NATURAL STONE INSTITUTE

Industry-wide Type III EPD

Natural Stone Flooring and Paving

Natural stone is an easy solution to many green building goals. It is nearly complete as a building material in its natural state as mother nature does most of the manufacturing. It is a single-ingredient natural material that emits no VOCs. Its durability allows stone to perform impeccably in commercial & residential applications, interior or exterior.

Participating manufacturers

- Coldspring
- Colorado Stone Quarries
- Continental Cut Stone
- Delgado Stone Distributors
- Independent Limestone Company
- Polycor
- Quality Stone
- Royal Bedrock
- Russel Stone
- Stony Creek Quarry
- Vermont Quarries
- Vetter Stone

Performance dashboard

Features & functionality

Stone tiles are supplied in typical sizes and atypical pieces are field cut to fit

Fabrication of custom cut-to-size stone products occurs in a factory setting, but partial fabrication may occur during installation

Thickness of tile and cut-to-size products vary by application, exterior pavements have textured surfaces such as flamed, sanded, bush-hammered, natural cleft

Surface finishes include honed, polished, sanded, flamed, sawn, sanded, natural cleft

Stone types include granite, limestone, marble, quartzite, sandstone, serpentine, slate, soapstone, and travertine

Visit NSI for more product information

Environment & materials

Similar processing operations for interior flooring and exterior paving reduces amount of equipment needed to create products

Emits no VOCs, and poses no health hazards

Quarries and processing facilities are located across N. America, making shipping distances never too far

Can be refinished and recycled with endless opportunities for reuse after initial service life

Scrap stone used as fill on premises, kept onsite for reclamation, or crushed as aggregates used in construction

Select natural stone products have qualified for one or more of the following certifications, rating systems, and disclosures:

Sustainable Stone Certified

Dimension Stone Design Manual

Health Product Declaration (HPD)

MasterFormat® 09 30 33, 09 63 40, 32 14 40

For specification information, refer to:

Dimension Stone Design Manual

TCNA Handbook for Ceramic, Glass, and Stone Tile Installation

Natural Stone Sustainability Standard

For spec help, contact us or call 440.250.9222

See LCA, interpretation & rating systems

SM Transparency Report (EPD)™

VERIFICATION	LCA
3rd-party reviewed	✔
	Transparency Report (EPD)
3rd-party verified	✔

Validity: 2022/11/01 – 2027/10/31

Decl #: NSI – 20221101 – 002

This environmental product declaration (EPD) was externally verified, according to ISO 21930:2017, SM Part A, and ISO 14025:2006, by Jack Geibig, President, Ecoform.

Ecoform, LLC
11903 Black Road,
Knoxville, TN 37932
www.ecoform.com
(865) 850-1883

SUMMARY

Reference PCR
SM PCR Part B: Interior and Exterior Stone Flooring

Regions; system boundaries
North America; Cradle to grave

Functional unit / reference service life:
1 m² of floor covering; 75 years

LCIA methodology: TRACI 2.1

LCA software; LCI database
SimaPro Developer 9.4
EcoInvent 3.8, US-EI 2.2

LCA conducted by: Sustainable Minds

Public LCA:
Industry wide Life Cycle Assessment of Natural Stone Flooring for NSI

Sponsoring organization:
Natural Stone Institute
380 E Lorain St.
Oberlin, OH 44074
www.naturalstoneinstitute.org
440-250-9222
Member Directory

Contact us

LCA results & interpretation

Natural Stone Flooring and Paving

Life cycle assessment

Scope and summary

○ Cradle to gate ○ Cradle to gate with options ✔ Cradle to grave

Product description

Stone flooring can be applied as interior flooring, exterior flooring, landscaping, and terracing. It tends to be durable and easy to maintain, with an elegant outlook. Natural stone makes up 100% of the total mass and the different stone types included in this study are granite, marble, quartzite, limestone, and sandstone. It is used in commercial, residential, and public sector buildings.

This transparency report represents both interior flooring with thickness ranging from 0.3125 inch to 1 inch and exterior paving with thickness ranging from 1 to 2 inch.

Functional unit

The functional unit is one square meter of floor covering. The natural stone flooring product system is an industry-average product, i.e., the product profile represents the weighted average of NSI's natural stone flooring based on NSI's industry-average quarrying for all stone types and also includes the industry-average production of flooring of all stone types. The product system in this study also includes the ancillary materials used in the installation of the product – mortar, grout, and acrylate. Materials needed to meet functional unit are:

Natural stone - 24.32 kg per m^2
Mortar - 4.07 kg per m^2
Grout - 0.21 kg per m^2
Acrylate - 0.04 kg per m^2
Water - 0.4 liter per m^2

Manufacturing data

The data for all stone products were collected from NSI members covering a period of two years: January 2019 to December 2020. Data for quarry operations were collected from twelve NSI quarry members covering 36 quarries across North America. The participant quarries in this study are Coldspring, Delgado Stone Distributors, Freshwater Stone, Independent Limestone Company, Polycor, Quality Stone Corporation, Royal Bedrock Inc., Russell Stone Products, Stony Creek Quarry, Vermont Quarries Corporation, and Vetter Stone Company.

After the stone is extracted from the quarry, it goes to a processing facility. Stone processor operations data were collected from six NSI member processors covering 17 facilities across North America. The participant processors in this study producing flooring are Delgado Stone Distributors, Polycor, Russell Stone Products, Vetter Stone Company, and Continental Cut Stone. NSI resources and other literature data were used to develop estimates or assumptions for other upstream or downstream activities where necessary.

Industry-wide results calculation methodology

Based on data provided by the participating natural stone processors, granite and limestone represented much of natural stone flooring at 72.71% and 26.88%, respectively. Marble flooring covered 0.15% of the market share, while the rest (0.27%) was from other natural stones (including quartzite and sandstone).

For quarry data, an average inventory per kg of stone quarried for each stone category (granite, limestone, marble, and other natural stone) was developed, and later a weighted inventory per kg of stone quarried was generated using the quarry production share of each stone type among the participant quarries. After that, the inventory per kg of stone quarrying specific to stone flooring was developed using the market distribution of natural stone flooring by stone type as collected from participant stone processing facilities (72.71% granite, 26.88% limestone, 0.15% marble, and 0.27% other natural stone).

Similarly, the inventory for one square meter of processed stone flooring was developed. An average inventory per square meter of stone processed for each stone category (granite, limestone, marble, and other natural stone) was developed, and later a weighted inventory per square meter of stone processed was generated using the production share of each stone type using the stone processing share of each stone type among the participant processors. After that, the inventory per square meter of stone processing specific to flooring was developed using the market distribution of natural stone flooring (72.71% granite, 26.88% limestone, 0.15% marble, and 0.27% other natural stone). The processing inventory data is based on square meter of stone processed, which sufficiently represents both interior flooring and exterior paving products with varied thicknesses.

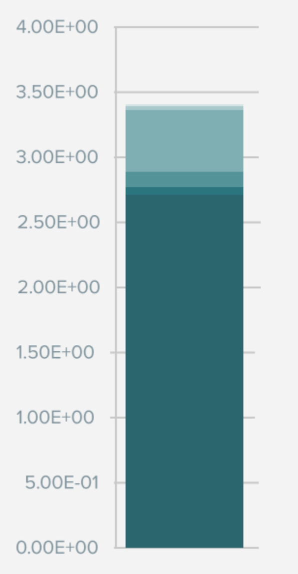
Data quality

Primary data was collected for a time period of two years, which represents typical operations of quarry and processors across North America. Inventory data is considered to have a good precision and provide a representative depiction of the industry average. Data is also considered to be complete as no know flows are deliberately excluded from this analysis other than those defined to be outside of the system boundary. Proxy and generic datasets have been used for some materials and processes, but are considered to be sufficiently representative.

Material composition greater than 1% by weight

FLOW	MASS PERCENTAGE
Natural stone	100%

Total impacts by life cycle stage [mPts per functional unit]



LIFE CYCLE STAGE	MPTS/FUNC. UNIT
Quarry and processor operations	2.71E+00
Stone transport to building sites	5.13E-02
Installation	1.91E-01
Maintenance	4.81E-01
Waste transport	2.57E-02
End of life disposal	3.66E-03

What's causing the greatest impacts

All life cycle stages

For the natural stone flooring product, the cradle-to-gate stage (A1-A3) dominates the results for all impact categories. This study assessed a multitude of inventory and environmental indicators. In addition to the six major impact categories (global warming potential, ozone depletion, acidification, smog, eutrophication, and fossil fuel depletion), additional impact categories have also been included. These six impact categories are globally deemed mature enough to be included in Type III environmental declarations. Other categories are being developed and defined, and LCA should continue making advances in their development. However, the EPD users shall not use additional measures for comparative purposes. LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

Overall results are consistent with expectations for stone flooring's life cycles, with most of the impacts being generated during cradle-to-gate stages, as flooring is not associated with energy consumption during its use stage.

The primary finding, across the environmental indicators, was that cradle-to-gate stage (A1-A3) dominates the impacts due to the energy consumed at the quarries and processing plants. The processor operations (A3) stage is the highest contributor to most of the impact categories, followed by the maintenance stage (B2) and quarry operations (A1). The cradle-to gate-stage (A1-A3) contributes to ~60% of the total impacts in all impact categories except for ozone depletion and eutrophication. The transportation of stone from quarries to processing plants, transportation of flooring from processing plants to the installation sites, and use of mortar during installation also generate significant impacts in the overall life cycle impacts of stone flooring.

Quarry operations and transport to processors

Impacts generated at quarries (A1) are mainly due to the use of grid electricity and fuels in the quarries. Other material inputs generate little impact in comparison to the electricity and fuel consumed. The transportation of stone from quarries to processing plants also generates significant impacts in numerous impact categories.

Processor operations and transport to building sites

Manufacturing operations at processing plants make up the greatest share of all impact categories except for ozone depletion. Energy consumed at processors (both electricity and fuels) is responsible for the majority of impacts, while other material inputs have an insignificant contribution. The transportation of stone flooring manufactured in processor plants to the building sites also makes a significant impact on the overall life cycle impacts of natural stone flooring.

Other life cycle stages

Resealing of the non-granite stone flooring every five years and use of mortar during installation also generate significant impacts to the overall life cycle impacts of stone flooring. Under normal operating conditions, stone flooring requires monthly cleaning. Due to the nature of natural stone, it is anticipated that the stone flooring products will last for the lifetime of the building. The reference service life (RSL) thus meets an ESL of 75 years, and flooring will need no replacements during its service life. End-of-life stages have lower contributions on the total life cycle impacts.

Variation analysis

A variation analysis was performed to study the environmental impacts variation between natural stone flooring from different stone types. Results were generated for both quarry operations and processor operations specific to various stone types based on the production share of different quarries and processors for each stone type. One of the major parameters that influences the results is the amount of stone that needs to be quarried to produce 1 m^2 of stone flooring.

The variation between weighted average, minimum, and maximum LCIA results is greater than 20% for all impact categories. This is due to varying quarry and processor operations used by different quarries and processors.

Sensitivity analysis

Based on NSI's expert judgement, it was assumed that energy consumed for processing of a square meter of stone flooring matches the average energy consumed for processing of different stone products. A sensitivity analysis was performed to check the robustness of the results when the energy consumed during processing is varied by +/-20% from the estimate used in this study. The resulting variation in the total life cycle impacts is about 10%, implying that the system is not sensitive to this assumed value.

Another parameter that affects the overall life cycle impacts is the thickness of stone flooring. The thickness of stone flooring studied in this study varied from 0.3125 inch to 2 inch. Results have been presented for a typical interior thickness of 0.5 inch but as the functional mass of varies with the thickness, the impacts also vary. A sensitivity analysis has thus been conducted for various thicknesses of stone flooring used for different flooring applications. For the thickness of 1.25 inch and larger, the variation in overall life cycle impacts is greater than 20%, implying that the system is sensitive to thickness value.

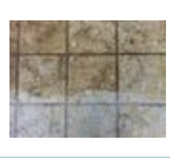
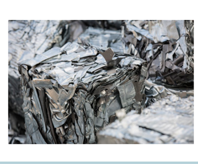
The natural stone industry is committed to making sure our inherently eco-friendly building material is produced efficiently and responsibly. Though the Natural Stone Sustainability Standard we have defined metrics for responsible production in the following categories:

- Energy
- Water
- Chemicals
- Land reclamation & adaptive reuse
- Site management
- Transportation
- Social governance
- Human health & safety
- Excess process materials
- Solid waste
- Innovation

Companies have the opportunity to third-party verify compliance with these metrics. As the industry's leader in education, the Natural Stone Institute is also striving to build awareness about best practices for sustainability among all quarriers and fabricators globally.

See how we make it greener

LCA results

LIFE CYCLE STAGE	A1-A3 PRODUCTION (QUARRY AND PROCESSOR OPERATIONS)	A4 STONE TRANSPORT TO BUILDING SITES	A5 INSTALLATION	B1-B7 USE	C1-C2 DECONSTRUCTION AND WASTE TRANSPORT	C3-C4 WASTE PROCESSING AND END-OF-LIFE DISPOSAL
Information modules: Included (X) | Excluded* (MND) Stages B1, B3-B7, C1, and C3 though included, have no associated activities. *Module D is excluded.	**A1 Quarry operations**	**A4 Transport to building sites**	**A5 Installation**	**B1 Use**	**C1 Deconstruction**	**C3 Waste Processing**
	A2 Transport to processors			**B2 Maintenance**	**C2 Waste transport**	**C4 End of life disposal**
	A3 Processor operations			**B3 Repair**		
				B4 Replacement		
				B5 Refurbishment		
				B6 Operational energy use		
				B6 Operational water use		
						

SM Single Score

Learn about SM Single Score results

Impacts of 1 square meter of floor covering	2.71E+00 mPts	5.13E-02 mPts	1.19E-01 mPts	4.81E-01 mPts	2.57E-02 mPts	3.66E-03 mPts
Materials or processes contributing >20% to total impacts in each life cycle stage	Energy consumed during stone quarrying and processing (electricity and fuels).	Truck transportation used to transport product to building site.	Use of ancillary materials (mainly mortar) for installation.	Materials consumed for maintenance.	Waste transport to the landfill centers.	Landfilling after the end of life.

TRACI v2.1 results per functional unit

LIFE CYCLE STAGE		A1-A3 PRODUCTION (QUARRY AND PROCESSOR OPERATIONS)	A4 STONE TRANSPORT TO BUILDING SITES	A5 INSTALLATION	B2 MAINTENANCE	C2 WASTE TRANSPORT	C4 END-OF-LIFE DISPOSAL
Ecological damage							
Impact category	Unit						
Acidification	kg SO_2 eq	1.07E-01	3.81E-03	1.18E-02	4.20E-02	1.91E-03	6.57E-04
Eutrophication	kg N eq	1.51E-02	5.13E-04	6.87E-04	2.61E-02	2.57E-04	6.42E-05
Global warming (Embodied Carbon)	kg CO_2 eq	2.20E+01	1.22E+00	2.55E+00	2.01E+00	6.10E-01	6.80E-02
Ozone depletion	kg CFC-11 eq	1.13E-06	2.43E-07	1.22E-07	1.51E-06	1.22E-07	1.16E-08
Human health damage							
Impact category	Unit						
Carcinogenics	CTU_h	8.53E-07	5.06E-10	1.70E-08	5.30E-08	2.54E-10	1.99E-11
Non-carcinogenics	CTU_h	1.80E-06	4.57E-08	1.97E-07	5.65E-07	2.29E-08	7.88E-10
Respiratory effects	kg $PM_{2.5}$ eq	2.75E-02	2.39E-04	1.07E-03	1.49E-02	1.20E-04	8.52E-05
Smog	kg O_3 eq	2.46E+00	1.00E-01	1.69E-01	5.58E-01	5.02E-02	1.98E-02
Additional environmental information							
Impact category	Unit						
Fossil fuel depletion	MJ, LHV	2.77E+01	2.48E+00	2.44E+00	1.06E+01	1.24E+00	1.44E-01
Ecotoxicity	CTU_e	2.38E+01	6.63E-01	5.82E-01	7.36E+00	3.32E-01	6.46E-03

See the additional content required by the SM PCR Part B for interior and exterior stone flooring on page 4 of the **Transparency Report PDF**.

References

LCA Background Report
NSI Natural Stone Flooring LCA Background Report (public version), NSI 2022. SimaPro Analyst 9.4, ecoinvent 3.4 database.

PCRs

ISO 21930:2017 serves as the core PCR along with EN 15804 and SM Part A.

SM PCR Part A: Life Cycle Assessment Calculation Rules and Report Requirements, v2018
March, 2018. Document created by Joep Meijer, Naji Kasem, and Kim Lewis and is managed and maintained by the Sustainable Minds Technical Advisory Board (TAB) as outlined in ISO 14025:2006.

SM PCR Part B: Product group definition for Interior and exterior stone flooring, 2022
April, 2022. Part B review conducted by the Sustainable Minds TAB, tab@sustainableminds.com

ISO 14025, "Sustainability in buildings and civil engineering works -- Core rules for environmental product declarations of construction products and services"

Download PDF SM Transparency Report, which includes the additional EPD content required by the SM Part B.

SM Transparency Reports (TR) are ISO 14025 Type III environmental declarations (EPD) that enable purchasers and users to compare the potential environmental performance of products on a life cycle basis. They are designed to present information transparently to make the limitations of comparability more understandable. A limitation to this study is that not all manufacturers in North America participated. TRs/EPDs of products that conform to the same PCR and include the same life cycle stages, but are made by different manufacturers, may not sufficiently align to support direct comparisons. They therefore, cannot be used as comparative assertions unless the conditions defined in ISO 14025 Section 6.7.2. 'Requirements for Comparability' are satisfied. Comparison of the environmental performance of building envelope thermal insulation using EPD information shall be based on the product's use and impacts at the building level, and therefore EPDs may not be used for comparability purposes when not considering the building energy use phase as instructed under the PCR. Full conformance with the PCR for stone flooring allows EPD comparability only when all stages of a life cycle have been considered, when they comply with all referenced standards, use the same sub-category PCR, and use equivalent scenarios with respect to construction works. However, variations and deviations are possible. Example of variations: Different LCA software and background LCI data sets may lead to different results upstream or downstream of the life cycle stages declared.

Rating systems

The intent is to reward project teams for selecting products from manufacturers who have verified improved life-cycle environmental performance.

LEED BD+C: New Construction | v4 - LEED v4
Building product disclosure and optimization
Environmental product declarations

✔ Industry-wide (generic) EPD	½product
○ Product-specific Type III EPD	1 product

LEED BD+C: New Construction | v4.1 - LEED v4.1
Building product disclosure and optimization
Environmental product declarations

✔ Industry-wide (generic) EPD	1 product
○ Product-specific Type III EPD	1.5 product

BREEAM New Construction 2018
Mat 02 - Environmental impacts from construction products
Environmental Product Declarations (EPD)

✔ Industry-average EPD	.5 points
○ Multi-product specific EPD	.75 points
○ Product-specific EPD	1 point

SM Transparency Report (EPD)™

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How we make it greener

Natural Stone Flooring and Paving

Collapse all

See LCA results by life cycle stage

RAW MATERIALS ACQUISITION

Usable material vs excess process material ratios vary at each quarry and at times the excess exceeds the usable. It is important to know that excess process materials are almost always reclaimed or recycled. It is extremely uncommon for any stone to be diverted to a landfill. The Natural Stone Institute is working with their quarrier members to identify ways to make use of this excess and educate the industry about techniques and product lines that can effectively improve quarry yield.

The design community can help with this issue. Most natural stone's have a specific set of characteristics for the most desirable pieces. For example, limestone is generally either buff or gray in color. The blocks that are variegated, containing both buff and gray hues, are less desirable. If design teams are more accepting of natural variation in the material, then there is more usable material, and less excess, available from the source.

TRANSPORTATION

Using stone from local sources is the single biggest opportunity to reduce its embodied carbon. Since natural stone is a heavy material, the environmental impacts for transporting it end up being the most significant accrual of carbon. Natural stone is sourced world-wide and each deposit has unique aesthetic and performance characteristics so this is not always avoidable. Be sure to understand the distances between the quarry, the fabrication facility, and sometimes the distribution centers. In most North American operations the quarry is within miles of the fabrication facility. However, some natural stone producers will take advantage of lower labor costs in other countries and ship the stone large distances to be fabricated and then back again.

MANUFACTURING

To ensure the health and safety of our workforce, water is used during quarrying and fabrication to reduce dust and heat. Recycling this water is both environmentally responsible and economical. It is very common for stone facilities to recycle over 85% of the water used in their facilities.

There are a large variety of sizes and finishes that are commonly used for natural stone cladding. Design teams can help to reduce energy consumption in the following ways:

- Appreciate natural color and pattern variations.
- Understand how finishes are achieved and additional work that may be required on edges or adjacent surfaces.
- Optimize panel sizes based on block availability.
- Reduce thickness if possible.
- Avoid complex geometries such as radiuses and solid corners.
- Consult an expert for guidance on most the sustainable ways of achieving your desired aesthetic.

OTHER (USE, END OF LIFE)

There are endless opportunities for natural stone to be refinished, reused, and recycled.

Flooring surfaces can be professionally refinished. This process will refresh the beauty of its original finish by removing evidence high use such as traffic patterns. It can also restore extreme cases including years of poor maintenance, exposure to water or fire, or other circumstances.

Because of these capabilities, stone rarely reaches an end to its potential service life. When an owner chooses to replace natural stone, it can be removed and altered into an entirely new product and reinstalled in a new location.

There are also stone companies that have 'take-back' programs, to divert the stone from a landfill back to a quarry to be used as part of their land reclamation plan. If stone does end up in a construction landfill, there will be no toxic chemicals seeping into the earth as the material degrades. It simply returns to the earth, cradle to cradle.

SM Transparency Report (EPD)™

VERIFICATION LCA

3rd-party reviewed ✓

Transparency Report (EPD)

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Contact us

Additional EPD content required by: SM PCR Part B: Interior and Exterior Stone Flooring EPD Requirements

Data

Background This industry-average declaration was created by collecting product data for one square meter of natural stone floor covering.

Allocation The allocation methods used were examined according to the updated allocation rules in ISO 21930:2017. Quarry inputs and outputs were divided evenly among the quarried stone by mass, and no co-product allocation was needed. Although different stone products go through different processing steps, processor inputs and outputs were also evenly distributed between different stone products based on their production area. The average stone processing for the entire industry represents the inventory for flooring products, and it required no adjustment from the industry average.

Cut-off criteria for the inclusion of mass and energy flows are 1% of renewable primary resource (energy) usage, 1% nonrenewable primary resource (energy) usage, 1% of the total mass input of that unit process, and 1% of environmental impacts. The total of neglected input flows per module does not exceed 5% of energy usage, mass, and environmental impacts. No known flows are deliberately excluded from this declaration. Biogenic carbon is included in reported results.

Representation of stone industry and geographic region This study covers ~20% of the dimension stone processed in US during the time period of study. No data was available for Canada.

Relevant Technical Properties

PARAMETER	VALUE	UNIT
CSI Masterformat classification	09 30 33; 09 63 40; 32 14 40	
Stone types	Granite, limestone, marble, quartzite, & sandstone	
Stone grades	All grades	
Thickness to achieve functional unit	12.70	mm
Length	1.52	m
Width	0.66	m

TECHNICAL PROPERTIES			NATURAL STONE TYPE			
Parameter	Unit	Test Method	Limestone (ASTM C568)	Granite (ASTM C615)	Marble (ASTM C503)	Quartzite (ASTM C616)
Product weight	kg		22.81	24.86	32.45	24.19
Density	kg/m^3		2339	2653	2699	2339
Flexural strength	Mpa	C880	3.45	8.27	6.89	NA
Modulus of rupture	MPa	C99	2.76	10.34	6.89	13.79
Compressive strength	MPa	C170	12.41	131.00	51.71	137.89
Thermal conductivity	W/m.k	C518	1.26	1.73	2.07	5.38
Thermal resistance	m.K/W	C518	0.79	0.56	0.49	0.19
Liquid water absorption	% of dry wt	C97	12.00	0.40	0.2	1.00

Major system boundary exclusions

- Capital goods and infrastructure; maintenance and operation of support equipment;
- Manufacture and transport of packaging materials not associated with final product;
- Human labor and employee transport;
- Building operational energy and water use not associated with final product.

Participant manufacturers and locations

Participant manufacturers and locations
Coldspring — SD, MN
Colorado stone quarries — CO
Continental cut stone — TX
Delgado stone interiors — CT
Independent limestone company — IN
Polycor — PA, VT, NH, IN, GA, OK (US); Quebec (CA)
Quality stone — TX
Royal bedrock — Ontario, CA
Russel stone — PA
Stony creek quarry — CT
Vermont quarries — VT
Vetter stone — MN
Freshwater stone — ME

Production flow-chart

Stone Quarrying — Use of explosives, power drills, power saws, diamond belts etc. — stone blocks extracted from natural rock layers.

Stone transport from quarries to processing facilities

Stone Processing — Stone blocks go through block saws, saw slabs, bridge saws etc.— stone blocks processed to stone flooring and paving products.

Calcination CO_2 emissions Although calcination and carbonation is not relevant to stone flooring products, calcination occurs during installation stage due to the use of mortar. Mortar includes cement calcination CO_2 emissions which is calculated & reported separately using a carbon intensity factor of 886 CO_2 per ton of cement (Source: U.S. Cement Industry Carbon Intensities (2019)).

Hazardous waste Stone flooring does not contain substances that are identified as hazardous according to the Resource Conservation and Recovery Act (RCRA), Subtitle C.

LCI dataset variability for major parameters

LCI parameter	Unit	For Quarry Operations			For Processor Operations		
		Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
Electricity	kWh	2.82E-02	1.28E-02	3.83E-02	2.91E+01	2.98E+01	2.03E+01
Gasoline	liters	5.10E-04	4.94E-04	3.24E-04	1.38E-01	6.51E-02	1.92E-01
Diesel	liters	9.84E-03	7.51E-03	9.78E-03	4.52E-01	4.60E-01	3.86E-01
Propane	liters	5.47E-05	6.08E-06	1.15E-04	1.30E+00	2.85E-01	2.21E+00
Natural gas	MJ	3.46E-05	NA	7.73E-05	7.50E+00	5.16E+00	9.35E+00
Diamond blades	kg	1.48E-04	7.06E-06	3.12E-04	3.88E-02	4.82E-03	7.07E-02
Carbide tooling	kg	1.39E-02	4.07E-07	NA	2.13E-04	3.72E-05	3.77E-04

Scenarios and additional technical information

Transport from Quarry to Processor [A2] Based on the primary data, the transport distance varies, & the weighted distance is 65 km. For quarries with no primary info, a conservative distance of 100 km via truck & trailer was assumed.

PARAMETER	VALUE	UNIT
Transport to the building site [A4]		
Vehicle type	Lorry, 16-32 ton	
Fuel type	Diesel	
Liters of fuel	0.41	l/100 km
Distance from manufacturer to installation site	301	km (weighted avg)
Capacity utilization (mass based)	100	%
Gross density of products transported	2,508	kg/m^3
Capacity utilization volume factor	1	

Packaging scenario assumptions Based on EPA's 2018 data, it has been assumed that 37% of all packaging will be landfilled, with the rest recycled.

Installation into the building [A5]
It is assumed that flooring fabrication (cutting and finishing to required size) is done at the processing plants and is typically delivered to the job site ready for installation. For the minor changes necessary to accommodate changes, we have considered the use of manual equipment like hackshaws, tile cutters, handle, chisels, tile nippers etc.

Installation scrap assumed	5	%
Ancillary materials - Mortar Grout Acrylate	4.07 0.21 0.04	kg
Net freshwater consumption	0.0004	m^3
Electricity consumption	0	kWh
Product loss per functional unit (scrap)	1.22	kg
Waste materials at the construction site before waste processing (stone scrap and packaging waste)	3.22	kg
Output materials from on-site waste processing	0	kg
Mass of packaging waste by type Plastic Cardboard Wood	0.003 0.002 2.005	kg
Biogenic carbon contained in packaging	0.27	kg CO_2
Direct emissions to ambient air, soil and water	0	kg
VOC emissions	0	µg/m^3

Maintenance scenario parameters

Maintenance process information	Cleaning the surface of stone flooring and resealing for non-granite floors	
Maintenance cycle	Monthly cleaning (900 cycles per RSL & per ESL) Sealing every 5 years (14 cycles per RSL & per ESL)	
Net freshwater consumption - municipal water supply	0.09 (for entire lifetime)	m^3
Ancillary materials - Soap Sealant	4.5 (for entire lifetime) 2.31 (for entire lifetime)	kg kg

Reference service life information

Reference service Life (RSL)	75	years
Design application parameters	Outdoor and indoor applications	
Outdoor environment	Installation as recommended by manufacturer.	
Indoor environment	Installation as recommended by manufacturer.	
Use conditions	All conditions	

End of life [C1-C4]

Assumptions for scenario development	The product is dismantled and removed from the building manually. It is transported to a local facility where it requires no further processing before final disposition.		
Collection process	Collected separately	0	kg
	Collected with mixed construction waste	28.39	kg
Recovery	Reuse	0	kg
	Recycling (0%)	0	kg
	Landfill (100%)	28.39	kg
Waste transport		161	km
Final disposal		28.39	kg
Removals of biogenic carbon (excluding packaging)		0	kg CO_2

Variation of TRACI impact categories

Impact category	Min. value	Max. value	Mean	Median
Ozone depletion	1.95E-06	3.59E-06	2.73E-06	2.78E-06
Global warming	2.33E+01	6.59E+01	3.98E+01	4.00E+01
Smog	3.23E+00	1.12E+01	5.95E+00	5.30E+00
Acidification	1.43E-01	4.20E-01	2.33E-01	2.14E-01
Eutrophication	1.52E-02	4.48E-02	2.64E-02	2.50E-02
Carcinogenics	2.15E-07	2.13E-06	9.46E-07	9.80E-07
Non-carcinogenics	1.78E-06	6.05E-06	3.31E-06	3.25E-06
Respiratory effects	1.39E-02	6.74E-02	3.79E-02	3.78E-02
Ecotoxicity	2.19E+01	8.94E+01	4.53E+01	4.43E+01
Fossil fuel depletion	3.95E+01	9.49E+01	6.09E+01	5.73E+01

LCIA results, resource use, output and waste flows, and carbon emissions and removals per m^2 of natural stone flooring

Parameter	Unit	A1-A3	A4	A5	B1	B2	B3-B7	C1	C2	C3	C4	Total
LCIA results (per m^2 of natural stone flooring)												
Ozone depletion	kg CFC-11 eq	1.13E-06	2.43E-07	1.22E-07	0	1.51E-06	0	0	1.22E-07	0	1.16E-08	**3.14E-06**
Global warming	kg CO2 eq	2.20E+01	1.22E+00	2.55E+00	0	2.01E+00	0	0	6.10E-01	0	6.80E-02	**2.85E+01**
Smog	kg O3 eq	2.46E-00	1.00E-01	1.69E-01	0	5.58E-01	0	0	5.02E-02	0	1.98E-02	**3.36E+00**
Acidification	kg SO2 eq	1.07E-01	3.81E-03	1.18E-02	0	4.20E-02	0	0	1.91E-03	0	6.57E-04	**1.67E-01**
Eutrophication	kg N eq	1.51E-02	5.13E-04	6.87E-04	0	2.61E-02	0	0	2.57E-04	0	6.42E-05	**4.27E-02**
Carcinogenics	CTUh	8.53E-07	5.06E-10	1.70E-08	0	5.30E-08	0	0	2.54E-10	0	1.99E-11	**9.24E-07**
Non-carcinogenics	CTUh	1.80E-06	5.06E-10	1.97E-08	0	5.65E-07	0	0	2.29E-08	0	7.88E-10	**2.63E-06**
Respiratory effects	kg PM2.5 eq	2.75E-02	2.39E-04	1.07E-03	0	1.49E-02	0	0	1.20E-04	0	8.52E-05	**4.39E-02**
Ecotoxicity	CTUe	72.8%	2.0%	1.8%	0%	22.4%	0%	0%	1.0%	0%	0%	**100%**
Fossil fuel depletion	MJ surplus	2.77E+01	2.48E+00	2.44E+00	0	1.06E+01	0	0	1.24E+00	0	1.44E-01	**4.46E+01**
Resource use indicators (per m^2 of natural stone flooring)												
Renewable primary energy used as energy carrier (fuel)	MJ, LHV	1.07E+02	2.54E-02	1.48E+00	0	1.99E+02	0	0	1.27E-02	0	1.97E-03	**3.08E+02**
Renewable primary resources with energy content used as material	MJ, LHV	4.17E+00	0	0	0	0	0	0	0	0	0	**4.17E+00**
Total use of renewable primary resources with energy content	MJ, LHV	1.11E+02	2.54E-02	1.48E+00	0	1.99E+02	0	0	1.27E-02	0	1.97E-03	**3.12E+02**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, LHV	3.61E+02	1.63E+01	2.34E+01	0	1.10E+02	0	0	8.20E+00	0	9.55E-01	**5.20E+02**
Non-renewable primary resources with energy content used as material	MJ, LHV	1.45E-01	0	0	0	0	0	0	0	0	0	**1.45E-01**
Total use of non-renewable primary resources with energy content	MJ, LHV	3.61E+02	1.63E+01	2.34E+01	0	1.10E+02	0	0	8.20E+00	0	9.55E-01	**5.21E+02**
Secondary materials	kg	0	0	0	0	0	0	0	0	0	0	**0**
Renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Non-renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Recovered energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Use of net fresh water resources	m3	3.99E+01	1.09E-05	2.33E+00	0	3.81E+00	0	0	7.60E-04	0	4.65E-05	**4.60E+01**
Output flows and waste category indicators (per m^2 of natural stone flooring)												
Hazardous waste disposed	kg	2.84E-04	0	0	0	0	0	0	0	0	0	**2.84E-04**
Non-hazardous waste disposed	kg	6.94E-01	0	2.45E+00	0	0	0	0	0	0	2.77E+01	**3.08E+01**
High-level radioactive waste, conditioned, to final repository	kg	5.90E-02	1.33E-06	3.10E-04	0	6.45E-04	0	0	6.67E-07	0	1.02E-07	**6.00E-02**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	1.25E-05	1.39E-08	5.84E-07	0	1.08E-06	0	0	6.99E-09	0	1.08E-09	**1.42E-05**
Components for re-use	kg	0	0	0	0	0	0	0	0	0	0	**0**
Materials for recycling	kg	8.29E+01	0	4.57E+00	0	0	0	0	0	0	0	**8.74E+01**
Materials for energy recovery	kg	0	0	0	0	0	0	0	0	0	0	**0**
Exported energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Carbon emissions and removals (per m^2 of natural stone flooring)												
Biogenic carbon removal from packaging	kg CO_2	3.66E+00	0	1.83E-01	0	0	0	0	0	0	0	**3.85E+00**
Biogenic carbon emission from packaging	kg CO_2	0	0	2.78E+00	0	0	0	0	0	0	0	**2.78E+00**
Biogenic carbon emission from combustion of waste from renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Calcination carbon emissions	kg CO_2	0	0	1.06E+00	0	0	0	0	0	0	0	**1.06E+00**
Carbon emissions from combustion of waste from non-renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**