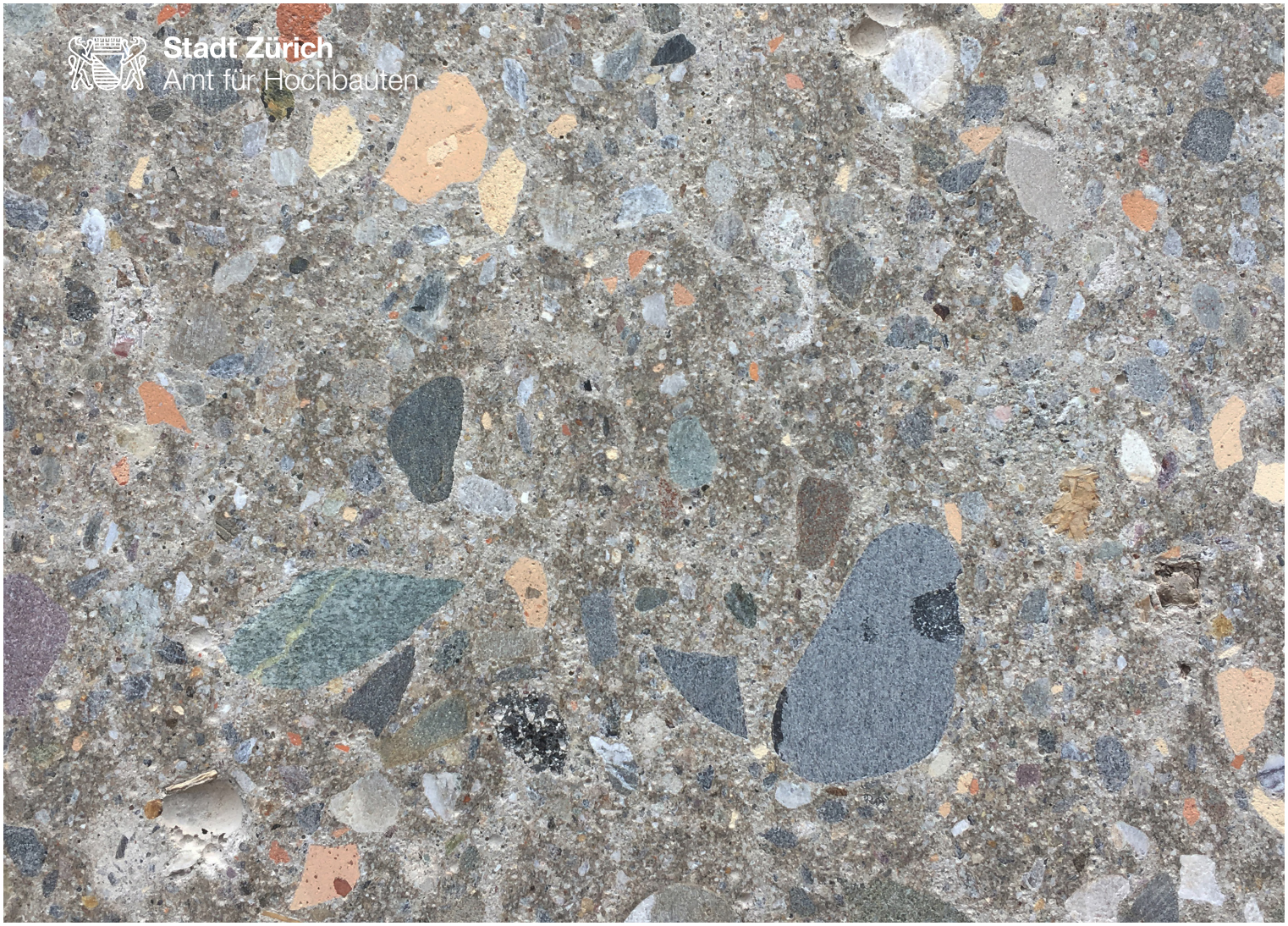
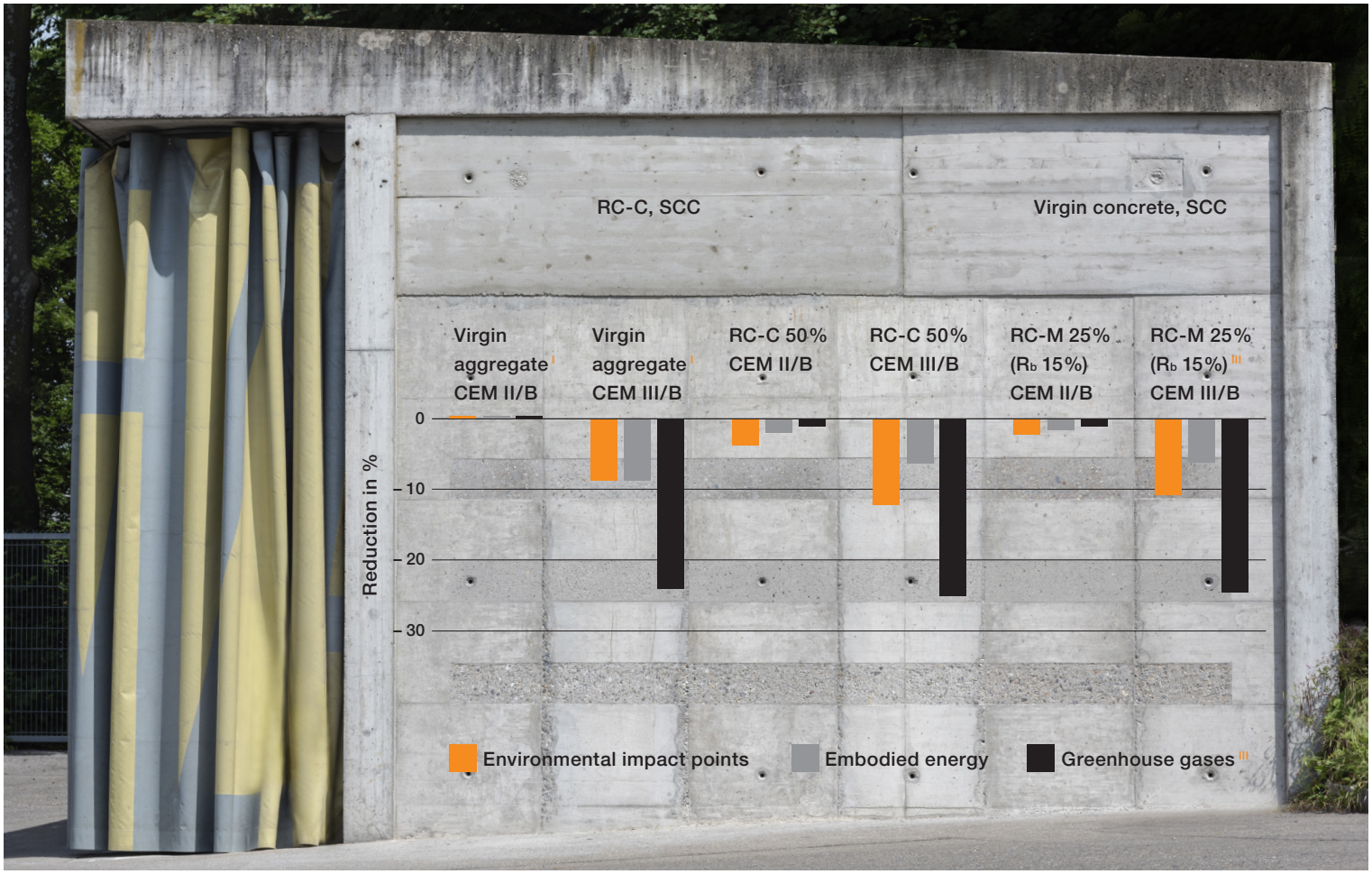


A CONCRETE EXAMPLE
Recycled concrete mock-up

Gravel is a finite resource; landfills are a stopgap solution. By using recycled concrete aggregate, the construction industry can promote closed-loop material cycles and preserve valuable natural resources and land area. The manufacture of concrete also produces greenhouse gases. Choosing CEM III/B instead of conventional cement in concrete formulations is a simple and cost-neutral way of reducing emissions without compromising on quality.

Although the ecological potential of such measures is undisputed,1, 2 reservations remain regarding the aesthetic quality of recycled concrete. And yet, the use of recycled components in concrete has only a moderate impact on its ultimate characteristics, such as its colour and lightness, homogeneity, potential inclusions and any intentional or unintentional traces of the fabrication process. The mock-up wall allows for a direct comparison of the effects of various aggregate types (virgin gravel, recycled aggregate comprising concrete demolition waste or mixed demolition waste) and cement types (CEM II/B or CEM III/B) on the finished product.

RECYCLED CONCRETE MOCK-UP



Key sustainability parameters of concrete types: reduction in comparison to conventional concrete made with virgin aggregate and CEM II/B.

Recycled mineral construction materials in Switzerland

In Switzerland, the building industry consumes around 50 million tons of mineral construction materials annually, three-quarters of which go to building construction. At the same time, around 10 million tons of mineral construction waste [3] are produced, of which around 60% is mixed demolition waste [4] comprising concrete, brick, calcium silicate brick and ceramic materials. Even today, much of this waste is still disposed of in landfill [5], even though recycled concrete (RC concrete) made of concrete demolition waste and mixed demolition waste could be effectively used in many building construction projects. With a serious commitment to recycled concrete, it would already be possible to reuse all mineral demolition materials incurred and attain a closed-loop mineral material cycle in urban areas.

The City of Zurich strives to use as much recycled concrete aggregate as possible (from mixed demolition waste in particular) in its projects.

Recycled concrete

To qualify as RC concrete, concrete products must contain at least 25 mass percent of recycled aggregate; [6, 7] in other words, material that has been previously used in the construction process. RC-C concrete uses aggregate C, a material sourced from processed concrete demolition waste. RC-M concrete contains aggregate M, which is sourced from mixed mineral waste from solid construction components.[3]

Cement type CEM III/B

Conventional concrete is composed primarily of clinker. The production of clinker is energy intensive and causes emissions of around 680 kg CO_2 per ton of cement. By using slag sand (a by-product of iron production) as a replacement for clinker, CO_2 emissions per cubic metre of concrete can be reduced by up to 25%.

RC concrete and CEM III/B: An opportunity for …

… land preservation: environmental impact points

The use of RC aggregate helps preserve valuable land: thanks to closed-loop material cycles, mining in gravel quarries and disposal of construction waste in landfills can be avoided. The use of RC aggregate also incurs slightly fewer environmental impact points (EIPs). Together with the use of CEM III/B, the environmental impact per cubic metre of concrete is reduced by more than 10%.

… the energy transition: embodied energy

CEM III/B improves the lifetime energy con-

SUSTAINABILITY CALCULATOR FOR CONCRETE TYPES

Aggregate for virgin concrete, 0–32 mm particle size
- 100 % virgin aggregate

Aggregate for RC-C concrete, 0–32 mm particle size
- 50 % virgin aggregate
- 50 % recycled concrete aggregate (recycled aggregate from processed concrete demolition waste), comprising 100 % R_c (= particles from concrete, concrete products, mortar and concrete bricks, in accordance with SN EN 933-11)

Aggregate for RC-M concrete, 0–32 mm particle size
- 75 % virgin aggregate
- 25 % mixed demolition aggregate (recycled aggregate from processed mixed demolition waste) comprising 40 % R_c and 60 % R_b (= particles from fired clay bricks and roofing tiles, calcium silicate bricks and non-floating aerated concrete, in accordance with SE EN 933-11)

sumption statistics of concrete by approximately 5%. Dismantling and processing of mineral demolition waste requires somewhat less embodied energy than the mining of virgin gravel in quarries.

On the other hand, recycled concrete requires somewhat more cement and, depending on the circumstances, must be transported further. The use of recycled concrete makes sense from an energy perspective when it is available within a 25 km radius of the construction site – which is the case throughout the Greater Zurich Area today.

… the climate: greenhouse emissions

Using CEM III/B reduces greenhouse emissions per cubic metre of concrete by around 25%. By using recycled concrete aggregate and CEM III/B, the environmental impact of whole buildings can be simply but effectively reduced.

Applications

RC concrete is suited for most building construction applications – even exposed concrete elements and watertight basement systems. Due to insufficient experience to date, RC materials are not yet used in precast concrete components or concrete mixtures formulated to be resistant to frost and de-icing salt. [1] RC concrete can be pumped (see concrete lintel of the mock-up), but due to the necessary admixtures, the use of CEM III/B concrete in this application is limited. Likewise, the longer curing periods of CEM III/B concrete (and consequently longer stripping times) and its limited suitability as exposed concrete at low temperatures must also be considered in the construction process.

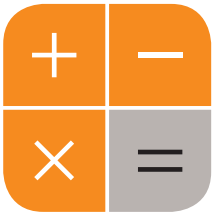
Costs

RC concrete is generally cheaper than virgin concrete. It is thus worth reviewing quotes to see if both cost and environmental impact can be optimised by choosing RC concrete.

Surface treatments

Concrete is a heterogeneous material and its surface can be treated in a variety of ways: for instance, it can be bush-hammered, sandblasted, polished, treated with a colour wash and coated to resist water or graffiti [III]. The effect of these treatments on the various types of concrete can also be seen in the mock-up (colour-washed surface on interior side of wall).

Calculate the environmental impact of various concrete types directly online.
↗ Sustainability calculator for concrete types



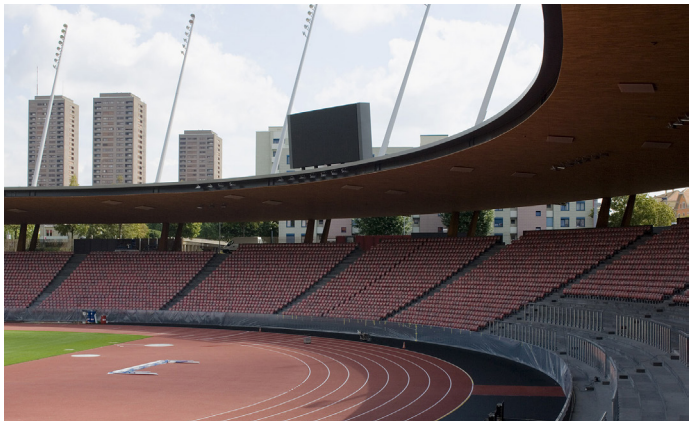
REFERENCE PROJECTS

“Im Birch” school building (2004), Peter Märkli with Gody Kühnis, Zurich: produced concrete elements using approximately 50 % processed or recycled concrete aggregate.
– Photo: G. Gisel

Hirzenbach school campus (2008), Boltshauser Architekten, Zürich: RC concrete coloured with liquid pigment for exposed concrete; RC concrete also used for all other concrete components.
– Photo: Y. André

Werdwies housing complex, 2007, Adrian Streich Architekten, Zurich: watertight basement and ceilings made of RC concrete; load-bearing walls made of RC-M from 100 % mixed mineral demolition waste.
– Photo: G. Aerni

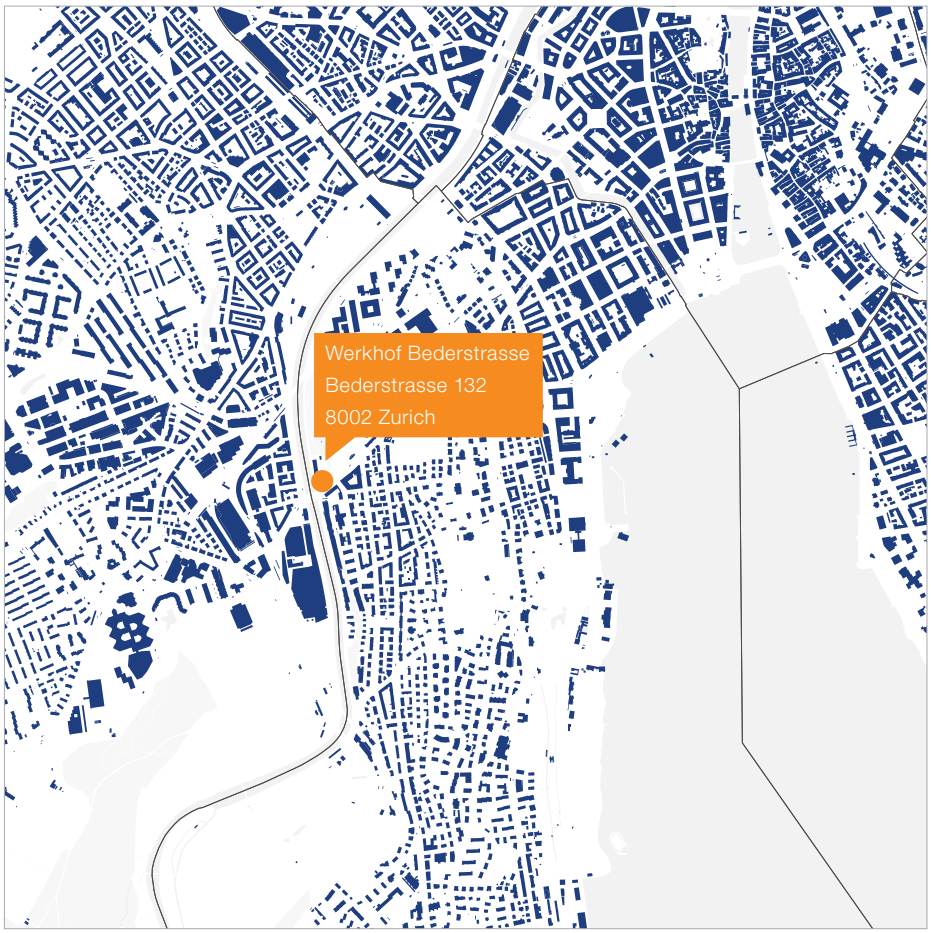
Heuried sports centre (2017), EM2N Architekten, Zurich: all in-situ concrete components incl. watertight components and pile foundations made of RC-C concrete and CEM III/B.
– Rendering: EM2N Architekten



Letzigrund stadium, Zurich (2008), Bétrix & Consolascio Architekten, Zurich/ Frei & Ehrensberger Architekten, Zurich: 40 000 m^3 of excavation materials recycled on site for concrete gravel.
– Photo: B. Bühler

“Kunsthaus Zürich” museum of fine arts (2020), David Chipperfield Architects, London: all in-situ concrete components incl. watertight components made of RC-C concrete und CEM III/B; CEM III/B, light-coloured concrete chosen partly for its aesthetic qualities.
– Rendering: David Chipperfield Architects

LOCATION



Recycled concrete mock-up

Kaufmann Widrig Architekten GmbH constructed an open shelter at the Bederstrasse public works yard (Werkhof Bederstrasse) in 2004.
In 2016, the City of Zurich Civil Engineering Office (Tiefbauamt) requested an additional wall for the structure; at the same time, Building Surveyor's Office (Amt für Hochbauten) was scouting locations for a recycled concrete mock-up. These synergies resulted in the erection of this mock-up in 2017.

The mock-up can be viewed by appointment.
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No. 1 in the series "Fachbeiträge", June, 2017

Notes

I In accordance with the relevant standards,[8] virgin materials may contain up to 1.3 M.-% foreign particles.
Such impurities – unwanted but within the range standards allow – are visible in the virgin gravel sample surfaces (types 1 and 2).

II The sixth sample surface was incorrectly prepared using CEM II/B instead of CEM III/B. Theoretical sustainability data is listed in this brochure; actual values are recorded on the mock-up.

III In Switzerland, a commitment to using CEM III/B has already reduced CO_2 emissions by around 2.65 million tons per year – without increasing costs or reducing quality.

Sources (in German only)

1 Beton aus rezyklierter Gesteinskörnung; KBOB/ecobau IPB-Empfehlung 2007/2
2 Betonsortenrechner – Hintergrundbericht; Studie im Auftrag des Amts für Hochbauten
3 Gugerli, Heinrich et al. (2015): Gesund und ökologisch bauen mit Minergie-ECO; Faktor-Verlag
4 Urban-Mining-Potenzial in der Stadt Zürich, Studie im Auftrag des Amts für Hochbauten
5 Hofmann, Werner; Patt, Bruno (2006): Konstruktionsbeton aus Mischabbruch; tec21 10/2006, S. 8–10
6 SIA Merkblatt 2030: Recyclingbeton, Ausgabe 2010
7 SN EN 206: 2013: Beton-Festlegung, Eigenschaften, Herstellung und Konformität
8 SN EN 270 102b-NA: Gesteinskörungen für Beton

Further literature (in German only)

– Ressourcenstrategie "Bauwerk Stadt Zürich" (2009), Stadt Zürich, Amt für Hochbauten, Tiefbauamt
– Durchstanzversuche mit Recyclingbeton aus Mischabbruch (2013); Studie im Auftrag des Amts für Hochbauten
– Kies-, Aushub- und Rückbaumateriallogistik (2014), Studie im Auftrag des Amts für Hochbauten

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