

Verification

Compilation and verification process

This LCA assessment has been commissioned by Royal Mosa and is authored by Luc Hillege. The original report was made for the Dutch Assessment Method for Environmental Performance Buildings & Civil Engineering works version 3.0 [1]. The results of the product assessments and resulting 'Environmental Product Declarations' in this report are only comparable to others, if these others also comply to the norms and standards used in this report, and as set out above. The study was conducted in June 2020 and the reporting was completed on 08-10-2020.

Based on

PCR for ceramic tiles NEN-EN 17160: 2019 [6]
In addition the c-PCR is adopted in this LCA to comply
to the new EN-15804+A2:2019 (based on ISO 1404014044 standards). Complementary Product Category
Rules (C-PCR) TO PCR 2019:14 CERAMIC TILES (EN
17160:2019) PRODUCT GROUP CLASSIFICATION: UN
CPC 373

Created with

LCA software: Ecochain version 2.8.1 Database: Ecoinvent version 3.5

Revision

1.1

Date of publication 01-06-2021

Mosa declaration nr.

Mosa-FT-2021

Verification statement

CEN standards EN158042012+A2:2019 and EN 17160:2019 - Product category rules for ceramic tiles serve as the core and product PCRs.

External independent verification of the declaration and data: Environmental Product Declaration Floor Tiles, v.1.1, Mosa decla-ration nr. Mosa-FT-2021, 01-06-2021 and the underlying LCA report and dossier fulfil the requirements for EPD according to the PCRs, ISO 14040 and ISO 14044 standards.

SGS INTRON, drs. A. Schuurmans, June 15, 2021

Valid until

5 years after publication

Author

Ecochain Technologies B.V.

Peer review

Agnes Schuurmans, June 2021

Recycled materials

Mosa floor tile collections contain 21% preconsumer recycled material, with exception of Globalgrip / Softgrip tiles that contain 45% recycled material.

Declare / Red List Free

Mosa Cradle to Cradle Certified® Gold floor tiles have a DECLARE label and are Red List free.

Please find the Declare labels for floor tiles <u>mosa.com/en/mosa/sustainability</u>

Low-emitting Materials / VOC

Mosa tiles do not contain significant organic volatile pollutants due to the burning process.

Learn more how Mosa tiles contribute to

Green Labels, such as <u>LEED</u> and <u>BREEAM</u> at:
mosa.com/en/mosa/sustainability

Substances of Very High Concern

Our products do not contain any Substances of Very High Concern.

HPD

Health Product Declaration is available for Mosa Cradle to Cradle certified floor tiles.

Download it from the HPD Public Repositor or find it here: mosa.com/en/mosa/sustainability

Manufacturer

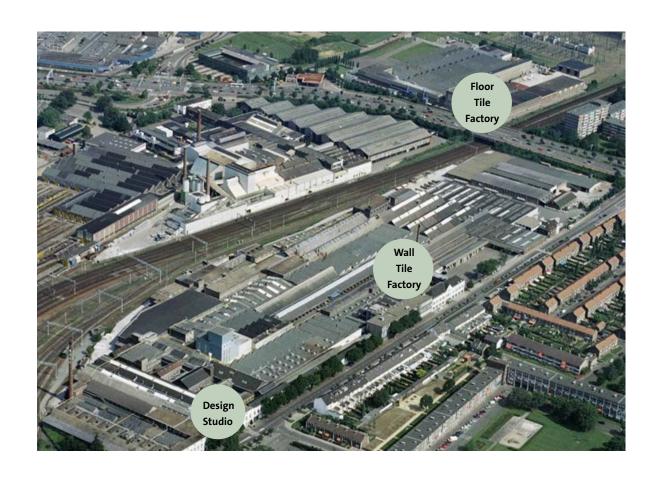
Royal Mosa B.V., founded in 1883, is an innovative Dutch tile company that manufactures its entire collection using sustainable production methods. Mosa is perceived as a leader in the design of ceramic tiles and its tiles have frequently been awarded international design awards. The company intends to be also a leader in sustainability and wellbeing, and in the pursuit of this goal cooperates with a number of relevant parties, such as German/American knowledge institute EPEA/MBDC, and the founders of the Cradle to Cradle philosophy.

Mosa started working according to Cradle to Cradle principles in 2007, and today has 99% of its tiles Cradle to Cradle Certified® since early 2011, Mosa is being designated as a Cradle to Cradle char-tered organisation, an award reserved for those companies making an exceptional contribution to the implementation of the Cradle to Cradle philosophy in their operations. There are 12 such companies in the world, and of these, Mosa is the only tile manufacturer.

Mosa is active in 30 countries on 4 continents. The key markets include Europe, Middle East, Asia Pacific and North America. Mosa manufactures its products in accordance with the ISO 9001 and the ISO 14001 environmental care system. Mosa's products are very suitable for the development of green buildings and buildings aiming at LEED or BREEAM certification. Mosa is member of the US, UK and Dutch Green Building Council as well as the German Sustainable Building Council.

For further information visit www.mosa.com

We are Royal Mosa. And Mosa is inseparable from Maastricht in the Netherlands. Maastricht is where the Mosa company designs, develops and manufactures its ceramic tiles today. Approximately 85% of our raw materials are sourced within a 200 km supplier range. Main ingredients continue to be natural materials – silver sand, quartz, kaolin and feldspar. Years of craftsmanship, and our passion and love for ceramics, can be felt whenever you walk through our factories.



Mosa. Scope

The following modules have been included in this LCA study and are shown in the following process tree. The extraction of raw materials / materials and energy (A1), transport to the production location (A2) and the production phase (A3). The construction phase (Module A4 - A5), the use phase (Module B), End-of-Life (Module C) and reuse and recycling phase (Module D) are also included.

Functional LCA unit

1 square meter (1 m2) of ceramic floor tile, covering a floor area for a period of 50 years in Europe. The chosen Reference Services Life (RSL) differs from Mosa's actual technical life span (75 years).

Product description

The product that is reported in this document is an average Mosa floor tile based on the complete collection. The products that were averaged for the Floor Tile Factory are: small size (15x15 cm), medium size (60x60 cm), large size (90x90 cm).



Data sources

The data used for the products, by-products and waste in this research originates from the energy and raw materials administrations at both the raw material extraction site and the Mosa production site in Maastricht. Production data from 2019 was used in each life cycle phase.

Based on data from

Production year 2019

Data collection procedure

Representative LCA references and records have been selected from Ecoinvent (v3.5) and the Dutch National Environmental Database (In short NMD version 3.1).

Allocation and cut-off criteria

All relevant inputs and outputs - like emissions, energy and materials - have been taken into account in this LCA. And in accordance with EN15804, the total neglected input flows per module do not exceed 1% of energy usage and mass. Retrieving primary data to determine the use of and disposal of packaging materials were beyond the scope of this analysis.

Tile composition drawing

Top layer with pigments

Base foundation ceramic

How do the Mosa tiles compare to the industry average?

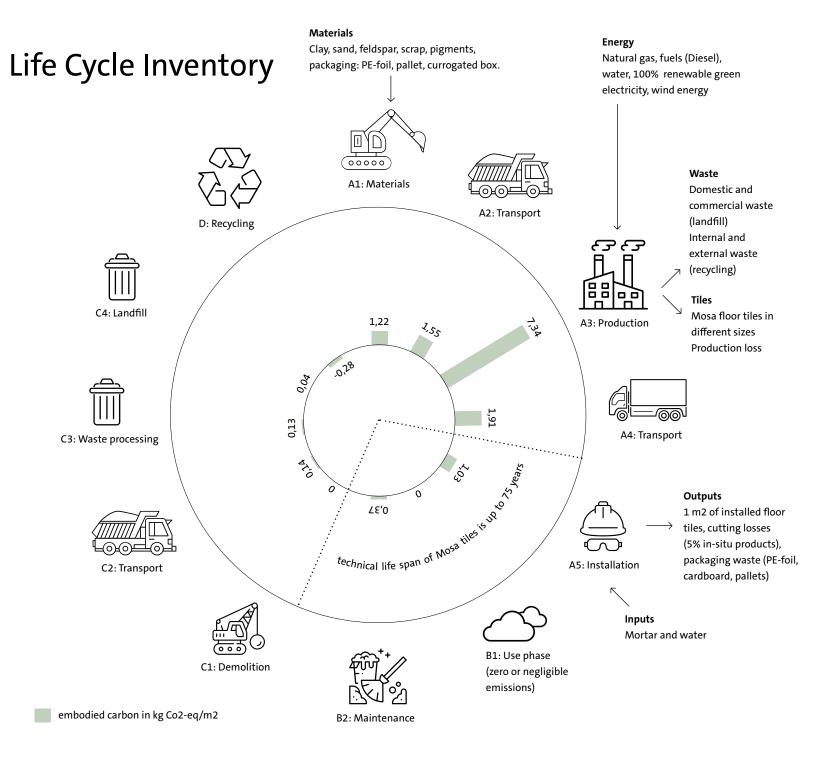
Industry average: Cradle-to-Gate
Ceramic Tile 1 kg (Ecoinvent 3.4)

0.82

Mosa Floor Tile Cradle-to-Gate
1kg (2019 production data)

0.46

NB: this metric is in kg CO₂ per kg because that is the unit of the industry average!



A1: Extraction of raw materials

The Mosa floor tiles consist of:

Material	Amount
Clay	58%
Sand	1%
Felspar	20%
Scrap	20%
Pigments	1%

A2: Transport

All relevant transports to Royal Mosa B.V. in Maastricht are included in this study. Means of transport were modelled based on supplier information from the transporter to the production location. As the EN-17160 indicates, return transports must be included. This is achieved when calculating with the single journey and average load factor. This load factor has already been incorporated into the Ecoinvent transport reference.

A3: Production

The production location for this study is the Floor Tile Factory of Royal Mosa B.V. in Maastricht. At this facility the floor tiles are produced. Mosa's production process is divided into a number of production steps. These are described in the table below.

Process	Process name	Description
Process 01	Mass preparation	After weighing the raw materials, the soft components are fed to the covered tubs. Hard components are milled in
		tumbling mills while supplying spring water. After this, this mass is also fed to the covered tubs and then everything
		is mixed with a number of additives to a suspension. This suspension is stored in a pit. The suspension is sieved and
		spray-dried in the spraying tower until it becomes a press granulate, which is stored in bunkers.
Process 02	Pressing of tiles	Press granulate is transported to the tile presses via conveyor belt, where the granulate is pressed into a 'green' tile
		under high pressure with hydraulic presses. The pressed tiles are deburred and transported to the drying section by
		boxes and automatically guided vehicles.
Process 03	Dry-fire	The tiles are passed through a horizontal drier to evaporate the residual moisture content. After drying the product
		is fed to the kiln, at this stage the material is transformed into ceramics.
Process 04	Rectification + Sorting	After the firing process, the tiles are rectified on exact dimensions, sorted by automatic camera control. The
		non-compliant tiles are rejected and reused as raw materials in the production process. The tiles are packed in card-
		board boxes, stacked on pallets and provided with a shrink-wrap.
Process 05	Other processes – offices, general	All other processes that are not related to production and do not have to be allocated to Mosa's floor tiles [5].
	heating systems	
Process 06	Pressured air	Pressured air that is applied in several steps in the production process.
Process 07	Lighting	Energy use related to lighting the Floor Tile Factory.
Process 08	Cutting - Aqua jet	Tiles are cut into shapes or strips.
Process 09	Production waste Mosa Floor Tile	Process added by Ecochain to allocate waste flows.
	Factory	

Production waste Mosa floor tiles

All the waste that arises during the production of ceramic floor tiles is collected separately and offered to an authorized waste processor. If recovery of materials is possible, this is applied, otherwise it is landfilled as landfill waste.

For the production losses, an internal recycling process has been set up in which waste flows from the ceramic Floor Tile Factory (for example broken waste) and are returned to the production process as much as possible. Mosa has invested a lot of time and research into this type of reuse, so that the quality of the tile is not affected by (re)usage of production losses. Recycling is therefore fully included in the modeling of Mosa floor tiles.

Packaging

Packaging is specified per product type.

A4-A5: Transport to construction site

In this study, all relevant transports and construction activities have been included in the construction and installation process. This includes the transport from the Floor Tile factory where Mosa floor tiles are produced to the construction site (A4), as well as the installation at work (A5). The removal and processing of the packaging material - which is released at the construction site - has also been included in this phase.

A4: Transport to client

It is assumed that all transport is done by 16-32-ton truck with a EURO5 engine or a better performing vehicle. This is the most representative for Mosa's current situation.

The transport values are based on actual Mosa sales volumes to different European countries from 2019. Whereby a weighted average approach has been adopted. The resulting average transport distance of 527 km was used in this LCA study.

A5: Installation

Module A5 concerns the installation of a Mosa foor tile. There are various options for installing a floor tile. In accordance with the PCR, various choices can be made for the installation, namely: bonding or laying by means of a cement mortar or grout. The second option from PCR-EN17160: 2019, table 11, p. 41 has been used for this study. This results in the use of: 3.3 kg of cement and 0.8 liters of water per square meter.

Module A5 also includes the waste processing of packaging and building materials (cement, glue, etc.). For the transport of packaging materials to the waste processor, a fixed distance of 50 kilometers is used to the waste processor (s) in accordance with PCR.

The following European waste scenario has been used and can be found in Module A5.

Packaging materials	Category	Recy- cling	Incine- ration	Land- fill
PE foil	polyolefinen (o.a. PE, PP)	37,2%	31,5%	31,3%
Cardboard	Value adopted from EN17160	84,6%	8,3%	7,1%
Pallet	Value adopted from EN17160	36,1%	30%	33,9%

Cutting losses

The products must be tailor-made on the construction site. When installing ceramic floor tiles, this usually results in more waste due to cutting losses. In addition, some of the materials are lost due to damage or possible weather influences. It has been assumed that 5% of the floor tiles are lost for cutting losses (based on the Dutch Norm SBK Bepalingsmethode 1.0, p. 20 in-situ products). Therefore, extra tiles are used for the installation of one square meter. This has been taken into account in the results. Thus, usage of 5% extra Mosa floor tile is included in module A5.

B1: Use phase

The materials used cause no or negligible emissions during the use phase. This is included in the PCR, EN17160: 2019, p. 41. Therefore, In Module $B1 - a\ 0$ is stated in the results table on page.

B2: Maintenance

Maintenance and replacement of Mosa floor tiles are included in this study. Maintenance in particular is an aspect that is important for floor tiles. During the lifespan of a Floor Tile, it is frequently cleaned (maintained). The EN17160:2019 (p.42) prescribes that in the case of household application, the following cleaning regime or 'maintenance cycle' can be assumed:

0.134 ml of cleaning agent every two weeks and 0.1 liter of water consumption per week per square meter (1 m2)

This comes down to:

52x 0.1 liters = 5.2 liters of water per year

26x 0.134 ml = 0.0003483 kg of cleaning agent (detergent) per year

These values are calculated and included for the full Reference Service Life (RSL) of 50 years.

B3-B5: Repair, Replacement and Refurbishment

The service life of ceramic tiles is in general the same as the building life time. Repair, replacement and refurbishment is not required for ceramic tiles.

This is included in the PCR, EN17160: 2019, p. 41. Therefore, in Module B3, B4 and B5 a zero is stated in the results table.

B6-B7: Operational energy and water use

These information modules relate to the operation of the building and are therefore not relevant for ceramic tiles.

C1: Demolition

Negligibly small and ignored according to PCR, EN-17190. A 0 has therefore been included in the results tables of this LCA study.

C2: Transport

The transport of a demolished Mosa floor tile is included in this phase. A fixed value of 50 km to a waste processor has been used for this.

C3-C4: Waste processing

For the EOL (End-of-Life) of a Mosa Floor Tile, the following EOL scenario has been used in accordance with EN17160, table 17. According to this scenario 70% is recycled and 30% will go to landfill. The Netherlands uses higher recycling rates for ceramic tiles (99%). Due to a lack of data on recycling and re-use scenarios for each European country a 'worst-case' approach is adopted. Therefore, using the default values provided by the PCR for ceramic tiles.

D: Benefits and loads beyond the product system boundary

In this case Mosa floor tiles are 70% recycled by means of crushing, thus 70% of raw material can be saved.

Crushed stone or gravel aggregate has been adopted in this LCA study as the saved material, because the use of this secondary material is deemed a best fit.

Note: Variability for the results for Climate Change

Variability of the results for Climate Change (GWP) Total is between -24,3 and -23,4% for the smaller size: 15x15 cm, the medium size 60x60 cm has a variability between 12,9 and 13,4%. The larger floor tiles 90x90 cm have a variability of 24,2 and 24,6%.

The difference between the weighted average and the individual tiles is the largest for the impact category human toxicity, cancer. Depending on the type of floor tile (low impact) the variability is between -20 and -60%. Mainly because the other floor tiles that were selected to investigate for the LCA contain materials considered to have a higher impact. However, this is only the case for specific indicators, such as human, toxicity, cancer.

Environmental profile of 1 m2 average Mosa floor tile applied in Europe over 50 years. Products averaged for the Floor Tile Factory are formats 15x15 cm, 60x60 cm and 90x90 cm. Values for the individual sizes may vary. (Note: Only the phases with values are presented in the results. Otherwise the value is zero)

Impact Category	Abbreviations	UNIT	A1	A2	А3	Total 'Cradle- to-Gate'	A4	A5	B2	C2	C3	C4	D	Total 'Cradle- to-Grave'
Environmental impact														
Climate change - total	GWP-total	kg CO2-eq	1,22	1,55	7,34	10,11	1,91	1,03	0,37	0,14	0,13	0,04	-0,28	13,46
Climate change - Fossil	GWP-f	kg CO2-eq	1,34	1,54	7,33	10,21	1,91	1,02	0,37	0,14	0,13	0,04	-0,28	13,54
Climate change - Biogenic	GWP-b	kg CO2-eq	-0,11	0,00	0,01	-0,10	0,00	0,01	0,00	0,00	0,00	0,00	0,00	-0,09
Climate change - Land use and LU change	GWP-luluc	kg CO2-eq	2,48E-03	4,52E-04	3,94E-04	3,33E-03	5,58E-04	5,10E-04	3,02E-04	4,27E-05	8,04E-05	9,53E-06	-2,58E-04	4,57E-03
Ozone depletion	ODP	kg CFC11 eq	1,61E-07	3,54E-07	1,03E-06	1,54E-06	4,39E-07	7,88E-08	4,26E-08	3,34E-08	2,83E-08	1,57E-08	-3,63E-08	2,14E-06
Acidification	AP	mol H+ eq	8,75E-03	6,33E-03	7,61E-03	2,27E-02	7,83E-03	4,09E-03	2,46E-03	8,22E-04	1,16E-03	3,42E-04	-2,04E-03	3,73E-02
Eutrophication, freshwater	EP-fw	kg P eq	9,68E-05	2,29E-05	7,90E-05	1,99E-04	2,83E-05	2,57E-05	2,82E-05	2,16E-06	4,92E-06	6,21E-07	-1,40E-05	2,75E-04
Eutrophication, marine	EP-m	kg N eq	2,04E-03	1,83E-03	1,92E-03	5,79E-03	2,26E-03	9,85E-04	3,54E-04	2,88E-04	3,99E-04	1,12E-04	-4,96E-04	9,69E-03
Eutrophication, terrestrial	EP-T	mol N eq	2,26E-02	2,04E-02	2,17E-02	6,47E-02	2,52E-02	1,12E-02	4,49E-03	3,19E-03	4,61E-03	1,24E-03	-6,14E-03	1,09E-01
Photochemical ozone for- mation	РОСР	kg NMVOC eq	0,01	0,01	0,01	0,02	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,03
Resource use, minerals and metals	ADP-mm	kg Sb eq	4,44E-05	4,58E-06	5,30E-06	5,43E-05	5,68E-06	3,36E-06	1,86E-06	4,06E-07	1,46E-07	3,89E-08	-1,69E-06	6,41E-05
Resource use, fossils	ADP-f	MJ	19,51	23,54	116,79	159,84	29,13	8,13	11,22	2,23	2,36	1,06	-3,76	210,20
Water use	WDP	m3 depriv.	0,85	0,18	0,69	1,71	0,22	0,35	11,38	0,02	0,06	0,05	-0,25	13,53
Particulate matter	PM	disease inc.	1,04E-07	1,08E-07	4,10E-08	2,53E-07	1,34E-07	4,50E-08	2,20E-08	1,30E-08	8,30E-08	6,40E-09	-2,27E-08	5,33E-07
lonising radiation	IR	kBq U-235 eq	0,05	0,10	0,06	0,20	0,12	0,03	0,02	0,01	0,01	0,00	-0,02	0,38
Ecotoxicity, freshwater	ETP-fw	CTUe	92,34	16,59	14,55	123,47	20,52	19,22	7,56	1,60	1,51	0,63	-4,44	170,07
Human toxicity, cancer	HTP-c	CTUh	4,43E-09	4,92E-10	1,29E-09	6,21E-09	6,08E-10	3,47E-10	1,23E-09	6,06E-11	5,62E-11	1,38E-11	-2,02E-10	8,32E-09
Human toxicity, non-cancer	HTP-nc	CTUh	3,71E-08	1,92E-08	1,73E-08	7,36E-08	2,38E-08	1,06E-08	1,59E-08	2,04E-09	1,35E-09	4,46E-10	-4,66E-09	1,23E-07
Land use	SQP	Pt	30,04	15,85	3,68	49,56	19,62	7,34	1,46	1,86	2,26	2,03	-2,87	81,25
Resource use														
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	PERE	WJ	4,99	0,25	22,61	27,85	0,31	2,11	0,42	0,02	0,11	0,01	-0,19	30,64

Impact Category	Abbreviations	UNIT	A1	A2	А3	Total	A4	A5	B2	C2	С3	C4	D	Total
						'Cradle								'Cradle-
						-to-Gate'								-to-Grave
Use of renewable primary energy resources used as raw materials	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
Total use of renewable pri- mary energy resources	PERT	MJ	4,99	0,25	22,61	27,85	0,31	2,11	0,42	0,02	0,11	0,01	-0,19	30,64
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	PENRE	WI	20,91	24,99	129,43	175,33	30,93	15,13	11,95	2,37	2,49	1,13	-4,00	235,34
Use of non-renewable pri- mary energy resources used as raw materials	PENRM	WJ	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total use of non-renewable primary energy resources	PENRT	MJ	20,91	24,99	129,43	175,33	30,93	15,13	11,95	2,37	2,49	1,13	-4,00	235,34
Total Energy	PET	MJ	25,90	25,24	152,04	203,18	31,24	17,24	12,37	2,39	2,61	1,14	-4,19	265,98
Use of secondary material	SM	kg	2,157	0	0	2	0	0	0	0	0	0	0	2,157
Use of renewable sec. fuels	RSF	MJ	0	0	0	0	0	0	0	0	0	0	0	0
Use of non-renewable secondary fuels	NRSF	MJ	0	0	0	0	0	0	0	0	0	0	0	0
Use of net fresh water	FW	m3	0,01	0,00	0,01	0,03	0,00	0,01	0,21	0,00	0,00	0,00	-0,01	0,25
Output flows and waste categ	ories													
Hazardous waste disposed	HWD	kg	4,75E-05	1,49E-05	1,59E-04	2,21E-04	1,84E-05	2,43E-05	1,03E-05	1,42E-06	1,88E-06	7,11E-07	-1,18E-05	2,67E-04
Non-hazardous waste disposed	NHWD	kg	1,01	1,11	0,22	2,33	1,37	0,24	0,04	0,14	2,68	6,55	-0,11	13,24
Radioactive waste disposed	RWD	kg	5,33E-05	1,59E-04	8,02E-05	2,93E-04	1,97E-04	4,12E-05	1,58E-05	1,50E-05	1,58E-05	7,03E-06	-1,89E-05	5,66E-04
Components for re-use	CRU	kg	0	0	0	0	0	0	0	0	0	0	0	0
Materials for recycling	MFR	kg	0	0	0	0	0	0	0	0	15,28	0	15,28	15,28
Materials for energy recovery	MER	kg	0	0	0	0	0	0	0	0	0	0	0	0
Exported energy	EE	MJ	0	0	0	0	0	0	0	0	0	0	0	0
1														
Exported energy thermic	EET	MJ	0	0	0	0	0	0	0	0	0	0	0	0

7 / References

[1] 'ISO 14040: Environmental management - Life cycle assessment – Principles and Framework', International
Organization for Standardization, ISO14040:2006.

[2] 'ISO 14044: Environmental management - Life cycle assessment - Requirements and guidelines', International Organization for Standardization, ISO14044:2006.

[3] EN 15804+A2:2019 - Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products.

[4] 'ISO 14025: Environmental labels and declarations -- Type III environmental declarations -- principles and procedures', International Organization for Standardization, ISO14025:2006.

[5] 'SBK Bepalingsmethode Milieuprestatie Gebouwen en GWW werken', Stichting Bouwkwaliteit, versie 3.0. Januari 2019, aangepast .

[6] EN 17160:2019 - Product category rules for ceramic tiles.

[7] L. Hillege & T. van der Kruk (2020) LCA background report Royal Mosa wall and floor tile factory - report conform the Dutch Assessment Method Environmental Performance version 3.0 and EN-17160

[8] Ecochain 2.7.6, 2020, web: http://app.ecochain.com.

[9] Wikipedia, Detergent. 30 juli 2020. Web: https://en.wikipedia.org/wiki/Detergent





Sustainability as foremost priority

We cherish our rich past, but we look to the future. Our history has taught us that change is the only constant, which is why we are constantly looking for ways of doing things better. It's what drives us. We listen, look, research and experiment. We know what's going on in the world around us, and we respond to the challenges of today and tomorrow. Time and again, we reinvent our traditional product. Only by being at the forefront we can continue our heritage for future generations. What sets our products apart are their aesthetic and functional properties, and their sustainability. We are aware of the impact that our decisions, and those of our customers, make every day, so we go for long-term solutions.

Circularity is part of everything we do. In fact, we have taken that so far that we aligned our business and production with the Cradle to Cradle principles in full. This has resulted in us being the only tile manufacturer in the world with Cradle to Cradle Certified® Gold certification version 3.1.

Cradle to Cradle

Cradle to Cradle is based on five main criteria:

Material Health, Product Circularity, Clean Air &
Climate Protection, Water & Soil Stewardship and
Social Fairness. Our Cradle to Cradle products
contribute to a healthy indoor climate and are
VOC-free. In addition to having positive national and
international material scores, our products
contribute to green building labels such as LEED,
WELL, BREEAM, DGNB, and HQE.

Our journey continues ...

As sustainability will always be the foremost priority at Mosa, we are driven to look beyond tiles. We are committed to excel in the various applicable criteria to lay the foundation for the Cradle to Cradle Certified® Gold certification version 4.0 before the end of 2025.



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We believe that people deserve healthy living environments that lasts. Our tiles are not an end product. They are the start of creating spaces where people live, work and socialize, which is why we co-develop our products with the architects and builders who bring our tiles to life. We inspire them with our passion, knowledge and experience. And they, in turn, inspire us. Because making a difference is something we do together. This is how Mosa contributes to creating distinctive, healthy, sustainable buildings of lasting value.

Mosa.

