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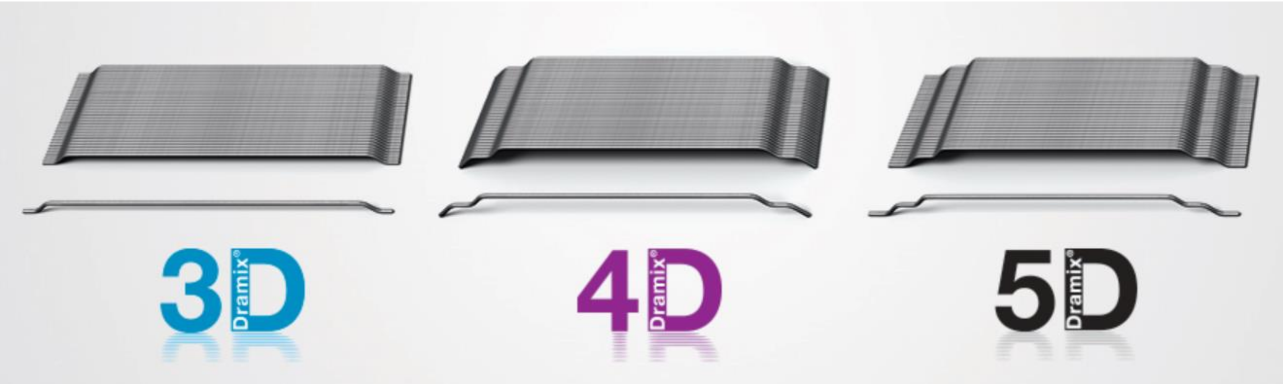
Dramix® Steel fibers for Concrete Reinforcement



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ITB is the verified member of The European Platform for EPD program operators and LCA practitioner www.eco-platform.org

Basic information

This declaration is the Type III Environmental Product Declaration (EPD) based on EN 15804:2012+A1 and verified according to ISO 14025 by an external auditor. It contains the information on the impacts of the declared construction materials on the environment. Their aspects were verified by the independent body according to ISO 14025. Basically, a comparison or evaluation of EPD data is possible only if all the compared data were created according to EN 15804:2012+A1 (see point 5.3 of the standard).

Life cycle analysis (LCA): A1-A4, C1-C4 and D modules in accordance with EN 15804:2012+A1 (Cradle to Gate with options)

The year of preparing the EPD: 2021

Service Life: not declared by producer**,** specific calculation in accordance to EN 1990:2004

PCR: ITB-PCR A (PCR based on EN 15804+A1)

Declared unit: 1 kg of steel fibers

Product Standards: EN 14889-1 and ISO 13270–class A & conforms to ASTM A-820

Reasons for performing LCA: B2B

Representativeness: manufactured in Czech Republic, year 2019

PRODUCTS DESCRIPTION

Bekaert (www.bekaert.com) is a global technological and market leader in advanced solutions based on metal transformation and coatings, and the world's largest independent manufacturer of drawn steel wire products. Dramix® fibers for concrete reinforcement (3D, 4D and 5D) covered by this EPD are manufactured in the manufacturing plant, located at Petrovice u Karviné, Czech Republic. Dramix® is the company brand name of steel fibers for concrete reinforcement. Bekaert produces fibers in different variants according to the intended application. There are different product variants like glued or loose fibers. Gluing is applied for some of the variants to avoid fiber balling during mixing & to ensure homogeneous distribution of the fibers throughout the concrete mix. Figure 1 shows a basic 3D fiber type.

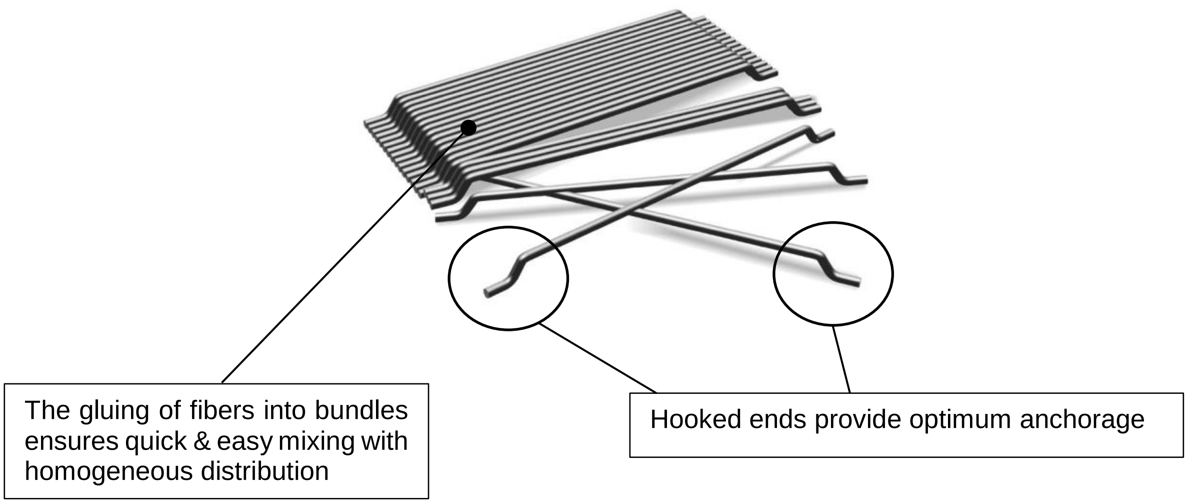


Figure 1. Technical concept of the Dramix® 3D fiber.

A specific product technical data is available at [Dramix® steel fiber concrete reinforcement solutions - Bekaert.com]

Bekaert Petrovice produces fibers with a nominal diameter ranging from 0,380 mm up to 1,050 mm & with an indicative length ranging from 30 mm up to 60 mm with nominal Tensile strength as mentioned in Tables 1, 2 & 3. Mainly according to the profile, steel fibers are grouped into 3D, 4D and 5D types. As per the surface coating, steel fibers are grouped into Bright (uncoated or brass/bronze coated) and Galvanized (zinc coated) types. There are also steel fibers made from stainless steel. Bekaert offers different types of packaging; the two main types are paper bags on pallets and big bags on pallets.

Table 1: Specification of 5D & 4D fiber types

Fiber type	Nominal Tensile Strength N/mm²	Nominal Length mm	Nominal Diameter mm
5D 65/60BG	2300	62	0.90
5D 65/60GG	2300	62	0.90
4D 55/50BG	1600	51	0.90
4D 55/60BG; BL	1450	61	1.05
4D 65/35BG	1850	36	0.55
4D 65/50BG; BL	1800	51	0.75
4D 65/60BG; BL	1600	61	0.90
4D 80/60BG	1800	61	0.75
4D 80/60BGP	2200	61	0.75

Table 2: Specification of 3D fiber types

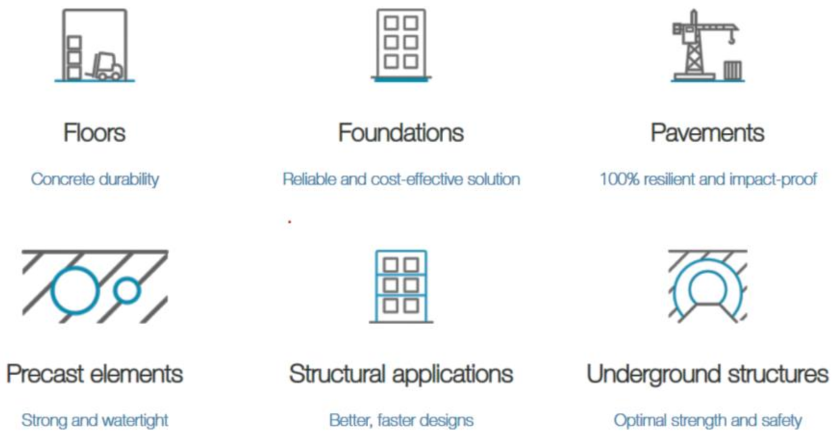
Fiber type	Nominal Tensile Strength N/mm²	Nominal Length mm	Nominal Diameter mm
3D 100/60BG	1270	60	0.62
3D 45/30BG; BL	1270	30	0.62
3D 45/30GG	1440	30	0.62
3D 45/35BG; BL	1225	35	0.75
3D 45/50BL	1115	50	1.05
3D 55/30BG	1345	30	0.55
3D 55/60BG; BL	1115	60	1.05
3D 65/35BG	1345	35	0.55
3D 65/35GG	1550	35	0.55
3D 65/40GG	1440	41	0.62
3D 65/50BG; BL	1225	50	0.75
3D 65/60BG; BL	1160	60	0.90
3D 65/60GG	1240	60	0.90
3D 80/30BGP	3070	30	0.38
3D 80/30GGP	3070	30	0.38
3D 80/30SL	2000	30	0.38
3D 80/50BG	1270	50	0.62
3D 80/60BG; BL	1225	60	0.75
3D 80/60BGP	1800	60	0.75
3D 80/60GG	1350	60	0.75

Table 3: Specification of BSF & other fiber types

Fiber type	Nominal Tensile Strength N/mm²	Nominal Length mm	Nominal Diameter mm
BSF 65/35BG	1300	35	0.55
BSF 65/60BG	1150	60	0.90
BSF 80/60BG	1200	60	0.75
BSF 45/35BL	1200	35	0.75
BSF 45/50BL	1100	50	1.05
BSF 55/60BL	1100	60	1.05
Dramix® Duo 100	1225	60	0.75
Dramix® Ready	1225	60	0.75
Dramix® MallaEnBolsa	1115	50	1.05
Dramix® MallaEnBolsa+	1800	61	0.75

PRODUCT APPLICATION

Dramix® steel fibers are used for concrete reinforcement and are an alternative to steel mesh and bars. They are discontinuous, three-dimensional and isotropic reinforcement. The steel fibers bridge cracks at their small widths, distribute stresses and increase the strength of concrete in a cracked state. Adding the adequate number of fibers to the concrete plasticizes it, increasing its tensile and shear strength, impact strength and fatigue resistance. Steel fibers for structural use are used for concrete & mortar reinforcement for below applications: over ground applications (flooring, building, civil engineering, etc.), underground applications (segmental linings for tunneling etc.) & precast.



The hooked ends of Dramix® 3D ensure the desired fiber pullout. This is the mechanism, which actually generates the renowned concrete ductility and post-crack strength. The improved anchorage of Dramix® 4D utilizes the same principle but translates it to greater steel strengths (Figure 2). Dramix® 5D, in contrast, is shaped to form the perfect anchor; the pullout mechanism is replaced by fiber elongation. The tensile strength of a steel fiber has to increase in parallel with the strength of its anchorage. Dramix® 3D, 4D, and 5D are each designed to capitalize on the wire strength to the maximum degree. Dramix® 3D and 4D create concrete ductility as a result of the slow deformation of the hook during the pullout process, and not due to the ductility of the wire itself. This is different for Dramix® 5D. Due to the anchor design, the fiber cannot be pulled out and does not move in concrete. Instead, the wire is elongated, providing the ductility on the same principle as classic reinforcement steel. The tensile strength level of the Dramix® product series is shown in Figure 2.

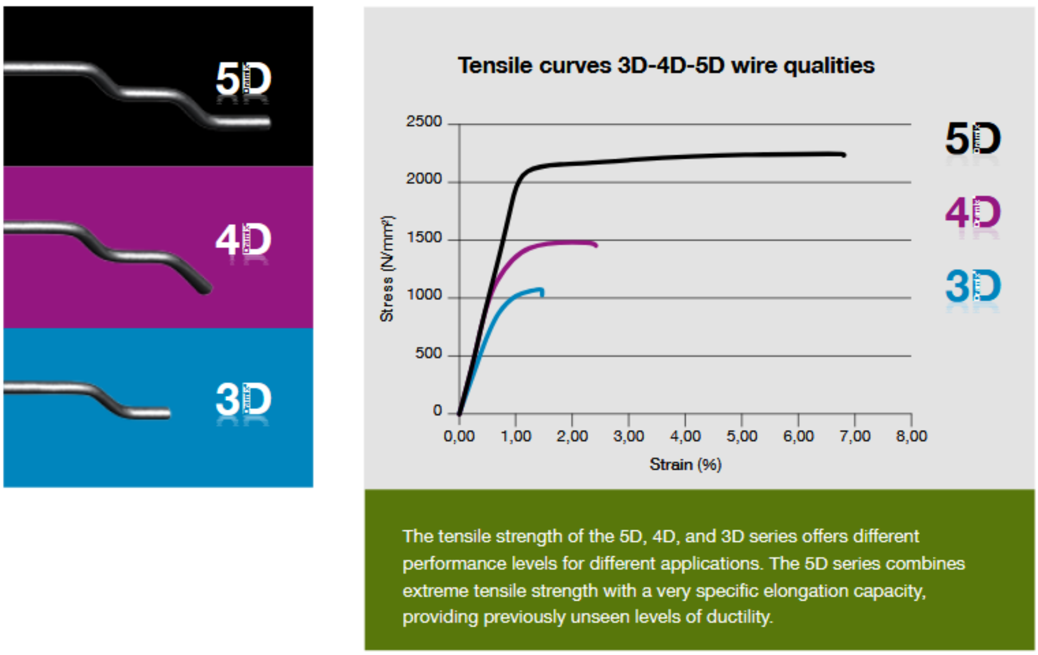


Figure 2. The tensile strength of the Dramix® product series

LIFE CYCLE ASSESSMENT (LCA) – general rules applied

Unit

The declared unit is 1 kg of Dramix® steel fiber.

System boundary

The life cycle analysis of the declared product covers “Product Stage” A1-A4 modules, “End of Life stage” C1, C2, C3, C4 modules and gains and loads beyond system in D module (Cradle to Gate with options) in accordance with EN 15804:2012+A1 and ITB PCR A.

Allocation

The allocation rules used for this EPD are based on general ITB PCR A. Production of steel fibers is a line process in a manufacturing plant located at Petrovice, Czech Republic (see Figure 3). Allocation of impacts is done on product mass basis. All impacts from raw materials production (wire rod, galvanized half product, bead wires, hose wires, stainless steel, widia dies, PCD dies, soaps, emulsion, inhibitor, glue, bags, paper and pallets) are allocated in the A1 module of the LCA. 99% of the impacts from a line production were allocated to products covered by this declaration. Module A2 includes transport of raw materials such as steel from supplier to manufacturing plant (Petrovice). Municipal wastes of the factory were allocated to module A3. Energy supply (gas Lama Energy) and electricity (Veolia) was inventoried and 100% was allocated to the product assessed. Emissions in the factory are assessed using statistical KOBIZE 2019 emission factors for energy carriers.

System limits

99% materials and 100% of the energy consumption (electricity, gas) were inventoried in the factory and were included in the calculation. In the assessment, all significant parameters from gathered production data are considered, i.e. all material used per formulation (main input is steel wire rod), utilized thermal energy and electric power consumption, direct production waste, and available emission measurements. Tire consumption for transport was not taken into account. Precomponents like labels & tapes with a percentage share of less than 0.2% were not included in the calculations. It is assumed that the total sum of omitted processes does not exceed 1% of all impact categories. In accordance with EN 15804 machines and facilities (capital goods) required for and during production are excluded, as is transportation of employees.

A1 and A2 Modules: Raw materials supply and transport

The steel input materials are produced in the mixed EAF/BOF technology (based on valid Ecoinvent data). Data on transport of the different input products to the manufacturing plants were inventoried in detail and modelled by the assessor. For calculation purposes European fuel averages are applied in module A2.

A3: Production

The production process (Petrovice plant) is presented in Figure 3.

A4: Transport to construction site

The following transport scenario to the place of use was assumed based on the manufacturer's declaration: large vehicle, 75% capacity over an average distance of 500 km. For calculation purposes, European fuel averages are applied in module A4.

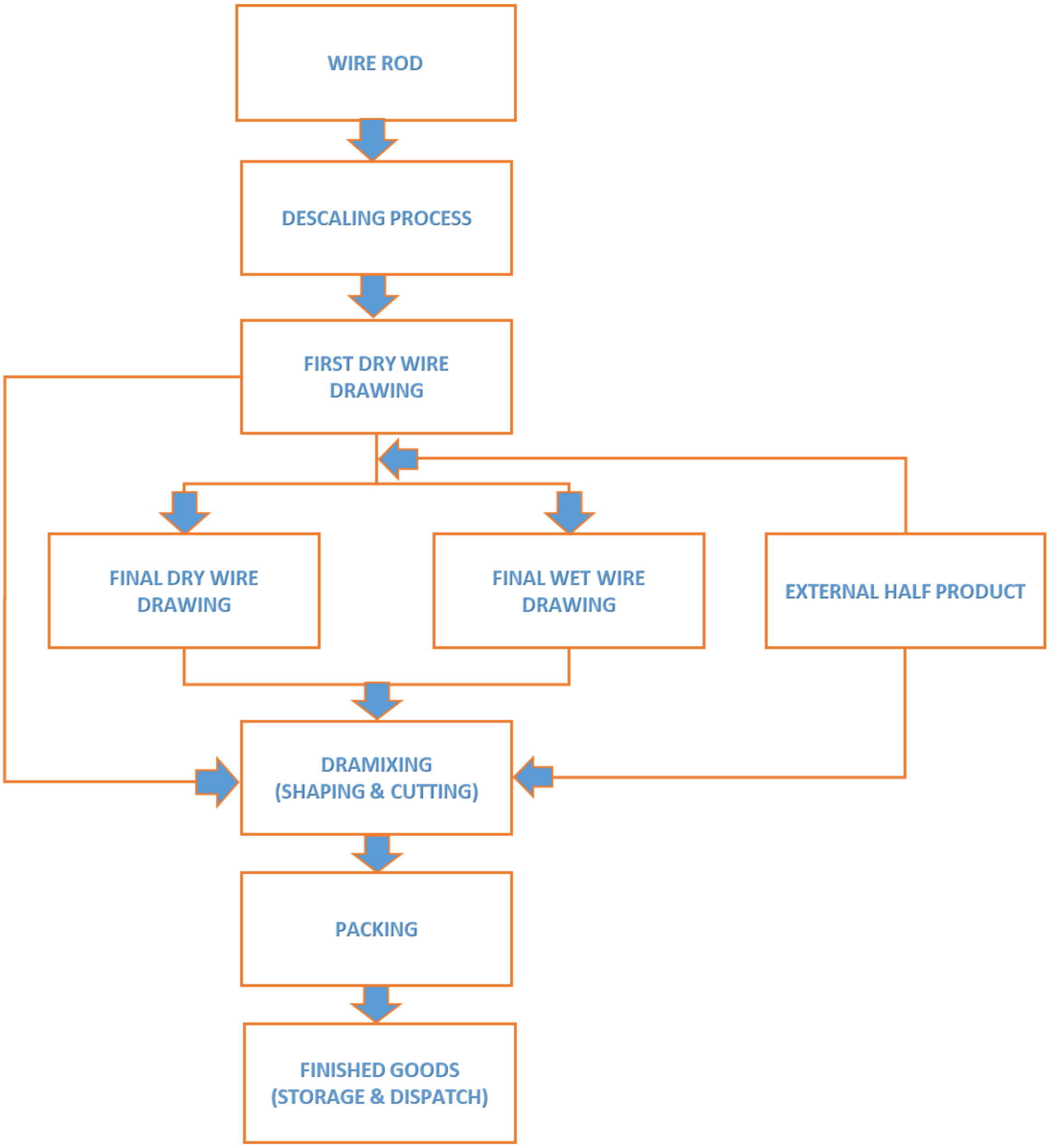


Figure 3. A schematic diagram of the industrial process (A3 module)

End of life scenarios (C and D modules)

The end of life scenario has been generalized. The steel fiber reinforced concrete is dismantled (C1 module) with cranes, power tools, hammers, breakers, and grappling hooks mounted onto heavy equipment. 100% material recovery during demolishing is assumed. The manufacturer declares the technology and the scenario in which the steel fibers can be separated (in the near future) from waste concrete: up to 95% with heavy crushers and a magnetic separator and 5% goes to a landfill. 10% of the recovered steel waste product can be reused or adapted to new applications (concrete reinforcement). 90% of the recovered steel can be used for new steel production (EAF process). It is assumed that at the end of life the transport distance from the product deconstruction place to waste processing (C2) is 50 km on > 16 t loaded lorry with 75% capacity utilization and fuel consumption of 35 l per 100 km. Materials recovered from dismantled products are recycled according to the BAT treatment practice. The reuse, recovery and recycling potential for a new product system is considered beyond the system boundaries (module D) based on World Steel recommendations and national practice (see references).

Table 4. End of life scenarios for Dramix® products

Progress products	Material recovery from concrete	Reuse	Recycling	Landfilling
Steel products	95%	10%	90%	5%

Data collection period

The data for manufacture of the declared products refers to the period between 01.01.2019 – 31.12.2019 (1 year). The life cycle assessments were done for Czech as reference area.

Data quality - production

The values determined to calculate A3 originate from verified Progress LCI inventory data. A1 values were prepared considering several European made steel products based on Ecoinvent. Allocation for steel production impacts is done in accordance with *LCI data for Steel products Report* compiled by Brayan Hughes and William Hare (2012 for World Steel Association).

Assumptions and estimates

The impacts of the representative products were aggregated using weighted average. Data regarding production per 1 kg of product was averaged for the analysed production of each product group. All production processes (A3) were assigned to different types of products in an equal way.

Calculation rules

LCA was done in accordance with the ITB PCR A document. Characterization factors are CML ver. 4.2 based. ITB-LCA algorithms were used for impact calculations. A1 was calculated based on data from the database and specific EPD for steel, A2 and A3 were calculated based on the LCI questionnaire provided by the manufacturer.

Databases

The background data for the processes come from the following databases: Ecoinvent v.3.7 (steel, ancillary items, packaging), specific production data (Moravia. Lama Energy), KOBIZE and Veolia (Czech electricity mix and combustion factors for fuels). Specific (LCI) data quality analysis was a part of the audit. The time related quality of the data used is valid (5 years).

LIFE CYCLE ASSESSMENT (LCA) – Results

Declared unit

The declaration refers to the unit DU– 1 kg of the Dramix® & Steel fibers (Tables 1, 2 & 3). The following life cycle modules are included in the declaration (Table 5).

Table 5. System boundaries (life stage modules included) in a product environmental assessment

Environmental assessment information (MA – Module assessed, MNA – Module not assessed, INA – Indicator Not Assessed)																
Product stage			Construction process		Use stage							End of life				Benefits and loads beyond the system boundary
Raw material supply	Transport	Manufacturing	Transport to construction site	Construction-installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction 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**
MA	**MA**	**MA**	**MA**	**MNA**	**MNA**	**MNA**	**MNA**	**MNA**	**MNA**	**MNA**	**MNA**	**MA**	**MA**	**MA**	**MA**	**MA**

Table 6. Environmental product characteristic – 1 kg of Dramix® steel fibers

Environmental impacts: (DU) 1 kg										
Indicator	**Unit**	**A1**	**A2**	**A3**	**A4**	**C1**	**C2**	**C3**	**C4**	**D**
Global warming potential	kg CO_2	5.77E-01	6.82E-03	2.97E-01	5.25E-02	2.52E-03	3.20E-03	1.68E-03	3.00E-03	-2.36E-01
Depletion potential of the stratospheric ozone layer	kg CFC 11	3.96E-08	0.00E+00	7.57E-09	0.00E+00	2.89E-11	0.00E+00	1.92E-11	1.15E-10	-4.49E-09
Acidification potential of soil and water	kg SO_2	2.37E-03	5.25E-05	1.03E-03	4.16E-04	2.31E-06	2.21E-05	1.53E-06	3.50E-06	-9.11E-04
Formation potential of tropospheric ozone	kg Ethene	1.38E-04	3.53E-06	3.50E-05	2.67E-05	1.19E-05	1.48E-06	7.94E-06	6.50E-07	-1.02E-04
Eutrophication potential	kg $(PO_4)^{3-}$	1.15E-03	9.30E-06	1.70E-03	7.38E-05	9.61E-08	3.90E-06	6.39E-08	1.72E-06	-3.17E-04
Abiotic depletion potential (ADP-elements) for non-fossil resources	kg Sb	5.57E-04	0.00E+00	1.74E-03	0.00E+00	1.94E-05	0.00E+00	1.29E-05	6.00E-05	-2.18E-04
Abiotic depletion potential (ADP-fossil fuels) for fossil resources	MJ	6.59E+00	7.30E-02	2.75E+00	7.17E-01	3.00E-02	3.92E-02	2.00E-02	1.30E-02	-2.19E+00
Environmental aspects: (DU) 1 kg										
Indicator	**Unit**	**A1**	**A2**	**A3**	**A4**	**C1**	**C2**	**C3**	**C4**	**D**
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA
Use of renewable primary energy resources used as raw materials	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)	MJ	1.07E+00	9.34E-04	1.89E+00	7.17E-03	4.50E-03	3.92E-04	2.99E-03	0.00E+00	-3.56E-01
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA
Use of non-renewable primary energy resources used as raw materials	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA
Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials)	MJ	9.22E+00	7.81E-02	2.89E+00	7.50E-01	3.30E-02	4.12E-02	2.19E-02	1.35E-02	-2.52E+00
Use of secondary material	kg	1.25E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-1.19E-02
Use of renewable secondary fuels	MJ	0.00E+00	4.90E-03	0.00E+00	3.77E-02	0.00E+00	2.06E-03	0.00E+00	0.00E+00	-4.66E-04
Use of non-renewable secondary fuels	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-0.00E+00
Net use of fresh water	m^3	6.86E-03	1.00E-06	3.58E-04	1.29E-06	9.48E-06	4.20E-07	6.30E-06	1.00E-05	-1.01E-04
Other environmental information describing waste categories: (DU) 1 kg										
Indicator	**Unit**	**A1**	**A2**	**A3**	**A4**	**C1**	**C2**	**C3**	**C4**	**D**
Hazardous waste disposed	kg	7.43E-04	3.60E-06	3.14E-04	4.64E-06	4.00E-08	1.51E-06	2.66E-08	1.90E-08	-1.01E-04
Non-hazardous waste disposed	kg	3.87E-01	4.27E-03	7.17E-03	5.51E-03	3.61E-04	1.79E-03	5.02E-02	5.01E-03	-3.98E-02
Radioactive waste disposed	kg	4.53E-05	0.00E+00	6.52E-06	0.00E+00	4.00E-08	0.00E+00	2.66E-08	7.20E-08	-2.95E-05
Components for re-use	kg	0.00E+00	0.00E+00	8.80E-03	0.00E+00	0.00E+00	0.00E+00	9.50E-02	0.00E+00	-8.36E-04
Materials for recycling	kg	0.00E+00	0.00E+00	8.13E-05	0.00E+00	0.00E+00	0.00E+00	8.55E-01	0.00E+00	-7.72E-06
Materials for energy recover	kg	0.00E+00	0.00E+00	1.21E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-1.15E-06
Exported energy	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

RESULTS INTERPRETATION

The environmental impact of Dramix® products (cradle to gate with options) is largely dependent on the energy-intensive production of steel (half product) on which the manufacturer has a limited influence only. The carbon impact of steel production (Wire Rods) in the product stage A1 is as high as 85%. The impact of the production line A3 largely depends on the amount of electricity consumed by the manufacturing plant (0.34 kWh/kg of product). There are no significant emissions or environmental impacts in the A3 production processes alone (partly gas combustion). The production process itself does not have significant environmental impacts in the life cycle.

Interrogation of the LCA results show that the cradle-to-gate carbon (Global Warming Potential) impact of 1 kg of fiber production is 0.88 kg CO_2eq. In comparison, a ton of steel produced worldwide in 2019 emitted on average 1.85 tons of carbon dioxide. Tables 7, 8 & 9 below show the calculated Global Warming Potential per fiber type.

The LCA results show that the cradle-to gate primary energy demand of fossil fuel is equal to 9.4 MJ. This is due to the production of nuclear energy by the Czech Republic. The transport of raw materials from considerable distances is optimized and not significant (0.007 kg CO_2/kg).

Due to the high potential for recycling and reuse (95%), the products have noticeable D module potential (beneficial to other product systems).

Table 7. Global warming potential per 5D,4D types

Fiber type	Global warming potential Kg CO_2
5D 65/60BG	0.96
5D 65/60GG	1.02
4D 55/50BG	0.88
4D 55/60BG; BL	0.87
4D 65/35BG	0.92
4D 65/50BG; BL	0.90
4D 65/60BG; BL	0.88
4D 80/60BG	0.90
4D 80/60BGP	0.91

Table 8. Global warming potential per 3D type

Fiber type	Global warming potential Kg CO_2
3D 100/60BG	0.85
3D 45/30BG; BL	0.85
3D 45/30GG	0.93
3D 45/35BG; BL	0.85
3D 45/50BL	0.83
3D 55/30BG	0.86
3D 55/60BG; BL	0.83
3D 65/35BG	0.86
3D 65/35GG	0.92
3D 65/40GG	0.91
3D 65/50BG; BL	0.85
3D 65/60BG; BL	0.84
3D 65/60GG	0.90
3D 80/30BGP	0.95
3D 80/30GGP	0.99
3D 80/50BG	0.85
3D 80/60BG; BL	0.85
3D 80/60BGP	0.88
3D 80/60GG	0.91

Table 9. Global warming potential per BSF & other Dramix® types

Fiber type	Global warming potential Kg CO_2
BSF 65/35BG	0.86
BSF 65/60BG	0.84
BSF 80/60BG	0.85
BSF 45/35BL	0.85
BSF 45/50BL	0.83
BSF 55/60BL	0.83
Dramix® Duo 100	0.85
Dramix® Ready	0.85
Dramix® MallaEnBolsa	0.83
Dramix® MallaEnBolsa+	0.90

VERIFICATION

The process of verification of this EPD was in accordance with ISO 14025 and ISO 21930. After verification, this EPD is valid for a 5-year-period. EPD does not have to be recalculated after 5 years if the underlying data have not changed significantly.

The basis for LCA analysis was EN 15804:2012+A1 and ITB PCR A	
Independent verification corresponding to ISO 14025 (sub clause 8.1.3.)	
[X] external	[ ] internal
External verification of EPD: Ph.D. Eng. Halina Prejzner LCA. LCI audit and input data verification: Ph.D. D.SC.Eng. Michał Piasecki. m.piasecki@itb.pl Verification of LCA: Ph.D. Eng. Justyna Tomaszewska. j.tomaszewska@itb.pl	

Normative references

- ITB PCR A General Product Category Rules for Construction Products
- EN 14889-1:2006 Fibres for concrete. Steel fibres. Definitions, specifications and conformity
- LCI DATA FOR STEEL PRODUCTS at https://www.worldsteel.org/en/dam/jcr:04f8a180-1406-4f5c-93ca-70f1ba7de5d4/LCI%2520study_2018%2520data%2520release.pdf
- ISO 14025:2006. Environmental labels and declarations – Type III environmental declarations – Principles and procedures
- ISO 21930:2017 Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services
- ISO 14044:2006 Environmental management – Life cycle assessment – Requirements and guidelines
- EN 15804:2012+A1 Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products
- PN-EN 1992-1-1:2008 „Eurokod 2 - Projektowanie konstrukcji z betonu - Część 1-1: Reguły ogólne i reguły dla budynków"

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Thermal Physics, Acoustics and Environment Department
02-656 Warsaw, Ksawerów 21

CERTIFICATE № 215/2021
of TYPE III ENVIRONMENTAL DECLARATION

Products:

Dramix® Steel fibres for Concrete Reinforcement

Manufacturer:

N.V. Bekaert S.A.

Bekaertstraat 2, 8550 Zwevegem, Belgium

Produced in the manufacturing plant,

Bekaert Petrovice s.r.o.

Petrovice 595, CZ-735 72 Petrovice u Karviné, Czech Republic

confirms the correctness of the data included in the development of
Type III Environmental Declaration and accordance with the requirements of the standard

PN-EN 15804

Sustainability of construction works.
Environmental product declarations.
Core rules for the product category of construction products.

This certificate, issued for the first time on 1st June 2021 is valid for 5 years
or until amendment of mentioned Environmental Declaration

Acting Head of the Thermal Physic, Acoustics and Environment Department

Agnieszka Winkler-Skalna, PhD

INSTYTUT TECHNIKI BUDOWLANEJ

Deputy Director for Research and Innovation

Krzysztof Kuczyński, PhD

Warsaw, June 2021