UKZN CALIN.

UKZN CALIN.

UKZN CALIN.
Building more with less: Urban Mining and Recycling

Arch. Giulia Peretti
Werner Sobek Green Technologies

11 05 2020
Arch. Giulia Peretti
Werner Sobek Green Technologies
Stuttgart/Germany

Team leader for sustainability, building physics and certification

Architect, DGNB Auditor, Expert of sustainable building (Steinbeis Transfer Institute Berlin)
Content

Why recyclable construction?
Circular Economy
Legal Framework
Numbers and Facts
Urban Mining/ Recyclable and Resource-saving Construction
Project NEST UMAR
Conclusion
Why recyclable construction?
Why recyclable construction?

Motivation

In 1950 we were 2.5 Billion people on earth. According to the forecast of the United Nations (UN), we’ll be 9.7 Billion in 2050 and 10.9 Billion in the year 2100.

World population forecast until 2100

Population in Billions

Grafik: Deutsche Stiftung Weltbevölkerung (DSW)
Quelle: Vereinte Nationen, World Population Prospects: The 2019 Revision
Why recyclable construction?

Motivation

The demand for raw materials is growing.
Why recyclable construction?

Motivation

The world’s building stock is expected to double by 2060, the equivalent of building another New York City every month.

- 10-15% of building material wasted during construction
- 60% of European offices are not used even in working hours
- 20-40% of energy in existing buildings can be profitably conserved
- 54% of demolition materials landfilled, while some countries only landfill 6%

- 0-0.5% productivity increase per year in most European countries 1990-2015, whereas 2% per year achieved in some countries
- 50% of residential dwellers report living in too much space
- Passive building standards at or near profitability for most new-build segments, but still only constitute minority of buildings
- Most materials unsuitable for reuse as they contain toxic elements

Ellen MacArthur Foundation Homepage 2020
Why recyclable construction?

Motivation

Status Real Estate

Energy-Problem! Material-Problem!

- Water: 17%
- Wood: 25%
- CO₂: 33%
- Energy: 30-40%
- Raw Material: 40-50%
- Waste: 60%
Why recyclable construction?

Motivation

The waste volume due to construction and demolition of buildings is by far the largest part of Germany's incoming waste.

![Wastevolume diagram](image)

- Import
- Wasteplants
- Settlement waste
- Industrial waste
- Waste from gaining raw materials
- Waste of construction and demolition

Statusbericht Kreislaufwirtschaft 2018
Why recyclable construction?

Motivation

Secondary raw materials could be even more attractive than primary raw materials.

![Bar chart showing the amount of energy required to generate aluminium from secondary and primary sources. Secondary aluminium requires 5% of the energy, while primary aluminium requires 100% of the energy.](chart.png)

Statusbericht Kreislaufwirtschaft 2018
Why recyclable construction?

Motivation

Disposal sites are getting fuller and fuller.

Number of disposal sites

1970: 65,000

2015: 1,100

Statusbericht Kreislaufwirtschaft 2018
Circular Economy
Ecological design = Circular Thinking = Urban Mining
Circular Economy

Current Linear Economy

- Nowadays, substantially we still have a linear economy, not a circular one.
- The German declared rates of recycling only cover collected waste which is brought to a processing plant. The result of these plants is not listed. So in reality German recycles around 35% of the waste volume, which is collected. Mainly this contains easy to recycle materials, like glass, paper, PET or aluminum.
Circular Economy
Linear Economy

Linear business model

But: Our resources are finite

Source: DGNB
Circular Economy
Circular Model

Take ➔ Make ➔ Use ➔ Dispose

Biological cycle
Technical cycle

Source: DGNB
Circular Economy

Ecological design = Circulatory thinking

Circular Economy-Principles according to the Ellen MacArthur Foundation (2015)

1. Value finite resources and control their stocks/material flow.
2. Improve raw materials yields by closing cycles. While always maintaining the maximum value of those materials.
3. Always consider external impacts to hold the system on it’s maximum efficiency.
Legal Framework
Many European countries already published strategies and guidelines for a transformation toward a circular economy approach.
Legal Framework
Legal principles/Standards

Overview

European level
Abfallrahmenrichtlinie

State level
Kreislaufwirtschaftsgesetz
Abfallverzeichnisverordnung
Deponieverordnung
Entwurf: Ersatzbaustoffverordnung
Altholzverordnung
Bioabfallverordnung
Gewerbeabfallverordnung

Federal state level
Landesabfallgesetze
LAGA M20 – Regelwerk der Länderarbeitsgemeinschaft Abfall

Municipal
Abfallsatzungen der Kreise und kreisfreien Städte
Legal Framework

Legal principles/Standards

- **Circular Economy Package (Dec. 2015)**

  Released by the European Commission, including an action plan, where the transition to a circular economy is described as a central lever for a “sustainable low-CO2 resource efficient and competitive economy”

- **Waste Framework Directive (July 2018)**

  The EU set Targets for packaging and municipal waste by 2030 and 2035 respectively. “by 2035 the amount of municipal waste landfilled must be reduced to 10% or less pof the total amount of waste generates”. This amending directive must be implemented by the Member State within a period of 3 years
Legal Framework

Legal principles/Standards

- Construction Products Regulation (EU BauPVO 2011)

A building must »be designed, erected and demolished in such a way that natural resources are used in a sustainable way«. In particular, ”the building, its building materials and parts must be reusable or recycled after demolition” and ”environmentally friendly raw materials and secondary building materials must be used for the building”
Legal Framework

Legal principles/Standards

- Waste legislation
  
  **Waste Framework Directive**
  
  The European Waste Framework Directive applies to EU member states, which defines important terms such as the demarcation between waste and by-products and the end of waste properties.

  **Circular Economy Act**
  
  At the national level, the EU directive was implemented in the German Waste Management Act (KrWG).

- Waste Directory Ordinance
  
  Classification of waste according to origin and danger.

- Commercial Waste Ordinance (2017)
  
  Separate construction and demolition waste into the following fractions and, in accordance with the KrWG, to prepare them for reuse or to recycle them: glass, plastics, metals, wood, insulation materials, bitumen mixtures, gypsum-based building materials, concrete, bricks, tiles, and ceramics.
Legal Framework

Legal principles/Standards

- **Legal restrictions**
  - For non-hazardous construction and demolition waste, measures to achieve a recovery rate of 70 percent by mass by 2020 are required by law at European and national level, however without further quality requirements for recycling.

- **Groundwater / substitute building materials / soil protection ordinance (Mantelverordnung)**
  - It should regulate requirements for the production and installation of mineral substitute building materials in technical construction nationwide and strengthen the acceptance of recycling building materials (RC building materials) with legally binding quality monitoring (However, the regulation does not include the use of RC building materials in building construction).
  - Communication 20 of the Waste Working Group (LAGA M 20) Requirements for the recycling of mineral waste - here also with a focus on recycling in civil engineering
Legal Framework

Legal principles/Standards

- Dismantling rights
  - in particular in the building regulations of the federal states (state building regulations) as well as in the awarding and contract regulations for building services
  - DIN 18 007 demolition works
  - ATV DIN 18 459 Demolotion and dismantlich works
  - VDI Richtlinie 6210 Blatt 1 Demolition of structural and technical systems

→ Legal requirements for dismantling relate to waste law
→ As long as there are no increased demands on the quality of usability in waste legislation, the demolition will meet the high demands in terms of selective dismantling only in individual cases
Federal states try to provide guidelines on recycling-compatible and resource-saving construction methods.
Legal Framework
Publication / Different associations

Statusbericht der deutschen Kreislaufwirtschaft (2018)

BAuA - Seletitiver Abbruch und verwendungsorientierter Rückbau (2010)

BBSR - Ökologische Baustoffwahl

Leitlinien für Abbruch- und Umbauarbeiten an Gebäuden vorgeschaltete Abfallaudits (2018)

UBA - Leitsätze einer Kreislaufwirtschaft (2020)

BMI - Baufachliche Richtlinie Recycling (2018)

ProgRess - Deutsches Ressourceneffizienzprogramm

DGNB - Kriterienkatalog + Leitfaden Circular Economy
DGNB – Circular Economy 2019

Guide to closing the loops in construction

Background on the necessity of Circular Economy and its relevance in construction

Fokus:
- Conversion and deconstruction-friendly design
- Multiple use of areas („Spacesharin“)

Presentation of concrete solutions and practical implementation in planning with a tool box
DGNB – Circular Economy Toolbox

Presentation of concrete solutions and tools in the form of a toolbox

→ Best Practice Example: NEST
Numbers and Facts on waste generation and recovery rates in the construction sector
Waste generation and recovery rates
Germany

⇒ Construction and demolition waste account for more than half of the waste.

The largest portion of construction and demolition waste is attributable to heavy mineral building materials.

Statistisches Bundesamt (2019) - Abfallbilanz 2017

Waste 2017 divided into it’s streams (in %)

- Remaining waste: 14
- Waste of gaining raw materials: 8
- Waste from wasteplants: 13
- Settlement waste: 13
- Waste from construction and demolition: 53

412 Mill. t
Waste generation and recovery rates

Germany

The Circular Economy Building (Kreislaufwirtschaft Bau) initiative has been publishing statistics on mineral construction waste in Germany every two years since 2006.

Source: Initiative Kreislaufwirtschaft Bau 2019
Compared to the previous reporting year, the volume of mineral construction waste rose by almost 13 million tons (2014: 202 million tons). The distribution of mass flows has remained roughly the same.
Waste generation and recovery rates

Germany

Soil and stones

About 77% of soil excavation and spoil was reused in the construction and mining industry.

However, this is not real recycling, but so-called downcycling, i.e. recycling with a lower range of services compared to the starting material: the rubble is broken, processed into recycled aggregate and used primarily in road construction.

In the production of concrete, the material cycle is not closed because broken concrete cannot be used to produce new concrete without adding cement again. Cement production is a major problem due to high environmental pollution, as CO2 is emitted automatically in the process.

Source: Initiative Kreislaufwirtschaft Bau 2019
Waste generation and recovery rates
Germany

Demolition waste (building rubble)

About 77% of demolition waste was used as filling for excavations or sent to landfill.

Accumulation of construction waste 2016 (in M t.)

- Construction waste: 27.3%
- Accumulation: 58.5%
- Other recovery: 16.1%
- Disposal: 6.2%
- Remaining: 45.5%

Source: Initiative Kreislaufwirtschaft Bau 2019
Waste generation and recovery rates
Germany

Road construction waste

About 95% of road construction waste was recycled. 2.5% was used as filling for excavations and 2% was sent to landfill.

Source: Initiative Kreislaufwirtschaft Bau 2019
Waste generation and recovery rates
Germany

Gypsum-based construction waste

Only about 4.5% of gypsum based waste was recycled. 55% was sent to landfill and the rest was used in the mining industry and landfill construction.

Source: Initiative Kreislaufwirtschaft Bau 2019
Waste generation and recovery rates

Germany

Construction site waste

Construction and demolition waste from wood, glass, plastic and metal as well as insulation and mixed construction waste are summarized in the monitoring of the circular economy construction to the so-called construction site waste.

Most of the waste was downcycled, 1.6% recycled and just 1.4% sent to landfill.

Accumulation of construction site waste 2016 (in M t.)

Source: Initiative Kreislaufwirtschaft Bau 2019
Dismantling and demolition in Germany
Dismantling and demolition process
Germany

= Key function for recycling options

The more selectively the dismantling or demolition is carried out, the cleaner the materials used can be recovered and the easier it is to meet the quality requirements for the recycled materials.
Separating valuable materials at the dismantling site is the first step to Recycling.

Different types:

- **Conventional demolition** = grossest way of removing buildings. The building is demolished without prior gutting or accompanying separation of waste.

- **Selective demolition** = The materials are selected before, during or after the demolition (currently most common use in Germany).

- **Selective dismantling** = The different materials are removed and dismantle, before the bearing structure is demolished.
Dismantling and demolition process

Germany

Separating valuable materials at the dismantling site is the first step to Recycling.

Different types:

- Disassembly for scrapping / recycling
  = Materials are dismantled or dismantled and then dismantled for scrapping (mainly used for steel)

- Disassembly for reuse
  = Components are carefully dismantled in the reverse order of assembly in order to reuse them undamaged elsewhere (mainly for historical components)

→ Best resource protection, as all raw materials, including energy, that were previously used for manufacturing are preserved (mainly for historical components)
Dismantling and demolition process

Germany

Economy feasibility depends on:

- Dismantling / disassembly costs
- Personnel expenses (number and qualifications)
- Devices / machine use (type and quantity, operating materials)
- Material (security measures, protective equipment)
- Disposal costs

Cost estimates are subject to relatively large uncertainties

→ Calculation in dismantling and demolition is mostly based on the contractors’ experience.
→ In contrast to costing in building construction, there is no publicly available data (e.g. BKI)
Urban Mining/ Recyclable and Resource-saving Construction

Overview of the Principles
Urban Mining Design
Basics

The deposits of raw materials are shifting worldwide

Many raw materials can no longer be found on the site of their natural occurrence, but in new, anthropogenic deposits.

→ I.e. a large part of these raw materials are bound in our building stock.
Urban Mining Design
Basics

- At the end of the usage phase, there is currently too much thinking in waste categories.

- Urban mining → recycling categories and the recoverability of post-use building materials.

- Future buildings must be planned as a raw material storage facility - the building as a resource.
Urban Mining Design
Realisation – Urban Areas

- Intensification of urban areas
  → Land use and resource expenditure for new infrastructures are avoided by redensification.

Consideration:
- Creation / promotion of fresh air corridors
- Counteracting or avoiding "hotspots"
- Increasing the albedo of surfaces
- Unsealing transport infrastructure areas
- Creation of infiltrable areas
- Plantations of climate change-resistant and biodiversity-promoting trees
- Reuse of fallow land and existing buildings
- Problem: insufficient technical and energetic performance of the old building
Urban Mining Design
Realisation – Building volumes

- Flexibility of floor plan and section
- → A building with an urban mining design is already designed for various future uses
  - Reduction of load-bearing components on supports and beams → free definition of space
  - sufficiently dimensioned for technical retrofits
  - Adequate arrangement of access cores (stairs, elevators) and their size (larger numbers of people require wider escape routes!)
- Revisionability
- Ease of repair
Urban Mining Design
Realisation – Building volumes

- Flexibility of the facade
  - Facades of commercial or office space require different elements than for residential use and must meet different requirements
  - Removability and exchange friendliness of the facade components
Urban Mining Design
Realisation – Building structure

- Roof use
  - Greening - biodiversity, water retention, protection against extreme temperatures and weather influences, load against wind suction (it is not necessary to glue the roof membrane)
  - Power generation
Urban Mining Design
Realisation – MEP

- **Water management**
  - Rainwater should be able to seep away on your own property
  - Cascade use: Drinking water (food, personal care) is cleaned on site in a facility after use (gray water) and this clear water (cleaned gray water) is used for garden irrigation or as process water (dishwasher or washing machine, toilet flush) before it is used as black water leaves the building

- **Energy management**
  - only regenerative energy (generation and storage takes place decentrally in the building or on the property)
  - Coupling with e-mobility
  - minimized consumption through appropriate end devices, LED lighting and good thermal insulation of the house
Urban Mining Design
Realisation - Joining and material

- Recyclable material
  - Goal = after recycling product at the same quality level
  - Downcycling is unavoidable with the mass building materials currently used in the mineral material group and the materials of fossil, petroleum-based origin.
  - free of additives that are harmful to health or impair recycling
  - No entire component layers in favor of the material visible surface
    → The materials used remain raw, cladding and surface coatings are not used.
    → Authentic aging comes before conservation, which can usually only be maintained through ongoing renovation.
  - Multiple use of components
Urban Mining Design
Realisation - Joining and material

- Construction and building technique
  - Easily dismantled, high degree of prefabrication
  - Little maintenance
  - Consider dismantling in statics (e.g. avoid problematic prestressed concrete structures)
    - Reduction of the connecting elements (fewer, but larger screws)
    - Using the same fasteners (one screw size)
    - Short disassembly routes
    - Uniform disassembly directions (direction of rotation)
    - Damage-free disassembly (cutting torches shortens the length of the beam)
Urban Mining Design
Realisation - Joining and material

- Reuse or recycling
  - Modular construction of a building improves the chances of later reuse or reuse of the individual components
  - The market share of reuse has so far been very limited

Disadvantage:
- Even before a design process begins, funds must be spent on testing, buying and storing used components
- Appearance cannot be freely designed
- Further development → after just a few years, components no longer meet the standards, and manufacturer's guarantees or building inspectorate approvals are missing for old materials

- Manufacturer take-back, rental, deposit systems ("borrow instead of own"), especially with complex composite building materials or multi-layer building material systems necessary for high-quality reuse
Urban Mining Design Realisation - Joining and material

- Evaluation of Circular Economy potential I.e. DGNB and BNB Certification System
Urban Mining Design
Realisation - BIM

- Great potential of digital data
- Mapping of all materials used in the building in their exact quantity and their exact composition
  → Quantity, quality and availability of regionally available recycling materials can be made calculable
Urban Mining Design
Realisation - Costs

- Disposal costs of non-recyclable materials are expected to increase exponentially
- Short lifetimes of cheap materials require fast renewal cycles and often generate higher repair costs through frequent replacement.
- Materials contaminated with hazardous substances cause extremely high disposal costs

→ In the foreseeable future it will come to include the end of use of a property in the overall cost analysis.

→ Buildings with an urban mining design will experience an increase in value regardless of their location as optimally planned raw material deposits.
Project NEST UMAR
NEST

Next Evolution in Sustainable Building Technologies

UMAR

Urban Mining & Recycling
Nest-Unit UMAR
Dübendorf/Switzerland

Concept, Design and Project Planning:
Werner Sobek with Dirk E. Hebel and Felix Heisel,
Stuttgart and Karlsruhe/Germany

Design
2015 - 2016

Construction
2017

Services Werner Sobek
Design and architecture
Facade Design
Sustainability and material concept

Client
EMPA, Dübendorf/Schweiz
Local Materials
Glass
MAGNA Glaskeramik

glass panel
recycled glass

100% recyclable
100% reusable
Sheet Materials
Black Dapple Sheets
High Density Polyethylene

100% recyclable
100% reusable
ECOR
FlatCOR
Cellulose

100% reusable
Technical Solutions
StoneCycling
Waste Based Brick
mineral building waste

100% recyclable
100% reusable
Construction
The recycling quotas required by legislation can currently only be met at a low quality level.

Germany is far from a real circular economy with closed material cycles.

For economic reasons, demolition techniques are primarily geared towards speed and low personnel expenditure.

The stricter separation regulations of and the increasing disposal costs will lead to selective dismantling becoming more prevalent.
Conclusion Circular Economy
Building sector in Germany

The material cycles in building construction must be closed!

Urgent need for action!
- resources are becoming scarcer
- increasing demolition activities
- landfill capacities becoming scarcer
- increased requirements for secondary raw materials in civil engineering

Solution: Urban mining
Building materials will have a different value in the future.
Buildings as an anthropogenic material store.
Conclusion Circular Economy
Building sector in Germany

Research

- Concrete is broken down into aggregate and cement stone using electrodynamic fragmentation.
- Efficient and automated production of multifunctional graded components with mineralized hollow bodies