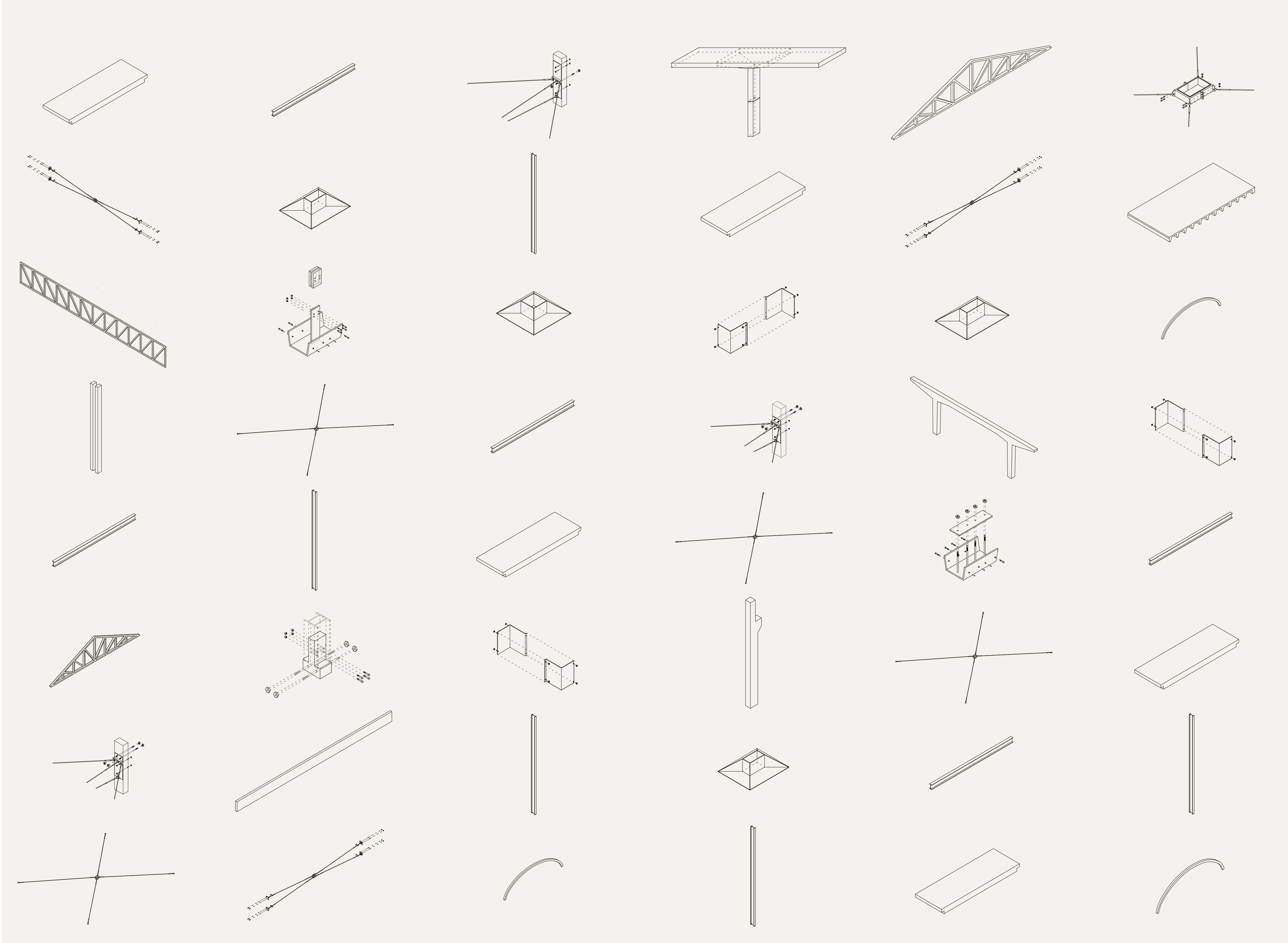


REUSE CONCRETE!

The potential for a reuse of concrete structures for a sustainable building culture
An urban production facility for Zurich Hard

Architektur, Gestaltung
und Bauingenieurwesen

Institut Konstruktives Entwerfen

Institut Konstruktives Entwerfen *Adrian Kiesel* *Masterthesis*

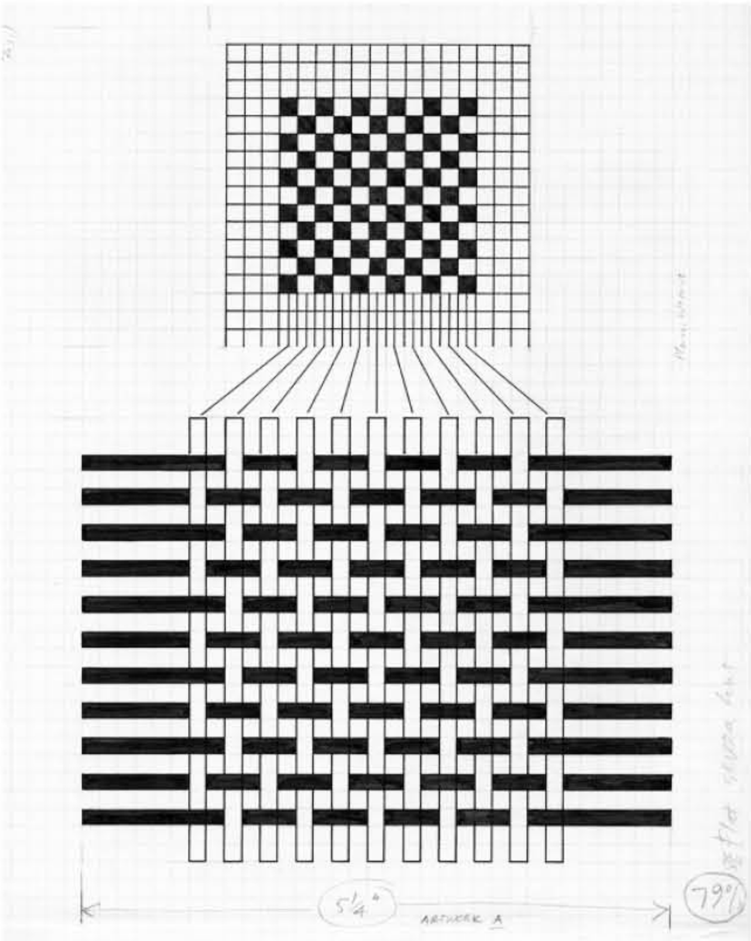


Abb. 1.01 Anni Albers - Weaving
a discipline of resilienve

Table of contents

Status quo 1

The complex whole

The earth is getting hotter. Energy is getting more expensive. The air is getting dirtier. Our resources are becoming scarcer. To meet the Paris climate targets, global CO2 emissions must be drastically reduced. Great potential for this can be found in the construction industry.

To deal with this situation, we need to develop a new awareness of sustainability. That is why questions whose answers we do not know yet are especially promising. In other words: where the perplexity is greatest, the potential for change is also greatest.

> *«A crisis is a productive state. You just have to remove the taint of disaster from it.»*
>
> Max Frisch

Reuse as chance

The change in the global climate makes sustainable building strategies highly interesting. The reuse of building components is increasingly becoming the focus of architectural discussions due to the comparatively low CO_2 emissions. For centuries, the careful reuse of building materials was a matter of course. However, this has changed since the 1950s due to rising labour costs. Reuse was pushed further and further into the background for economic reasons. The reprocessing of reclaimed materials became unprofitable for widespread use. Currently, European building culture is dominated by new, industrially produced building components.

Today, we are not aware that the demolition of existing buildings in favour of new replacements is an exception in the building history of mankind. Be it in prehistoric times, be it in the advanced civilisations of antiquity or in the vernacular buildings of the mountain cantons. Building components were always considered valuable and integrated into new buildings wherever possible. Knitted wood buildings in alpine regions were even considered furniture, which were sometimes dismantled and rebuilt several times. In today's industrial building environment, reuse hardly ever takes place.

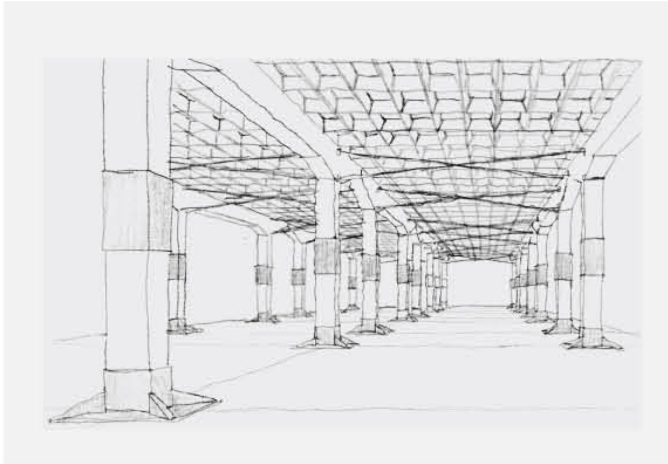
Grey energy

With the development of passive houses and zero-energy houses over the last twenty years, it has been to minimise operational CO_2 emissions of buildings to a large extent. The greatest potential for reducing emissions, to which, however, little attention has been given so far, is the grey energy that accumulates during the construction and demolition of buildings and building components.

Building with harvested components

When a building is demolished, most of the demolition materials end up in landfill. If you want to avoid construction waste, you should try to reuse as many components as possible. In the project "Head Building Hall K 118", the construction office In Situ meticulously dealt with building with reused building components. In the case of the extension, greenhouse gas emissions were reduced by 59% compared to a conventional building. This was mainly achieved by reusing existing building components. For example, the supporting structure is made of steel that was reclaimed from a commercial hall in Basel. These components were originally constructed in such a way that they could be removed and reinstalled without damage. How do we deal with buildings that are constructed from a reinforced concrete structure and were not originally designed for reuse? How would reuse look like here?

In the search for an alternative to conventional reinforced concrete construction, attempts are being made to construct with reused reinforced concrete elements. Can these structures contribute to a new understanding of sustainable aesthetics of contemporary building culture? Is it possible, that reuse could experience a renaissance after all due to its properties regarding sustainability, component recycling and new possibilities of expressiveness? What are the consequences of this building technique and how do we identify potential buildings for demolition? How are these components deconstructed and reused? How high are the costs and greenhouse gas emissions compared to conventional construction methods? This masterthesis seeks answers to the above mentioned questions.



Design sketch of the interior atmosphere of house one

Design sketch of the interior atmosphere of house two

Design sketch of the interior atmosphere of house three

Building with concrete 2.1

Concrete is one of the most widely used materials in our construction industry. Globally, over 4.6 billion tonnes of cement are used every year. This means that if you look at it on a globe scale, we newly build as much as the city of New York every month. The production of this massive amount of concrete generates 2.8 billion tonnes of CO_2. This corresponds to about 8% of global greenhouse gas emissions. By comparison, global air traffic is responsible for 2.5% and the continent of Africa for 3.5% of global CO_2 emissions. The emissions from cement and concrete production are largely caused by the burning and deacidification of limestone, one of the major components of modern concrete.

If we look at the economics of concrete, a surprising picture emerges. Despite the enormous environmental impact of the concrete production process, it is comparatively cheap to build with concrete. One cubic metre of concrete costs between CHF 180 and CHF 250. However, due to the current construction boom and various hurdles caused by the Covid-19 pandemic and the war in Ukraine, concrete now costs more than 55% more than it did a year ago.

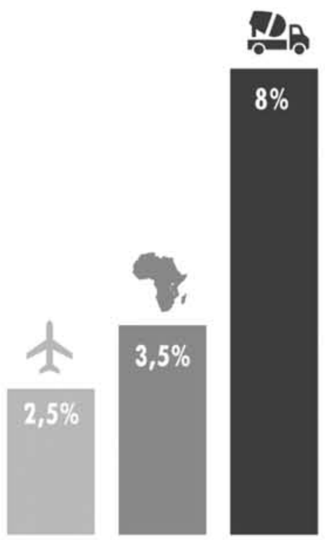


Abb. 2.11 Comparison of global CO2 emissions, 2017

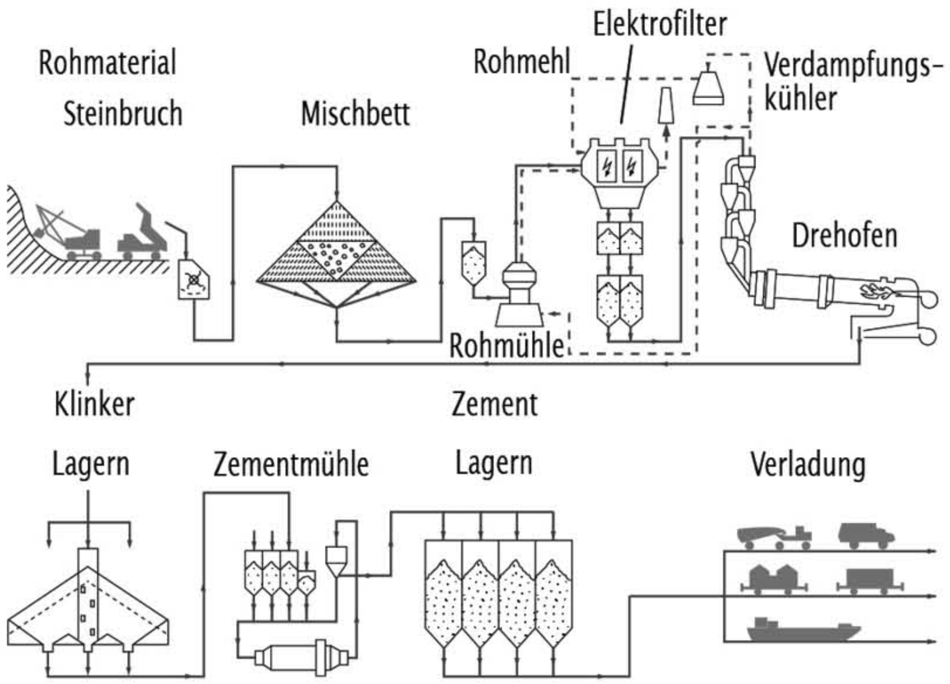
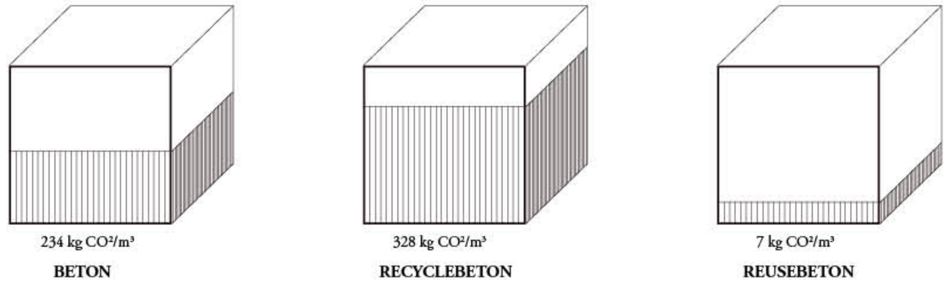


Abb. 2.12 Concrete production process



Greenhouse gas emissions from concrete

"Worldwide, we build the equivalent of the city of New York every month"

Abb. 2.13 Concrete is processed on the construction site

Abb. 2.14 A concrete structure is demolished

"The cement industry is responsible for 8% of global CO2 emissions"

Reuse concrete

2.2

There are already initial efforts to reuse concrete. Researchers at the École Polytechnique Fédérale de Lausanne have constructed a pedestrian bridge from reused reinforced concrete blocks that they had cut from the walls of a building that was due for demolition. The walls were cut into pieces on site with a concrete saw. Two holes were drilled in each of these. By inserting steel cables, the elements were then assembled into a prestressed arch.

Concrete saws or hydrocutters are particularly suitable for demolishing reinforced concrete structures in a controlled manner. If one cuts the structural element with the concrete saw, not only the concrete but also the armoring is separated. By using the hydrocutter, the existing reinforcement can be preserved. Depending on the construction method of the new design, the recovered elements can be used again in a targeted manner. However, the effort, time, emissions and costs of deconstruction must be taken into account. If one now imagines this procedure in relation to multi-storey skeleton buildings, the deconstruction must be planned similarly to the construction of such a building. Not only is the same machinery required, but also a complete site set-up is necessary. The entire building has to be sprouted in order to be cut and to harvest the elements one by one. Reassembling these elements is reminiscent of the Japanese repair method Kintsugi, in which broken ceramics are put back together.

Abb. 2.21 a wall slice is cut

Abb. 2.22 The elements are newly installed

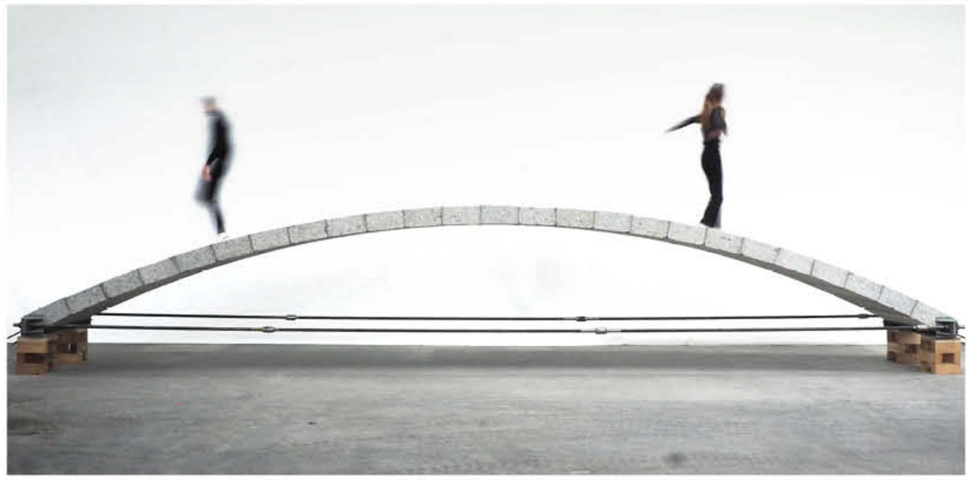
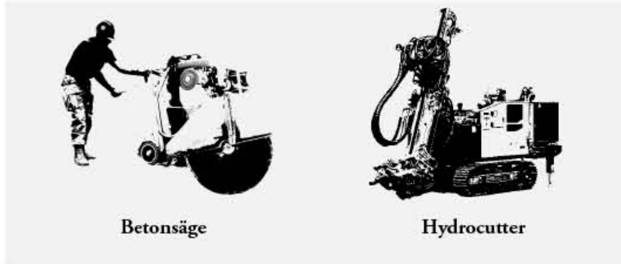


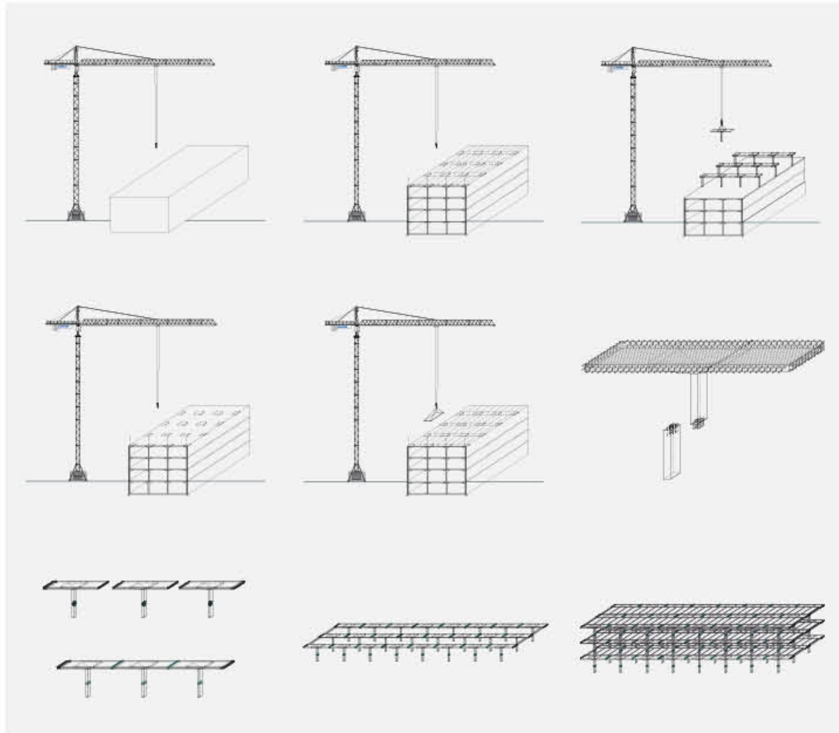
Abb. 2.23 Newly constructed bridge from harvested components

Demolition process



Demolition machines to cut concrete

Deconstruction



steps for a successful deconstruction of a building

New composition

Abb. 2.24 Kintsugi - Japanese reperation method

Sorting building components

2.3

To build with harvested components, they have to be measured, digitised and re-sorted. Similar to the methodology of the artist Urs Wehrli, who "tidies up" well-known art objects, i.e. rearranges their elements and divides them into groups, it helps to do the same in the design process. Components which, after digitisation, are first assigned to the buildings from which they were extracted, have to be re-sorted according to their future function. In this research, the following categorisation was made: Vertical supporting elements, horizontal supporting elements and filling elements are distinguished. Elements needed for roof structures were given a special treatment. Due to design intentions, these elements are also sorted according to design potential and iconographic expressiveness. Shaping the volumes into elegant proportions is a challenge. Due to their fixed dimensions, certain components provide a framework for the entire composition. In order to control these specifications, the filling elements are cut according to the intended size.

Abb. 2.31 Wassily Kandinsky
Roter Fleck, 1921

Abb. 2.32 Urs Wherli
Roter Fleck sortiert

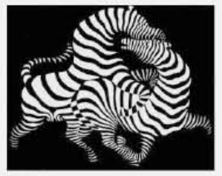


Abb. 2.33 Urs Wherli, Kunst aufräumen - basis Kunstwerk

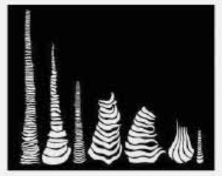
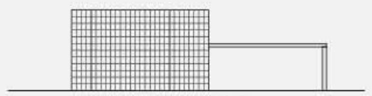
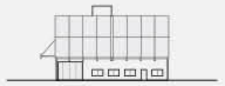


Abb. 2.34 Urs Wherli, Kunst aufräumen

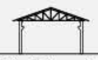
Method



Maag Hallen, Zürich 1



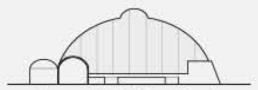
Gewerbegebäude Erlenmatt Ost, Basel 2



Lagerhalle Kochareal, Zürich 3

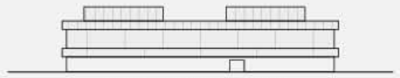
Gewerbehalle Manegg, Zürich 4

Zürich Versicherung Binz, Zürich 5

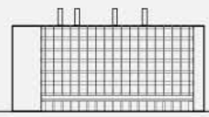


Kunsteisbahn Oerlikon, Zürich 6

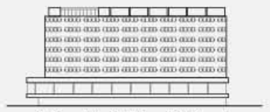
Gewerbehallen Wallisellen, Zürich 7



Schwimmbad Oerlikon, Zürich 8



Laborgebäude Haus 6 Rosental Mitte, Basel 9



Laborgebäude Universität, Basel 10

Buildings

Abb. 2.35 Maag Hallen

Abb. 2.36 Maag Hallen innen

Abb. 2.37 Gewerbehalle Basel

Abb. 2.38 Gewerbehalle Basel

Abb. 2.39 Kochareal Zürich

Abb. 2.40 Kochareal Zürich

Abb. 2.41 Manegg Gewerbehallen

Abb. 2.42 Manegg Gewerbehallen

Abb. 2.43 Zürich Versicherung

Abb. 2.44 Zürich Versicherung

Abb. 2.45 Kunsteisbahn

Abb. 2.46 Kunsteisbahn

Abb. 2.47 Gewerbehallen Wallisellen

Abb. 2.48 Gewerbehallen Wallisellen

Abb. 2.49 Schwimmbad Oerlikon

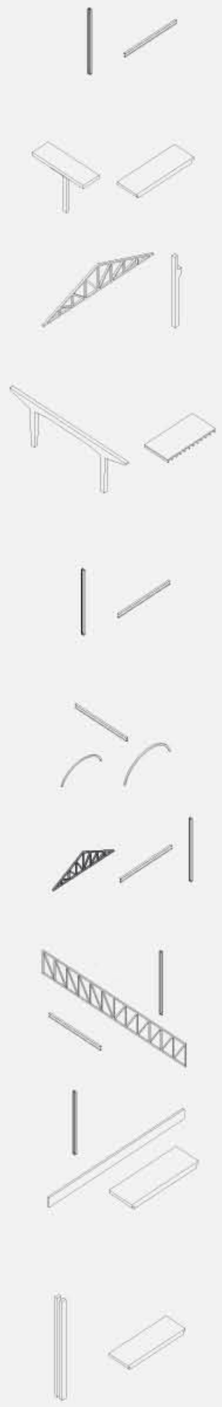
Abb. 2.50 Schwimmbad Oerlikon

Abb. 2.51 Laborgebäude Basel

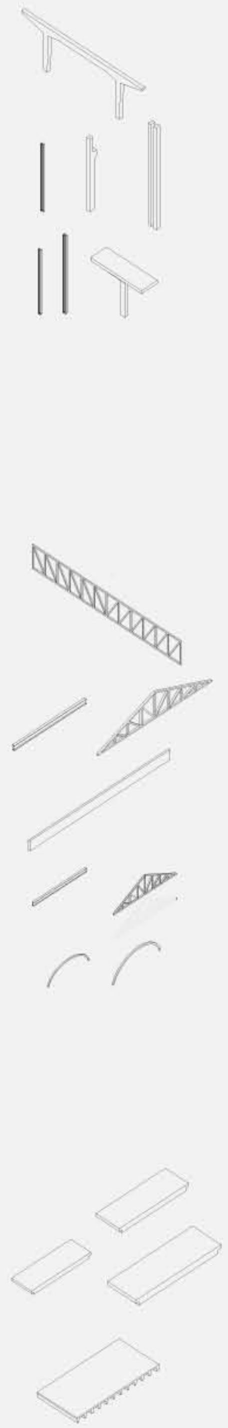
Abb. 2.52 Laborgebäude Basel

Abb. 2.53 Laborgebäude Campus

Abb. 2.54 Laborgebäude Campus



Harvested components



Sorted components

Documentation - Costs & Greenhouse gas emissions 4

Calculation basis 4.1

Calculating the processes of deconstruction is a challenge. While industrial processes for the construction of a building have become increasingly efficient over the years, this development is completely lacking for sustainable deconstruction. There is also a lack of know-how on the part of the deconstruction companies and of empirical values. The machines used in this estimate come partly from road construction or are mainly used for redevelopment. The potential for optimising these processes is enormous. All benchmarks used in the calculation are estimates made by contractors and are intended to provide a first indication. The following calculation is intended to show a comparison between a conventionally constructed concrete structure and a structure made out of reused concrete elements. Each component and each construction site is calculated.

Materials - Greenhouse gas emissions

Reinforced concrete:

m^3	**350.00 kg CO_2-eq**
1 m^3	**2.5 kg/m^3**

Steel beams / steel columns:

1 t	**1500.00 kg CO_2-eq**

Materials - Costs

Reinforced concrete:

m^3	**90.00 CHF**
roof m^2	**250.00 CHF**
column meter	**800.00 CHF**

Steel beams / steel columns

1 t	**5200.00 CHF**
1 kg	**5.00 F**
1 m^3	**8.000.00 Kg**
1 dm^3	**8 Kg**

Abb. 4.01 Steel girder before installation

Abb. 4.02 Concrete structure before demolition

Equipment

Tyrolit - FugenschneiderFSE 1022

Abb. 4.03

m^2	**300 CHF**
power	**22 kW**
CO^2 pro h	**0.6 kg CO_2**
energy	**electricity**

Flach - Base Jet 250 1500-90-0-e

Flach - Surface Rob 250 30-2000-e

Abb. 4.04

Abb. 4.05

m^2	**200 CHF**
power	**300 kW**
CO_2 / h	**9 kg CO_2**
energy	**electricity**

m^2	**200 CHF**
Leistung	**300 kW**
CO_2 pro h	**9 kg CO_2**
energy	**electricity**

Lissmac Multicut 605

Abb. 4.06

meter cut	**200 CHF**
power	**55 kW**
CO_2 pro h	**17 kg CO_2**
energy	**diesel**

Mobile crane

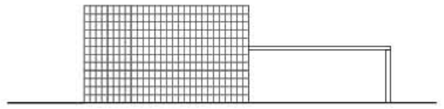
Abb. 4.07

day	**2000 CHF**
power	**455 kW**
CO_2 pro h	**141 kg CO_2**

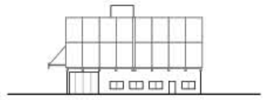
Semitrailer

Abb. 4.08

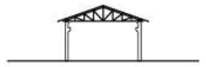
space:	**13.8m x 2.7m x 3m**
100 km	**400 CHF**
100 km	**100 kg CO_2**



Maag Hallen, Zürich
Construction site duration: five days Costs: 17.835.00

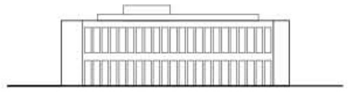


Gewerbegebäude Erlenmatt Ost, Basel
Construction site duration: twenty days Costs: 125.000.00

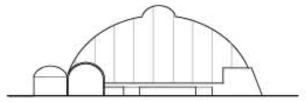


Lagerhalle Kochareal, Zürich
Construction site duration: two days Costs: 6.000.00

Gewerbehalle Manegg, Zürich
Construction site duration: fifeteen days Costs: 63.000.00

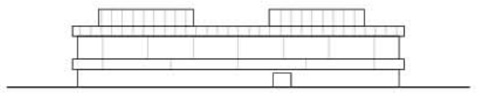


Zürich Versicherung Binz, Zürich
Baustellendauer: eine Woche Costs: 18.650.00

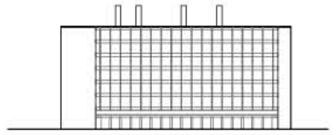


Kunsteisbahn Oerlikon, Zürich
Construction site duration: three days Costs: 8500

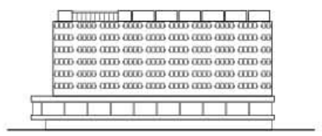
Gewerbehallen Wallisellen, Zürich
Construction site duration: five days Costs: 23.500.00



Schwimmbad Oerlikon, Zürich
Construction site duration: five days Costs: 35.000.00



Laborgebäude Haus 6 Rosental Mitte, Basel
Construction site duration: twenty days Costs: 88500



Laborgebäude Universität, Basel
Construction site duration: twenty days Costs: 92250

Costs for all construction sites, machines and expenses:

438.235.00 CHF

Abb. 4.09: Dismantling of the steel structure of an existing commercial hall in Basel. After dismantling, the components were processed and reused.

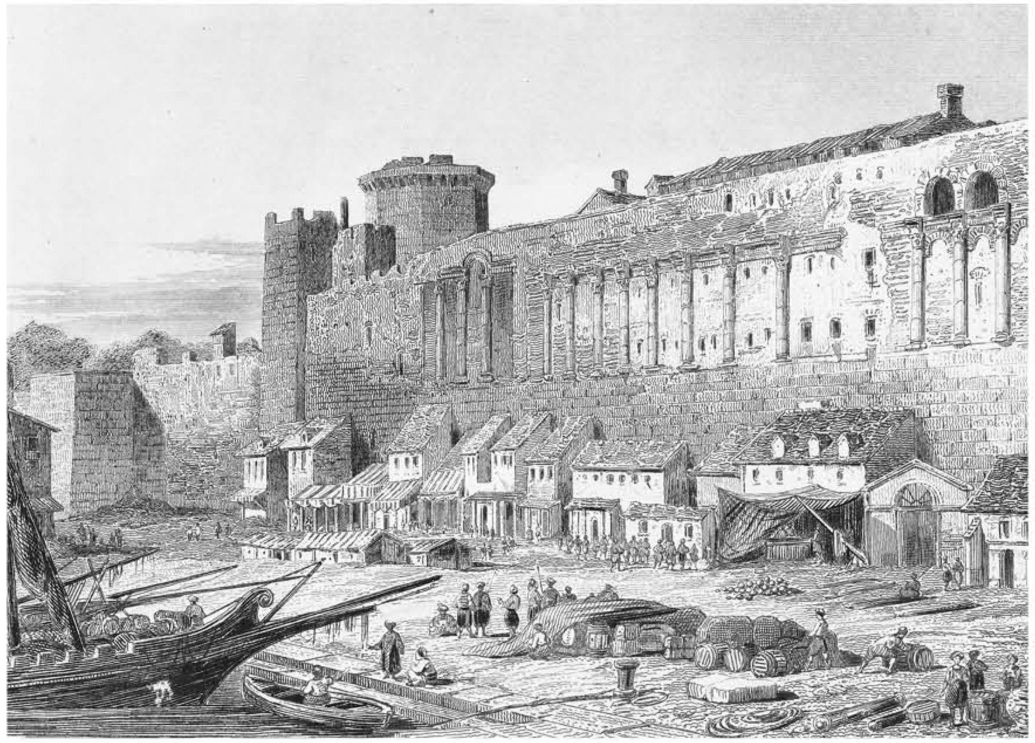
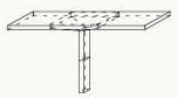
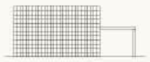
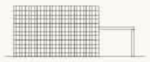


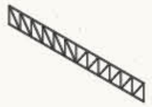
Abb. 4.10: In Split, the medieval buildings were constructed from reused stones and columns of ancient buildings. The defensive wall was used as a back wall for new buildings and filled with old components when needed.

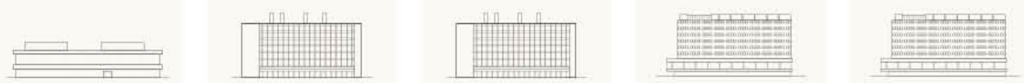
Harvested components

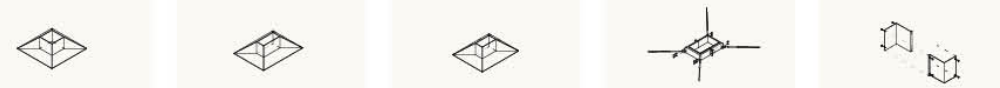
	Pilzstütze	Deckenelement	Deckenelement	Stahlstütze	Stahlstütze
					
Emissions Re-Use	37 T CO_2 - eq	19 T CO_2 - eq	37 T CO_2 - eq	1.2 T CO_2 - eq	1.3 T CO_2 - eq
Costs Re-Use	**852.720.00 CHF**	**831.600.00 CHF**	**1.566.000.00 CHF**	**49.900.00 CHF**	**52.250.00 CHF**
Building					
	Gewerbegebäude Erlenmatt Ost **Basel**	Gewerbegebäude Erlenmatt Ost **Basel**	Gewerbegebäude Erlenmatt Ost **Basel**	Zürich Versicherung Binz **Zürich**	Zürich Versicherung Binz **Zürich**
Origin					
Transport in km	82	82	82	87	87
Material	Stahlbeton	Stahlbeton	Stahlbeton	Stahl	Stahl
Quantity	108 Stk.	108 Stk.	216 Stk.	72 Stk.	72 Stk.
Dimensions L x B x H in Meter	8.5 x 2.9 x 0.4	6.0 x 3.0 x 0.4	6.0 x 2.75 x 0.4	0.2 x 0.1 x 5.5	0.25 x 0.15 x 5.5
Volume in m³	11.51	7.20	6.60	126 kg	135 kg
Reuse Emissions in kg CO_2-eq	336	176	175	17	18
New part Emissions in kg CO_2-eq	4025	2520	2310	189	198
Reuse Costs in CHF	9.895.00	7.700.00	7.250.00	693.00	726
New part Costs in CHF	10.835.50	4.500.00	4.125.00	630.00	660

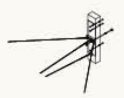
	Stahlträger	Stahlträger	Fachwerkträger	Betonstütze	Betonrahmen
					
Emissions Re-Use	0.7 T CO_2 - eq	3.0 T CO_2 - eq	5.9 T CO_2 - eq	0.2 T CO_2 - eq	0.2 T CO_2 - eq
Costs Re-Use	**30.250.00 CHF**	**123.550.00 CHF**	**240.127.50 CHF**	**13.500.00 CHF**	**26.400.00 CHF**
Building					
	Zürich Versicherung Binz **Zürich**	Maag Hallen Industriequartier **Zürich**	Lagerhalle Koch Areal Altstetten **Zürich**	Lagerhalle Koch Areal Altstetten **Zürich**	Gewerbehalle Manegg **Zürich**
Origin					
Transport in km	2	2	3	3	6
Material	Stahl	Stahl	Stahl	Stahlbeton	Stahlbeton
Quantity	24 Stk.	96 Stk.	17 Stk.	34 Stk.	12 Stk.
Dimensions L x B x H in Meter	5.4 x 0.15 x 0.3	5.4 x 0.09 x 0.18	13 x 0.1 x 2.8	0.6 x 0.4 x 7.5	25 x 0.4 x 6.0
Volume in m³	234 kg	234 kg	2575 kg	1.8	9.90
Reuse Emissions in kg CO_2-eq	32	32	350	7.2	35
New part Emissions in kg CO_2-eq	351	351	3861	630	3465
Reuse Costs in CHF	1287	1287	14157	397	2200
New part Costs in CHF	1170	1170	12870	6375	4675

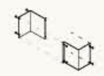
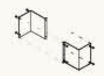
	Kassettendecke	Stahlstütze	Stahlträger	Holzbogen	Holzbogen
					
Emissions Re-Use	1.2 T CO_2 - eq	1.1 T CO_2 - eq	0.23 T CO_2 - eq	0.54 T CO_2 - eq	1.0 T CO_2 - eq
Costs Re-Use	**307.200.00 CHF**	**45.540.00 CHF**	**9.500.00 CHF**	**22.000.00 CHF**	**41.360.00 CHF**
Building	 Gewerbehalle Manegg **Zürich**	 Maag Hallen Industriequartier **Zürich**	 Maag Hallen Industriequartier **Zürich**	 Kunsteisbahn Oerlikon **Zürich**	 Kunsteisbahn Oerlikon **Zürich**
Origin					
Transport in km	6	2	2	6	6
Material	Stahlbeton	Stahl	Stahl	Holz	Holz
Quantity	48 Stk.	72 Stk.	24 Stk.	16 Stk.	32 Stk.
Dimensions L x B x H in Meter	4.0 x 5.0 x 0.3	0.2 x 0.1 x 5.5	3.75 x 0.09 x 0.18	5.5 x 0.3 x 2.75	5.8 x 0.3 x 2.35
Weight in kg	3.0 kg	115 kg	72 kg	250 kg	235 kg
Reuse Emissions in kg CO_2-eq	25	15.25	10	33	31.75
New part Emissions in kg CO_2-eq	1050	172.50	108	375	352.5
Reuse Costs in CHF	6.400.00	632.50	396.00	1.375.00	1.292.50
New part Costs in CHF	5.400.00	575.00	360.00	1.200.00	1.175.00

	Fachwerkträger	Stahlstütze	Stahlträger	Fachwerkträger	Stahlstütze
					
Emissions Re-Use	4.5 T CO_2 - eq	1.0 T CO_2 - eq	0.2 T CO_2 - eq	9.8 T CO_2 - eq	1.0 T CO_2 - eq
Costs Re-Use	**185.320.00 CHF**	**40.480.00 CHF**	**9.500.00 CHF**	**401.500.00 CHF**	**41.320.00 CHF**
Building	 Gewerbehalle Wallisellen **Zürich**	 Gewerbehalle Wallisellen **Zürich**	 Gewerbehalle Wallisellen **Zürich**	 Schwimmbad Oerlikon **Zürich**	 Schwimmbad Oerlikon **Zürich**
Origin					
Transport in km	9	9	9	5.5	5.5
Material	Stahl	Stahl	Stahl	Stahl	Stahl
Quantity	24 Stk.	64 Stk.	24 Stk.	40 Stk.	64 Stk.
Dimensions L x B x H in Meter	6.8 x 0.2 x 1.80	0.2 x 0.1 x 5.50	6.8 x 0.2 x 1.80	10 x 0.15 x 2.0	0.2 x 0.1 x 5.50
Weight in kg	1404 kg	115 kg	72 kg	1825 kg	115 kg
Reuse Emissions in kg CO_2-eq	189.50	15.50	189.5	245.370	15.25
New part Emissions in kg CO_2-eq	2.105	172.50	2.105	2737.50	172.50
Reuse Costs in CHF	7.722	632.50	7.722	10.035.50	632.50
New part Costs in CHF	7.020	575	7.020	9125	575

	Stahlträger	Stahlbetonträger	Betondecke	Betondoppelstütze	Betondecke
					
Emissions Re-Use	**0.45 T CO_2 - eq**	**11.25 T CO_2 - eq**	**9.5 T CO_2 - eq**	**9.0 T CO_2 - eq**	**0.45 T CO_2 - eq**
Costs Re-Use	**19.000.00 CHF**	**206.000.00 CHF**	**1.132.000.00 CHF**	**203.650.00 CHF**	**19.000.00 CHF**
Building					
	Schwimmbad Oerlikon **Zürich**	Laborgebäude Rosental Mitte **Basel**	Laborgebäude Rosental Mitte **Basel**	Laborgebäude Universität **Basel**	Laborgebäude Universität **Basel**
Origin					
Transport in km	5.5	82	82	87	87
Material	Stahl	Stahlbeton	Stahlbeton	Stahlbeton	Stahlbeton
Quantity	48 Stk.	64 Stk.	200 Stk.	256 Stk.	88 Stk.
Dimensions L x B x H in Meter	6.25 x 0.09 x 0.18	10.75 x 0.25 x 1.0	5.6 x 2 x 0.3	0.2 x 0.45 x 5.75	5.6 x 2 x 0.3
Weight in kg	72 kg	2.75	3.36	2.75	3.36
Reuse Emissions in kg CO_2-eq	10	175.82	87.6	35	89.5
New part Emissions in kg CO_2-eq	108	940	1.176	363	1.176
Reuse Costs in CHF	396.00	3.231.00	4.135.00	795.00	4.175
New part Costs in CHF	360.00	6.450.00	2.800.00	4800.00	2.800.00

	Stahlschuh	Stahlschuh	Stahlschuh	Stahlverbindung	Stahlschelle
					
Emissions Re-Use	**37 T CO_2 - eq**	**75 T CO_2 - eq**	**11.2 T CO_2 - eq**	**11.2 T CO_2 - eq**	**62 T CO_2 - eq**
Costs Re-Use	**129.800.00 CHF**	**262.800.00 CHF**	**39.800.00 CHF**	**39.800.00 CHF**	**216.215.00 CHF**
Building					
	Stahlwerk Gerlafingen **Solothun**	Stahlwerk Gerlafingen **Solothun**	Stahlwerk Gerlafingen **Solothun**	Stahlwerk Gerlafingen **Solothun**	Stahlwerk Gerlafingen **Solothun**
Origin					
Transport in km	90	90	90	90	90
Material	Stahl	Stahl	Stahl	Stahl	Stahl
Quantity	64 Stk.	108 Stk.	24 Stk.	108 Stk.	108 Stk.
Dimensions L x B x H in Meter					
Weight in kg	390 kg	468 kg	312 kg	54.5 kg	385 kg
Reuse Emissions in kg CO_2-eq					
New part Emissions in kg CO_2-eq	585.00	702.22	486.00	82.00	577.50
Reuse Costs in CHF					
New part Costs in CHF	2.028.00	2.433.00	1.625.00	283.00	2.002.00

	Stahlverbindung	Stahlverbindung	Zugelement	Zugelement	Betonverbindung
					
Emissions Re-Use	2.2 T CO_2 - eq	2.2 T CO_2 - eq	0.15 T CO_2 - eq	0.33 T CO_2 - eq	2.0 T CO_2 - eq
Costs Re-Use	7.800.00 CHF	7.800.00 CHF	520.00 CHF	1.200.00 CHF	5.000.00 CHF
Building	Stahlwerk Gerlafingen **Solothun**	Stahlwerk Gerlafingen **Solothun**	Stahlwerk Gerlafingen **Solothun**	Stahlwerk Gerlafingen **Solothun**	Stahlwerk Gerlafingen **Solothun**
Origin					
Transport in km	90	90	90	90	90
Material	Stahl	Stahl	Stahl	Stahl	Beton
Quantity	64 Stk.	64 Stk.	16 Stk.	32 Stk.	128 Stk.
Dimensions L x B x H in Meter					
Weight in kg	25 kg	25 kg	6.5 kg	7 kg	0.05
Reuse Emissions in kg CO_2-eq					
New part Emissions in kg CO_2-eq	35.00	35.00	10.00	10.00	15.00
Reuse Costs in CHF					
New part Costs in CHF	121.00	121.00	35.00	36.00	40.00

	Stahlverbindung	Stahlverbindung	Zugelement	Zugelement	Zugelement
					
Emissions Neubauteil	14.0 T CO_2 - eq	74.0 T CO_2 - eq	14.7 T CO_2 - eq	10.7 T CO_2 - eq	0.6 T CO_2 - eq
Costs Neubauteil	48.600.00 CHF	259.600.00 CHF	51.100.00 CHF	37.100.00 CHF	2.100.00 CHF
Building	Stahlwerk Gerlafingen **Solothun**	Stahlwerk Gerlafingen **Solothun**	Stahlwerk Gerlafingen **Solothun**	Stahlwerk Gerlafingen **Solothun**	Stahlwerk Gerlafingen **Solothun**
Origin					
Transport in km	90	90	90	90	90
Material	Stahl	Stahl	Stahl	Stahl	Stahl
Quantity	24 Stk.	128 Stk.	36 Stk.	24 Stk.	64 Stk.
Dimensions L x B x H in Meter					
Weight in kg	390 kg	405 kg	273 kg	296 kg	6.5 kg
Reuse Emissions in kg CO_2-eq					
New part Emissions in kg CO_2-eq	585.00	615.00	410.00	445.00	10.00
Reuse Costs in CHF					
New part Costs in CHF	2.028.00	2.135.00	1.420.00	1.541.00	35.00

Greenhouse gas emissions

As part of the follow-up, the construction of the building was analysed in terms of economic efficiency and greenhouse gas emissions.

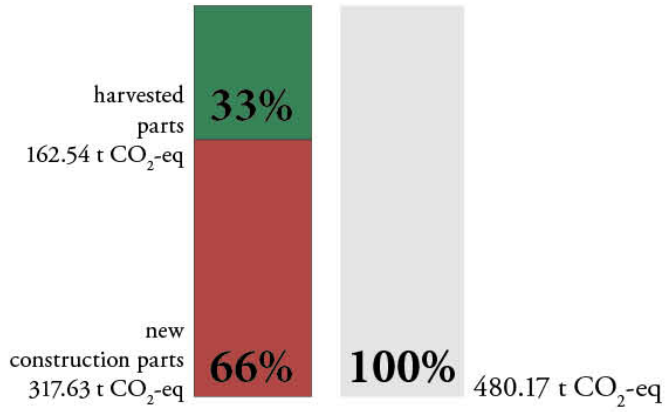
The construction of the building structure is calculated. The main focus is on the reused concrete elements. Due to the high complexity of the deconstruction process, each component is calculated individually. The values for greenhouse gas emissions are made up of the following factors: Deconstruction process (site equipment, concrete saw/hydrocutter, truck-mounted crane)transport and reinstallation. The calculated value of the re-use construction is compared with the values that would result from a conventional reinforced concrete construction. Factors here would be: the production of the material, transport and reinstallation. Due to the comparison, the reinstallation part of the process is neglected for both methods. This should have no, effect on the calculated comparison.

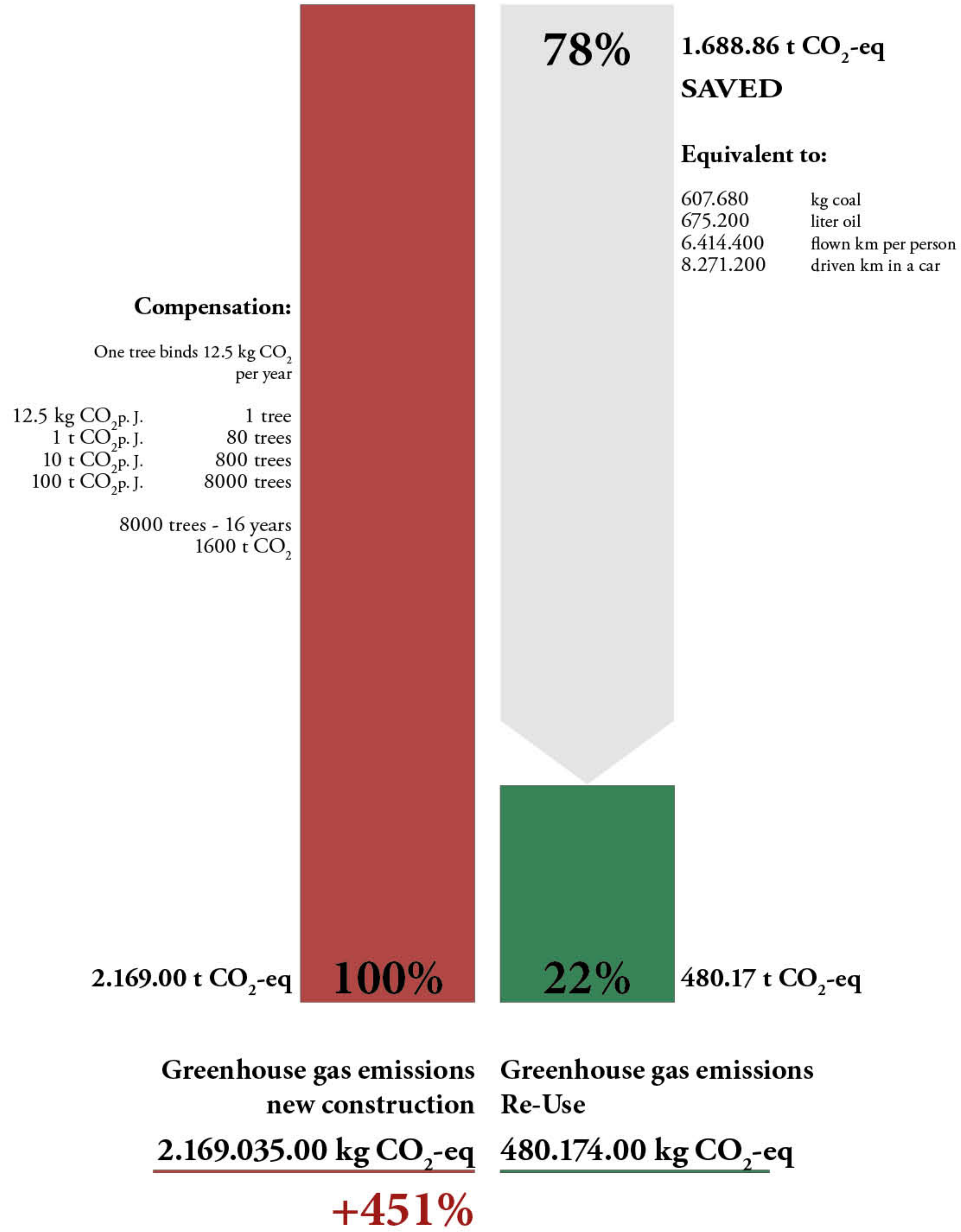
The preceding documentation of the individual components states the calculated values. It is interesting to note that the grey energy generated by cutting and transporting the deconstructed elements is low compared to the grey energy required to newly produce the same components. Despite a large amount of mechanical effort, it amounts to only 22% of the total grey energy enbodied within the component. Overall 1688 tonnes of CO_2 can be saved. The calculation was interpreted generously, so that the exact value is most likely lower.

The comparison between the harvested concrete elements and the new steel elements required for the construction is astonishing. Even the small number and quantities required results in twice the amount of greenhouse gas emissions being released due to the energy-intensive manufacturing process of steel parts. There is definitely still potential for optimisation here. However, all construction details of the newly assembled building are reversible and can be used again.

4.3

Re-use construction
Greenhouse gas emissions





Construction costs

The calculation of the construction costs is carried out accordingly to the method used to determin the amount of the greenhouse gas emission. Each component is calculated individually. In addition, there are costs for dismantling, transport and refurbishment of the components. These values were estimated by contractors who have some experience but the generall know how is not available yet. It is important to note that the proposed dismantling process is experimental in nature. Automated and industrially optimised processes have become increasingly cheaper since the of industrialisation. This also applies to the construction of buildings. The targeted deconstruction of buildings for reuse is also expensive because there has been very little innovation in this area.

The costs of deconstruction and transport are calculated for each component. These are added up and multiplied by the number of components. The new construction detail solutions are estimated with the material value and the production costs. Conventional construction is calculated entirely by contractor-estimated values.

Since the planning of construction with reused components is much more complex than that of conventional construction, a fee of ≈ 10% is included in conventional construction. For re-use construction, a fee of ≈ 30% is calculated since the effort is much higher.

In order to arrive at a representative value which we can work with, costs for emitted CO_2 are also calculated in the form of certificates. These are set at CHF 120 per tonne which is the amount that is discussed at the moment. This certificate is a tax measure to promote sustainable construction. Since the price per tonne is so low it can be negligible at this level doe to its lack of impact. The cost of the CO_2 certificates would have to be increased by a factor of 5-10 to make a real difference.

It is astonishing that even with a calculation method where one would generously calculate in favour for conventional construction when in doubt, the supporting structure from reused components is only 34% more expensive.