EPD® – Environmental Product Declaration

The International EPD System. EPD International AB

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SHOTCRETE (B35 M45 E1000, B35 M45 E700, B35 M45) PRODUCED ON MossIA RAILWAY PROJECT

EN 15804+A1 and ISO 14025:2010 compliant

Registration number: S-P-03597

Publication date: 2021-05-10

Valid until: 2026-05-09

Scope of the EPD: International

Verification date: 2021-05-10

Version of the EPD: 1st

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 environmental impact of production of Shotcrete in MossIA railway project. The program operator of this EPD® is EPD International AB, Box 210 60, SE-100 31 Stockolm, Sweeden (www.environdec.com)

The EPD® covers shotcrete production only. It includes the modules *A1-A3 Production stage* (extraction and processing of raw materials, transportation up of raw material to the factory gate, and manufacturing of the Shotcrete). It is based on ISO standard 14025, this EPD® was drawn up in accordance with the Product Category Rules, UN PCR Construction products and construction services 2012:01, version 2.33 and PCR 2012:01-SUB-PCR-G concrete and concrete elements (EN 16757:2017).

The intended use of the EPD® is to communicate environmentally relevant information and LCA results to support the assessment of the sustainable use of resources and of the impact of construction works on the environment.

As this EPD® is based on data relating to MossIA railway project from 2020, the results might not be representative for the Shotcrete of other railway projects. EPD® of construction products may not be comparable if they do not comply with EN 15804+A1. Environmental Product Declarations within the same product category from different programs may not be comparable. In order to decide if the results can be representative for other railway project, the most important aspects that should be checked to be comparable with other Shotcrete are:

- Composition
- Origin of materials
- Shotcrete functionality
- The geographical representativeness of data

The owner of this EPD is MossIA ANS joint venture located at Dronningens gate 16. 1530 Moss, Norway. The geographical scope of this EPD is Norway.

2. DESCRIPTION OF THE COMPANY

MossIA ANS is a joint venture between Implenia Norge AS and ACCIONA Construction S.A. Implenia and ACCIONA are international leaders in sustainable infrastructure who have combined their resources in a fully integrated partnership to complete the railway between Sandbukta in the north and Såstad in the south.

MossIA ANS is organized as a responsible Norwegian company (ANS) and is located in Moss with a head project office in centrum and construction offices located at the following construction sites: Kransen, Carlberg, Verket and Larkollveien. As of today, MossIA has more than 220 employees represented by approximately 20 nationalities, and its workforce is comprised of approximately 30% female and 70% male employees.

Implenia is a contracting company specializing in complex infrastructure projects in Norway. Implenia Norway can demonstrate many years of experience and expertise in complex infrastructure projects across the country. The company offers services in road and groundwork, water and sewerage, concrete structures, bridges, tunnels and storage rooms, water and frost protection, mountain protection and environmental services.

ACCIONA is a leading provider of sustainable infrastructure solutions and renewable energy projects worldwide. The service offering

encompasses the entire value chain, from design and development to operation and maintenance. The company is present in over 40 countries and is committed to contributing to economic and social development in the communities in which it operates. ACCIONA is a leader in the transition to a low-carbon economy by working on quality and innovation process criteria, thus achieving efficient use of resources and environmental considerations in all its projects.

3. DESCRIPTION OF THE SHOTCRETE

This EPD® refers to Shotcrete fabricated and used by MossIA ANS at the Bane NOR Intercity (SMS 2A) Railway Project. It is a double rail project through and under the municipality of Moss in Norway. It consists of 2 tunnels: under Moss (2.7 km), and from Moss station to Carlberg (2.3 km); Moss Station (800m); 2 significant culverts: Kransen and Carlberg; and 10 km demolition of the existing tracks. The shotcrete for rock support requires certain properties of strength, durability and minimum energy absorption. Its thickness is variable, and it depends on the type and quality of the rock mass. The material composition and design are suitable for the area of application to ensure that the reinforcement and fixing details are properly grouted. The material composition has reduced shrinkage properties. Due to technical requirements mentioned before, three dosages of shotcrete were developed and analyzed. The strength of different dosages of shotcrete was determined conforming to EN 12390-1, EN 12390-2, EN 12350-1 and NS-EN 206. The required compressive strength for cored samples converted to cylinders H/D=2.0 is specified by NS-EN 13791 to be 85% of the required characteristic strength. The shotcrete has a B35 strength class and 2.31 Ton/m^3 of density.

The life expectancy of the tunnel as well as the studied Shotcrete is at least 150 years taking into account technical requirements specified on the MossIA project.

Regarding to production process, there are two twins independent batching plants to produce concrete and shotcrete for the project. There is also a shed to store the aggregates and protect them against the weather. For producing shotcrete, all raw materials are mixed on the concrete plant, taking into account dosages determined on laboratory tests. Shotcrete produced is trucked to the tunnel for the application

4. FUNCTIONAL UNIT

According to construction products PCR Construction products and construction services 2012:01, version 2.33 and PCR 2012:01-SUB-PCR-G concrete and concrete elements (EN 16757:2017), the Declared Unit provides a reference by means of which the material flows of the information module of a construction product are normalized to produce data, expressed on a common basis. The Declared Unit of this EPD is 1 m^3 of shotcrete with a B35 strength class and 2.31 Ton/m^3 of density.

5. SYSTEM BOUNDARIES AND DATA QUALITY

Life cycle stages and information modules are defined in the standard EN 15804+A1. This "Cradle-to gate" LCA analysis includes only upstream module *(A1-A3 Production stage) as is shown in Figure 2*. This EPD considers extraction and processing of raw materials, transportation up of raw material to the factory gate, and manufacturing of the Shotcrete according to PCR PCR Construction products and construction services 2012:01, version 2.33 and PCR 2012:01-SUB-PCR-G concrete and concrete

elements (EN 16757:2017). The impact method CML 2001 (updated in January 2016) has been used. This model is an LCA methodology developed by the Center of Environmental Science (CML) of Leiden University in the Netherlands.

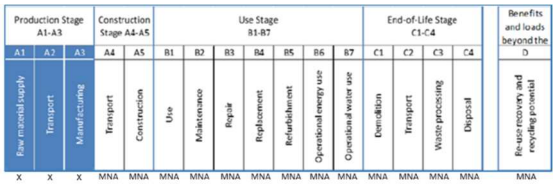

Figure 1. Stages of the LCA according to EN15804

At least 99% of the total materials and energy consumption, and 95% of the materials and energy consumption by stage have been included. The substances contained in the product that are listed in the "Candidate List of Substances of Very High Concern (SVHC) for authorization"1 do not exceed 0,1% 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.

The electricity used comes from Norway national grid in 2020 is composed of 96.2% hydropower, 1.4%wind power, 1.8% natural gas, 0.3% waste, 0.2 hard coal and 0.1% others. [database 2019, GaBi software]. The contribution to global warming of the Norwegian gas is 0.031 kg CO_2 equiv./kWh.

The time coverage for data collection is one year. The geographical system boundary is Norway. All processes are valid for the production sites in Norway. An overview of system boundaries and included processes are given in Figure 2.

Where necessary an allocation based in mass has been applied. Both the polluter payer and modularity principles have been followed.

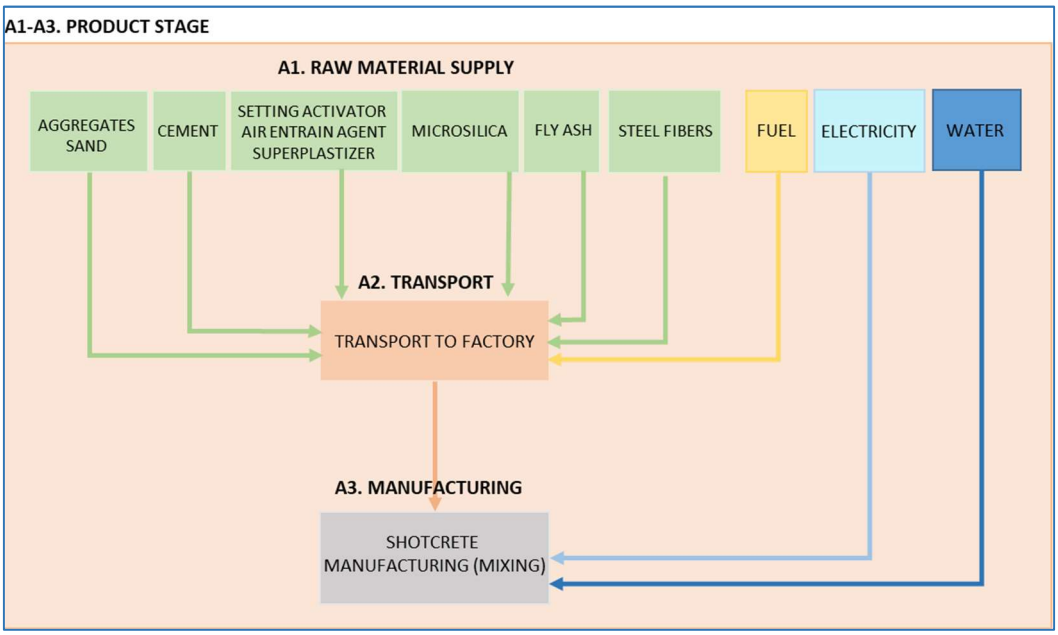

Figure 2. System boundaries of the production of the 1 m^3 of shotcrete

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

6. CONTENT DECLARATION

Specific data regarding Shotcrete production, origin and quantities of raw materials as well as energy requirements were collected from the work site. All available data were considered for the LCA assessment of the production stage (A1-A3) of the Shotcrete. The material and energy flows are presented by all raw materials, and electric power consumption. Environmental information from EPDs listed below was taking into account in LCA analysis. For such indicators that are not included in the EPDs, environmental impacts were determined using Gabi Database.

- NEPD-2275-1028-NO.Norcem Standardsement FA, Brevik - CEM II/B-M 42.5 R. EPD NORGE
- NEPD-1383-447-NO. Steelfibre (DE 35/0.55 DE 50/0.75 og DE 50/1.0). Mapei AS. EPD NORGE
- EPD-EFC-20150091-IAG1-EN. Concrete admixtures, Plasticisers and Superplasticisers. EFCA
- EPD-EFC-20150086-IAG1-EN. Concrete admixtures – Air entrainers. EFCA

The same applies to the transport A2 - from the factory of raw materials to the factory of Shotcrete, located at Bane NOR Intercity (SMS 2A) -. All these data are owned and provided by MossIA ANS. All necessary background data relevant for modelling of the production process were taken from database within *GaBi ts 2020* (GaBi Software-System and Database). The geographical representativeness of data reflects the region where the production is located, Norway in this case. Energy consumption was determined taking into account the real consumption of the plant for producing 1m3 of shotcrete.

This EPD includes three different dosages of shotcrete that will be used in MossIA project. Life cycle inventory (LCI) includes the main raw materials used in each case. The weight of raw materials of all dosages included is given in the table below:

Table 1. Required raw materials for production of 1 m³ of Shotcrete

COMPONENTS	WEIGHT (%)
Cement	18 - 21
Silica dust	0.6 - 0.8
Sand	68 - 71
Steel fiber	0 - 2
Additives	0,2 - 0,4
Water	8 - 10

Flows related to human activities such as employee transport are excluded. The construction of plants, production of machines and transportation systems are excluded since the related flows are supposed to be negligible compared to the production of the shotcrete when compared at these systems lifetime level.

7. ENVIRONMENTAL PERFORMANCE

The environmental performance section of the declaration is based on data provided by MossIA referring to 2020. Environmental potential was assessing according to EN 15804+A1 PCR Construction products and construction services 2012:01, version 2.33 and PCR 2012:01-SUB-

PCR-G concrete and concrete elements (EN 16757:2017). The results are given per 1 m3 of shotcrete and include only production stage module. The indicators presented in the table below were evaluated via GaBi ts software and taking into account, EPDs mentioned in content declaration part. Results of LCA analysis are presented in the following table.

Estimated impact results are only relative statements which do not indicate the end points of the impact categories, exceeding threshold values, safety margins or risks.

Table 2: LCA results: Environmental Impacts for 1m³ of Shotcrete

PARAMETER	UNIT	SHOTCRETE B35 M45 E1000				SHOTCRETE B35 M45 E700				SHOTCRETE B35 M45			
Environmental Impact (CML 2001 - Jan. 2016)		A1	A2	A3	A1-A3	A1	A2	A3	A1-A3	A1	A2	A3	A1-A3
Abiotic Depletion (ADP elements)	kg Sb eq.	2,45E-04	1,32E-06	1,56E-06	2,48E-04	1,79E-04	1,28E-06	1,56E-06	1,82E-04	4,26E-05	1,18E-06	1,56E-06	4,54E-05
Abiotic Depletion (ADP fossil)	MJ	1,09E+03	2,13E+02	8,31E+00	1,31E+03	9,79E+02	2,06E+02	8,31E+00	1,19E+03	7,44E+02	1,90E+02	8,31E+00	9,43E+02
Acidification Potential (AP)	kg SO_2 eq.	2,08E-01	2,00E-02	7,80E-04	2,29E-01	1,91E-01	1,73E-02	7,81E-04	2,09E-01	1,56E-01	1,19E-02	7,80E-04	1,69E-01
Eutrophication Potential (EP)	kg Phosphate eq.	1,86E-01	4,37E-03	1,40E-04	1,90E-01	1,38E-01	3,75E-03	1,40E-04	1,42E-01	3,86E-02	2,47E-03	1,40E-04	4,13E-02
Global Warming Potential (GWP 100 years)	kg CO_2 eq.	3,09E+02	1,57E+01	1,12E+00	3,26E+02	3,00E+02	1,52E+01	1,12E+00	3,16E+02	2,80E+02	1,40E+01	1,12E+00	2,95E+02
Ozone Layer Depletion Potential (ODP, steady state)	kg CFC11 eq.	4,59E-06	2,57E-15	1,09E-14	4,59E-06	3,60E-06	2,48E-15	1,09E-14	3,60E-06	1,55E-06	2,30E-15	1,09E-14	1,55E-06
Photochem. Ozone Creation Potential (POCP)	kg Ethene eq.	1,72E-02	3,00E-04	6,58E-05	1,76E-02	1,41E-02	7,37E-05	6,59E-05	1,43E-02	7,66E-03	-3,97E-04	6,58E-05	7,33E-03
Resource use													
Use of renewable primary energy (PERE)	MJ	1,21E+01	1,20E+01	1,58E+02	1,82E+02	1,21E+01	1,16E+01	1,58E+02	1,82E+02	1,22E+01	1,07E+01	1,58E+02	1,81E+02
Use of primary renewable energy resources used as raw materials	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	0,00E+00	0,00E+00	0,00E+00
Total use of renewable primary energy resources (PERT)	MJ	1,21E+01	1,20E+01	1,58E+02	1,82E+02	1,21E+01	1,16E+01	1,58E+02	1,82E+02	1,22E+01	1,07E+01	1,58E+02	1,81E+02
Use of non-renewable primary energy (PENRE)	MJ	7,89E+01	2,14E+02	1,19E+01	3,05E+02	7,90E+01	2,06E+02	1,19E+01	2,97E+02	7,93E+01	1,91E+02	1,19E+01	2,82E+02
Use of primary non-renewable energy resources used as raw materi	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	0,00E+00	0,00E+00	0,00E+00
Total use of non-renew. primary energy resources (PENRT)	MJ	7,89E+01	2,14E+02	1,19E+01	3,05E+02	7,90E+01	2,06E+02	1,19E+01	2,97E+02	7,93E+01	1,91E+02	1,19E+01	2,82E+02
Use of renewable secondary fuels (RSF)	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	0,00E+00	0,00E+00	0,00E+00
Use of non renewable secondary fuels (NRSF)	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	0,00E+00	0,00E+00	0,00E+00
Secondary materials	Kg	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	0,00E+00	0,00E+00	0,00E+00
Use of net fresh water (FW)	m^3	3,60E+00	1,39E-02	4,40E-01	4,05E+00	2,48E+00	1,34E-02	4,41E-01	2,93E+00	1,55E-01	1,24E-02	4,40E-01	6,08E-01
Waste categories													
Hazardous waste disposed (HWD)	kg	7,23E-04	9,95E-06	1,22E-08	7,33E-04	5,41E-04	9,60E-06	1,22E-08	5,51E-04	1,61E-04	8,89E-06	1,22E-08	1,70E-04
Non-hazardous waste disposed (NHWD)	kg	1,10E+02	3,27E-02	1,26E-01	1,11E+02	1,04E+02	3,16E-02	1,26E-01	1,04E+02	9,02E+01	2,92E-02	1,26E-01	9,04E+01
Radioactive waste disposed (RWD)	kg	9,10E-03	2,65E-04	1,48E-03	1,08E-02	9,10E-03	2,55E-04	1,48E-03	1,08E-02	9,13E-03	2,36E-04	1,48E-03	1,08E-02

Table 3. Output flows categories of 1 m3 of shotcrete

OUTPUT FLOWS	UNIT	A1-A3
Components for reuse	kg	0
Material for recycling	kg	0
materials for energy recovery	kg	0
Exported energy-electricity	kg	0
Exported energy-thermal	kg	0

As it can be seen in Table 2, the impact of the LCA of 1m³ of Shotcrete is mainly dominated by stage A1 –Raw material supply-. This contributes with nearly 70-100% to the total environmental impacts for the three dosages of the Shotcrete included in this EPD.

Global Warming Potential (GWP 100 years) is higher on dosage 1, but the difference between dosages included in this EPD is lower than 9.3%.

Three dosages of shotcrete included in this analysis were developed taking into account the compromise of MOSSIA project for reducing environmental impacts in the concrete production. Since Global Warming Potential (GWP 100 years) point of view, it was possible to reduce CO_2 emissions not only using alternative materials but also applying all knowhow of the MOSSIA project for re-formulating a more sustainable shotcrete.

8. VERIFICATION AND CONTACT

Table 3: Verification information

ISO standard ISO 21930 and CEN standard EN15804 serves as the core Product Category Rules (PCR)
Product Category Rules (PCR): *PCR Construction products and construction services 2012:01, version 2.33* *PCR 2012:01-SUB-PCR-G concrete and concrete elements (EN 16757:2017)*
PCR review was conducted by: *The technical Committee of the International EPD® System. See www.environdec.com for a list of members. Review chair: Massimo Marino. contact via info@environdenc.com*
Independent third-party verification of the declaration and data, according to ISO 14025:2006 ☐ *EPD process certification* ☒ *EPD verification*
Third-party verifier: *Marcel Gómez Ferrer* *Marcel Gómez Ferrer Consultoría Ambiental* www.marcelgomez.com info@marcelgomez.com Barcelona SPAIN *Approved by:* *The International EPD® System.* Technical Committee, supported by the Secretariat

Table 4: Contact information

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9. REFERENCES

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- EFCA. EPD-EFC-20150086-IAG1-EN. Concrete admixtures – Air entrainers.
- EN 15804:2012+A1 Sustainability of construction works. Environmental product declaration. Core rules of the product category of construction products.
- EN 16757:2018 Sustainability of Construction Works - Environmental Product Declarations - Product Category Rules for Concrete and Concrete Elements
- ISO 14020:2000 Environmental labels and declarations. General principles.
- ISO 14025:2006 Environmental labels and declarations-Type III Environmental Declarations-Principles and procedures.
- ISO 14040:2006 Environmental management-Life Cycle Assessment-Principles and framework.
- ISO 14044:2006 Environmental management-Life Cycle Assessment-Requirements and guidelines.
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- Mapei AS. NEPD-1383-447-NO. EPD NORGE Steelfibre (DE 35/0.55 DE 50/0.75 og DE 50/1.0).
- PCR 2012:01-SUB-PCR-G concrete and concrete elements (EN 16757:2017)
- PCR Construction products and construction services 2012:01, version 2.33