EPD® – Environmental Product Declaration

READY-MIX CONCRETE FCK 55 MPa for Follo Line Project “Railway Tunnel”

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PCR UN CPC 375 Concrete 2013:02 V 1.02

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1. INTRODUCTION

Mandatory statements of environmental product declaration (EPD®) describes, from a lifecycle perspective, the total environmental impact of a "Ready-mix concrete" included in the twin railway tunnels that connect the cities of Oslo and Ski, establishing a central axis for interurban development to the south of the Norwegian capital. The goal of this study is to provide information regarding the environmental impact of the Ready-mix concrete fabricated and used by the alliance between ACCIONA Construction and Ghella within the Joint Venture AGJV, for the Follo Line Project (Norway). The program operator of this EPD® is The International EPD® System.

The EPD® covers "Ready-mix concrete" including A1: Raw materials (Extraction and processing of raw materials), A2: Transport (Transportation up of raw material to the factory gate) and A3: Manufacturing (Manufacturing of the Ready-mix concrete. Related packaging please see chapter 7 Content declaration). Within the International EPD® system based on ISO standard 14025, this EPD® was drawn up in accordance with Product Category Rules (PCR) *UN CPC 375 Concrete 2013:02 Version 1.02* [1] (See www.environdec.com for further information about the EPD® system) and with CEN standard 15804 (Sustainability of construction works) [2]. The data used for the production stage of the product are average values of the three concrete plants located on site, gathered during one year factory analysis.

The intended use of this 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.

This EPD® was developed by AGJV and has been verified by Marcel Gómez Ferrer, individual verifier. The certification is valid internationally and for a five years period.

As this EPD® is based on data related to Follo Line railway tunnels during 2017, the results might not be representative for the Ready-mix concrete of other railway tunnels. EPD® of construction products may not be comparable if they do not comply with EN 15804. 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 tunnels, the most important aspects that should be checked to be comparable with other Ready-mix concrete are:

- Composition
- Origin of materials
- Ready-mix concrete functionality
- The geographical representativeness of data

2. DESCRIPTION OF THE COMPANY

The Spanish company Acciona and Italian Ghella have joined forces and established AGJV, an innovative company with extensive international tunnel experience.

Acciona Ghella Joint Venture is commissioned by the Norwegian government's agency for railway services (Bane NOR) to construct the main part of the tunnel at the Follo Line (EPC TBM). The company is located at the construction site at Åsland in Oslo, and started up in 2015. The project will be finalized in 2021, and includes Scandinavia's longest railway tunnel.

3. DESCRIPTION OF THE READY-MIX CONCRETE

This EPD® refers to ready-mix concrete fabricated by AGJV at Follo Line Project. This project is the biggest rail project in Norway, and consists of two twin rail tunnels, each 19.5km long with an inside diameter of 8.8 meters, that will connect the cities of Oslo and Ski, establishing a central axis for interurban development to the south of the Norwegian capital. Designed for trains traveling at 250km/h, connecting the inhabitants of the two cities, the tunnels are being excavated simultaneously by four huge, double shield tunnel boring machines (TBMs).

Ready-mix concrete is fabricated in the three concrete factories located at Äsland in Norway and is used for TBM segments produced in these same factories. The project will comprise a 20 km long tunnel which will be Norway's first long twin tube rail tunnel. The life expectancy of the tunnel will be at least 100 years.

This Ready-mix concrete is intended to meet the requirements of the Jernbaneverket template for Environmental Accounts in Norway. This EPD® covers all the batches of Ready-Mix Concrete produced by the three factories at Äsland with care for sustainable development principles.

Figure 1. Ready-mix concrete plant.

4. FUNCTIONAL UNIT

The studied Ready-mix concrete is being used in the Follo Line railway tunnel (Norway). A Functional Unit is a concept used to compare the life cycle results of different products on a like-for-like basis. In this case, the declared unit for the EPD® is 1 cubic meter (1000 l and 2432.93 kg at density 2, 43 t/m^3) of average Ready-mix concrete. The characteristic strength of the Ready-mix concrete obtained is 55 MPa measured with cylindrical test.

5. SYSTEM BOUNDARIES AND DATA QUALITY

Life cycle stages and information modules are defined in the standard EN 15804, Figure 2. It must be highlighted that raw materials, transport and manufacturing processes are included in the LCA calculations, and core modules according to PCR. This "Cradle-to gate" LCA analysis includes modules A1- A3, as an aggregated module, where the following stages are included: A1-Extraction and processing of raw materials, A2-Transportation up of raw material to the factory gate, and A3-Manufacturing of the Ready-mix concrete. Construction, Use and End of life stages of the Ready-mix concrete, have not been taken into account during the analysis. Following PCR *UN CPC 375 Concrete 2013:02 Version 1.02*. Rules, 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.

It must be noted that at least 99% of materials and energy requirements for the life cycle have been considered. The substances contained in the product that are listed in the "Candidate List of Substances of Very High Concern (SVHC) for authorization" do not exceed 0,1% weight of the product. The time coverage for data collection is one year.

During this year, data from the three factories has been gathered. 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 3.

Production Stage A1-A3			Construction Stage A4-A5		Use Stage B1-B7							End-of-Life Stage C1-C4				Benefits and loads beyond the
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport	Construction	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Demolition	Transport	Waste processing	Disposal	Re-use recovery and recycling potential

Figure 2. Stages of the LCA according to EN15804[2].

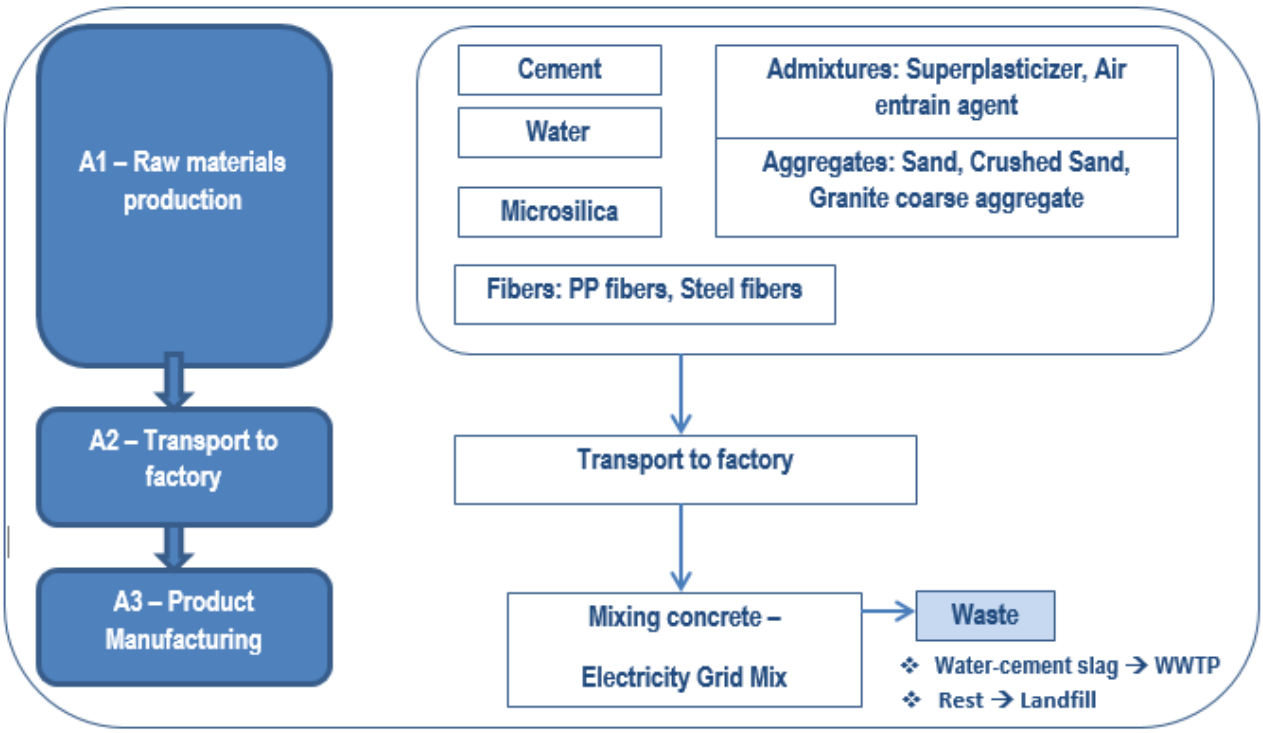

Figure 3. Flow chart of the product system for Ready mix-concrete.

6. CONTENT DECLARATION

The data used for the production stage of the product are average values of the three concrete plants (Figure 4), gathered during one year factory analysis.

The process of the Ready-mix concrete production consists of the steps that are listed below:

1. Dose aggregates
2. Dose cement + Silica fume
3. Dose water
4. Dose admixtures
5. Dose fibers
6. Mix in SUN 3001

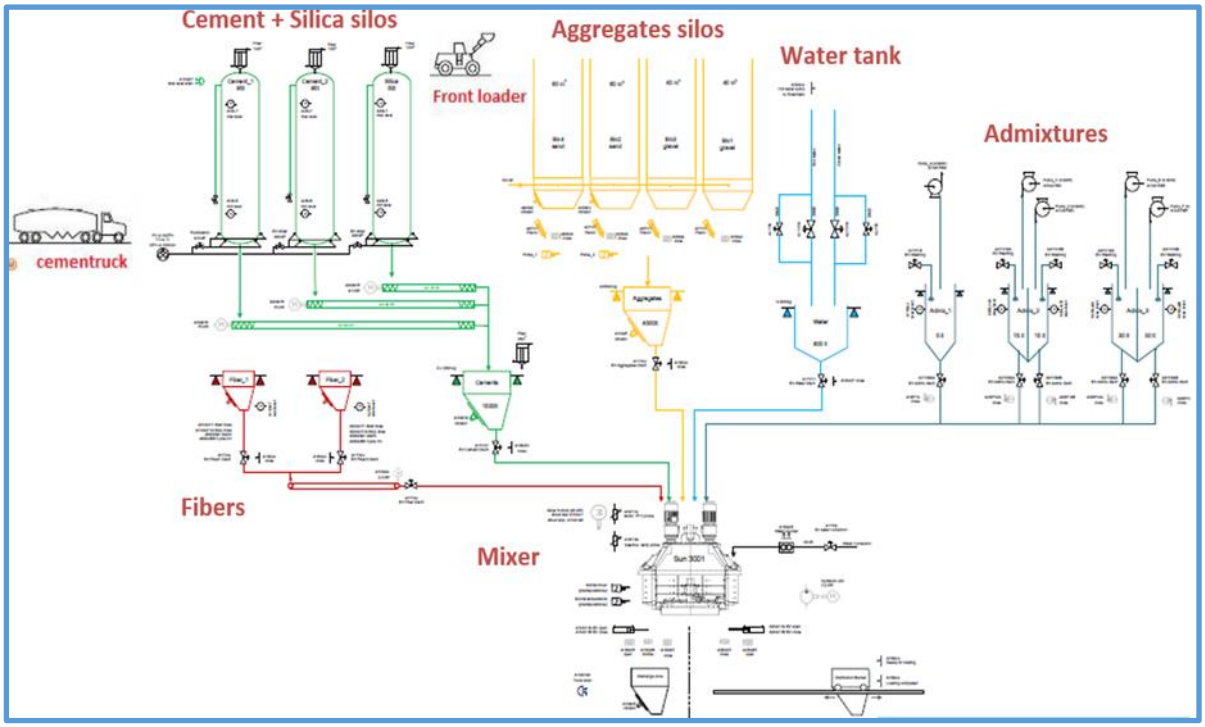

Figure 4. Ready mix-concrete production flow.

The dosage for the three different concrete plants remains the same. However the provider of the additives is different in the three plants. It can be assumed that the impact will remain the same for the three concrete plants and the model can be simulated as one concrete plant with the distance of the trucks from the two different additive providers to worksite assumed as average value for the LCA model. Company and production specific data are applied in the foreground system of the LCA.

In the assessment of the production stage (A1-A3), all available data from production, regarding raw materials and manufacturing are considered. The material and energy flows are presented for all raw materials and electric power consumption. The PCR on concrete [1] states that the production of blast furnace sludge, fly ash, silica fume and artificial gypsum can be excluded from the analysis when the origin of the materials is Europe.

The only materials supplied in packaging are fibers. They are contained in polypropylene big bags of 150 kg weight. Two big bags contribute to the total amount of raw materials in 0.12%. Thus, packaging contributes less than 1% to the total weight module and it is not expected to have a major environmental impact. According to the standard [2] and PCR [1], it can be excluded from the study.

Finally, the wastes generated in the production of Ready-mix concrete are measured daily. The average production for one factory is around 300m^3 of concrete, of which 0, 5 m^3 is waste. This means that 0, 16% of the total concrete weight is waste. This waste is separated into water-cement sludge, aggregates and reinforcement steel. The sludge is treated in a waste water treatment plant while the aggregates and reinforcement steel are sent to landfill. Thus, as occurred with packaging, concrete waste contributes less than 1% to the total weight and it is not expected to have a major environmental

impact. According to the standard [1] and PCR [1], it can be excluded from the study.

Table 1, lists the materials not included in the product system under study. In total 0.90 % of materials are excluded due to cut-off. This is less than 5 % which is the total threshold defined by the underlying PCR [1]. Silica fume is excluded due to specific statements in the PCR [2]. While the production of this material is excluded, the material itself is part of the calculation. All process data are owned by AGJV.

Table 1: Materials excluded from the product system

Material	Weight [%]	Reason for exclusion	Process
Silica Fume	0.62	PCR rules	Cement production
Big bags	0.12	PCR rules	Packaging
Concrete wastes	0.16	PCR rules	Cement production

All necessary background data relevant for modelling of the production process were taken from database within *GaBi ts 2017* (GaBi Software-System and Database) [8]. Life cycle inventory (LCI) gathering the main raw material used in each stage is given in the table below:

Table 2: Required raw materials for production of 1 m^3 of Ready-mix concrete.

Component	Weight [%]
Cement	13-16
Microsilica	0.4-0.7
Sand	17-20
Crushed sand	11-14
Coarse aggregate	8-11
Coarse aggregate	32-35
Water	3-6
Superplasticizer	0.1-0.4
Air entrain agent	0.1-0.4
Polypropylene fibers	0.02-0.05
Steel fibers	0.6-0.9
TOTAL	**100**

Electricity was considered applying data for the Norwegian electricity mix. Electricity used for production of 1m^3 of the Ready-mix concrete: 9.87 kWh/m^3.

Some assumptions for the following data are: The characteristic strength of the Ready-mix concrete obtained is 55 MPa. The environmental exposures (exposure classes) anticipated for the Ready-mix concrete is according with the results. Primary data for the steel fibers was not available from supplier. However, they reported some technical specifications that helped to reproduce the production process for the fibers in GaBi Software,

since no exact dataset was available in AGJV owned databases.

7. ENVIRONMENTAL PERFORMANCE

The environmental performance section of the declaration is based on a life cycle assessment (LCA) carried out by AGJV in 2017. In order to assess the environmental potential according to EN 15804 [2] and PCR "*UN CPC 375 - Concrete*" [1] the most, related to the Ready-mix concrete, the indicators presented in the table below were evaluated via GaBi ts software. Results of LCA analysis are presented in Table 4.

Table 4: LCA results: Environmental Impacts for 1m³ of average Ready-mix concrete.

Parameter	Unit	Production stage
		A1-A3
Environmental impact *(according to CML2001-Jan.2016)*		
Global warming potential	kg CO_2-eq	361,20
Depletion potential of the stratospheric ozone layer	kg CFC11-eq	1,31E-06
Acidification potential of soil and water	kg SO_2-eq	0,69
Eutrophication potential	kg PO_4-eq	0,15
Formation potential of tropospheric ozone	kg ethene-eq	0,06
Abiotic depletion potential for non-fossil resources	kg Sb-eq	1E-04
Abiotic depletion potential for fossil resources	MJ, net calorific value	2764,32
Resource use		
Renewable primary energy excluding renewable primary energy resources used as raw materials	MJ, net calorific value	450,32
Renewable primary energy resources as raw material	MJ, net calorific value	0

Total use of renewable primary energy resources	MJ, net calorific value	450,32
Non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	MJ, net calorific value	3182,88
Non-renewable primary energy as raw material	MJ, net calorific value	0
Total use of non-renewable primary energy resources	MJ, net calorific value	3182,88
Use of secondary material	kg	80,59
Use of renewable secondary fuels	MJ, net calorific value	0
Use of non-renewable secondary fuels	MJ, net calorific value	484,06
Use of net fresh water	m3	1,03
Waste to disposal		
Hazardous waste disposed	kg	0,03
Non-hazardous waste disposed	kg	34,60
Radioactive waste disposed	kg	0,05

Figure 5 shows how upstream processes (A1) contribute with nearly 85-100% to the total environmental impacts.

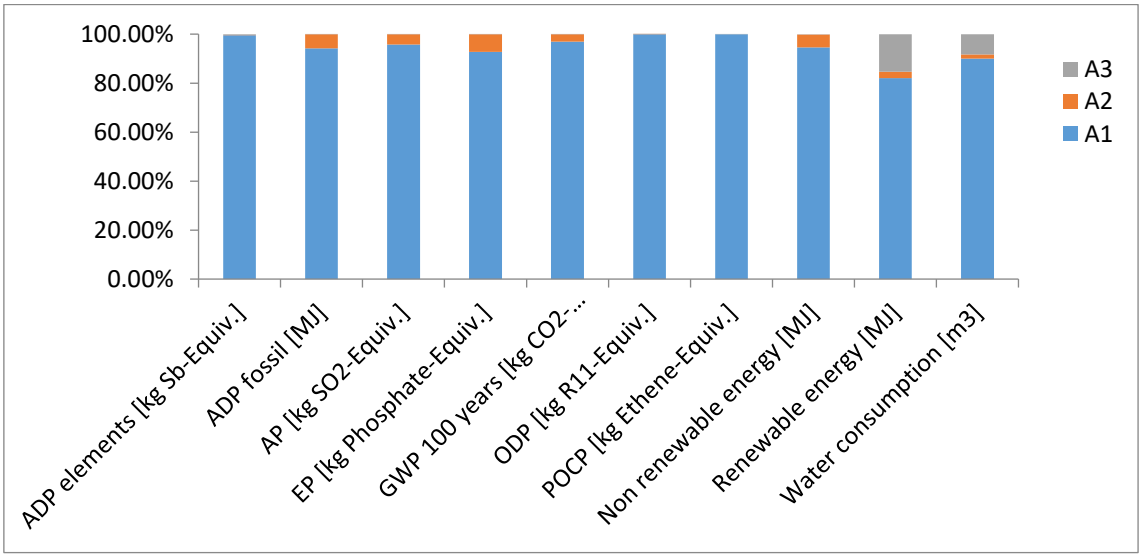

Figure 5. Dominance analysis according to different modules (A1, A2 and A3).

8. VERIFICATION AND CONTACT

Table 5: Demonstration of verification

CEN standard EN 15804 served as the core PCR *The PCR 2013:02 for UN CPC 375 serves as the specific PCR for this EPD®* *Product Category Rules (PCR) review was conducted by the Technical Committee of the International EPD®* System. Chair: Massimo Marino. Contact via info@environdec.com
Independent verification of the declaration, according to ISO 14025:2006 ☐ *internal* ☒ *external*
Independent Verifier: *Marcel Gómez Ferrer* *Marcel Gómez Ferrer Consultoría Ambiental* www.marcelgomez.com info@marcelgomez.com Barcelona SPAIN *Approved by:* *The International EPD® System.* Operated by EPD® International AB, www.environdec.com, Sweden.

Table 6: Contact

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9. REFERENCES

- [1] PCR 2013:02 UN CPC 375 “Concrete” Version 1.02.
- [2] EN 15804:2012 Sustainability of construction works. Environmental product declaration. Core rules of the product category of construction products.
- [3] ISO 14020:2000 Environmental labels and declarations. General principles.
- [4] ISO 14025:2006 Environmental labels and declarations-Type III Environmental Declarations-Principles and procedures.
- [5] ISO 14040:2006 Environmental management-Life Cycle Assessment-Principles and framework.
- [6] ISO 14044:2006 Environmental management-Life Cycle Assessment-Requirements and guidelines.
- [7] ISO 21930:2007 Sustainability in building construction. Environmental declaration of building products.
- [8] GaBi ts 2017. GaBi Software-System and Database for Life Cycle Engineering. Thinkstep AG.
- [9] EPD® CEM II, Anlegg FA og Standard FA Sement (ISO 14025; ISO 21930; EN15804). Norcem AS.
- [10] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (Reach). Research Innovation

10. CHANGES FROM THE PREVIOUS VERSION OF THE EPD

This EPD has been modified from revision 2020-11-06 in the following points:

1. The company description has been changed from ACCIONA to ACCIONA GHELLA JOINT VENTURE
2. The logo of the company has been modified
3. The index has been updated