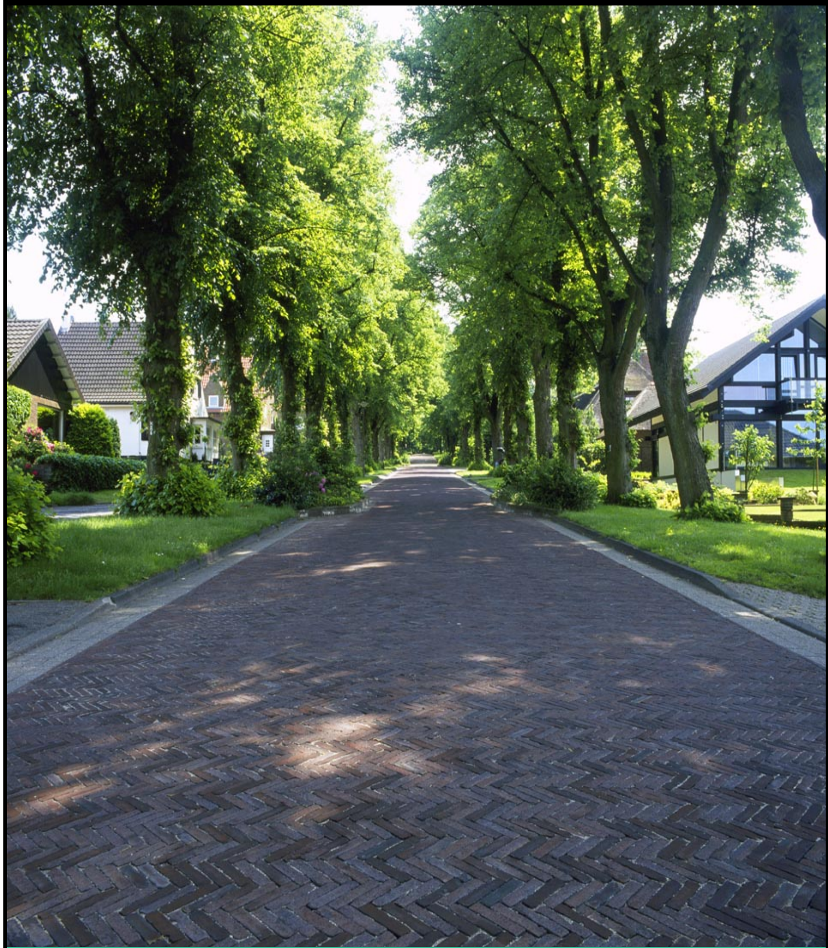
Environmental Product Declaration
according to ISO 14025 and EN 15804

milieu relevante product informatie

This declaration is for:
Clay pavers representative for the Dutch ceramic industry (KNB members)

vereniging Koninklijke Nederlandse Bouwkeramiek

Provided by:
KNB the Royal Dutch Construction Ceramics Association



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ECO PLATFORM EPD
EN 15804 VERIFIED

COMPANY INFORMATION

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PRODUCT

Clay pavers representative for the Dutch ceramic industry (KNB members)

DECLARED UNIT/FUNCTIONAL UNIT

Street covering with an application period of 25 years, expressed per m² applied product, as: clay pavers for use in road pavements for pedestrian and vehicular traffic in accordance with NEN-EN 1344.

DESCRIPTION OF PRODUCT

Clay pavers in accordance with NEN-EN 1344 applied in road pavements for pedestrians and vehicular traffic, made wholly or partly from Dutch extracted river clay.

VISUAL PRODUCT

MRPI® REGISTRATION

1.1.00194.2021

DATE OF ISSUE

12-04-2021

EXPIRY DATE

12-04-2026

MORE INFORMATION

www.knb-keramiek.nl

SCOPE OF DECLARATION

This MRPI®-EPD certificate is verified by **Kamiel Jansen, Primum.**
The LCA study has been done by **Bob Roijen, SGS Intron.**
The certificate is based on an LCA-dossier according to ISO14025 and EN15804+A1. It is verified according to the 'MRPI®-EPD verification protocol November 2020.v4.0'. EPDs of construction products may not be comparable if they do not comply with EN15804+A1. Declaration of SVHC that are listed on the 'Candidate List of Substances of Very High Concern for authorisation' when content exceeds the limits for registration with ECHA.

PROGRAM OPERATOR

Stichting MRPI®
Kingsfordweg 151
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ir. J-P den Hollander, Managing director MRPI®

DEMONSTRATION OF VERIFICATION
CEN standard EN15804 serves as the core PCR[a]
Independent verification of the declaration and data, according to EN ISO 14025:2010: internal: external: X
Third party verifier: Kamiel Jansen, Primum
[a] PCR = Product Category Rules

DETAILED PRODUCT DESCRIPTION

The main raw material for paving bricks is clay. Clay is abundantly available in the Dutch floodplain. The clay stock is large and the supply by nature is a continuous process. Every year, more clay is deposited in the flood plains than is extracted. The mineral raw material is clay thus a renewable resource [Van der Meulen M.J, Deltares, Sediment management and the renewebility of floodplain clay for structural ceramics, 2009]. Clay extraction is subject to strict rules and is done with respect for flora and fauna. Extraction is done according to a ministerial approved Code of Conduct. After excavation of the clay, the clay extraction areas are returned to nature or given a new destination such as e.g. a recreational area.
The clay is often mixed with sand and water prior to the production of the clay pavers. Depending on the type of clay paver, additives are added. To turn the clay mix into a ceramic product, a production process is in place that has been thoroughly optimized and automated. The production process consists of the following process steps:

- pre-treatment of the clay;
- shaping of the desired product;
- drying and firing process.

Paving bricks are sold both packed and unpacked, therefore the packaging is taken into account on a pro rata basis. Thorough quality control is carried out at all stages of the production process.

The average technical lifespan of clay pavers (RSL - reference service life) is 125 years [Sukking R.G., Vroonhof J.T.W., Royal Haskoning report No. 9V1632 / R00004 / 903492 / Rott, October, 2009]. However, in the life cycle assessment there is a period of use (RSP, reference study period) of 25 years used because on average every 25 years a major road maintenance is carried out, i.e. clay pavers are removed and the road is repaved.
In the context of the Soil Quality Decree (BBK), the pavers are provided with the NL-BBKcertificate. The Soil Quality Decree sets the preconditions for the application of building materials on or in the soil or in surface water, to prevent unwanted dispersion of substances to the environment.

COMPONENT (> 1%)	[kg /per kg]
Clay	0.922
Sand	0.102
Additives	0.035
LDPE foil (packaging)	0.000048
Wooden pallets	0.00036

(*) > 1% of total mass

SCOPE AND TYPE

Clay pavers representative of the products made by members of KNB. The clay paver is manufactured in whole or in a part made from river clay extracted in the Netherlands with natural gas and elektricity at production sites with flue gas purifiers. The LCA study was carried out according to the rules formulated in the "SBK Assessment method for the environmental performance of Buildings and civil engineering works, version 3.0, January 2019 and the accompanying "SBK Verification Protocol recording environmental data in the national environmental database", Version 3.0, January 2019.

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
Raw material supply	Transport	Manufacturing	Transport gate to site	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
x	x	x	x	x	x	x	x	x	x	ND	ND	x	x	x	x	x

X = Modules Assessed

ND = Not Declared

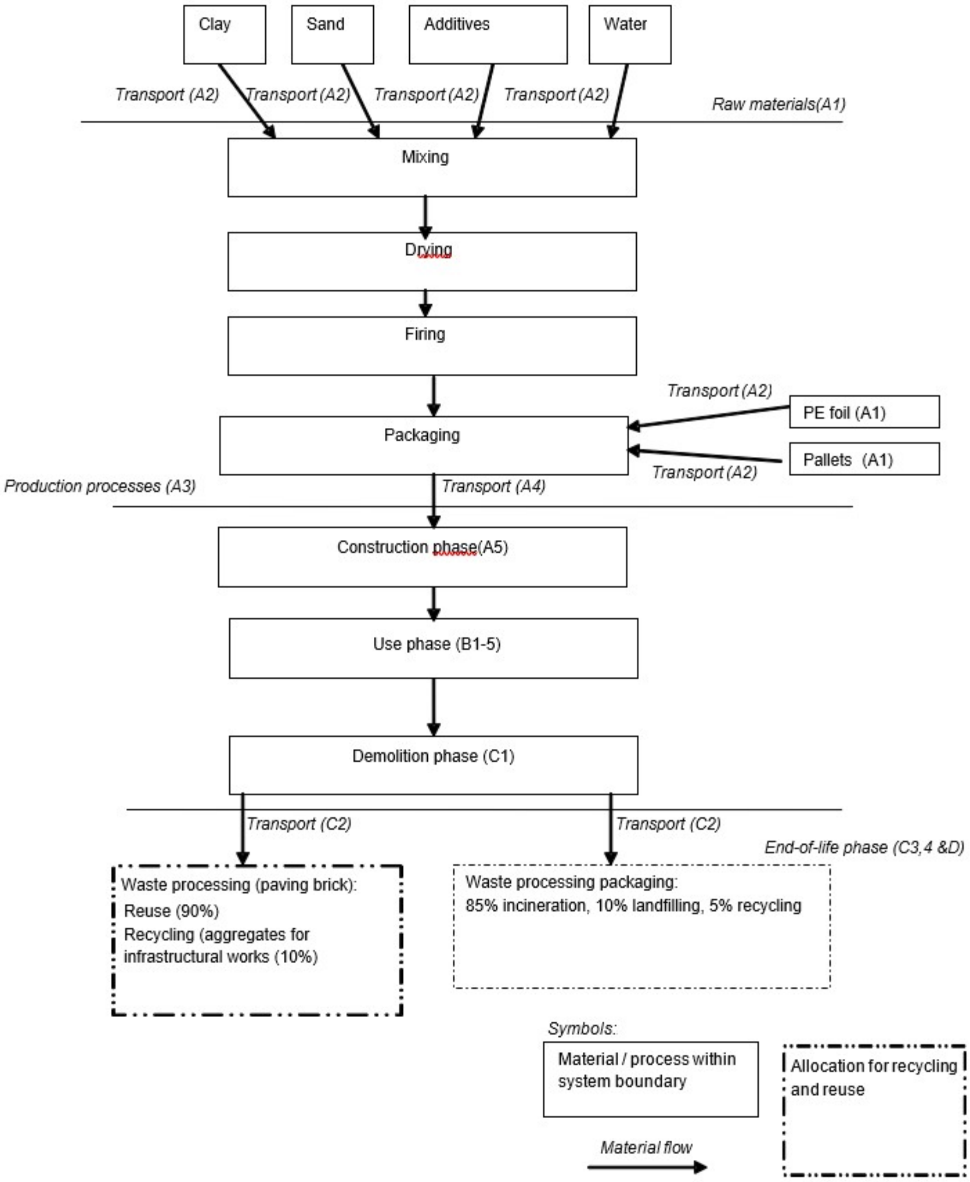

Figure: LCA process diagram according to EN 15804(7.2.1)

REPRESENTATIVENESS

All KNB members that produce clay pavers provided data for this study. The geographical coverage reflects the physical reality for the declared product group. The data that together determine > 80% of the environmental impacts were collected in a similar manner, with similar accuracy.

ENVIRONMENTAL IMPACT per functional unit or declared unit (indicators A1)

	UNIT	A1	A2	A3	A1-A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
ADPE	kg Sb eq.	7.38 E-6	6.92 E-7	5.29 E-6	1.34 E-5	9.72 E-6	1.79 E-7	0.00	0.00	0.00	0.00	0.00	3.85 E-9	1.14 E-6	3.05 E-8	1.00 E-9	-1.21 E-5
ADPF	MJ	1.55 E-2	2.15 E-3	2.29 E-1	2.47 E-1	2.52 E-2	8.29 E-4	0.00	0.00	0.00	0.00	0.00	5.32 E-5	2.97 E-3	3.22 E-4	1.20 E-5	-2.24 E-1
GWP	kg CO2 eq.	2.14 E+0	3.01 E-1	3.05 E+1	3.29 E+1	3.42 E+0	1.36 E-1	0.00	0.00	0.00	0.00	0.00	7.74 E-3	4.03 E-1	4.21 E-2	8.80 E-4	-2.99 E+1
ODP	kg CFC 11 eq.	3.15 E-7	5.29 E-8	2.52 E-6	2.89 E-6	6.30 E-7	1.93 E-8	0.00	0.00	0.00	0.00	0.00	1.35 E-9	7.42 E-8	5.21 E-9	2.91 E-10	-2.64 E-6
POCP	kg ethene eq.	1.68 E-3	1.77 E-4	6.17 E-3	8.03 E-3	2.02 E-3	7.77 E-5	0.00	0.00	0.00	0.00	0.00	7.73 E-6	2.38 E-4	2.40 E-5	9.33 E-7	-7.47 E-3
AP	kg SO2 eq.	1.39 E-2	1.51 E-3	7.28 E-2	8.82 E-2	1.48 E-2	5.68 E-4	0.00	0.00	0.00	0.00	0.00	5.72 E-5	1.75 E-3	1.96 E-4	6.51 E-6	-8.13 E-2
EP	kg (PO4)3- eq.	2.89 E-3	3.12 E-4	6.82 E-3	1.00 E-2	2.95 E-3	1.20 E-4	0.00	0.00	0.00	0.00	0.00	1.28 E-5	3.48 E-4	4.39 E-5	1.22 E-6	-9.47 E-3

Toxicity indicators and ECI (Dutch market)

HTP	kg DCB-Eq	6.93 E-1	1.08 E-1	9.95 E+0	1.08 E+1	1.37 E+0	4.03 E-2	2.69 E-1	0.00	0.00	0.00	0.00	3.05 E-3	1.61 E-1	9.74 E-3	3.59 E-4	-9.77 E+0
FAETP	kg DCB-Eq	1.01 E-2	3.10 E-3	2.78 E-2	4.09 E-2	4.01 E-2	9.95 E-4	4.26 E-1	0.00	0.00	0.00	0.00	3.91 E-5	4.72 E-3	1.75 E-4	8.93 E-6	-3.81 E-2
MAETP	kg DCB-Eq	3.81 E+1	1.10 E+1	1.52 E+3	1.57 E+3	1.45 E+2	3.34 E+0	4.62 E+2	0.00	0.00	0.00	0.00	1.32 E-1	1.70 E+1	6.63 E-1	3.07 E-2	-1.42 E+3
TETP	kg DCB-Eq	1.95 E-3	4.07 E-4	1.79 E-2	2.03 E-2	4.85 E-3	1.18 E-4	4.37 E-3	0.00	0.00	0.00	0.00	6.79 E-6	5.71 E-4	1.20 E-4	1.06 E-6	-1.84 E-2

ADPE = Abiotic Depletion Potential for non-fossil resources
ADPF = Abiotic Depletion Potential for fossil resources
GWP = Global Warming Potential
ODP = Depletion potential of the stratospheric ozone layer
POCP = Formation potential of tropospheric ozone photochemical oxidants
AP = Acidification Potential of land and water
EP = Eutrophication Potential
HTP = Human Toxicity Potential
FAETP = Fresh water aquatic ecotoxicity potential
MAETP = Marine aquatic ecotoxicity potential
TETP = Terrestrial ecotoxicity potential
ECI = Environmental Cost Indicator
ADPF = Abiotic Depletion Potential for fossil resources expressed in [kg Sb-eq.]
ND = Not Declared

RESOURCE USE per functional unit or declared unit (A1 / A2)

	UNIT	A1	A2	A3	A1-A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
PERE	[MJ]	1.15 E+0	6.84 E-2	3.56 E+1	3.68 E+1	7.20 E-1	1.71 E-2	0.00	0.00	0.00	0.00	0.00	9.07 E-4	8.48 E-2	3.27 E-2	6.42 E-4	-3.31 E+1
PERM	[MJ]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PERT	[MJ]	1.15 E+0	6.84 E-2	3.56 E+1	3.68 E+1	7.20 E-1	7.20 E-1	7.20 E-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PENRE	[MJ]	3.45 E+1	4.78 E+0	4.93 E+2	5.33 E+2	5.62 E+1	1.84 E+0	0.00	0.00	0.00	0.00	0.00	1.19 E-1	6.62 E+0	6.78 E-1	2.68 E-2	-4.83 E+2
PENRM	[MJ]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PENRT	[MJ]	3.45 E+1	4.78 E+0	4.93 E+2	5.33 E+2	5.62 E+1	1.84 E+0	0.00	0.00	0.00	0.00	0.00	1.19 E-1	6.62 E+0	6.78 E-1	2.68 E-2	-4.83 E+2
SM	[kg]	ND	ND	ND	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RSF	[MJ]	ND	ND	ND	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NRSF	[MJ}	ND	ND	ND	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
FW	[m3]	2.08 E-2	8.87 E-4	4.57 E-3	2.62 E-2	1.01 E-2	2.59 E-4	0.00	0.00	0.00	0.00	0.00	1.13 E-5	1.19 E-3	1.28 E-4	2.70 E-5	-2.39 E-2

PERE = Use of renewable energy excluding renewable primary energy resources
PERM = Use of renewable energy resources used as raw materials
PERT = Total use of renewable primary energy resources
PENRE = Use of non-renewable primary energy resources excluding non-renewable energy resources used as raw materials
PENRM = Use of non-renewable primary energy resources used as raw materials
PENRT = Total use of non-renewable primary energy resources
SM = Use of secondary materials
RSF = Use of renewable secondary fuels
NRSF = Use of non renewable secondary fuels
FW = Use of net fresh water
ND = Not Declared

OUTPUT FLOWS AND WASTE CATEGORIES per functional unit or declared unit (A1 / A2)

	UNIT	A1	A2	A3	A1-A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
HWD	[kg]	8.46 E-4	3.29 E-5	6.91 E-4	1.57 E-3	3.88 E-4	1.12 E-5	0.00	0.00	0.00	0.00	0.00	8.21 E-7	4.58 E-5	3.99 E-6	1.82 E-7	-1.44 E-3
NHWD	[kg]	1.63 E-1	2.20 E-1	3.75 E-1	7.58 E-1	3.23 E+0	5.33 E-2	0.00	0.00	0.00	0.00	0.00	1.80 E-4	3.81 E-1	2.21 E-1	1.65 E-1	-6.85 E-1
RWD	[kg]	ND	ND	ND	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CRU	[kg]	ND	ND	ND	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MFR	[kg]	ND	ND	ND	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MER	[kg]	ND	ND	ND	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
EEE	[MJ]	ND	ND	ND	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
EET	[MJ]	ND	ND	ND	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

HWD = Hazardous Waste Disposed
RWD = Radioactive Waste Disposed
MFR = Materials for recycling
EEE = Exported Electrical Energy
ND = Not Declared

NHWD = Non Hazardous Waste Disposed
CRU = Components for reuse
MER = Materials for energy recovery
ETE = Exported Thermal Energy

CALCULATION RULES

Input and output data

In the LCA, all data is collected from the processes in the life cycle that fall within the system boundaries and related to so-called environmental interventions. Environmental interventions are "inputs from the environment" such as the extraction of raw materials and energy sources and "outputs to the environment" such as emission of CO2. In order to incorporate these environmental interventions into the LCA, data were collected on:

- raw materials;
- energy consumption;
- emissions to air, water and soil.

Allocation

Allocation is the distribution of environmental interventions among different products or processes. There are three types of processes in which allocation must take place namely multi-export, multi-import, and recycling and reuse processes. In these processes, emissions, waste, energy and energy and raw material consumption must be divided among multiple products or processes and a certain allocation key must be formulated. Allocation occurs in this LCA in the following processes:

- Production of different types of clay pavers

Allocation on a mass basis takes place in cases where several types of clay pavers are produced at one location of which one or more types are not included in the LCA. Allocation on a mass basis means that the share of emissions, energy consumption and other inputs to the product studied in the LCA is determined on the basis of the mass ratio of the various products. For paving brick and masonry brick, in general different factories are involved. For the production sites where both masonry bricks and paving bricks are manufactured, separate data for energy has been provided by TCKI provided separate energy data for the different product groups. This has also led to the allocation of process data.

- Reuse of clay pavers

Here the value of the material being reused is important. The value of used clay pavers corresponds to the value of new paving bricks and is in some cases even higher [10]. In this case, environmental interventions that take place after the application of the original clay pavers may be fully attributed to the new product (reused clay pavers).

- Open-loop recycling of clay pavers after disposal

Clay pavers after disposal are processed in the Netherlands as mixed granulate in the civil engineering and road construction sector. To do this, the clay paver need to be crushed. The processing up to the economic tipping point is allocated to the production chain: the clay paver. Here the economic tipping point is at about half of the crushing process.

- Landfill and incineration processes of waste flows

These processes are multi-input processes, environmental effects such as leaching and emissions are determined on the basis of the chemical composition of the material to be landfilled or incinerated. In the case of incineration of plastic and wood in the waste scenario, restitution of electricity and heat is deducted from the product system as prescribed in the SBK assessment method.

Validation and data quality

Data was collected for energy consumption and emissions from the brick industry to perform the update of the LCA of clay pavers. This data was collected by TCKI with the base year 2017. Energy data is derived from the registration for multi-year agreements (MJA-3). In addition, gross consumption figures have been used to map the raw materials balance. All this data is measured at the company level. Where fixed values for background processes for energy generation, transport and waste processing processes are used, the guidelines from the SBK assessment method have been followed.

SCENARIOS AND ADDITIONAL TECHNICAL INFORMATION

The LCA includes the following phases of the clay pavers life cycle:

- Extraction of raw materials (A1);
- Transport to the production location (A2);
- Production of the (final products) clay pavers (A3);
- The transport of the clay pavers to the construction site (A4);
- Construction site processes (A5);
- Use of clay pavers (B1);
- Maintenance, replacements, repairs (B2-5);
- Demolition (C1);
- Transport waste processing (C2);
- Waste processing (C3);
- Final waste processing (C4);
- Module (D).

Clay pavers are usually re-used in pavements at the end of the application period (of 25 years). According to KNB, used clay pavers are often even have a higher value in practice than new clay pavers. This is a form of reuse and is therefore included in the LCA. KNB has commissioned research into the reuse of clay pavers. In this study 5% cutting waste is taken into account when laying an application. Furthermore, the picking up and repaving of a road application every 25 years is taken into account. In every 25 year cycle there is 10% breakage loss. One cycle has been modelled. The part of the clay pavers that is reused has been deducted from the product system in module D. The waste treatment scenario is modelled as follows:

Demolition (C1)

The clay pavers are picked up with an excavator. Sand and other contaminants are shaken out, and the clay pavers are set aside for reuse.

Transport to depot (C2)

If the pavers are not reused on site, they are transported to a depot. A transport distance of 15 km (by truck) has been calculated. The part that is not being reused (10%) goes to a breaking / sorting location. This has been calculated with 50 km transport distance per truck.

Waste processing (C3)

The part of the clay pavers that is not reused is broken into recycled granulate. This is modelled according to: SBK Crushing stony MRPI - NMD* v3.0. This is applied based on the weight of the application. In this process, the breaking process is fully allocated to the use of paving brick.

Final waste processing (C4)
The disposal of 1% of the part that is not reused of the application according to scenario: 0247-sto & Landfill inert waste (based on Inert waste, for final disposal {RoW} | treatment of inert waste, inert material landfill | Cut-off, U) fine / coarse ceramic, gravel, sand-lime brick, shells, sand - NMD* v3.0. transport to the landfill is taken 50 km by truck.

Module D, raw material equivalent and net output flow
The raw material equivalent of recycled clay pavers is primarily clay pavers. For the part of the pavers that is reused (90%), primary production is deducted from the product system in module D. The part of the pavers that is not reused is broken into recycled granulate. The raw material equivalent of recycled granulate is crushed stone. Because the clay pavers consist (almost) entirely of primary material, 1 kg of recycled granulate from this application replaces 1 kg of crushed stone minus the losses during the crushing process. This loss has been set at 1% in accordance with the flat-rate waste processing scenarios from the determination method. The avoided production of primary crushed stone is modelled on the basis of scenario 0205-fab & Steenslag, quarry (NVLB: A3) (based on only Diesel, burned in building machine {GLO} | processing | Cut-off, U) - NMD* v3.0

** NMD = Nationale Milieu Database (Dutch Environmental Database)*

DECLARATION OF SVHC

Paving bricks do not emit substances or gases that are harmful to human health or the environment.

REFERENCES

• Stichting Bouwkwaliteit, Bepalingsmethode Milieuprestatie Gebouwen en GWW Werken;
• B. Roijen, Update LCA Baksteen, A895710/R20180391, juli 2019.

REMARKS

QUALITATIVE INFORMATION:
The value of the Dutch environmental cost indicator (MKI) over the entire life cycle (modules A to D) is € 0.848 per m² of pavement with a thickness of 80 mm.

An important side effect of the extraction of river clay is the limitation of the danger of flooding. The clay extraction lowers the flood plains (space for river water) and contributes to river safety. Over the centuries it has been proven that clay pavers have a very long life. Research by Royal Haskoning (2009) shows that the lifespan of clay pavers is long: an average of 125 years, sometimes up to 250 years. Clay pavers are multiple reused in a high-quality manner and are even increasing in economic value. Research by Royal Haskoning concludes that clay pavers have a reuse percentage of at least 90%. The demand in the Netherlands for used clay pavers even exceeds the supply. The long life and the high degree of reuse of clay pavers fits very well within circular construction.