ENVIRONMENTAL PRODUCT DECLARATION

"Arroyo Valchano" railway bridge

EN 15804 and ISO 14025:2010 compliant

Reg. no. S-P-00455 **UN CPC 53221** **PCR 2018:01 Bridges, elevated highways and tunnels v1.12**

Publication date: 2015-10-26 **Revision date: 2020-12-07** **Valid until: 2025-12-06**

Programme: The International EPD® System **Programme operator: EPD International AB**

Version of the EPD: 2nd **Scope of the EPD: International**

An EPD should provide current information and may be updated if conditions change. The stated validity is therefore subject to the continued registration and publication at www.environdec.com."

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1. INTRODUCTION

This environmental product declaration (EPD®) describes, from a lifecycle perspective, the total environmental impact of a railway bridge on Madrid-Galicia North-Northwest high-speed line. Stretch: Zamora-Lubián. Sub-stretch: Otero de Bodas-Cernadilla. The program operator of this EPD® is The International EPD® System.

The EPD® covers bridge "structure" only. Track, power, signaling and telecom systems on the bridges are not included. Within the International EPD® system based on ISO standard 14025, this EPD® was drawn up in accordance with the Product Category Rules, PCR 2013:23 Bridges and elevated highways v 1.12, and with EN 15804.

The aim of this EPD® is that it should provide experts and scientists (in the construction and infrastructure sectors) with objective and reliable information on the environmental impact of constructing a railway bridge.

This EPD® was developed by ACCIONA Construction (Construction Technology Center). It has been verified by Marcel Gómez Ferrer, individual verifier, and the certification is valid internationally and for five years.

As this EPD® is based on data relating to Arroyo Valchano railway bridge from 2019, the results might not be representative of other railway bridges. In order to decide if the results can be representative for other railway bridges, the most important areas that should be checked to be comparable with other railway bridges are:

- Topography (impact on, for example, the length of bridge piers).
- Type of bridge (e.g. concrete or steel beam).
- Origin of materials (mainly steel and concrete).
- Railway functionality (single or double track, type of traffic, axle load, etc.).

2. DESCRIPTION OF THE COMPANY

ACCIONA is a global group that develops and manages sustainable infrastructure solutions. It business spans the entire value chain, from design and construction through to operation and maintenance. ACCIONA's goal is to lead the transition towards a low-carbon economy, bringing technical excellence and innovation to all of its projects to design a better planet. With a presence in more than 60 countries and sales of €7.191 billion in 2019, the company is committed to contributing to the economic and social development of the communities in which it operates.

Through the evolution of its positioning, ACCIONA shows that the smartest choice for achieving sustainable development is to invest in the planet through renewable energies, resilient infrastructures, and water management and treatment. This is a different way of doing business, one it considers to be essential in the bid for sustainability in response to major global challenges, such as the consequences of climate change and the transition toward a decarbonised economy.

This commitment is underscored by the fact that the Company is a component of several highly reputed sustainability indices, such as the Dow Jones Sustainability World Index (DJSI World) and the Dow Jones Stoxx Sustainability Index (DJSI Stoxx), in which ACCIONA obtained the highest score in its sector. ACCIONA's has consolidated its bet on innovation by stepping up investment and coming up with more and more projects, programmes and resources. Its intention is clear: ACCIONA aims to continue to lead the field in more sustainable solutions and alternatives.

ACCIONA Construction is at the forefront of R&D and Innovation and is one of the world's leading construction companies. The Company has the ability to put into practice the most highly advanced and innovative techniques, always choosing the most appropriate technologies for each project. This is down to an intense and uninterrupted research activity that has made ACCIONA Europe's leading company in terms of application of technology; also has the EU's largest R&D and Innovation division in terms of resources and projects all of which have been approved in a number of EU, American and Spanish programs.

ACCIONA Construction takes part in projects that share a number of common denominators, namely, social value, applied technical excellence and razor-sharp management. No construction project is beyond its capabilities. Its work on highways, ports, railways, airports, water treatment plants, hydro works-urban infrastructure, buildings, industrial and energy production facilities and a long list of others, is all helping to improve the quality of life not only for end-users but also for the environment and the local community overall.

3. DESCRIPTION OF THE RAILWAY BRIDGE

The viaduct is part of Madrid-Galicia North-Northwest high-speed line. Stretch: Zamora-Lubián. Sub-stretch: Otero de Bodas-Cernadilla.

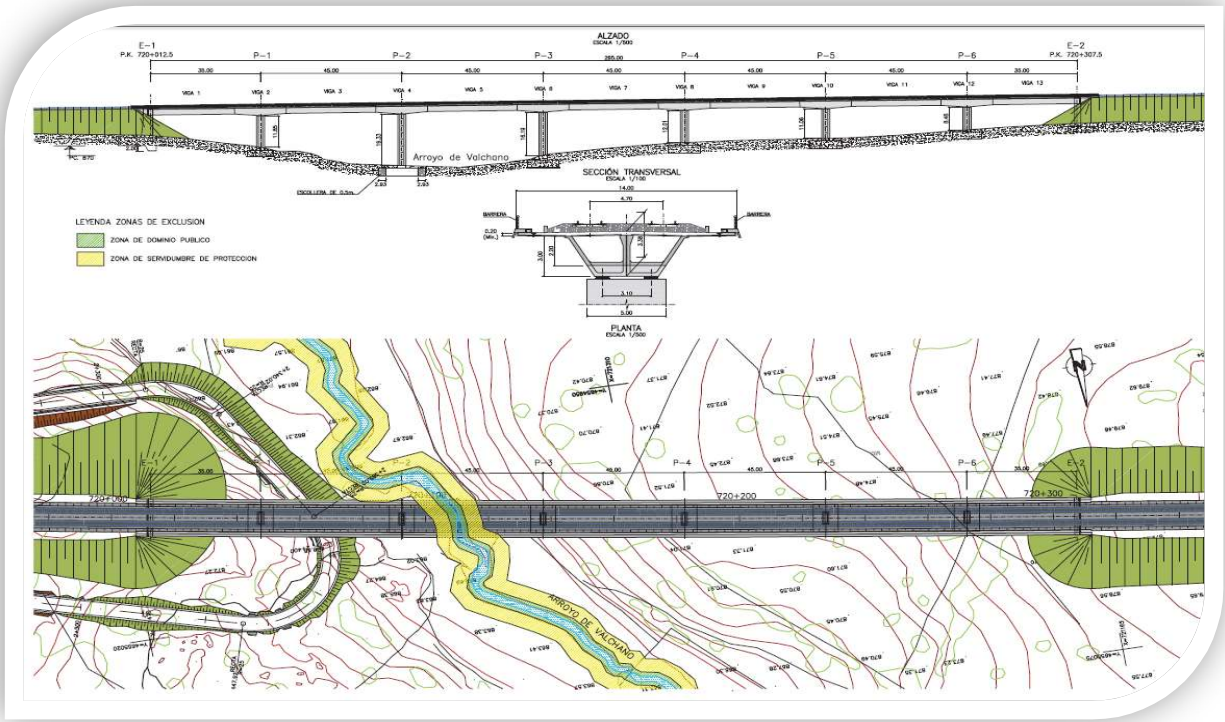
The railway bridge over the Arroyo de Valchano is built to save the step of the way on this river. The terrain features under the viaduct advise saving a total of 295.00 m span between PK's 720 + 012,5 and 720 + 307,5. The layout on the ground in the area of the viaduct is a 15,000 radius circular curve. In sum the viaduct stands at 14.5 ‰ slope ramp. The width of the necessary board is 14.0 m.

The railway bridge is a double track railway and it is built only for transportation of passengers**.** The board consists of precast beams and a slab "in situ" with the following span distribution: 35 + 5x 45.+35 = 295.0 m. The beams have variable depth between 2.20 m in midspan and 3.00 m on piers. The beams have 14m wide slabs and over them, an "in situ" slab of variable thickness.

In order to create an indeterminate structure, continuity between both longitudinal and transverse beams is shown. Longitudinal continuity between beams is performed with tensioning bars at first phase and with pre-stressing strands in slab and beams in the second phase, while the transverse continuity is carried by a dowel pin in the bottom of the beam and the "in situ" slab at the top.

Panel construction is built in different stages, using provisional supports for the beams installation to carry out subsequently the different phases of assembling of pre-slabs, joints and "in situ" concreting slab.

The substructure consists of 4.80 x 2.00 m of hollow rectangular piers and heights varying between 9.46 and 20.33 m. The abutments are of similar heights, being the board anchored to the bracket 1 by a swivel concrete with passive armor next to the slab. The support of the board in the substructure is by POT type supports, transversely spaced 3.10 m in piers and 4.00 m in abutments.



4. FUNCTIONAL UNIT

According to the PCR, UN CPC 53221, 53222 Bridges, elevated highways and tunnels (2018), the functional unit is one kilometer of bridge and year, with a Reference Service Life of 60 years.

5. SYSTEM BOUNDARIES AND DATA QUALITY

This is a cradle to grave EPD (it includes upstream, core and downstream modules, and Module D). Upstream module considers all raw materials required for the construction of the viaduct. Core module includes the transport to work site, installation and construction itself. Downstream module includes the operation, maintenance and end of life. The operation activities are few and they are usually related to the tracks or signaling and telecommunication systems and thus were not included in the bridge model (not significant impact). Maintenance activities for railway bridges are also insignificant. The product is 100% recycled during its end of life, with a transportation distance to waste manager of 50 km. The potential environmental savings due to recycling at the end of life has been included (Module D), being the result of the recycling process (avoided products) steel and crashed gravel.

According to PCR indications the next processes have been excluded:

- Manufacturing of production equipment, buildings and other capital goods.
- Business travel of personnel.
- Travel to and from work by personnel.
- Research and development activities.

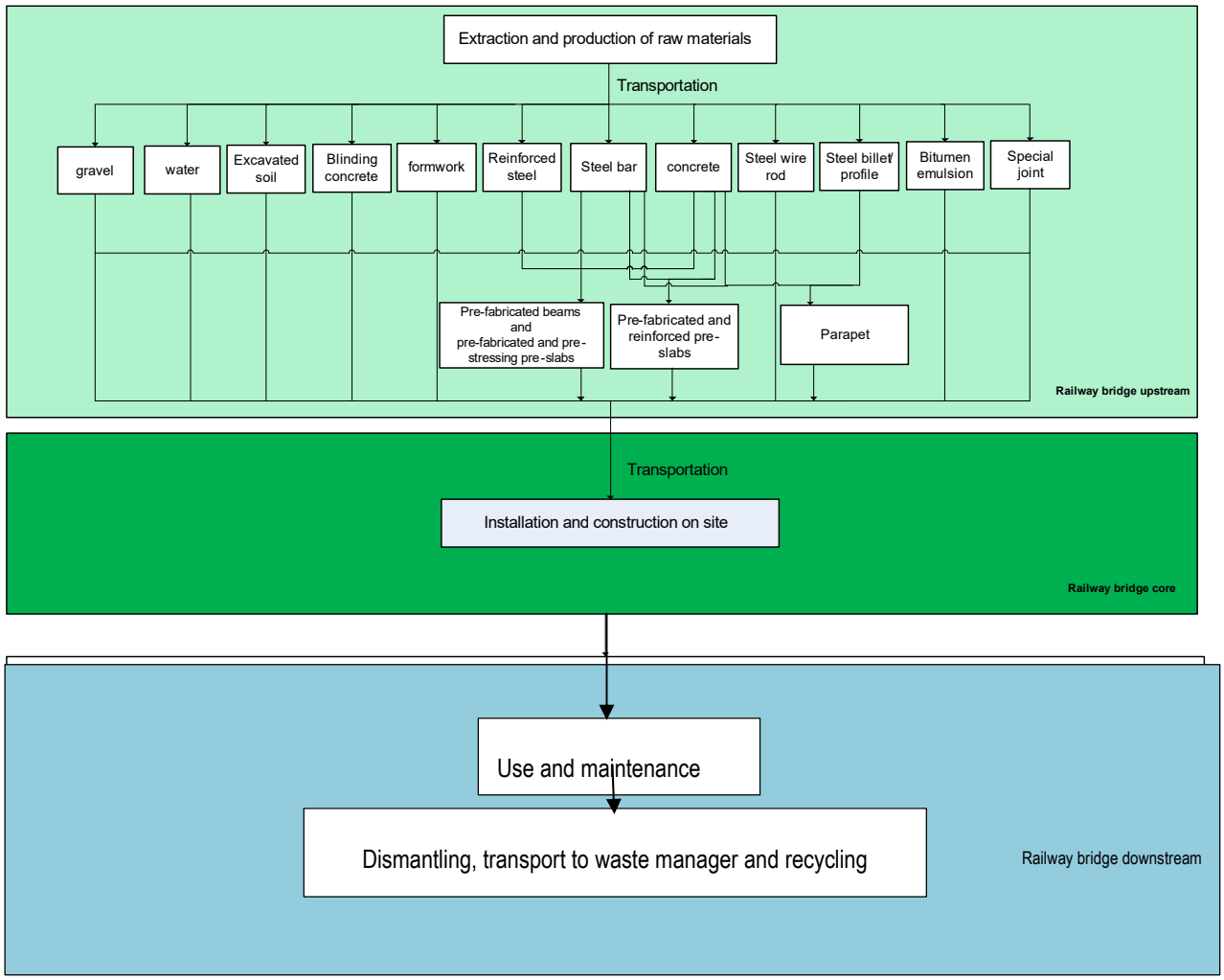
CO_2 sequestration due to concrete carbonatation during the use phase has been included. CO_2 release occurred during land deforestation needed for bridge construction has been taken into account, following the methodology described in EN 16757. The impact method CML IA v 3.05 has been used, together with AWARE 1.2 for water footprint calculation and GHG Protocol v 1.02 for carbon footprint calculation.

LCA of the railway bridge mainly consists of the production of different materials used and on-site construction of the bridge (including transport from production site to work area). The process of construction consists of many different small operations, which are listed below:

1. Construction of service roads
2. Execution of foundation
3. Shaft of piers and execution of abutments
4. Installation of pre-fabricated beams
5. Installation of pre-slabs
6. Construction of slab
7. Application of erosion protection (sealing)
8. Expansion joint
9. Construction of parapet

At least 99% of the total materials and energy consumption, and 95% of the materials and energy consumption by module have been included. The modularity principle, as well as the polluter payer principle have been followed. Where necessary, an allocation based on mass or labor hours has been performed.

An overview of system boundaries and included processes is given in the figure below.



6. CONTENT DECLARATION

Specific data regarding construction processes and quantities of raw materials and energy requirements was collected from the work site as well as manufactures and design project and draws.

During the life cycle of the product any hazardous substance listed in the "Candidate List of Substances of Very High Concern (SVHC) for authorization[1]" has been used in a percentage higher than 0.1% of the weight of the product. The verifier and the program operator do not make any claim nor have any responsibility of the legality of the product.

[1] https://echa.europa.eu/web/guest/candidate-list-table

Table 1. Materials for construction of 1km of "Arroyo Valchano" railway bridge per year.

concrete HA-30/B/20/IIa+Qa	39,59%
excavated soil	32,41%
gravel	25,36%
Steel (bars, reinforced, wire rod, billet,profiles)	2,07%
blinding concrete HL-150/B/20	0,54%
others (bituminous mixture, special joint)	**0,02%**
Total	

7. ENVIRONMENTAL PERFORMANCE

The environmental performance section of the declaration is based on a life cycle assessment (LCA) carried out by ACCIONA Construcción in 2020.

A full set of impact categories are calculated and the results are presented in Table 2. The results are given per 1 km of railway bridge and include construction, maintenance, operation and end of life per year of RSL (60 year).

As shown from the figure, the production of different materials (upstream) for the bridge is the most important factor for the overall environmental performance. The construction work and transports (core) play some role while operation activities are small. End of life has a small impact (100% landfill at end of life).

CO2 uptake in concrete during the use phase has been included. Based on EN 16757 standard, the calculation done is the next:

$$CO2\ uptake = k * \left(\frac{\sqrt{t}}{1000}\right) * Utcc * C + Dc$$

Where:

K (K factor, mm of carbonatation/year^{0,5})=1,1 for >35 MPa concrete exposed to rain

Utcc (maximum theorical uptake in g CO2/Kg of cement: the value is 0,49 for Portland cement (CEM I)

C (cement content in kg/m^3 of concrete): 315,34 Kg/m^3 in our case.

Dc (degree of carbonation): 85%

CO_2 uptake=1,1*(7,75/1000)*0,49*315,34*0,85=1,12 Kg/m^2 (60 years)

Table 2. Impact categories of 1 km of "Arroyo Valchano" railway bridge per year of RSL.

Impact categories	Unit	Upstream	Core	Downstream	Total	Module D
Global warming (GWP)-fossil	kg $CO_{2\ eq.}$	1,90E+05	2,18E+04	6,53E+03	2,19E+05	-6,13E+04
Global warming (GWP)-biogenic	kg $CO_{2\ eq.}$	9,42E+03	7,60E+01	3,13E+01	9,52E+03	7,40E+01
Global warming (GWP)-land use and land transformation	kg $CO_{2\ eq.}$	1,22E+02	4,46E+01	1,93E+01	1,29E+02	-1,09E+01
Global warming (GWP)-total	kg $CO_{2\ eq.}$	2,00E+05	2,19E+04	6,58E+03	2,29E+05	6,12E+04
Acidification potential (AP)	kg $SO_{2\ eq.}$	6,12E+02	1,02E+02	1,80E+01	7,32E+02	-2,31E+02
Eutrophication potential (EP)	Kg PO_4^{2-} eq.	1,02E+02	1,96E+01	2,60E+00	1,25E+02	-3,89E+01
Formation potential of tropospheric ozone (POCP)	Kg C_2H_4 eq.	6,09E+01	3,84E+00	1,05E+00	6,58E+01	-4,22E+01
Abiotic depletion potential-elements	Kg Sb-eq	4,69E-01	4,12E-02	1,98E-02	5,30E-01	-2,96E-01
Abiotic depletion potential-fossil fuels	MJ	1,48E+06	3,24E+05	1,03E+05	1,90E+06	-5,99E+05
Water scarcity potential	m^3	1,66E+05	1,60E+03	5,29E+02	1,68E+05	-2,08E+04

Table 3. Resource use categories of 1 km of "Arroyo Valchano" railway bridge per year of RSL.

Use of primary and secondary resources	Unit	Upstream	Core	Downstream	Total	Module D
Use of primary renewable energy resources used as energy carrier	MJ	5,02E+05	2,82E+03	1,09E+03	5,07E+05	-1,76E+04
Use of primary renewable energy resources used as raw materials	MJ	2,15E+05	0	0	2,15E+05	0
Total use of primary renewable energy resources	MJ	7,17E+05	2,82E+03	1,09E+03	7,22E+05	-1,76E+04
Use of primary non-renewable energy resources used as energy carrier	MJ	1,73E+06	3,49E+05	1,11E+05	2,19E+06	-6,05E+05
Use of primary non-renewable energy resources used as raw materials	MJ	0	0	0	0	0
Total use of primary non-renewable energy resources	MJ	1,73E+06	3,49E+05	1,11E+05	2,19E+06	-6,05E+05
Secondary material	kg	3,04E+04	0	0	0	7,96E+06
Renewable secondary fuels	MJ	0	0	0	0	0
Non-renewable secondary fuels	MJ	0	0	0	0	0
Net use of fresh water[2]	m^3	9,04E+03	5,06E+01	1,93E+01	9,09E+03	-4,58E+02

[2] Water used for turbine and refrigeration use in electricity production have not been included, since it is considered that the quality of the water before and after use is the same.

Table 4. Waste production categories of 1 km of "Arroyo Valchano" railway bridge per year of RSL.

Waste production	Unit	Upstream	Core	Downstream	Total	Module D
Hazardous waste disposed	Kg	6,72E+00	1,82E-01	6,55E-02	6,97E+00	-5,53E+00
Non-hazardous waste disposed	Kg	4,00E+05	9,36E+03	4,76E+03	4,14E+05	-1,15E+04
Radioactive waste disposed	Kg	5,96E+00	2,25E+00	7,06E-01	8,91E+00	-2,16E-01

Table 5. Output flows categories of 1 km of "Arroyo Valchano" railway bridge per year of RSL.

Output flows	Unit	Upstream	Core	Downstream	Total	Module D
Components for reuse	Kg	0	0	0	0	0
Material for recycling	Kg	0	0	7,96E+06	7,96E+06	0
Materials for energy recovery	Kg	0	0	0	0	0
Exported energy-electricity	Kg	0	0	0	0	0
Exported energy-thermal	Kg	0	0	0	0	0

As we can see in Figure 1, the impact of the life cycle of Arroyo Valchano bridge is dominated by Upstream module, since it represents at least 82% of the total impact for all impact categories under study. Core module presents a moderated impact, representing at least 6% of the total impact (except for water scarcity, where the impact is very low). Downstream module represents low impact, since it never represents more than 5% of the total impact. Module D presents significative environmental savings. Hence, the recycling of steel and concrete allows to save up to 64% of the total impact.

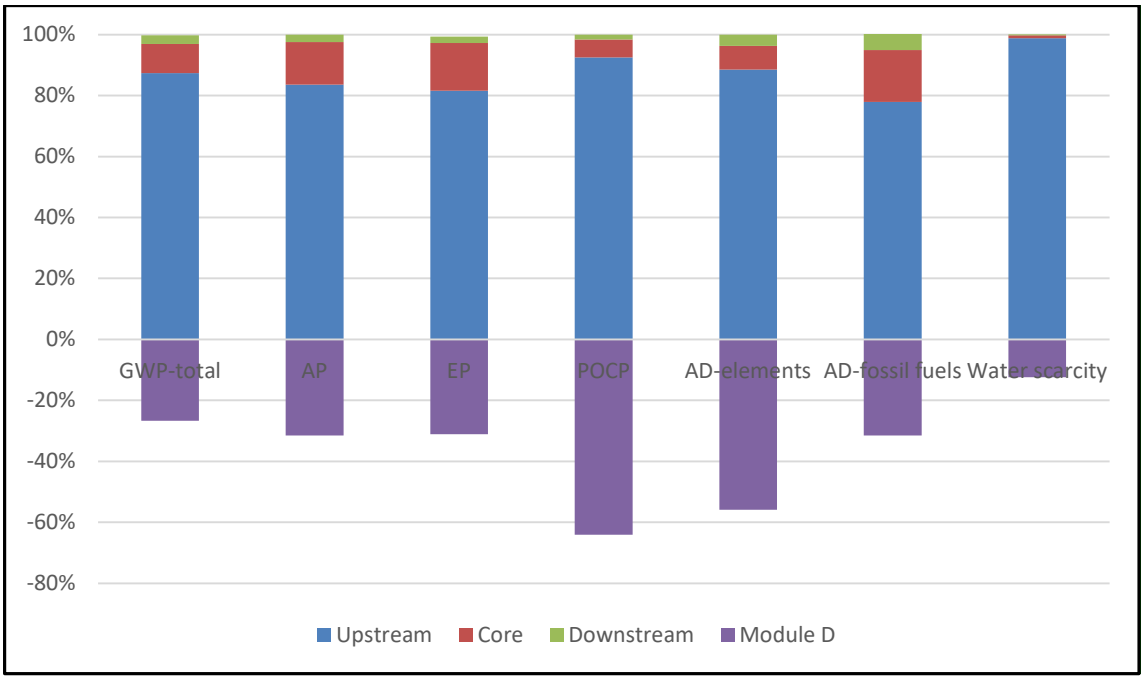


Figure 1. Relative impact of the life cycle stages of the life cycle of 1 Km of Arroyo Valchano bridge, per year of RSL.

8. EPD MODIFICATIONS REGARDING PREVIOUS VERSION

The EPD has been adapted to PCR 2018:01 Bridges, elevated highways and tunnels (v 1.12).

Maintenance, end of life and module D have been included. CO_2 uptake during the use phase has been included.

Description of the Company has been updated.

9. VERIFICATION AND CONTACT

- Owner of the declaration: Acciona Contrucción SA. Avenida de Europa 18. 28108 Alcobendas, Madrid (Spain).www.acciona.com
- Programme used: The International EPD® System. More information at www.environdec.com
- EPD prepared by: Andrea Casas Ocampo-Acciona Construcción LCA team
- Contact: Andrea Casas Ocampo. Email: andrea.casas.ocampo@acciona.com. Tlf: 91 791 20 99

"EPDs of construction products may be not comparable if they do not comply with EN 15804". "Environmental Product Declarations within the same product category from different programs may not be comparable".

Product category rules (PCR): PCR 2018:01 Bridges, elevated highways and tunnels, version 1.11. UN CPC 53221, 53222
PCR review was conducted by: The Technical Committee of the International EPD® System. Review chair: Andrew Norton Contact via info@environdec.com.
Independent third-party verification of the declaration and data, according to ISO14025:2010: ***EPD process certification*** ***EPD verification : X***
Third party verifier: ***Marcel Gómez Ferrer*** ***Marcel Gómez Consultoria Ambiental*** **www.marcelgomez.com** **Tlf 34630643593** ***info@marcelgomez.com*** ***Barcelona SPAIN*** ***Accredited by: "The International EPD® System"***
Procedure for follow-up of data during EPD validity involves third party verifier: ***Yes: X*** ***No***

10. REFERENCES

- PCR 2018:01 Bridges, elevated highways and tunnels, version 1.11. UN CPC 53221, 53222.
- ISO 14025: Environmental labels and declarations-Type III Environmental Declarations-Principles and procedures (2010)
- ISO 14040: Environmental management-Life Cycle Assessment-Principles and framework (2006)
- ISO 14044: Environmental management-Life Cycle Assessment-Requirements and guidelines (2006)
- EN 15804:2012+A1:2014 Sustainability of construction works – Environmental product declaration – Core rules of the product category of construction products
- EPD International (2017) General Programme Instructions for the International EPD® System. Version 3.0, dated 2017-12-11

- EN 16757:2018 Sustainability of Construction Works - Environmental Product Declarations - Product Category Rules for Concrete and Concrete Elements
- ISO 14046:2014, Environmental management – Water footprint – Principles, requirements and guidelines
- ISO 21930:2017, Sustainability in buildings and civil engineering works -- Core rules for environmental product declarations of construction products and services