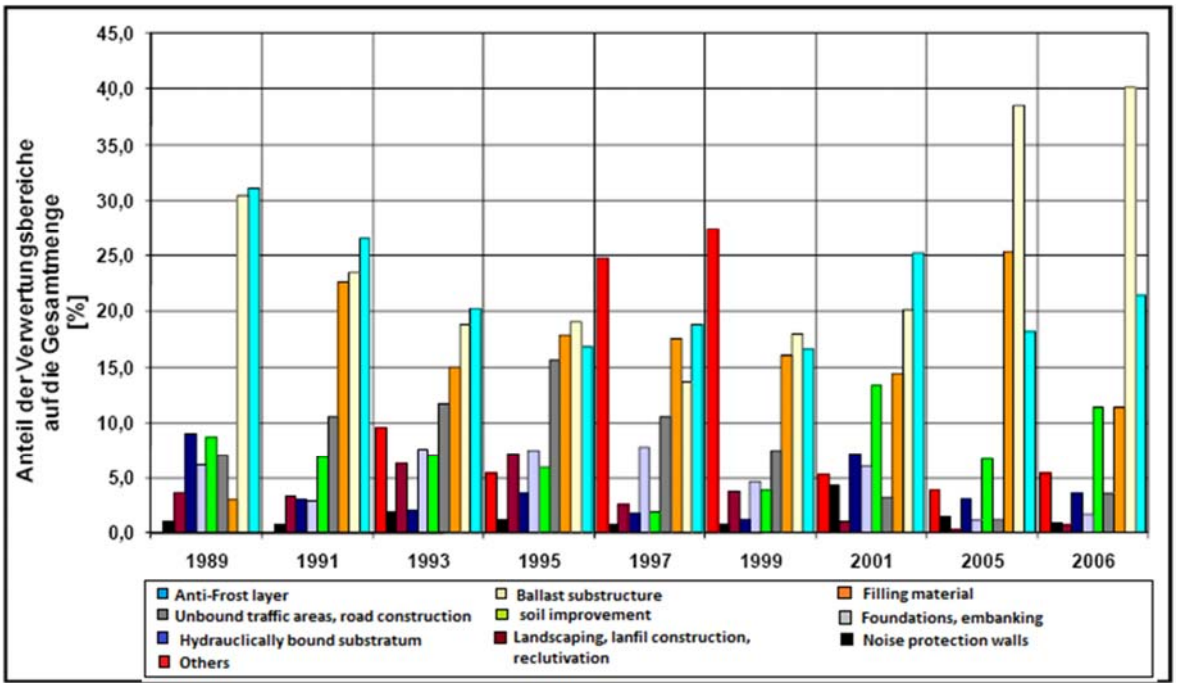
= Concrete Rubble

= concrete rubble + brickwork rubble



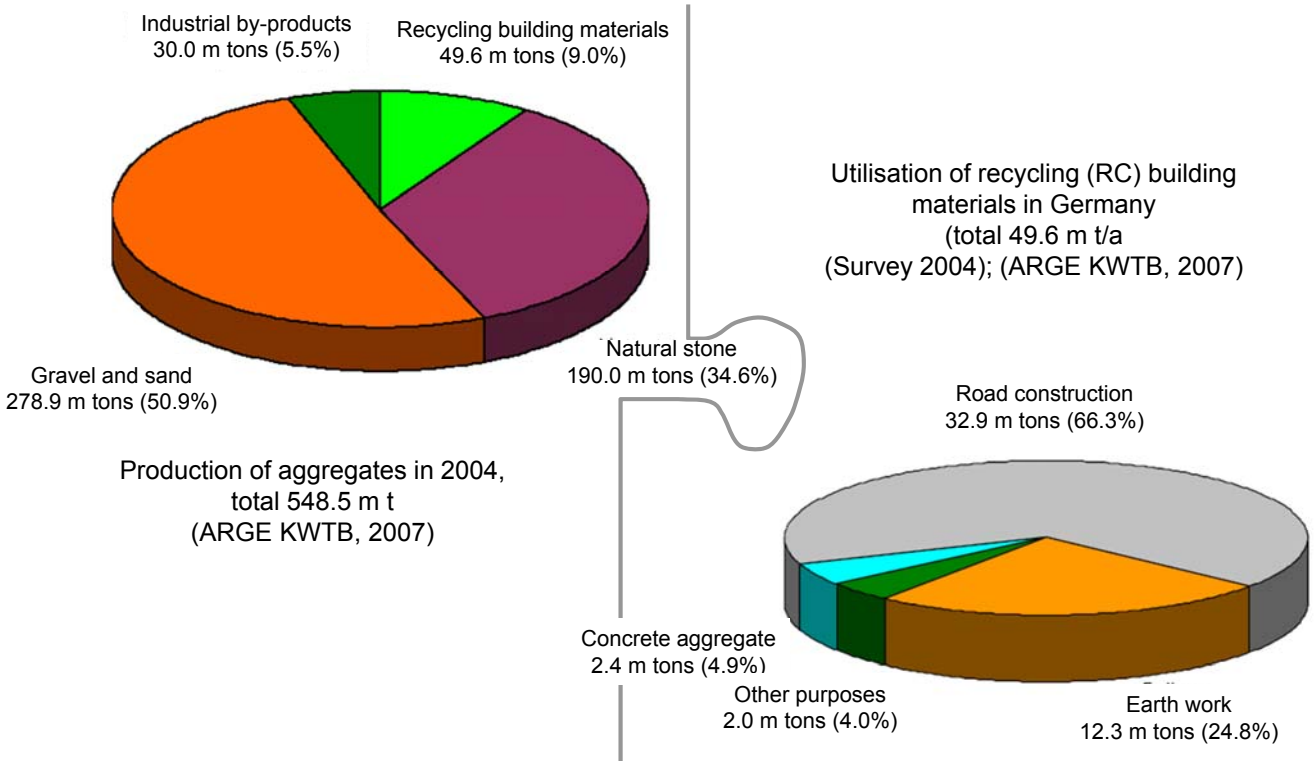
- Landscaping, landfill construction, recultivation
- Noise protection walls
- Foundations, embanking
- Filling material
- Soil improvement
- Unbound traffic areas, road construction
- Hydraulically bound substratum
- Anti-frost layer
- Ballast substructure
- Others
- Intermediate storage

Quelle: Krass, K.; Jungfeld, I.; Trogisch, H. Anfall, Aufbereitung und Verwertung von Recycling-Baustoffen und industriellen Nebenprodukten im Wirtschaftsjahr 1999 – Teil 1: Recycling-Baustoffe. Straße und Autobahn 53 (2002) 1, S. 22 – 30.



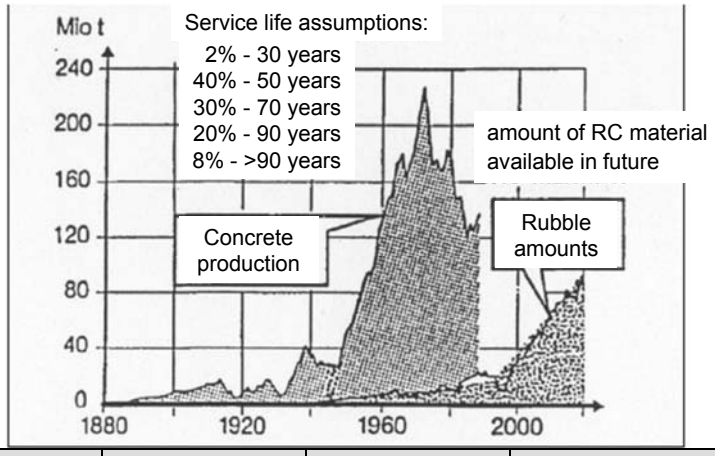
Porzentuale Verteilung des aufbereiteten Bauschutts auf die verschiedenen Verwertungsbereich (Percental allocation)

Utilisation of Recycling Building Material



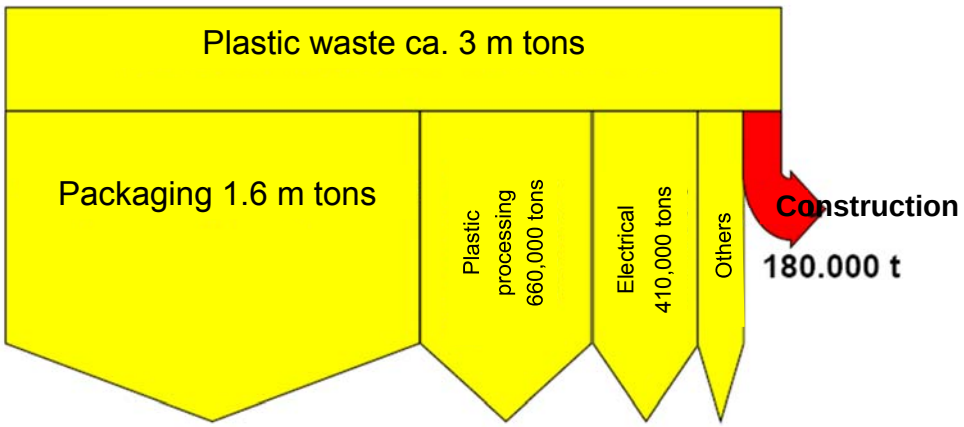
Forecasts on the production of construction waste

- Rahlwes [1991] to 2020
- Görg [1997] to 2010
- Fleckenstein et al. [1998] to 2040
- Study DIW [1999] to 2010



Sand and gravel		Natural stone		RC building material		Industrial by-products	
Mio. t	%	Mio. t	%	Mio. t	%	Mio. t	%
State 1997							
388	55,2	225	32	50	7,1	40	5,7
Forecast 2010							
364	52	206	29,4	90	12,9	40	5,7

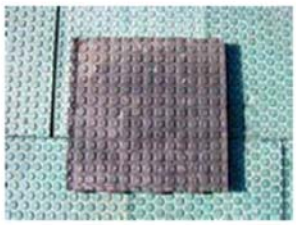
Mass flow diagram for plastic waste produced each year



nach L. WOLTERS; J. V. MARWICK; K. REGEL; V. LACKNER; B. SCHÄFER

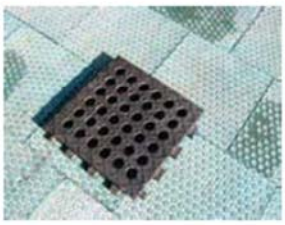
Bottom attachments

Knob plates



Plates with knob surface and mounting pins, for hall floors, parking lot surfaces, pavements, etc., elastic, break-proof, heat and cold resistant, recycled PE/PP

Grid blocks



Grid plates with mounting pins, as temporary floor cover, natural infiltration warranted, very resilient, break-proof, heat and cold resistant, recycled PE/PP

Paving “stones”

As floor cover for roads, drives or parking lots, resilient up to 40 t at a mass of 1520 g/piece, easily laid, break-proof, heat and cold resistant, recycled PE/PP

Construction

Roofing

Roofing tiles with a guaranteed durability of 50 years, algae-resistant, warp-resistant, and weatherproof, UV stable, very good heat and sound insulation, different colours, recycled plastic

Profiles

Spacers for the armouring in concrete formwork in variable cross-sections and lengths, U and H press cuts possible, PVC grinding material from production scrap of the plastic-processing Industry

Pipes, bushings

Pressure-less pipes for rainwater or wastewater pipelines, or as insulation of hot water pipes, also fittings, cable protection pipes, and cladding tubes, among others made of post-consumer yoghurt cup grinding material from the collections of the DSG

Landscaping

Hydraulic engineering	Noise and Sight Protection Walls	Profile Boards
		
Embankments, wave Breakers, also posts, plates, jetties, etc., chemically resistant, rot-proof, elastically and mechanically highly resilient, inherently stable, maintenance-free and biologically inactive; recycled plastic	Noise protection walls and screens for landscaping, simple mounting through relatively low mass of the single components, inherently stable, weather-resistant, usable for planting; recycled plastic	Profile boards for the building of paddocks, fences, railings and gates, simple maintenance and high durability without impregnation, cleaning with hot steam, moisture repellent and frost-proof; recycled plastic

Legal Framework and Waste Management Targets for Construction Waste

- Aspects like waste prevention (service life), material utilisation, and environment-friendly disposal (low pollutant amounts; few composites; soluble compounds) should already be considered during the development of new building materials, building products and building methods.
- Waste for disposal should be prevented as much as possible through suitable measures (such as choice of construction materials, construction methods, procedure of demolitions, direct re-use at the building site).
- Utilisation under observation of the quality requirements according to the KrwG-/AbfG has priority over disposal.
- At the sites where waste is produced, waste which is utilisable according to KrwG-/AbfG should be kept separate from polutted construction waste (for instance, asbestos-containing waste should be separated from other polluted types) and non-utilisable waste
- Extraneous material should be collected and disposed of separately.
- Special landfill categories D0 and D I for unpolluted mineral waste
- For construction waste, there is no Ordinance, but the negotiated environment agreement of the *Kreislaufwirtschaftsträger Bau (KWTB), i.e. the* participants in the recycling waste management in the building industry.

Quality Requirements on Recycling Building Material

- Quality requirements
  - suitability as building material, and
  - environmental behaviour
- suitability as building material/ seal of quality → Equivalence
  - Weather-resistance, frost-resistance
  - Grain shape, ratio of crushed grains
  - Grain strength, grain density, bulk density
  - Affinity to bitumous binding agents
  - Proctor density; settlement behaviour, shearing strength
  - DIN 4426-100 requirements on aggregates in regard to material composition and raw grain density for concrete and mortar

Components	Composition Percent by weight			
	Type 1	Type 2	Type 3	Type 4
Concrete and aggregates acc. to DIN 4226-1	≥ 90	≥ 70	≤ 20	≥ 80
Tiles, non-porified bricks	≤ 10	≤ 30	≥ 80	
Lime sand brick			≤ 5	
Other mineral components [a]	≤ 2	≤ 3	≤ 5	≤ 20
Asphalt	≤ 1	≤ 1	≤ 1	
Alien components[b]	≤ 0,2	≤ 0,5	≤ 0,5	≤ 1
Minimal grain density (kg/m³)	2000		1800	1500
Variation range raw grain density (kg/m³)	± 150			no requirements

Quality Requirements on Recycling Building Materials

- Environmental behaviour
  - LAGA Directive „Requirements on the material utilisation of mineral waste“

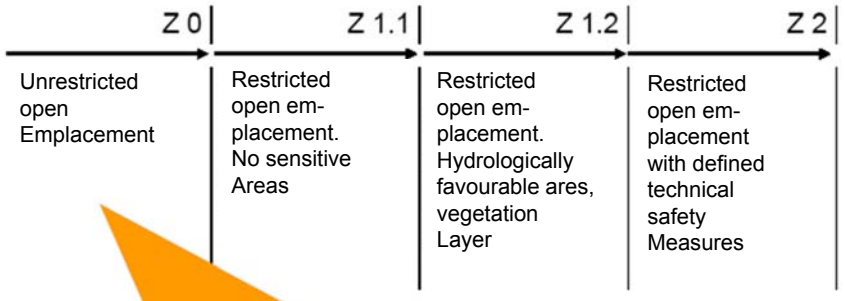
	Z 0	Z 1.1	Z1.2	Z 2	Z 3	Z 4	Z 5	
Emplacement categories (LAGA)	Utilisation unrestricted emplacement	Utilisation restricted open emplacement		Restricted emplacement with defined safety measures	Disposal = Landfill Category I	Disposal = Landfill Category II	Disposal Special waste aboveground landfill	Disposal Special waste underground landfill
	W 0	W 1.1	W 1.2	W 2				
Mining-specific utilisation above ground (LAB)	Unrestricted utilisation	Restricted utilisation (emission-neutral application)		Restricted utilisation with defined technical safety measures	(Waste Depositing Ordinance	(Waste Depositing Ordinance)	(TI Waste)	(TI Waste)
	$V 0_a$	$V 0_b$	V 1 (Z 4 Eluate)				V 2	
Stowing underground (LAB)	Unrestricted stowing with extensively low-pollution material		Restricted stowing (emission-neutral application)				Restricted stowing with defined safety measures (complete encapsulation)	

Significance of the LAGA-Z Values

- Utilisation of mineral waste depending on components and eluatability (Pollutant classes Z.....)

Z 0	Unrestricted emplacement (comparable to natural soils))	No impairment to be expected; still: no application on particularly sensitive areas
Z 1.1	Restricted (usage-related) open emplacement	Exceptions: water-protection areas, nature reserves, biotope areas
Z 1.2	Restricted (usage-related) open emplacement	Exceptions: agricultural areas; hydro-geologically unfavourable areas; necessary: protection against erosion (closed plant cover); >1m distance to groundwater
Z 2	Restricted (usage-related) emplacement with defined technical safety measures	Under upper sealings (d>0,50 m kf <1·10^{-8}m/s) or little or non-permeable cover layers

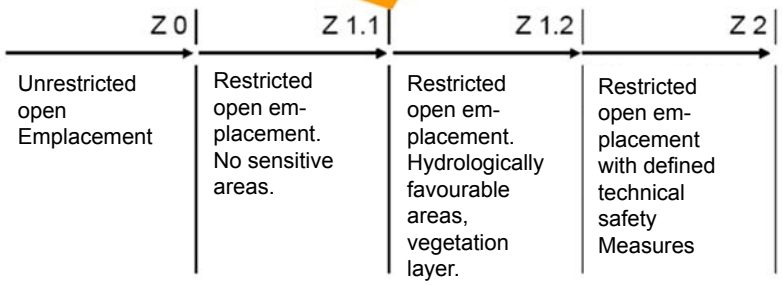
Emplacement conditions according to LAGA Z 0



Application permitted:
Playgrounds, footballs areas, sports facilities, unsealed schoolyards, allotments and domestic gardens, horticulturally or agriculturally used areas, defined or planned drinking water protection areas or mineral spring protection areas (Zones I and II)

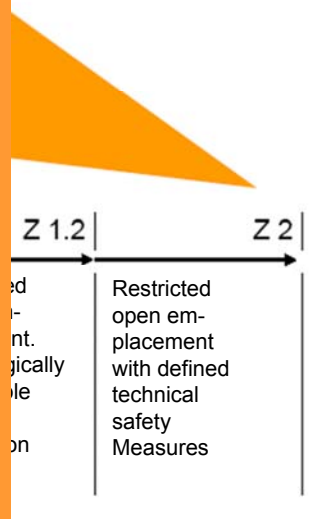
Emplacement Conditions according to LAGA Z 1

Application permitted:
recultivation areas in mining regions, road construction and accompanying earth work measures, industrial, commercial, and storage areas, parks with closed vegetation layers. Distance between pouring body bottom and highest assumed groundwater level at least 1m
Application not permitted:
drinking water or mineral spring protection areas which have been defined, temporarily seized or planned by the responsible authorities, areas with frequent flooding (e.g. flood control reservoirs, dammed-in areas), particularly sensitive areas (Z 0)



Emplacement Conditions according to LAGA Z 2

Application permitted:
Substratum under water-impermeable cover layer (concrete, asphalt, pavement),
bound substratum under little permeable cover layer (paving, plates), noise protection
wall with mineral surface sealing d ≥0.5 m and kf ≤ 10-8 m/s and overlying recultivation layer,
road embankment (roadbed) with water-impermeable road surface and mineral
surface sealing d ≥0.5 m and kf ≤ 10-8 m/s in the batter area with overlying recultivation layer
Distance between the pouring body bottom and the highest assumed groundwater level at least 1 m.
Application not permitted:
Water priority areas, karst areas, drainage layers or filling of utility trenches without technical
safety measures, surfaces according to Z 0 and Z 1



LAGA-Z Values

Directive			LAGA 1997				AbfAblV 2001 / LAGA 1997
Specification			Z 0	Z 1.1	Z 1.2	Z 2	Z 3 =Landfill Category I
Description			unrestricted	restricted open	like Z 1.1; in hydro-geolog. Favourable areas	restricted	Inert material landfill DI
Solids criteria							
Ignition losse		% of the DS	---			---	3
TOC		% of the DS	---			---	1
Extractable lipophile substances		% of the OS	---			---	0,4 /
Extractable org. halogenes	EOX	mg/kg	1		5	10	10
Hydrocarbons	HC	mg/kg	100	300	500	1.000	1.000
Polycyclical aromatic HCs (Σ 16 PAH acc. to US/EPA)	PAH	mg/kg	1	5 (20)	15 (50)	75 (100)	75 (100)
PCB (Σ 6 PCB acc. To DIN 51527)		mg/kg	0,02	0,1	0,5	1	1
Cyanides, total	CN^-	mg/kg	1				
Arsenic	As	mg/kg DS	20				
Lead	Pb	mg/kg DS	100				
Cadmium	Cd	mg/kg DS	0,6				
Chromium	Cr	mg/kg DS	50				
Copper	Cu	mg/kg DS	40				
Nickel	Ni	mg/kg DS	40				
Mercury	Hg	mg/kg DS	0,3				
Zinc	Zn	mg/kg DS	120				
Eluate criteria							
pH-value		---				7,0-12,5	5,5 - 13,0
Conductivity		µS/m	500	1.500	2.500	3.000	10.000
Chloride Cl-		mg/l	10	20	40	150	
Sulphate	SO_4	mg/l	50	150	300	600	
Arsenic	As	µg/l	10	10	40	50	200
Lead	Pb	µg/l	20	40	100	100	200
Cadmium	Cd	µg/l	2	2	5	5	50
Chromium (total)	Cr	µg/l	15	30	75	100	
Chromium VI	Cr VI	µg/l					50 /
Nickel	Ni	µg/l	40	50	100	200	200
Copper	Cu	µg/l	50	50	150	100	1.000
Mercury	Hg	µg/l	0,2	0,2	1	2	5
Zinc	Zn	µg/l	100	100	300	400	2.000
Phenole index		µg/l	< 10	10	50	100	200
Organic carbon	TOC	µg/l	---				20.000 /
Ammonium-N	NH_4-N	µg/l	---				4.000 /
Adsorbable. org. halog.	AOX	µg/l	---				300 /

Scrap wood

Scrap wood: collective term for residual industrial wood and used wood

Residual industrial wood:

wood residues emerging from wood machining and processing as well as residues
of derived timber products and wood composite
produced in the derived timber industry.
The latter need to contain at least
> 50 mass % wood.

Used wood:

wood residues originating from
used products made of solid wood,
derived timber products,
or wood composites
(wood ratio > 50 mass %)

Scrap Wood Ordinance

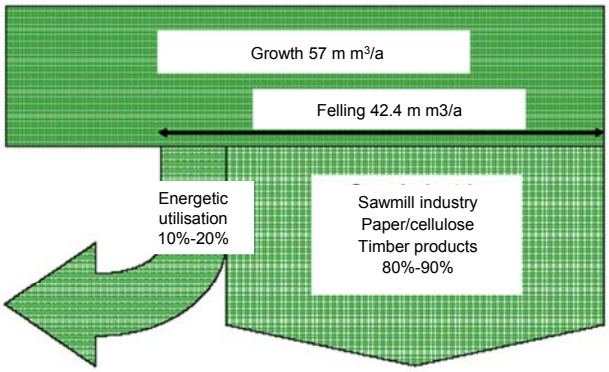
- Scrap Wood Ordinance (AltholzV, 2002; Ordinance on the Disposal of Scrap Wood)
  - Quality categories
  - Allocation to different disposal ways
  - Requirements on material and energetic utilisation and disposal

Quality Class	Allocation Criteria
A 1	Natural or only mechanically treated scrap wood which during its usage was polluted only insignificantly with substances foreign to wood
A 2	Bonded, painted, coated, varnished, or otherwise treated scrap wood without organic halogen compounds in the coating and without wood preservatives
A 3	Scrap wood with organic halogen compounds in the coating without wood preservatives
A 4	Scrap wood treated with wood preservatives, such as railroad sleepers, telephone posts, hop poles, vine poles, and other scrap wood which because of its pollutant load cannot be allocated to Scrap Wood Categories A I, A II or A III, excluding PCB scrap wood
PCB Scrap Wood	Scrap wood which is PCB waste according to the PCB/PCT Scrap Wood Ordinance and which must be disposed of in line with its regulations, particularly insulation and sound-insulation plates treated with agents that contain poly-chlorinated biphenyls

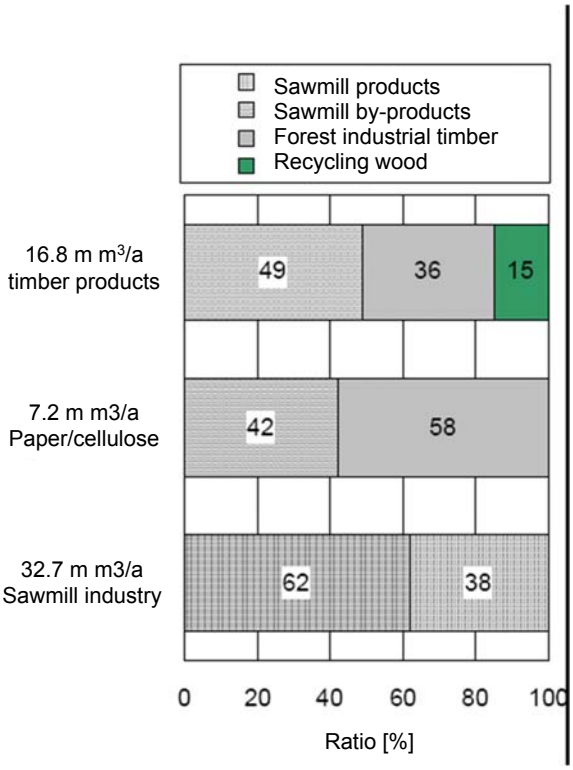
Construction Waste in the Scrap Wood Ordinance

Popular SW Selections			Standard allocation	Waste Key
Scrap wood from construction	Building site goods	Natural solid wood	A I	17 02 01
		Derived timber products, cladding timber, treated solid wood (without harmful pollutions)	A II	17 02 01
	Scrap wood from demolition and deconstruction	Floorboards, dead floors, plank boarding from interior work (without harmful pollution)	A II	17 02 01
		Door leaves and sashes of inside doors (without harmful pollution)	A II	17 02 01
		Profile leaves for interior design, ceiling panels, decoration beams, etc. (without harmful pollution)	A II	17 02 01
		Insulation and sound-proofing plates treated with PCB-containing agents	Disposal	17 06 03*
		Building chiboards	A II	17 02 01
		Construction timber for supporting parts	A IV	17 02 04*
		Wood framework and rafters	A IV	17 02 04*
		Windows, window stocks, outside doors	A IV	17 02 04*
		Impregnated building wood from the exterior	A IV	17 02 04*
	Building and demolition wood with harmful pollution		A IV	17 02 04*

Raw wood balance and material wood utilisation in Germany 2002 (without import and export)

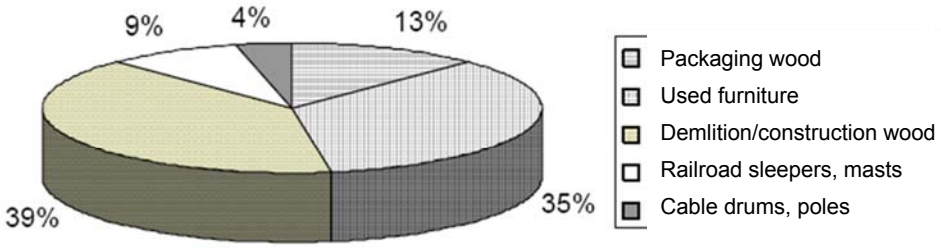


Quelle: Marutzky „Biomassen auf Basis von Holz als Brennstoffe in Österreich, der Schweiz und Deutschland" Referat zum VDI-Wissensforum, Salzburg 2004 Biobrennstoffe.pdf

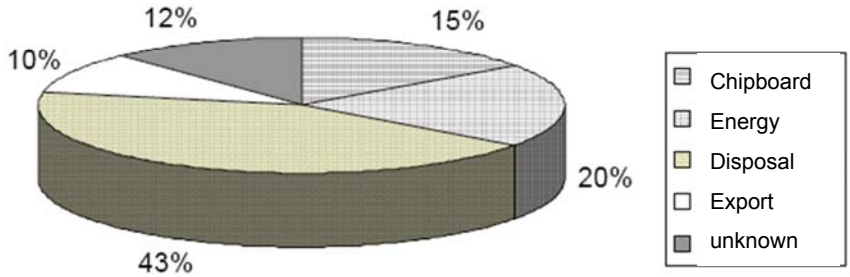


Amounts of used wood: ca 8 m t/a -> ca. 100 kg/l·a

Origin of used wood

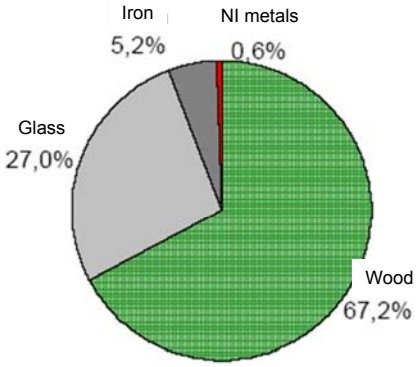


Disposal ways



Amount of scrap windows:
15 m pieces/a = 450,000 t/a

Components



Category ⇒ A IV

Amount of Railroad Sleepers:
150,000 m^3/a

Components:
Beech wood, impregnated with coal tar

Category ⇒ A IV

Pollutant contents in scrap wood from HSM

	Scrap Wood Ordinance	Natural Wood	Used Wood
	[mg/kg DM]		
Arsenic	2	~ LoD (0.02 - 1)	1 - 4
Chromium	30	0.5 - 5.6	20 – 30 Single values of fences and poles up to 100 times higher
Copper	20	< 2 – 6.2	7.5 - 55
Mercury	0.4	~ LoD (0.01 – 0.05)	around 0.1
Fluorine total	600	around 100	x·100 - x·1000
Fluorine	100	n.d.	n.d.
Lindan		~ LoD (0.001 – 0.13)	< 0.1 – 0.6
PAH		~ LoD (0.01 – 0.1)	20 - 80
PCB	3	0.01	0.2 – 0.5
PCP	5	0.01 – 0.1	1 - 10

LoD = Limit of detection

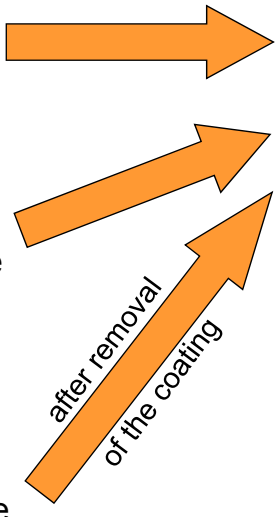
Pollutant contents from dye pigments in scrap wood

	Scrap Wood Ordicance	Natural Wood	Used Wood
	[mg/kg DM]		
Lead	30	~ LoD (0.1 – 5)	100 – 200
Cadmium	2	~ LoD (0.1 – 0.3)	0.8 – 1.6
Nickel		~ LoD	3 – 10
ZInc		6 - 61	100 - 1000

Scrap Wood Category A I: Natural or only mechanically treated used wood, which during its usage was not more than insignificantly polluted with substances which are foreign to wood

Scrap Wood Category A II: Bonded, painted, coated, varnished, or otherwise treated scrap wood without organic halogen compounds in the coating and without wood preservatives

Scrap Wood Category A III: Scrap wood with organic halogen coumpounds in the coating without wood preservatives



Material Utilisation
- Derived timber products
- Synthetic gas
- Wood oil
- Activated carbon/ industrial charcoal

Requirements on the application of derived timber products

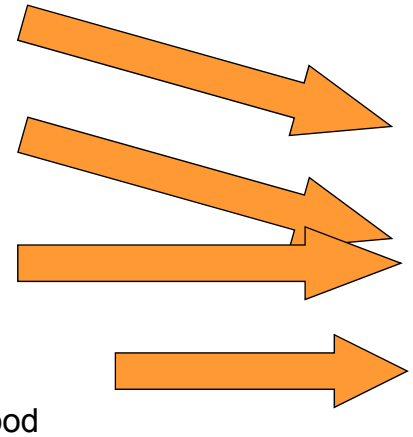
	[mg/kg DM]
Arsenic	2
Lead	30
Cadmium	2
Chromium	30
Copper	20
Mercury	0.4
Chlorine	600
Fluorine	100
PCP	3
PCB	5

Scrap Wood Category A I

Scrap Wood Category A II

Scrap Wood Category A III

Scrap Wood Category A IV:
Scrap wood treated with wood preservatives, such as railroad sleepers, telephone posts, hop poles, vine poles, and other scrap wood which due to its pollutant load cannot be allocated to Scrap Wood Categories A I, A II or A III, excluding PCB scrap wood



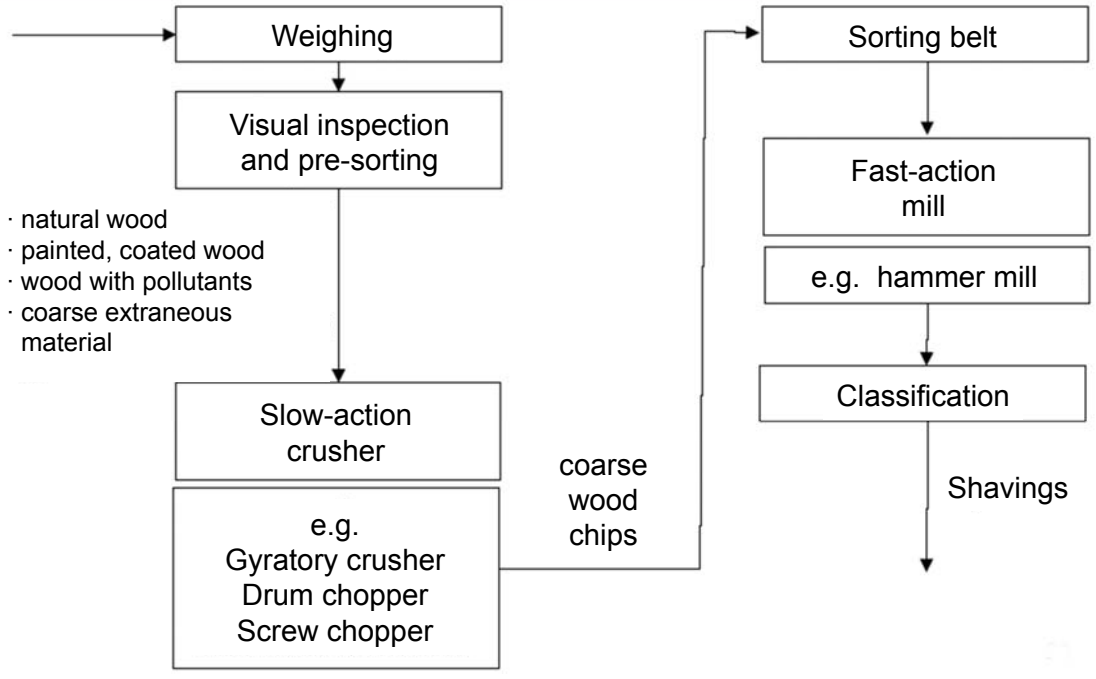
Energetic Utilisation

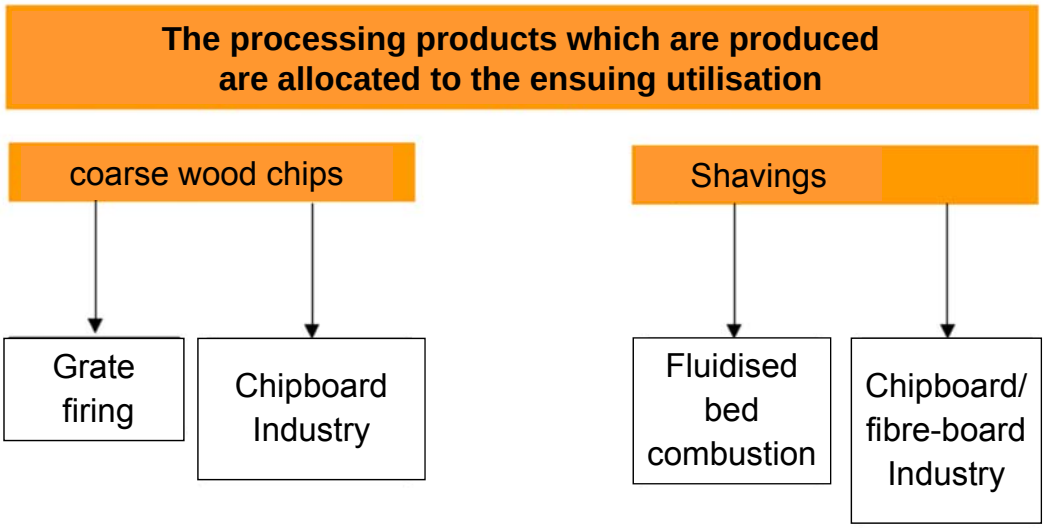
Small heating systems

plants approved according to the 4th BImSchV

plants approved according to the 4th BImSchV with flue gas scrubbing according to the 17th BImSchV

Processing steps prior to material or energetic utilisation





Material utilisation in building materials and basic materials

- Production of derived timber products
- Production of wood concrete
- Application as porosing agent in bricks or expanded clay

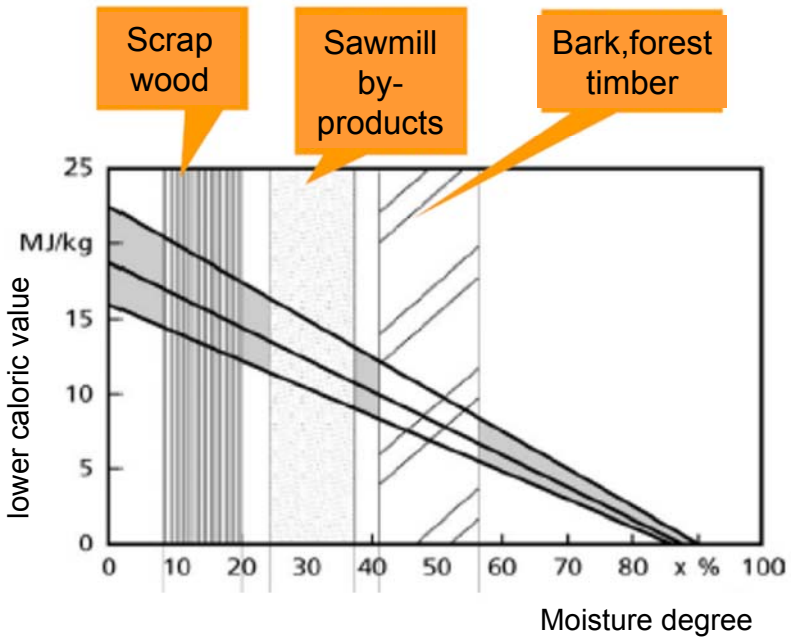
Material utilisation as raw material or auxiliary agent

- Application as reducing agent in the steel production
- Application to condition sewage sludge or special waste

The energetic utilisation is based on the caloric value of wood.

Reference value
Fuel oil: 44,000 KJ/Kg

Heavily dependent
on the water contents



Pollutant contents in the ash fraction of wood firing

		Type of ash		
		coarse	medium	fine
Ca	[g/kg]	283	215	167
Mg	[g/kg]	34	34	25
K	[g/kg]	129	98	76
Na	[g/kg]	20	18	13
P	[g/kg]	14	70	28
As	[mg/kg]	n.d.	2	7
Cd	[mg/kg]	< 1	15	63
Cu	[mg/kg]	98	90	122
Cr	[mg/kg]	69	61	50
Hg	[mg/kg]	n.d.	n.d.	0.05
Pb	[mg/kg]	3	18	59
Zn	[mg/kg]	112	816	2920
Cl	[mg/kg]	198	1120	5250
F	[mg/kg]	68	2100	4860

Substance Separation Through Controlled Deconstruction

- Instead of „mixed demolition “: deconstruction and preliminary separation at the building site
  - Pollutant loads ↓; Resources quality ↑
  - Acceptance criteria of disposal plants achievable
  - Disposal costs decrease, demolition costs increase
- Building material usage in structural engineering in weight % according to WALKER et al., 1993

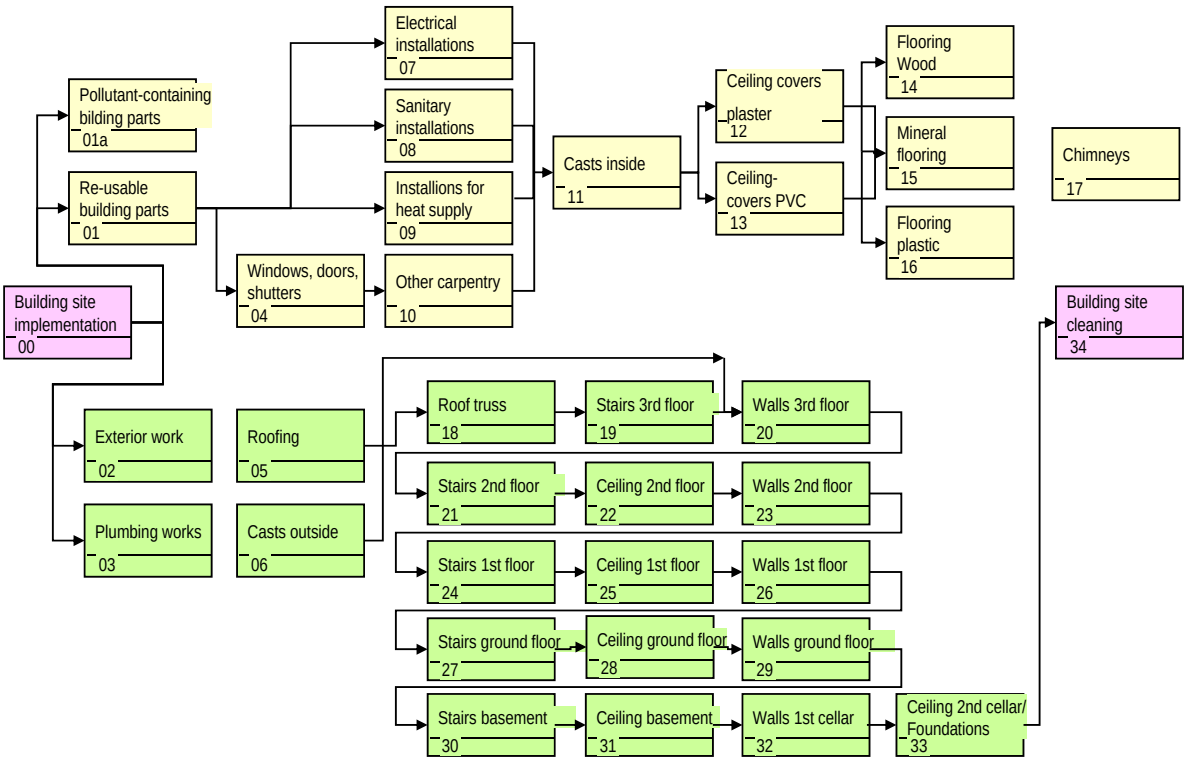
Year of Construction	1949	1961	1973	1987
Ready-mix concrete	0	2	25	41
Site-mixed concrete and precast concrete units	28	45	27	13
Brickwork	46	31	24	15
Mortal, floor pavement, et al.	19	15	11	8
Others (insulation material, steel, fibre-boards, plaster-boards, etc.	7	7	13	23

- Deconstruction steps

Step	Activities	Extracted substance
1	Demounting of contaminated areas	Lightly-bound asbestos building elements, harmful dusts
2	Non-destructive dismantling of directly re-usable components, emptying of pip-ing	Fitments, fittings, lamps, aggregates, switching cabinets, ra-diators, machines
3	Dismantling of components re-usable after preliminary treatment	Stairs, windows, banisters, roofing tiles, pipes, parquet floors
4	Disassembly and separate collection of all other re-usable materials	Glass, wood, metals
5	Removal and separate collection of all non-reusable materials	Insulation material, filling foam, tarpaper, treated wood, plas-terboards
6	Deconstruction of the building stock incl. outside and underground parts	Brickwork, concrete constructions, foundations, staircases, steel profiles

Dismantling Network Plan for a 3-Storey Residential Building

according to Schultmann and Rentz, MuA 1999, p. 206-217



Constrcution Waste from Sanitation / Renovation

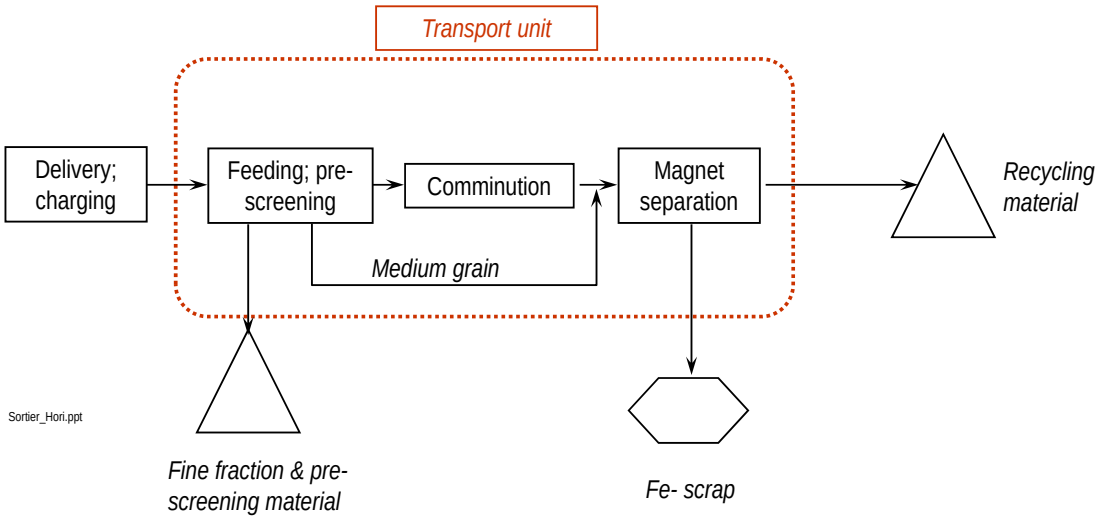
- Instead of mixed construction waste, separate collection as follows:
  - dry organic resources (cardboard, foils, other plastic [possibly PVC and EPS separately]; cardboard
  - Scrap wood according to Categories A 1 - A 4
  - Fe metals, NI metals
  - Building rubble (stones, sand, concrete, brickwork, building materials containing plaster)
  - Special waste (varnishing residues, packaging material with harmful residual contents, cleaning rags, batteries, unknown liquids, tarry materials, asbestos, etc.)
  - non-usable, predominantly organic construction waste (soiled resources, insulation material, cable cuttings, treated wood, sandpaper and wallpaper residues, etc.)
  - domestic waste-like commercial waste (waste accrued during breaks in the work, office waste)

Sorting and Processing of Construction Waste

- Plant licensing procedure see 4th BImSchV
  - according to §10 BImSchG with public procedure for ≥ 10 t/h
  - according to §19 BImSchG with simplified procedure for < 10 t/h
- Plant components:

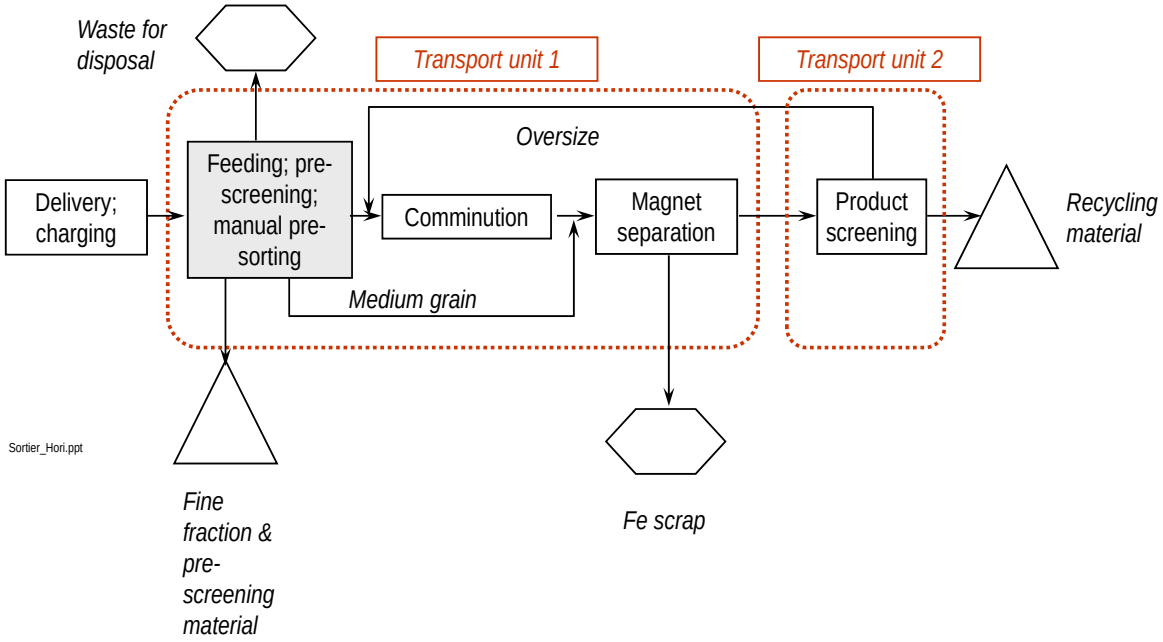
Plant component	Application, target
Wheel-loader, dredge	Charging and loading
Screening units	Separation of undersize particles before comminution, of over-size particles for recirculation or different utilisation, classifica-tion into defined grain size categories
Crushers	Comminution (impact crushers, gyratory crushers, jaw crushers, cone crushers)
Conveyor belts, apron conveyors, push floors, vibrating chutes	Transport and connection elements
Magnet separators; NI metal separators	Steel/iron separation; NI metal separation
Manual sorting Air classifier Aquamator, hydro-drum	Separation of extraneous material and light fractions dry separation of light fractions wet separation of light fractions
Storage heaps	For basic material and processed material

Mobile Building Rubble Processing Plant according to Bilitewski, 1995

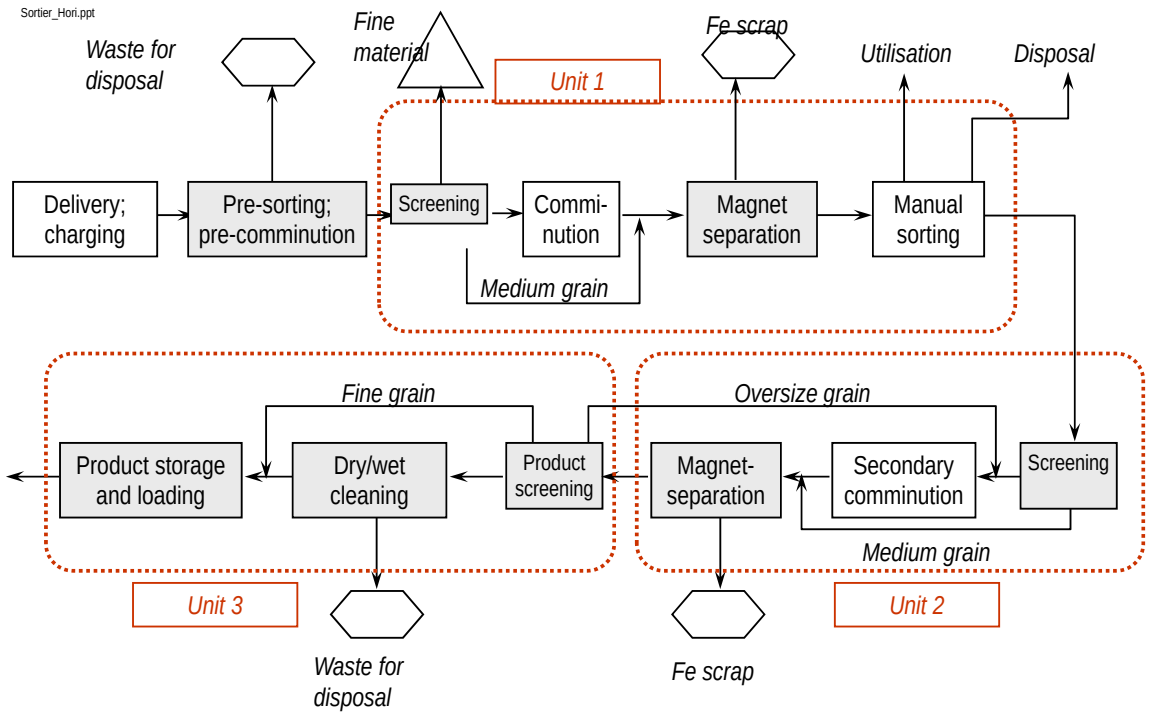


Mobile Crusher metsominerals

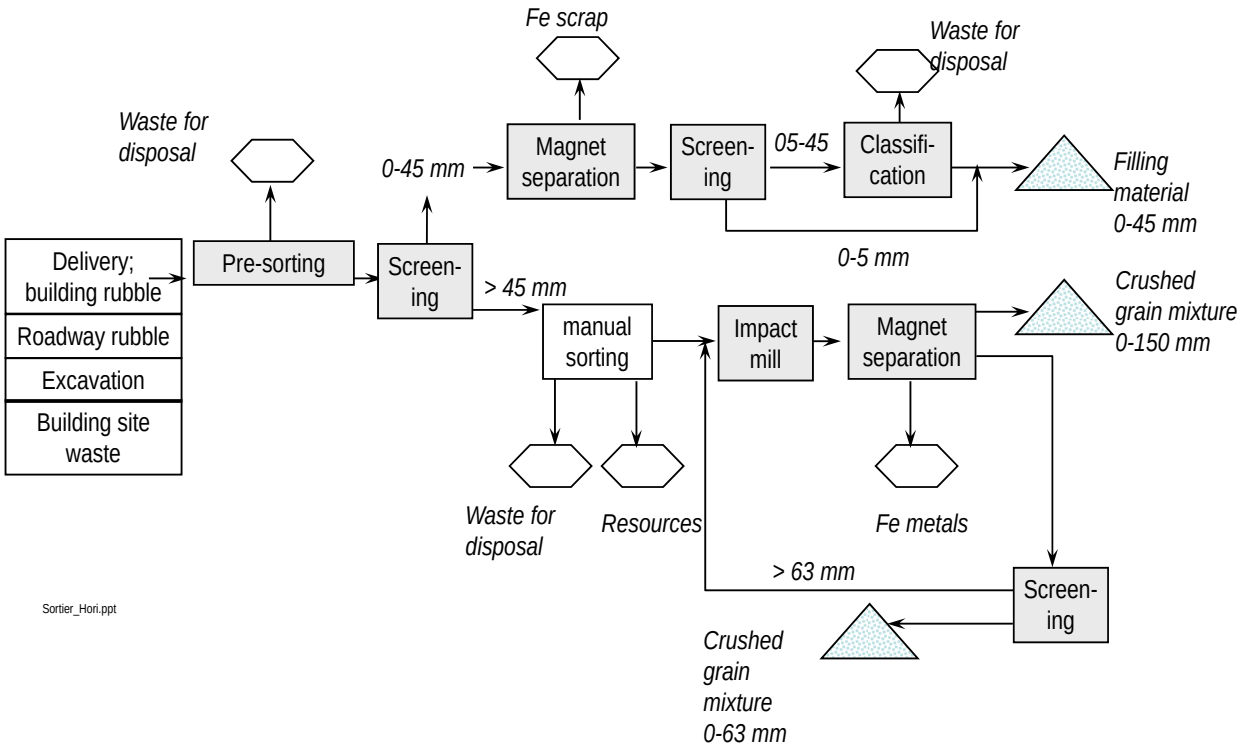
Semi-Mobile Construction Waste Processing Plant according to Bilitewski, 1995



Stationary Construction Waste Processing Plant according to Bilitewski, 1995

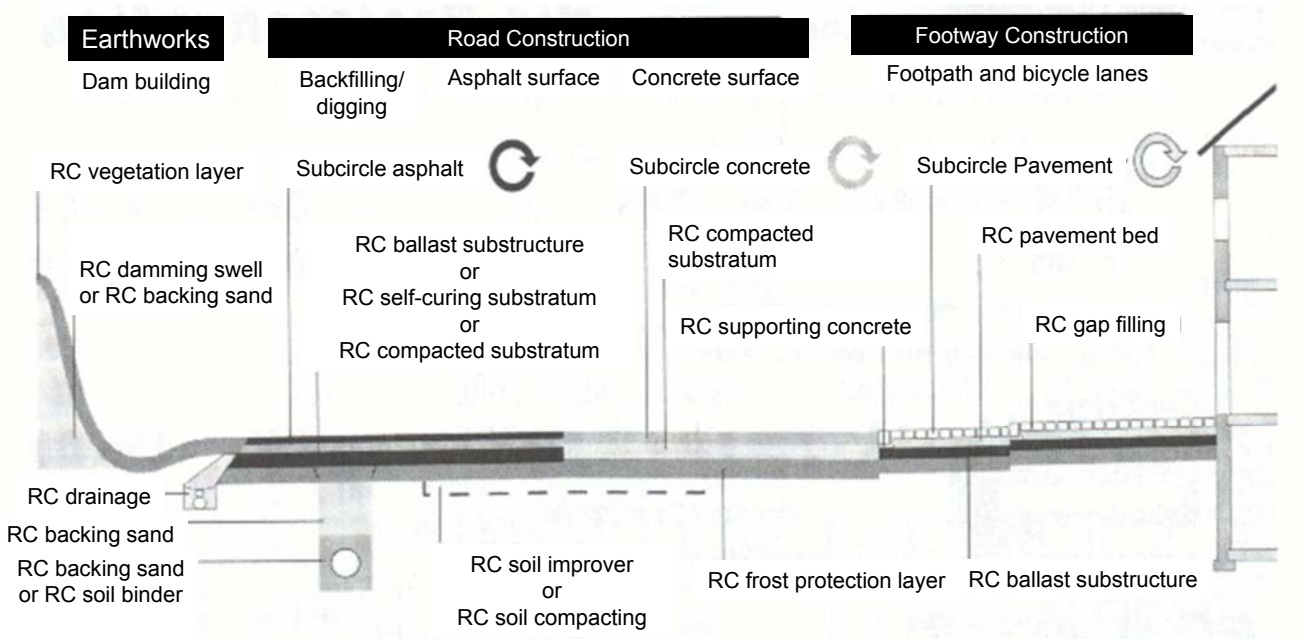


Construction Waste Processing Plant ISV at Hannover-Altwarmbüchen 26



Application Options of Recycling Building Material in Earthworks and Road Construction

according Kohler et al., 2001



Utilisation of Bitumous Roadway Rubble

- More than 90% of the road surfaces in Germany are blacktops; concrete is used almost only for the
  federal motorway, paving in residential and inner city areas
- Bitumous building materials can be utilised without problems; old blacktops may contain pitch (formerly tar; from coal coking; PAH-containing (carcinogenic)); waste which contains pitch should as much as possible be utilised in cold processes
- Bitumen utilisation in building site or mixed plant method; requirements of the federal lands

Methods for the Re-Use of Demolition Asphalt

In-situ

· Demolition asphalt is processed with or without additional mixing materials

· The potential quality improvement is limited

· Three methods:

- Re-shape
- Re-pave
- Re-mix

At the plant

· Demolition can purposefully be processed with additional mixing materials

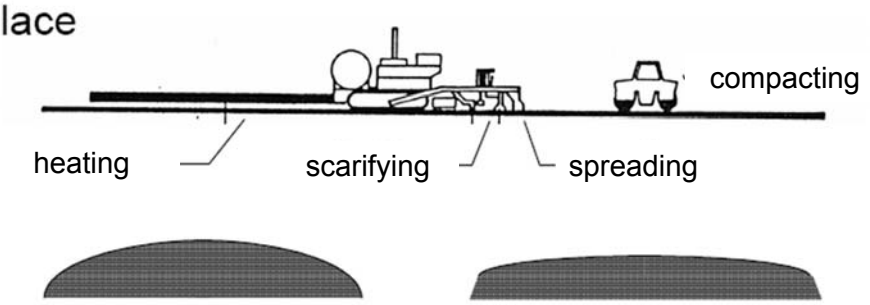
· High-quality asphalt can be produced

· Batch method and continuous method possible

Recycling in place

Reshape (1):

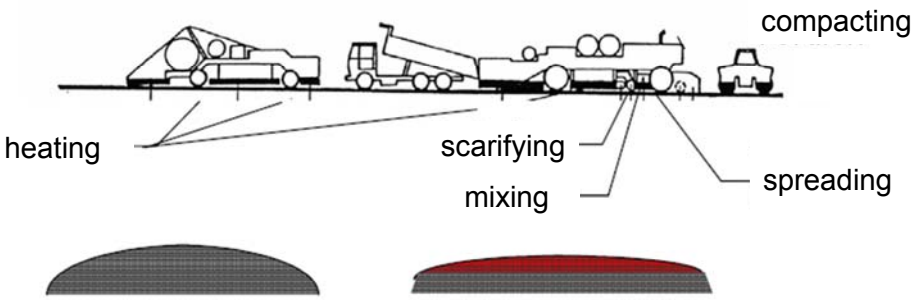
Reshaping without admixing of additional material



Repave (2)

Remix (3):

Reshaping with admixing of additional material



Ecological advantages of Conrete with Recycled Aggregates ?

	Concrete with recycled aggregates			Gravel concrete
	BIM Project: Hundertwasser House in Darmstadt	BIM Project: Gesundheitshaus in Münster	Concrete with RC Aggregates (Manufacturer information)	Concrete with natural aggregates (manufacturer information)
Concrete	1	2	3	4
Strength class DIN	B 25	B 25	B 25	B 25
Consistency	KR	KR	KR	KR
Application	Interior building element	Interior building element	Interior building element	Interior building element
Composition per m^3 concrete				
Cement (CEM 1)	280 kg	340 kg	240 kg	240 kg
Fly ash	60 kg	70 kg	80 kg	70 kg
Natural aggregate	1196 kg	1129 kg	878 kg	1830 kg
Recycling aggregate	581 kg	528 kg	840 kg	-
Plastifying admixture	1.4 kg	1 kg	1.2 kg	1.2 kg
Water	180 kg	187 kg	186 kg	180 kg
Total weight	2298.4 kg	2255 kg	2225.2 kg	2321.2 kg

Comparison of 3 reference numbers:

- Saving of resources
- CED (Cumulative energy demand): guide indicator of energy-related environmental effects
- CO_2 equivalent

	Concrete with recycled aggregates			Gravel concrete
	BIM Project: Hundertwasser House in Darmstadt	BIM Project: Gesundheitshaus in Münster	Concrete with RC Aggregates (Manufacturer information)	Concrete with natural aggregates (manufacturer information)
Concrete	1	2	3	4
Resource saving gravel	581 kg	528 kg	840 kg	
CED_H*	1774.8 MJ	2105.0 MJ	1604.3 MJ	1418.1 MJ
CO_2 equivalent	269.6 kg	326.5 kg	232.3 kg	229.8 kg

* 65% of all greenhouse gas including the CO_2 emissions, 90% of the SO_2 emissions, and 85% of the NO_x emissions are caused by energy consumption