Antonia Vincenza

LOCAL SHIT

Cow manure in an architectural context

A sustainable plaster that combines surplus cow manure with clay. In consideration with the farmers' perspective, small experiments are conducted to manage the cow manure and transform it into a locally applicable product.

Cowdung

As a waste resource coming from cows, cowdung can be defined as undigested residue of consumed food.
It is rich in minerals like potassium, magnesium and phosphorous which have good binding properties. Cowdung also typically contains undigested plant fibers (Bondre et al, 2023, 2).

Origins

In traditional earthern structures in several Asian and African countries, such as India, Burkina Faso, Swaziland and Botswana cowdung is used in combination with clay as a plaster compund or final layer for its water-resistant properties. (Kulshreshtha et al, 2022)
Especially in India, traditional loam plasters contain high amounts of cowdung. This technique is still in use, next to industrialized products that are using the waste cowdung of indian farms (Choudhary, 2023).

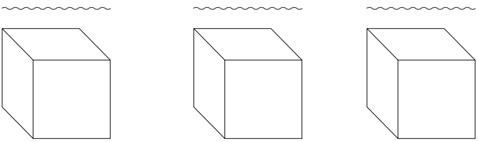
Water resistance

The reason why cowdung has waterproofing properties are small-sized microbial aggregates (SSMA) that are composed of clay-sized negatively charged particles that are rich in fatty acids. SSMA make up about a third of the mass of cow dung. Because of their shape, water droplets have the tendency to slide down the SSMA. When dried, the particles adhere to each other which makes their surface bigger. Therefore dried cowdung is less suitable for use than fresh cowdung.
One of the dominant fatty acids that is present, called OCTADECANOID ACID, is also reported to be used in the preparation of super hydrophobic coatings.
While fibres are known to improve the flexural strenght of plaster, in the context of waterproofing, reducing the fibres can acturally improve the water-resistance of stabilised earthen blocks Kulshreshtha et al, 2022).

Stabiliser: fresh cow-dung (2%)

Immersion duration

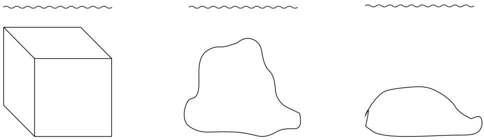
5 minutes 30 minutes 60 minutes



Stabiliser: dried cow-dung (2%)

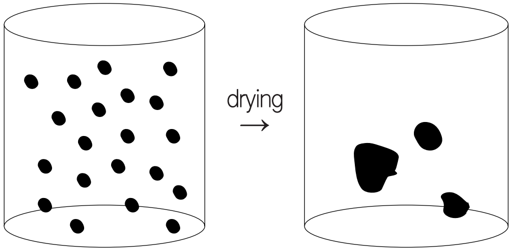
Immersion duration

5 minutes 30 minutes 60 minutes



Fresh SSMA powder
Ø2.7 μm

Dried SSMA powder
Ø26.6 μm



(Kulshreshtha et al, 2022)

Fresh cowdung

Extremely fresh cowdung should be collected within a few hours after being dropped. It should be wrapped in several bags to keep the moisture content high and bacterial activity to a minimum. The dung should be used within 5 days after collecting (Katale et al,2014).

Medium fresh cowdung

Still considered fresh is cowdung that is collected within 14 days after being dropped. The dung then has dried out slightly and not much odur can be detected. When collecting, there should be payed attention to the absence of worms and beetles (Katale et al,2014).

Cow dung ash

Also the ash of burned cowdung can be considered as a supplement in the cement industry, since its chemical composition meets the ASTM C150/C150M requirements for cement. Cowdung ash is composed primarily of SiO_2, Al_2O_3, and Fe_2O_3, which makes it to a pozzolonic material.
Mixing in cowdung into cementious material, it prolongs initial and final setting times of the blended cement paste by a range of 12%-59% and 3%-44% . Therefore it can be used as set retarder in hot weather concrete works (Worku et al, 2023).

The composition of materials varies strongly, depening on the additives and desired outcome. Since cowdung does not only have waterproofing, but also stabilising properties, it is also used to make stabilised earth bricks. The following recipes are examples for the use of cowdung in construction.

Generally it can be said that:
Soil (also depending which soil) mixed with cowdung has higher compressive strenght but lower water resistance.
Sand mixed with cowdung has higher waterproofing properties but lower strength (Kulshreshtha, 2021)

Adobe bricks
80% soil
20% cowdung (with a minimum of 10%)
(Katale et al,2014)

Compressed bricks
98 % soil
2% fresh cowdung

1. Mixed, left alone for 5 days
2. Pressed into mould (2.5 MPa force)
3. Cured for fourteen days at 55% humidity and twenty degrees Celsius.

(Kulshreshtha et al, 2022)

→ Adobe bricks (14)

Plaster
1 part clay
2,5 parts sand
3 parts fresh cow dung
(Heca, F. 2020)

Plaster
3 (5 gallon) buckets of 1/16 inch sifted sand
1 bucket of screened clay
1 bucket fresh screened cow manure (not dried)
8 cups wheat waste
fluff of 3-4 cattails
(Liloia, Z. 2024)

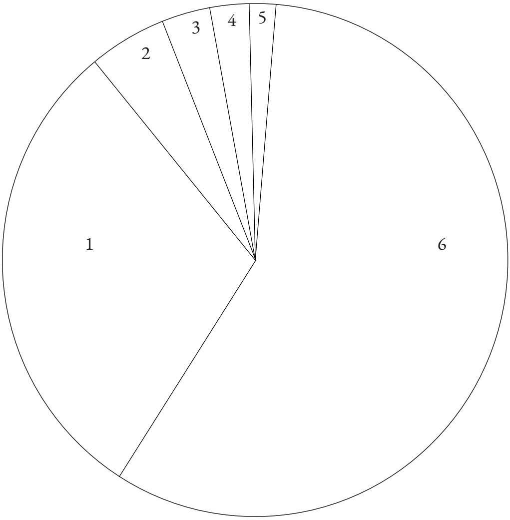
Industrial plaster

An industrially made product called Vedic plaster uses cowdung of Indian farms in their product. In this product, the cowung part is 30%.

Composition of the vedic plaster

1 Cow dung 30%
2 Guar gum 5%
3 Mud 3%
4 Water 2%
5 Citric acid 1%
6 Gypsum 60%

(Choudhary, R., 2023)



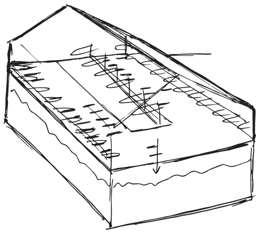
← Vedic plaster (14)

Dung slurry

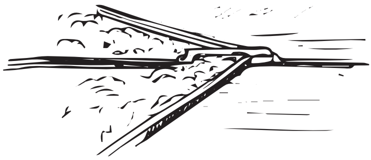
A water-resistant shell can made by creating a slurry. Therefore cowdung is mixed with water to as paste and then being applied on top of plasters and floors. However, if spreaded carelessly, it can result in mechanical weathering and decay of the crust (Gur-Arieh et al, 2028).

→ Floor coaring (13)

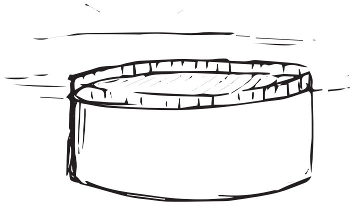
Manure collection / separation



Traditional floor systems: urine and excrement mix in slurry basement

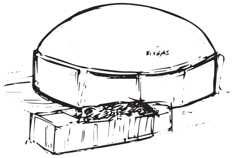


Modern floor systems: excrements are scraped while urine is drained



Long term storage

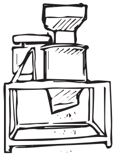
Applications



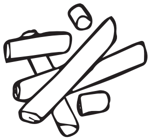
Biogas plant

Field fertilizer

Decanter: Presses liquid out of slurry



Powder



Pellets

very little products in the building industry

Problems

Much more manure than land to fertilise.

Harmful gases like ammonia and methane produced as soon as urine and excrements mix together.

Strict governemental regulations on ma-nure management.

Cowdung plays a mayor role in the nitrogen crisis in the Netherlands. The Netherlands has a very high density of livestock, with over 15 million pigs and cows, nearly matching the human population (Centraal Bureau voor de Statistiek 2023). This intensive animal agriculture has led to a massive production of manure, which releases high levels of ammonia and other nitrogen compounds.

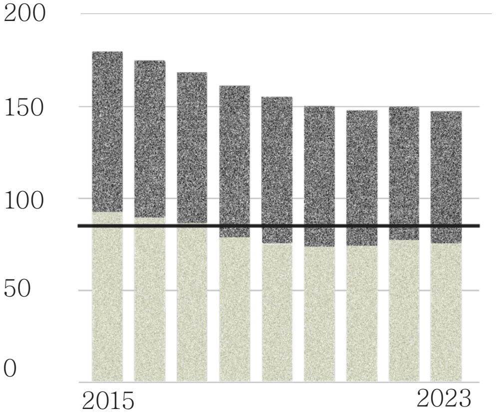
The nitrogen from cow manure, both from the animals' digestive process (enteric fermentation) and the storage and application of the manure, is a significant source of the nitrogen pollution (Mele, 2022).

The fermentation of organic matter in the manure under anaerobic conditions produces methane as well as nitrogen compounds like ammonia (Mele, 2022). The excessive nitrogen deposition has damaged ecosystems, harming native plant and animal species (Mukpo, 2023). This has led to legal challenges and political turmoil, as the Dutch government has struggled to meet EU environmental regulations and balance the interests of the powerful agricultural lobby against the need to protect nature (Mukpo, 2023). Besides reducing the number of livestock, there are measures being taken to manage the cow manure. This is includes providing funding to farmers to implement more sustainable manure management practices (Tullis, 2023).

Cow manure makes up 80% of the 75 million tons manure every year. That means an annual production of 60 million tonnes and a daily amount of 164,000 tonnes are produced in the Netherlands (Dollmann et al, 2021). Using cow manure as a construction material would divert this nitrogen-rich waste away from being applied to fields, where it can volatilize and contribute to nitrogen pollution.

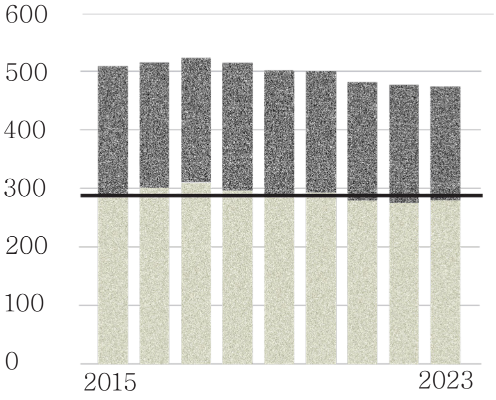
Nitrogen pollution in animal manure

Million kg



Phosphate production in animal manure

Million kg



Dairy production

Other

Sector ceiling

↑ Dutch Dairy in Figures, 2023.

How much plaster can be made from the 60 million tonnes of yearly cow manure?

Plaster recipe

1 (clay)
+ 3 (cow manure)
+ 2.5 (sand)
= 6.5 parts

Cow manure portion

3 / 6.5 = 0.4615 or ~ 46.15%

Tons of plaster

60,000,000 tons/0.4615 = 130,000,000

Assuming an average density of 1,600 kg/m3 for plaster, this equates to:

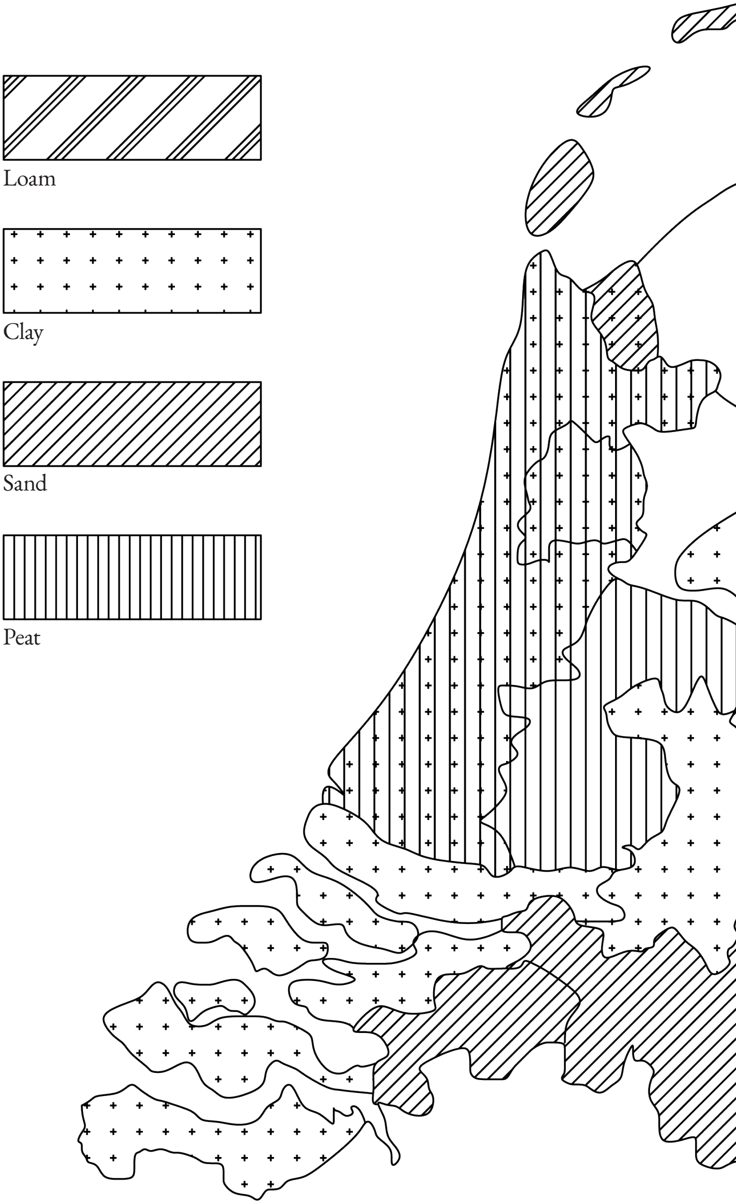
(130,000,000 tons x 1000 kg/ton) : 1600 kg/m3 = 81,250,000 m3 of plaster

Area Covered

With a plaster thickness of 7 mm or 0.007 m, the area that can be covered is:
81,250,000 m3/ 0.007 m = 11,607,142,857 m3 or approximately 11.6 billion m^2

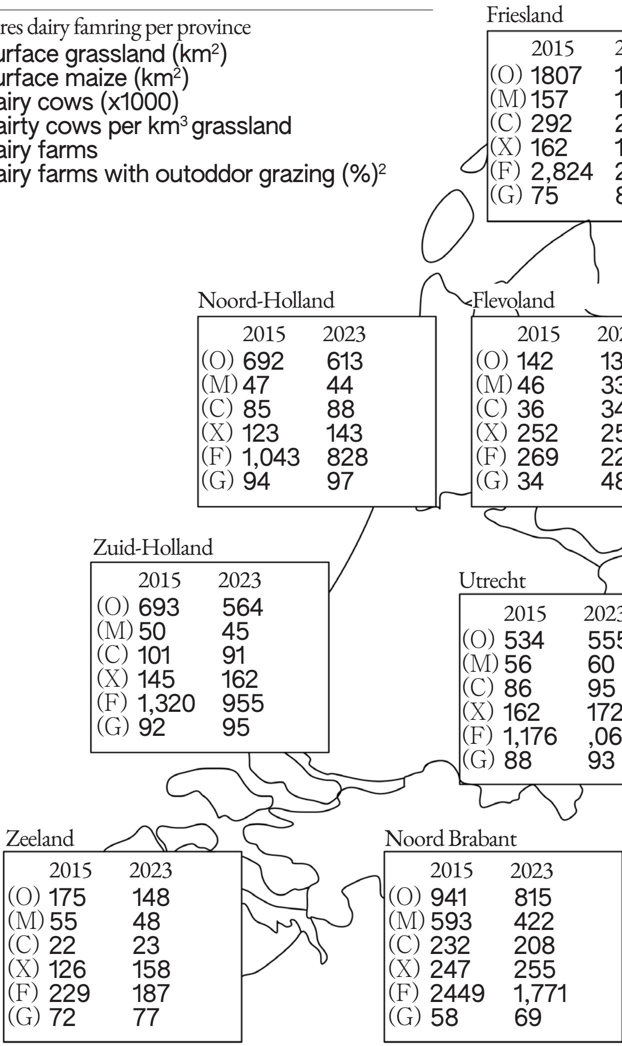
With an annual cow manure production of 60 million tons in the Netherlands, and using the given recipe, approximately 130 million tons or 81.25 million cubic meters of plaster could be produced, covering an area of around 11.6 billion square meters at a thickness of 7 mm.

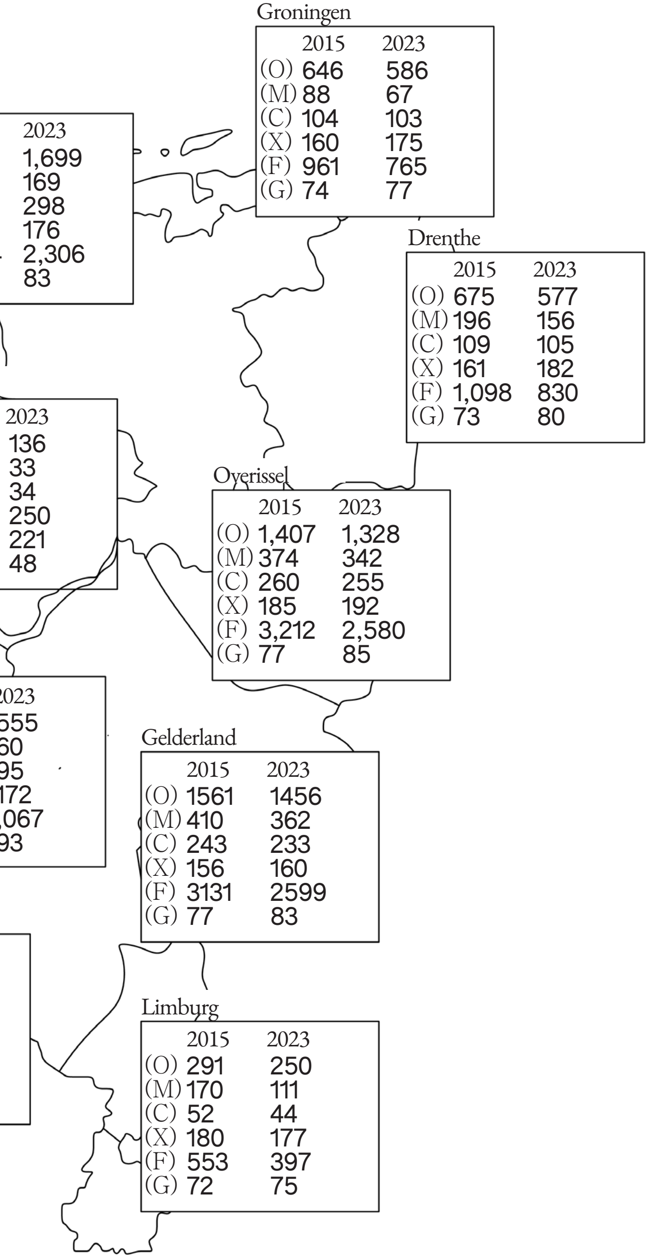
MATERIAL AVAILABILITY
DUTCH SOIL TYPE



↑ Schreefel et al, 2022.

Key figures dairy famring per province
(O) Surface grassland (km^2)
(M) Surface maize (km^2)
(C) Dairy cows (x1000)
(X) Dairty cows per km^3 grassland
(F) Dairy farms
(G) Dairy farms with outoddor grazing (%)[2]





Groningen

	2015	2023
(O)	646	586
(M)	88	67
(C)	104	103
(X)	160	175
(F)	961	765
(G)	74	77

Drenthe

	2015	2023
(O)	675	577
(M)	196	156
(C)	109	105
(X)	161	182
(F)	1,098	830
(G)	73	80

Overissel

	2015	2023
(O)	1,407	1,328
(M)	374	342
(C)	260	255
(X)	185	192
(F)	3,212	2,580
(G)	77	85

Gelderland

	2015	2023
(O)	1561	1456
(M)	410	362
(C)	243	233
(X)	156	160
(F)	3131	2599
(G)	77	83

Limburg

	2015	2023
(O)	291	250
(M)	170	111
(C)	52	44
(X)	180	177
(F)	553	397
(G)	72	75

↑ According to the "Dutch Dairy in Figures 2023" report, there were 14,264 dairy farms in the Netherlands in 2022.

Product Carbon Footprint Dairy Farming
grams of Co2 equivalents per kg of measuring milk
deliveried by source

Notes

(1) animal manure emissions from fermentation processes in anaerobic environment;
(2) emissions from nitrification and de-nitrification processes in the storage of animal manure in the soil, and the indirect emission after atmospheric deposition of N-compounds and by wash out of N agricultural soils;
(3) direct fossil fuel emissions (assuming that 80% of the total fossil fuel emissions occur during combustion on dairy farm), including contract work and cultivation work;
(4) emissions that occur during the production of electricty (100%) and fossil fuels (assuming that 20% of the total emissions of fossil fuels occur during production;§
(5) emissions from the prodcution of other raw materials supplied, for example agricultural plastics and pesticides.

→ Dutch Dairy in Figures, 2020.

On the dairy farm	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Rumen fermentation & digestion (methane)	571	572	581	581	572	573	552	509	506	525
Manure (methane)[1]	152	150	154	157	153	157	149	141	139	144
Manure and soil (nitrous oxide)[2]	147	149	152	151	151	137	127	118	115	118
Energy use (CO_2)[3]	31	33	34	31	33	31	30	29	29	30
Total on the dairy farm	900	904	920	919	910	898	858	797	789	817

In production of raw materials	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Concentrated feed (CO_2)	298	310	331	339	330	351	346	340	322	312
Roughage and by-products (CO_2)	16	21	23	24	26	27	23	20	16	14
Fertilizer (CO_2)	43	41	44	43	44	41	37	33	36	36
Energy use (CO_2)[4]	37	20	21	22	20	19	19	19	19	17
Other (CO_2)[5]	34	38	37	31	32	32	28	31	34	36
Total production raw materials	429	431	456	459	452	470	453	446	423	415
Total dairy farming	1,329	1,335	1,376	1,378	1,362	1,368	1,312	1,243	1,211	1,232

GENNEPER HOEVE
EINDHOVEN

In the Netherlands

The Genneper Hoeve is a biodinamic farm with around 100 milk cows in Eindhoven. For the material experiments that were conducted for this study, the farm provided me with their clay rich soil, that was escavated during the build of their new proeflokaal, compact cow dung that is stored in piles outside and cow dung slurry that is stored in the basement of the cow stable. (Age Opdam, 2024)

ADVANTAGES
VS
DISADVANTAGES

Advantages

1. Reduces nitrogen emissions; by incorporating cow manure into building products, the manure is diverted from traditional management practices such as storage and spreading on agricultural land, which are major sources of nitrogen emissions (Jun, P. et al, 2001).

2.Provides a sustainable alternative to cement for its stabilizing properties (Katale et al, 2014).

3. Improves waterresistance of clay (Kulshreshtha et al, 2022).

4. Lower density and thermal conductivity than usual cement plaster (Bondre et al, 2023).

5. Utilizes Agricultural Waste, (Tullis, 2023).

Disadvantages

1. Time and energy intense as there is no infrastructure yet.

2. Odour and bacterial hazards (see Manyi-Loh et al, 2016).

Looking forward

Thinking of a construction fully based on clayey soil, cowdung and sand, it should consist of different layers to provide the optimal properties of each material (Kulshreshtha, 2021).

Compressive strenght

It can be achieved by using small amounts of cowdung, mixed with larger amount of loam (Kulshreshtha, 2021).

Flexural strenght

It is achieved by making use of the fibres in the cowdung, as well as added fibers if needed (Kulshreshtha, 2021).

Waterproofing

A final layer on the clay/cowdung bricks should contain higher amounts of cowdung and sand, and lower or no clay (Kulshreshtha et al, 2022).

Cowdung is a highly underrated material. Especially in places like the Netherlands, where there is an access quantity available, its properties and benefits for the sustainable construction sector should be further researched and experimented with.

INDIVIDUAL PRODUCTION ON SITE

1

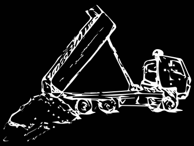
Farm: Surplus
Cow Manure

Logistic Company
Truck A

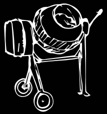
Escavation Site:
Clay + Sand

Logistic Company Truck B

2



Drop Off
A + B



*

Mix
Plaster

3

Logistic Company
(Only With Option b)

Construction Site

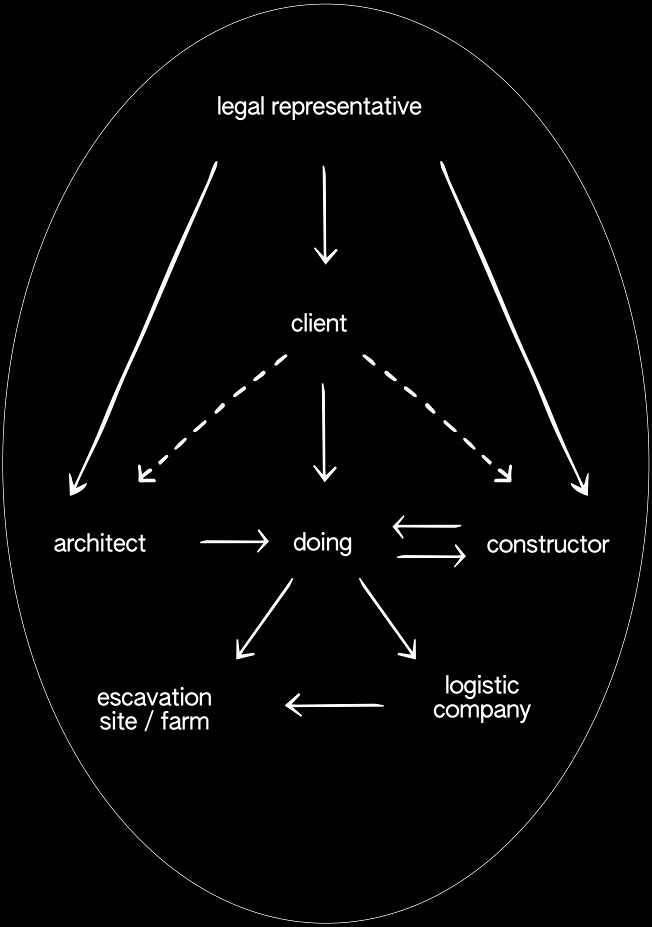
---

* Who?
Option a: Constructor
Option b: Processing company

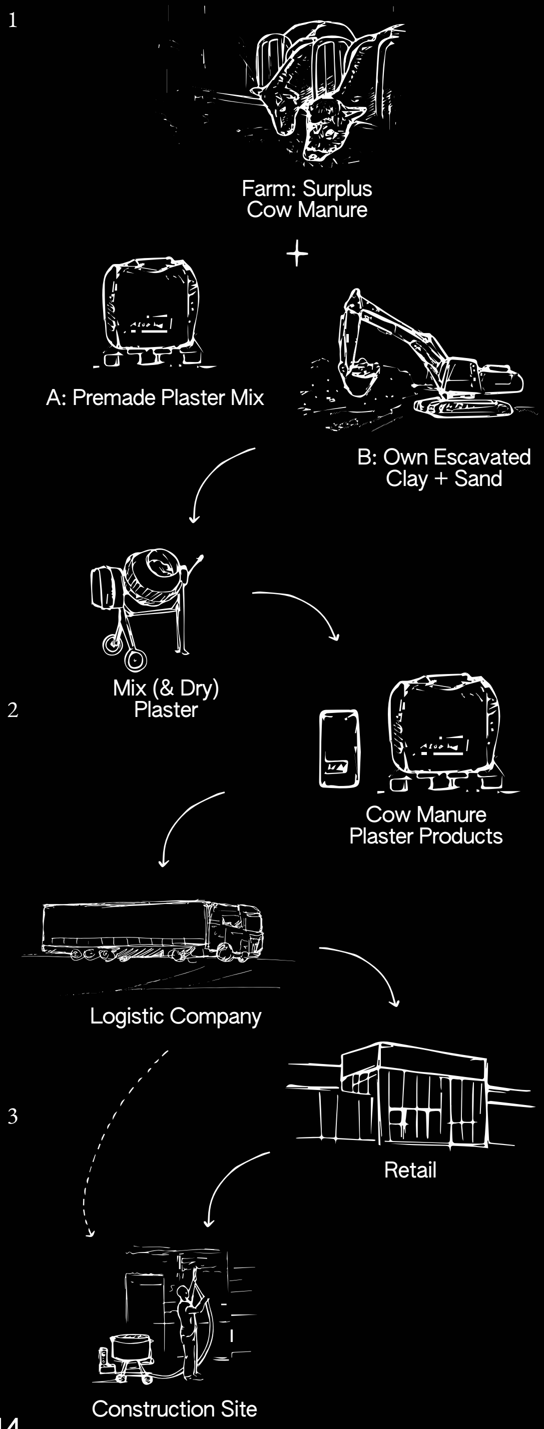
Where?
Option a: At final destination
Option b: Extra location

+
local
production on demand

-
no existing system
many logistics

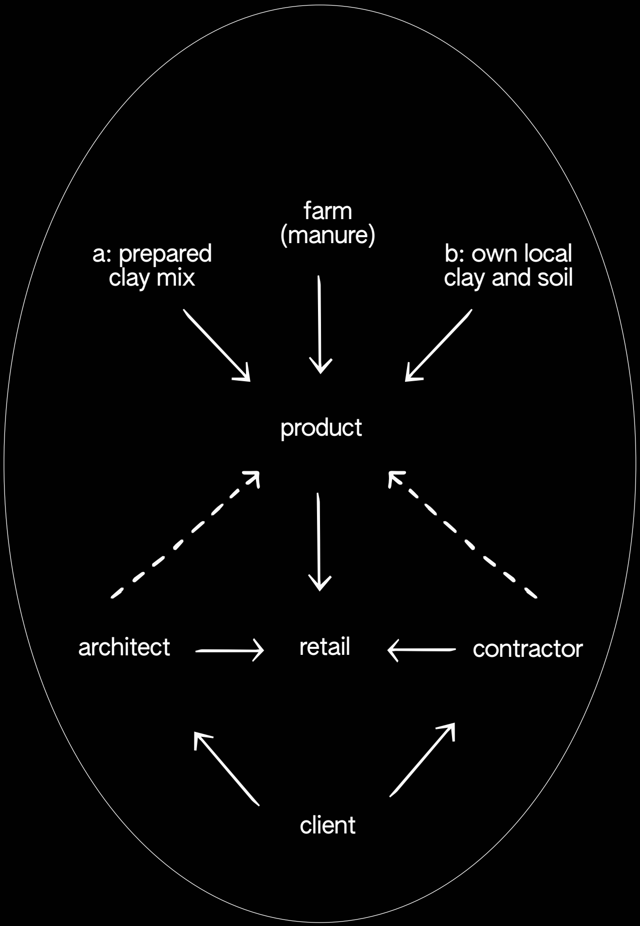


SMALL PRODUCTION ON FARM

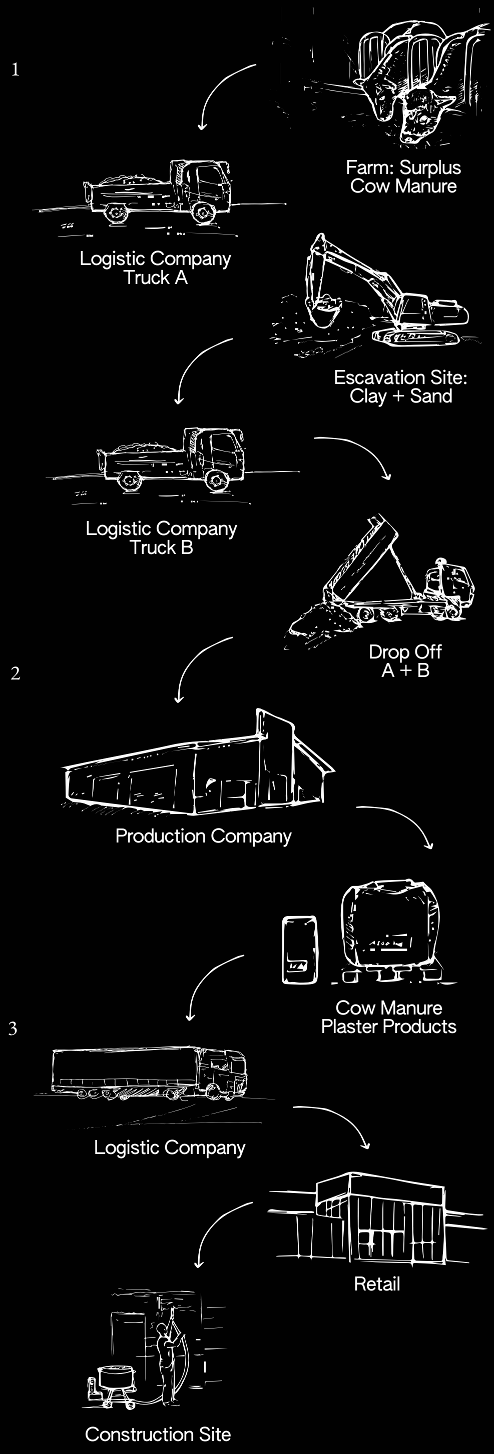


+
less permits needed
less logistics
farmers can sell products
short process - less (ammonia) emissions

-
no existing system
if dried - plaster looses (a part of its)

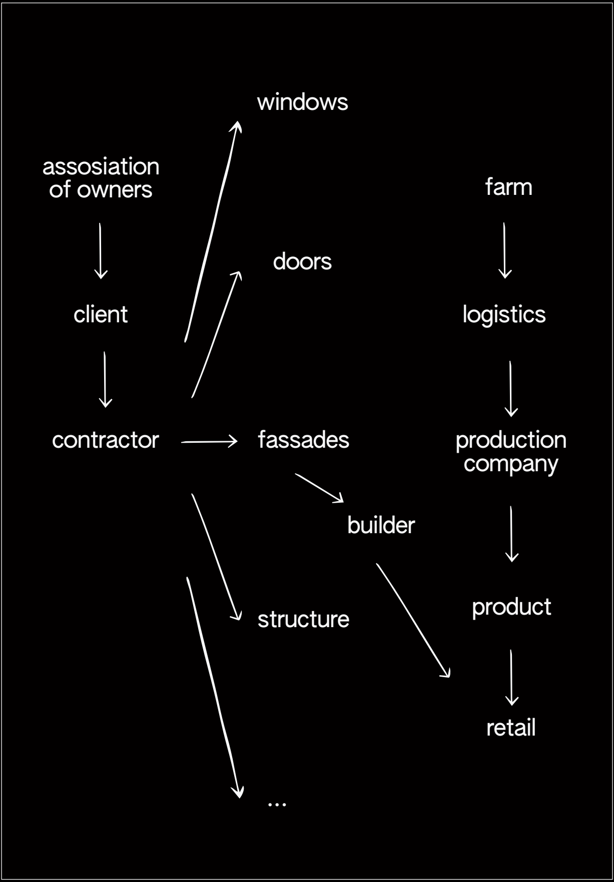


LARGE SCALE PRODUCTION



+
works in existing system
big scale solution
easy for farmers

-
need of permits
more logistics
longer process - more (ammonia



↑ Winner of Kazerne Design Award 2025.

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ACKNOWLEDGEMENTS

Thanks to
Age Opdam, Genneper Hoeve Eindhoven, Farmer; Paul Willems, Arla, Farm Sustainability Coordinator Central Europe; Martijn den Besten, Friesland Campina; Projectmanager Klimaat en Natuurverwaarding; Cyriel Heemels, Architect, Project Manager; Nuno Vasconcelos, Architect; Joost Botteram, Prehistorisch Dorp Eindhoven, Hoofd Technische Dienst .

Photography
Theodor Winter

Typeset in
Authentic Sans 90 Regular, Adobe Myungjo Std Regular, EB Garamond Regular and Italic.

Editorial design
Benedetta Pompili

Printing
Block Design, Palermo, Italy

A sustainable plaster that combines surplus cow manure with clay. In consideration with the farmers' perspective, small experiments are conducted to manage the cow manure and transform it into a locally applicable product.