



Registration Number: DAP 002:2022



Slabs for exterior and interior claddings and flooring in natural limestone

ISSUE DATE: 17/01/2022

VALID UNTIL: 16/01/2027

SOLANCIS — SOCIEDADE EXPLORADORA DE PEDREIRAS, S.A.



VERSION 1.1. EDITION JULY 2015

Index


GENERAL INFORMATION	1
1.1. THE DAPHABITAT SYSTEM.....	1
1.2. EPD OWNER.....	1
1.3. INFORMATION CONCERNING THE EPD.....	2
1.4. DEMONSTRATION OF THE VERIFICATION.....	2
1.5. EPD REGISTRATION	2
1.6. PCR OF REFERENCE	3
1.7. INFORMATION CONCERNING THE PRODUCT/PRODUCT CLASS	4
2. ENVIRONMENTAL PERFORMANCE OF THE PRODUCT	6
2.1. CALCULATION RULES OF THE LCA	6
2.1.1. FLOW DIAGRAM OF INPUT AND OUTPUT OF THE PROCESSES.....	7
2.1.2. DESCRIPTION OF THE SYSTEM BOUNDARIES	8
2.2. PARAMETERS DESCRIBING ENVIRONMENTAL IMPACTS	9
2.3. PARAMETERS DESCRIBING RESOURCE USE.....	9
2.4. OTHER ENVIRONMENTAL INFORMATION DESCRIBING DIFFERENT WASTE CATEGORIES.....	10
2.5. OTHER ENVIRONMENTAL INFORMATION DESCRIBING OUTPUT FLOWS	10
3. SCENARIOS AND ADDITIONAL TECHNICAL INFORMATION	11
3.1. ADDITIONAL ENVIRONMENTAL INFORMATION ABOUT THE RELEASE OF DANGEROUS SUBSTANCES.....	11
3.2. CERTIFICATIONS.....	11
REFERENCES	12

GENERAL INFORMATION

1.1. The DAPHabitat System

Program operator:	Associação Plataforma para a Construção Sustentável www.centrohabitat.net centrohabitat@centrohabitat.net	 centroHabitat Plataforma para a Construção Sustentável
Address:	Departamento Engenharia Civil Universidade de Aveiro 3810-193 Aveiro	
Email address:	deptecnico@centrohabitat.net	
Telephone number:	(+351) 234 401 576	
Website:	www.daphabitat.pt	
Logo:		



1.2. EPD owner

Name of the owner:	SOLANCIS — Sociedade Exploradora de Pedreiras, S.A.
Production site:	Rua da Sindocal, 22, Casal do Carvalho, 2475-016 – Benedita- Portugal
Address (head office):	Rua da Sindocal, 22, Casal do Carvalho, 2475-016 – Benedita- Portugal
Telephone:	Eng.º Marco Aniceto: +351 262 925 080
E-mail:	marco.aniceto@solancis.com
Website:	http://www.solancis.com
Logo:	
Information concerning the applicable management Systems:	SOLANCIS has an integrated quality, environment, health and safety management system implemented, following the ISO 9001:2015, EN ISO 14001:2015 and ISO 45001:2018 standards. This management system meets the requirements of the StonePT (Premium) and StonePT – Green specifications for the Extraction + Primary Transformation + Secondary Transformation activities. All its products thus benefit from the procedures associated with the quality and environment control system.
Specific aspects regarding the production:	SIC Code 23701 – Manufacture of marble, and of similar stones, articles
Organization's environmental policy:	


1.3. Information concerning the EPD

Authors:	CERIS - Civil Engineering Research and Innovation for Sustainability, José Dinis Silvestre	CERIS : Civil Engineering Research and Innovation for Sustainability
Contact of the authors:	Av. Rovisco Pais 1049-001 Lisboa Phone contact: +351 218 419 709; E-mail: jose.silvestre@tecnico.ulisboa.pt	
Emission date:	17/01/2022	
Registration date:	08/03/2022	
Registration number:	DAP 002:2022	
Valid until:	16/01/2027	
Representativity of the EPD (location, manufacturer, group of manufacturers):	This is the cradle-to-gate EPD of all types of slabs for claddings and flooring produced in one (1) industrial unit belonging to a single producer (SOLANCIS — Sociedade Exploradora de Pedreiras, S.A.).	
Where to consult explanatory material:	www.solancis.com	
Type of EPD:		

1.4. Demonstration of the verification

External independent verification, accordingly with the standard ISO 14025:2009 and EN 15804:2012+A1:2013	
Certification Body	Verifier (s)
	
(CERTIF – Associação para a Certificação)	(Marisa Almeida)


1.5. EPD Registration

Program Operator

(Plataforma para a Construção Sustentável)

1.6. PCR of reference

Name:	<ol style="list-style-type: none"> 1. PCR: Basic module for construction products and services 2. PCR: Wall coverings 3. PCR: Floor coverings
Emission date:	<ol style="list-style-type: none"> 1. November 2020 2. November 2020 3. November 2020
Number of registration on the data base:	<ol style="list-style-type: none"> 1. RCP-mb001 2. RCP002:2014 3. RCP001:2014
Version:	<ol style="list-style-type: none"> 1. Version 2.1 2. Version 1.1 3. Version 1.1
Identification and contact of the coordinator (s):	<ol style="list-style-type: none"> 1. PCR: basic module for construction products and services <ul style="list-style-type: none"> • Marisa Almeida marisa@ctcv.pt • Luís Arroja arroja@ua.pt • José Silvestre jds@civil.ist.utl.pt 2. PCR: Wall coverings <ul style="list-style-type: none"> • Luís Arroja arroja@ua.pt • Marisa Almeida marisa@ctcv.pt 3. PCR: Floor coverings <ul style="list-style-type: none"> • Luís Arroja arroja@ua.pt • Marisa Almeida marisa@ctcv.pt
Identification and contact of the authors:	<ol style="list-style-type: none"> 1. PCR: basic module for construction products and services <ul style="list-style-type: none"> • Marisa Almeida marisa@ctcv.pt • Luis Arroja arroja@ua.pt • José Silvestre jds@civil.ist.utl.pt • Fausto Freire • Cristina Rocha • Ana Paula Duarte • Ana Cláudia Dias • Helena Gervásio • Victor Ferreira • Ricardo Mateus • António Baio Dias 2. PCR: Wall coverings <ul style="list-style-type: none"> • Marisa Almeida marisa@ctcv.pt • Luís Arroja arroja@ua.pt • Ana Cláudia Dias acdias@ua.pt 3. PCR: Floor coverings <ul style="list-style-type: none"> • Marisa Almeida marisa@ctcv.pt • Luís Arroja arroja@ua.pt • Ana Cláudia Dias acdias@ua.pt
Composition of the Sector Panel:	<ol style="list-style-type: none"> 2. RCP: Wall coverings <ul style="list-style-type: none"> • RMC - Revestimentos de Mármore Compactos, S.A. • APICER – Associação Portuguesa da Indústria de Cerâmica • Sonae Indústria, SGPS, S.A. • Gyptec Ibérica - Gessos Técnicos, S.A. 3. RCP: Floor coverings <ul style="list-style-type: none"> • RMC - Revestimentos de Mármore Compactos, S.A. • Dominó – Indústrias Cerâmicas, S.A. • MAS – Manuel Amorim da Silva, Lda. • Sonae Indústria, SGPS, S.A. • APICER – Associação Portuguesa da Indústria de Cerâmica
Consultation period:	<ol style="list-style-type: none"> 1. 18/11/2015 - 18/01/2016 2. 12/08/2013 - 30/11/2013 3. 01/08/2013 - 30/11/2013
Valid until:	<ol style="list-style-type: none"> 1. December of 2022 2. January of 2022 3. January of 2022

1.7. Information concerning the product/product class

Identification of the product:	Slabs for exterior and interior claddings and flooring, in natural limestone, including the following references: <i>beige pacífico, pérola, sonato and topázio; amazona topázio; semi-rijo branco real, imperial, snow and of mar; estremadura creme, azul and amazona; moca-creme fino, médio and grosso; azul primavera and atlântico; creme champanhe, vale amazona and lioz; beige clássico, azul clássico, amazona clássico and branco clássico.</i>																		
Illustration of the product:																			
Brief description of the product:	<p>The product corresponds to slabs for exterior and interior claddings and flooring, in natural limestone. This limestone has light beige, white to light beige, brownish beige, or cream to bluish grey colour, depending on the reference of the product. The production of these slabs is made at the Solancis industrial plant, in Benedita.</p> <p>These slabs are available in the maximum dimension of (3,200x2,000) mm and, usually, in the following thicknesses:</p> <ul style="list-style-type: none">• Façade and interior wall claddings: 20 to 40 mm;• Interior and exterior flooring: 10 to 80 mm. <p>Since the production process is the same for all the natural stone slabs produced at the Solancis plant, for every thickness, it is possible to transform the results of this EPD for 1 m² of slab with the referred thickness, taking into account the average density of these products (2,500 kg/m³), using a conversion factor, as indicated in Table 1.</p> <p>Table 1: Conversion factor to apply to the EPD results for 1 m² of slab with different thickness (in relation to the values presented in this EPD)</p> <table><tr><th>Thickness of the slab with 1 m²</th><th>Factor to be applied</th></tr><tr><td>10 mm</td><td>0.0250</td></tr><tr><td>20 mm</td><td>0.0500</td></tr><tr><td>30 mm</td><td>0.0750</td></tr><tr><td>40 mm</td><td>0.1000</td></tr></table>	Thickness of the slab with 1 m ²	Factor to be applied	10 mm	0.0250	20 mm	0.0500	30 mm	0.0750	40 mm	0.1000								
Thickness of the slab with 1 m ²	Factor to be applied																		
10 mm	0.0250																		
20 mm	0.0500																		
30 mm	0.0750																		
40 mm	0.1000																		
Main technical characteristics of the product:	<p>The main physical and technical characteristics of the product are presented in Table 2 (average values – these characteristics should be confirmed on the most recent technical sheet of the manufacturer for each application and geometry of the product).</p> <p>Table 2: Physical and technical characteristics of the product</p> <table><tr><th>Essential characteristic</th><th>Performance in accordance with EN 12058</th><th>Harmonized technical standard</th></tr><tr><td>Petrographic description</td><td>Pelsparite Limestone</td><td>EN 12407</td></tr><tr><td>Apparent density</td><td>Mean – 2,500 kg/m³</td><td>EN 1936</td></tr><tr><td>Flexural strength</td><td>Mean – 11.7 MPa Lower expected value – 7.9 MPa</td><td>EN 12372</td></tr><tr><td>Open porosity</td><td>Mean – 7.6 %</td><td>EN 1936</td></tr><tr><td>Water absorption at atmospheric</td><td>Mean 2,7 %</td><td>EN 13755</td></tr></table>	Essential characteristic	Performance in accordance with EN 12058	Harmonized technical standard	Petrographic description	Pelsparite Limestone	EN 12407	Apparent density	Mean – 2,500 kg/m ³	EN 1936	Flexural strength	Mean – 11.7 MPa Lower expected value – 7.9 MPa	EN 12372	Open porosity	Mean – 7.6 %	EN 1936	Water absorption at atmospheric	Mean 2,7 %	EN 13755
Essential characteristic	Performance in accordance with EN 12058	Harmonized technical standard																	
Petrographic description	Pelsparite Limestone	EN 12407																	
Apparent density	Mean – 2,500 kg/m ³	EN 1936																	
Flexural strength	Mean – 11.7 MPa Lower expected value – 7.9 MPa	EN 12372																	
Open porosity	Mean – 7.6 %	EN 1936																	
Water absorption at atmospheric	Mean 2,7 %	EN 13755																	

	pressure	Maximum expected value	3,16 %	
	Reaction to fire	Class A1		EN 13501-1
	Water absorption by capillarity	Maximum expected value – 53.5 g/m ² .s ^{0.5}		EN 1925
	Open porosity	Mean – 7.5 %		EN 1936
	Thermal shock resistance	Change in flexural strenght – 7.0 %		EN 14066
	Breaking load at a dowel hole (d=40 mm)	Mean – 2250 N Lower expected value – 1867 N		EN 13364
	Flexural strength after 56 freeze-thaw cycles – in normal conditions	Mean value before Mean value after	11.7 MPa 9.3 MPa	EN 12371
	Frost resistance (identification test)	84 cycles		EN 12371
	Abrasion resistance	Maximum expected value – 23.5 mm		EN 14157
	Slip resistance (Finish: Sawn)			
	Dry conditions	Mean – 44 SRV		CEN/TS 16165
	Wet conditions	Mean – 25 SRV		
Description of the products' application:	The main application of these slabs is in the execution of exterior and interior claddings and flooring, in natural limestone.			
Reference service life:	Not specified			
Placing on the market / Rules of application in the market / Technical rules of the product:	<ul style="list-style-type: none"> Decision No. 768/2008 / EC of the European Parliament and of the Council of 9 July 2008 Regulation (EC) No 764/2008 of the European Parliament and of the Council of 9 July 2008 Regulation (EC) No 765/2008 of the European Parliament and of the Council of 9 July 2008 Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 and its amendments. Technical Product Standards: <ul style="list-style-type: none"> EN 1469:2015: Natural stone products – Slabs for cladding - Requirements; EN 12057:2015: Natural stone products – Modular Tiles - Requirements; EN 12058:2004: Natural stone products – Slabs for floors and stairs - Requirements. 			
Quality control:	Quality control assured in accordance with the integrated quality management system and with the technical standards of the product.			
Special delivery conditions:	Not applicable			
Components and substances to declare:	Not applicable			
History of the LCA studies:	-			

2. ENVIRONMENTAL PERFORMANCE OF THE PRODUCT

2.1. Calculation rules of the LCA

Declared unit:	One tonne (1 ton) of slabs for exterior and interior claddings and flooring, in natural limestone, with a density of 2,500 kg/m ³ , packaging included.
Functional unit:	-
System boundaries:	EPD from cradle-to-gate
Criteria for the exclusion:	<p>The following processes were not considered in this study, since they meet the cut-off criteria of 1% use of renewable and non-renewable primary energy and 1% of the total input mass of the unit process where they occur, with a maximum of 5% energy and mass use in the considered stages (A1-A3):</p> <ul style="list-style-type: none"> • Construction of industrial infrastructures, manufacture and exchange of equipment and machinery; • Impacts of infrastructure (vehicle manufacturing, road maintenance) associated with the transport of pre-products and raw materials; • Transport of small consumables to the industrial unit; • Other negligible flows, considering their contribution below the cut-off criteria.
Assumption and limitations:	This EPD represents all types of slabs for cladding and flooring that are produced in one (1) manufacturing unit and may have different thicknesses and finishing.
Quality and other characteristics about the information used in the LCA:	<p>Production data was collected for the year of 2018, from internal and official records of the production plant and is according to with the reality.</p> <p>Generic data used belongs to Ecoinvent, ELCD and Simapro industrial database (Industry data 2.0), and meets the quality criteria (age, geographical and technology coverage, plausibility, etc.) for generic data.</p>
Allocation rules:	<p>In the blocks extraction stage from all quarries, the specific consumption of electricity and oil in 2018 was considered, making a mass allocation between the blocks transported to the plant and the material not used for block and used as raw material for the lime industry of sold for other uses.</p> <p>The manufacturing plant where these natural stone slabs are produced also produces other products, namely curbs. Taking it into account, an allocation methodology was used to define which input and output flows associated only to the production of the natural stone slabs being studied.</p> <p>Since the production is the same for all the natural stone slabs produced at the Solancis plant, regardless of the origin, a mass allocation was made between all the total inflows and outflows related to the production of the natural stone slabs in study and the weight of all the slabs produced in 2018, in order to calculate average data.</p>
Comparability of EPD for construction products:	The EPD of construction products and services cannot be comparable in case they are not produced according to EN 15804 and EN 15942 and according to the comparability conditions determined by ISO 14025.

2.1.1. Flow diagram of input and output of the processes

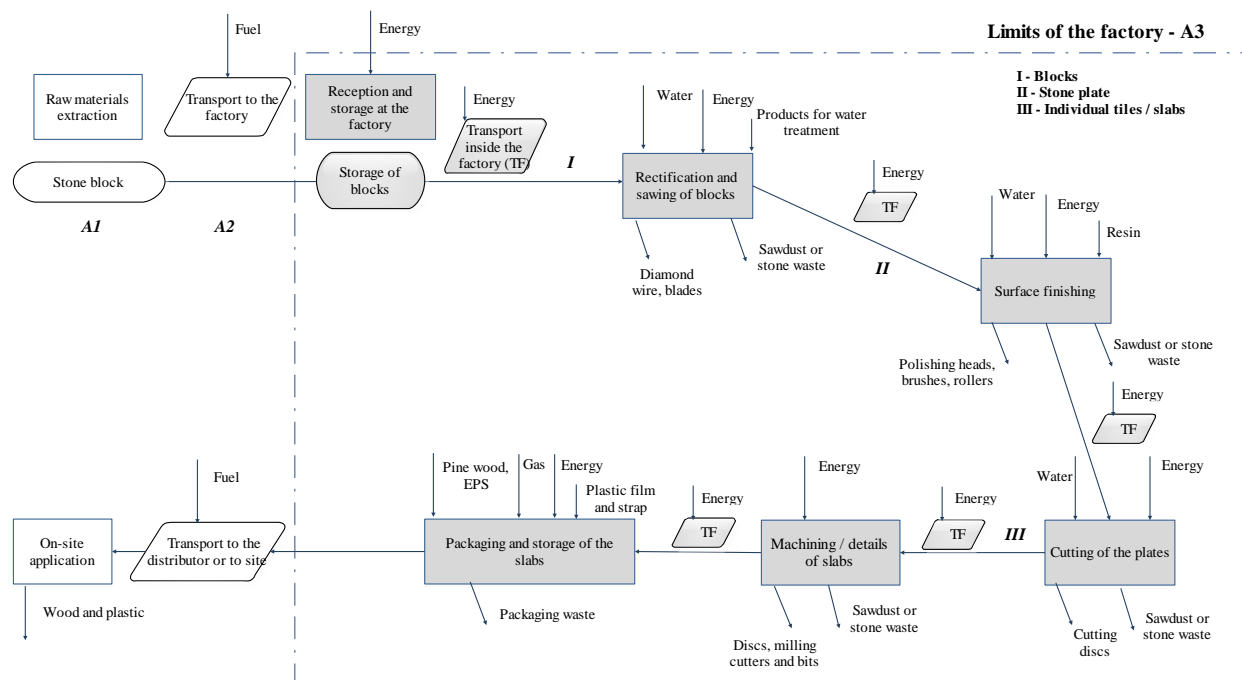


Figure 1. Life cycle stages of natural stone slabs from Solancis

The following paragraphs describe the life cycle stages studied for the development of this EPD.

Upon arrival at the factory, limestone blocks are stored. The slabs' production process starts in the Cutting Machines through the sawing process (which can be preceded by the rectification). Diamond saws laminate the blocks to the required thickness, resulting in several stone plates.

After measuring the thickness of the plates, they are introduced in the polisher. The stone receives here, through friction, the desired finishes (polished, sawn, hammered, sandblasted, aged or flamed – consuming gas and oxygen in this last case, which are not represented in Figure 1 - as tiles are to be visible by the inside or outside). Next is the cutting process, which turns them into individual tiles / slabs.

The modelling of the pieces into more complex formats (machining / details) is done in CNC (Computer Numerical Control). Following labelling and inspections, the slabs are finally packed in wooden structures (wrapped in plastic film and wrapped in a plastic strap, with expanded polystyrene – EPS as protection elements of the slabs) and stored according to the placement plans, the form of transport and the destination.

Transport to the construction site or the distributor and the application on site are outside of the boundaries of this EPD.

2.1.2. Description of the system boundaries

(✓= included; ✕= module not declared)

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY
Raw material supply	Transport	Manufacturing	Transport	Construction installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-constructions, demolition	Transport	Waste processing	Disposal	Re-use, recovery, recycling potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
✓	✓	✓	✕	✕	✕	✕	✕	✕	✕	✕	✕	✕	✕	✕	✕	✕

2.2. Parameters describing environmental impacts

		Global warming potential; GWP kg CO ₂ equiv.	Depletion potential of the stratospheric ozone layer; ODP kg CFC 11 equiv.	Acidification potential of soil and water, AP kg SO ₂ equiv.	Eutrophication potential, EP kg (PO ₄) ³⁻ equiv.	Formation potential of tropospheric ozone, POCP kg C ₂ H ₄ equiv.	Abiotic depletion potential for non-fossil resources kg Sb equiv.	Abiotic depletion potential for fossil resources MJ, P.C.I.
Raw material supply	A1	1.15E+01	1.83E-06	8.97E-02	1.75E-02	2.14E-03	4.42E-06	1.56E+02
Transport	A2	1.31E+00	2.65E-09	5.88E-03	1.34E-03	4.18E-04	5.22E-08	1.84E+01
Manufacturing	A3	5.95E+01	3.27E-06	4.24E-01	9.15E-02	2.30E-02	2.40E-04	7.98E+02
Total	Total	7.23E+01	5.10E-06	5.20E-01	1.10E-01	2.55E-02	2.45E-04	9.72E+02

LEGEND:

 Product stage


NOTES: P.C.I. – Low Heating Value (LHV).

Units expressed per declared unit (1 ton).

2.3. Parameters describing resource use

		Primary energy						Secondary materials and fuels, and use of water			
		EPR	RR	TRR	EPNR	RNR	TRNR	MS	CSR	CSNR	Net use of fresh water
		MJ, P.C.I.	MJ, P.C.I.	MJ, P.C.I.	MJ, P.C.I.	MJ, P.C.I.	MJ, P.C.I.	kg	MJ, P.C.I.	MJ, P.C.I.	m ³
Raw material supply	A1	9.12E+00	0.00E+00	9.12E+00	1.68E+02	0.00E+00	1.68E+02	0.00E+00	0.00E+00	0.00E+00	4.70E-02
Transport	A2	2.09E-02	0.00E+00	2.09E-02	1.96E+01	0.00E+00	1.96E+01	0.00E+00	0.00E+00	0.00E+00	1.17E-04
Manufacturing	A3	2.10E+02	8.32E-02	2.10E+02	8.49E+02	6.76E+01	9.25E+02	0.00E+00	0.00E+00	0.00E+00	2.03E+00
Total	Total	2.19E+02	8.32E-02	2.19E+02	1.05E+03	6.76E+01	1.11E+03	0.00E+00	0.00E+00	0.00E+00	2.08E+00

LEGEND:

 Product stage

EPR = use of renewable primary energy excluding renewable primary energy resources used as raw materials;

RR = use of renewable primary energy resources used as raw materials;

TRR = total use of renewable primary energy resources (EPR + RR);

EPNR = use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials;

RNR = use of non-renewable primary energy resources used as raw materials;

TRNR = total use of non-renewable primary energy resources (EPNR + RNR);

MS = use of secondary material;

CSR = use of renewable secondary fuels;

CSNR = use of non-renewable secondary fuels.


Net use of fresh water = net use of fresh water.

NOTE: Units expressed per declared unit (1 ton).

2.4. Other environmental information describing different waste categories

		Hazardous waste disposed kg	Non-hazardous waste disposed kg	Radioactive waste disposed kg
Raw material supply	A1	3.61E-04	1.92E-02	1.03E-03
Transport	A2	0.00E+00	1.63E-06	0.00E+00
Manufacturing	A3	5.44E-04	1.26E+02	1.76E-03
Total	Total	9.05E-04	1.26E+02	2.79E-03

LEGEND:

 Product stage

NOTE: Units expressed per declared unit (1 ton).

2.5. Other environmental information describing output flows

Parameters	Units*	Results
Components for re-use	kg	0.00E+00
Materials for recycling	kg	5.44E+00
Radioactive waste disposed	kg	0.00E+00
Materials for energy recovery	kg	1.33E-02
Exported energy	MJ by energy carrier	0.00E+00

* expressed per declared unit (1 ton)

3. SCENARIOS AND ADDITIONAL TECHNICAL INFORMATION

This EPD evaluates only the production stage of the natural stone slabs from Solancis, integrating stages A1 to A3. Thus, the following scenarios of the construction stage (modules A4 and A5), stage of use (B1 to B7) and end of life stage (C1 to C4), are not applicable.

3.1. Additional environmental information about the release of dangerous substances

No tests related to the release of dangerous substances or equivalent were carried out. There are no known toxic effects of this product. Due to its properties, no danger to the environment is expected. Natural stone slabs are considered an inert product, non-biodegradable.

3.2. Certifications

SOLANCIS — Sociedade Exploradora de Pedreiras, S.A. has a management system that meets the requirements of the StonePT (Premium) specification for the Extraction + Primary Transformation + Secondary Transformation activities, as audited and verified by APCER (Certificate of Conformity n.º 11/2020 valid until 15/03/2023) and that that meets the requirements of the StonePT– Green specification for the Extraction + Primary Transformation + Secondary Transformation activities, as audited and verified by APCER (Certificate of Conformity n.º 11/2026V valid until 15/03/2023).

REFERENCES

- ✓ CEN/TR 15941:2014 - Sustainability of construction works. Environmental product declarations. Methodology for selection and use of generic data.
- ✓ DAPHabitat. General Program Instructions of DAPHabitat, V. 1.1, 2015.
- ✓ DAP Habitat. PCR - Basic model products and construction services according to EN 15804: 2012 + A1: 2013, V. 2.1, 2020.
- ✓ DAP Habitat. PCR – Wall coverings. V. 1.1; 2020.
- ✓ DAP Habitat. PCR – Floor coverings. V. 1.1; 2020.
- ✓ EN 15804:2012+A1:2013 - Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products.
- ✓ EN ISO 14020:2005 - Environmental labels and declarations - General principles (EN ISO 14020:2005).
- ✓ EN ISO 14021:2016 - Environmental labels and declarations - Self declarations (Type II environmental declarations).
- ✓ EN ISO 14024:2018 - Environmental labels and declarations - Type I environmental declarations - Principles and procedures.
- ✓ EN ISO 14050:2010 - Environmental management – Vocabulary.
- ✓ ISO 14025:2009 - Environmental labels and declarations - Type III environmental declarations – Principles and procedures.
- ✓ ISO 14040:2008 - Environmental management - Life cycle assessment - Principles and framework.
- ✓ EN ISO 14044:2006/A1:2018 - Environmental management - Life cycle assessment - Requirements and guidelines.
- ✓ ISO 21930:2017 - Sustainability in building construction - Environmental declaration of building products.
- ✓ Tong, C., “Introduction to materials for advanced energy systems”, Springer, 2019, doi: 10.1007/978-3-319-98002-7.
- ✓ Tsiamis, D. A.; Castaldi, M. J.. 2016. Determining accurate heating values of non-recycled plastics (NRP). Earth Engineering Center | City College City University of New York.
- ✓ Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., and Weidema, B., 2016. The Ecoinvent database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp.1218–1230.