Resource Efficiency in Concrete Construction

IEA Experts' Dialogue on Material trends in Buildings Construction - Paris - 9 March 2018

Michael Scharpf

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1) **The context**
2) The question
3) The options
4) The way forward

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Concrete construction started as a paradigm change...

Einstein Tower Potsdam

Sydney Opera House

Bauhaus and **Modernism** built upon the quantum leap that reinforced concrete construction introduced into architecture.

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… opening the door for a new performance in construction …

Vancouver

Millau Viaduct, France

> The **versatility** and **performance** of reinforced concrete is the backbone of today's cities and infrastructure construction.

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… using a completely local construction material.

Cement

Aggregates

Water

> Concrete consists out of locally available materials:
> **Cement** (limestone etc.)**, Aggregates** and **Water**.

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Why select reinforced concrete as construction material for a structure?

- Economy
- Suitability of the material for structural and architectural functions
- Low maintenance
- Availability of materials
- Rigidity
- Fire resistance

Source: The Constructor (2018), https://theconstructor.org/concrete/reinforced-concrete-as-construction-material/19080/

> Concrete combines **safe**, **affordable** and **resilient** construction with a **whole-life performance** and local business.

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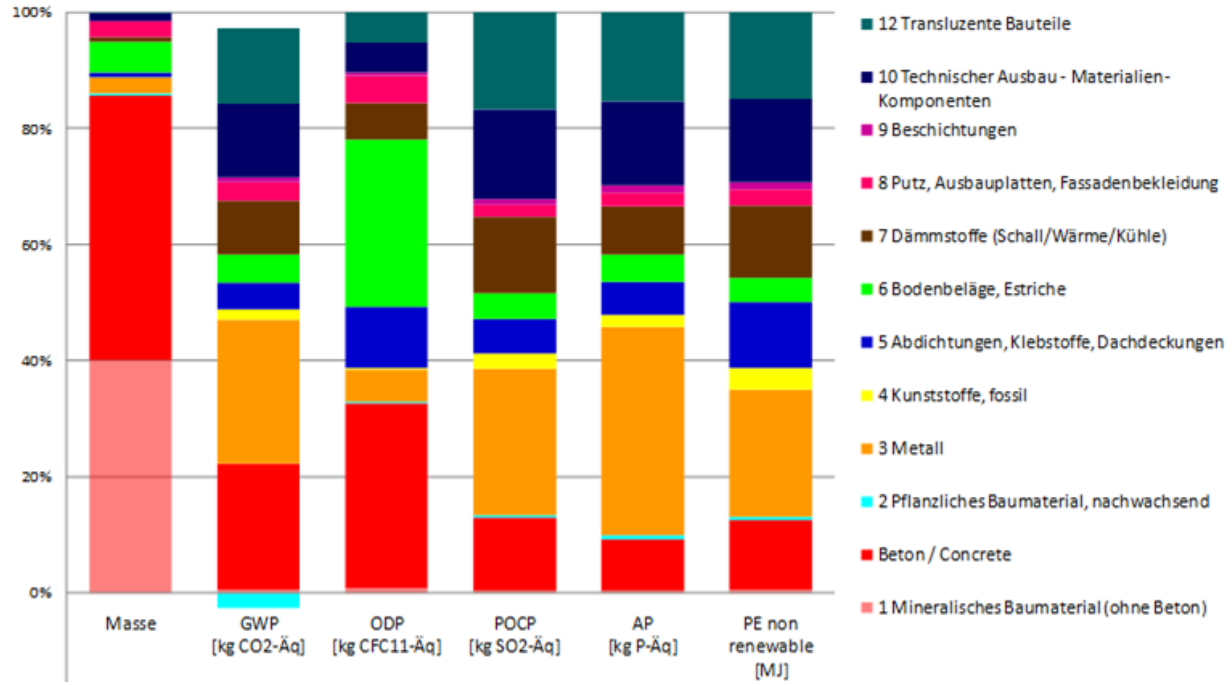
Construction related material consumption is a function of population growth and urbanization



Source: Dr. Kati Herzog, Apleona (2011), Environmental Impacts due to Construction

How can we further optimize the efficiency of construction?
How can we build more with less?

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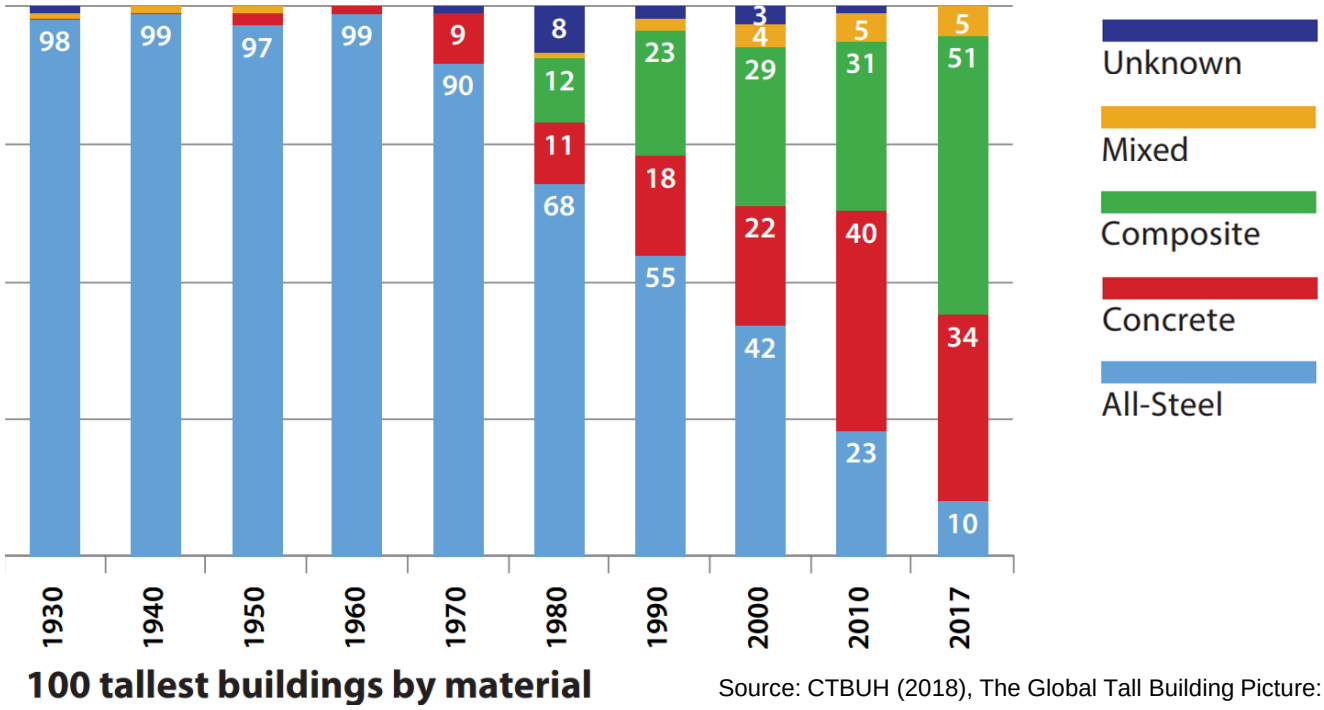
High-performance construction



100 tallest buildings by material

Source: CTBUH (2018), The Global Tall Building Picture: Impact of 2017

Key enablers:

Life cycle performance approach.
Performance based specifications.

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High-performance construction - Singapore CUI

LEVEL	CONCRETE USAGE FOR THE SUPERSTRUCTURE (m^3)			CONSTRUCTED FLOOR AREAS (m^2)
	BEAM	SLAB	COLUMN	
1st Sty	12.80	37.50	6.25	110.00
2nd Sty	10.50	35.00	5.20	106.00
Typical floor (22 stys) 3rd to 24th	3.6 x 22 = 79.20	32.40 x 22 = 712.80	5.00 x 22 = 110.00	106 x 22 = 2,332.00
Roof level	10.50	35.00	5.20	108.00
Total	113.00	820.30	126.50	2656.00 m^2
Grand Total	1,059.95 m^3			2,656.00 m^2

$$\text{Concrete Usage Index} = \frac{1{,}059.95}{2{,}656.00} = 0.40$$

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

BCA GREEN MARK

Green building labels can incentivize high performance construction.

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Hybrid construction

Timber-Concrete

Source: Frangi e.a. (2015), ETH Zurich

Bamboo-Concrete

Source: Hebel, Heisel (2013), Future City Lab Singapore

> Combining the individual strengths of materials and construction types can save resources - and create new values & aesthetics.

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Digital design, fabrication & construction

Venice Biennale

Tension less structures

Source: Block Research Group (2016)

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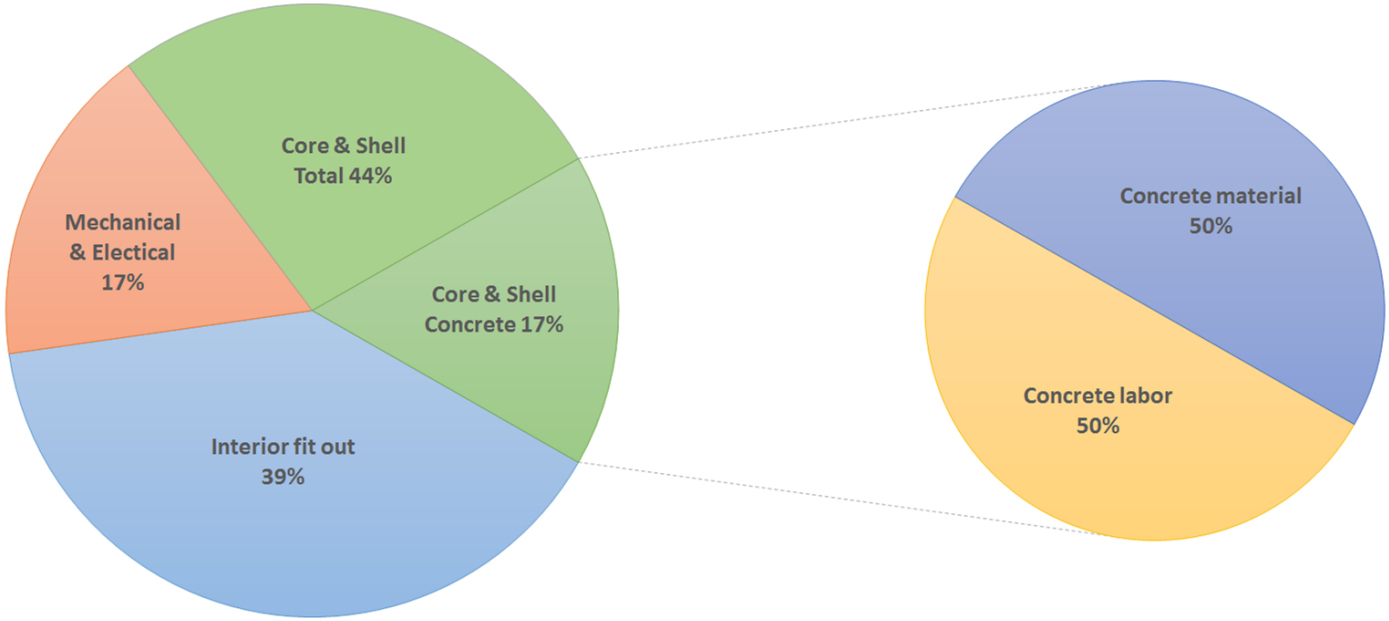
Digital design, fabrication & construction

Typical cost distribution in buildings



Digital fabrication & construction can free investments in performance materials and structures.

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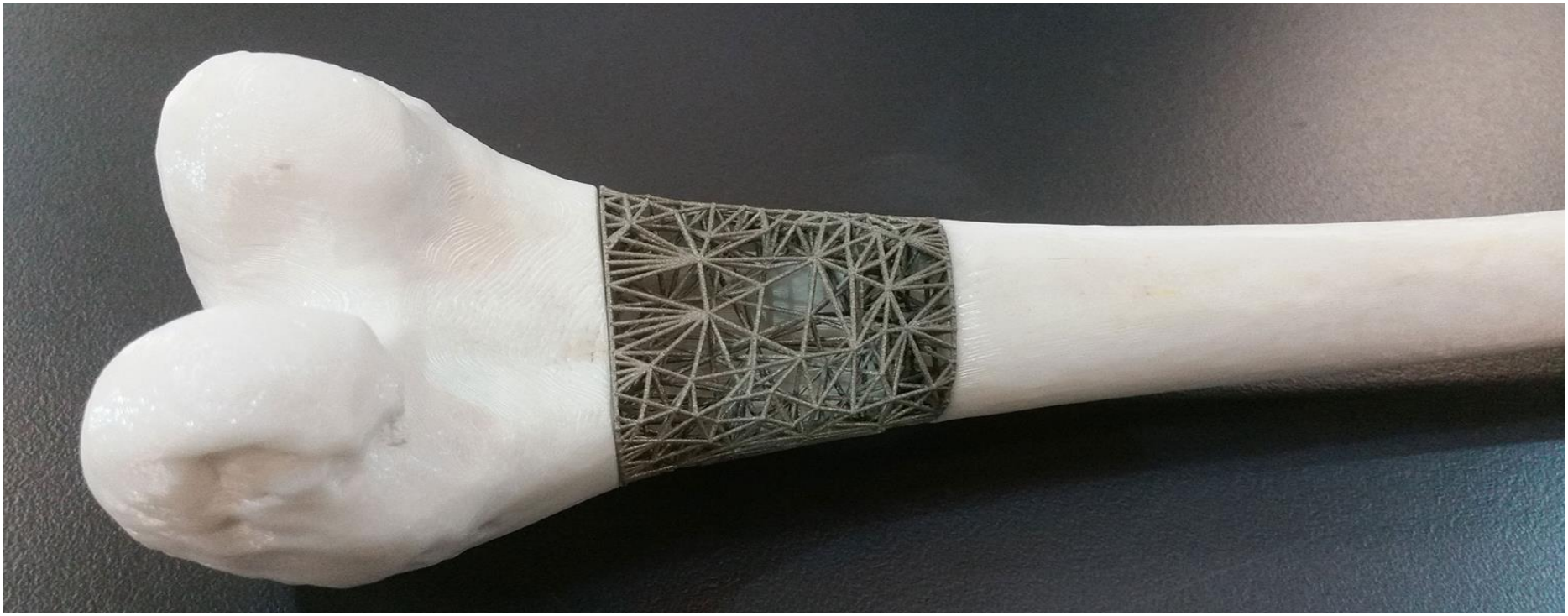
Digital design, fabrication & construction



Functionally Graded Printing

Source: Neri Oxman, Steven Keating (2018), MIT Medial Lab

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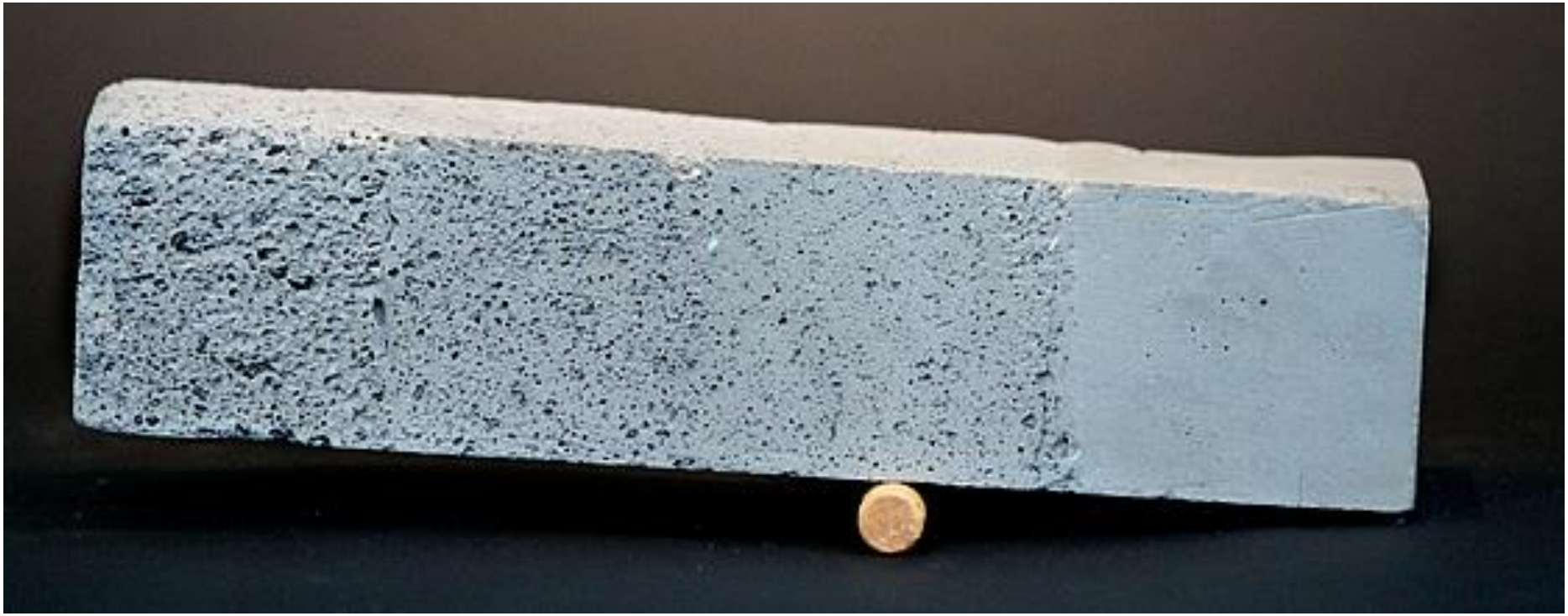
Digital design, fabrication & construction



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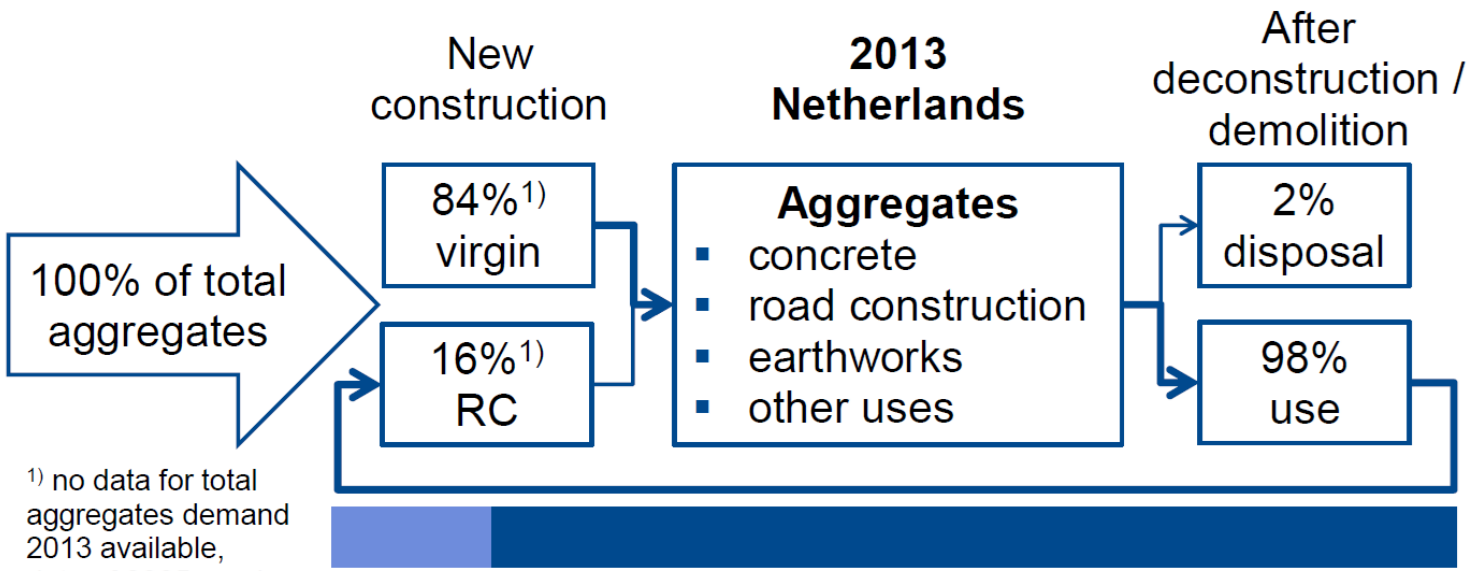
Material recycling



	use of recycled aggregates, Data 2010: Ramon Janssen (AVG): Recycling in the Netherlands
concrete, asphalt	14%
road construction, earthworks, other uses	86%

Figure 5 Recycling situation in the Netherlands 2013 [17]

Source: Müller, Reiners (2015), ECRA Technical Report , Closing the loop: What type of concrete re-use is the most sustainable option?

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Material recycling

The process:

1) Removal of building pollutants (asbestos, PCB joints, etc.)

2) «Clean» separation on construction site using “selective demolition system"

3) Separate removal by truck

4) Treatment of different materials in specialized plants

Source: Van der Hagen, Eberhard Enterprises (2018)

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Material recycling

Demolished concrete

Mixed demolition

> Diligently fractionated and processed, construction & demolition material is nearly **unlimited in its use for new construction**.

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How to promote resource efficiency in concrete construction

- **Life cycle approach** to make **material neutral** and **performance based** construction decisions
- **Consistent way** to measure and design life cycle performance
- Open **standards for innovative solutions** (e.g. for recycling materials)
- **Level playing field** (price of CO_2, cost of landfill etc.)
- **Green Building Labels** recognizing performance construction

> It requires a policy framework that provide **regulatory push and market pull to …**

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… to build a livable world.

Source: WOHA (2018), Breathing Architecture

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