# Emancipating Excavated Earth

EXTRACTED MATERIAL
AS A
NO-WASTE PRODUCT

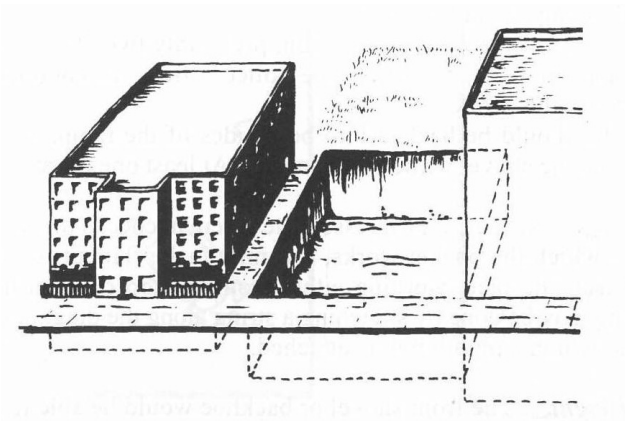
*With many thanks to Beat Manni, to Felix Hilgert, to Thomas Dimov, and other people I had the chance to talk to or from whom I received inspiring and helpful information.*

Booklet by
Sereina Fritsche

ARCHITECTURES OF CORRESPONDENCE

Diploma ETH Zürich, HS 2023
Chair of Affective Architectures
Chair of the History and Theory of Urban Design
Chair of Circular Engineering for Architecture

Architecture has always something to do with changing the terrain. With mostly every architectural or infrastructural project earth is excavated. Considered as waste, it is mostly transported to landfills. Why is it “waste” when other material is excavated by purpose? Shouldn’t excavated earth as by-product be reevaluated as valuable resource and potential building material?
In today’s world with the threatening climate crisis, we need to rethink many habits and procedures in the construction sector and enter a circular construction. Since the building sector is a major contributor to global warming we can’t deal with materials as we did until now and must build with what is locally available. There is a change needed from ‘material of choice’ to ‘material of necessity’ where excavated earth is a great example. Shouldn’t we emancipate excavated earth from the notion of “waste” and let it act and construct our built environment?



Excavation pit as first step to construct a building

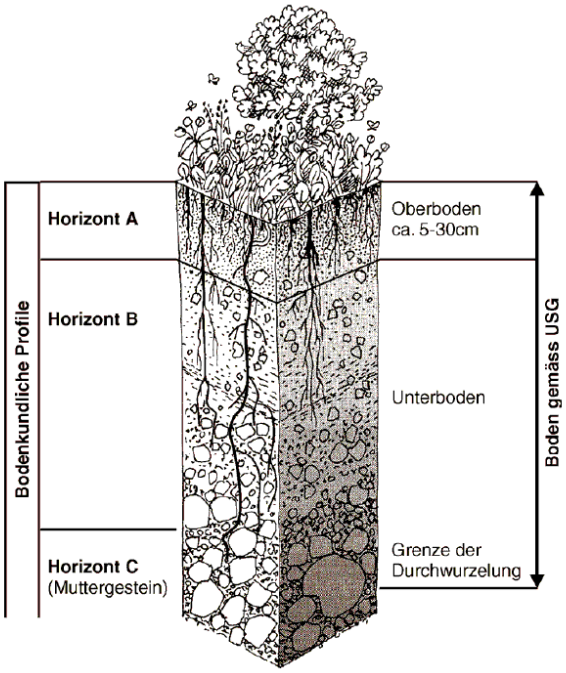
*Herbert L. Nicholas, Jr. David A. Day, p.e., Moving the Earth - The Workbook of Excavation, 2010, p. 4.19.*

# Excavated Earth

*Art. 3 f.* *Aushub- und Ausbruchmaterial: Material, das bei Bauarbeiten ausgehoben oder ausgebrochen wird, ausgenommen ist abgetragener Ober- und Unterboden;*

*translated:* *„Excavated material: material excavated during construction work,excluding removed topsoil and subsoil;“*

*Source: https://www.fedlex.admin.ch/eli/cc/2015/891/de (visited 04.10.2023)*




Soil composition (Topsoil A, Subsoil B, Excavation C)

*https://www.sz.ch/umweltdepartement/amt-fuer-umwelt-und-energie/umwelt/bodenschutz/bodenschutz.html/8756-8758-8802-9447-9453-10707-10753-10847 (visited 06.10.2023)*

‚La Terre, un Matériau Urbain‘

*©amàco, https://www.cycle-terre.eu/cycle-terre/le-projet/ (visited 06.10.2023)*

# GEOLOGY OF ZURICH

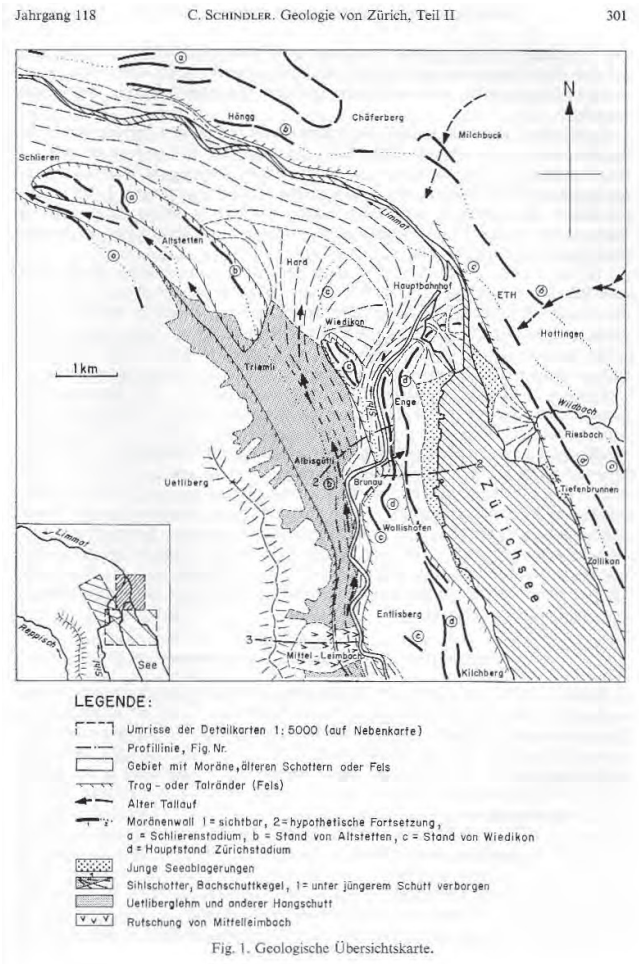
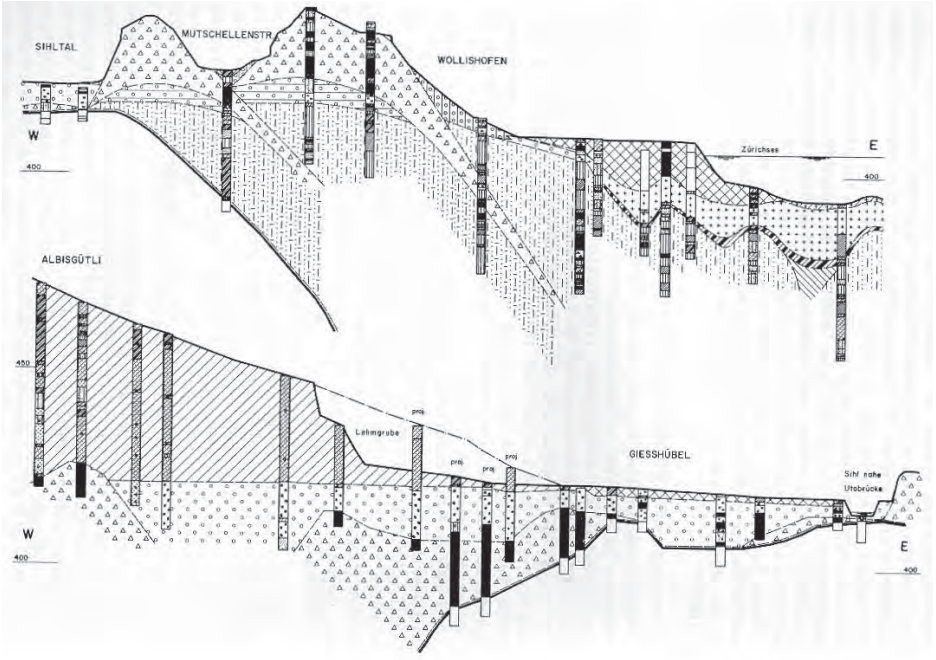
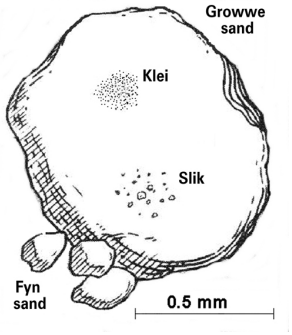



Fig. 1. Geologische Übersichtskarte.




Geological map and section of Zurich showing different geological layers

*Geologie von Zürich, Teil II: Riesbach- Wollishofen, Conrad Schindler, 1971. https://www.ngzh.ch/archiv/1973_118/118_3/118_26.pdf (visited 06.10.2023)*




Soil particles

*https://www.grainsa.co.za/soil-the-producers-most-important-asset--part-5-physical-properties-of-soil?print=1 (visited 06.10.2023)*

Earth never equals earth. It has a unique character that depends on its geological location and as such its site of excavation. Earth consists of clay, silt, sand, gravel, and pebbles. Depending on the composition, earth can be used better or less well as a building material and the construction technique must be chosen according to the type of earth.

Since Binz was a former clay pit we do have clay rich soil in some parts of Zurich. A certain percentage of clay is necessary since it is the “glue” in the earthen material that holds everything together. Earth can easily be mixed such as the mixture has a good consistency. Testing is very important.

# Where does Excavated Earth go to?

There is a lot of construction going on in Zurich, which usually starts with the excavation of a construction pit, with the excavated earth being considered waste. Once a building is constructed, the original excavation pit becomes invisible. Likewise, the large amount of excavated earth disappears without anyone noticing. But where does it go?
I want to make the invisible visible and explore the material flow of excavated earth. Where does it end up?
Most excavated earth is filled into gravel pits. We dig a hole somewhere to get gravel to make concrete, and bring excavated earth from somewhere else to fill the hole back in. But shouldn‘t a material have the right to stay in its original place? What if the place of material production also becomes the place of material consumption?

With 40-60 million tons of excavated material per year it is the biggest waste flow in Switzerland and emits through transportation a lot of CO2.[1]
In Zurich in 2020, there was 3’980’000m$^3$ earth excavated where 54% was transported to gravel pits in the north of the canton to backfill them. 30% was deposited outside the canton and the remaining 16% were equally brought to dumpsites because of contamination, were recycled in soil washing plants to be used as building material (gravel or sand for concrete) or used to make terrain changes on the construction site.[2]

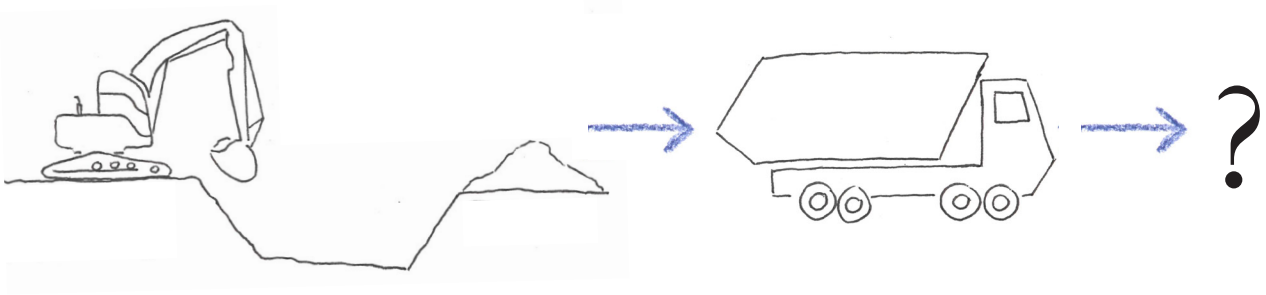
Based on the KAR model the resource and excavation flow in the canton of Zurich were analyzed (1995-2025). One of the conclusions was that the amount of extracted gravel will decrease while the amount of excavated earth stays constant. In Zurich, we will face a systematic excess of excavated material. Where to put all this “waste”? An inter-cantonal approach needs to be worked out, as excavated material disposal is a cross-cantonal, long-term problem.[3]

“Art. 19 of the Ordinance on the Prevention and Disposal of Waste (Waste Ordinance, VVEA, SR 814.600) requires that uncontaminated and slightly contaminated excavated material be recycled as completely as possible. The filling of material extraction points, such as gravel pits, also counts as recycling, whereas depositing in a landfill does not count as recycling and must be justified.[1] Why is filling a gravel pit different than depositing the excavated material in a landfill? Landfilling in the increasingly scarce landfill space should only take place if, due to material properties, recycling is not possible according to the state of the art.”[1]

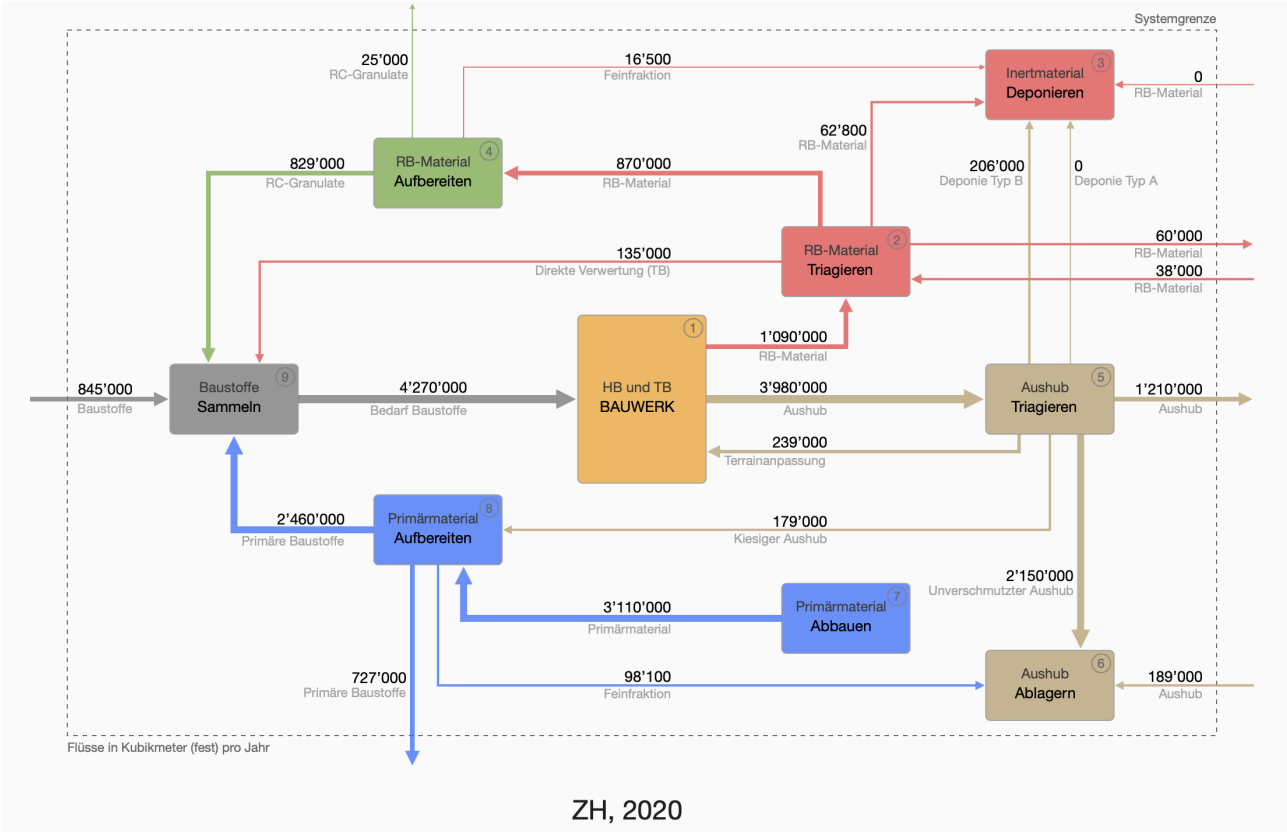
*1 https://www.bafu.admin.ch/bafu/de/home/themen/abfall/abfallwegweiser-a-z/aushubmaterial.html (quote translated by deepl from German)*

*2 http://www.kar-modell.ch/resultat_statMod.html*

*3 Schneider, Martin and Dr. Stefan Rubli. Rohstoff- und Aushubflüsse im Kanton Zürich: Ein dynamisches Modell der Materialflüsse für die Jahre 1995-2025. Schlussbericht November 2009, AWEL, Energie- und Ressourcen-Management GmbH.*

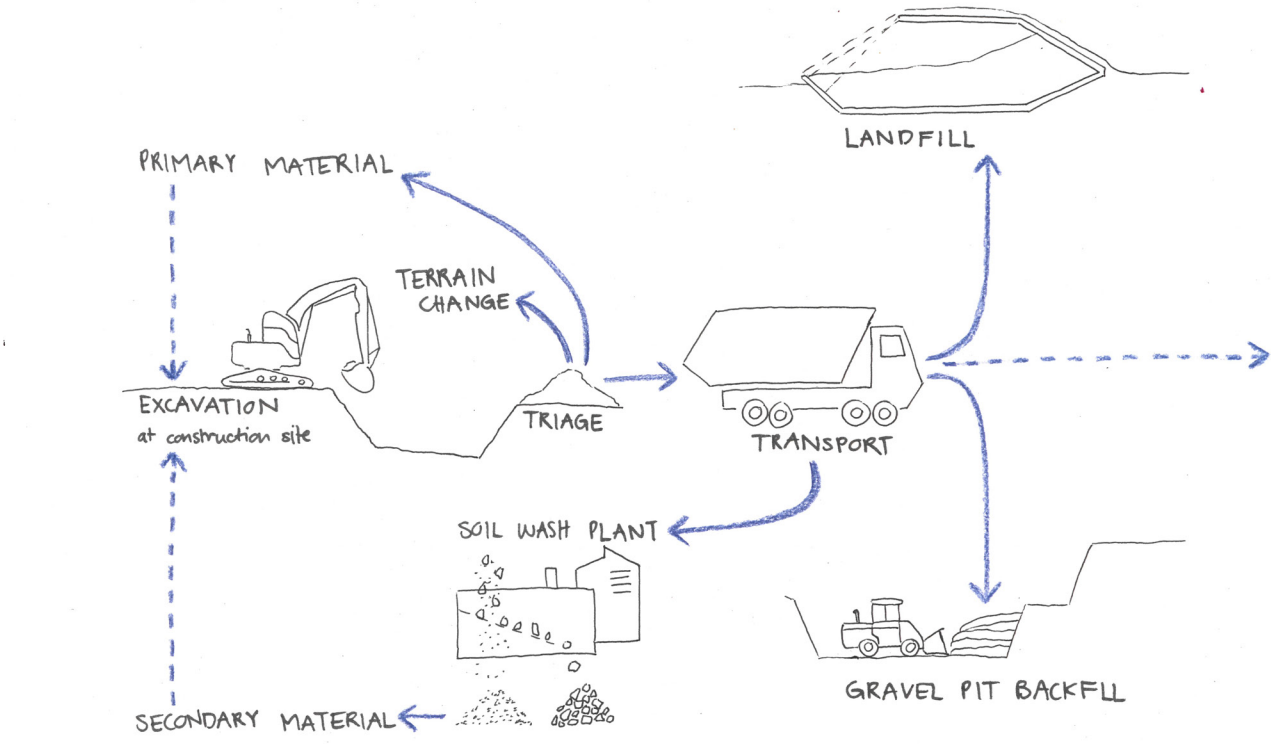


# RESOURCE TRAJECTORY OF EXCAVATED EARTH




Static KAR model of the material flow system in Zurich in 2020; arrow thickness corresponds to the value of the material flow

*Energie- und Ressourcen-Management GmbH, 2020, http://www.kar-modell.ch/resultat_statMod.html (visited 04.09.2023)*



# Rules and Regulations

„The strategic approach of the Waste Ordinance [VVEA] is to consider waste as a source of raw materials and thus also as raw materials in a high-quality cycle.“[1]

- A disposal concept has to be written which must be completed after **excavation** in the form of a disposal certificate.
- Non-contaminated and slightly contaminated excavated material should be recycled as completely as possible. Possible uses are as building material, as raw material for the production of building materials, for terrain changes, or the backfilling of material extraction sites such as gravel pits.[2]
- Depositing the excavated earth in a landfill is not considered as recycling and must be justified.
- At least 50% of slightly contaminated excavated material must be treated. A maximum of 50% may be landfilled.[2] The recycling obligation helps to close material cycles as far as possible.

- Since July 1, 2021, clean excavated material from excavation pits with a volume exceeding 25‘000$m^3$ must be transported away by rail. The rail **transport** obligation is justified with the traffic congestion.[3]

- The treatment in a **soil washing plant** depends on the degree of contamination and fine grain content. Excavated material that corresponds to landfill type B and has a fine grain content of < 0.063 mm must be recycled as completely as possible.[4]
- Every 500t, washed products must be analyzed for contamination and reused accordingly. If uncontaminated, they can be used as secondary material, otherwise they are used as raw meal for cement production.

- The aftercare period of a **landfill** may not exceed 50 years. A risk assessment must be carried out every 5 years. Landfills must be regularly inspected and groundwater monitored to ensure that the environment is not endangered. It must be ensured that a closed landfill has no harmful effects on usable groundwater or surface water.[1]

- A reclamation requirement applies to recultivate **gravel pits** for agricultural purposes. The operator is „required by law to provide ecological compensation [natural areas], replacement or restoration measures.“[5]
- If there is groundwater the gravel extraction has to stop at least 3m above the groundwater to avoid water contamination.[6]

- In Switzerland, there are no standards for **earthen building** yet. Since August 2013, there have been DIN standards for earthen construction (last revised in 2018). They mainly define requirements and test methods for clay blocks, clay masonry mortar, clay plaster mortar, and clay panels, as well as Load-bearing clay block masonry - construction, design and execution.[7]

*Sources on the back*

*Sources:*


*1 BAFU (Hrsg.) 2019: Deponien. Ein Modul der Vollzugshilfe zur Verordnung über die Vermeidung und die Entsorgung von Abfällen. Bundesamt für Umwelt, Bern. Umwelt-Vollzug Nr. 1826 (translated by deepl from German).*

*2 https://www.lignum.ch/auf_einen_klick/news/lignum_journal_holz_news_schweiz/news_detail/kanton-zuerich-will-mehr-bauabfaelle-wiederverwerten/ (visited 04.10.2023).*

*3 https://www.terrarail-modalsplit.ch/dienstleistung (visited 05.09.2023).*

*4 PDF ‚Behandlungsregel für verschmutzte Bauabfälle und Aushub- und Aus-bruchmaterial im Hinblick auf die Verwertung', AWEL, 2020, zh.ch.*

*5 https://www.biodivers.ch/de/index.php/Abbaugebiete (visited 04.10.2023).*

*6 https://www.wkw-rafzerfeld.ch/oekologie-2/ (visited 04.10.2023).*

*7 https://www.dachverband-lehm.de/wissen/lehmbau-din-normen (visited 12.10.2023).*

# Gravel Pit Backfilling

Since more than 50% of excavated earth is backfilled into gravel pits, I researched where they are located. There were many gravel pits in the city of Zurich, which had to be relocated outward with the growing urbanization. Nowadays you find most of the gravel pits in the countryside at the edge of the canton.
Filled and built over, nothing can be guessed of the once big holes for gravel extraction anymore. Only the map 'Rohstoffkarte Kies des Kantons Zürichs' as well as archival images tell us the story. At that time, the backfilling conditions were not yet so strict that they were probably also filled with demolition waste and other contaminated material. The locations of former gravel pits within the city are all part of the cadastre of contaminated sites. It is likely that Zurich's soil in the river area is still quite gravelly, which results in qualitative gravel when the excavated material is washed.

Due to the increasing use of recycling gravel, gravel extraction is becoming smaller and thus also the possibility to deposit excavated earth in the gravel pits. At the same time, however, we are observing an increasing amount of excavated material.[1]

*1 Schneider, Martin and Dr. Stefan Rubli. Rohstoff- und Aushubflüsse im Kanton Zürich: Ein dynamisches Modell der Materialflüsse für die Jahre 1995-2025. Schlussbericht November 2009, AWEL, Energie- und Ressourcen-Management GmbH, pp. 3.*

Gravel pit in Wil
*SF, 2023.*

Excavation landfill of Weiacher Kies AG in Weiach ZH
*unknown, https://eberhard.ch/baustoffe/verwertung/aushub-unverschmutzt (visited 05.09.2023).*

# GRAVEL MAP OF ZURICH WITH FORMER GRAVEL PITS, 1996


Rohstoffkarte Kies des Kantons Zürich

1:25 000

Blatt Zürich



Ausgabe 1996

Direktion der öffentlichen Bauten des Kantons Zürich
Amt für Gewässerschutz und Wasserbau
Amt für Raumplanung

**Hochwertige Alluvialkiese in der Talsohle**

nachgewiesen – vermutet

Kies unter dem Grundwasserspiegel

0 – 5 m
5 – 10 m
10 – 20 m
> 20 m

Kiesmächtigkeit über dem höchstmöglichen Grundwasserspiegel (inkl. allfälliger Deckschichten bis ca. 3 m)

Deckschichten über dem Kies mehr als 3 m mächtig (Angabe der Kiesmächtigkeit ohne Deckschichten)

**Alluvialkiese über der Talsohle, oft verkittet**

nachgewiesen – vermutet

Kies unter dem Grundwasserspiegel

0 – 5 m
5 – 10 m
10 – 20 m
> 20 m

Kiesmächtigkeit über dem höchstmöglichen Grundwasserspiegel (inkl. allfälliger Deckschichten bis ca. 3 m)

Deckschichten über dem Kies mehr als 3 m mächtig (Angabe der Kiesmächtigkeit ohne Deckschichten)

**Andere kiesige Lockergesteine**

0 – 10 m
> 10 m

Kiesreiche Moräne, Wallmoräne, Drumlin, Bachschutt, kiesiger Gehängeschutt

Mächtigkeit ohne Berücksichtigung von Grundwasserspiegel und Quellen

**Festgesteine**

Nagelfluhschichten der Molasse

Zusammenhängende Nagelfluhvorkommen im Hörnligebiet

Kalk

**Kiesabbaustellen**

Kiesgruben Stand 1993

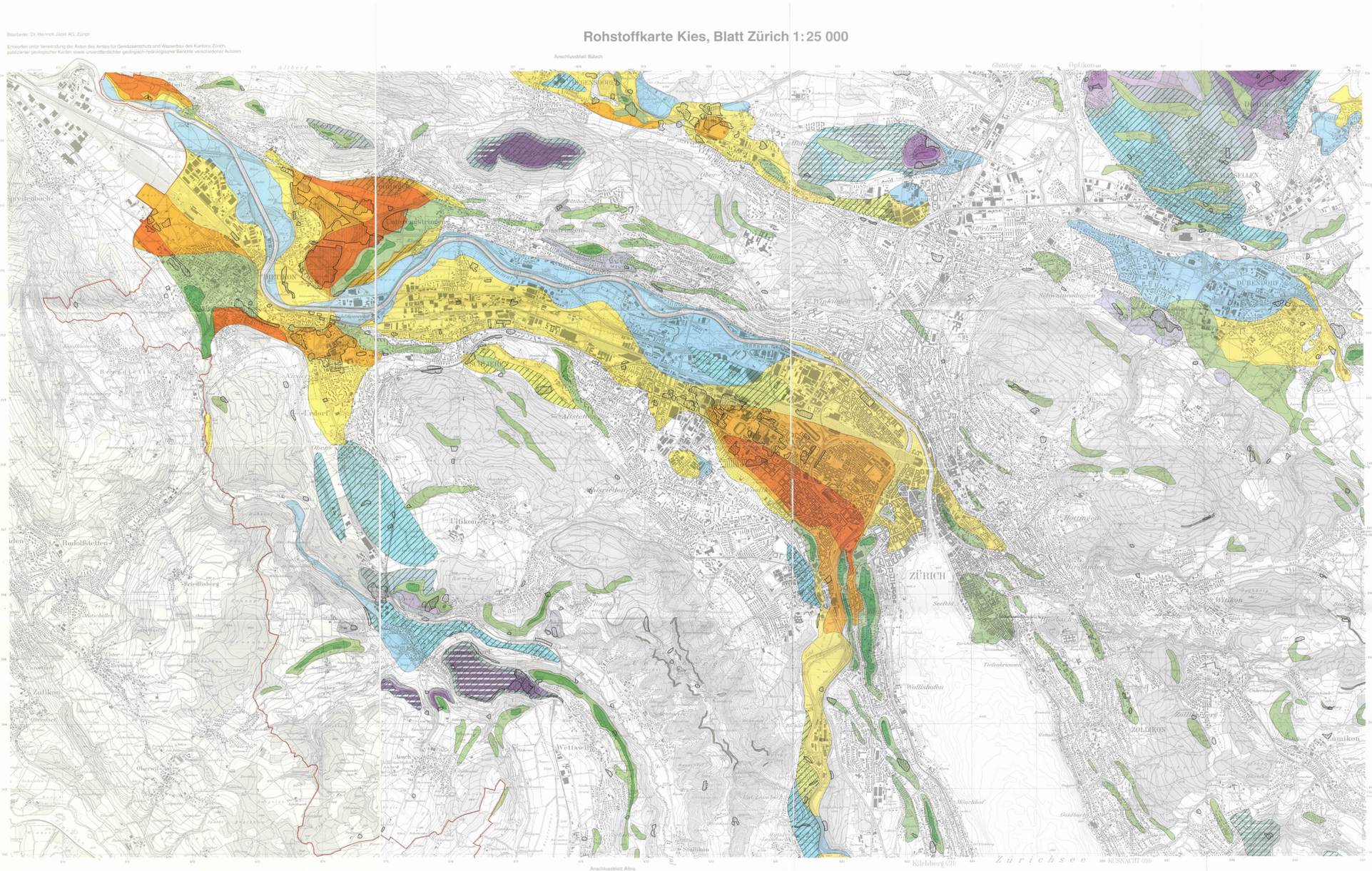
Ehemalige Kiesgruben

Bearbeiter: Dr. Heinrich Jäckli AG, Zürich

Entworfen unter Verwendung der Akten des Amtes für Gewässerschutz und Wasserbau des Kantons Zürich, publizierter geologischer Karten sowie unveröffentlichter geologisch-hydrologischer Berichte verschiedener Autoren.

## Rohstoffkarte Kies, Blatt Zürich 1:25 000

Anschlussblatt Bülach




Anschlussblatt Albis

Redaktion und kartographische Bearbeitung:
Dr. Heinrich Jäckli AG, Zürich

Druck:

1:25000

100 m 500 m 0 1 2km
1000 m: 4cm

Aequidistanz der Höhenkurven 10m

Topographische Kartengrundlage: Landeskarte 1:25000, Blätter 1090, 1091
Stand 1988

Workers on wagons to unload excavated earth at the landfill Herdern

*Johannes Meiner, 1925, Baugeschichtliches Archiv.*

Gravel Pit in ‚Mittlerem Hard' with Uetliberg in the background

*unknown, 1891-1894, e-pics.*

Backfilled gravel pit in Höngg

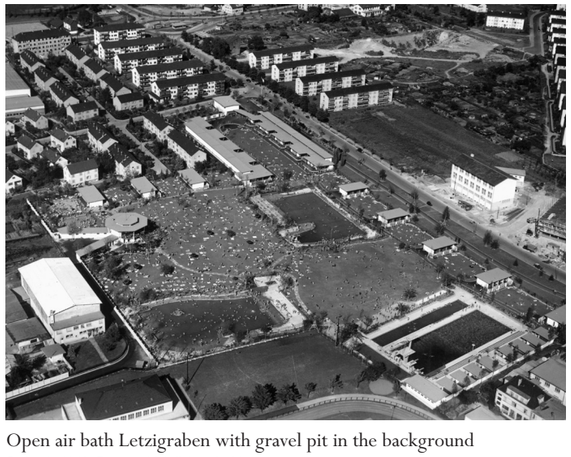
*Erwin Küenzi, ca. 1970, e-pics.*


Höngg with gravel pit at Winzerstrasse

*Otto Wyrsch, 1938, e-pics.*

Housing Colony Heiligfeld in formation where a former gravel pit was

*Comet Photo AG, around 1951, e-pics.*



Open air bath Letzigraben with gravel pit in the background

*Swissair, 1949, Baugeschichtliches Archiv.*

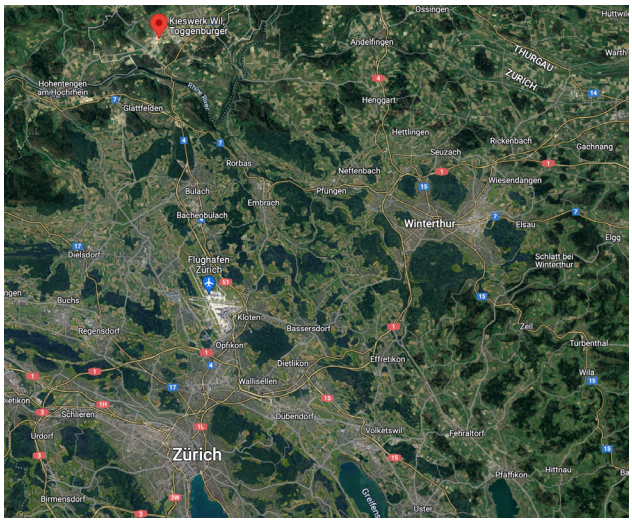
# VISITED GRAVEL PIT OF CASE STUDY WITH TOGGENBURGER AG IN WIL

Gravel exploitation in the Rafzerfeld - deep gorge of gravel pit

*Studio AG für Film Foto Ton (St‘ AG‘ F‘ F‘ T): Zürich, ca. 1970, Schweizerisches Sozialarchiv.*

Gravel pit in Wil

*SF, 2023.*




Distance Zurich - gravel pit/excavation landfill Wil ZH: 29.5km

*Google, 2023, google maps.*


Areal image of gravel pit/excavation landfill Rafzerfeld in Wil

*Google, 2023, google maps.*

# TRANSPORT - A LOGISTICAL CHALLENGE

Most of excavation happens in the bigger cities and villages in the south of the canton of Zurich whereas most of the gravel pits are located on the edges of the canton, many of them up north. This distance of the ‘site of material production’ of excavated earth and ‘material consumption’ in the gravel pits causes a lot of transport. For two years now, there has been a law in Zurich that clean excavated earth must be transported by train if it is more than 25’000m$^3$ in order to relieve traffic. TerraRail Modalsplit AG is a merge of companies to offer several locations where the earth can be transferred from trucks to train.[1]

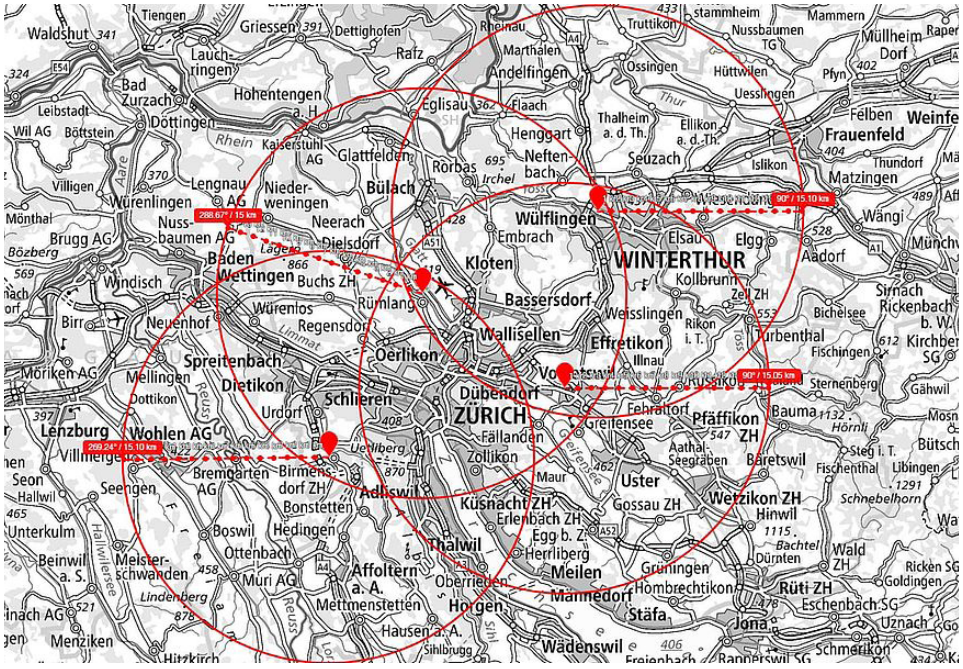
*1 https://www.terrarail-modalsplit.ch/dienstleistung (visited 06.10.2023).*


Still from SRF news about Rafzer Feld - already in the 80ies were political discussions about the problem of truck traffic

*unknown, 17.03.1986, SRF.*

Transportation of excavation earth by train, mandatory since 01.07.21

*TerraRail Modalsplit AG, https://www.baublatt.ch/baupraxis/wird-im-kanton-zuerich-bald-mehr-aushub-per-bahn-befoerdert-33115 (visited 05.09.2023).*




Distribution network of TerraRail Modalsplit AG with four locations: Rümlang, Volketswil, Winterthur, Birmensdorf

*unknown, https://www.terrarail-modalsplit.ch/standorte (visited 05.09.2023).*

# ECOLOGICAL VALUE

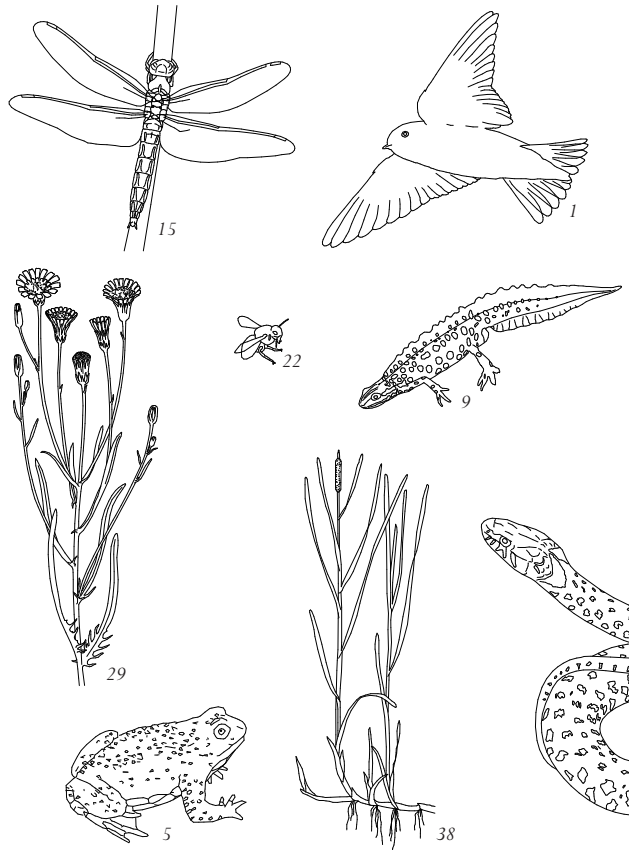
Gravel pits as biodiverse habitat

*Andreas Keel, unknown, https://www.naturschutz-illnau-effretikon.ch (visited 05.09.2023).*

Illustration of a gravel pit and the flora and fauna living in it

*Berthold Faust, 1985, Schweizerisches Sozialarchiv (WWF).*

Gravel pits are valuable and unique habitats for many species. Certain species such as the sand martin (Riparia riparia), for example, live almost exclusively in the steep walls of gravel pits. Backfilling displaces pioneer animals and plants and destroys their habitat in order to return the land to agriculture. Shouldn't we stop backfilling and operating gravel pits and give them back to nature?




## Possible species to find in gravel pits:

*https://www.biodivers.ch/de/index.php/Abbaugebiete (visited 13.10.2023)*

*Birds*
- *1 Riparia riparia*
- *2 Charadrius dubius*
- *3 Sylvia communis*

*Amphibians*
- *4 Epidalea calamita*
- *5 Bombina variegata*
- *6 Alytes obstetricans*
- *7 Hyla arborea*
- *8 Triturus cristatus*
- *9 Lissotriton vulgaris*
- *10 Rana dalmatina*

*Reptilians*
- *11 Lacerta agilis*
- *12 Natrix natrix*
- *13 Coronella austriaca*

*Dragonflies*
- *14 Orthetrum brunneum*
- *15 Orthetrum cancellatum*
- *16 Ischnura pumilio*
- *17 Anax parthenope*

*Butterflies*
- *18 Satyrium spini*
- *19 Plebeius idas*

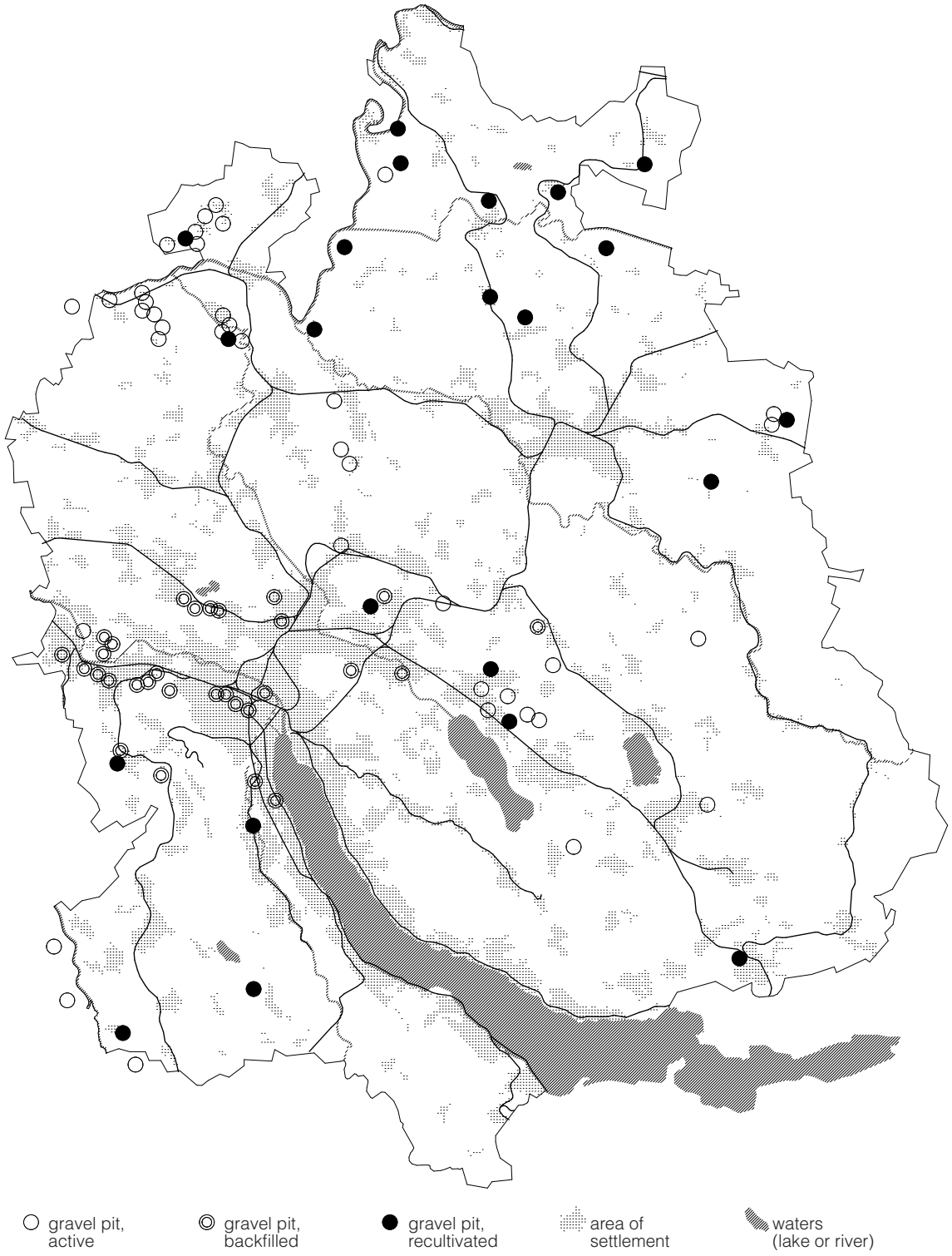
*Grasshoppers*
- *20 Sphingonotus caerulans*
- *21 Oedipoda caerulescens*

*Wild Bees und Hymenopteras*
- *22 Megachile parietina*

*Plants and Mosses*
- *23 Centaurium pulchellum*
- *24 Epilobium dodonaei*
- *25 Galeopsis angustifolia*
- *26 Alopecurus aequalis*
- *27 Chenopodium ficifolium*
- *28 Chenopodium glaucum*
- *29 Crepis foetida*
- *30 Cyperus fuscus*
- *31 Dipsacus pilosus*
- *32 Kickxia spuria*
- *33 Legousia speculum-veneris*
- *34 Minuartia hybrida*
- *35 Polygonum amphibium*
- *36 Reseda luteola*
- *37 Schoenoplectus tabernaemontani*
- *38 Typha shuttleworthii*
- *39 Cerastium brachypetalum*
- *40 Cerastium semidecandrum*
- *41 Erysimum cheiranthoides*
- *42 Diplotaxis muralis*
- *43 Porella arboris-vitae subsp. arboris-vitae*

# MAP OF ACTIVE AND FORMER GRAVEL PITS

Learning that the spatial capacity of backfilling gravel pits is shrinking and moreover that gravel pits are important and rare habitats I see it in our responsibility as architects to rethink this material flow and the logic of backfilling gravel pits with clean excavated earth. Digging, extracting, and backfilling cannot go on forever. We have to find alternative ideas what to do with the excavated material and should turn gravel pits into nature reserves, protecting what found live within those anthropogenic created sublime landscapes.



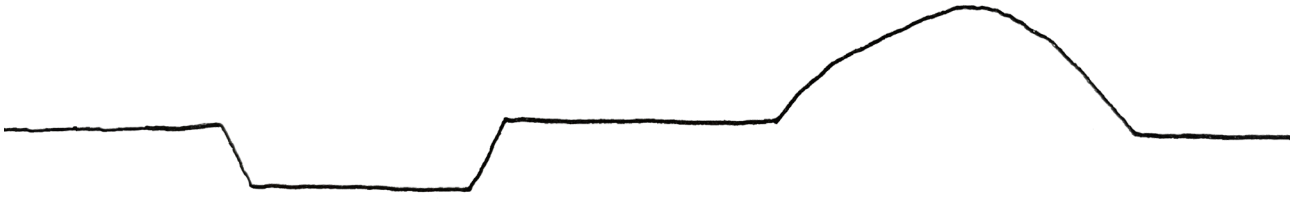
# Alternative Ideas - Examples from Zurich

Excavated earth is about turning earth inside out, about shifting earth from one place to another, about creating holes and backfilling other holes. From negative to positive - an impressive thought that every hole creates a „mountain“ somewhere else.
What alternatives can we observe in Zurich?
The grain size and the structural properties of the excavated material are decisive for the various possible uses.
Excavated earth is an interesting material in landscape architecture where only clean excavated material can be used for terrain alterations. Examples are embankments or terrain elevations for flood protection or noise barriers. In addition, excavated material can be used for the design of nature reserves, recreational areas such as inner-city parks or settlement edges. Furthermore, it is partly used for lake fills in order to create shallow water zones for plants and animals. However, it must be used in a technically correct manner to avoid turbidity of the water. Also, river engineering is done to ecologically upgrade delta areas and shore zones and to construct flood retention basins.[1]
Some architectural approaches show how to use excavated earth to build with as substrate for green roofs where probably moreover the top- and subsoil was used. The reemerging technique of rammed earth can be executed with the excavated earth, or you can use parts of it as for example the washed gravel as components for concrete.


“Where to put the 1.5 million cubic meters of excavated material from the seelisberg tunnel?” - This is the big question and challenge of our time; where to go with all the excavated material?

*Werner Büchi, Nebelspalter: das Humor- und Satire-Magazin (p. 26), 1973.*

*1 https://www.bafu.admin.ch/bafu/de/home/themen/abfall/abfallwegweiser-a-z/aushubmaterial.html*



# ALTERNATIVE IDEAS WHAT TO DO WITH EXCAVATED EARTH

Kantonsschule Freudenberg at Zurich Enge,1957-61

*Comet Photo AG, 15.04.1964, e-pics.*

These two examples show an interesting approach how to use excavated earth close by for terrain changes instead of just depositing it.
The earth from the excavation of the high school building Freudenberg was transported by truck to Wollishofen where it was filled into the lake of Zurich to create the Saffa island - a popular recreation area.
The other example is the Irchel park that has been designed with the excavation earth of the university campus next by. It is an artificial topography including a lake shaped with around 400‘000m$^3$ excavated earth.

Film still about the preparation of SAFFA 1958

*www.saffa1958-snf.ch (visited 05.09.2023).*

Construction of University Campus Irchel

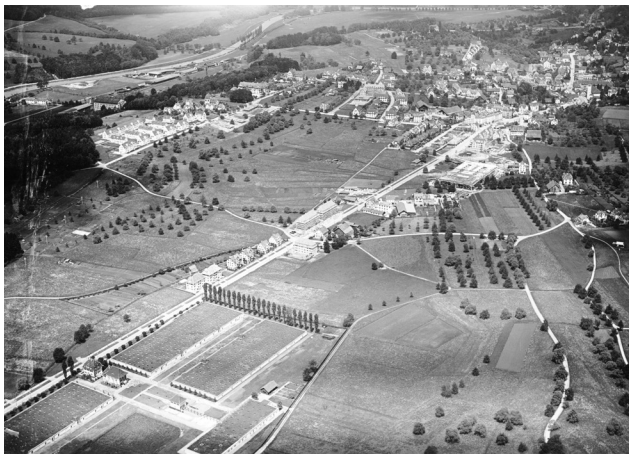
*Comet Photo AG, 08.1978, e-pics.*

Saffa Island as local recreation area of Zurich - filled in 1958

*Reto Oeschger, 04.09.2022, Tagesanzeiger.*

Irchel Park shortly after completion

*Jules Vogt, 10.1985, e-pics.*



Areal view of Seewasserwerk Moos, Wollishofen

*Ad-Astra Aero, 1928, e-pics.*

Excavated earth can be used as building material. These are three different ideas - at the Seewasserwerk Moos in Wollishofen the excavated earth (probably the top- and subsoil) was put on the roof to cool the building and to keep the local biodiverse orchids meadow.

The school Allenmoos appears very harmonious in its surrounding thanks to the rammed earth walls.

Part of the excavated material at stadion Letzigrund was valuable gravel, which was crushed on site, sorted, and processed into concrete to be used as in-situ concrete for the stadium construction. To mention is that around the Letzigraben were many former gravel pits located what explains the gravely ground.

Rare orchids on the roof or Seewasserwerk Moos since 1914

*PD, 2018, Tagesanzeiger.*

Rammed earth facade of School Allenmoos

*Beat Bühler, https://www.erden.at/Schulpavillon-Allenmoos-II (visited 05.09.2023).*

Excavation depot during the construction of the stadion Letzigrund, January 2007

*Energie- und Ressourcen-Management GmbH.*

# Re-Evaluating Excavated Earth

Excavation from Basel
*Lara Almarcegui, Kunsthaus Baselland (artsy.net), 2015.*

*„it is desirable that ‚we, humans, have an ecological, sustainable consciousness of the earth'."*

*Ines Goldbach, Lara Almarcegui, Kunsthaus Baselland and Christoph Merian Verlag, 2015, p. 13.*

*„[The excavated earth in the Kunshaus Baselland] is a much-needed contribution, which allows us to see a phenomenon that is perceived through a mist of prejudices and myths more clearly."*

*Philip Ursprung, Lara Almarcegui, Kunsthaus Baselland and Christoph Merian Verlag, 2015, p. 53.*

Lara Almarcegui's art addresses the relationship between nature and the city, as well as the physical reality of the urban landscape. In doing so, she explores themes such as construction, development, regeneration, and decay and demolition. She seeks to make the invisible visible and, by shifting the context, to enable a new view of materials, such as here in the excavation in the museum space. Suddenly you experience and feel this very ordinary material completely different and start asking yourself questions as where are our cities standing on? Where does all this excavated material go to?

We have to reconsider excavated earth as valuable resource rather than waste and to deal with it more respectfully. Lara Almarcegui is not the only artist bringing earth into a museum space. Two other examples are The New York Earth Room of Walter de Maria and Riverbed of Olafur Eliasson. Excavated earth as the main actor of an artwork suddenly changes its perception from dirty to precious.

# Emancipating Excavated Earth

Material patchwork at gravel pit in Wil

*SF, 2023.*

*«[…] matter intra-acts within the world, it is inherently agentic, discursive, and an important participant in the making of the world.»*

- Jane Hutton, Reciprocal Landscapes, p. 8.

*«Reciprocal Landscapes stems from a desire to think of construction materials […] as continuous with the landscapes they come from, and with the people that shape them […] to understand materials as fragments of other landscapes;»*

- Jane Hutton, Reciprocal Landscapes, p. 5.

Earth is a topic that spans from the micro scale to the very macro scale. Many organisms live in the earth, plants grow, and we step on earth every day. We can take a hand full of earth and start forming a ball out of it. It is very tangible but still forms huge landscapes we walk on. I'd like to discover the "consequential relationship" of those different scales - earth in its small components that need to be well mixed to build with or earth in its huge scale how it forms and shapes our landscapes.

Shifting the earth from one place to another means mixing up ecosystems from different places and creating a patchwork of the most varied habitats. Shouldn't a material as well as an organism have the right to stay in its original place?

If we stop backfilling gravel pits to preserve them as nature reserves, we have to find other solutions what to do with excavated earth. Why don't we consider excavated earth as building material rather than waste where the site of material production becomes as well the site of material consumption? The house could literally grow out of the ground being composed out of excavated earth.

# 1 Excavated Earth as Building Material

Why do we consider excavated earth as „waste“ that has to be deposited? Learning from vernacular architecture it is nothing else than a valuable, locally available, carbon-neutral, healthy, inclusive material, that can be used to build with. It is about newly interpreting this traditional material. Depending on its characteristics different techniques are to be applied.

Building with earth requires different processes – the project is about designing a possible resource flow from excavating, storing, drying, processing, constructing. What are the challenges in constructing with earth? How could the construction process look like? Inspired by companies like BC Architects, Cycleterre, LEHMAG or architects like Roger Boltshauser, Martin Rauch, or Anna Heringer, I‘d like to rethink the project at Hubenstrasse 17 in a hybrid construction using the excavated earth produced on site.
Building with excavated earth would support the cities’ strategy ‘Circular Zürich’ which aims to close the cycle in focusing on design and production, distribution, consume and use, as well as collecting, recycling, and processing of raw materials.[1]

*1 https://www.stadt-zuerich.ch/gud/de/index/departement/strategie_politik/umweltstrategie/klw/strategie-klw.html*

*«Cheap, easy to use, requiring no external power supply, and leaving no pollution in its wake, it could secure the future of [construction] for countless years to come.»*

*- Tim Ingold, Correspondences, p. 5.*

*«The NEW PISÉ […] a material that is always at hand; earth: yes! the earth we walk on every day can be converted into building materials, to erect even the greatest monuments.» [by François Cointeraux, 1806]*

*- Jean-Philippe Garric, Vers une Agritecture, p. 57. (translated with deepl from French)*

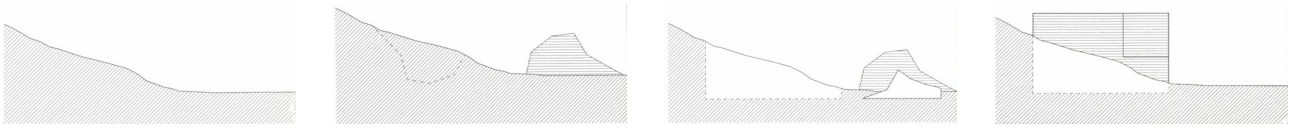
“Manhattan of the desert” - Shibam in Yemen -250 AC

*Hidden Architecture, 10.01.2016, hiddenarchitecture.net.*

Ricola Herb Centre in Laufen BL - rammed in 2012

*VOGT, unknown, vogt-la.com.*

# WHEN SOIL… … BECOMES A WALL



*Boltshauser Roger and Martin Rauch. Haus Rauch : Ein Modell Moderner Lehmarchitektur. Birkhäuser 2011, pp. 3, 5, 7, 9.*

Excavation pit of Haus Rauch

*unknown, unknown, book: Heringer, Blair Howe, Rauch - Upscaling Earth, p. 115.*

Haus Rauch with its rammed earth wall in Austria

*Albrecht Imanuel Schnabel, unknown, book: Heringer, Blair Howe, Rauch - Upscaling Earth, p. 78.*

Martin Rauch aimed to build a house that can turn back into the natural cycle after its decay without contaminating the environment or producing waste. 85% of the excavated material was used to build the house. The clay can without any problems be reused after the deconstruction of the house since there are no additives added. With no much additional energy the clay can be reused in a similar quality as before. The gray energy counts around 40% less than in a conventional construction.

*Boltshauser Roger and Martin Rauch. Haus Rauch : Ein Modell Moderner Lehmarchitektur. Birkhäuser 2011, pp. 163, 171.*

Konventionell/Conventional

**Außenwand oberhalb Terrain/Exterior wall above-grade**
22 cm Stahlbeton 2.400 kg/m³/Reinforced concrete 2,400 kg/m³
10 cm Steinwollisolation 40 kg/m³/
Weißputz/Gypsum plaster

**Außenwand unterhalb Terrain/Exterior wall below-grade**
22 cm Stahlbeton 2.400 kg/m³ (2 % Armierung)/
Reinforced concrete 2,400 kg/m³ (2 % reinforcing)
10 cm EPS 40 kg/m³

**Dach/Roof**
22 cm Stahlbeton 2.400 kg/m³/Reinforced concrete 2,400 kg/m³
Dampfsperre/Vapor barrier
10 cm Wärmedämmung EPS/EPS thermal insulation
Bitumenbahn/Bitumen sheeting
5 cm Kiesbett/Gravel bed
3 cm Platten/Ziegel/Roofing slabs/tiles

Stampflehm/Rammed earth

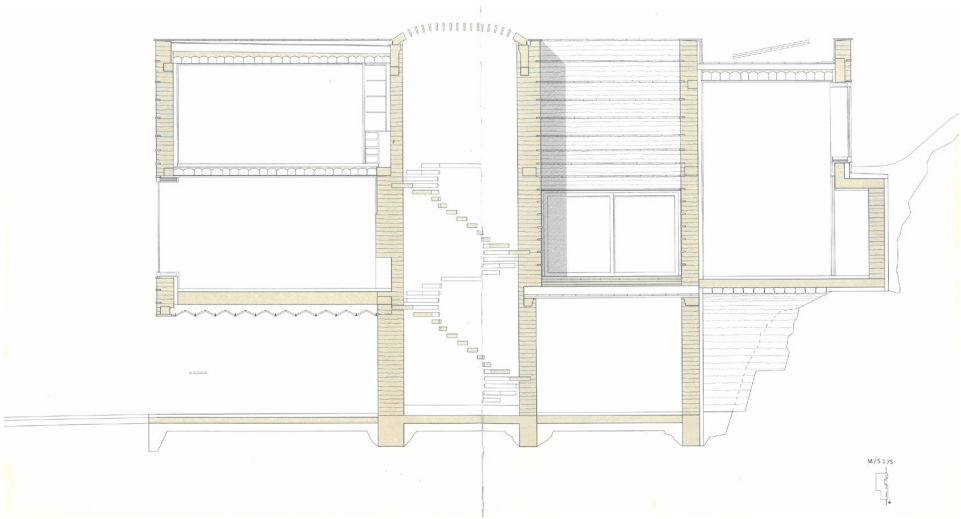
**Außenwand oberhalb Terrain/Exterior wall above-grade**
45 cm Stampflehm 1.800 kg/m³/Rammed earth 1,800 kg/m³
10 cm Schilfmatte/Reed mat
3 cm Lehmputz/Earth plaster

**Außenwand unterhalb Terrain/Exterior wall below-grade**
45 cm Stampflehm 1.800 kg/m³/Rammed earth 1,800 kg/m³
10 cm Schaumglas/Foam glass

**Dach/Roof**
3 cm Lehmbauplatte/Lehmputz/Clay building panels/earth plaster
24 cm Dippelbaumdecke/Timber beams
20 cm Schilfmatte/Reed mat
3-Schichtplatte/Three-ply panel
Bitumenbahn/Bitumen sheeting
5 cm Kiesbett/Gravel bed
3 cm Schlammziegel/Mud bricks

Comparison of Conventional and Rammed Earth Construction

*Boltshauser Roger and Martin Rauch. Haus Rauch : Ein Modell Moderner Lehmarchitektur. Birkhäuser 2011, p. 164.*



Longnitudinal Section of Haus Rauch - rammed earth walls touching the ground

*Boltshauser Roger and Martin Rauch. Haus Rauch : Ein Modell Moderner Lehmarchitektur. Birkhäuser 2011, p. 164.*

# BC ARCHITECTS & STUDIES

Brussels Cooperation (BC) believes there is a change in the construction culture needed to face societal and environmental challenges and to respect the planets' limits of the production capabilities. Vernacular principles are adopted and adapted to existing cultures of construction, using local techniques and materials, craftsmanship, as well as reginal typologies. Learning by doing, collaborating, "'getting close' to a material or a method, through processes of trial and error" are approaches to achieve this transition in practice. BC's idea is to be more involved in projects, not only to design but to offer material consultancy and share the knowledge in workshops where interested people can participate in earthen construction what helps making it economically viable through voluntary labor.

Since 2018 transforms BC Materials locally excavated earth into building materials in stock production. To avoid the spatial need for storage they produce to order turning a material legally considered waste into circular, carbon-neutral, no-waste products such as clay plaster, compressed earth blocks, and rammed earth. Depending on the geological layer, excavated earth are heterogenous and need to be mixed. Important are the mix recipes and to monitor them continuously since the product needs to be homogenous, following the German DIN norms. They aim to translate the DIN into Belgian norms to strengthen the trust in earthen construction materials and spread its use. BC produces in a demountable and transportable production hall on the wastelands of Brussels as a cooperative of workers. They aim "to show, and to implement, strategies for a proper transitioning of our construction sector to a culture of local, circular, almost CO2-neutral construction in between craftsmanship and industry." The business model is not only a commercial activity but as well a societal mission.

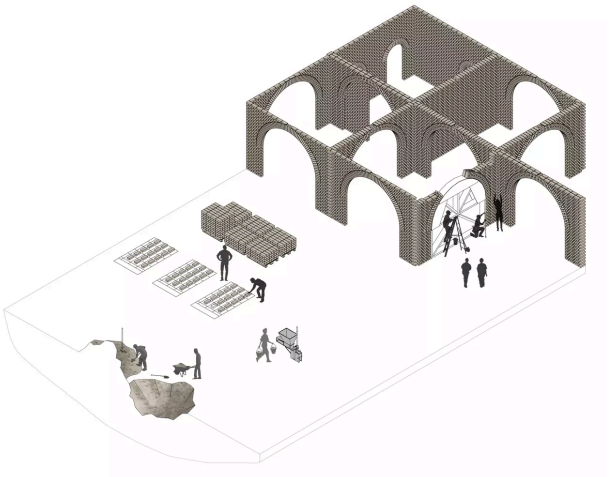
*De Cooman, Ken. «Down to Earth. Tranforming Urban Excavated Earth into Building Materials» in Beyond Concrete: Strategies for a Post-Fossil Baukultur. Triest Verlag GmbH 2022, pp. 149-152.*

*«The use of [local resources such as earth] makes it possible to shorten the supply chain, and to spend the construction budget within the local community. They can quite easily (yet not without a controlled series of transformations) be turned into a construction material for foundations, walls, columns, beams, plasters and so forth. BC tries as often as possible to produce these materials on the site where they will be implemented.»*

*- Pauline Lefebvre, BC Architects & Studies - The Act of Building, p. 17.*

*«Ideally, the excavated material from the excavation pit - i.e. the mixture of clay, sand and gravel that often occurs in nature - is used as building material. At the end of its life cycle, the structure decomposes and fills the excavation pit again as if nothing had happened. That is why the gray energy in the production, processing and deconstruction of clay is practically zero.»*

*- Thomas Auer, Gewerbebauten in Lehm und Holz: Mehrwert durch Material, p. 141-142. (translated with deepl from German)*



‚The Act of Building' - Exhibition in Antwerp, 2017

*BC, https://bc-as.org/studies/exhibitions/act-building (visited 14.10.2023).*

Images below: excavation site - excavated earth - workshop

*BC materials, https://bcmaterials.org (visited 04.09.2023).*

# CYCLE TERRE

Cycle Terre is operating in Paris in the similar way like BC in Brussels. They propose to reevaluate and reuse clean excavated earth as raw building material for the construction of Paris. They see the possibility to change the reality of excavated earth considered as waste into a valuable resource aiming to reuse it directly to build with rather than storing. It is a political, economic, and social challenge to face where earthen products offer an ecological and social impact: when not stabilized earth is 100% reusable and thus circular, it is carbon-neutral, and balances the temperature and humidity in a healthy way.
There are four main steps in the earthen circular economy. First, the excavation – earth never equals earth. The process has to be adapted to the material rather than finding the process fitting resource. Building with earth means building with the material you get. Second, the storage, sorting, and preparation of the excavated earth – sorting the earth depending on its geological and thus mechanical characteristic is important to prepare and transform the heterogenous resource into homogenous material. Third, the material production – they plan three production lines of earthen material to deal with the different earths and to offer a wider range of applications. Fourth, building with earthen products – the products will be mainly used in regional constructions.

They aim to start a production chain - from excavated earth to products following three French technical certifications: bricks, clay panels, and mortar. The idea is to offer environmental friendly building materials and to develop and test in co-working with property developers and architects the use of earthen building materials and the benefits of the process. Cycle Terre involve local residents through participation and form and train local construction companies.

*https://www.cycle-terre.eu/documentation/ (visited 14.10.2023)*


The fabrication process of Cycle Terre

*© J. Germain, Réplication du Démonstrateur Cycle Terre: points clef et boîte à outils, 2021, p. 8.*

‚Earthen Industry'

*©amàco, https://www.cycle-terre.eu/cycle-terre/le-projet/ (visited 14.10.2023).*

# 2 Gravel Pit as „Site of Memory„

The visit on the gravel pit in Wil left a strong impression on me. This incredible landscape makes you feel being on another planet. The knowledge that gravel extraction actually creates important and unique habitats for many species changes the negative perception of this scars within the landscape and turns gravel pits into a place of beauty, diversity, and sublime. I consider it as important to stop backfilling the gravel pits. Why don‘t we turn gravel pits into „sites of memories“ - showing the human impact on nature through the violent act of gravel extraction, creating huge holes within the landscape and therewith new and rare habitats. How would a gravel pit be gained back by nature when we stop operating them? Should it be accessible for humans as nature reserve or only observable form viewing platforms close by?

*«For life on earth to carry on, and to flourish, we need to learn to attend to the world around us, and to respond with sensitivity and judgement.»*

*- Tim Ingold, Correspondences, p. 3.*

Gravel Pit in Wil - „Lines in the Landscape„

*SF, 2023.*

*«There are lines in the landscape because every landscape is forged in movement, and because this movement leaves material traces along the manifold paths of its proceeding.»*

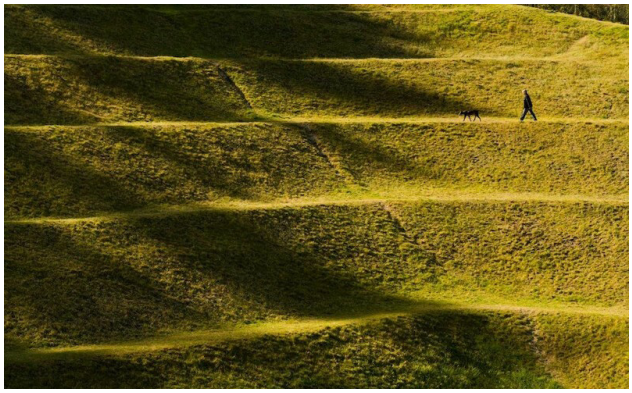
*«The question is: are any of these lines really there, or do they exist only in the mind‘s eye? In drawing them, are you merely following a graphic convention […] or are you participating - in the roaming of your eyes and corresponding gestures of the hand - in the formative process of the landscape itself?»*

*- Tim Ingold, Correspondences, p. 169, 165.*

# A LANDSAPE SCULPTURE

Untitled Earthwork (Johnson Pit #3) by Robert Morris

*Colleen Chartier, 1979, WA. King County Public Art Collection.*



Untitled Earthwork (Johnson Pit #3) by Robert Morris

*Joe Freeman, 1979, WA. King County Public Art Collection.*

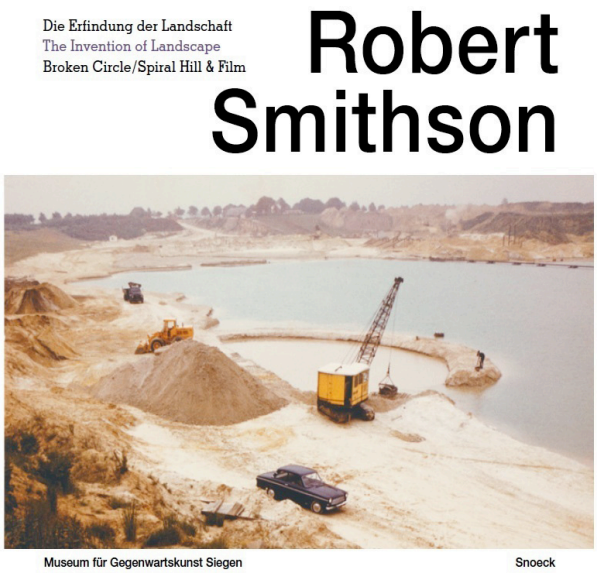
Untitled (Johnson Pit #3) by Robert Morris

*unknown, 1979, Courtesy King County Archives.*

Terraced Earth and Rye Grass

*Colleen Chartier, 1979, WA. King County Public Art Collection.*

# ‚DIE ERFINDUNG DER LANDSCHAFT' - THE LANDSCAPE INVENTION




Book ‚Die Erfindung der Landschaft' by Robert Smithson

*Eva Schmidt, Cover of Exhibition Catalogue at Museum für Gegenwartskunst Siegen, Snoeck 2012.*

‚Asphalt Rundown' as the „crystalline structure of time" -

*Robert Smithson, 1969, © Holt/Smithson Foundation.*

„another sedimentary layer in the infinite accumulation of time"

*Robert Smithson, 1969, © Holt/Smithson Foundation.*

# Appendix

The following pages is a selection out of more research material that might be of interest for the development of the projects.

# TALK WITH FELIX HILGERT

Felix Hilgert studied civil engineering at ETH Zurich and did his master thesis to the topic of Excavation material as the new building resource for Zurich. He founded the company LEHMAG where they build with excavated earth and is scientific assistant at the chair of Roger Boltshauser.

Can excavated earth be used as construction material?

Yes, of course. The problem is only the costs. Since constructing with earth is time intensive and a quite crafted work where human power is needed it is expensive. Would there be a $CO_2$ tax on building materials this would shift because building with earth produces compared to industrial materials very little $CO_2$.

Another point is that there is around 50 years research knowledge and experience missing on the material of earth as a construction material. This also comes together with the question of responsibility. Since there are no norms in Switzerland about building with earth you have to find people taking the responsibility when building with earth. The problem is that we grew into a society of insurance ("Versicherungsgesellschaft"). We don't like to take on responsibility and we want to be insured. We have to learn to take on risks and to try and do things without being insured.

Washing the excavated earth to gain secondary material as gravel or sand is only economically worthwhile when there are not more than 12% fine particles (clay or silt). It is all about the money that decides what is done.

MFH KILCHBERG, ZÜRICH, 2021-2022 - the inner walls are made out around 10% of the excavated earth

LEHMAG built a multi-family house in Kilchberg together with Roger Boltshauser where they excavated around 200'000$m^3$ earth from the hilly topography, so it was a one-sided construction pit within the hill. They reused 200$m^3$ of it to build 800$m^2$ inner walls (with 10cm thick earth blocks). This shows how little material is used to build a house compared to the amount that is excavated. Felix says that you can reuse maximum 50% of the excavated earth for the construction, more volume you don't need. Ramming a wall means you fill the mold up with 15cm earth and ramm it layer by layer. The earth will be compressed down to 10-7cm thickness, what means you "loose" 1/3 up to 1/2 of the volume.

At LEHMAG they use excavated earth for making rammed earth walls or clay floors where they gain the excavated earth from stone quarries, foundation contractors or excavation companies. To do clay plaster or clay tiles/discs they buy clay from Lehmwerk.

Feeling the excavated earth

Compressed Eartht Blocks out of excavated earth

*all images: Sandro Livio Straube, Kuster Frey, Lehmag AG, lehmag.ch (visited 26.09.23).*

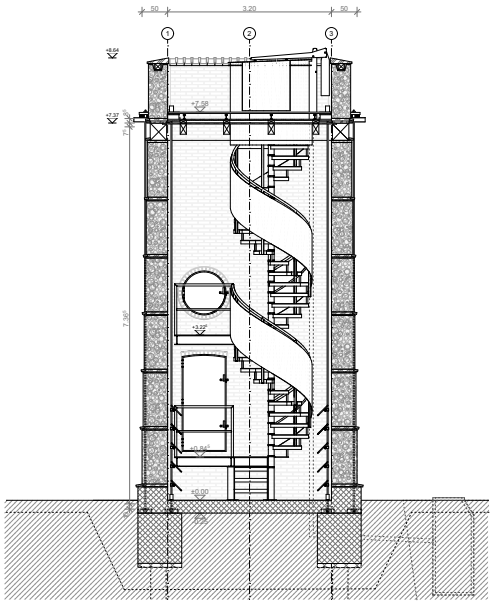
# OFENTURM ZIEGELEIMUSEUM CHAM - A PROTOTYPE

At the Ziegeleimuseum in Cham, an important clay extraction site since the 17th century,[1] is the 'Ofenturm' located, a prototype to test the potential of the nearly forgotten building tradition of rammed earth. The tower stands on the slightly elevated meadow since it was landfilled with excavated earth from the highway construction in the 70ies.[2] In Switzerland, every year around 60 million tons of excavated earth is deposited which is actually a natural and sustainable building material that can be rammed to walls, molded to ceilings, or being used as a clay finish.[3]
The design was developed by students of Roger Boltshauser. The 91 wall elements were prefabricated in a summer school in the production halls of LEHMAG in Brunnen, rammed with demolition waste from one single family house. The size of the elements is defined through transportation conditions, and they are rammed on wooden boards to facilitate transport, as well as the stacking, and allow the reuse after dismantling. Weatherboards are screwed into the boards to stop erosion. The rammed earth elements are stabilized against horizontal forces such as wind or earthquake with a prestressed system out of steel cables anchored in the concrete fundament. The prestressing of rammed earth walls allows building higher, estimated is a possible height of 40 meters. Rammed earth should not substitute other materials but being part of a hybrid construction as answer of the challenges of future construction. [1, 3]

*1 https://www.ziegelei-museum.ch/uploads/pdf/2021_Details_Ofenturm.pdf (visited 19.09.2023)*

*2 https://geoblog.ch/1628-ziegeleimuseum-hagendorn/ (visited 14.10.2023)*

*3 Exhibition text of the exhibition 'Aus Boden gestampft' (visited 01.10.2023)*

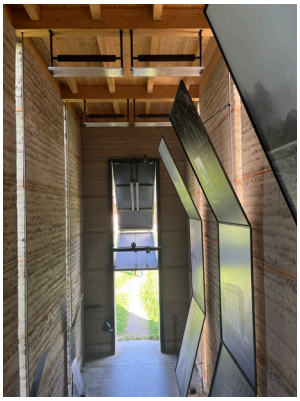


Crosssection of the ‚Ofenturm' 1:50

*PDF Ofenturm Ziegelei-Museum Cham, 2021..*

Construction process of the ‚Ofenturm'

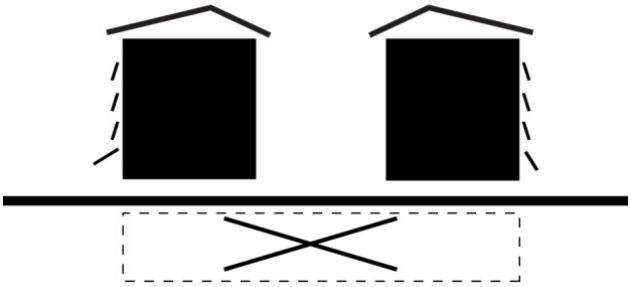
*Sandro Livio Straube, 2021, PDF Ofenturm Ziegelei-Museum Cham.*



# HORTUS - HERZOG & DE MEURON WITH MARTIN RAUCH

HORTUS is ‘resource positive’: “In the construction of Hortus, no more resources will be wasted/used than necessary, relying as much as possible on renewable or recycled building materials and planning cycles ahead.”
“Earth and Fire - the potential of rammed earth is enormous.” As combination with timber construction it is an ecological alternative to poured concrete. It is easy available and reused from excavation pits from close by transportation costs and emissions are reduced. Furthermore, rammed earth regulates the temperature as well as the air humidity through storing the moisture that wood cannot absorb.
The aim was a sustainable construction where they looked for inspiration in the Middle Ages, combining craftsmanship with high-tech. The construction idea is “a column-frame structure made of wood with as little glue as possible, with spruce beams and clay vaults, above which solid wood panels, sand fill and oak planks.”
Besides, Hortus has no underground level and thus barely produces excavated earth itself.

*https://www.hortus.ch (visited 26.09.2023).*

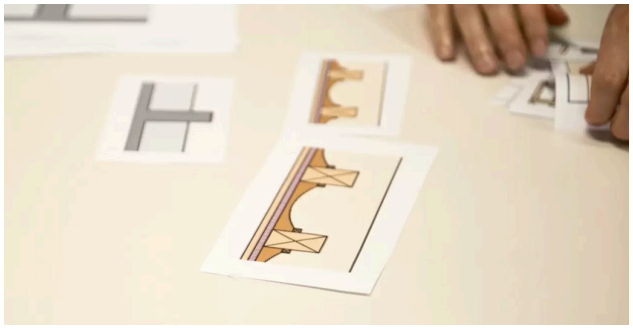


Conceptual Section - no underground to avoid excavation

*Herzog & de Meuron, herzogdemeuron.com (visited 26.09.2023), 2021.*

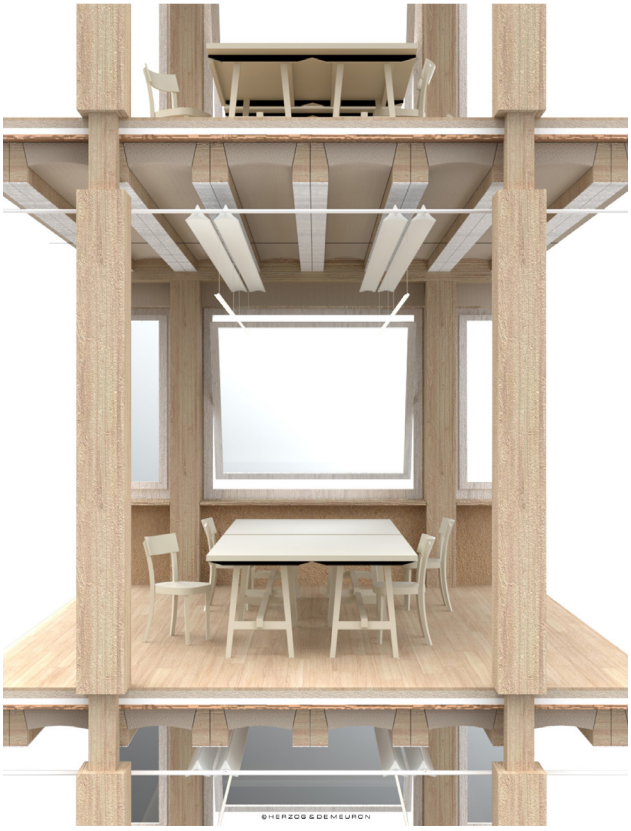
Filling of a ceiling element with rammed earth

*©Lehm Ton Erde, hortus.ch (visited 26.09.2023).*



Sketches of rammed earth ceilings

*Sketches by ZPF engineers, hortus.ch (visited 26.09.2023).*



Material section showing the rammed earth ceiling elements

*Herzog & de Meuron, herzogdemeuron.com (visited 26.09.2023), 2021.*

# TALK WITH THOMAS DIMOV

I met Thomas Dimov from zoë circular building gmbh an office that I came across through the exhibition 'Think Earth!' which is conceptualized by them. Zoë circular works with sustainable natural materials which stay within the material cycle even after demolishing. They consult architects and house builders in ecological construction, offer workshops and trainings, and sell selected natural materials. They sell clay materials from Claytec such as clay plaster, clay painting, clay panels, and rammed earth. All the Claytec materials standardized according to DIN norms. In collaboration with the German office ZRS zoë circular has access to a clay laboratory.
Clay panels can be used instead of plaster panels for the planking of inner walls. But they do not fulfill the fire protection requirements since they are porous and therefore open to diffusion.
Clay renderings can be mixed with structural aggregates such as glimmer, herbs, or straw chaff. The climatic benefits are only active with a minimal thickness of 15mm. Clay vouches only mechanically what requires a holding primer when the material below is not rough enough. Furthermore, clay renderings are applied with a armoring web which absorbs tensile forces.

Thomas is working on a survey ordered by the city if at the planned school Triemli tit is possible to reuse the excavated earth and to build with it. He is analyzing the earth to see what would be possible. His idea is to adapt the idea of Cycle Terre to Zurich and to see if and how it would be possible to turn Zurich's' excavated earth into building materials. Due to spatial scarcity in the city the in-situ construction is not possible and manufactures need to be established in the close surrounding to avoid big transportation distances. For him the big questions is: where lies the value creation of excavated earth?


‚Think Earth!' as touring exhibition

*https://think-earth.org (visited 04.09.2023).*


Fachmesse appli-tech, Luzern, 31.1.-2.2.2018

*https://think-earth.org (visited 04.09.2023).*

Markthalle, Basel, 16.1.-21.1.2018

*https://think-earth.org (visited 04.09.2023).*

Haupthalle, ETH Zürich, 30.10.-6.11.2018

*https://think-earth.org (visited 04.09.2023).*

# METI SCHOOL - ANNA HERINGER

METI school in Bangladesh - the school was built collectively with the local available material earth. The school children took part as well in the construction since earth is a very inclusive material and does not require experts to build with it.

*"The final result (…) is a building that creates beautiful, meaningful and humane collective spaces for learning, so enriching the lives of the children it serves."*
*[Jury of The Aga Khan Award for Architecture 10th Circle]*

*all images: Kurt Hoerbst, anna-heringer.com (visited 26.09.2023).*

# EARTH - AN ‚INCLUSIVE MATERIAL' FOR COLLECTIVE CONSTRUCTION

Ramming walls and pressing CEBs

*Lefebvre, Pauline. BC Architects & Studies - The Act of Building, Flanders Architecture Institute, 2018, pp. 57, 130-131.*

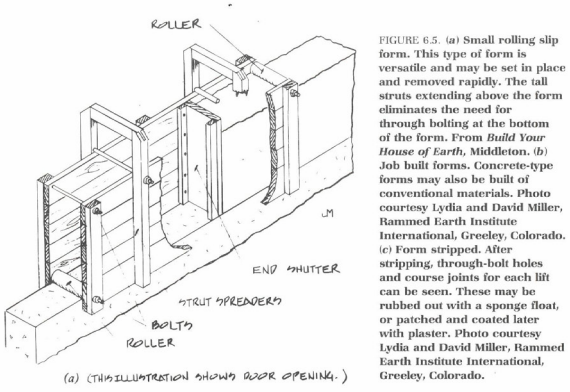
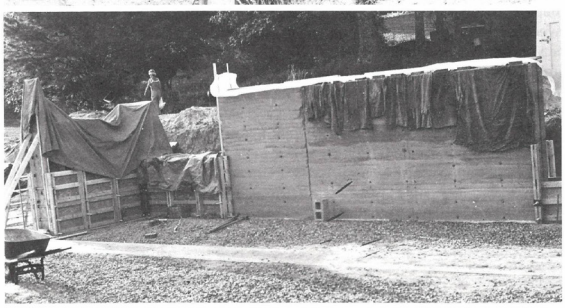



FIGURE 6.5. (*a*) **Small rolling slip form. This type of form is versatile and may be set in place and removed rapidly. The tall struts extending above the form eliminates the need for through bolting at the bottom of the form. From *Build Your House of Earth*, Middleton.** (*b*) **Job built forms. Concrete-type forms may also be built of conventional materials. Photo courtesy Lydia and David Miller, Rammed Earth Institute International, Greeley, Colorado.** (*c*) **Form stripped. After stripping, through-bolt holes and course joints for each lift can be seen. These may be rubbed out with a sponge float, or patched and coated later with plaster. Photo courtesy Lydia and David Miller, Rammed Earth Institute International, Greeley, Colorado.**

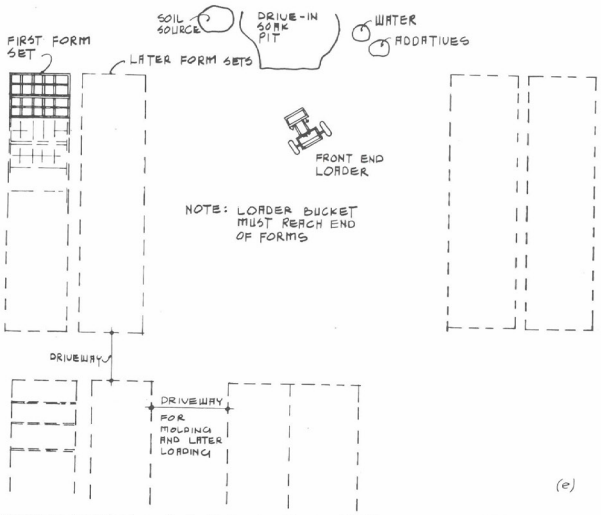




FIGURE 4.9. (*a*) **Drive-in soak pit with front-end loader.** (*b*) **Filling gang molds with loader. Note the screed rake for smoothing fill at right.** (*c*) **Filling and leveling brick pour. Note bricks tipped for drying in foreground.** (*d*) **Leveling the pour with screed rakes.** (*e*) **Yard layout for mechanized production.**

The collective act of ramming earthen walls and molding adobe bricks

*McHenry, Paul Graham. Adobe and Rammed Earth Buildings: design and construction. Wiley 1984, pp. 102, 71.*

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**Lehm Ton Erde Baukunst GmbH**
Quadernstraße 7
6824 Schlins
Österreich

www.erden.at
info@erden.at

erden.at
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# Design Guide für Stampflehm

Bauen mit 100% Erde

05
09
23

Ohne Frage, das Bauen mit Lehm kann komplex sein. Doch es kann auch ganz einfach sein. Denn mit jedem Projekt, das wir in den vergangenen Jahrzehnten umsetzen durften, ist unser Verständnis für das Material und seine Eigenschaften gewachsen. Was wir gelernt haben, wollen wir in diesem Design Guide weitergeben. An dich. Und an alle, die bereit sind, sich der vielleicht schönsten Form des Bauens hinzugeben. Viel Freude damit!

Die Grundsätze in diesem Design Guide gelten für stampfen vor Ort und die vorgefertigte Bauweise. Vor allem betreffen sie das Bauen mit unstabilisiertem Stampflehm. Das Mischen von Zement mit Stampflehm ergibt “schmutzigen Beton”. Er sieht aus wie Stampflehm und ist etwas stärker, aber die Vorteile enden hier. Durch das Hinzufügen von Zement zu der Mischung werden alle natürlichen Vorteile der Erde aufgehoben. Der CO2-Ausstoß steigt enorm, das Material kann nicht recycelt werden und die Wände atmen nicht mehr. Wir bei ERDEN verwenden ausschließlich 100% Erde. Bei gutem Design ist keine Zementstabilisierung nötig!

Lehm Ton Erde Baukunst GmbH
Quadernstraße 7
6824 Schlins, Österreich

## Schnelle Zahlen

Diese groben Zahlen gehen auf unsere Erfahrungswerte zurück. Sie können für Grobkalkulationen verwendet werden. In der Fachplanung und Umsetzung müssen wir die Werte je nach Aushubmaterial im Einzelfall prüfen und freigeben.

| | |
|---|---|
| Wärmeleitzahl<br>λ=0,9 W/mK | Mittlere Druckfestigkeit<br>2,4 N/mm² |
| Minimale Außenwanddicke<br>350 mm | Minimale Innenwanddicke<br>70 mm |
| Trocknungszeit<br>4–6 Wochen | $CO_2$-Emissionen der Produktion*<br>46 Kg/m³ |
| Feuerwiderstandsklasse<br>RE(I)90 ab 25 cm Wandstärke | Bewertetes Schalldämmmaß<br>53 dB ab 20 cm Wandstärke |
| Masse<br>2250 Kg/m³ | Produktion Energie*<br>930 MJ/m³ |

*Quelle: KBOB: Ökobilanzdaten im Baubereich 2009/1:2016. URL: https://www.kbob.admin.ch/kbob/de/home/themen-leistungen/nachhaltiges-bauen/oekobilanzdaten_baubereich.html, abgerufen am 02.02.2021.



## Inhalt



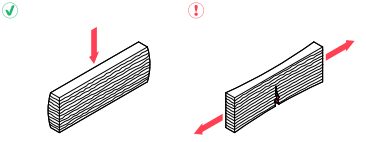


## konstruktive Vorgaben

Stampflehmwände können wie riesige Ziegel verwendet werden. Sie lassen sich gut auf Druck belasten, man stapelt sie zu Wandscheiben und Öffnungen benötigen Stürze.

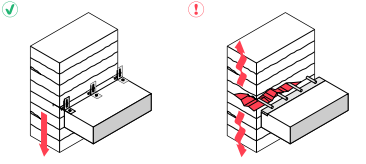
**Gut auf Druck**

Durch das «Stampfen» können Stampflehmwände Druckkräfte sehr gut aufnehmen. Statisch funktionieren sie wie ein unbewehrtes Mauerwerk. Kräfte sollen möglichst rechtwinklig zu den einzelnen Stampflagen abgetragen werden und die Aufnahmefähigkeit von Zugkräften ist vernachlässigbar.



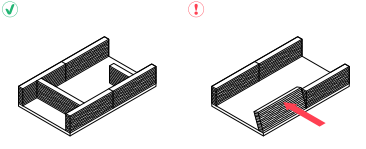
**Kriechen bei Bauteilanschlüssen**

Bei Verbindungen von unterschiedlichen Materialien, wie z.B. einer Stampflehmwand und einer Holzdecke, muss das unterschiedliche Verformungsverhalten der Materialien durch eine Bewegungsfuge berücksichtigt werden. Dieses Verhalten tritt nicht nur bei Stampflehm auf, daher haben sich bereits verschiedenste Lösungsansätze etabliert, die auch im Stampflehmbau angewendet werden können.



**Keine Säulen, sondern Wandscheiben**

Stampflehm ist eine Massivbauweise. Bei vorhandener Deckenscheibe und gelenkig gelagerten Wandscheiben benötigt es für eine räumliche Stabilität mind. drei Wandscheiben, welche sich nicht alle in einem Punkt schneiden und die nicht alle parallel zueinander sind.



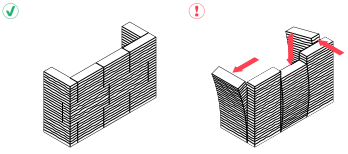




## konstruktive Vorgaben

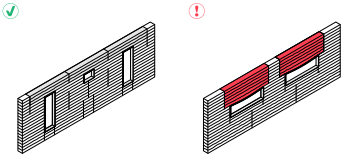
**Mauerwerksverband**

Ähnlich wie bei einem Mauerwerk aus Ziegeln sollten bei Stampflehmwänden die einzelnen Blöcke im Verband gemauert werden. Um bei Punktlasten eine Lastverteilung zu erreichen, ist ein Überbinden der Steine vorgesehen.



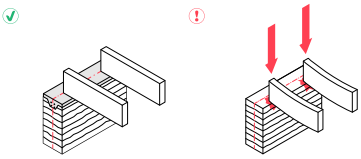
**Öffnungen**

Wegen der geringen Zugfestigkeit von Stampflehm müssen Sturzelemente über Öffnungen normalerweise verstärkt werden. Die Tragfunktion eines Sturzes kann z.B. auch von einem Schließkranz aus Beton übernommen werden. Es ist jedoch offensichtlich, dass größere Öffnungen auch einen größeren Aufwand darstellen.



**Kräfte durch die Mitte abtragen lassen**

Unmittelbar auf Stampflehm einwirkende Punktlasten sollten möglichst vermieden werden, da diese lokale Spannnungsspitzen hervorrufen können. Zudem kann bei einer ausmittigen Belastung die Tragfähigkeit einer Stampflehmwand deutlich reduziert werden. Als möglicher Lösungsansatz sei hier ein Schließkranz (z.B.: Beton) erwähnt.

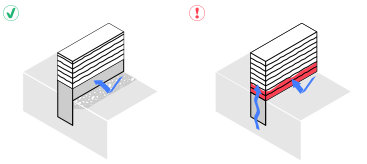


## Wetterschutz

**Stampflehm ist wasserlöslich, deshalb ist er auch einfach zu recyceln ist. Es bedeutet aber auch, dass Wände gute Stiefel und einen guten Hut als Schutz brauchen.**

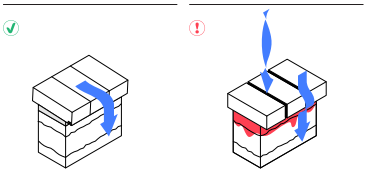
### Ein guter Stiefel

Staunässe zerstört die Struktur von Stampflehm und die Festigkeit der Wände. Erdberührende Teile sollten daher zum Beispiel aus Beton gefertigt werden. Der Spritzwasserschutz sollte sich etwa 30-40cm über Bodenniveau erheben. Entlang des Sockels ist im Idealfall ein sickerungsfähiger Untergrund zu wählen, der das Spritzen mindert.



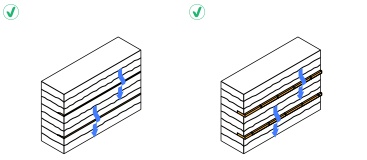
### Ein guter Hut (mit Krempe)

Um Staunässe an dem Dachanschluss zu vermeiden kann ein Dachüberstand den Stampflehmwänden zusätzlichen Schutz bringen. Somit kann kein Wasser tief in die Wände eindringen und die Festigkeit bleibt bestehen.



### Erosionsbremsen

Das an den Seitenflächen herabfließende Wasser wäscht mit der Zeit oberflächlich Lehmteile heraus, was zu Erosion führt. Je höher die Geschwindigkeit des Wassers, desto stärker die Erosion. Um dies zu verringern werden Erosionsbremsen (z.B. aus Trasskalkleisten) eingestampft, die gleichzeitig ein Gestaltungselement darbieten. Der Idealabstand von diesen Schichten liegt bei etwa 40-50 cm.



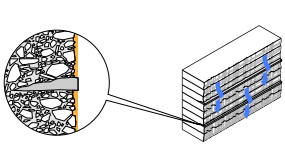




## Wetterschutz

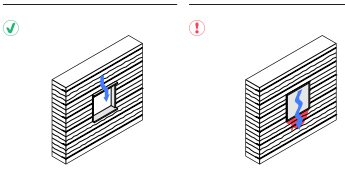
### Kalkulierte Erosion

Bei Stampflehmwänden im Aussenbereich gibt es Erosion. Diese lässt sich konstruktiv kontrollieren. Durch die zunehmend unebene Wandoberfläche verliert Wasser an Geschwindigkeit und die Erosionsgeschwindigkeit nimmt stark ab. Erosion kann schon im Planungsprozess einkalkuliert werden und gehört zum Gestaltungsprozess dazu.



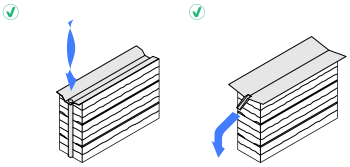
### Schutz durch Gestaltung

Auch Laibungen bei Öffnungen müssen gut vor Staunässe geschützt werden. An jeglichen Orten, wo Wasser sich ansammeln könnte, müssen erosionsbremsende Gestaltungselemente eingeplant werden.



### Regenrinne

Regenwasser muss stets abgeleitet werden, bestenfalls über Regenrinnen oder Wasserspeier. Grundsätzlich gilt es, sowenig Wasser wie möglich an die Stampflehmwand zu bringen. Abgeleitetes Wasser darf nicht zurück an die Lehmwand spritzen.





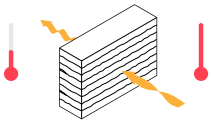


## Bauphysik

**Stampflehmwände haben viel thermische Masse. Sie regulieren passiv die extremen Innentemperaturen und Luftfeuchtigkeit.**

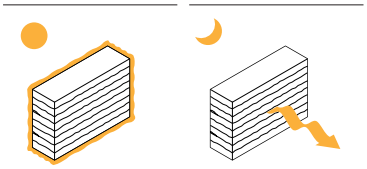
### λ-Wert

Der Wärmeleitkoeffizient von Stampflehmwänden ist vergleichbar mit dem von Beton, etwa 1 W/mK. Wände müssen zusätzlich gedämmt werden wenn sie als Außenwand eingesetzt werden damit sie die OIB Richtlinien erfüllen können.



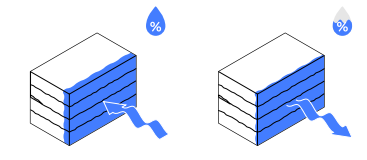
### Thermische Masse

Durch seine hohe Masse und Wärmekapazität kann Stampflehm viel Wärme speichern, was sich positiv auf den gesamten Energieverbrauch auswirkt. Stampflehmwände wirken als «Wärmepuffer». Wärme kann gespeichert werden und verlangsamt an den Raum zurückgegeben werden.



### Passive Feuchtigkeitskontrolle

Zusätzlich zu Wärme kann Stampflehm auch Feuchtigkeit speichern. Dies wirkt sich positiv auf das Raumklima aus, da er diese Feuchtigkeit wieder an die Raumluft abgibt, wenn die Luftfeuchtigkeit niedrig ist.



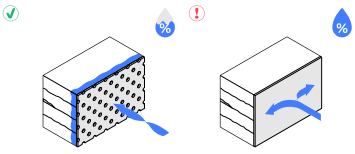




## Bauphysik

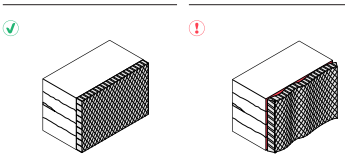
### Wasserdampfdurchlässigkeit

Da Stampflehmwände Feuchtigkeit aufnehmen können, müssen zusätzliche Wandschichten diffusionsoffen sein, um die Feuchtigkeitsregulierenden Eigenschaften nicht zu verlieren. Schichten wie Dampfbremsen und Dampfsperren können zu Bauschäden führen, sollen also unbedingt mit einem Bauphysiker besprochen werden.



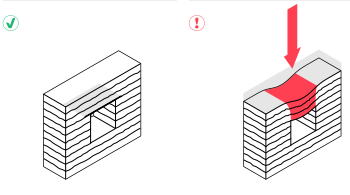
### Gute Verbindung mit anderen Materialien

Bei Dämmungen ist darauf zu achten, dass ein Dämmmaterial verwendet wird welches Feuchtigkeit aufnehmen und abgeben kann. Es ist auch so einzubauen, dass möglichst keine Lufträume zwischen Dämmung und Stampflehmwand entstehen.



### Kriechmaß & Schwinden

Wie andere Baustoffe unterliegt auch Stampflehm bei anhaltender Belastung einer Kriechverformung oder einem Kaltfluss. Das Schwinden tritt unmittelbar nach der Herstellung auf, während die Erde trocknet. Kriechen tritt langsam auf, wenn die schwere Last der Wand das darunter liegende Material mit der Zeit zusammendrückt. Verformungen infolge von Schwinden und Kriechen müssen bei der Planung berücksichtigt werden.

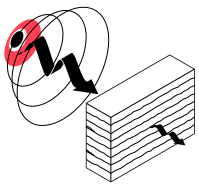


## Akustik

Stampflehm hat sehr gute akustische Eigenschaften. Es bietet eine hervorragende Geräuschdämmung zwischen Räumen und reduziert den Nachhall in Innenraum.

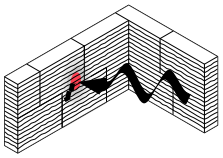
**Schallübertragung**

Stampflehm hat sehr hohe Schalldämmungswerte aufgrund seiner hohen Masse und Dichte. Ähnlich wie bei Beton können in Verbindung mit anderen Materialien Schallanforderungen leicht erfüllt werden.



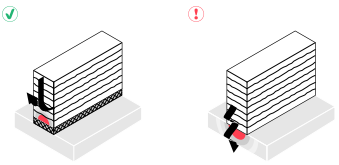
**Raum und Akkustik**

Stampflehm hat eine hohe Oberfläche und unterschiedlich harte Bestandteile. Diese Eigenschaften haben große Vorteile in der Raumakkustik. Die Stampflehmwand verringert Hall und Echos deutlich.



**Schallabsorbierende Eigenschaften**

Aufgrund der hohen Dichte von Stampflehm ist die Körperschallübertragung sehr hoch. Daher müssen, wie bei Beton, falls bauphysikalisch erforderlich manche Elemente schalltechnisch voneinander entkoppelt werden.







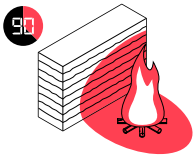
## Brandschutz

Erde ist ein nicht brennbares Material. Verschiedene Stampflehmwandsysteme haben alle erforderlichen Feuerwiderstandsbestimmungen erfüllt.

**Feuerbeständigkeit**

Mit Lehmbauelementen können die höchsten Brandschutzanforderungen lt. OIB-Richtlinien erreicht werden. Bereits eine 25 cm dicke Stampflehmwand besitzt eine Brandwiderstandsklasse von RE90. In Bezug auf Feuerschutz ist der massive Lehmbau gut geeignet.

Mit Konstruktionen aus Lehm können Feuerwiderstandsklassen gem. EN 13501 erreicht werden.





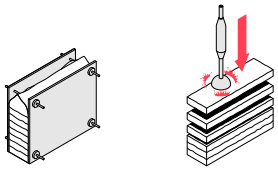



## Produktionsprozess

Stampflehmwände werden, ähnlich wie Betonwände, in einer Schalung hergestellt. Sie werden in einer Produktionslinie vorgefertigt und zugeschnitten.

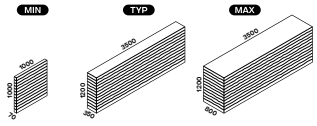
**Schichtenproduktion**

Stampflehm wird in Schichten produziert. Während des Prozesses wird Material in die Schalung gefüllt und in etwa 10cm Schichten kompakt gestampft. Dies wird anschließend auf die ganze Elementhöhe wiederholt. Die Schichtenoptik ist eines der prominentesten Merkmale des Stampflehmbaus.



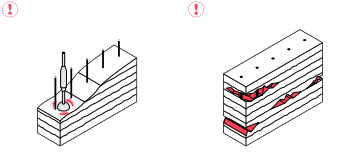
**Typische Elementgröße**

Eine Typische Elementgröße hängt stark von dem Einsatz und dem Transport ab. Eine Elementhöhe von bis zu 1300mm und ein Gesamtgewicht von unter 4 Tonnen pro Element ist optimal um den Transport und das Versetzen zu vereinfachen.




**Beinhaltet keine Armierung**

Stampflehmwände benötigen normalerweise keine innere Bewehrung (Stahlbewehrung). Diese würde zu einer Rissbildung während des Trocknungsprozesses führen und das stampfen würde dadurch erschwert werden.



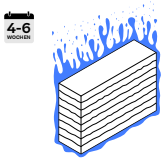




## Produktionsprozess

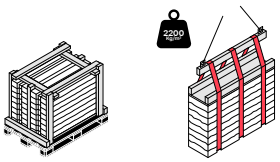
**Trocknungszeit**

Stampflehm wird im feuchten Zustand produziert. Danach werden die Elemente zugeschnitten und gelagert. Nach ca. 6 Wochen Trocknungszeit (Abhängig von der Elementstärke) wird die volle Festigkeit erreicht und die Elemente können versetzt und belastet werden.



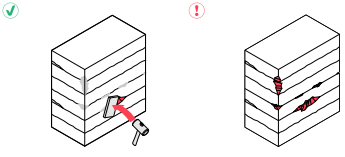

**Gewicht und Transport**

Durch seine relativ hohe Dichte ist Stampflehm ein massives, schweres Bauteil, ähnlich wie Beton. Die Elementgröße muss daher bereits in der Planungsphase so abgestimmt werden, dass im weiteren Bauprozess in Bezug auf Abmessungen und Gewicht keine Einschränkungen (Transport und Montage) auftreten.




**Retuschieren**

Stampflehmelemente werden wie Ziegelsteine versetzt und die Fugen müssen anschließend gefüllt und retuschiert werden, damit die Wand eine geschlossene Oberfläche erhält. Da unser Stampflehm nicht mit Zement stabilisiert ist, kann nach Belieben nachretuschiert werden, auch Jahre später. Alle Schichten wirken letzten Endes durchgehend und geben dem Stampflehm sein charakteristisches Erscheinungsbild.

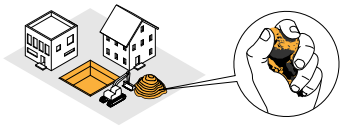


## Material

**Das von uns verwendete Aushubmaterial unterliegt großen Schwankungen, deshalb führen wir ein umfangreiches Qualitätsmanagement durch und lassen die Materialkennwerte laufend durch Prüflabore bestimmen. Die angegebenen Kennwerte können als Mindestwerte verstanden werden, unterliegen aber einer gewissen Streuung.**

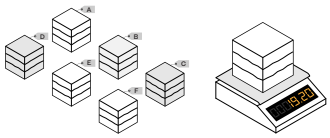
**Materialbeschaffung**

Entweder über eigenes Aushubmaterial des Bauherren, falls geeignetes Material vorhanden ist, oder über Materialbeschaffung (aus der Region) von ERDEN GmbH. Zuerst wird die Zusammensetzung des Bodens auf Eignung für den Stampflehmbau grob Vor-Untersucht (Sieblinienanalyse und Bindigkeit des Lehms, uvm.), dann kann eine Aussage getroffen werden ob dieses Aushubmaterial geeignet ist



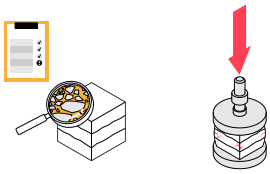
**Optimale Materialmischung**

Mit dem geeigneten Aushubmaterial wird dann im eigenen Labor die optimale Mischung in Hinblick auf Druckfestigkeit und Erosionsbeständigkeit ermittelt. Dazu werden Ton oder unterschiedliche Gesteinskörnungen hinzugefügt und verschiedene Laboruntersuchungen solange durchgeführt, bis die geeignete Rezeptur gefunden wurde.




**Prüfung der Materialmischung**

Die geeignete Rezeptur wird zum Schluss dann nochmal in einem zertifizierten Prüflabor unter Einhaltung der gängigen Prüf-Normen getestet um die von uns festgelegten Parameter wie z.B. Druckfestigkeit, Rohdichte, Feuchte zu verifizieren.





## Material

Wärmeleitzahl

λ = 0,9 W/mK

Mittlere Druckfestigkeit

2,4 N/mm²

Max. zul. Druckspannung

0,34 N/mm²

Schwindmaß

0,25 % bis 1 % je nach Materialwahl

Kriechmaß

0,2 %

Wärmedehnung

0,005 mm/mK

Bewertetes Schalldämmmaß

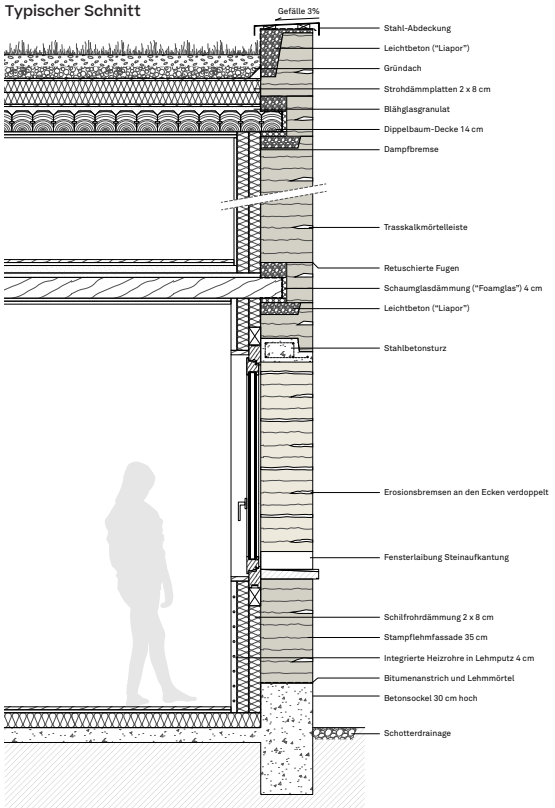
53 dB ab 20 cm Wandstärke

Feuerwiderstandsklasse

RE(I)90 ab 25 cm Wandstärke

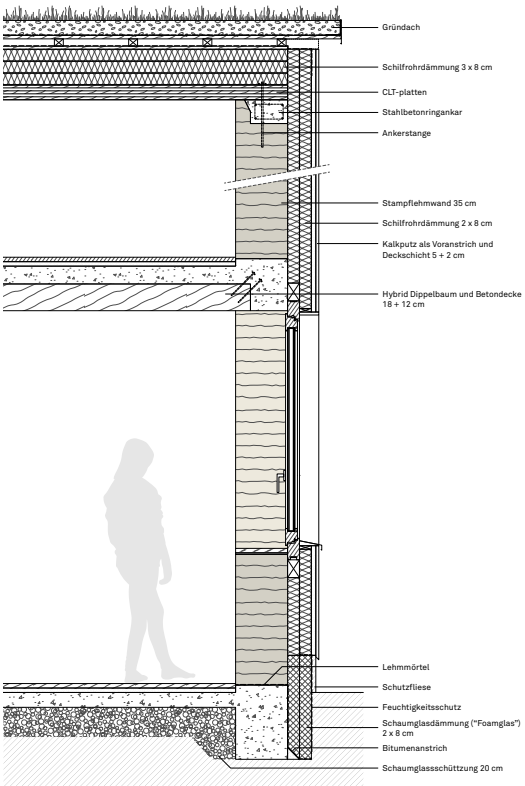


## Typischer Schnitt






## Typischer Schnitt



# ‚VERWERTUNG VON AUSHUB- UND AUSBRUCHMATERIAL' - PART OF THE ABFALLVERORDNUNG, VVEA BY BAFU

**Tabelle 1**

**Verschmutzungskategorien von Aushub- und Ausbruchmaterial**

| Bezeichnung und Codierung | | | Kriterien | | | | |
|---|---|---|---|---|---|---|---|
| **Kategorie gemäss LVA** | **VVEA-Code Anhang 1** | **LVA-Code VeVA** | **Anteil Gewichtsprozent Lockergestein oder lockerer Fels** | **Anteil Gewichtsprozent andere mineralische Bauabfälle** | **Fremdstoffe*** | **Anforderungen gemäss VVEA** | **Praxisbezeichnung** |
| Unverschmutztes Aushub- und Ausbruchmaterial | 4301 | 17 05 06 | > 99% | < 1% | Keine | Anhang 3 Ziff. 1 eingehalten | A-Material |
| Schwach verschmutztes Aushub- und Ausbruchmaterial | 4302 | 17 05 94 | > 95% | < 5% | So weit wie möglich entfernt | Anhang 3 Ziff. 2 eingehalten | T-Material |
| Wenig verschmutztes Aushub- und Ausbruchmaterial | 4201 | 17 05 97 ak | – | – | – | Anhang 5 Ziff. 2.3 eingehalten | B-Material |
| Stark verschmutztes Aushub- und Ausbruchmaterial | 4201 | 17 05 91 akb | – | – | – | Anhang 5 Ziff. 5.2 eingehalten | E-Material |
| Aushub- und Ausbruchmaterial, das durch gefährliche Stoffe verunreinigt ist | 4101 | 17 05 05 S | – | – | – | Anhang 5 Ziff. 5.2 überschritten | S-Material |

* Fremdstoffe wie Siedlungsabfälle, biogene Abfälle oder nicht mineralische Bauabfälle

## Categories of Contamination of Excavated Material

*BAFU (Hrsg.) 2021: Verwertung von Aushub- und Ausbruchmate- rial. Teil des Moduls Bauabfälle der Vollzugshilfe zur Verordnung über die Vermeidung und die Entsorgung von Abfällen. Bundes- amt für Umwelt, Bern. Umwelt-Vollzug Nr. 1826: 36 S, p. 8.*

**Tabelle 2**

**Verwertungsmöglichkeiten (zulässige Verwertung / ** Verwertung nicht erlaubt)**

| **Verschmutzungskategorie** / **Verwertung** | **Unverschmutztes Aushub- und Ausbruchmaterial** **A-Material** | **Schwach verschmutztes Aushub- und Ausbruchmaterial** **T-Material** | **Wenig verschmutztes Aushub- und Ausbruchmaterial** **B-Material** | **Stark verschmutztes Aushub- und Ausbruchmaterial** **E-Material** | **Aushub- und Ausbruchmaterial, das durch gefährliche Stoffe verunreinigt ist** **S-Material** |
|---|---|---|---|---|---|
| Optionale Behandlung | | In Abfallanlage gemäss Art. 26ff VVEA mit anschliessender Verwertung oder Ablagerung | | | |
| Als Baustoff vor Ort | | (a) | (b) | ** | ** |
| Als Baustoff auf Deponie | (c) | (c) | (c) | ** | |
| Als Rohstoff für die Herstellung von Baustoffen | | Nur hydraulisch oder bituminös gebunden | ** | ** | ** |
| Als Rohmaterial im Zementwerk | | | Gemäss Vorgaben Anh. 4 VVEA | Gemäss Vorgaben Anh. 4 VVEA | Gemäss Vorgaben Anh. 4 VVEA |
| Wiederauffüllung von Materialentnahmestellen | | ** | ** | ** | ** |
| Terrainveränderungen | Nur mit Bewilligung | ** | ** | ** | ** |
| Export | Gemäss VeVA (mit Notifikation) | | | | |

a) Gemäss Art. 19 Abs. 2 Bst. d VVEA.

b) Gemäss Art. 19 Abs. 3 Bst. b VVEA.

c) Gemäss den Bestimmungen nach Anhang 2 Ziff. 2.3.1 bis 2.3.3 VVEA resp. Anhang 2 Ziff. 2.3.4 VVEA.

## Possibilities of Reutilization of Excavated Material depending on its contamination

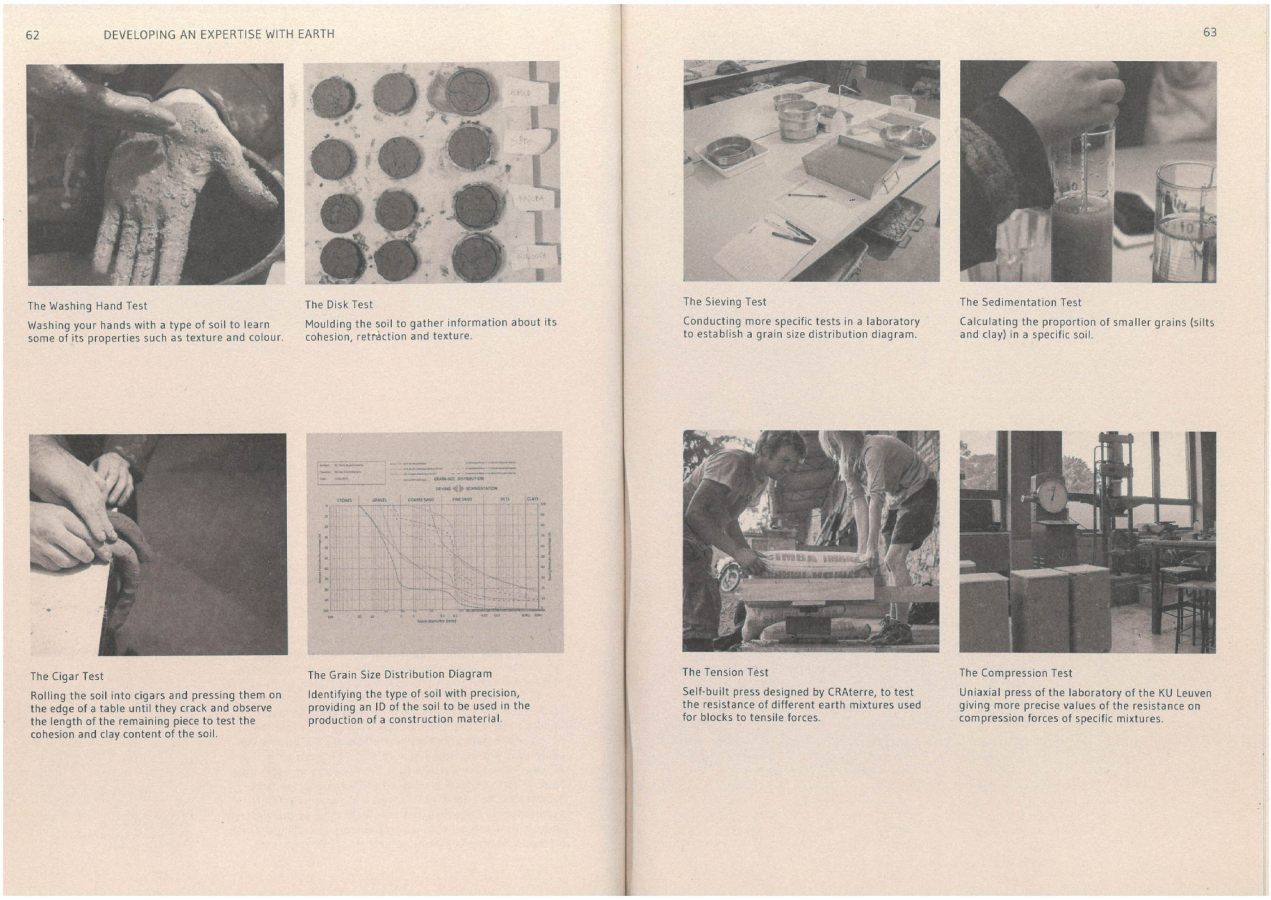
*BAFU (Hrsg.) 2021: Verwertung von Aushub- und Ausbruchmate- rial. Teil des Moduls Bauabfälle der Vollzugshilfe zur Verordnung über die Vermeidung und die Entsorgung von Abfällen. Bundes- amt für Umwelt, Bern. Umwelt-Vollzug Nr. 1826: 36 S, p. 13.*

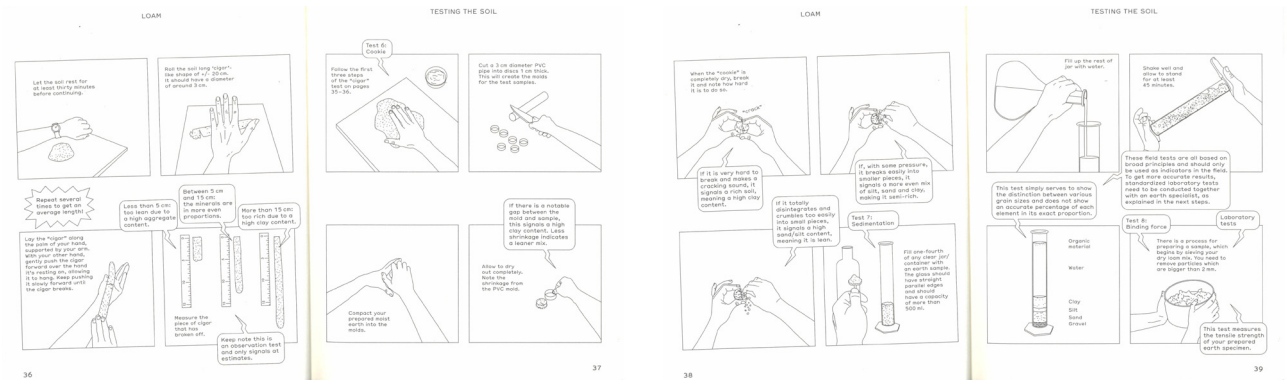
# TESTING THE SOIL - DEVELOPING AN EXPERTISE WITH EARTH

Testing the soil is a must to achieve the right proportions of aggregates to obtain a qualitative building material. There are several tests and most of them are comparative what makes it important that the same person executes them. It is a methodological test that relies a lot on haptic experiences - the muscle memory.

‚Developing an Expertise with Earth'

*Lefebvre, Pauline. BC Architects & Studies - The Act of Building, Flanders Architecture Institute, 2018, pp. 62-63.*




Pages about ‚Testing the Soil' from the SUDU Manual

*Hebel, Dirk E. and Melakeselam Moges, Zara Gray in collaboration with Something Fantastic. SUDU Manual, Ruby Press, pp. 36-39.*

# BEYOND CONCRETE - DOWN TO EARTH

*De Cooman, Ken. ‚Down to Earth. Transforming Urban Excavated Earth into Building Materials' in Beyond Concrete : Strategien Für Eine Postfossile Baukultur = Strategies for a Post-Fossil Baukultur. Triest Verlag GmbH 2022, pp. 149-152.*

## Down to Earth. Transforming Urban Excavated Earth into Building Materials

Ken De Cooman, Brussels Cooperation

Human activity is broadly measured by gross domestic product (GDP)—a monetary measure of the market value of all the goods and services produced in a year, which is often used as a rough indicator when judging the state of a nation. The GDP is supported by a paradigm of growth in which higher growth is considered better, and it presupposes a definition of value as: that which can be counted in terms of market value. It reduces human interactions to services and commodifies time into working hours. That which cannot be counted is left out of the GDP equation: justice, equality, ecology, sharing, caring. This focus primarily on human activity leads to 'overgrowth': focusing on a limited kind of human productivity, while turning a blind eye to the long-term effects of extraction and exploitation of natural, social and human resources. A belief prevails that scientific knowledge and resulting technology will come up with a solution to make the overgrowth model possible within the limited production capabilities of our planet. Histories of technological innovation, such as the work of Professor Vaclav Smil, counter this belief. The current model cannot decouple economic growth from the material and social externalities it is supported by. It seems like the faults in the overgrowth model are built into its structure and there is no technological innovation which could overturn the effects of this model.

We believe the kind of change that is needed is cultural. Transition needs to be learned as a practice. This is especially true for the culture of the construction sector. It takes time for construction communities to imbibe certain kinds of knowledge—a knowledge more often accrued through learning by doing, and by collaborating. A kind of knowledge that arises from an act of 'getting close' to a material or a method, through processes of trial and error, resulting in the reformation of relationships with those resources that supply our materials and therefore our buildings.

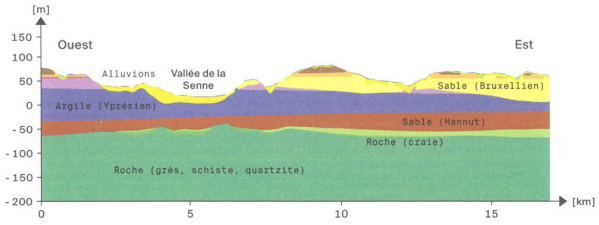
Brussels Cooperation (BC) has built extensively outside of Belgium with projects in Morocco, Burundi, Ethiopia and Benin, where we used local techniques and materials such as earth blocks, fibres, wood and natural stone. We tapped into locally available craftsmanship and regional typologies in mostly rural areas, where there is not yet a prevalence of industrial materials. The existent culture of construction in each place encouraged us to adopt and adapt vernacular and bioclimatic principles. Together with the sites' foremen, community members and partner organisations, BC rethought how buildings could be made, what economic models they presume, what role they will assume in the future, and how they will be perceived.

BC subsequently brought these experiences back to Europe, intending to find a solution to keep the practice economically viable in a higher-wage construction culture. In contrast to the classic solution to take on more projects, BC's response was to be more involved in each project. Expanding our role beyond design, BC was also hired as material consultants and asked to organise workshops about material production and execution on-site, spreading knowledge, and encouraging the use of new materials. Local materials such as earth and hemp are not necessarily expensive, but the labour involved in their transformation and implementation can be, and workshops provide a way to lower the costs of construction. People interested in these materials can participate and learn the techniques by implementing them in a running BC project, providing voluntary labour while doing so.

After a set of public and private projects undertaken in this way, interest from other architectural offices and contractors rose, and BC decided to spin off the activities of material production and consultancy. At the same time, we adapted the concept of using local materials on a project-by-project basis to the more systemic and scalable stock production from urban mining of locally excavated earths. In October 2018, the co-operative BC Materials was started, transforming excavated earths from construction sites into building materials.

Different excavated earths from different geological layers and sites are mixed according to recipes. [ FIG.1 ] These recipes need to be monitored continuously in order to transform heterogenous resources from urban mining into homogenous building materials—this requires a level of continuous and local craftsmanship. This means that the work cannot be delocalised, neither can it be fully automated nor fully industrialised. BC Materials' resources come from an existing waste stream of around 36 million tonnes of earth per year in Belgium with all its issues of transport and disposal. Around 75 per cent of this stream is non-polluted, and of this amount 40 per cent is reused in a non-circular way for road infrastructure and 60 per cent is dumped as waste in quarries and landfills. These numbers are proportionally similar in almost all European countries. BC Materials transforms these resources into beautiful, local, healthy, carbon-neutral, no-waste products. We hence operate doubly in a circular economy: our building materials are circular in origin, coming from excavated earth streams legally considered as waste and hence preventing quarry extraction; and they are circular in destination, as earth building materials can be endlessly reused without loss of quality. BC Materials produces and sells three stock products: the Brusseleir (clay plaster), the Brickette (compressed earth block), and the Kastar (rammed earth). These products are sold mainly B2B, through our network of architects and contractors and building material shops, or directly to professional (public and private) clients. We allow a small part of B2C, however, B2C is not our core market. We produce to order, to avoid the need for big storage areas. We receive most of our resources for free from earthworks contractors, who take it from waste streams of construction sites. Besides three stock products, BC Materials also provides two further services: consultancy on a project-per-project basis, and workshops. These services are conceived to help architects, contractors and clients implement quality earth construction projects, from A to Z.

FIG.1 Geotechnical Section Brussel: High Brussels (yellow) is a mountain of sand, with historical presence of quarries for mortar sand. Low Brussels has alluvial deposits with loam and clays available. BC Materials uses excavated earths from all over Brussels as resources for building materials. The Metro3 project in Brussels digs its way through all of Brussel's geological layers, facilitating the definition of perfect reformulations for clay plaster, compressed earth blocks and rammed earth. © BBRI




As such, BC Materials is not a normal material production company. It operates on a Brussels wasteland in a fully demountable and circular production hall, which can be transported to other wastelands in the Brussels region. It is governed as a cooperative of workers and other interested parties, reflecting its aim to achieve broad and lasting impact in the construction sector by building a community and creating capacity around earth construction, and one which does not aim for the fastest possible sale of building materials with the highest possible profit margins. The balance between a commercial activity and a societal mission is one that keeps driving our business model forward. In the current overgrowth model of production, BC Materials aims to show, and to implement, strategies for a proper transitioning of our construction sector to a culture of local, circular, almost $CO_2$-neutral construction in between craftsmanship and industry.

Of course, we don't do this alone, BC Materials is operating within a fantastic network of actors including other European earth construction colleagues, funding organisations, investors, laboratories, governments, architects, contractors, earth movers, standardisation institutions and universities. And the impact of this is already felt both in the construction culture in general, and more specifically in the market for building materials. BC Materials is currently working together with the Belgian Building Research Institute (BBRI) to translate DIN 18945, -46 and -47 into Belgian norms (in response to our Clay-Bio-Masonry research projects). Our hope is that this research will make it viable for earth building materials to become a trusted standard for widespread use in Belgium. In the meantime, we use the German DIN norms tested in Belgian labs for classifying our building materials.

BC Materials has also filed for R&D funding with BBRI to transform excavated earths from the Metro3 project in Brussels into 27 000 m³ of compressed earth blocks (UTUBE project). Here, we are researching how to feed excavated earth resources into the existing compressing infrastructure of the concrete sector, with the aim to scale up production and lower the cost per block. This exemplary and innovative urban mining project might then be repeatable for big infrastructure projects in Benelux or other European cities. Cycle Terre in Paris, France, is already operating in the same field with a factory which will process excavated earths from the Paris region.

At BC Materials, we believe the policy in Europe is being put in place to allow for these new production models to become viable. Due to the Circular Economy Package to be passed by the EU, and the Green Public Procurement obligations (already a legal obligation since 2021), more and more players on the building market will be forced to produce, buy and use circular products in building projects, with a low life cycle costing and clean end-of-use treatment. The Circular Economy Package also outlines waste reduction targets, which will become more demanding in 2022. As McKinsey notes in the report *Value Creation in Building Materials:* 'While sustainability is an important decision factor already, we are only at the very beginning of an increasingly rapid development. […] Manufacturing will become more sustainable (for example, using electric machinery), and supply chains will be optimised for sustainability as well as resilience. […] Water consumption, dust, noise, and waste are also critical factors.'

We dare to envision a decentralised European network of earth-based material producers, linked to urban mining activities in specific cities in Europe. We are optimistic the rise of the circular economy will allow a breakthrough in the use of contemporary earth-based materials.

keywords:

bioclimatic
caring
circular economy
collaborating
community
cooperative
cultural change
ecology
economic model
encouraging
equality
‚getting close'
human resources
involvement
justice
knowledge
learning by doing
local craftmanship
local materials
local techniques
long-term effects
material consultants
natural resources
network
on-site execution
participate
practical transition
process
produce to order
recipes
reformation of relationships
regional typology
sharing
social resources
societal mission
time
trial and error
trusted standard
urban mining
value
vernacular
voluntary labour
workshops

# REFERENCES OF ACTIVITIES - BUILDING WITH EARTH

TerrraTerrre
Genf
earth exchange platform
https://terrraterrre.ch

terrabloc
Waadt/Luzern
earthen blocks of excavation material
https://www.terrabloc.ch

LehmAG
Brunnen
rammed earth
https://lehmag.ch/lehmag/

BC Architects/Materials/Studies
Brüssel (Belgien)
earthen products out of excavated material
https://lehmag.ch/lehmag/

zoë circular gmbh
Zürich
circular building with clay; exhibition THINK EARTH!
https://zoe-circular.com

Cycle Terre
France
https://www.cycle-terre.eu

amàco
France
https://amaco.org

IG Lehm
Schweiz
https://www.iglehm.ch/lehmbau

Oxara
Zürich
https://oxara.earth

ERDEN
Schlins Bauen mit. 100% Erde (Martin Rauch)
https://www.erden.at

Landify
Genf
https://landify.ch

Boltshauser Architekten
Zürich
https://boltshauser.info

Terres de Paris
Paris
exhibition
https://www.pavillon-arsenal.com/fr/expositions/10485-terres-de-paris.html

# GUIDING QUESITIONS

## EXCAVATION PIT

Where are the big construction sites where excavation is done at the moment in Zurich?
Who are the big companies in Zurich excavating construction pits?
Who decides what happens with the earth and when? What are the regulations?
How is earth excavated? (machinery, process, etc.)
What earth layers are excavated? Are they separately treated? (hummus, etc.)
How is a construction site organized during the excavation?
Who is the owner of excavated material?
How is excavated earth sorted? And how temporally stored on the construction site? (Triage)
When and how is excavated earth analysed? (composition, contamination, etc.)
What is the geological history of Zurich? What 'earth' is excavated in Zurich?
What are the components of excavated earth?

## AS BUILDING MATERIAL

What are traditional building techniques with earth? (Adobe, Cob, Rammed Earth, Fracois Cointeraux)
What are companies/activities/etc. that are researching in this field? What is their approach?
Where do we have examples of earthen buildings in Zurich? What can we learn from those references?
What earth is excavated in Zurich? Is it good for rammed earth?
Can every excavated earth be used as building material?
What is the construction process in building with earth? How could it look like if on site?
What are the challenges using excavated earth as building material?
What are the norms when building with earth? How can those norms be guaranteed? What are tests that need to be done?

## SOIL WASHING PLANT

What are the regulations of contaminated earth?
Where in Zurich do we have contaminated earth?
When and how is contamination analysed?
Can all contaminated earth be cleaned?
How does an excavation washing plant work?
What primary material is sorted out?

## TERRAIN CHANGE

Where do we have examples of terrain changes in Zurich?
What does a terrain change make with the local ecosystem? Is the "artificial landscape" still biodiverse worthy?
What are the regulations of terrain changes in Zurich? (Richtplan?)

## LANDFILL

Where are the dumpsites where Zurich's earth is brought to? (inside and outside ZH)
How are they operated/owned/…?
What happens with contaminated earth brought to a dumpsite? How long does it rest there?
Can it be cleaned over time? If yes, how?
Does a dumpsite further contaminate the close surrounding? (soil, air etc.)

## GRAVEL PIT BACKFILL

Where are the gravel pits where Zurich's earth is brought to? (inside and outside ZH)
How are they operated/owned/…?
Why is excavated earth good for the gravel pit backfill?
How does the backfilling work?
What is "constructed" with the earth? (machinery, layers, process, etc.)
Until when do the gravel pits have space for even more earth? What do you do when it is full?
What is the ecological aspect of the gravel pits?
What plants and animals are impacted?
How were the former gravel pits within the city of Zurich filled?
With the gravel pits on the edge of the canton the earth has to be transported much further...
How is excavated earth transported?
What are the regulations?
How is TerraRail Modalsplit AG organized?
How much from the gray energy of earth is because of transport?