BRIDGES IN A CIRCULAR ECONOMY

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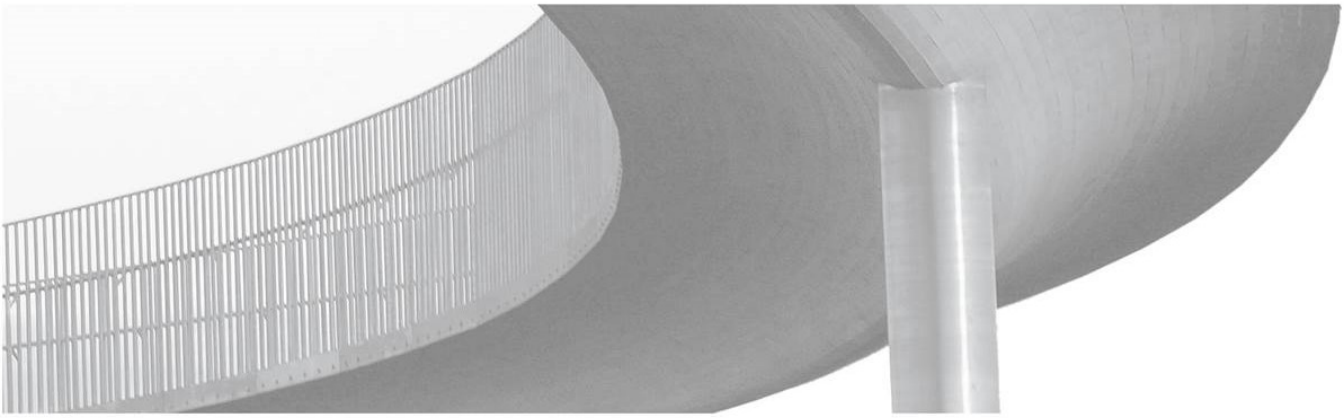

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PROJECT MANAGER – EFLA	**PROJECT**
Magnús Arason	Bridges in a circular economy
CUSTOMER REPRESENT.	**CUSTOMER**
Ólafur Sveinn Haraldsson	Icelandic Road and Coastal Administration Research Fund
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EXTRACT

This report builds upon the groundwork laid in the previous collaboration report between EFLA and Arup, demonstrating the practical application of the Circular Design Framework for bridges. The focus lies in devising a bridge design that aligns with circular economy principles while catering to the unique requirements of the Icelandic market with a spotlight on the “Design for Disassembly” strategy.

The circular economy emphasizes resource efficiency and minimizing waste. While sustainability considers environmental impacts holistically, circularity focuses on material flows and longevity. The purpose of this research is to investigate how circular design principles can be incorporated into bridge infrastructure. More specifically, how bridge infrastructure can be designed for disassembly.

To evaluate the circular bridge design and concept, a comparison is made to a conventional Icelandic bridge using two critical indicators: Material Circularity Indicator (MCI) and Environmental Cost Indicator (ECI). MCI is a metric that gauges how efficiently materials flow through a reuse and/or recycle system, while ECI considers the full lifecycle impact by assessing the environmental cost in carbon dioxide or cost.

The comparison and analysis investigate two bridge lifespans, revealing a modest difference in environmental impact between the circular alternative (a precast girder bridge) and the conventional Icelandic bridge design. While the circular design shows promise through a reduction in environmental cost and improvement in material circularity, further investigation is required to verify its feasibility.

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Summary

This report builds upon the groundwork laid in the previous collaboration report between EFLA and Arup, demonstrating the practical application of the Circular Design Framework for bridges. The focus lies in devising a bridge design that aligns with circular economy principles while catering to the unique requirements of the Icelandic market with a spotlight on the "Design for Disassembly" strategy.

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Drawing inspiration from Dutch methodologies, precast elements are proposed as the key to enable efficient component separation during decommissioning. Standardization and modularity are pivotal in achieving circularity. Smaller, adaptable components are essential to this approach, as they facilitate disassembly and repurposing.

The comparison and analysis investigate two bridge lifespans, revealing a modest difference in environmental impact between the circular alternative (a precast girder bridge) and the conventional Icelandic bridge design. While the circular design shows promise through a reduction in environmental cost and improvement in material circularity, further investigation is required to verify its feasibility.

In conclusion, this study provides insights into circular bridge design, displaying the advantage of adaptable components and mindful material choices. Further research is required to establish and assure the quality of components for reuse in infrastructure projects. The logistical possibilities are also an area of interest for future investigations. Nevertheless, circularity still stands as a favourable solution to increase the sustainability of infrastructure projects.

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1 Introduction

1.1 The IRCA research fund

The Icelandic Road and Coastal Administration (IRCA) research fund is currently sponsoring the third year of a research into Bridges in a circular economy. The research addresses the objectives of the research fund of exploring circular economy and life cycle assessment methodologies in the context of road network infrastructure, and ways to reduce the carbon footprint of Vegagerðin operations. This links closely to the IRCA policy of promoting sustainable transportation systems, in line with national environmental target setting. Circular economy is an essential integral part of Sustainability reflected in the statement of the European Environmental Agency, which claims that "...and without a circular economy, Europe cannot achieve sustainability" [European Environment Agency,].

1.2 Circular Economy

1.2.1 Basis

The approach of circular economy in this report will follow the *Ellen Macarthur foundation* principles [Goddin et al., 2019] (method followed in the previous reports [Arason et al., 2022]). Three main principles define the circular economy in the construction industry:

1. Eliminate waste and pollution
   The first principle is to eliminate waste from the site, i.e. to explore reusing or recycling all the materials. Extracting raw materials is not a sustainable solution. This angle will be approached in this research by trying to optimize the reuse of whole bridge elements during the design phase to avoid the need for transforming and altering elements for reuse. Also through discussing what would be preferable between optimizing the reuse potential and the volumes of materials in terms of waste and pollution.
2. Circulate products and materials (at their highest value)
   The second principle aims to keep products and materials in use. The goal is to explore reusing materials. For instance, considering a concrete element, it should be attempted in priority to reuse it within its original shape. If not possible, then it should be reused either as components or raw materials.
3. Regenerate nature
   The third principle emphasizes on supporting natural process to rebuild soils after a site work or a project. This point is major, but not investigated in this report.

The circular economy cannot be implemented if not every actor in the construction industry isn´t committed to it. Although, once a circular loop has come full circle, then circular economy will grow increasingly, as will its profits: lower material costs without the need to manufacture every elements, faster implementation on site, less engineering calculations thanks to more standardized situations etc. A circular economy has the potential to bring time and money savings for the construction industry as well as tangible environment benefits.

1.2.2 Iceland and its Circular Economy Ambitions

The government of Iceland aims to achieve a carbon neutrality by 2040 [Government of Iceland, 2020]. The global construction industry represented an estimated 37% of global operational energy and process-related CO_2 emissions in 2022 [United Nations Environment Programme, 2022]. In Iceland, 50% of all waste generated comes from the construction and demolition waste [Jagodzinska, 2024]. In aim to succeed in the reduction of the construction industry environmental impact, the *CIRCON project* (The circular economy in construction : eco-design of circular buildings) has been launched by the *Green Building Council Iceland* in cooperation with *Polish Green building Council* and the *Silesian University of Technology* in April 2022 . Although the project does not specifically address infrastructure like bridges, it does propose a plan for Life Cycle Assessment (LCA) implementation that stakeholders should adhere to, according to [Jagodzinska, 2024].

The bridge sector should follow this dynamic to reduce its environmental impact.

On average, Icelandic bridges are 45 years old [Birgisson, 2023] (57 years is the average age of single lane bridges, for dual-lane ones 30 years). 1186 bridges are managed by Vegagerðin across Iceland. The aging bridge population in Iceland is one indicator of the significant amount of bridge construction and maintenance there is in the pipeline for the coming decades. Notably a lot of single lane bridges, of which there are 360 on key road connections, are on its way out. An exploration of how circular economy considerations can be applied to bridge design is therefore timely.

1.3 Background

1.3.1 Basis from previous years´ work

This review marks the third year of consecutive collaboration between *Arup* and *EFLA* on sustainability and circularity research. The previous report analyzed the circularity potential and environmental impact of two bridges (one in steel, and the other in concrete) through the calculation of their Material Cost Indicator (MCI) and Environmental Cost Indicator (ECI).

Every project should be anchored in a circularity assessment process, so that comparison and improvement towards more circular projects would be eased. The MCI and the ECI were applied in the research. The indicators focus on two main ambitions of a circular economy: the protection of material availability and the protection of environmental boundaries.

In the previous report, MCI around 0,4 has been computed for the two bridges. Given that a fully circular project would have an MCI equal to 1, there is room for improvement. The comparison has led to a Circular Design Framework that outlines efficient design actions and follow-up suggestions [Arason et al., 2022]. The recommendations listed in the report were, among others, to include a circular design strategy checklist into the bridge design process. The goal was to increase the multi-use of bridge components and to restrain the resource depletion. If thought about at the earliest stages of the project, circularity has greater chance to be implemented and to have implications beyond just the current one project. The horizon of possibilities opens up all the more if the potential for re-use is considered at the very start of the design process. For bridges, the design strategy is based on the following principles [Arason et al., 2022]:

1. Refuse unnecessary new construction
2. Increase intensity of use
3. Design for longevity
4. Design for adaptability
5. Design for disassembly
6. Refuse unnecessary components
7. Increase material efficiency
8. Reduce the use of virgin materials
9. Reduce the use of carbon intensive materials
10. Design out hazardous/pollutant materials

The focus for this research is on design strategy 5: Design for disassembly.

1.3.2 Environmental Assessment Methodology in the Netherlands

Circular economies are slowly emerging around the world, and in the Netherlands, the ambition of becoming a 100% circular country works as a springboard for the rise of new reusable technologies in the construction industry [Scheuer, 2019].

The Netherlands aims to be circular by 2050. In the Netherlands, the executive agency of the Ministry of Infrastructure and Water Management, Rijkswaterstaat (RWS), set ambitions to work in a circular way earlier, by 2023. Platform CB'23 (Circular Construction 2023) is committed to Dutch industry-wide agreements on circular construction. Formal standards have not yet been implemented, but working agreements defined in guidelines have been drawn up, which could become standards in the near future.

Reference is to made to the previous report of this project, [Arason et al., 2022], for background to Material Circularity and Environmental Cost Indicators, but both are also explored here. Of these, the Material Circular Indicator originates in the Netherlands. The *Ellen Macarthur foundation* method is used to calculate the MCI in this research, to numerically assess the circularity potential of bridge designs.

1.4 Scope

1.4.1 Aim of the research

The aim of the research is to carry out a concept design of a bridge with the circular economy design principle: design for disassembly, and to compare this to a more conventional design in terms of Circularity and Sustainability. The evaluation will be done with a MCI and an ECI. The case study is aimed to explore a relatively standard design for Icelandic context, allowing the research to have national resonance.

The ambition of the research is to assess whether a circular design for Icelandic bridges has potential to contribute to the global challenge of resources depletion.

1.4.2 Frame of work

With reference to the circular bridge design strategy disclosed in the previous report [Arason et al., 2022], see also 1.2.1 above, and following an internal review, the focus of this report is on the Design-for-Disassembly principle. Design-for-Disassembly links closely to the other principles that aim to incorporate long term value, i.e. Design for longevity and Design for adaptability. Following the design for disassembly principle in the conceptual design of a circular bridge provides numerical indicators for comparison with the baseline concept.

1.5 Methodology

1.5.1 Workshop

At the onset of this third year of the project, the authors ran a workshop setting out the strategy for the upcoming work. The workshop proceedings are included as an appendix to this report. The main points taken away from the workshop can be summarized as:

- Basing the work on a comparison between a conventional design and a more circular alternative
- The "circular" design will employ pre-cast concrete components
- Focus on future re-use potential of unbuilt bridges rather than exploring re-use of existing components
- Exploring how increased circularity can be to the detriment of environmental cost and aiming to strike a balance between the two

1.5.2 MCI and ECI calculations

The Dutch MCI mentioned above will be used in this research to evaluate the circularity of a project or its components. This indicator takes its value between zero and one. A MCI equal to one indicates that the element evaluated was conceived from 100% of reused elements, and also that it will be reused in its entirety.

The *Ellen Macarthur Foundation* method is followed through this review to calculate the MCI [Goddin et al., 2019].

The notations will be the following:

$$\begin{cases} MCI \quad \in [0;1] & \text{Material Circular Indicator (1 is for an absolute circular element)} \\ LFI \quad \in [0;1] & \text{Linear Flow Index (1 is for an element from 100\% raw materials that will go the landfill} \\ & \text{after use)} \\ X \quad \in [0;1] & \text{utility of an element} \\ F(X) \quad \in [0;1] & \text{utility factor} \\ m_i \quad (kg) & \text{mass of i} \\ E_F \quad \in [0;1] & \text{efficiency of the recycling process used to produce the recycled feedstock} \\ E_C \quad \in [0;1] & \text{efficiency of the recycling process used for recycling the product at the end of its use} \\ & \text{phase} \end{cases}$$

The following hypotheses from [Goddin et al., 2019] are considered:

- The "utility" of a product measures how long and intensely it is used compared to an average product of the same type. In the work, the utility for each element is taken equal to 1 (X=1), a simplification [Goddin et al., 2019] mentions as suitable in some cases.
- The utility factor is calculated following another simplifying but suitable assumption. $F(X) = \frac{X}{0{,}9}$

According to these hypotheses, the LFI and MCI can be defined and calculated for each element of the project:

$$\begin{aligned} LFI &= \frac{m_{\text{virgin material}} + m_{\text{overall waste}}}{2m_{\text{total production}}} \\ and \quad MCI &= 1 - LFI \times F(X) \end{aligned} \tag{1}$$

This method makes no difference between reused and recycled elements since it follows a 50:50 approach [Goddin et al., 2019]. The effective part of recycled elements ($E_F \times m_{\text{recycled material}}$) has the same weight factor than the reused elements for the MCI calculation in this method. A reused or recycled material is valued equally in the MCI indicator. Therefore this report considers two lifespans of the bridge design to compare the average result of the MCI and ECI values. This is to value reused elements higher than recycled.

While setting out a circular project, its environmental impact should be calculated in parallel to ensure an overall positive balance. Increasing the MCI of a project can mean using more materials than structurally needed and in such cases the sustainability can be adversely affected.

To investigate this balance, the ECI is calculated also to give an overview on the environmental impact of the project. The calculations are based on the Environmental Product Declarations (EPDs) that were used in the previous study [Arason et al., 2022], see chapter 3.3. EPDs are initially grouped into four categories, A,B,C and D. These categories respectively represent construction, operation, end of life and end of life benefits in relation to their environmental cost indicators. The weighing factors or shadow-price used for the ECI calculation is reproduced in the table below.

Environmental Impact Category	Unit	Weighting factor or Shadow price (€/kg equivalent)
Global warming potential	kg CO_2e	0,05
Ozone layer depletion	kg $CFC11e$	30
Acidification	kg SO_2e	4
Eutrophication	kg PO_4e	9
Photochemical oxidant creation, smog	kg C_2H_4e	2
Depletion of abiotic resources	kg Sbe	0,16

Table 1: Weighting factors or shadow prices considered for the different environmental impact categories

1.5.3 Bridge Design Life

In this report, the lifespan of a bridge is assumed to be 100 years, in accordance with the IRCA bridge design rules.

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2 Case Study - the Axarvegur Bridge

The case study bridge has been put forward as a part of the concept design (IS: frumdrög) of a new road, Axarvegur, located in the East of Iceland [Óskarsson et al., 2023]. The bridge design is representative of a standard configuration for mid-size road bridges in Iceland, and represents the baseline alternative in this comparative case study.

2.1 Design

The Axarvegur bridge is a post-tensioned concrete bridge, designed with a continuous structure. The superstructure is a pair of post-tensioned concrete girders supporting the deck slab and edge girders, continuous over three spans (15 - 18.5 - 15 m). Longitudinal slope is 2%, and a $3,5\%$ crossfall, and a slight curvature in the plane of the deck following the road alignment. The deck is cast on site, and guardrails are attached to the edge girders. The pillars are cylindrical concrete elements cast in-situ and the foundations are also in-situ concrete elements. The figure below shows the plan, elevation and cross section of the concept design.

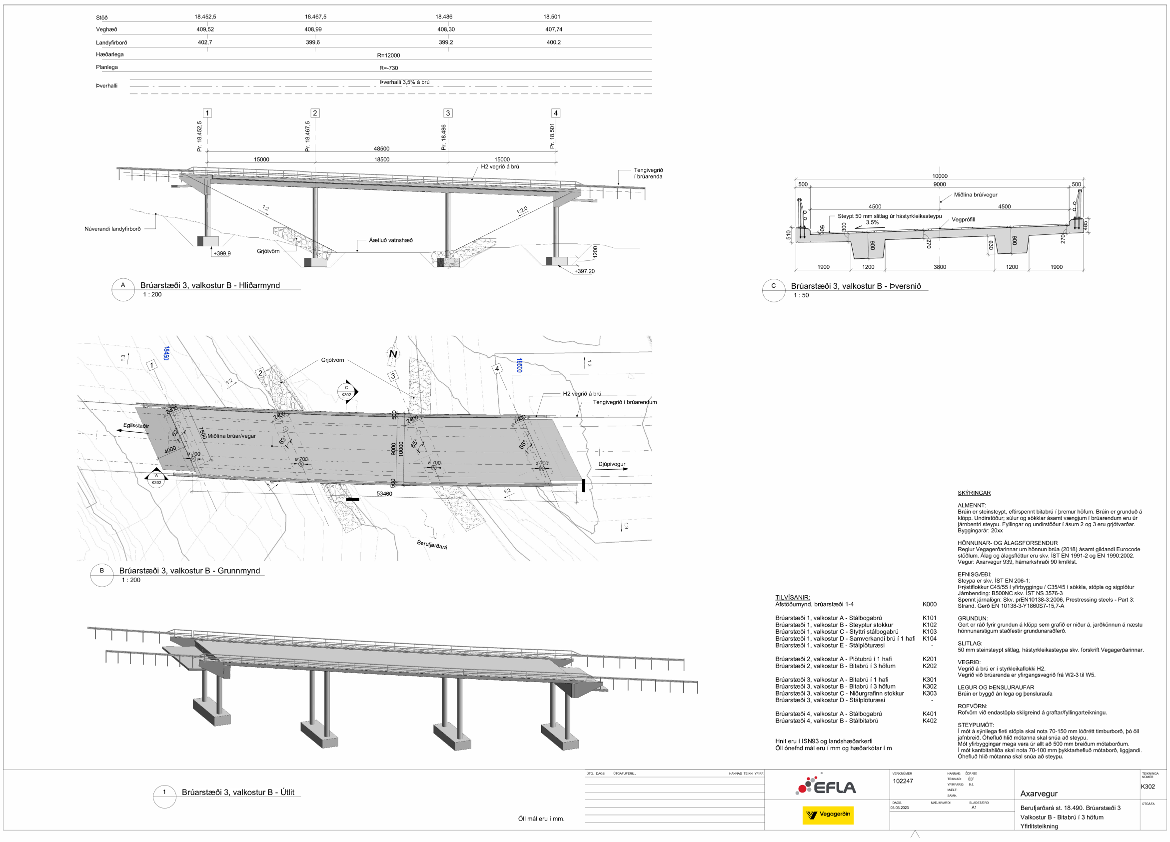

Figure 1: Axarvegur bridge concept design - overview drawing

2.2 Quantities

The material quantities for the Axarvegur Bridge are compiled in the following table :

Item nb.	Item description	Quantity	Unit
2,1	Contractor site costs, preparations, markings,...	1(7%)	RS
4,1	Surveying and setting out	1	RS
33,1	Fill material, road embankment	2600	m3
74,6	Erosion protection	600	m3
81,1	Cofferdams	1	RS
81,2	Excavation	600	m3
81,31	Fill material next to concrete	600	m3
84,1	Scaffolding and formworks support	1	RS
86,521	Utilities, duct telecommunications...	150	m
84,37	Post tensioning, tensioning and grouting works	10	pcs
75,61	Road guardrail, overlap between bridge and road guardrail	80	m
75,62	Bridge guardrail	111	m
84,21	Concrete formwork - foundations	100	m2
84,23	Concrete formwork - pillars	140	m2
84,25	Concrete formwork - superstructure	830	m2
84,311	Concrete reinforcement - foundations	8100	kg
84,313	Concrete reinforcement - pillars	4200	kg
84,315	Concrete reinforcement - superstructure	43500	kg
84,41	Concrete - foundations	90	m3
84,43	Concrete - pillars	30	m3
84,45	Concrete - deck/superstructure	290	m3
63,4	Concrete for road surfacing on bridge	25	m2
84,364	Post-tensioning, cables	8000	kg

Table 2: Material quantities for the Axarvegur Bridge, baseline alternative

These quantities will be used for processing of this baseline concept design for the rest of the study. However, the elements highlighted in grey will be excluded from MCI and ECI calculations.

3 Case study - A more Circular Design Alternative

To improve the circularity of baseline design, a couple of circular design interventions will be applied in the case study. The resulting design is referred to as the circular design alternative for the Axarvegur bridge site.

3.1 Design

The previous report provided a list of actions to focus on in an aim to improve bridge design circularity [Arason et al., 2022]. As mentioned above the focus of this study has been set on the "Design for disassembly" strategy. Observe that the following bridge design is at the conceptual stage and requires further evaluation before practical implementation.

As shown in Figure 1, the Axarvegur bridge baseline alternative is slightly curved in plan (R=730). This geometry constrains the superstructure to this curvature, which limits the reuse potential. Reusing a skewed or curved bridge may increase the difficulty of finding a suitable reuse location or increase the need for structural interventions causing loss of materials. One of the design decisions for the circular alternative is therefore to assume a bridge straight in plan. This would of course have implications for the eventual road layout by the bridge site, but this can be relatively easily accommodated.

3.1.1 Superstructure

As the superstructure accounts for the main concrete and reinforcement quantities, it is important to maximize its reuse potential. The baseline alternative assumed a deck cast in-situ on top of continuous post-tensioned girders. To improve reuse potential, the superstructure of the circular design alternative will utilize pre-cast elements. A girder bridge is suitable for the site, with spans within the range that can be covered by a girder-based structure. To increase reusability the span length is adjusted to three equal distances of 16m simply supported spans.

It can be noted that besides improved potential for re-use, pre-cast girders can bring other advantages, most of whom apply to pre-cast construction in general. Factory conditions during casting and pre-stressing of girders can bring quality assurance improvements in comparison to in-situ works, and with it increased confidence in the characteristics and durability of the structure. Also, pre-casting simplifies site activities somewhat, with less scaffolding and formwork required for the site. Those advantages can be argued to be somewhat offset by a negative effect on the aesthetics of pre-cast bridges compared to the more smooth and continuous appearance of for example post-tensioned concrete structures cast in situ.

For this research the *HKP-ligger girder* - by Haitsma beton - is selected for the circular bridge alternative. The assumption is that a cross section made up of such girders can be disassembled and re-used at another site.

The section chosen for the box girder is the 700mm HKP-girder from the Haitsma beton catalogue. This choice is made after a verification of the beam deflection and stresses in simplified serviceability and ultimate limit states. The girder width is 1480 mm. 7 girders are assembled to obtain a total width of 10500mm. The section of the Circular Design Alternative bridge is presented below (see figure 2).

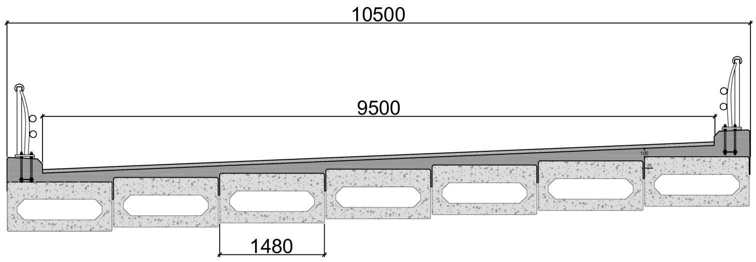

Figure 2: Superstructure Section (with a 3,5% slope)

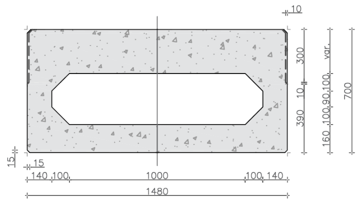

Figure 3: Box Girder section

When the Circular Alternative bridge will be decommissioned (the assumptions would be that this will happen 100 years after build, and that the concrete girders will still be in good condition at that point), the girders could be reused, with a reuse potential between 80 and 95%, depending on the design of their future use. Only the joints and the cover layer which forms the edge girders and road surface need to be cut off and replaced for the second life span ([Groeneweg, 2023]). An average reuse potential of 90% has been assumed for the precast girders in this study. The assumed re-use volumes are represented in red on the figure on the right.

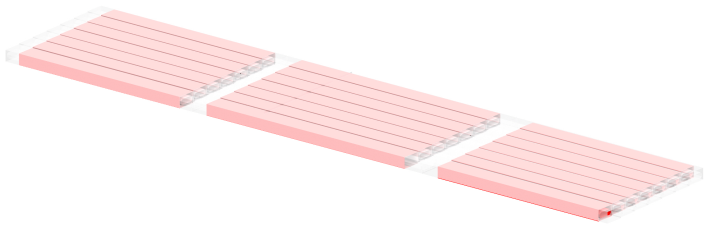

Figure 4: Girders possible reuse

3.1.2 Pillars

The columns of the pillars are precast elements, with re-use assumed possible similarly to the superstructure girders [Groeneweg, 2023].

Based on [Sigurjonsson et al., 2023] and [Haraldsson et al., 2013b]'s work, it is possible to connect a precast column to a foundation, analogous to what those researchers have studied for bridge abutment walls. This requires thicker foundations compared to columns cast in situ, but instead the columns are configured for re-use. This concept is documented in [Haraldsson et al., 2013a] and [Wang, 2000], and is assumed to be applicable for both the bottom (foundations) and top (cross girders) of the columns.

The principle is called by [Haraldsson et al., 2013b] a "wet socket connection". The columns are precast in a factory. Then, on site, after earthworks and formwork- and reinforcement preparations for the foundations, the precast columns are placed into their final position and braced, before the foundations are cast. Later, the process is repeated at the top of the columns, i.e. site casting of the cross girders around the top of the columns. According to [Sigurjonsson et al., 2023], the connection between the column and the foundation should respect the rule that the embedment depth is at least column diameter times 1,5. Furthermore, this case study follows the process explained by [Haraldsson et al., 2013a] for the precast columns, i.e. the reinforcement of the cast-in-situ elements will not cross the columns. The surface of the columns that will be in contact with cast-in-situ concrete needs to have a roughened surface, and the shape of the embedded part is hexagonal and not circular in cross section (surface shown on, figure 5). The resistance and transfer of vertical loading of the interface is through shear friction of the roughened interface. The assumption is that the cast-in-situ part can be water jetted off the precast elements during disassembly, and to facilitate this the cement content of the precast elements is higher compared to the cast-in-situ components, increasing the likelihood of the cast-in-situ part being less resistant to the water jetting operations.

The dimensions retained for the circular alternative design regarding the top and bottom pillars connections respect the requirements listed above as well as the site constraints (the foundations and the abutment cross girders are wider than what the wet socket connection strictly needs due to the longitudinal slope and the site characteristics).

[Groeneweg, 2023] puts the potential for reusing the pillars at between 90% and 95%. The value used in this review is 90%. The pillars are drawn in red as reusable elements.

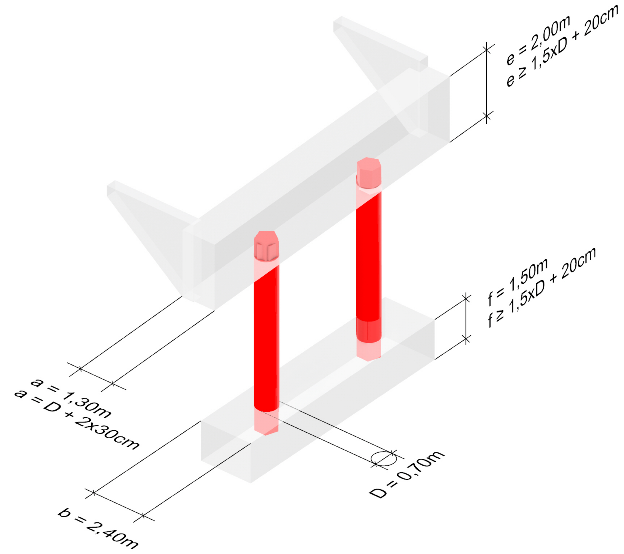

Figure 5: Connection between pillars, foundations and cross girders

3.1.3 Foundations

Choosing precast pillars and the "wet socket connection" studied by [Haraldsson et al., 2013a] implies to cast the foundations in-situ. Also, the concept of re-using foundations that have been embedded in the ground for a whole bridge life span seems far-fetched. Cast in situ foundations are therefore assumed in this assessment. The footprint of the foundations of the circular design alternative is the same as for the baseline alternative, 2,4 m x 7,8 m, but the thickness is greater as discussed above, assumed 1,5 m compared to 1,2 m for the baseline alternative.

3.1.4 Cross girders

As discussed for the pillars above, the assumption for this circular design alternative is that the top of the cylindrical pillars also has a "wet socket connection" to the cross girders, both at the end abutments and at the intermediate pillars. The cross girders themselves are assumed to be cast-in-situ, not defined for re-use, mainly because of perceived challenges in connecting the pre-cast pillars to the cross girders if they were also pre-cast. The cross girders at the intermediate pillars are 1,3m thick to respect the embedment depth ($1,5\times$pillar diameter) plus a reinforced concrete layer. Their plan section is a rectangle of 1,3m x 10,0m. For the two end abutment cross girders, their height is the same as for the baseline design (2,0m) to respond to the site constraints, while their plan section is a rectangle of 1,3m x 10,0m.

3.1.5 Circular design alternative summary

The above defined elements combine to form the design for the circular design alternative for the Axarvegur bridge site.

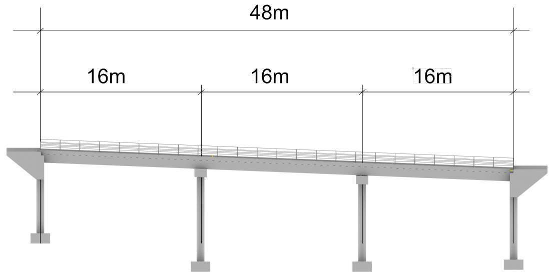

Figure 6: Elevation

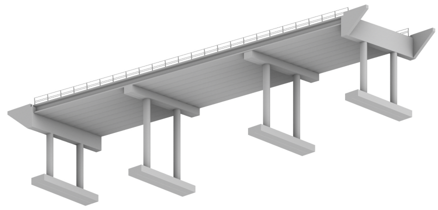

Figure 7: Perspective

When the bridge is decommissioned, the elements are assumed to be disassembled, some of them for re-use and others for landfill/end-of-life decommissioning.

Based on the Dutch reuse experience ([Groeneweg, 2023]), the girders and the pillars are the elements with the highest reuse potential (respectively between $80-95\%$ and between $90-95\%$). The deck layer and edge girders as well as the foundations and cross girders cast in-situ have limited reuse potential.

The components for re-use are highlighted in red in figure 8 and 9. The highlighted components can form the main elements of a Re-used bridge alternative, which is discussed and evaluated below. The re-used bridge has a slightly shorter span than the circular alternative (42m total length compared to 48m) to account for material lost during disassembly, corresponding to the 90% re-use assumption.

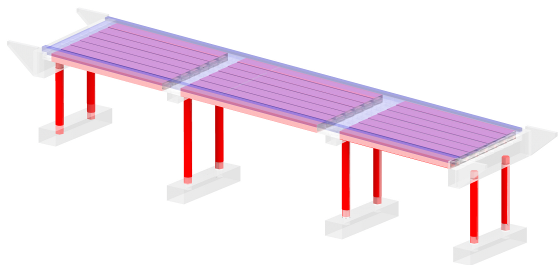

Figure 8: *Circular Design Alternative*

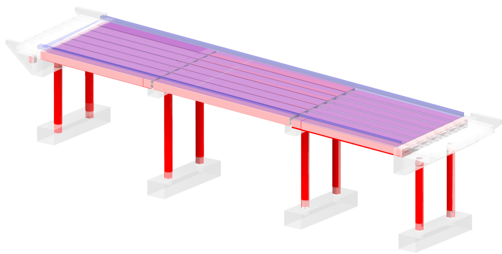

Figure 9: *Reused Bridge*

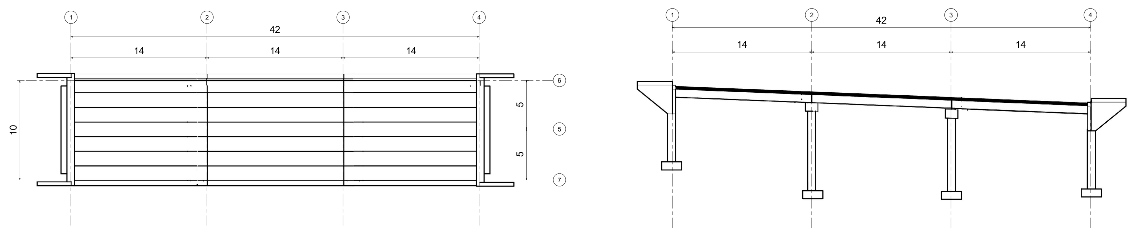

Figure 10: Plan and elevation of the potential *Reused Bridge*

3.2 Quantities

The material quantities for the Circular Design Alternative are compiled in the following table :

Item nb.	Item description	Quantity	Unit
75,61	Road guardrail, overlap between bridge and road guardrail	80	m
75,62	Bridge guardrail	111	m
84,21	Concrete formwork - foundations	125	m^2
84,23	Concrete formwork - pillars	0	m^2
84,25	Concrete formwork - superstructure	304	m^2
84,311	Concrete reinforcement - foundations	10080	kg
84,313	Concrete reinforcement - pillars	0	kg
84,315	Concrete reinforcement - superstructure	27825	kg
84,41	Concrete - foundations	112	m^3
84,43	Concrete precast - pillars	30	m^3
84,45	Concrete cast in situ - deck/superstructure	185,5	m^3
84,75	Concrete precast - deck/superstructure	240	m^3
63,4	Concrete for road surfacing on bridge	25	m^2
84,364	Post-tensioning, cables	0	kg

Table 3: Material quantities for the Circular Alternative Design

As the pillars and girders of the Circular Alternative Bridge are prefabricated, no in-situ formwork is required for the girders or the pillars. The formwork for the foundations is larger compared to the baseline alternative as the foundations are thicker, and there is a requirement for formwork for the end abutments configuration, cross girders and the edge girder upstands of the superstructure. In the calculations below, the reinforcement of the pre-cast elements is included with the concrete volume of those elements, and for the same reason, post-tensioning cables are not included in this alternative. It is worth pointing out that the $185,5m^3$ is the concrete cast in-situ quantity for the thin cover on top of precast girders, and also the end abutment configuration and the cross girders, so it includes more than just the deck itself.

In the ideal scenario presented above, the *Reused Bridge* has its girders and pillars coming from the circular alternative of the Axarvegur bridge.

Item nb.	Item description	Quantity	Unit
75,61	Road guardrail, overlap between bridge and road guardrail	80	m
75,62	Bridge guardrail	111	m
84,21	Concrete formwork - foundations	125	m^2
84,23	Concrete formwork - pillars	0	m^2
84,25	Concrete formwork - superstructure	304	m^2
84,311	Concrete reinforcement - foundations	10080	kg
84,313	Concrete reinforcement - pillars	0	kg
84,315	Concrete reinforcement - superstructure	26475	kg
84,41	Concrete - foundations	112	m^3
84,43	Concrete precast - pillars	27	m^3
84,45	Concrete cast in situ - deck/superstructure	176,5	m^3
84,75	Concrete precast - deck/superstructure	216	m^3
63,4	Concrete for road surfacing on bridge	24	m^2
84,364	Post-tensioning, cables	0	kg

Table 4: Material quantities for the *Reused Bridge*

4 MCI and ECI Evaluation

Below, the Material Circularity Indicator and Environmental Cost Indicator are calculated for the three cases; baseline alternative, circular design alternative and the reused bridge. The calculations are done for comparison purposes, i.e. an evaluation of how effective the circular design actions are with respect to those indicators.

4.1 Baseline Alternative results

Firstly, the post-tensioned concrete bridge design for Axarvegur, the baseline alternative, is assessed for both MCI and ECI.

4.1.1 Material Circularity Indicator

The formulas explained in the section 1.5.3 have been used, and compiled into a spreadsheet to calculate the MCIs.

The ratios between the primary sources/recycled elements/reused elements, for build and end-of-life are shown below. For the guardrails the ratios come from an Environmental Product Declaration (EPD) for a guardrail commonly used in Iceland. For the formwork the ratios assume that the formwork panels are in general used 5 times. For the concrete reinforcement the ratios are standard from production, for example referenced in EPDs. For the concrete cast in situ 100% primary materials are assumed for the build phase, with recycling of 90% at end-of-life (not for concrete though, rather for landfill). For the PT-cables the ratios come from an Environmental Product Declaration (EPD) for cables used in Iceland.

By using the formulas from section1.5.3 and the quantities presented on Table 2., the MCI can be computed for the baseline alternative of Axarvegur Bridge. It should be noted that the calculations exclude both earthworks and work components that do not require much material input, see grey items in Table 2.

Item nb.	Item description	Quantity	Unit	Mass (kg)	Mass %	3 main components	Primary sources	Recycled elements	Reused elements	Waste/Go to landfill	Recycled potential	Reused potential	Average weighted by mass MCI	Elements impact on the global MCI
75,61	Road guardrail, overlap between bridge and road guardrail	80	m	2400	0,2%		93%	7%		15%	85%	0%	0,001	0,2%
75,62	Bridge guardrail	111	m	6660	0,6%		93%	7%		15%	85%	0%	0,003	0,6%
84,21	Concrete formwork - foundations	100	m^2	3600	0,3%		20%	0%	80%	20%	0%	80%	0,003	0,5%
84,23	Concrete formwork - pillars	140	m^2	5040	0,4%		20%	0%	80%	20%	0%	80%	0,004	0,7%
84,25	Concrete formwork - superstructure	830	m^2	29880	2,6%		20%	0%	80%	20%	0%	80%	0,022	4,3%
84,311	Concrete reinforcement - foundations	8100	kg	8100	0,7%		13%	87%	0%	3%	97%	0%	0,006	1,2%
84,313	Concrete reinforcement - pillars	4200	kg	4200	0,4%		13%	87%	0%	3%	97%	0%	0,003	0,6%
84,315	Concrete reinforcement - superstructure	43500	kg	43500	3,8%		13%	87%	2%	3%	97%	0%	0,034	6,8%
84,41	Concrete - foundations	90	m^3	220500	19,5%	22,0%	100%	0%	0%	10%	90%	0%	0,092	18,1%
84,43	Concrete - pillars	30	m^3	73500	6,5%	7,3%	100%	0%	0%	10%	90%	0%	0,031	6,0%
84,45	Concrete - deck/superstructure	290	m^3	710500	62,8%	70,7%	100%	0%	0%	10%	90%	0%	0,297	58,4%
63,4	Concrete for road surfacing on bridge	25	m^2	15312,5	1,4%		100%	0%	0%	10%	90%	0%	0,006	1,3%
84,364	Post-tensioning, cables	8000	kg	8000	0,7%		3%	97%	0%	3%	97%	0%	0,007	1,3%
		Total (kg)		1131193	kg	1004500	1043436	56940,2	31686	112958,25	987418,25	30816	0,509	100%
							92,2%	5,0%	2,8%	10,0%	87,3%	2,7%		

Table 5: MCI calculations for the Axarvegur Bridge baseline alternative [Arason et al., 2022]

The baseline alternative of the Axarvegur bridge has a low MCI for its concrete elements compared to its steel elements and cables. The numerical result is comparable to the concrete bridge alternative analyzed in the previous report. The table shows that the MCI of the three main concrete components (see rows highlighted in blue) count for 83% of the whole bridge MCI (weighted by mass), with the biggest contribution coming from the superstructure. Efforts made to increase the MCI of these elements should therefore have significant impact for the bridge circularity.

4.1.2 Environmental Cost Indicator

Similarly to the MCI, the ECI calculation will follow the methodology applied for the previous report, see section 1.5.3. Following a review of representative Environmental Product Declarations for material on the Icelandic market, six EPD were identified to represent the items summarized in the table below. The complete tables for the ECI calculations are included as an Appendix to this report.

Item nb.	Item description	Quantity	Unit	ECI based on EPDs		Mass (ton)	Unit price	Cost	Price (€)	ECI (€ for the project)								Price % total
										A		B		C		D		
				Quantity	Unit					total	CO2	total	CO2	total	CO2	total	CO2	
75,61	Road guardrail, overlap between bridge and road guardrail	80	m	80	m	2,4	30.000 kr	2.400.000 kr	16.152 €	24,10 €	23,99 €	- €	- €	4,56 €	0,83 €	- 7,99 €	- 7,90 €	0%
75,62	Bridge guardrail	111	m	111	m	6,7	130.000 kr	14.430.000 kr	97.113 €	66,87 €	66,56 €	- €	- €	12,65 €	2,30 €	- 22,18 €	- 21,94 €	1%
84,21	Concrete formwork - foundations	100	m2	5,3	m3	3,6	45.000 kr	4.500.000 kr	30.285 €	58,72 €	37,12 €	- €	- €	7,09 €	1,08 €	- 127,44 €	- 80,17 €	-1%
84,23	Concrete formwork - pillars	140	m2	7,42	m3	5,0	45.000 kr	6.300.000 kr	42.399 €	82,20 €	51,96 €	- €	- €	9,93 €	1,51 €	- 178,42 €	- 112,24 €	-1%
84,25	Concrete formwork - superstructure	830	m2	43,99	m3	29,9	55.000 kr	45.650.000 kr	307.221 €	487,34 €	308,06 €	- €	- €	58,86 €	8,96 €	- 1.057,75 €	- 665,43 €	-5%
84,311	Concrete reinforcement - foundations	8100	kg	8,1	tons	8,1	750 kr	6.075.000 kr	40.884 €	388,88 €	275,36 €	- €	- €	174,23 €	173,34 €	- 9,96 €	- 7,21 €	5%
84,313	Concrete reinforcement - pillars	4200	kg	4,2	tons	4,2	750 kr	3.150.000 kr	21.199 €	201,64 €	142,78 €	- €	- €	90,34 €	89,88 €	- 5,17 €	- 3,74 €	3%
84,315	Concrete reinforcement - superstructure	43500	kg	43,5	tons	43,5	750 kr	32.625.000 kr	219.564 €	2.088,44 €	1.478,78 €	- €	- €	935,69 €	930,90 €	- 53,51 €	- 38,72 €	26%
84,41	Concrete - foundations	90	m3	90	m3	220,5	85.000 kr	7.650.000 kr	51.484 €	1.748,70 €	1.397,70 €	- €	- €	57,60 €	29,70 €	- 162,00 €	- 136,80 €	15%
84,43	Concrete - pillars	30	m3	30	m3	73,5	85.000 kr	2.550.000 kr	17.161 €	582,90 €	465,90 €	- €	- €	19,20 €	9,90 €	- 54,00 €	- 45,60 €	5%
84,45	Concrete - deck/superstructure	290	m3	290	m3	710,5	90.000 kr	26.100.000 kr	175.651 €	5.634,70 €	4.503,70 €	- €	- €	185,60 €	95,70 €	- 522,00 €	- 440,80 €	47%
63,4	Concrete for road surfacing on bridge	25	m2	25	m2	15,3	220.000 kr	5.500.000 kr	37.015 €	297,52 €	237,80 €	- €	- €	9,80 €	5,05 €	- 27,56 €	- 27,56 €	2%
84,364	Post-tensioning, cables	8000	kg	8	tons	8	2.400 kr	19.200.000 kr	129.215 €	319,12 €	235,27 €	- €	- €	1,76 €	1,56 €	- 93,36 €	- 70,80 €	2%
							Total:	238.443.000 kr	1.604.704 €	11.981,1 €	9.225,0 €	- €	- €	1.567,3 €	1.350,7 €	- 2.321,3 €	- 1.658,9 €	100%

ECI € tot:	11.227 €	total
ECI € tot:	8.917 €	for CO2 emissions

Table 6: ECI calculations for the Axarvegur Bridge *(complete version Table 13)*

4.2 The Circular Design Alternative results

The same calculations are done for the Circular Design Alternative from **Chapter 3**.

4.2.1 Material Circularity Indicator

The circular design alternative has pre-cast pillars and superstructure girders with a 90% reuse potential, but in order to accommodate the installation of those, the cast in situ concrete around the precast elements has somewhat thicker cross sections compared to the baseline alternative. As a result, the elements of the circular design alternative that are included in the calculations are around 300 tons heavier than the corresponding elements of the baseline alternative. The same ratio inputs as used for chapter 4.1.1 are used here, and in addition, it is assumed that precast elements are originally made from 100% primary sources, and 90% can be re-used at end of life.

Item nb.	Item description	Quantity	Unit	Mass (kg)	Mass %	3 main components	Primary sources	Recycled elements	Reused elements	Waste/Go to landfill	Recycled potential	Reused potential	Average weighted by mass MCI	Elements impact on the global MCI
75,61	Road guardrail, overlap between bridge and road guardrail	80	m	2400	0,2%		93%	7%		15%	85%	0%	0,001	0,2%
75,62	Bridge guardrail	111	m	6660	0,5%		93%	7%		15%	85%	0%	0,002	0,4%
84,21	Concrete formwork - foundations	125	m^2	4500	0,3%		20%	0%	80%	20%	0%	80%	0,003	0,5%
84,23	Concrete formwork - pillars	0	m^2	0	0,0%		20%	0%	80%	20%	0%	80%		0,0%
84,25	Concrete formwork - superstructure	304	m^2	10944	0,7%		20%	0%	80%	20%	0%	80%	0,006	1,2%
84,311	Concrete reinforcement - foundations	10080	kg	10080	0,7%		13%	87%	0%	3%	97%	0%	0,006	1,2%
84,313	Concrete reinforcement - pillars	0	kg	0	0,0%		13%	87%	0%	3%	97%	0%		0,0%
84,315	Concrete reinforcement - superstructure	27825	kg	27825	1,9%		13%	87%	2%	3%	97%	0%	0,017	3,3%
84,41	Concrete - foundations	112	m^3	274400	18,7%	19,7%	100%	0%	0%	10%	90%	0%	0,088	17,0%
84,43	Concrete - pillars	30	m^3	73500	5,0%	5,3%	100%	0%	0%	1%	9%	90%	0,027	5,2%
84,45	Concrete cast in situ - deck/superstructure	185,5	m^3	454475	31,0%	32,7%	100%	0%	0%	10%	90%	0%	0,146	28,2%
84,75	Concrete precast - deck/superstructure	240	m^3	588000	40,1%	42,3%	100%	0%	0%	1%	9%	90%	0,217	41,9%
63,4	Concrete for road surfacing on bridge	25	m^2	15312,5	1,0%		100%	0%	0%	10%	90%	0%	0,005	1,0%
84,364	Post-tensioning, cables	0	kg	0	0,0%		3%	97%	0%	3%	97%	0%		0,0%
		Total (kg)		1468097	kg	1390375	1422130	33611,55	12911,7	86618,7	773772,6	607705,2	0,519	100%
							125,7%	3,0%	1,1%	7,7%	68,4%	53,7%		
													2%	

Table 7: MCI calculation for the Circular Design Alternative

The table above shows that the increase in MCI between the circular design alternative and the baseline is only small, or around 2% for the whole bridge, based on mass weighted averaging of all items. The small increase is because the MCI calculations defined by the Ellen MacArthur foundation do not make a distinction between recycling and re-use at end-of-life [Goddin et al., 2019], and the concrete of the baseline alternative is defined for recycling like most of concrete in Iceland. Therefore, the methods chosen for circularity evaluation in the project are not set up to reveal significant circularity improvements between the baseline and the circular design alternatives, however, more significant changes are introduced to the circularity evaluation when looking at the re-used bridge, defined in 3.1.5 and 3.2 above.

MCI calculation for the re-used bridge is summarized in the table below. The assumptions are the same as for the Circular Design Alternative, except that the precast pillars and girders are all coming from reused elements.

Item nb.	Item description	Quantity	Unit	Mass (kg)	Mass %	3 main components	Primary sources	Recycled elements	Reused elements	Waste/Go to landfill	Recycled potential	Reused potential	Average weighted by mass MCI	Elements impact on the global MCI
75,61	Road guardrail, overlap between bridge and road guardrail	80	m	2400	0,2%		93%	7%		15%	85%	0%	0,001	0,2%
75,62	Bridge guardrail	111	m	6660	0,5%		93%	7%		15%	85%	0%	0,002	0,4%
84,21	Concrete formwork - foundations	125	m^2	4500	0,3%		20%	0%	80%	20%	0%	80%	0,003	0,5%
84,23	Concrete formwork - pillars	0	m^2	0	0,0%		20%	0%	80%	20%	0%	80%	0,000	0,0%
84,25	Concrete formwork - superstructure	304	m^2	10944	0,7%		20%	0%	80%	20%	0%	80%	0,006	1,2%
84,311	Concrete reinforcement - foundations	10080	kg	10080	0,7%		13%	87%	0%	3%	97%	0%	0,006	1,2%
84,313	Concrete reinforcement - pillars	0	kg	0	0,0%		13%	87%	0%	3%	97%	0%	0,000	0,0%
84,315	Concrete reinforcement - superstructure	26475	kg	26475	1,8%		13%	87%	2%	3%	97%	0%	0,016	3,1%
84,41	Concrete - foundations	112	m^3	274400	18,7%	19,7%	100%	0%	0%	10%	90%	0%	0,088	13,2%
84,43	Concrete - pillars	27	m^3	66150	4,5%	4,8%	0%	0%	100%	1%	9%	90%	0,045	8,6%
84,45	Concrete cast in situ - deck/superstructure	176,5	m^3	432425	29,5%	31,1%	100%	0%	0%	10%	90%	0%	0,139	26,9%
84,75	Concrete precast - deck/superstructure	216	m^3	529200	36,0%	38,1%	0%	0%	100%	1%	9%	90%	0,358	69,0%
63,4	Concrete for road surfacing on bridge	24	m^2	14700	1,0%		100%	0%	0%	10%	90%	0%	0,005	0,9%
84,364	Post-tensioning, cables	0	kg	0	0,0%		3%	97%	0%	3%	97%	0%	0,000	0,0%
		Total (kg)		1377934	kg	1302175	737791,8	32437,05	608234,7	83650,45	746113,35	548170,2	0,669	100%
							65,2%	2,9%	53,8%	7,4%	66,0%	48,5%		
													32%	

Table 8: MCI calculation for the *Reused Bridge*

Sourcing the precast elements from reuse increases the MCI by almost a third compared to the Baseline Alternative. The Reused bridge is the closest model to a circular bridge in this study, highlighting how designing for disassembly can lead to improving the circularity of infrastructure.

4.2.2 Environmental Cost Indicator

As the Circular Design Alternative is a heavier bridge compared to the baseline alternative (1470 vs. 1130 tons, see tables 5 and 8), it results in a higher ECI. The difference in calculated ECI is however not as great as the proportional overall mass difference, or 16% for the 30% heavier structure.

Item nb.	Item description	Quantity	Unit	ECI based on EPDs		Mass (ton)	Unit price	Cost	Price (€)	ECI (€ for the project)								Price % total
										A		B		C		D		
				Quantity	Unit					total	CO2	total	CO2	total	CO2	total	CO2	
75,61	Road guardrail, overlap between bridge and road guardrail	80	m	80	m	2,4	30.000 kr	2.400.000 kr	16.152 €	24,10 €	23,99 €	- €	- €	4,56 €	0,83 €	- 7,99 €	- 7,90 €	0%
75,62	Bridge guardrail	111	m	111	m	6,66	130.000 kr	14.430.000 kr	97.113 €	66,87 €	66,56 €	- €	- €	12,65 €	2,30 €	- 22,18 €	- 21,94 €	0%
84,21	Concrete formwork - foundations	125	m2	6,625	m3	4,5	45.000 kr	5.625.000 kr	37.856 €	73,40 €	46,40 €	- €	- €	8,87 €	1,35 €	- 159,30 €	- 100,22 €	-1%
84,23	Concrete formwork - pillars	0	m2	0	m3	0	45.000 kr	- kr	- €	- €	- €	- €	- €	- €	- €	- €	- €	0%
84,25	Concrete formwork - superstructure	304	m2	16,112	m3	10,944	55.000 kr	16.720.000 kr	112.524 €	178,50 €	112,83 €	- €	- €	21,56 €	3,28 €	- 387,42 €	- 243,72 €	-1%
84,311	Concrete reinforcement - foundations	10080	kg	10,08	tons	10,08	750 kr	7.560.000 kr	50.878 €	483,94 €	342,67 €	- €	- €	216,82 €	215,71 €	- 12,40 €	- 8,97 €	5%
84,313	Concrete reinforcement - pillars	0	kg	0	tons	0	750 kr	- kr	- €	- €	- €	- €	- €	- €	- €	- €	- €	0%
84,315	Concrete reinforcement - superstructure	27825	kg	27,825	tons	27,825	750 kr	20.868.750 kr	140.445 €	1.335,88 €	945,91 €	- €	- €	598,52 €	595,46 €	- 34,22 €	- 24,76 €	15%
84,41	Concrete - foundations	112	m^3	112	m^3	274,4	85.000 kr	9.520.000 kr	64.069 €	2.176,16 €	1.739,36 €	- €	- €	71,68 €	36,96 €	- 201,60 €	- 170,24 €	16%
84,43	Concrete precast - pillars	30	m^3	30	m^3	73,5	85.000 kr	2.550.000 kr	17.161 €	525,60 €	418,11 €	- €	- €	30,30 €	19,97 €	- 11,70 €	- 8,10 €	4%
84,45	Concrete cast in situ - deck/superstructure	185,5	m^3	185,5	m^3	454,475	90.000 kr	21.600.000 kr	145.366 €	3.604,27 €	2.880,82 €	- €	- €	118,72 €	61,22 €	- 333,90 €	- 281,96 €	26%
84,75	Concrete precast - deck/superstructure	240	m^3	240	m^3	588				4.204,80 €	3.344,88 €	- €	- €	242,40 €	159,72 €	- 93,60 €	- 64,80 €	33%
63,4	Concrete for road surfacing on bridge	25	m2			15,3125	220.000 kr	5.500.000 kr	37.015 €	297,52 €	237,80 €	- €	- €	9,80 €	5,05 €	- 27,56 €	- 23,28 €	2%
84,364	Post-tensioning, cables	0	kg	0	tons	0	2.400 kr	- kr	- €	- €	- €	- €	- €	- €	- €	- €	- €	0%
							Total:	169.086.750 kr	1.137.942 €	12.971,0 €	10.159,3 €	- €	- €	1.335,9 €	1.101,8 €	- 1.291,9 €	- 955,9 €	100%
										ECI € tot:		13.015 €		total			15,93%	
										ECI € tot:		10.305 €		for CO2 emissions			15,57%	

Table 9: ECI calculation for the Circular Alternative *(complete version Table 14)*

Similarly to what is discussed above for the Material Circularity Indicator, sustainably benefits of the circular design alternative are not realized in the Environmental Cost Indicator calculations for a stand-alone circular bridge. The main principles of a circular economy are to limit waste and pollution and resource depletion. Therefore it is of interest to assess a combination of the circular design alternative and the Reused Bridge drawn on figures 9 and 10.

The Reused bridge has 100% of its girders and pillars coming from the Circular Design Alternative. Therefore, the quantities of reused elements from the Circular Alternative bridge to the Reused bridge are known (percentages reported in the blue columns of the MCI calculation table 9). The ECI corresponding to these quantities can be approximated as zero in the evaluation of the Re-used bridge, leading to an overall almost 30% lower ECI compared to the baseline alternative.

Item nb.	Item description	Quantity	Unit	ECI based on EPDs		Mass (ton)	Unit price	Cost	Price (€)	ECI (€ for the project)								Price % total
										A		B		C		D		
				Quantity	Unit					total	CO2	total	CO2	total	CO2	total	CO2	
75,61	Road guardrail, overlap between bridge and road guardrail	80	m	80	m	2,4	30.000 kr	2.400.000 kr	16.152 €	24,10 €	23,99 €	- €	- €	4,56 €	0,83 €	- 7,99 €	- 7,90 €	0%
75,62	Bridge guardrail	111	m	111	m	6,66	130.000 kr	14.430.000 kr	97.113 €	66,87 €	66,56 €	- €	- €	12,65 €	2,30 €	- 22,18 €	- 21,94 €	1%
84,21	Concrete formwork - foundations	125	m2	6,625	m3	4,5	45.000 kr	5.625.000 kr	37.856 €	73,40 €	46,40 €	- €	- €	8,87 €	1,35 €	- 159,30 €	- 100,22 €	-1%
84,23	Concrete formwork - pillars	0	m2	0	m3	0	45.000 kr	- kr	- €	- €	- €	- €	- €	- €	- €	- €	- €	0%
84,25	Concrete formwork - superstructure	304	m2	16,112	m3	10,944	55.000 kr	16.720.000 kr	112.524 €	178,50 €	112,83 €	- €	- €	21,56 €	3,28 €	- 387,42 €	- 243,72 €	-2%
84,311	Concrete reinforcement - foundations	10080	kg	10,08	tons	10,08	750 kr	7.560.000 kr	50.878 €	483,94 €	342,67 €	- €	- €	216,82 €	215,71 €	- 12,40 €	- 8,97 €	9%
84,313	Concrete reinforcement - pillars	0	kg	0	tons	0	750 kr	- kr	- €	- €	- €	- €	- €	- €	- €	- €	- €	0%
84,315	Concrete reinforcement - superstructure	26475	kg	26,475	tons	26,475	750 kr	19.856.250 kr	133.631 €	1.271,06 €	900,02 €	- €	- €	569,48 €	566,57 €	- 32,56 €	- 23,56 €	23%
84,41	Concrete - foundations	112	m^3	112	m^3	274,4	85.000 kr	9.520.000 kr	64.069 €	2.176,16 €	1.739,36 €	- €	- €	71,68 €	36,96 €	- 201,60 €	- 170,24 €	26%
84,43	Concrete precast - pillars	0	m^3	0	m^3	66,15	85.000 kr	- kr	- €	- €	- €	- €	- €	- €	- €	- €	- €	0%
84,45	Concrete cast in situ - deck/superstructure	176,5	m^3	176,5	m^3	432,425	90.000 kr	- kr	- €	3.429,40 €	2.741,05 €	- €	- €	112,96 €	58,25 €	- 317,70 €	- 268,28 €	41%
84,75	Concrete precast - deck/superstructure	0	m^3	0	m^3	529,2				- €	- €	- €	- €	- €	- €	- €	- €	0%
63,4	Concrete for road surfacing on bridge	24	m2			14,7	220.000 kr	5.280.000 kr	35.534 €	285,62 €		- €		9,41 €			- 26,46 €	4%
84,364	Post-tensioning, cables	0	kg	0	tons	0	2.400 kr	- kr	- €	- €		- €		- €			- €	0%
							Total:	143.704.250 kr	967.119 €	7.989,0 €	5.972,9 €	- €	- €	1.028,0 €	885,2 €	- 1.141,2 €	- 871,3 €	100%

ECI € tot:	7.876 €	total	-29,85%
ECI € tot:	5.987 €	for CO2 emissions	-32,86%

Table 10: ECI calculation for the *Reused Bridge (complete version Table 15)*

This low ECI makes the Reused bridge attractive in terms of sustainability. However, since this design requires the Circular alternative Bridge to be built first, those two bridges have to be compared together, and the interesting comparison of this combination is to compare against two baseline alternative bridges.

2 Baseline bridges				
Scenario: Another similar baseline alternative bridge is built after the decommission of the first one	ECI € tot:	22.454 €	total	
	ECI € tot:	17.834 €	for CO2 emissions	
Circular Alternative + Reused Bridge		316.903 €		
Scenario: The Reused Bridge is built after the decommission of the Circular Alternative	ECI € tot:	20.891 €	total	-6,96%
	ECI € tot:	16.292 €	for CO2 emissions	-8,64%

Table 11: ECI comparison between two baseline alternatives and a combination of a circular design alternative and a re-used bridge

The lower case, i.e. reusing the primary elements of the circular design alternative to build a new one, constitutes ECI savings of approximately 7%. In terms of volume, $270\,m^3$ of concrete are reused, which means that the equivalent quantities of raw materials are kept in use for longer.

4.3 MCI and ECI results summary

The results presented above are summarized in the table below.

Design	MCI	ECI
Baseline	0,509	11 227 €
Circular Alternative	0,519	13 015 €
Reused Bridge	0,669	7 876 €
2 Baselines	0,509	22 454 €
Circular + Reused	0,594[1]	20 891 €
Comparison b/w 2 scenarios	$+16,7\%$	$-7,0\%$

Table 12: MCI and ECI summary

These results are based on several assumptions intrinsic to the assessment, as detailed above. The calculation of the MCI is based on a method from *Ellen Macarthur Foundation*, which somewhat surprisingly does not reward re-use over recycling in terms of circularity. The ECI calculation has been made based on the assumption that the selected Environmental Product Declarations are representative of current bridge construction

[1] MCI calculated as an average of the Circular Bridge MCI and the Reused bridge MCI

in the Icelandic market. The EPDs reported in the Appendix. The reused bridge represents as somewhat optimistic operational model, mainly for two reasons. Firstly, precast elements that have already been used for 100 years are considered to be operational for a further hundred years. Secondly, the reuse potential from the Circular Design Alternative defines the reused quantities for the Reused Bridge. This assumes successful removal of the original pre-cast components intact for direct reuse, without any additional material loss in the process.

Moreover, the economical approach is simplified. The ECI for the bridge that will be built in a hundred year is not discounted (in the sense than one euro today represents more than one euro tomorrow $1€_{today} = e^{-r_t} \times 1€_{\text{in one year}}$ according to [Gollier, 2012], where r_t is the discount rate).

5 Discussion

While some assumptions made in the report may be optimistic, the outcomes do not strongly support the adoption of a Circular Economy using pre-cast elements from the Circular Design Alternative. The comparison between the two defined scenarios—one based on current practices in Iceland and the other involving a more circular alternative with a partially precast structure used twice—indicates a modest reduction in Environmental Cost Index (ECI) of 7%. Especially noteworthy are the uncertainties associated with reusing precast elements to achieve a 200-year service life. These uncertainties play a significant role in the decision-making process.

The baseline alternative remains an attractive choice for bridges of this size in Iceland, although, the circular scenario could become more viable if shadow costs associated with environmental impacts rise in the future. It is likely that such an increase will occur. For instance, consider the carbon emission shadow cost, which is projected to be $775€/tCO_2$ in 2050 according to [Quinet, 2019]). This is significantly higher than the $50€/tCO_2$ used in the present study. These evolving costs will play a crucial role in shaping decisions regarding sustainable infrastructure. For further research it is worth investigating at what point the carbon cost will make the circular alternative more advantageous.

In line with the Design for Disassembly, the focus of the alternative design efforts have been on girders, since they are responsible for the largest volume, mass, and resulting MCI among the structural elements (as shown in Table 5), whilst also possessing the highest potential for reuse. Therefore, facilitating the reuse of a large percentage of the girder's volume is essential for circularity and increasing the overall MCI. Whilst other elements have potential to be redesigned for circularity, their size and complex connections both reduce the impact of reduction on the overall MCI and percentage reusability.

Pre-casting as a method to improve bridge circularity and preferably thereby sustainability can be argued to serve other circular design strategies than just the Design for Disassembly that was subject to special focus in this report. Using pre-cast elements in design can also bring advantages to Design for Longevity, by assuming that the controlled factory conditions of precast concreting bring improved characteristics.

Nevertheless, as presented in the report, prefabricated elements may create heavier or larger bridges in comparison to a continuous cross-section that is designed to be structurally efficient and in result materially efficient. The case study of this report, the Axarvegur bridge, is an example of this compromise and the resulting design effects.

Previous research and documented methods in the Netherlands find that bridge decks in general have low re-usability due to degraded quality at the time of demolition. A bridge deck is subject to significant wear during its lifespan due to its direct exposure to traffic, weather, and air- and waterborne degrading agents. Consequently, the quality eliminates the bridge deck for reuse as it requires more interventions to recondition its quality than beneficial, rendering a new deck a better investment of materials. Therefore, in this study, it has been assumed for the Circular Design Alternative that the precast girders are protected by a (sacrificial) layer of cast in situ concrete.

Other elements along the bridge have been dismissed as potentially having lower percentages of reuse due to their connections. In this report, this applies to the end abutments and intermediate cross girders, which are neglected from any re-use considerations.

Circularity actions must align with local regulations and challenges. For instance, transitioning from a continuous bridge structure to a simply supported one introduces more joints, which may be vulnerable to harsh weather and necessitate maintenance. As the case study is performed in Iceland, changes to locally established methods have unique considerations and it should be borne in mind that the pinned connections assumed for the circular design alternative may leave details that are susceptible to deterioration from for example freeze-thaw cycles and de-icing salts, both of which are components in the life cycles of bridges in Iceland.

As depicted in Table 9, a circular bridge, designed for reuse, increases material and carbon cost in comparison to the baseline alternative, a structurally efficient bridge. An area of further investigation includes researching the average functional lifespan of a conventional bridge and bridge constructed in reusable elements by comparing the design lifespan of its elements. The lower average functional lifespan of a bridge may defend the increase in carbon cost of a reuseable bridge. Designing for disassembly focuses on simplifying deconstruction to preserve the maximum amount of reusable and functional material. Effective circularity also entails administrative challenges such as the registration of bridge parts or logistics such as the storage of elements for future reuse.

As previously discussed, the possibility of reuse is highly dependent on local planning and commitment. Without a clear agenda and drive for reuse in the future, a heavier bridge will simply result in higher carbon emissions and less sustainable projects. Therefore, a structurally and materially efficient bridge that is well designed, will ultimately be the more sustainable option.

6 Conclusion

In conclusion, Design for Disassembly, manifested as the use of precast concrete elements for bridges, does not necessarily imply a more sustainable bridge product, but does ensure better possibilities for future reuse and circularity. Any sustainability benefits from adopting the circular design intentions investigated in this report are dependent on high durability of pre-cast concrete. Potential future developments in carbon costing is likely to increase the attractiveness of re-use and longevity. The Axarvegur bridge case study thus exemplifies the balance between structural efficiency and material reuse.

Designing for disassembly needs to be executed by considering the feasibility of transferring the product into the next stage, the reuse stage. This report and research assumes this process as achievable. However, the proposed process requires that suitable locations for component reuse are identified. For the circularity chain to begin, the disassembled bridge part needs a new project or area of use.

To increase the chance and probability of reuse, bridge parts must be standardized and less customized to its original location and purpose. The purpose of standardization is to have a wider range of projects where the products can be reused but also to avoid future adjustments, for example shortening of elements or additional reinforcement.

For further investigations into bridges in the circular economy, the following topics have been identified for future interest:

- Identifying circularity indicators that reward re-use over recycling
- Defining realistic durability of pre-cast concrete components for bridges, seeking experience from different markets worldwide
- Disassembly methods and their impact on reuseability of precast components connected by cast in situ concrete
- Likely future development of environmental impact shadow costs used for ECI evaluations of bridge structures.

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7 Appendix

Item nb.	Item description	Quantity	Unit	ECI based on EPDs		Mass (ton)	Unit price	Cost	Price (€)	ECI (€/ton)								ECI (€ for the project)								Price % total
										A		B		C		D		A		B		C		D		
				Quantity	Unit					total	CO2	total	CO2	total	CO2	total	CO2	total	CO2	total	CO2	total	CO2	total	CO2	
75,61	Road guardrail, overlap between bridge and road guardrail	80	m	80	m	2,4	30.000 kr	2.400.000 kr	16.152 €	10,04 €	9,99 €	- €	- €	1,90 €	0,35 €	-3,33 €	-3,29 €	24,10 €	23,99 €	- €	- €	4,56 €	0,83 €	-7,99 €	-7,90 €	0%
75,62	Bridge guardrail	111	m	111	m	6,7	130.000 kr	14.430.000 kr	97.113 €	10,04 €	9,99 €	- €	- €	1,90 €	0,35 €	-3,33 €	-3,30 €	66,87 €	66,56 €	- €	- €	12,65 €	2,30 €	-22,18 €	-21,94 €	1%
84,21	Concrete formwork - foundations	100	m2	5,3	m3	3,6	45.000 kr	4.500.000 kr	30.285 €	16,31 €	10,31 €	- €	- €	1,97 €	0,30 €	-35,40 €	-22,27 €	58,72 €	37,12 €	- €	- €	7,09 €	1,08 €	-127,44 €	-80,17 €	-1%
84,23	Concrete formwork - pillars	140	m2	7,42	m3	5,0	45.000 kr	6.300.000 kr	42.399 €	16,31 €	10,31 €	- €	- €	1,97 €	0,30 €	-35,40 €	-22,27 €	82,20 €	51,96 €	- €	- €	9,93 €	1,51 €	-178,42 €	-112,24 €	-1%
84,25	Concrete formwork - superstructure	830	m2	43,99	m3	29,9	55.000 kr	45.650.000 kr	307.221 €	16,31 €	10,31 €	- €	- €	1,97 €	0,30 €	-35,40 €	-22,27 €	487,34 €	308,06 €	- €	- €	58,86 €	8,96 €	-1.057,75 €	-665,43 €	-5%
84,311	Concrete reinforcement - foundations	8100	kg	8,1	tons	8,1	750 kr	6.075.000 kr	40.884 €	48,01 €	34,00 €	- €	- €	21,51 €	21,40 €	-1,23 €	-0,89 €	388,88 €	275,36 €	- €	- €	174,23 €	173,34 €	-9,96 €	-7,21 €	5%
84,313	Concrete reinforcement - pillars	4200	kg	4,2	tons	4,2	750 kr	3.150.000 kr	21.199 €	48,01 €	34,00 €	- €	- €	21,51 €	21,40 €	-1,23 €	-0,89 €	201,64 €	142,78 €	- €	- €	90,34 €	89,88 €	-5,17 €	-3,74 €	3%
84,315	Concrete reinforcement - superstructure	43500	kg	43,5	tons	43,5	750 kr	32.625.000 kr	219.564 €	48,01 €	34,00 €	- €	- €	21,51 €	21,40 €	-1,23 €	-0,89 €	2.088,44 €	1.478,78 €	- €	- €	935,69 €	930,90 €	-53,51 €	-38,72 €	26%
84,41	**Concrete - foundations**	**90**	**m3**	**90**	**m3**	**220,5**	**85.000 kr**	**7.650.000 kr**	**51.484 €**	**19,43 €**	**15,53 €**	**- €**	**- €**	**0,64 €**	**0,33 €**	**-1,80 €**	**-1,52 €**	**1.748,70 €**	**1.397,70 €**	**- €**	**- €**	**57,60 €**	**29,70 €**	**-162,00 €**	**-136,80 €**	**15%**
84,43	**Concrete - pillars**	**30**	**m3**	**30**	**m3**	**73,5**	**85.000 kr**	**2.550.000 kr**	**17.161 €**	**19,43 €**	**15,53 €**	**- €**	**- €**	**0,64 €**	**0,33 €**	**-1,80 €**	**-1,52 €**	**582,90 €**	**465,90 €**	**- €**	**- €**	**19,20 €**	**9,90 €**	**-54,00 €**	**-45,60 €**	**5%**
84,45	**Concrete - deck/superstructure**	**290**	**m3**	**290**	**m3**	**710,5**	**90.000 kr**	**26.100.000 kr**	**175.651 €**	**19,43 €**	**15,53 €**	**- €**	**- €**	**0,64 €**	**0,33 €**	**-1,80 €**	**-1,52 €**	**5.634,70 €**	**4.503,70 €**	**- €**	**- €**	**185,60 €**	**95,70 €**	**-522,00 €**	**-440,80 €**	**47%**
63,4	Concrete for road surfacing on bridge	25	m2	25	m2	15,3	220.000 kr	5.500.000 kr	37.015 €	19,43 €	15,53 €	- €	- €	0,64 €	0,33 €	-1,80 €	-1,52 €	297,52 €	237,80 €	- €	- €	9,80 €	5,05 €	-27,56 €	-27,56 €	2%
84,364	Post-tensioning, cables	8000	kg	8	tons	8	2.400 kr	19.200.000 kr	129.215 €	39,89 €	29,41 €	- €	- €	0,22 €	0,19 €	-11,67 €	-8,85 €	319,12 €	235,27 €	- €	- €	1,76 €	1,56 €	-93,36 €	-70,80 €	2%
							Total:	238.443.000 kr	1.604.704 €	330,7 €	244,4 €	- €	- €	77,0 €	67,3 €	-135,4 €	-91,0 €	11.981,1 €	9.225,0 €	- €	- €	1.567,3 €	1.350,7 €	-2.321,3 €	-1.658,9 €	100%

ECI € tot:	11.227 €	total	
ECI € tot:	8.917 €	for CO2 emissions	

Table 13: ECI calculations for the Axarvegur Bridge

Item nb.	Item description	Quantity	Unit	ECI based on EPDs		Mass (ton)	Unit price	Cost	Price (€)	ECI (€/ton)								ECI (€ for the project)								Price % total
										A		B		C		D		A		B		C		D		
				Quantity	Unit					total	CO2	total	CO2	total	CO2	total	CO2	total	CO2	total	CO2	total	CO2	total	CO2	
75,61	Road guardrail, overlap between bridge and road guardrail	80	m	80	m	2,4	30.000 kr	2.400.000 kr	16.152 €	10,04 €	9,99 €	- €	- €	1,90 €	0,35 €	-3,33 €	-3,29 €	24,10 €	23,99 €	- €	- €	4,56 €	0,83 €	-7,99 €	-7,90 €	0%
75,62	Bridge guardrail	111	m	111	m	6,66	130.000 kr	14.430.000 kr	97.113 €	10,04 €	9,99 €	- €	- €	1,90 €	0,35 €	-3,33 €	-3,30 €	66,87 €	66,56 €	- €	- €	12,65 €	2,30 €	-22,18 €	-21,94 €	0%
84,21	Concrete formwork - foundations	125	m2	6,625	m3	4,5	45.000 kr	5.625.000 kr	37.856 €	16,31 €	10,31 €	- €	- €	1,97 €	0,30 €	-35,40 €	-22,27 €	73,40 €	46,40 €	- €	- €	8,87 €	1,35 €	-159,30 €	-100,22 €	-1%
84,23	Concrete formwork - pillars	0	m2	0	m3	0	45.000 kr	- kr	- €	16,31 €	10,31 €	- €	- €	1,97 €	0,30 €	-35,40 €	-22,27 €	- €	- €	- €	- €	- €	- €	- €	- €	0%
84,25	Concrete formwork - superstructure	304	m2	16,112	m3	10,944	55.000 kr	16.720.000 kr	112.524 €	16,31 €	10,31 €	- €	- €	1,97 €	0,30 €	-35,40 €	-22,27 €	178,50 €	112,83 €	- €	- €	21,56 €	3,28 €	-387,42 €	-243,72 €	-1%
84,311	Concrete reinforcement - foundations	10080	kg	10,08	tons	10,08	750 kr	7.560.000 kr	50.878 €	48,01 €	34,00 €	- €	- €	21,51 €	21,40 €	-1,23 €	-0,89 €	483,94 €	342,67 €	- €	- €	216,82 €	215,71 €	-12,40 €	-8,97 €	5%
84,313	Concrete reinforcement - pillars	0	kg	0	tons	0	750 kr	- kr	- €	48,01 €	34,00 €	- €	- €	21,51 €	21,40 €	-1,23 €	-0,89 €	- €	- €	- €	- €	- €	- €	- €	- €	0%
84,315	Concrete reinforcement - superstructure	27825	kg	27,825	tons	27,825	750 kr	20.868.750 kr	140.445 €	48,01 €	34,00 €	- €	- €	21,51 €	21,40 €	-1,23 €	-0,89 €	1.335,88 €	945,91 €	- €	- €	598,52 €	595,46 €	-34,22 €	-24,76 €	15%
84,41	**Concrete - foundations**	**112**	**m^3**	**112**	**m^3**	**274,4**	**85.000 kr**	**9.520.000 kr**	**64.069 €**	**19,43 €**	**15,53 €**	**- €**	**- €**	**0,64 €**	**0,33 €**	**-1,80 €**	**-1,52 €**	**2.176,16 €**	**1.739,36 €**	**- €**	**- €**	**71,68 €**	**36,96 €**	**-201,60 €**	**-170,24 €**	**16%**
84,43	**Concrete precast - pillars**	**30**	**m^3**	**30**	**m^3**	**73,5**	**85.000 kr**	**2.550.000 kr**	**17.161 €**	**17,52 €**	**13,94 €**	**- €**	**- €**	**1,01 €**	**0,67 €**	**-0,39 €**	**-0,27 €**	**525,60 €**	**418,11 €**	**- €**	**- €**	**30,30 €**	**19,97 €**	**-11,70 €**	**-8,10 €**	**4%**
84,45	**Concrete cast in situ - deck/superstructure**	**185,5**	**m^3**	**185,5**	**m^3**	**454,475**	**90.000 kr**	**21.600.000 kr**	**145.366 €**	**19,43 €**	**15,53 €**	**- €**	**- €**	**0,64 €**	**0,33 €**	**-1,80 €**	**-1,52 €**	**3.604,27 €**	**2.880,82 €**	**- €**	**- €**	**118,72 €**	**61,22 €**	**-333,90 €**	**-281,96 €**	**26%**
84,75	**Concrete precast - deck/superstructure**	**240**	**m^3**	**240**	**m^3**	**588**				**17,52 €**	**13,94 €**	**- €**	**- €**	**1,01 €**	**0,67 €**	**-0,39 €**	**-0,27 €**	**4.204,80 €**	**3.344,88 €**	**- €**	**- €**	**242,40 €**	**159,72 €**	**-93,60 €**	**-64,80 €**	**33%**
63,4	Concrete for road surfacing on bridge	25	m2			15,3125	220.000 kr	5.500.000 kr	37.015 €	19,43 €	15,53 €	- €	- €	0,64 €	0,33 €	-1,80 €	-1,52 €	297,52 €	237,80 €	- €	- €	9,80 €	5,05 €	-27,56 €	-23,28 €	2%
84,364	Post-tensioning, cables	0	kg	0	tons	0	2.400 kr	- kr	- €	39,89 €	29,41 €	- €	- €	0,22 €	0,19 €	-11,67 €	-8,85 €	- €	- €	- €	- €	- €	- €	- €	- €	0%
							Total:	169.086.750 kr	1.137.942 €	346,3 €	256,8 €	- €	- €	78,4 €	68,3 €	-134,4 €	-90,0 €	12.971,0 €	10.159,3 €	- €	- €	1.335,9 €	1.101,8 €	-1.291,9 €	-955,9 €	100%

ECI € tot:	13.015 €	total	15,93%
ECI € tot:	10.305 €	for CO2 emissions	15,57%

Table 14: ECI calculation for the Circular Alternative

Item nb.	Item description	Quantity	Unit	ECI based on EPDs		Mass (ton)	Unit price	Cost	Price (€)	ECI (€/ton)								ECI (€ for the project)								Price % total
										A		B		C		D		A		B		C		D		
				Quantity	Unit					total	CO2	total	CO2	total	CO2	total	CO2	total	CO2	total	CO2	total	CO2	total	CO2	
75,61	Road guardrail, overlap between bridge and road guardrail	80	m	80	m	2,4	30.000 kr	2.400.000 kr	16.152 €	10,04 €	9,99 €	- €	- €	1,90 €	0,35 €	-3,33 €	-3,29 €	24,10 €	23,99 €	- €	- €	4,56 €	0,83 €	-7,99 €	-7,90 €	0%
75,62	Bridge guardrail	111	m	111	m	6,66	130.000 kr	14.430.000 kr	97.113 €	10,04 €	9,99 €	- €	- €	1,90 €	0,35 €	-3,33 €	-3,30 €	66,87 €	66,56 €	- €	- €	12,65 €	2,30 €	-22,18 €	-21,94 €	1%
84,21	Concrete formwork - foundations	125	m2	6,625	m3	4,5	45.000 kr	5.625.000 kr	37.856 €	16,31 €	10,31 €	- €	- €	1,97 €	0,30 €	-35,40 €	-22,27 €	73,40 €	46,40 €	- €	- €	8,87 €	1,35 €	-159,30 €	-100,22 €	-1%
84,23	Concrete formwork - pillars	0	m2	0	m3	0	45.000 kr	- kr	- €	16,31 €	10,31 €	- €	- €	1,97 €	0,30 €	-35,40 €	-22,27 €	- €	- €	- €	- €	- €	- €	- €	- €	0%
84,25	Concrete formwork - superstructure	304	m2	16,112	m3	10,944	55.000 kr	16.720.000 kr	112.524 €	16,31 €	10,31 €	- €	- €	1,97 €	0,30 €	-35,40 €	-22,27 €	178,50 €	112,83 €	- €	- €	21,56 €	3,28 €	-387,42 €	-243,72 €	-2%
84,311	Concrete reinforcement - foundations	10080	kg	10,08	tons	10,08	750 kr	7.560.000 kr	50.878 €	48,01 €	34,00 €	- €	- €	21,51 €	21,40 €	-1,23 €	-0,89 €	483,94 €	342,67 €	- €	- €	216,82 €	215,71 €	-12,40 €	-8,97 €	9%
84,313	Concrete reinforcement - pillars	0	kg	0	tons	0	750 kr	- kr	- €	48,01 €	34,00 €	- €	- €	21,51 €	21,40 €	-1,23 €	-0,89 €	- €	- €	- €	- €	- €	- €	- €	- €	0%
84,315	Concrete reinforcement - superstructure	26475	kg	26,475	tons	26,475	750 kr	19.856.250 kr	133.631 €	48,01 €	34,00 €	- €	- €	21,51 €	21,40 €	-1,23 €	-0,89 €	1.271,06 €	900,02 €	- €	- €	569,48 €	566,57 €	-32,56 €	-23,56 €	23%
84,41	**Concrete - foundations**	**112**	**m^3**	**112**	**m^3**	**274,4**	**85.000 kr**	**9.520.000 kr**	**64.069 €**	**19,43 €**	**15,53 €**	**- €**	**- €**	**0,64 €**	**0,33 €**	**-1,80 €**	**-1,52 €**	**2.176,16 €**	**1.739,36 €**	**- €**	**- €**	**71,68 €**	**36,96 €**	**-201,60 €**	**-170,24 €**	**26%**
84,43	**Concrete precast - pillars**	**0**	**m^3**	**0**	**m^3**	**66,15**	**85.000 kr**	**- kr**	**- €**	**17,52 €**	**13,94 €**	**- €**	**- €**	**1,01 €**	**0,67 €**	**-0,39 €**	**-0,27 €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**0%**
84,45	**Concrete cast in situ - deck/superstructure**	**176,5**	**m^3**	**176,5**	**m^3**	**432,425**	**90.000 kr**	**- kr**	**- €**	**19,43 €**	**15,53 €**	**- €**	**- €**	**0,64 €**	**0,33 €**	**-1,80 €**	**-1,52 €**	**3.429,40 €**	**2.741,05 €**	**- €**	**- €**	**112,96 €**	**58,25 €**	**-317,70 €**	**-268,28 €**	**41%**
84,75	**Concrete precast - deck/superstructure**	**0**	**m^3**	**0**	**m^3**	**529,2**				**17,52 €**	**13,94 €**	**- €**	**- €**	**1,01 €**	**0,67 €**	**-0,39 €**	**-0,27 €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**0%**
63,4	Concrete for road surfacing on bridge	24	m2			14,7	220.000 kr	5.280.000 kr	35.534 €	19,43 €	15,53 €	- €	- €	0,64 €	0,33 €	-1,80 €	-1,52 €	285,62 €		- €		9,41 €			-26,46 €	4%
84,364	Post-tensioning, cables	0	kg	0	tons	0	2.400 kr	- kr	- €	39,89 €	29,41 €	- €	- €	0,22 €	0,19 €	-11,67 €	-8,85 €	- €		- €		- €			- €	0%
							Total:	143.704.250 kr	967.119 €	346,3 €	256,8 €	- €	- €	78,4 €	68,3 €	-134,4 €	-90,0 €	7.989,0 €	5.972,9 €	- €	- €	1.028,0 €	885,2 €	-1.141,2 €	-871,3 €	100%

ECI € tot:	7.876 €	total	-29,85%
ECI € tot:	5.987 €	for CO2 emissions	-32,86%

Table 15: ECI calculation for the *Reused Bridge*

MEETING MINUTES

DOCUMENT SYSTEM CODE	PROJECT
2970-413-FUN-001-V01 Workshop w. Arup 20240201	**Bridges in a circular economy**

MEETING DATE / TIME	CLIENT
01.02.2024 / 12:30	Icelandic Road and Coastal Administration Research Fund

MEETING NO.

01

AGENDA

- Introduction of participants
- Background
- Workshop discussions
  - Short break at ~14:00
- Summary and work ahead

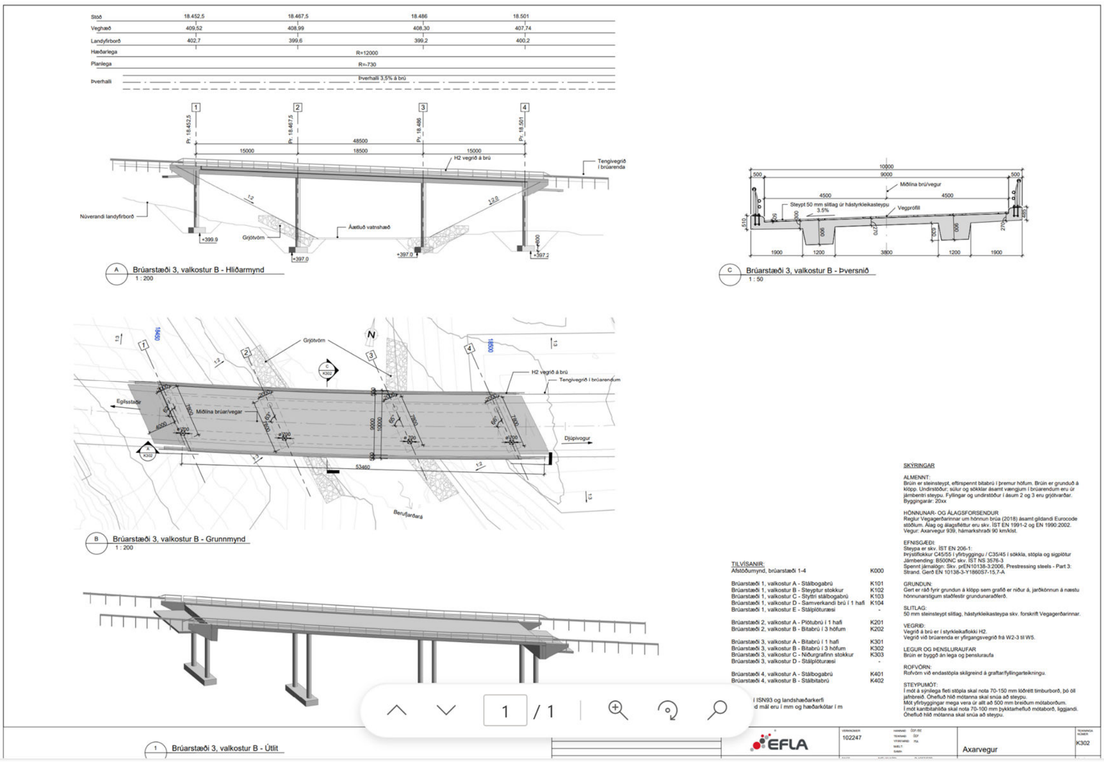
NOTE TAKER / MINUTES DATE	MEETING CALLED BY	LOCATION
CD / 01.02.2024	MA	Teams

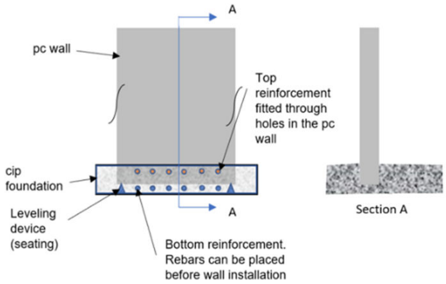
PRESENT	COMPANY
Magnús Arason (MA), Cécile Daniellou (CD), Franz Sigurjónsson (FS)	EFLA
Kevin Frederik (KF), Dimitri Tuinstra (DT), Alice Sormon (AS)	Arup

ABSENT	COMPANY
-	

DISTRIBUTION	COMPANY
Attendees, project records	

MEETING DOCUMENTS	NEXT MEETING DATE / TIME
	N/A

Nr.	MEETING CONTENT AND DISCUSSION	RESPONS-IBLE
01.1	**Introduction of attendees** A quick presentation of the six participants took place. A quick review of the background was given by MA, see attached slides.	
01.2	**Workshop proceedings** The team had identified a bridge design to use during this year´s work, from EFLA bridge concept design for Axarvegur:  The original proposal for the seminar was to evaluate the bill of quantities associated with this design, consider how re-use potential could be maximized for each component, and then to compare MCI and ECI (see last year´s report) for the original design and the revised one, “optimized” for circularity. DT suggested a clear distinction should be made between adjusting the design to maximize future reuse potential and the possible re-use of the components as they are designed originally. All agreed the importance of this distinction, and it was decided that the focus should be on revision of the bridge details with a view to build maximized re-use potential into the design, rather than to consider re-use possibilities for the components as they were originally drawn. Discussion followed; the following points were among those that were raised: - Why do bridges get decommissioned? (often either end of lifespan or new urbanism)	

- Considering circularity during the design phase is good, especially in case of a new plan of urbanism concerning the bridge before its end of lifespan. In that case, its elements can still be robust enough for a reuse.
- But circularity doesn't necessarily imply environmental efficiency. A bridge design with an optimization of its materials and demolished after its life can be (usually is) more sustainable than a 100% circular bridge. Illustrated by the Rijkswaterstaat (2019) Circular viaduct presented by AS and KF.
- Pre-cast elements appear to be the most efficient for circularity (In Germany, precast elements can be used for almost every part of a bridge according to DT). Pre-stressed, enhances durability.
- A standardization of bridges' elements should be a good step towards circularity. Typical bridges, DT pointed out an analogy to cars, where people worldwide make do with a finite set of makes and models.
- Even if we focus on laying the ground for only one reuse of the bridge components, this is still a big improvement.
- FS presented his conclusions from his MSc thesis on connections between a precast wall and a foundation cast in situ. The connection, when compared to a traditional cast in situ abutment, was found to behave acceptably w.r.t. ultimate limit state loading. He mentioned that the precast wall has to be embedded into the foundation, leading to a higher cross section of the foundation.
- 

Examination of the Axarvegur Bridge:

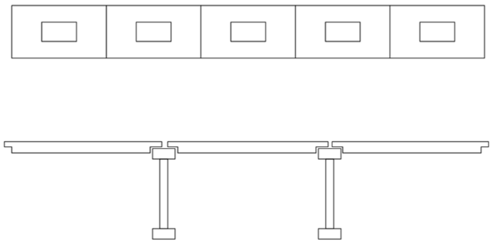
- No need for piles for the foundations, as the bridge is founded on bedrock.
- Curvature and skewness of abutment in relation to the road alignment are both a hindrance for circularity. This shall be among the conclusions of the report, that in terms of maximizing circularity potential, this (and future) bridge(s) should be straight. Curved girders and other elements are much more challenging to re-use as number of potential re-use sites reduces drastically.

01.3 Connections

1. Foundation to bottom of column
2. Top of column to end abutment cross girder
3. End of slab + longitudinal PT girders to end abutment cross girder
4. Division of superstructure to spans?
5. Top of column to underside of superstructure

Foundations to bottom of columns:

	- Should prefer circular columns rather than rectangular ones for circularity (efficient, no overweighted, modular). - Can use what FS presented: pre cast column with transversal holes at its bottom to receive reinforcement before site-casting the foundations. - Also, design the column with another set of holes so that after 1 use, the column can be cut and immediately reused with the same process as before. - This solution is a wet connection. Even better if we find a mechanical one, but those are challenging for durability etc. Other aspects: - Further protection, like an external membrane, or pre-stressing the column elements to ensure a compressive state in them to inhibit ingress of deteriorates, is beneficial for aiding in securing that the elements are in good shape for re-use when that time comes, particularly if the elements are submerged in ground during the service life. **Top of columns to end abutment cross girder:** - It seems like the same process as for the previous connection could also work here. **End of slab + longitudinal PT girders to end abutment cross girder:** - In discussions of this connection, it was identified that the post-tensioned, grouted tendons (bonded) are not really suitable for re-use, and should therefore not be included in the “circular” bridge. - This construction method has other advantages, such as durability and allowing for reduced overall material use. It was discussed that optimal use of materials (minimum carbon footprint for construction) may not go hand in hand with maximized material circularity. - The only feasible approach for re-use of a post-tensioned structure would be if the ducts were grease-filled as opposed to grouted, then the strands could (in theory) be released one at a time. A pre-requisite to this would be temporary supports in the middle of the spans. However such re-use would be dependent on elements lining up exactly as in original structure in the re-use configuration. - It was concluded that the circularity of this connection could not really be increased because the structural system of the case study superstructure does not allow itself to be re-used. - In order to increase the circularity of the superstructure and all its connections to other components, an alternative system will be drawn up.	

	 - - This system has equal length spans, all simply supported. - We will end up with cross girders at each axis (much used in the USA). - This configuration is likely to have an increased maintenance cost.	
01.4	**Follow-up and discussion** KF offered to look up the specific box girders. Also, he will look at the report. DT could send data/brochures on Dutch circular solutions, with the box girders for instance. CD will draw up the components discussed and share with the team.	KF DT CD
01.5	**Next meeting** MA calls in for next meeting in two weeks. CD will continue the work at EFLA.	MA CD

Nr.	PREVIOUS MEETINGS	RESPONS-IBLE

Circular economy for bridges

Workshop EFLA-Arup

01.02.2024

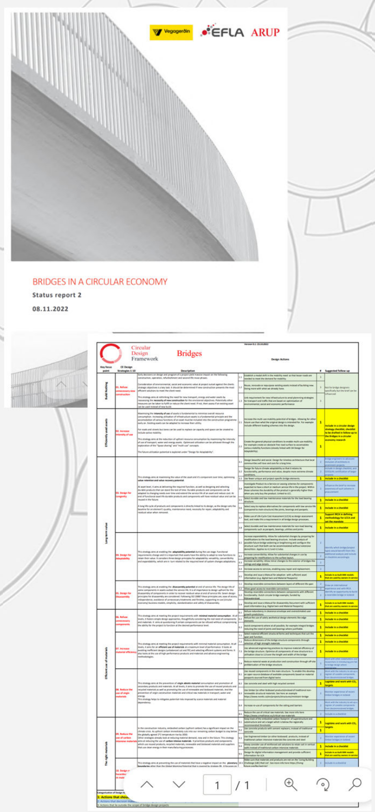
Magnús Arason

Cécile Daniellou

EFLA Bridges

Workshop 01.02.2024 - Agenda

- Introduction of participants
- Background
- Workshop discussions
  - Short break at ~14:00
- Summary and work ahead

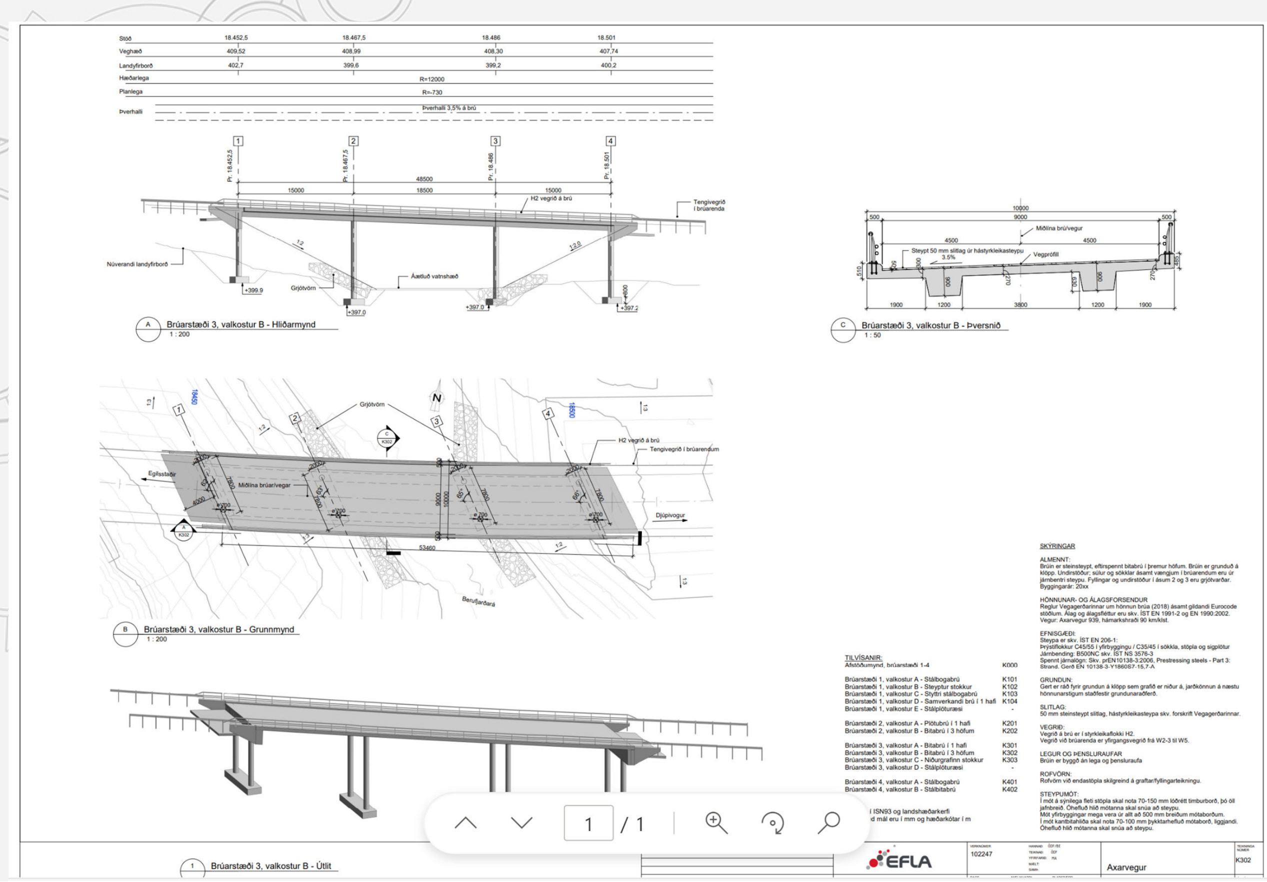


Background

- Continue from last year´s findings
- Report and circular design framework
- Work with MCI and ECI
- Go into more details on components in the workshop

Summary by CD yesterday

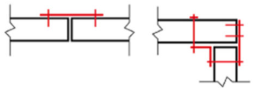
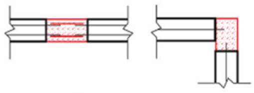
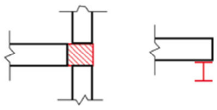
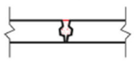
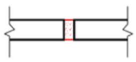
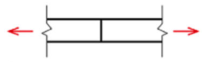
- [x] Compute Masses
- [x] Define a few materials of interest (3.3)
- [x] Compute ECI
- [ ] Verify the MCI method
- [ ] Gather data on usual among of reused/recycled materials in construction
- [ ] Compare usual data with circular examples already done
- [ ] Workshop 01.02.2024
  - **Work through the quantities for the bridge design to define range of circularity for each item**
- [ ] Compare the results with a linear economy projects to see the benefits/costs
- [ ] Use the two scenarii to place the potential circularity of the bridge into a range.


Stöð
Veghæð
Landyfirborð
Hæðarlega
Planlega
Þverhalli
R=12000
R=-730
Þverhalli 3,5% á brú
48500
15000
18500
15000
H2 vegrið á brú
Tengivegrið í brúarenda
Núverandi landyfirborð
Grjótvörn
Áætluð vatnshæð
Brúarstæði 3, valkostur B - Hliðarmynd
1 : 200
10000
9000
Miðlína brú/vegur
Steypt 50 mm slitlag úr hástyrkleikasteypu
3.5%
Vegprófíll
Brúarstæði 3, valkostur B - Þversnið
1 : 50
Grjótvörn
H2 vegrið á brú
Tengivegrið í brúarendum
Egilsstaðir
Miðlína brúarvegar
Djúpivogur
53460
Berufjarðará
Brúarstæði 3, valkostur B - Grunnmynd
1 : 200
Brúarstæði 3, valkostur B - Útlit
TILVÍSANIR:
Afstöðumynd, brúarstæði 1-4 K000
Brúarstæði 1, valkostur A - Stálbogabrú K101
Brúarstæði 1, valkostur B - Steyptur stokkur K102
Brúarstæði 1, valkostur C - Styttri stálbogabrú K103
Brúarstæði 1, valkostur D - Samverkandi brú í 1 hafi K104
Brúarstæði 1, valkostur E - Stálplöturæsi -
Brúarstæði 2, valkostur A - Plötubrú í 1 hafi K201
Brúarstæði 2, valkostur B - Bitabrú í 3 höfum K202
Brúarstæði 3, valkostur A - Bitabrú í 1 hafi K301
Brúarstæði 3, valkostur B - Bitabrú í 3 höfum K302
Brúarstæði 3, valkostur C - Niðurgrafinn stokkur K303
Brúarstæði 3, valkostur D - Stálplöturæsi -
Brúarstæði 4, valkostur A - Stálbogabrú K401
Brúarstæði 4, valkostur B - Stálbitabrú K402
í ISN93 og landshæðarkerfi
d mál eru í mm og hæðarkótar í m
SKÝRINGAR
ALMENNT:
Brúin er steinsteypt, eftirspennt bitabrú í þremur höfum. Brúin er grunduð á klöpp. Undirstöður; súlur og sökklar ásamt vængjum í brúarendum eru úr járnbentri steypu. Fyllingar og undirstöður í ásum 2 og 3 eru grjótvarðar.
Byggingarár: 20xx
HÖNNUNAR- OG ÁLAGSFORSENDUR
Reglur Vegagerðarinnar um hönnun brúa (2018) ásamt gildandi Eurocode stöðlum. Álag og álagsfléttur eru skv. ÍST EN 1991-2 og EN 1990:2002.
Vegur: Axarvegur 939, hámarkshraði 90 km/klst.
EFNISGÆÐI:
Steypa er skv. ÍST EN 206-1:
Þrýstiflokkur C45/55 í yfirbyggingu / C35/45 í sökkla, stöpla og sigplötur
Járnbending: B500NC skv. ÍST NS 3576-3
Spennt járnalögn: Skv. prEN10138-3:2006, Prestressing steels - Part 3: Strand. Gerð EN 10138-3-Y1860S7-15,7-A
GRUNDUN:
Gert er ráð fyrir grundun á klöpp sem grafið er niður á, jarðkönnun á næstu hönnunarstigum staðfestir grundunaraðferð.
SLITLAG:
50 mm steinsteypt slitlag, hástyrkleikasteypa skv. forskrift Vegagerðarinnar.
VEGRIÐ:
Vegrið á brú er í styrkleikaflokki H2.
Vegrið við brúarenda er yfirgangsvegrið frá W2-3 til W5.
LEGUR OG ÞENSLURAUFAR
Brúin er byggð án lega og þensluraufa
ROFVÖRN:
Rofvörn við endastöpla skilgreind á graftar/fyllingarteikningu.
STEYPUMÓT:
Í mót á sýnilega fleti stöpla skal nota 70-150 mm lóðrétt timburborð, þó öll jafnbreið. Óhefluð hlið mótanna skal snúa að steypu.
Mót yfirbyggingar mega vera úr allt að 500 mm breiðum mótaborðum.
Í mót kantbitahliða skal nota 70-100 mm þykktarhefluð mótaborð, liggjandi. Óhefluð hlið mótanna skal snúa að steypu.
EFLA
VERKNÚMER
102247
HANNAÐ ÓDF/BE
TEIKNAÐ ÓDF
YFIRFARIÐ MA
Axarvegur
TEIKNINGA NÚMER
K302
1 / 1

Case study connections

1. Foundation to bottom of column
2. Top of column to end abutment cross girder
3. End of slab + longitudinal PT girders to end abutment cross girder
4. Division of superstructure to spans?
5. Top of column to underside of superstructure

Table 2
Connection types identified from the case-study documentation. Red lines and textures correspond to added reinforcement devices and concrete.

Connection-type description	Illustrative example	Featuring case studies
Steel plates or angles with bolts or anchor rods		C29; C31; C32; C34; C41; C54; C62; C63; C75
Post-installed rebars sealed with mortar or chemical adhesive		C54; C58; C59; C63; C67; C77
New rebars welded to existing ones, imbedded in mortar or concrete		C39; C47; C63;
Reinforced concrete or steel support beam		C34; C47; C50; C58; C59; C63; C75
Longitudinal shear key with reinforced mortar or concrete		C67
Mortar between pieces		C29; C31; C32; C34; C41; C62; C63; C68; C69; C77
Internal post-tensioning		C69
New structural topping with (reinforced) concrete		C75
Reinforced concrete matrix		C61

epd-norge
Global program operatør

Environmental product declaration

In accordance with ISO 14025 and EN15804+A2

Ørsta Brurekkverk BR3

Eier av deklarasjonen:
Vik Ørsta AS

Produkt:
Ørsta Brurekkverk BR3

Deklarert enhet:
1 m

Deklarasjonen er basert på PCR:
EN 15804:2012+A2:2019 tjener som kjerne-PCR
NPCR 013:2021 Part B for Steel and aluminium construction products

Programoperatør:
Næringslivets Stiftelse for miljødeklarasjoner

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Næringslivets Stiftelse for miljødeklarasjoner

Generell informasjon

Produkt

Ørsta Brurekkverk BR3

Eier av deklarasjonen:

Vik Ørsta AS
Kontaktperson: Teknisk sjef - Jan Olav Hoggen
Telefon: 0047 95170854
e-post: jan.olav.hoggen@vikorsta.no

Programoperatør:

Postboks 5250 Majorstuen, 0303 Oslo, Norge
Næringslivets Stiftelse for miljødeklarasjoner
Telefon: +47 23 08 80 00
web: post@epd-norge.no

Produsent:

Vik Ørsta AS

Deklarasjonsnummer: NEPD-5529-4834-NO

Produksjonssted:

Vik Ørsta AS
Strandgata 59,
No-6150 Ørsta, Norway, Norway

Deklarasjonen er basert på PCR:

EN 15804:2012+A2:2019 tjener som kjerne-PCR
NPCR 013:2021 Part B for Steel and aluminium construction products

Kvalitet/Miljøsystem:

NS-EN ISO 9001:2015 NS-EN ISO 14001:2015

Erklæring om ansvar:

Eieren av deklarasjonen skal være ansvarlig for den underliggende informasjon og bevis. EPD Norge skal ikke være ansvarlig med hensyn til produsent informasjon, livsløpsvurdering data og bevis.

Org. no.:

985001952

Deklarert enhet:

1 m Ørsta Brurekkverk BR3

Godkjent dato: 08.12.2023

Deklarert enhet med opsjon:

A1-A3,A4,A5,C1,C2,C3,C4,D

Gyldig til: 08.12.2028

Årstall for studien:

2022

Funksjonell enhet:

1m komplett brurekkverk med gitterpanel/sprossepanel

Sammenlignbarhet:

EPD av byggevarer er nødvendigvis ikke sammenlignbare hvis de ikke samsvarer med NS-EN 15804 og ses i en bygningskontekst.

Generelt om verifikasjon av EPD fra verktøy:

Uavhengig verifikasjon av data, annen miljøinformasjon og EPD er foretatt etter ISO 14025:2010, kapittel 8.1.3 og 8.1.4. Verifikasjon av hver EPD foretas i henhold til EPD-Norge sine retningslinjer for verifikasjon og godkjenning som krever at EPD-verktøy er i integrert i bedriftens miljøstyringssystem, ii prosedyrer for bruk av EPD-verktøy er godkjent av EPD-Norge og iii prosessen gjennomgås årlig av en uavhengig 3.parts verifikator. Se vedlegg G i EPD-Norge sine retningslinjer for mer informasjon om EPD-verktøy.

Utarbeidelse og verifikasjon av miljødeklarasjon:

Deklarasjonen er utarbeidet og verifisert ved bruk av EPD-verktøy lca.tools ver EPD2022.03, utviklet av LCA.no. EPD-verktøyet er integrert i bedriftens miljøstyringssystem, og godkjent av EPD-Norge

EPD er utarbeidet av: Daniel Fossberg

Bedriftsspesifikke data og EPD er kontrollert av: Heidi Lauvåsen

Verifikasjon av EPD-verktøy:

Uavhengig tredjepartsverifikasjon av verktøy, bakgrunnsdata og test-EPD er gjort i henhold til EPD-Norge sine prosedyrer og retningslinjer for verifisering og godkjenning av EPD-verktøy.

Tredjeparts verifikator:

Alexander Borg, Asplan Viak AS

(krever ikke signatur

Godkjent:

Håkon Hauan

Håkon Hauan, CEO EPD-Norge

Produkt

Produktbeskrivelse:

Ørsta Brurekkverk er fullskalatestet i hht. NS-EN 1317 i styrkeklasse H2, med arbeidsbredde W2.
Rekkverket har runde, myke former som også gir god sikkerhet mot skade.
Ørsta Brurekkverk leveres i flere varianter og tilpasses det enkelte prosjekt.

Produktspesifikasjon:

Denne EPD'en er gjeldane for Ørsta Brurekkverk BR3 i fleire variantar som 1050mm og 1200mm, med tilhøyrande gitterpanel eller sprossepanel.

Materialer	kg	%
Metal - Steel	64,52	95,67
Metal - Zinc	2,92	4,33
Total	67,44	

Tekniske data:

Styrkeklasse H2
Arbeidsbredde W2
Skadeklasse B
Inntrengingsklasse VI4
Høyde 1200 mm
Bredde 370 mm
Stolpeavstand 2000 mm
Forankring Fotplate
CE Sertifikat Ja
Snøklasse 4

Markedsområde:

Hovedsaklig Norden, men også resten av verden

Levetid, produkt:

50 år

Levetid, bygg eller anlegg:

LCA: Beregningsregler

Deklarert enhet:

1 m Ørsta Brurekkverk BR3

Cut-off kriterier:

Alle viktige råmaterialer og all viktig energibruk er inkludert. Produksjonsprosessen for råmaterialene og energistrømmer som inngår med veldig små mengder (mindre enn 1%) er ikke inkludert. Disse cut-off kriteriene gjelder ikke for farlige materialer og stoffer.

Allokering:

Allokering er gjort iht. bestemmelser i EN 15804. Inngående energi og vann, samt produksjon av avfall i egen produksjon er allokert likt mellom alle produktene gjennom masseallokering. Miljøpåvirkning og ressursforbruk for primærproduksjonen av resirkulerte materialer er allokert til det opprinnelige produktsystemet. Bearbeidingsprosessen og transport av materialet til produksjonssted er allokert til analysen i denne EPDen.

Datakvalitet:

Spesifikke data for produktsammensetningen er fremskaffet av produsenten. De representerer produksjonen av det deklarerte produktet og ble samlet inn for EPD-utvikling i det oppgitte året for studien. Bakgrunnsdata er basert på EPDer iht. EN 15804 og ulike LCA databaser. Datakvaliteten for råmaterialene i A1 er presentert i tabellen nedenfor.

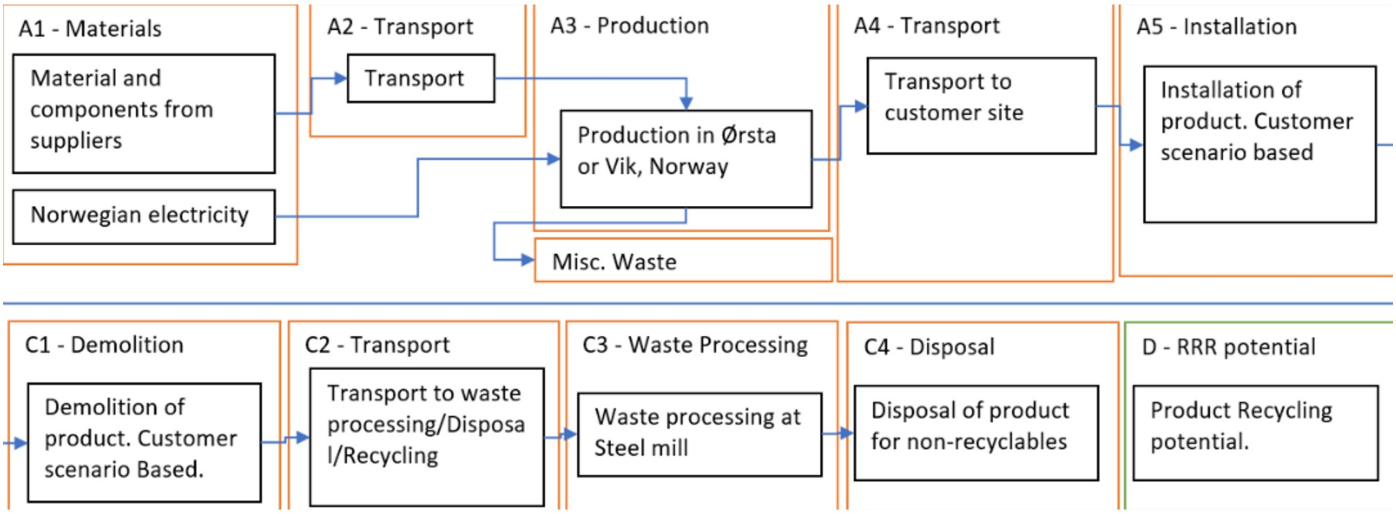
Materialer	Kilde	Datakvalitet	År
Metal - Steel	ecoinvent 3.6	Database	2019
Metal - Zinc	ecoinvent 3.6	Database	2019
Metal - Steel	S-P-02241	EPD	2020
Metal - Steel	S-P-02242	EPD	2020
Metal - Steel	SSAB	EPD (EN15804A1) + company dataset (EN15804A2)	2020

Systemgrenser (X=inkludert, MND=modul ikke deklarert, MNR=modul ikke relevant)

Produktfase			Sammenstillingsfase		Bruksfase							Sluttfase				Gevinst og belastninger etter endt levetid (D)
Råmaterialer	Transport	Tilvirkning	Transport	Konstruksjons/ installasjonsfase	Bruk	Vedlikehold	Reparasjon	Utskiftinger	Renovering	Operasjonell energibruk	Operasjonell vannbruk	Demontering	Transport	Avfallsbehandling	Avfall til sluttbehandling	Gjenbruk/gjenvinning/ resirkulering-potensiale
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	MND	MND	MND	MND	MND	MND	MND	X	X	X	X	X

Systemgrenser:

Flytskjemaet nedenfor illustrerer systemgrensene for analysen:



Teknisk tilleggsinformasjon:

LCA: Scenarier og annen teknisk informasjon

Følgende informasjon beskriver scenariene for modulene i EPDen.

Transport fra produksjonssted til bruker (A4)	Kapasitetsutnyttelse inkl. retur (%)	Distanse (km)	Brennstoff/Energiforbruk	Enhet	Verdi (Liter/tonn)
Truck, 16-32 tonnes, EURO 6 (km)	36,7 %	300	0,043	l/tkm	12,90

Byggefase (A5)	Enhet	Verdi			
Diesel, burned (L)	L/DU	1,01			

Demontering (C1)	Enhet	Verdi			
Diesel, burned (L)	L/DU	1,01			

Transport til avfallsbehandling (C2)	Kapasitetsutnyttelse inkl. retur (%)	Distanse (km)	Brennstoff/Energiforbruk	Enhet	Verdi (Liter/tonn)
Truck, 16-32 tonnes, EURO 6 (km)	36,7 %	300	0,043	l/tkm	12,90

Avfallsbehandling (C3)	Enhet	Verdi			
Materials to recycling (kg)	kg	57,50			

Avfall til sluttbehandling (C4)	Enhet	Verdi			
Waste, scrap steel, to landfill (kg)	kg	6,39			

Gevinst og belastninger etter endt levetid (D)	Enhet	Verdi			
Substitution of primary steel with net scrap (kg)	kg	52,99			
Substitution of zinc (kg) - RoW	kg	2,49			

LCA: Resultater

LCA resultatene er presentert under for enheten som er definert på side 2 av EPD dokumentet.

Miljøpåvirkning (Environmental impact)										
	Indikator	Enhet	A1-A3	A4	A5	C1	C2	C3	C4	D
	GWP-total	kg CO_2 -eq	1,93E+02	3,31E+00	3,57E+00	3,57E+00	3,31E+00	0,00E+00	2,74E-02	-6,59E+01
	GWP-fossil	kg CO_2 -eq	1,92E+02	3,31E+00	3,57E+00	3,57E+00	3,31E+00	0,00E+00	2,74E-02	-6,58E+01
	GWP-biogenic	kg CO_2 -eq	8,65E-01	1,37E-03	6,69E-04	6,69E-04	1,37E-03	0,00E+00	2,33E-05	-1,05E-01
	GWP-luluc	kg CO_2 -eq	9,73E-02	1,18E-03	2,81E-04	2,81E-04	1,18E-03	0,00E+00	5,37E-06	-5,11E-02
	ODP	kg CFC11 -eq	5,47E-06	7,49E-07	7,71E-07	7,71E-07	7,49E-07	0,00E+00	1,33E-08	-2,43E-06
	AP	mol H+ -eq	6,47E-01	9,51E-03	3,73E-02	3,73E-02	9,51E-03	0,00E+00	2,67E-04	-3,64E-01
	EP-FreshWater	kg P -eq	2,38E-03	2,64E-05	1,30E-05	1,30E-05	2,64E-05	0,00E+00	2,04E-07	-4,45E-03
	EP-Marine	kg N -eq	1,53E-01	1,88E-03	1,65E-02	1,65E-02	1,88E-03	0,00E+00	1,00E-04	-7,63E-02
	EP-Terrestial	mol N -eq	1,67E+00	2,10E-02	1,81E-01	1,81E-01	2,10E-02	0,00E+00	1,10E-03	-7,97E-01
	POCP	kg NMVOC -eq	4,80E-01	8,06E-03	4,97E-02	4,97E-02	8,06E-03	0,00E+00	3,16E-04	-3,38E-01
	ADP-minerals&metals[1]	kg Sb -eq	2,33E-01	9,14E-05	5,48E-06	5,48E-06	9,14E-05	0,00E+00	2,42E-07	-1,94E-01
	ADP-fossil[1]	MJ	2,24E+03	5,00E+01	4,91E+01	4,91E+01	5,00E+01	0,00E+00	8,83E-01	-6,02E+02
	WDP[1]	m^3	3,15E+03	4,84E+01	1,04E+01	1,04E+01	4,84E+01	0,00E+00	1,86E+00	2,74E+03

GWP-total = Globalt oppvarmingspotensial totalt; GWP-fossil = Globalt oppvarmingspotensial fossile brensler; GWP-biogenic = Globalt oppvarmingspotensial biogene kilder; GWP-luluc = Globalt oppvarmingspotensial arealbruk og arealbruks endringer; ODP = Potensial for nedbryting av stratosfærisk ozon; AP = Forsuringspotensial for kilder på land og vann; EP = overgjødslingspotensial til ferskvann, hav og jord; POCP = Potensial for fotokjemisk oksidantdanning; ADP-minerals&metals = Abiotisk utarmingspotensial for ikke-fossile ressurser, mineraler og metaller; ADP-fossil = Abiotisk utarmingspotensial for fossile ressurser, fossile brensler; WDP = Utarmingspotensial for vannressurser

"Leseeksempel: 9,0 E-03 = 9,0*10 -3 = 0,009"
*INA Indicator Not Assessed (indikator ikke vurdert)

1. Resultatene av denne miljøpåvirkningsindikatoren skal brukes med forsiktighet ettersom usikkerheten til resultatene er høy eller det er begrenset erfaring med bruk av indikatoren.

Merknad om miljøpåvirkningen

Supplerende indikatorer for miljøpåvirkning

Indikator	Enhet	A1-A3	A4	A5	C1	C2	C3	C4	D
PM	Disease incidence	4,08E-06	2,03E-07	9,88E-07	9,88E-07	2,03E-07	0,00E+00	5,69E-09	-5,13E-06
IRP[2]	kgBq U235 -eq	3,89E+00	2,19E-01	2,11E-01	2,11E-01	2,19E-01	0,00E+00	3,83E-03	-6,10E-01
ETP-fw[1]	CTUe	1,34E+03	3,71E+01	2,69E+01	2,69E+01	3,71E+01	0,00E+00	4,37E-01	-3,64E+03
HTP-c[1]	CTUh	1,33E-07	0,00E+00	1,04E-09	1,04E-09	0,00E+00	0,00E+00	1,10E-11	-3,23E-07
HTP-nc[1]	CTUh	2,51E-06	4,05E-08	2,47E-08	2,47E-08	4,05E-08	0,00E+00	2,57E-10	4,85E-06
SQP[1]	dimensionless	3,27E+02	3,50E+01	6,24E+00	6,24E+00	3,50E+01	0,00E+00	3,22E+00	-8,82E+01

PM = Partikkelutslipp; IRP = Ioniserende stråling (helseeffekt); ETP-fw = Økotoksisitet (ferskvann); HTP-c = Toksisitet påvirkning på mennesker, kreft; HTP-nc = Toksisitet påvirkning på mennesker, andre effekter enn kreft; SQP = Påvirkninger knyttet til arealbruksendringer / jordkvalitet

"Leseeksempel: 9,0 E-03 = 9,0*10 -3 = 0,009"
*INA Indicator Not Assessed (indikator ikke vurdert)

1. Resultatene av denne miljøpåvirkningsindikatoren skal brukes med forsiktighet ettersom usikkerheten til resultatene er høy eller det er begrenset erfaring med bruk av indikatoren.
2. Denne påvirkningskategorien omhandler hovedsakelig den eventuelle effekten av lavdose ioniserende stråling på menneskers helse i atombrenselsyklusen. Den tar ikke hensyn til effekter på grunn av mulige atomulykker, yrkesmessig eksponering eller på grunn av fjerning av radioaktivt avfall i underjordiske anlegg. Potensiell ioniserende stråling fra jorda, fra radon og fra noen byggematerialer måles heller ikke av denne indikatoren.

Ressursbruk (Resource use)										
Indikator		Enhet	A1-A3	A4	A5	C1	C2	C3	C4	D
	PERE	MJ	2,95E+02	7,16E-01	2,66E-01	2,66E-01	7,16E-01	0,00E+00	1,36E-02	-5,46E+01
	PERM	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
	PERT	MJ	2,95E+02	7,16E-01	2,66E-01	2,66E-01	7,16E-01	0,00E+00	1,36E-02	-5,46E+01
	PENRE	MJ	2,26E+03	5,00E+01	4,91E+01	4,91E+01	5,00E+01	0,00E+00	8,83E-01	-6,01E+02
	PENRM	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
	PENRT	MJ	2,26E+03	5,00E+01	4,91E+01	4,91E+01	5,00E+01	0,00E+00	8,83E-01	-6,01E+02
	SM	kg	5,02E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-1,19E-01
	RSF	MJ	1,02E+00	2,56E-02	6,54E-03	6,54E-03	2,56E-02	0,00E+00	2,81E-04	1,70E+00
	NRSF	MJ	4,05E+00	9,16E-02	9,62E-02	9,62E-02	9,16E-02	0,00E+00	8,07E-04	6,09E+01
	FW	m^3	1,87E+00	5,35E-03	2,53E-03	2,53E-03	5,35E-03	0,00E+00	1,05E-03	-3,58E-01

PERE = Fornybar primærenergi brukt som energibærer; PERM = Fornybar primærenergi brukt som råmateriale; PERT = Total bruk av fornybar primærenergi; PENRE = Ikke fornybar primærenergi brukt som energibærer; PENRM = Ikke fornybar primærenergi brukt som råmateriale; PENRT = Total bruk av ikke fornybar primærenergi; SM = Bruk av sekundære materialer; RSF = Bruk av fornybart sekundære brensel; NRSF = Bruk av ikke fornybart sekundære brensel; FW = Netto bruk av ferskvann.

"Leseeksempel: 9,0 E-03 = 9,0*10 -3 = 0,009"
*INA Indicator Not Assessed (indikator ikke vurdert)

Livsløpets slutt - Avfall (End of life - Waste)

Indikator		Enhet	A1-A3	A4	A5	C1	C2	C3	C4	D
	HWD	kg	2,37E+00	2,58E-03	1,45E-03	1,45E-03	2,58E-03	0,00E+00	0,00E+00	-4,06E-01
	NHWD	kg	2,15E+01	2,43E+00	5,82E-02	5,82E-02	2,43E+00	0,00E+00	6,39E+00	-2,49E+01
	RWD	kg	2,29E-02	3,41E-04	3,41E-04	3,41E-04	3,41E-04	0,00E+00	0,00E+00	-4,17E-04

HWD = Avhendet farlig avfall; NHWD = Avhendet ikke-farlig avfall; RWD = Avhendet radioaktivt avfall

"Leseeksempel: 9,0 E-03 = 9,0*10 -3 = 0,009"
*INA Indicator Not Assessed (indikator ikke vurdert)

Livsløpets slutt - Utgangsfaktorer (End of life - Output flow)

Indikator		Enhet	A1-A3	A4	A5	C1	C2	C3	C4	D
	CRU	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
	MFR	kg	1,53E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,75E+01	0,00E+00	-1,04E-01
	MER	kg	1,61E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-4,33E-03
	EEE	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-1,85E-01
	EET	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-2,80E+00

CRU = Komponenter for gjenbruk, MFR Materialer for resirkulering, MER = Materialer for energigjenvinning, EEE = Eksportert elektrisk energi; EET = Eksportert termisk energi

"Leseeksempel: 9,0 E-03 = 9,0*10 -3 = 0,009"
*INA Indicator Not Assessed (indikator ikke vurdert)

Informasjon om innholdet av biogent karbon

Indikator	Enhet	Ved port
Innhold av biogent karbon i produkt	kg C	0,00E+00
Innhold av biogent karbon i emballasjen	kg C	3,41E-02

Merk: 1 kg biogent karbon tilsvarer 44/12 kg CO2

Tilleggskrav

Klimagassutslipp fra bruk av elektrisitet i produksjonsfasen

Nasjonal produksjonsmiks fra import, lavspenning (inkludert produksjon av overføringslinjer, i tillegg til direkte utslipp og tap i nett) er brukt for anvendt elektrisitet i produksjonsprosessen (A3). Bakgrunnsdata er presentert i tabellen under. Karakteriseringsfaktorer fra EN15804:2012+A2:2019 er benyttet.

Electricity mix	Data source	Amount	Enhet
Electricity, Norway (kWh)	ecoinvent 3.6	24,33	g CO2-eq/kWh

Farlige stoffer

Produktet er ikke tilført stoffer fra REACH Kandidatliste eller den norske prioritetslisten.

Inneklima

Ytterligere miljøinformasjon

Ytterligere indikatorer for miljøpåvirkning nødvendig i NPCR Part A for construction products									
Indikator	**Enhet**	A1-A3	A4	A5	C1	C2	C3	C4	D
GWPIOBC	kg CO_2 -eq	1,94E+02	3,31E+00	3,57E+00	3,57E+00	3,31E+00	0,00E+00	2,74E-02	-9,49E+01

GWP-IOBC: Globalt oppvarmingspotensial beregnet etter prinsippet om umiddelbar oksidasjon. For å øke tydeligheten av biogent karbonbidrag til klimapåvirkning, kreves indikatoren GWP-IOBC da den erklærer klimapåvirkninger beregnet i henhold til prinsippet om øyeblikkelig oksidasjon. GWP-IOBC er også referert til som GWP-GHG i sammenheng med svensk lov om offentlige anskaffelser.

Bibliografi

NS-EN ISO 14025:2010 Miljømerker og deklarasjoner - Miljødeklarasjoner type III - Prinsipper og prosedyrer.
NS-EN ISO 14044:2006 Miljøstyring - Livsløpsvurderinger - Krav og retningslinjer.
NS-EN 15804:2012+A2:2019 Bærekraftig byggverk - Miljødeklarasjoner - Grunnleggende produktkategoriregler for byggevarer.
ISO 21930:2017 Sustainability in buildings and civil engineering works -
Core rules for environmental product declarations of construction products and services.
ecoinvent v3, Allocation, cut-off by classification, Swiss Centre of Life Cycle Inventories.
Iversen et al., (2021) eEPD v2021.09 Background information for EPD generator tool system verification, LCA.no rapportnummer: : 07.21.
Graafland and Iversen, (2022) EPD generator for EPD generator for NPCR 013 Part B for Steel and Aluminum, Background information for EPD generator application and LCA data, LCA.no report number: 08.22
NPCR Part A: Construction products and services. Ver. 2.0. April 2021, EPD-Norge.
NPCR 013 Part B for Steel and Aluminium Construction Products , Ver. 4.0, 06.10.2021, EPD Norway.

epd-norge Global program operatør	**Programoperatør og utgiver** Næringslivets Stiftelse for miljødeklarasjoner Postboks 5250 Majorstuen, 0303 Oslo, Norge	Telefon: +47 23 08 80 00 e-post: post@epd-norge.no web: www.epd-norge.no
VIKØrsta	**Eier av deklarasjonen:** Vik Ørsta AS Strandgata 59, , No-6150 Ørsta, Norway	Telefon: 0047 95170854 e-post: jan.olav.hoggen@vikorsta.no web: www.vikorsta.no
LCA.no	**Forfatter av livsløpsrapporten** LCA.no AS Dokka 6B, 1671	Telefon: +47 916 50 916 e-post: post@lca.no web: www.lca.no
LCA.no	**Utvikler av EPD-generator** LCA.no AS Dokka 6B,1671 Kråkerøy	Telefon: +47 916 50 916 e-post: post@lca.no web: www.lca.no
ECO PLATFORM EPD VERIFIED	ECO Platform ECO Portal	web: www.eco-platform.org web: ECO Portal

KOSKISEN

Rakennustietosäätio RTS
Building Information Foundation RTS

RTS EPD, RTS_EPD_41_19

KoskiStandard birch plywood, uncoated

Scope of the declaration

This environmental product declaration covers the environmental impacts of uncoated birch plywood. The declaration has been prepared in accordance with EN 15804:2012A1: 2013 and ISO 14025 standards and the additional requirements stated in the RTS PCR (English version, 14.6.2018). This declaration covers the life cycle stages from from cradle-to-gate with options including transportation to installation site, deconstruction, transportation, treatment and recovery of the product at its end-of-life.

RAKENNUSTIETO

14.11.2019
Building Information Foundation RTS
Malminkatu 16 A
00100 Helsinki

http://epd.rts.fi

Committee secretary

RTS managing director

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General information, declaration scope and verification (7.1)

KOSKISEN

1. Owner of the declaration, manufacturer

Koskisen Oy
Tehdastie 2, 16600 Järvelä, Finland

Riitta Ahokas

358 40 5534 410

riitta.ahokas@koskisen.com

2. Product name and number

KoskiStandard birch plywood, uncoated

3. Place of production

Järvelä mill, Finland

4. Additional information

www.koskisen.com

5. Product Category Rules and the scope of the declaration

This EPD has been prepared in accordance with EN 15804:2012A1:2013 and ISO 14025 standards together with the RTS PCR (Eglish version, 14.6.2018). Product specific category rules have not been applied in this EPD. EPD of construction materials may not be comparable if they do not comply with EN 15804 and seen in a building context.

6. Author of the life-cycle assessment and declaration

Riitta Ahokas

Koskisen Oy

Riitta Ahokas

7. Verification

This EPD has been verified according to the requirements of ISO 14025:2010, EN 15804: 2012A1:2013 and RTS PCR by a third party. The verification has been carried out by Bionova Oy Anastasia Sipari.

8. Declaration issue date and validity

14.11.2019-18.10.2024

European standard EN 15804: 2014 A1 serves as the core PCR	
Independent verification of the declaration and data, according to ISO14025:2010	
☐ Internal	☑ External
Third party verifier: Bionova Oy/ Anastasia Sipari	

Product information

9. Product description

This EPD represents uncoated birch plywood produced in Järvelä,Finland. KoskiStandard is a Finnish plywood with high-quality. The product is used in various end uses like construction, die-cutting, and with various coatings in vehicle business.
Wood species used are certified according to PEFC and FSC Chain of Custody and certified ISO 9001 and environmental (ISO 14001) Management system, which include a wood origin tracking system.

10. Technical specifications

The product consists of the following materials birch veneers in 1,5 mm thickness and phenol or urea based formaldehyde resins. The product is available in thicknesses ranging from 4 mm to 50 mm. The nominal density of the product is as average 680 kg/m3. More information on web-page www.koskisen.com

11. Product standards

Koskisen birch plywood complies with the following standards:
EN 636-1 Plywood specifications; Part 1: Requirements for plywood for use in dry conditions
EN 636-2 Plywood specifications; Part 2: Requirements for plywood for use in humid conditions
EN 636-3 Plywood specifications; Part 3: Requirements for plywood for use in exterior conditions

12. Physical properties

Detailed physical properties available at web-pages of the company:
www.koskisen.com/plywood. Also some technical details are shown in Handbook of Finnish plywood.

In order to adapt results of EPD to plywood of different size the conversion factors presented below can be applied

Panel thickness mm	kg/m2	m2/m3
4	2,7	250,00
6,5	4,4	153,85
9	6,1	111,11
12	8,2	83,33
12,2	10,2	81,97
18	12,2	55,56
21	14,3	47,62
24	16,3	41,67
27	18,4	37,04
30	20,4	33,33
35	23,8	28,57
40	27,2	25,00
45	30,6	22,22
50	34	20,00

13. Raw-materials of the product

Product structure / composition / raw-material	Amount %
Wood	93,2 %
Phenolic resin	5,6 %
Limestone aggregate	0,5 %
Urea formaldehyde resin	0,4 %
Hardeners	0,3 %
Polypropylene	0,0 %
Total	100,0 %

14. Substances under European Chemicals Agency’s REACH, SVHC restrictions

Name	EC Number	CAS Number

The product does not contain REACH SVHC substances.

15. Functional / declared unit

m3 of plywood

16. System boundary

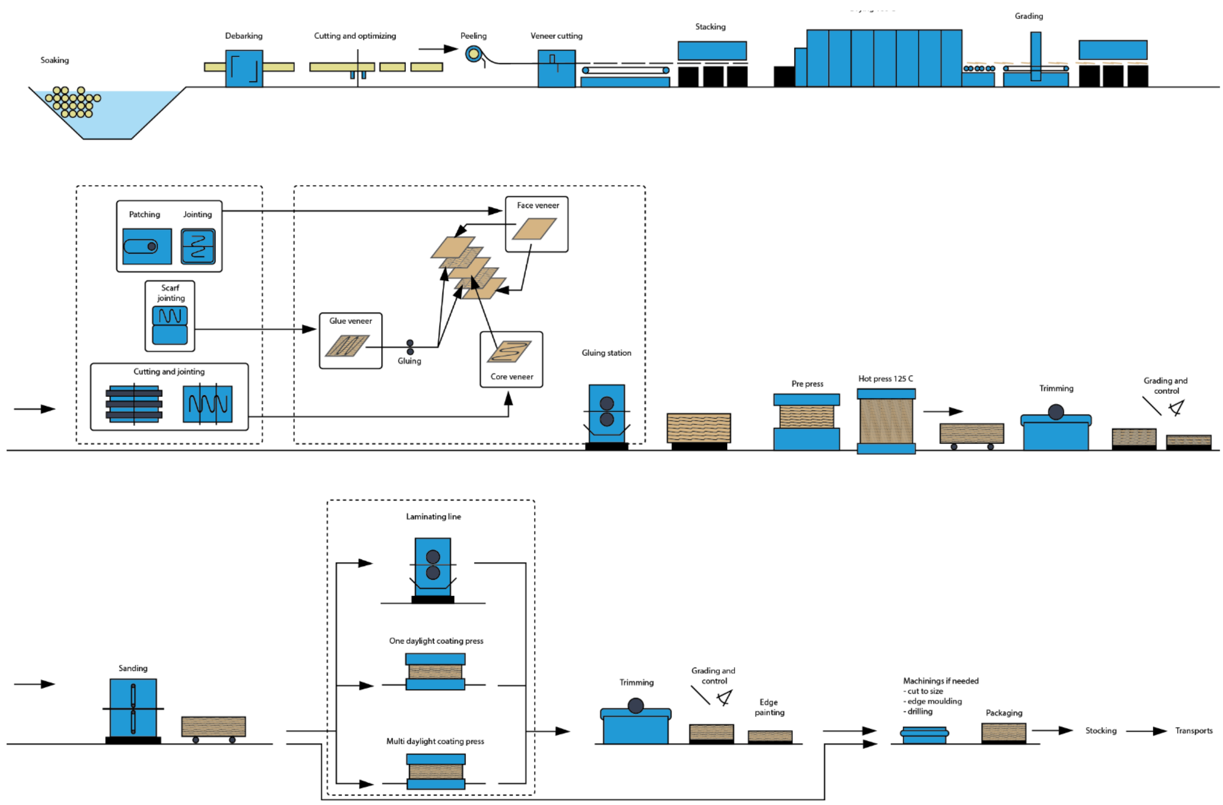
This EPD covers the following modules; A1 (Raw material supply), A2 (Transport), A3 (Manufacturing) and A4 (Transportation of the product to the building site) as well as C1 (Deconstruction), C2 (Transport at end-of-life), C3 (Waste processing) and C4 (Disposal). In addition, module D - benefits and loads beyond the system boundary - have been included.

17. Cut-off criteria

All used materials, energy , packaging, transportation fuel and waste treatment until the end-of-waste state have been included in the product stage (A1-A3). Results for the product stage have been provided as an aggregate. A4 transportation has been estimated to be 100 km, the return trip has not been considered. Module B information has not been presented or included in the LCA calculation. Energy consumption of demolition (C1) is assumed to be negligible. Transportation distance to treatment facility is assumed to be 100 km. Collected chipboard is shredded and incinerated for energy production purposes (C3), generated ash is landfilled (C4). Module D considers the benefits of energy recovery which replaces district heat

18. Production process

The product is manufactured from birch logs certified according to PEFC/FSC and phenol formaldehyde resin for exterior applications and with urea formaldehyde for interior applications. The logs are peeled into veneers and then various thicknesses are laid up from the veneers in various construction.



Scope of the Life-Cycle Assessment (7.2.1-2)

Mark all the covered modules of the EPD with X. Mandatory modules are marked with blue in the table below. This declaration covers “cradle-to-gate with options”. For other fields mark MND (module not declared) or MNR (module not relevant)

Product stage			Assembly stage		Use stage							End of life stage				Beyond the system boundaries		
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D	D	D
x	x	x	x	MND	MND	MND	MND	MND	MND	MND	MND	x	x	x	x	x	x	x
Raw materials	Transport	Manufacturing	Transport	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse	Recovery	Recycling

Mandatory modules
Mandatory as per the RTS PCR section 6.2.1 rules and terms
Optional modules based on scenarios

Environmental impacts and raw-material use (7.2.3-7.2.4)

19. Environmental impacts

The results of a life cycle assessment are relative. They do not predict impact on category endpoints, exceeding of limit values, safety margins or risks. The impacts are presented per declared unit, 1 m3 of product. The impacts are mainly caused by the manufacturing process(A3).

Environmental impact								
Parameter	**Unit**	**A1-A3**	**A4**	**C1**	**C2**	**C3**	**C4**	**D**
Global warming potential	kg CO2 -eqv	2,91E2	3,47E0	0E0	2,6E0	6,15E0	3,68E-2	-6,55E2
Depletion of stratospheric ozone layer	kg CFC11-eqv	3,09E-5	7,84E-7	0E0	5,14E-7	7,14E-7	9,43E-9	-3,34E-5
Formation of photochemical ozone	kg C2H4 -eqv	2,24E-1	5,66E-4	0E0	1,47E-4	1,99E-3	1,18E-5	-1,94E-1
Acidification	kg SO2 -eqv	1,42E0	1,78E-2	0E0	1,20E-2	1,50E-1	2,53E-4	-3,63E0
Eutrophication	kg PO4 3--eqv	2,91E-1	4,15E-3	0E0	2,61E-3	1,97E-1	7,63E-5	-4,94E-1
Abiotic depletion of non fossil resources	kg Sb-eqv	2,5E0	1,10E-5	0E0	1,89E-2	1,60E-5	4,86E-8	-7,75E-5
Abiotic depletion of fossil resources	MJ	6,01E3	9,36E1	0E0	7,43E1	6,05E1	8,67E-1	-6,49E3

20. Use of natural resources

Resource use								
Parameter	**Unit**	**A1-A3**	**A4**	**C1**	**C2**	**C3**	**C4**	**D**
Renewable primary energy resources used as energy carrier	MJ	1,68E4	1,31E0	0E0	1,22E-1	2,41E0	2,73E-2	-1,77E2
Renewable primary energy resources used as raw materials	MJ	8,89E3	0E0	0E0	0E0	0E0	0E0	0E0
Total use of renewable primary energy resources	MJ	1,69E4	1,31E0	0E0	1,22E-1	2,41E0	2,73E-2	-1,77E2
Nonrenewable primary energy resources used as energy carrier	MJ	7,62E3	1,00E2	0E0	7,4E1	6,87E1	9,43E-1	-7,06E3
Nonrenewable primary energy resources used as materials	MJ	3,56E1	0E0	0E0	0E0	0E0	0E0	0E0
Total use of non-renewable primary energy resources	MJ	7,66E3	1,00E2	0E0	7,4E1	6,87E1	9,43E-1	-7,06E3
Use of secondary materials	kg	6,88E-3	0E0	0E0	0E0	0E0	0E0	0E0
Use of renewable secondary fuels	MJ	0E0	0E0	0E0	0E0	0E0	0E0	0E0
Use of non-renewable secondary fuels	MJ	3,25E0	0E0	0E0	0E0	0E0	0E0	0E0
Use of net fresh water	m3	3,72E0	3,18E-3	0E0	0E0	7,07E-1	9,33E-5	-4,10E-1

21. End of life - Waste

Waste								
Parameter	**Unit**	**A1-A3**	**A4**	**C1**	**C2**	**C3**	**C4**	**D**
Hazardous waste	kg	7,73E-1	1,02E-5	0E0	1,02E-5	1,75E-4	6,97E-7	-2,23E-3
Non-hazardous waste	kg	3,15E1	7,93E-3	0E0	7,93E-3	6,68E0	3,47E0	-1,62E1
Radioactive waste	kg	2,54E-2	2,91E-4	0E0	2,91E-4	2,12E-4	5,38E-6	-1,35E-2

22. End of life - Output flow

Output flow								
Parameter	**Unit**	**A1-A3**	**A4**	**C1**	**C2**	**C3**	**C4**	**D**
Components for reuse	kg	0E0	0E0	0E0	0E0	0E0	0E0	0E0
Materials for recycling	kg	7,08E-4	0E0	0E0	0E0	0E0	0E0	0E0
Materials for energy recovery	kg	3,37E-3	0E0	0E0	0E0	6,8E2	0E0	0E0
Exported energy	MJ	0E0	0E0	0E0	0E0	0E0	0E0	-2,453

Scenarios and additional technical information (7.3)

23. Electricity in the manufacturing phase (7.3.A3)

A3 Sähkön tiedon laatu ja CO_2 päästö kg CO_2 ekv. /kWh	**FI 0,23**	Based on country specific fuel mixes for the production year 2017 from IEA Imported electricity has been considered. The environmental impacts of the fuels are based on ecoinvent 3,4 database. The impacts include all upstream processes as well as transmission losses.

24. Transport from production place to user (7.3.2 A4)

Variable	Amount	Data quality
Fuel type and consumption in **liters / 100 km**	38	Source: Driver
Transportation distance **km**	100	Transportation report
Transport capacity utilization **%**	100	Full load transport to production area.
Bulk density of transported products **kg/m^3**	680	Producer data
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	1	Assumption

25. End-of-life process description (7.3.4)

Process	**Unit**(expressed per functional unit or per declared unit of components products or materials and by type of material)	**Amount kg/m3** **Data quality**
Collection process specified by type	kg collected separately	680
	kg collected with mixed construction waste	0
Recovery system specified by type	kg for re-use	0
	kg for recycling	0
	kg for energy recovery	680
Disposal specified by type	kg product or material for final deposition	4
Assumptions for scenario development, e.g. transportation	units as appropriate	Transportation distance estimation based on average recycling facility locations; 100 km

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26. Additional technical information

Biogenic carbon of studied product is calculated in accordance to NS-EN 16449:2014 Dry wood content of plywood is 633 kg per m3 that is equal to biogenic carbon content 1161kg CO2 per m3 of the plywood.

27. Product data sheet

Technical specifications – KoskiStandard

Base plywood	Koskisen Finnish birch plywood
Bonding	Phenolic resin according to EN 314-2/ class 3 exterior conditions Formaldehyde emission levels of panels fulfil requirements of Class E1 (EN13986) , CARB Phase II , ULEF (Ultra Low Emitting Formaldehyde)
Face qualities	S, BB, WG, WG+
Standard thicknesses	4-50 mm S-qualities 4-21 mm and other thicknesses on request.
Standard sizes	1200/1220/1250 x 2400/2440/2500 mm 1200/1220 x 3000/3300/3600/4000 mm 1500/1525 x 3000/3300/3600/4000 mm S-qualities: 1220 x 2440 mm 1500 x 3000 mm Other sizes on request up to 2900 x 13000 mm
Density	Approx 700 kg/m³
Fire classification	D-s2, d0 (EN 13501), this is valid for thicknesses of 9 mm and up E17 118RII for buses 95/28/EC Approval for vehicle floors B-s1, d0 on request (EN 13501)
Machining	Drilling of holes edge machining like T&G, chamfer and rebate on request.
Other data	Detailed technical values can be found in Koskisen's Declaration of Performance (DoP). Please visit koskisen.com/download.

Additional information

Environment
Our raw material, wood is an ecological and renewable material and it stores carbon during its whole life cycle. Koskisen plywood products are manufactured in Finland according to the strictest sustainability principles. Koskisen is a pioneer in the Finnish forest industry in paying attention to the environment and the wood's supply chain is always known in detail. Finnish forests are primarily privately owned and the owners are guided by a strong commitment to long-term forestry and forest cultivation. Yearly, Finnish forests grow more than they are harvested. This guarantees a sustainable and environmentally sound raw material.

Additional information
Wood is a living material and every panel is unique. Therefore a photograph or a sample piece cannot represent a full sized panel as regards colours, shades, figure, knots etc. Please note that a slight colour variation is accepted between panels.

The information, although based on extensive testing, is intended as a guideline only and comes without warranty. We reserve the right to amend specifications without notice. Any defects other than those caused by clearly verified production or service faults by the supplier are the responsibility of the user. Any claim for compensation is limited to the value of the defective panels. The Seller makes no guarantee that the goods are fit for a particular purpose, unless it provides a written declaration of their suitability.

Koskisen Panel Industry
Tehdastie 2, 16600 Järvelä, FINLAND
tel. +358 20 553 41
fax +358 20 553 4207

www.koskisen.com
committedtowood.koskisen.com

FSC PEFC CE 2412-CPR-1301-01

One Click LCA

28. Additional information (7.4)

Air, soil and water impacts during the use phase have not been studied.

29. Bibliography

ISO 14025:2010 Environmental labels and declarations – Type III environmental declarations Principles and procedures. ISO 14040:2006 Environmental management. Life cycle assessment. Principles and frameworks. ISO 14044:2006 Environmental management. Life cycle assessment. Requirements and guidelines. EN 15804:2012A1 Sustainability in construction works – Environmental product declarations – Core rules for the product category of construction products. RTS PCR 14.6.2018 RTS PCR protocol: EPDs published by the Building Information Foundation RTS sr. PT 18 RT EPD Committee. (English version)

NS-EN 16449:2014 Wood and wood-based products - Calculation of the biogenic carbon content of wood and conversion to carbon dioxide

NS-EN 16485:2014 Round and sawn timber - Environmental Product Declaration - Product category rules for wood and wood-based products for use in construction

Environmental Product Declaration No 180/2021

Prefabricated steel elements manufactured in Włocławek: cutting, bending and de-coiling of reinforcing steel

First issuance date: 01.02.2016. Verification after 5 years: January 2021. Validity date: 01.02.2026

EPD program operator:

Building Research Institute (ITB), 00-611 Warsaw, Filtrowa 1
www.itb.pl; www.zb.itb.pl/epd
ITB is the member of The European Platform for EPD program operators. www.eco-platform.org

Manufacturer

thyssenkrupp Materials Poland S.A.
Office: Grudziądzka 159, 87-100 Toruń
Factory: Zbrojarnia Włocławek, Al. Kazimierza Wielkiego 7, 87-800 Włocławek
Telephone number: +48 56 611 94 94
Fax number: +48 56 611 95 75
Internet address: https://www.thyssenkrupp-materials.pl
E-mail address: biuro@tkmaterials.pl

Basic information

This declaration is the type III Environmental Product Declaration (EPD) based on EN 15804 and verified according to ISO 14025 by external auditor. It contains the information on the impacts of declared construction materials on environment and their aspects verified by the independent verficator 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 (see point 5.3 of the standard).
Life cycle: A1-A3 modules + C3 and D in accordance with EN 15804 (Cradle to Gate with Options)
The year of first EPD issuance: 2015 (EPD no 47/2016)
The year of re-validation: 2021
Declared durability: Under normal conditions. thyssenkrupp Materials Poland products are expected to last the service life of a building (60 years)
PCR: ITB PCR A (PCR based on EN 15804)
Declared unit: 1 tonne of prefabricated steel elements: steel for reinforcement of concrete. prefabricated wire rod
Reasons for performing LCA: B2B
Representativeness: Polish products, year 2020

Manufacturer and Product Information

thyssenkrupp Materials Poland S.A. is the leading supplier of steel products in Poland. According to the customer's design is producing reinforced steel elements of all shapes. as well as poles' framing including;

- Straight bars
- Cut and bend
- Big diameter pile cages
- Diaphragm wall reinforcement
- Assembly on site

Centrally managed logistics guarantees the safety of supplies both domestically and abroad. A full range of solutions is available to meet specific performance specifications (see http://www.thyssenkrupp-energostal.pl/building_industry.html).

The subject of this EPD is based on the actual technical documents for factory Włocławek of thyssenkrupp Materials Poland S.A. All actual technical documents are available on producer's website https://www.thyssenkrupp-materials.pl

Set of products for thyssenkrupp Materials Poland under this EPD covers prefabricated steel elements shown in Table 1.

Table 1. Product description and range

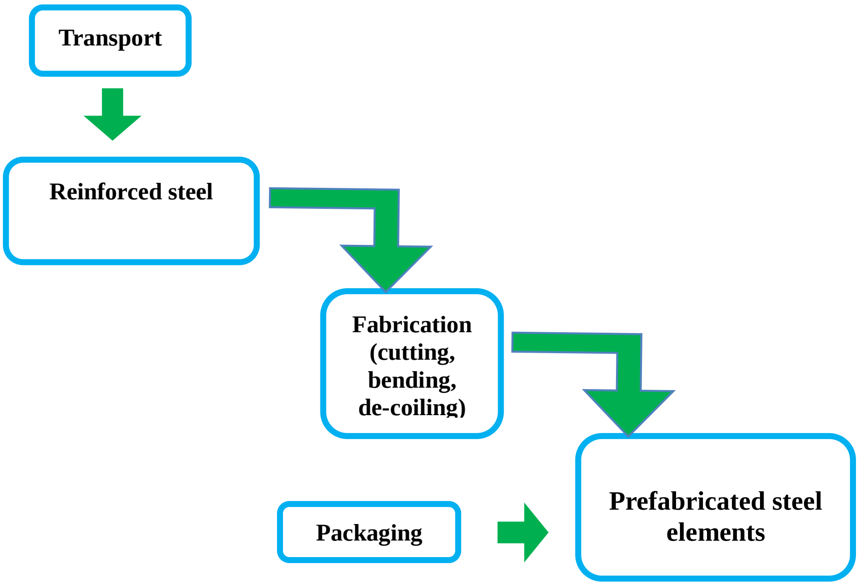
PRODUCT	TYPE	CLASS	STANDARD
Prefab rebar and wire rod ø6-8mm	type B500A	class A	PN-H-93247-1_2008; PN-EN 10080_2007; PN-EN 1992-1-1
Prefab rebar and wire rod ø10-16mm	type B500B and B500C	class B and C	PN-H-93220_2006; PN-EN 10080_2007; DIN-488; PN-EN 1992-1-1
Prefab rebar ø18-32mm	type B500B and B500C	class B and C	PN-H-93220_2006; PN-EN 10080_2007; DIN-488; PN-EN 1992-1-1

A1 and A2 Modules: Reinforcing steel supply and transport

Reinforced steel is produced by a local suppliers and input data for reinforced steel environmental impacts comes from specific EPDs. For the purposes of this EPD declaration it was assumed that 95% of the steel comes from the arc furnaces production (EAF). EAF - an electric furnace in which the charge is heated with an electric arc reaching a temperature of several thousand degrees Celsius, which enables the melted charge to be heated to temperatures from 1400 ° C to 2000 ° C. Data on transport of the different products to the manufacturing plant are collected by producer and modelled for Włocławek plant by ITB. Means of transport include truck. Polish and European fuel averages are applied.

A3: Production

Manufacture covers all processes linked to the production, which comprises various related operations besides on-site activities, including; cutting, bending and de-coiling of steel, finishing. packaging and internal transportation.



The manufacturing process also yields data on the combustion of refinery products such as diesel and gasoline related to the production process. Use of electricity, fuels and auxiliary materials in the production of reinforced steel products is taken into account using national specific data. The environmental profile of the energy carriers is modelled by ITB for average Polish conditions based on relevant Kobize 2019 data. Packaging-related flows in the production process and all upstream packaging are included in the manufacturing module. i.e. stretch foil. Apart from production of packaging material. the supply and transport of packaging material are also considered in the LCA model. It is assumed that packaging waste generated in the course of production and up-stream processes is 100% collected and incinerated based on a multi-input and multi-output process specific to the elementary composition of the waste.

C4 and D - End of life scenarios

The end-of-life scenario for all products has been generalized. Steel is considered as infinitely recyclable material. Typically is recovered by demolition contractors, who sell the recovered steel as ferrous scrap. Materials recovered from dismantled products are recycled (100%). The reuse, recovery and recycling potential for a new product system is considered beyond the system boundaries (module D) based on World Steel recommendations (net scrap approach).

Table 2. End of life scenarios for products

Progress products	Recycling
Steel products	100%

Allocation

The allocation rules used for this EPD are based on ITB-PCR A. The prefabricated steel reinforcing system production is a single line process without co-products. All impacts from raw materials extraction and production of reinforcing steel (outside Włocławek factory) are allocated in production of reinforcing steel and taken into consideration in A1 module of EPD. 100% of impacts from line production were inventoried and allocated to prefab reinforcing system in module A3. Municipal waste and waste water of whole factory were allocated to module A3. Electricity was inventoried for whole production process. Emissions are measured separately as well and presented in A3 module.

System limits

The life cycle analysis of the examined products covers "Product Stage". A1-A3 modules (Cradle to Gate) in accordance with EN 15804+A1 and ITB-PCR A. Details on systems limits are provided in product specific ITB-EPDs. For example for thyssenkrupp Materials Poland prefabs system includes production of reinforced steel outside of Włocławek factory(upstream process), transport to the factory and production stage in Włocławek. All materials and energy consumption inventoried in thyssenkrupp Materials Poland factory all sub were included in calculation. Office impacts were taken into consideration. In the assessment, all significant parameters from gathered production data are considered. i.e. all material used per formulation, utilised thermal energy, internal fuel and electric power consumption, direct production waste and all available emission measurements. It can be assumed that the total sum of omitted processes does not exceed 5% of all impact categories. The machines and facilities (capital goods) required for and during production are excluded. as is transportation of employees.

Data collection period

The data for manufacture of the examined products (reinforced steel products) refer to the year 2020. The life cycle assessments were prepared for Poland as the reference area.

Data quality

The values determined to calculate the LCIA originate from verified LCI thyssenkrupp Materials Poland Włocławek inventory data. This data was verified.

Assumptions and estimates

Impacts for each product and factory process were inventoried and calculated separately. All raw material consumption. emission water used were specific and presented in specific EPD. Emission into air from energy carriers was estimated using national conversion factors for carriers.

Databases

The data for LCA comes from the following databases: steel rods and wires (specific EPDs for EAF steel produced). Kobize 2019 (electricity). Specific data quality analysis was a part of external audit. Characterization factors are CML ver. 4.2 based on EN 15804:2013+A1 version. (PN EN 15804+A1:2014-04)

Calculation rules

LCA was done in accordance to PCR A document.

Power Mix

Selection of the power mix for 2019 in accordance with formal National Mix published by annual GUS report. Specific data for power production impact - KOBIZE.

Environmental characteristics (LCA)

The declaration refers to declared unit (DU) – 1 ton (Mg) of the reinforced steel product (Table 4).

Table 3. System boundaries (life stage modules included) in a product environmental assessment

Environmental assessment information (MNA – Module not assessed, MD – Module Declared, 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**
MD	**MD**	**MD**	**MNA**	**MNA**	**MNA**	**MNA**	**MNA**	**MNA**	**MNA**	**MNA**	**MNA**	**MNA**	**MNA**	**MD**	**MNA**	**MD**

Table 4. Environmental characteristic for Prefabricated rebar and wire (1 Mg)

Environmental impacts: 1 Mg						
Indicator	**Unit**	**A1**	**A2**	**A3**	**C3**	**D**
Global warming potential	[kg CO_2 eq.] (100 years)	6.41E+02	2.16E+01	1.73E+01	4.28E+02	-1.78E+01
Depletion potential of the stratospheric ozone layer	[kg CFC 11 eq.]	1.25E-07	6.50E-07	2.59E-07	1.24E-09	-7.93E-11
Acidification potential of soil and water	[kg SO_2 eq.]	2.64E+00	1.58E-01	5.52E-02	1.98E-02	-6.80E-02
Formation potential of tropospheric ozone	[kg Ethene eq.]	1.58E-01	1.15E-02	6.90E-02	1.80E-03	-9.96E-03
Eutrophication potential	[kg $(PO_4)^{3-}$ eq.]	2.07E-01	2.78E-02	1.61E-03	2.50E-03	-5.30E-03
Abiotic depletion potential (ADP-elements) for non-fossil resources	[kg Sb eq.]	2.20E-04	9.45E-07	0.173/1000	1.40E-06	-1.46E-06
Abiotic depletion potential (ADP-fossil fuels) for fossil resources	[MJ]	7.01E+03	1.83E+02	1.73E+02	4.28E+00	-1.50E+02
Environmental aspects on resource use: 1 Mg						
Indicator	**Unit**	**A1**	**A2**	**A3**	**C3**	**D**
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	[MJ]	INA	INA	INA	INA	INA
Use of renewable primary energy resources used as raw materials	[MJ]	INA	INA	INA	INA	INA
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)	[MJ]	1.24E+03	9.51E+00	1.04E+01	1.22E+01	-8.71E+00
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	[MJ]	INA	INA	INA	INA	INA
Use of non-renewable primary energy resources used as raw materials	[MJ]	INA	INA	INA	INA	INA
Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials)	[MJ]	9.12E+03	2.11E+02	2.21E+02	6.44E+01	-1.59E+02
Use of secondary material	[kg]	1.11E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary fuels	[MJ]	0.00E+00	0.00E+00	3.45E-01	0.00E+00	0.00E+00
Use of non-renewable secondary fuels	[MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Net use of fresh water	[dm^3]	3.23E+00	1.74E+00	6.90E-03	1.97E-02	-1.2E+00
Other environmental information describing waste categories: 1 Mg						
Indicator	**Unit**	**A1**	**A2**	**A3**	**C3**	**D**
Hazardous waste disposed	[kg]	2.45E-02	0.00E+00	1.34E-02	1.00E-06	-2.25E-07
Non-hazardous waste disposed	[kg]	2.56E+01	0.00E+00	1.73E+00	1.50E-02	-2.50E-01
Radioactive waste disposed	[kg]	4.30E-02	0.00E+00	4.30E-02	5.00E-03	-2.00E-03
Components for re-use	[kg]	0.00E+00	0.00E+00	0.00E+00	8.50E+02	0.00E+00
Materials for recycling	[kg]	0.00E+00	0.00E+00	2.54E+01	0.00E+00	0.00E+00
Materials for energy recovery	[kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy	[MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Verification

The process of verification of this EPD is in accordance with EN ISO 14025, clause 8 and ISO 21930, clause 9. After verification, this EPD is valid for a 5-year-period.

The basis for LCA analysis was EN 15804 and ITB PCR A
Independent verification corresponding to ISO 14025 & 8.3.1. ☒ external ☐ internal
External verification of EPD: PhD. Eng Halina Prejzner LCA, LCI data verification: PhD D.SC. Eng Michał Piasecki. m.piasecki@itb.pl Verification of LCA: PhD. Eng Justyna Tomaszewska, j.tomaszewska@itb.pl

Normative references

- LCI DATA FOR STEEL PRODUCTS at https://www.worldsteel.org/en/dam/jcr:04f8a180-1406-4f5c-93ca-70f1ba7de5d4/LCI%2520study_2018%2520data%2520release.pdf
- KOBiZE Wskaźniki emisyjności CO_2, SO_2, NOx, CO i pyłu całkowitego dla energii elektrycznej, grudzień 2019
- World Steel Association 2017 Life Cycle inventory methodology report for steel products
- ITB PCR A- General Product Category Rules for Construction Products
- ISO 14025:2006. Environmental management – Type III environmental declarations – Principles and procedure
- ISO 21930:2007. Sustainability in building and construction – Environmental declaration of building products
- ISO 14044:2006. Environmental management – Life cycle assessment – Requirements and guidelines
- ISO 15686-1:2000. Buildings and constructed assets — Service life planning — Part 1: General principles
- ISO 15686-8:2008. Buildings and constructed assets – Service life planning – Part 8: Reference service life
- EN 15804:2012+A1:2013. Sustainability in construction works – Environmental product declarations – Core rules for the product category of construction products.
- EN15942:2011. Sustainability of construction- Environmental product declarations. Communication format business-to-business

Instytut Techniki Budowlanej
00-611 Warsaw, Filtrowa 1

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

CERTIFICATE № 180/2021
of TYPE III ENVIRONMENTAL DECLARATION

Products:

Steel reinforcement prefabricates

Manufacturer:

Thyssenkrupp Materials Poland S.A.

Grudziądzka 159, 87-100 Toruń, Poland

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 on 1st February 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, February 2021

epd-norge.no
The Norwegian EPD Foundation

ENVIRONMENTAL PRODUCT DECLARATION

in accordance with ISO 14025, ISO 21930 and EN 15804

Owner of the declaration:	BM Vallá
Program operator:	The Norwegian EPD Foundation
Publisher:	The Norwegian EPD Foundation
Declaration number:	NEPD-2365-1103-EN
Registration number:	NEPD-2365-1103-EN
ECO Platform reference number:	-
Issue date:	08.09.2020
Valid to:	08.09.2025

Ready mix concrete C30/C37 outdoor

BM Vallá

www.epd-norge.no

General information

Product:

Ready mix concrete C30/C37 outdoor

Owner of the declaration:

BM Vallá
Contact person: Smári Valgarðsson
Phone: +3546175020
e-mail: smariva@bmvalla.is

Program operator:

The Norwegian EPD Foundation
Pb. 5250 Majorstuen, 0303 Oslo
Phone: +47 23 08 80 00
e-mail: post@epd-norge.no

Manufacturer:

BM Vallá

Declaration number:

NEPD-2365-1103-EN

Place of production:

BM Vallá, Reykjavík

ECO Platform reference number:

Management system:

ISO 9001

This declaration is based on Product Category Rules:

CEN Standard EN 15804:2012+A1:2013 serves as core PCR
NPCR 020:2018 Part B for Concrete and concrete elements

Organisation no:

10480

Statement of liability:

The owner of the declaration shall be liable for the underlying information and evidence. EPD Norway shall not be liable with respect to manufacturer information, life cycle assessment data and evidences.

Issue date:

08.09.2020

Valid to:

08.09.2025

Declared unit:

1 m3 Ready mix concrete C30/C37 outdoor

Year of study:

2020

Declared unit with option:

A1,A2,A3,A4

Comparability:

EPD of construction products may not be comparable if they not comply with EN 15804 and seen in a building context.

Functional unit:

Author of the Life Cycle Assessment:

The declaration is developed using eEPD v4.0 from LCA.no
Approval:
Company specific data are:

Collected/registered by: Smari Valgardsson

Internal verification by: Einar Einarsson

Verification:

Independent verification of data, other environmental information and the declaration according to ISO14025:2010, § 8.1.3 and § 8.1.4

External

Third party verifier:

Sign

Senior Research Scientist, Anne Rønning

(Independent verifier approved by EPD Norway)

Approved:

Sign

Håkon Hauan
Managing Director of EPD-Norway

Product

Product description:

Ready mix concrete for outdoor use, produced according to ÍST-EN 206:2013+A1:2016

Product specification

Materials	%
Cement	15,23
Aggregate	77,43
Water	7,18
Chemicals	0,16

Technical data:

C30/37-25; XC4 XF2/XF3 XS1

Dmax 25 - Air >5% - v/s < 0,50

Market:

Iceland

Reference service life, product

Same as for buildings

Reference service life, building

60 years

LCA: Calculation rules

Declared unit:

1 m3 Ready mix concrete C30/C37 outdoor

Cut-off criteria:

All major raw materials and all the essential energy is included. The production processes for raw materials and energy flows with very small amounts (less than 1%) are not included. These cut-off criteria do not apply for hazardous materials and substances.

Allocation:

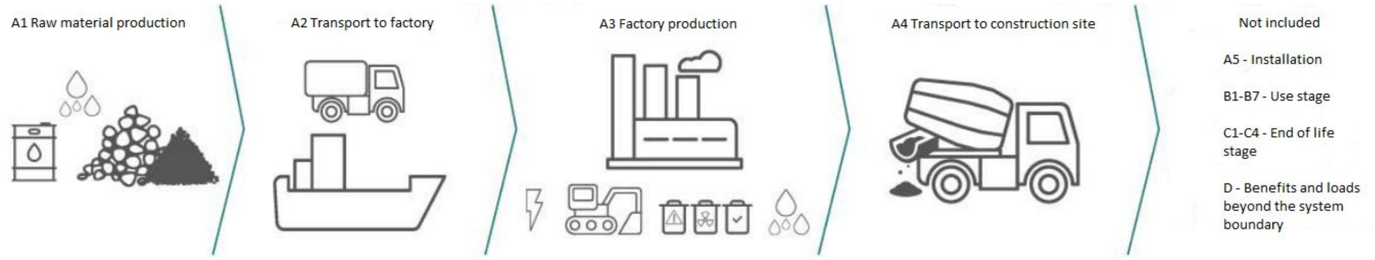
The allocation is made in accordance with the provisions of EN 15804. Incoming energy and water and waste production in-house is allocated equally among all products through mass allocation. Effects of primary production of recycled materials is allocated to the main product in which the material was used. The recycling process and transportation of the material is allocated to this analysis.

Data quality:

Specific data for the product composition are provided by the manufacturer. They represent the production of the declared product and were collected for EPD development in the year of study. Background data is based on registered EPDs according to EN 15804, Ostfold Research databases, ecoinvent and other LCA databases. The data quality of the raw materials in A1 is presented in the table below.

Materials	Source	Data quality	Year
Chemicals	EPD-EFC-20150086-IAG1-EN	EPD	2015
Chemicals	EPD-EFC-20150091-IAG1-EN	EPD	2015
Water	ecoinvent 3.4	Database	2017
Aggregate	Supplier specific data	Database	2019
Cement	NEPD-2277-1028-NO	EPD	2020

System boundary:



Additional technical information:

LCA: Scenarios and additional technical information

The following information describe the scenarios in the different modules of the EPD.

Transport from production place to user (A4)

Type	Capacity utilisation (incl. return) %	Type of vehicle	Distance km	Fuel/Energy consumption	Unit	Value (l/t)
Truck	53,0 %	Concrete truck, EURO 6	14	0,020216	l/tkm	0,28
Railway					l/tkm	
Boat					l/tkm	
Other Transportation					l/tkm	

Scenarios after A1-A4 are not included

Assembly (A5)

.	Unit	Value
Auxiliary	kg	
Water consumption	m^3	
Electricity consumption	kWh	
Other energy carriers	MJ	
Material loss	kg	
Output materials from waste treatment	kg	
Dust in the air	kg	
VOC emissions	kg	

Use (B1)

.	Unit	Value

Maintenance (B2)/Repair (B3)

.	Unit	Value
Maintenance cycle*		
Auxiliary		
Other resources		
Water consumption	m^3	
Electricity consumption	kWh	
Other energy carriers	MJ	
Material loss	kg	
VOC emissions	kg	

Replacement (B4)/Refurbishment (B5)

.	Unit	Value
Replacement cycle*		
Electricity consumption	kWh	
Replacement of worn parts		

* Described above if relevant

Operational energy (B6) and water consumption (B7)

.	Unit	Value
Water consumption	m^3	
Electricity consumption	kWh	
Other energy carriers	MJ	
Power output of equipment	kW	

End of Life (C1, C3, C4)

.	Unit	Value
Hazardous waste disposed	kg	
Collected as mixed construction waste	kg	
Reuse	kg	
Recycling		
Energy recovery		
To landfill	kg	

Transport to waste processing (C2)

Type	Capacity utilisation (incl. return) %	Type of vehicle	Distance km	Fuel/Energy consumption	Unit	Value (l/t)
Truck					l/tkm	
Railway					l/tkm	
Boat					l/tkm	
Other Transportation					l/tkm	

LCA: Results

System boundaries (X=included, MND=module not declared, MNR=module not relevant)

Product stage				Construction installation stage	User stage								End of life stage				.	Beyond the system bondaries
Raw materials	Transport	Manufacturing	Transport	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction 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
X	X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND		.	MND

Environmental impact

Parameter	Unit	A1	A2	A3	A4
GWP	kg CO_2 -eq	2,73E+02	3,44E+01	2,03E+00	1,18E+00
ODP	kg CFC11 -eq	2,34E-06	4,63E-06	3,22E-07	2,24E-07
POCP	kg C_2H_4-eq	3,73E-02	3,71E-03	3,87E-04	2,10E-04
AP	kg SO_2 -eq	4,91E-01	1,00E-01	1,37E-02	4,17E-03
EP	kg PO_4^{3-} -eq	1,37E-01	1,49E-02	2,92E-03	8,68E-04
ADPM	kg Sb -eq	1,68E-04	4,29E-05	1,14E-06	2,62E-06
ADPE	MJ	1,22E+03	3,30E+02	2,61E+01	1,81E+01

GWP Global warming potential; ODP Depletion potential of the stratospheric ozone layer; POCP Formation potential of tropospheric photochemical oxidants; AP Acidification potential of land and water; EP Eutrophication potential; ADPM Abiotic depletion potential for non fossil resources; ADPE Abiotic depletion potential for fossil resources

Reading example: 9,0 E-03 = 9,0*10-3 = 0,009
*INA Indicator Not Assessed

Resource use

Parameter	Unit	A1	A2	A3	A4
RPEE	MJ	2,88E+02	6,58E+00	2,38E+01	2,78E-01
RPEM	MJ	0,00E+00	0,00E+00	0,00E+00	8,51E-02
TPE	MJ	2,88E+02	6,58E+00	2,38E+01	3,63E-01
NRPE	MJ	1,26E+03	3,42E+02	2,65E+01	1,85E+01
NRPM	MJ	6,99E+00	0,00E+00	0,00E+00	0,00E+00
TRPE	MJ	1,26E+03	3,42E+02	2,65E+01	1,85E+01
SM	kg	2,03E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	5,49E+02	0,00E+00	0,00E+00	0,00E+00
W	m^3	2,16E-01	7,65E-02	1,20E-01	1,65E-02

RPEE Renewable primary energy resources used as energy carrier; RPEM Renewable primary energy resources used as raw materials; TPE Total use of renewable primary energy resources; NRPE Non renewable primary energy resources used as energy carrier; NRPM Non renewable primary energy resources used as materials; TRPE Total use of non renewable primary energy resources; SM Use of secondary materials; RSF Use of renewable secondary fuels; NRSF Use of non renewable secondary fuels; W Use of net fresh water

Reading example: 9,0 E-03 = 9,0*10-3 = 0,009
*INA Indicator Not Assessed

End of life - Waste

Parameter	Unit	A1	A2	A3	A4
HW	kg	5,67E-04	1,89E-04	1,50E-05	1,40E-05
NHW	kg	6,19E-01	2,73E+01	2,78E-01	1,83E+00
RW	kg	INA*	INA*	INA*	INA*

HW Hazardous waste disposed; NHW Non hazardous waste disposed; RW Radioactive waste disposed

Reading example: 9,0 E-03 = 9,0*10-3 = 0,009
*INA Indicator Not Assessed

End of life - Output flow

Parameter	Unit	A1	A2	A3	A4
CR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MER	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	INA*	INA*	INA*	INA*
ETE	MJ	INA*	INA*	INA*	INA*

CR Components for reuse; MR Materials for recycling; MER Materials for energy recovery; EEE Exported electric energy; ETE Exported thermal energy

Reading example: 9,0 E-03 = 9,0*10-3 = 0,009
*INA Indicator Not Assessed

Additional Norwegian requirements

Greenhouse gas emissions from the use of electricity in the manufacturing phase

National production mix from import, low voltage (production of transmission lines, in addition to direct emissions and losses in grid) of applied electricity for the manufacturing process (A3).

Electricity mix	Data source	Amount	Unit
El-mix Iceland (kWh)	Ecoinvent 3.6	50,38	g CO2-ekv/kWh

Dangerous substances

The product contains no substances given by the REACH Candidate list or the Norwegian priority list.

Indoor environment

Bibliography

ISO 14025:2010 Environmental labels and declarations - Type III environmental declarations - Principles and procedures.
ISO 14044:2006 Environmental management - Life cycle assessment - Requirements and guidelines.
EN 15804:2012+A1:2013 Environmental product declaration - Core rules for the product category of construction products.
ISO 21930:2017 Sustainability in buildings and civil engineering works - Core rules for environmental product declarations of construction products.
ecoinvent v3, Allocation, cut-off by classification, Swiss Centre of Life Cycle Inventories.
Iversen et al., (2018) eEPD v3.0 - Background information for EPD generator system. LCA.no report number 04.18
Vold, M. og Edvardsen, T. (2014) EPD-generator for betongindustrien, bakgrunnsinformasjon for verifisering, OR 04.14.
NPCR Part A: Construction products and services. Ver. 1.0. April 2017, EPD-Norge.
NPCR 020 Part B for Concrete and concrete elements. Ver. 2.0 October 2018, EPD-Norge.

epd-norge.no The Norwegian EPD Foundation	**Program operator and publisher** The Norwegian EPD Foundation Post Box 5250 Majorstuen, 0303 Oslo 0303 Oslo Norway	Phone: e-mail: web:	+47 23 08 80 00 post@epd-norge.no www.epd-norge.no
BM·VALLÁ	**Owner of the declaration** BM Vallá Bildshøfdi 7 110 Reykjavik, Iceland	Phone: Fax: e-mail: web:	+3546175020 smariva@bmvalla.is www.bmvalla.is
Østfoldforskning	**Author of the Life Cycle Assessment** Østfoldforskning AS Stadion 4 1671 Kråkerøy	Phone: Fax: e-mail: web:	+47 69 35 11 00 +47 69 34 24 94 www.ostfoldforskning.no
LCA.no	**Developer of EPD generator** LCA.no AS Dokka 1C 1671 Kråkerøy	Phone: e-mail: web:	+47 916 50 916 post@lca.no www.lca.no

Environmental Product Declaration

In accordance with ISO 14025 and EN 15804:2012+A2:2019 for:

Precast concrete beams

from

INHUS Prefab, UAB

Programme:	The International EPD® System, www.environdec.com
Programme operator:	EPD International AB
EPD registration number:	S-P-03860
Publication date:	2021-05-26
Revision date:	2022-01-03
Valid until:	2026-12-10
	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

Company information

Owner of the EPD:
INHUS Prefab, UAB
E-mail: prefab@inhus.eu
Tel. +370 5 2600120
https://www.inhusprefab.eu/en

Description of the organisation: INHUS Prefab is a manufacturing company implementing various architectural ideas of buildings, producing brick, coloured, matrix and graphic concrete facade elements, which make every building unique. The company has extensive experience in developing a variety of concrete structures and elements, including prefabricated wall elements, hollow core and balcony slabs, stair and linear structural elements.

Key facts about INHUS Prefab:

- 2 factories in Vilnius and Kaunas (Žarijų str. 6, 02300 Vilnius and Bituko str. 5, 52366 Kaunas)
- 200 000 m^2 of wall panel produced annually
- 200 000 m^2 of hollow core slabs produced annually
- 6 500 m^3 of frame constructions produced annually

INHUS Prefab is a part of INHUS - one of the leading “design-build” project developers in the Nordic region with sales of 60 million Euro and approximately 550 employees in 2021. INHUS cooperates with the largest Lithuanian and Scandinavian building enterprises and real estate developers to bring simplicity to “design-build” delivery.

INHUS vision is to build buildings without using construction sites - a world where clients only have to worry about their ideas and not the technical execution. Sustainability is at the core of this vision, because it requires to rethink the construction process, materials and the role of their employees. The company currently makes progress with a holistic approach, making net-positive investments into all three dimensions of sustainability - social, environmental and economical.

To create maximum value to their customers and to the environment, INHUS takes full responsibility for the entire production process; from the design and manufacturing of building components, to the development of logistic solutions and finally the construction itself. The company innovates in production methods, implements modern technologies, ensures efficient use of resources and invests in its employee’s development. INHUS has also developed a carbon reduction strategy, outlining its planned steps and obligations up to 2030.

Finally, the company is a member of Lithuanian Builders Association, Lithuanian Construction Industry Association, Lithuanian Construction Product Testing Laboratory and is recognized for meeting the management system standards - ISO 9001: 2015 (quality standard) and ISO 14001: 2015 (environmental protection standard).

Visit https://www.inhusprefab.eu/en to learn more.

Name and location of production site(s):
INHUS Prefab, UAB, Bituko str. 5, 52366 Kaunas, Lithuania.

Product information

Product name: Precast concrete beams

Product identification: Beams are certified and manufactured in accordance with the harmonized European standard EN 13225 Precast concrete products - Linear structural elements. It holds the CE mark and the declaration of performance issued by the manufacturer in accordance with requirements of Regulation (EU) No. 305.2011 of the European Parliament and of the Council issued on 2011 March 9th.

Product description: Precast concrete beam is an element, usually horizontal, for carrying loads primarily by flexure. Beams produced as load-bearing elements. Precast concrete beams can be various sizes, with one shelf (L-shaped), two shelfs (T-shaped) or without (rectangular shaped). Also, it can be manufactured as prestressed or non-prestressed beams.

Beams together with columns form a frame. Frame - structure composed of two or more linear elements jointed together to be stable. Beams, together with columns, are used in buildings for various purposes: parking lots, shopping malls, schools, industrial buildings.

The products are manufactured in the following dimensions and technical features:

- Height: 300 - 1000 mm,
- Width: 300 - 900 mm,
- Length: 3000 - 20000 mm,
- Concrete: C 30/37 - C 60/75.

UN CPC code: 375

Geographical scope: Lithuania, Sweden, Denmark, Poland, United Kingdom

LCA information

Functional unit / declared unit: In accordance with the PCR the declared unit is 1 metric tonne of the product.

Reference service life: The reference service life for the precast concrete beams is set at 50 years.

Time representativeness: Primary data was collected internally. The production data refers to the average of the year 2020.

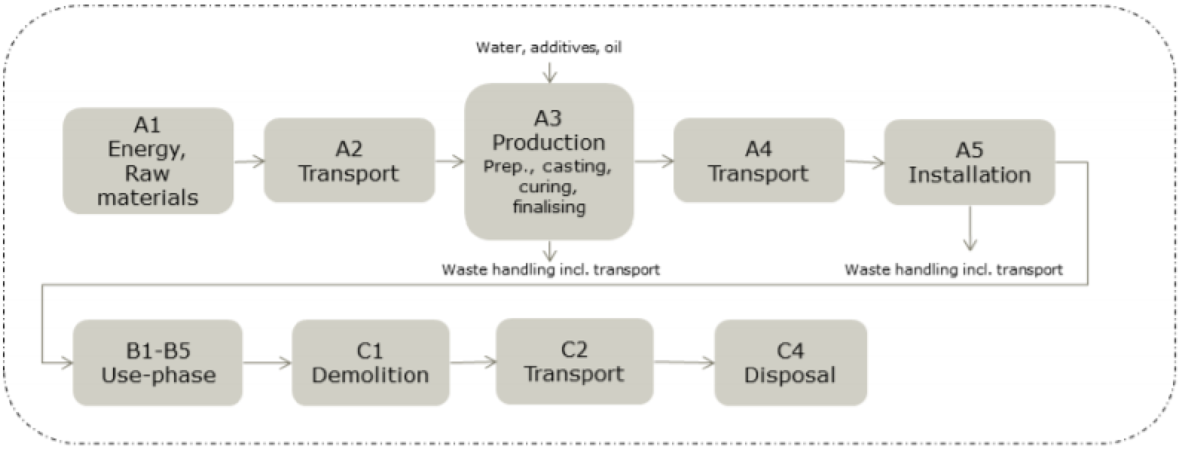
Database(s) and LCA software used: The Ecoinvent database provides the life cycle inventory data for the raw and process materials obtained from the background system. The used database is Ecoinvent 3.6. The LCA software used is One Click LCA.

Description of system boundaries: Cradle to gate with options, modules C1-C4 and module D. The LCA was carried out considering the Product stage phases (A1, A2, A3), Distribution (A4), Installation (A5), End of life (C1, C2, C3, C4), Potential environmental benefits (D) in accordance with EN 15804.

Data quality: The foreground data collected internally is based on yearly production amounts and extrapolations of measurements on specific machines and plants. Overall, the data quality can be described as good. The primary data collection has been done thoroughly.

Cut-off criteria: Life cycle inventory data for a minimum of 99% of total material and energy input flows have been included in the life cycle analysis. Although, only materials having in summa less than 1% of weight of product were not used in calculations.

System diagram:



System boundary:

	Product stage			Construction process stage		Use stage							End of life stage				Resource recovery stage
Module	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Modules declared	X	X	X	X	X	MND	MND	MND	MND	MND	MND	MND	X	X	X	X	X
	Raw material supply	Transport	Manufacturing	Transport	Construction installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential

Description of the system boundary (X = Included in LCA; MND = Module Not declared; MNR = Module Not relevant)

Product stage:

A1: This stage considers the extraction and processing of raw materials.

A2: The raw materials are transported to the manufacturing plant. In this case, the model includes road transportation of each raw material.

A3: This stage includes the manufacture of products and packaging. It has considered all the energy consumption and waste generated in the production plant.

Production process description

Beams are produced on heated pallets with dismountable broadsides. Reinforcement framework is produced in reinforcement production bar and transported to the production bar by trolley. Framework is put on the pallet by crane. Strands are dragged through the framework and prestressed. Inserts, loops, etc. are placed (if needed). Concrete produced in concrete batching plant is transported to the production bar by dolly for moulding. After moulding concrete surface is smoothened and protected from drying. After the concrete has reached the strength of not less than 70%, the columns are demoulded, inspected and transported to the warehouse by trolly.

Construction process stage:

A4: This stage includes transport from the production gate to the construction site where the product shall be installed. Transportation distances has been calculated using a most likely scenarios, an export to Lithuania, Sweden, Denmark, Poland, United Kingdom with the parameters described in the following table. The transportation doesn't cause losses as products are packaged properly.

Scenario parameter	Distance, km	Value kgCO2e/tonkm
1) Lithuania		
Truck, Euro 5	30	0.0909
Ferry	-	-
2) Lithuania		
Truck, Euro 5	100	0.0909
Ferry	-	-
3) Sweden		
Truck, Euro 6	200	0.0863
Ferry	413	0.0094
4) Sweden		
Truck, Euro 6	300	0.0863
Ferry	413	0.0094
5) Denmark		
Truck, Euro 6	400	0.0863
Ferry	862	0.0094
6) Denmark		
Truck, Euro 6	500	0.0863
Ferry	862	0.0094
7) United Kingdom		
Truck, Euro 6	400	0.0863
Ferry	2070	0.0094
8) United Kingdom		
Truck, Euro 6	500	0.0863
Ferry	2070	0.0094
9) Poland		
Truck, Euro 5	500	0.0909
Ferry		-
10) Poland		
Truck, Euro 5	800	0.0909
Ferry	-	-

Capacity of utilization for truck is 56% of the capacity in volume. Capacity of utilization for ferry is 50% of the capacity in volume.

A5: This stage considers the installation of the product into the building.
Tower cranes are used for the prefabricated elements installation works that are powered by electricity, which are installed after the customer hands over the work front (work field). The structures are delivered by trucks and installed in to designed place directly from the truck platform according to the design in

the prescribed place. Outdoor walls and partitions (inside walls) are installed at the first. Stair elements and the slab installation coming after. The installed walls are supported by using temporary supports that are placed acc., to prepared and confirm shoring plan and connected in between by using steel plates and welded connection method. In the outside joints (wall-to-wall joints), mineral-wool or glass wool is used to eliminate cold bridges. When the joint concrete reaches the designed strength, slab and staircase elements installation is proceeding. The joints of the installed slab elements (HCS slabs) are casted in place, forming in such way a rigid disk of the building. When the slab joints reach designed concrete strength, wall elements installation is allowed to proceed in that floor.

Use stage:

In normal use scenario, it is assumed that no maintenance (B2), repair (B3), replacement (B4) and refurbishment (B5) is needed.

End of Life stage:

This stage includes the following modules:

C1, Deconstruction, dismantling, demolition

Consumption of fuel in demolition process is calculated according to transported mass. Energy consumption for demolition is 10 kWh/1000 kg = 0,01 kWh/kg. The source of energy is diesel fuel used by work machines.

C2, Transport of the discarded product to the processing site

It is estimated that there is no mass loss during the use of the product, therefore the end-of-life product is assumed to have the same weight with the declared product. Whole end-of-life product is assumed to be sent to the closest facilities such as recycling and landfill. Transportation distance to the closest disposal area is estimated as 50 km and the transportation method is lorry which is the most common.

C3, Waste processing for reuse, recovery and/or recycling

Based on European average 90% of steel are transformed into secondary material at a recycling plant. According to European Commission Waste Framework Directive, the preparing for re-use, recycling and other material recovery of non-hazardous construction and demolition waste shall be increased to a minimum of 70 % by weight by 2020. It is assumed that 70% of the concrete waste is recycled.

C4, Discharge (disposal)

The remaining 30 % of concrete and 10 % of steel are assumed to be sent to the landfill.

Benefits and loads beyond the system boundary (D):

Benefits of recyclable waste generated in the phase C3 are taken into account in the phase D. The recycled steel has been modelled to avoid use of primary materials. The scrap content in the studied product has been acknowledged and only the mass of primary steel in the product provides the benefit in order to avoid double counting. Crushed concrete is made into rubble that can be used as a raw material in concrete production for road gravel.

Content information

Product components	Weight, kg	Weight, %
Sand	339.7	34.0
Stone	399.5	39.9
Cement	131.9	13.2
Water	66.4	6.6
Reinforcement	59.0	5.9
Embedded details	2.7	0.3
Additives	0.8	0.1
TOTAL	1000.0	100.0

No dangerous substances from the candidate list of SVHC for Authorisation are used in the product.

Packaging

Distribution packaging: wooden gaskets

After use, packaging materials can be re-used or recycled.

Environmental Information

Note: Environmental impacts according to EN 15804+A1, CML/ISO 21930 are presented below

Potential environmental impact – mandatory indicators according to 15804:2012+A2:2019

Results per functional or declared unit												
Indicator	Unit	A1	A2	A3	Tot.A1-A3	A4	A5	C1	C2	C3	C4	D
GWP-total	kg CO_2 eq.	1,81E+02	7,10E+00	1,35E+01	2,02E+02	See below	3,84E+00	3,30E+00	4,55E+00	3,94E+00	1,52E+00	−5,495E0
GWP-fossil	kg CO_2 eq.	1,80E+02	7,09E+00	1,34E+01	2,00E+02	See below	3,83E+00	3,30E+00	4,54E+00	4,01E+00	1,51E+00	−5,421E0
GWP-biogenic	kg CO_2 eq.	1,69E+00	−9,15E−4	1,276E−1	1,82E+00	See below	9,467E−3	9,168E−4	3,3E−3	−7,88E−2	3,002E−3	−6,7E−2
GWP-luluc	kg CO_2 eq.	1,026E−1	4,143E−3	1,495E−2	1,217E−1	See below	2,609E−3	2,785E−4	1,368E−3	1,798E−3	4,496E−4	−7,04E−3
ODP	kg CFC 11 eq.	1,082E−5	1,453E−6	1,972E−6	1,424E−5	See below	3,773E−7	7,119E−7	1,068E−6	7,665E−7	6,235E−7	−4,92E−7
AP	mol H^+ eq.	6,638E−1	2,122E−1	5,483E−2	9,308E−1	See below	2,422E−2	3,448E−2	1,909E−2	4,429E−2	1,437E−2	−3,55E−2
EP-freshwater	kg P eq.	4,917E−3	3,267E−5	4,404E−4	5,39E−3	See below	1,911E−4	1,333E−5	3,697E−5	1,064E−4	1,829E−5	−3,48E−4
EP-marine	kg N eq.	1,697E−1	5,304E−2	1,683E−2	2,395E−1	See below	7,091E−3	1,523E−2	5,752E−3	1,584E−2	4,948E−3	−7,48E−3
EP-terrestrial	mol N eq.	1,96E+00	5,895E−1	1,929E−1	2,75E+00	See below	7,712E−2	1,67E−1	6,352E−2	1,761E−1	5,45E−2	−9,86E−2
POCP	kg NMVOC eq.	5,724E−1	1,528E−1	5,569E−2	7,808E−1	See below	2,587E−2	4,592E−2	2,042E−2	4,835E−2	1,583E−2	−2,49E−2
ADP-minerals & metals*	kg Sb eq.	1,299E−2	5,487E−5	1,273E−4	1,317E−2	See below	4,418E−5	5,034E−6	7,754E−5	8,089E−5	1,383E−5	−5,99E−4
ADP-fossil*	MJ	1,46E+03	9,27E+01	2,11E+02	1,76E+03	See below	4,78E+01	4,54E+01	7,07E+01	5,54E+01	4,23E+01	−7,771E1
WDP	m^3	7,10E+01	1,971E−1	1,75E+00	7,30E+01	See below	1,50E+00	8,462E−2	2,629E−1	3,404E−1	1,96E+00	−9,694E0
Acronyms	GWP-fossil = Global Warming Potential fossil fuels; GWP-biogenic = Global Warming Potential biogenic; GWP-luluc = Global Warming Potential land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment; EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment; EP-terrestrial = Eutrophication potential, Accumulated Exceedance; POCP = Formation potential of tropospheric ozone; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (user) deprivation potential, deprivation-weighted water consumption											

** Disclaimer: The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.*

Potential environmental impact – mandatory indicators according to 15804:2012+A2:2019

Results per functional or declared unit (only scenarios of A4 stage)											
		Lithuania		Sweden		Denmark		UK		Poland	
		30 km	100 km	613 km	713 km	1262 km	1362 km	2470 km	2570 km	500 km	800 km
Indicator	Unit	A4 LT (1)	A4 LT (2)	A4 SWE (3)	A4 SWE (4)	A4 DK (5)	A4 DK (6)	A4 UK (7)	A4 UK (8)	A4 PL (9)	A4 PL (10)
GWP-total	kg CO_2 eq.	2,73E+00	9,11E+00	2,14E+01	3,01E+01	4,31E+01	5,18E+01	5,45E+01	6,32E+01	4,55E+01	7,29E+01
GWP-fossil	kg CO_2 eq.	2,73E+00	9,11E+00	2,14E+01	3,01E+01	4,30E+01	5,18E+01	5,44E+01	6,32E+01	4,55E+01	7,28E+01
GWP-biogenic	kg CO_2 eq.	7,739E−5	2,58E−4	−1,58E−3	−1,32E−3	−3,35E−3	−3,00E−3	−9,5E−3	−9,24E−3	1,29E−3	2,064E−3
GWP-luluc	kg CO_2 eq.	8,221E−4	2,74E−3	8,145E−3	1,089E−2	1,652E−2	1,926E−2	2,431E−2	2,705E−2	1,37E−2	2,192E−2
ODP	kg CFC 11 eq.	6,421E−7	2,14E−6	5,066E−6	7,208E−6	1,02E−5	1,234E−5	1,249E−5	1,463E−5	1,07E−5	1,712E−5
AP	mol H^+ eq.	6,418E−3	2,139E−2	1,694E−1	1,908E−1	3,497E−1	3,712E−1	7,199E−1	7,413E−1	1,07E−1	1,711E−1
EP-freshwater	kg P eq.	1,948E−4	6,492E−4	1,453E−3	2,102E−3	2,919E−3	3,569E−3	3,371E−3	4,02E−3	3,246E−3	5,194E−3
EP-marine	kg N eq.	9,182E−4	3,061E−3	3,722E−2	4,029E−2	7,716E−2	8,022E−2	1,681E−1	1,712E−1	1,53E−2	2,449E−2
EP-terrestrial	mol N eq.	9,806E−3	3,269E−2	4,109E−1	4,436E−1	8,519E−1	8,846E−1	1,86E+00	1,90E+00	1,634E−1	2,615E−1
POCP	kg NMVOC eq.	5,412E−3	1,804E−2	1,252E−1	1,432E−1	2,583E−1	2,763E−1	5,192E−1	5,372E−1	9,02E−2	1,443E−1
ADP-minerals & metals*	kg Sb eq.	4,661E−5	1,554E−4	3,397E−4	4,951E−4	6,819E−4	8,373E−4	7,665E−4	9,218E−4	7,769E−4	1,243E−3
ADP-fossil*	MJ	4,20E+01	1,40E+02	3,30E+02	4,70E+02	6,635E	8,04E+02	8,08E+02	9,48E+02	7,00E+02	1,12E+03
WDP	m^3	3,26E+01	1,09E+02	2,271E	3,36E+02	4,55E+02	5,64E+02	4,84E+02	5,93E+02	5,43E+02	8,69E+02
Acronyms	GWP-fossil = Global Warming Potential fossil fuels; GWP-biogenic = Global Warming Potential biogenic; GWP-luluc = Global Warming Potential land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment; EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment; EP-terrestrial = Eutrophication potential, Accumulated Exceedance; POCP = Formation potential of tropospheric ozone; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (user) deprivation potential, deprivation-weighted water consumption										

** Disclaimer: The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.*

Use of resources

Results per functional or declared unit												
Indicator	Unit	A1	A2	A3	Tot.A1-A3	A4	A5	C1	C2	C3	C4	D
PERE	MJ	1,19E+02	6,53E−1	1,99E+02	3,19E+02	See below	3,55E+00	2,454E−1	8,897E−1	3,21E+00	3,422E−1	−6,635E0
PERM	MJ	0,00E+00	0,00E+00	7,36E+01	7,36E+01	See below	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ	1,19E+02	6,53E−1	2,73E+02	3,92E+02	See below	3,55E+00	2,454E−1	8,897E−1	3,21E+00	3,422E−1	−6,635E0
PENRE	MJ	1,46E+03	9,27E+01	2,11E+02	1,76E+03	See below	4,78E+01	4,54E+01	7,07E+01	5,54E+01	4,23E+01	−7,771E1
PENRM	MJ.	0,00E+00	0,00E+00	0,00E+00	0,00E+00	See below	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ	1,46E+03	9,27E+01	2,11E+02	1,76E+03	See below	4,78E+01	4,54E+01	7,07E+01	5,54E+01	4,23E+01	−7,771E1
SM	kg	5,47E+01	0,00E+00	0,00E+00	5,47E+01	See below	7,949E−1	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	See below	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	See below	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	m^3	2,50E+00	9,708E−3	2,461E−2	2,53E+00	See below	3,181E−2	4,007E−3	1,472E−2	1,104E−2	4,63E−2	−7,74E−1
Acronyms		PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy re-sources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water										

Use of resources

Results per functional or declared unit (only scenarios of A4 stage)											
		Lithuania		Sweden		Denmark		UK		Poland	
		30 km	100 km	613 km	713 km	1262 km	30 km	100 km	613 km	713 km	1262 km
Indicator	Unit	A4 LT (1)	A4 LT (2)	A4 SWE (3)	A4 SWE (4)	A4 DK (5)	DK (6)	A4 UK (7)	A4 UK (8)	A4 PL (9)	A4 PL (10)
PERE	MJ	5,348E−1	1,78E+00	3,90E+00	5,69E+00	7,83E+00	9,62E+00	8,81E+00	1,06E+01	8,91E+00	1,43E+01
PERM	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
PERT	MJ	5,348E−1	1,78E+00	3,90E+00	5,69E+00	7,83E+00	9,62E+00	8,81E+00	1,06E+01	8,91E+00	1,43E+01
PENRE	MJ	4,28E+01	1,43E+02	3,35E+02	4,78E+02	6,75E+02	8,18E+02	8,20E+02	9,63E+02	7,13E+02	1,14E+03
PENRM	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
PENRT	MJ	4,28E+01	1,43E+02	3,35E+02	4,78E+02	6,75E+02	8,18E+02	8,20E+02	9,63E+02	7,13E+02	1,14E+03
SM	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
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
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
FW	m^3	8,846E−3	2,949E−2	6,367E−2	9,317E−2	1,278E−1	1,573E−1	1,415E−1	1,709E−1	1,474E−1	2,359E−1
Acronyms	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy re-sources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water										

Waste production and output flows

Waste production

Indicator	Unit	A1	A2	A3	Tot.A1-A3	A4	A5	C1	C2	C3	C4	D
Results per functional or declared unit												
Hazardous waste disposed	kg	1,74E+01	9,917E−2	2,585E−1	1,78E+01	See below	9,313E−1	4,882E−2	6,869E−2	0,00E+00	3,949E−2	−4,05E−1
Non-hazardous waste disposed	kg	2,31E+02	2,31E+00	1,11E+01	2,45E+02	See below	9,06E+00	5,218E−1	7,60E+00	0,00E+00	2,88E+02	−1,659E1
Radioactive waste disposed	kg	6,133E−3	6,502E−4	4,34E−4	7,217E−3	See below	1,838E−4	3,177E−4	4,852E−4	0,00E+00	2,8E−4	−3,58E−4

Waste production

Results per functional or declared unit (only scenarios of A4 stage)											
		Lithuania		Sweden		Denmark		UK		Poland	
		30 km	100 km	613 km	713 km	1262 km	30 km	100 km	613 km	713 km	1262 km
Indicator	Unit	A4 LT (1)	A4 LT (2)	A4 SWE (3)	A4 SWE (4)	A4 DK (5)	DK (6)	A4 UK (7)	A4 UK (8)	A4 PL (9)	A4 PL (10)
Hazardous waste disposed	kg	4,129E−2	1,376E−1	3,334E−1	4,711E−1	6,719E−1	8,096E−1	8,419E−1	9,795E−1	6,882E−1	1,10E+00
Non-hazardous waste disposed	kg	4,57E+00	1,52E+01	3,12E+01	4,64E+01	6,24E+01	7,77E+01	6,46E+01	7,98E+01	7,61E+01	1,22E+02
Radioactive waste disposed	kg	2,917E−4	9,723E−4	2,296E−3	3,269E−3	4,622E−3	5,595E−3	5,643E−3	6,616E−3	4,861E−3	7,778E−3

Output flows

Indicator	Unit	A1	A2	A3	Tot.A1-A3	A4 (all)	A5	C1	C2	C3	C4	D
Results per functional or declared unit												
Components for re-use	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
Material for recycling	kg	0,00E+00	0,00E+00	6,13E+01	6,13E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,13E+02	0,00E+00	0,00E+00
Materials for energy recovery	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
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	0,00E+00	0,00E+00

ENVIRONMENTAL IMPACTS – EN 15804+A1, CML / ISO 21930

Results per functional or declared unit												
Indicator	Unit	A1	A2	A3	Tot.A1-A3	A4 SWE (3)	A5	C1	C2	C3	C4	D
GWP	kg CO_2 eq.	1,77E+02	7,05E+00	1,31E+01	1,97E+02	2,12E+01	3,72E+00	3,27E+00	4,50E+00	3,97E+00	1,49E+00	−5,305E0
ODP	kg CFC 11 eq.	9,237E−6	1,15E−6	1,543E−6	1,193E−5	4,025E−6	3,202E−7	5,634E−7	8,491E−7	6,18E−7	4,94E−7	−4,49E−7
AP	mol H^+ eq.	4,773E−1	1,684E−1	3,318E−2	6,789E−1	1,385E−1	1,314E−2	4,866E−3	9,246E−3	1,433E−2	5,991E−3	−2,18E−2
EP	kg PO_4^{3-} eq.	2,074E−1	1,908E−2	1,144E−2	2,379E−1	1,876E−2	8,044E−3	8,573E−4	1,868E−3	4,952E−3	1,159E−3	−1,17E−2
POCP	kg Ethenee	3,158E−2	4,38E−3	2,362E−3	3,833E−2	4,772E−3	1,599E−3	5,011E−4	5,858E−4	8,892E−4	4,393E−4	−1,78E−3
ADP-minerals & metals*	kg Sb eq.	1,299E−2	5,487E−5	1,273E−4	1,317E−2	3,397E−4	4,418E−5	5,034E−6	7,754E−5	8,089E−5	1,383E−5	−5,99E−4
ADP-fossil*	MJ	1,46E+03	9,27E+01	2,11E+02	1,76E+03	3,33E+02	4,78E+01	4,54E+01	7,07E+01	5,54E+01	4,23E+01	−7,771E1
Acronyms		GWP = Global Warming Potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP = Eutrophication potential; POCP = Formation of ozone of lower atmosphere; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (user) deprivation potential, deprivation-weighted water consumption										

General information

Programme information

Programme:	The International EPD® System
Address:	EPD International AB Box 210 60 SE-100 31 Stockholm Sweden
Website:	www.environdec.com
E-mail:	info@environdec.com

CEN standard EN 15804 serves as the Core Product Category Rules (PCR)
Product category rules (PCR): PCR 2019:14 Construction products (version 1.1); Complementary PCR (c-PCR):C-PCR-003 (TO PCR 2019:14) - Concrete and concrete elements, version: 2019-12-20;
PCR review was conducted by: The International EPD® System
Independent third-party verification of the declaration and data, according to ISO 14025:2010: ☐ EPD process certification ☒ EPD verification
Third party verifier: Silvia Vilčeková, Silcert, s.r.o Approved by: The International EPD® System
Procedure for follow-up of data during EPD validity involves third party verifier: ☐ Yes ☒ No

The EPD owner has the sole ownership, liability, and responsibility for the EPD.

EPDs within the same product category but from different programmes may not be comparable. EPDs of construction products may not be comparable if they do not comply with EN 15804. For further information about comparability, see EN 15804 and ISO 14025.

During revision (2022-01-03) A5 stage calculations were added to the EPD.

References

- General Programme Instructions of the International EPD® System. Version 3.01;
- PCR 2019:14 Construction products (version 1.1);
- C-PCR-003 (TO PCR 2019:14) - Concrete and concrete elements, version: 2019-12-20;
- EN 15804:2012+A2:2019 Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products;
- ISO 14044:2006/Amd 2:2020 Environmental management. Life Cycle Assessment. Requirements and guidelines.
- ISO 14025:2010 Environmental labels and declarations. Type III environmental declarations. Principles and procedures.

Tools and database

- One Click LCA tool;
- Ecoinvent 3.6 database

Contact information

EPD owner:	INHUS Prefab, UAB https://www.inhusprefab.eu/en
LCA author:	Vesta Consulting, UAB https://www.vestaconsulting.lt/
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Environmental Product Declaration

EN ISO 14025:2010, EN 15804:2012+A2:2020, UNE 36904-2:2018

Drawn Steel products for prestressed concrete PC Wire, 3-Wire/7-Wire Bare Strand and 7-Wire Sheathed Strand.

By:

TYCSA PSC – Celsa Group

The declared validity is subject to registration and publication on www.aenor.com

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The EPD holder is responsible for the content of the Declaration. The holder is responsible for keeping the records and documents supporting the content of the Declaration.

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HOLDER OF THE DECLARATION

Tycsa PSC – Grupo Celsa
Pol. Industrial Nueva Montaña s/n. 39011Santander (Cantabria, España)

Tel: (+34) 942 200 336 / 630 885 950
Mail: icano@tycsa.com
Web: www.tycsapsc.com

LCA STUDY

Abaleo S.L.
D. José Luis Canga Cabañes
c/ Poza de la Sal, 8; 3º A
28031 Madrid, España.

Tel: (+34) 639 901 043
Mail: jlcanga@abaleo.es; info@abaleo.es
Web: www.abaleo.es

OPERATOR OF THE GLOBAL EPD PROGRAMME

AENOR Internacional S.A.U.
C/ Génova 6. 28009. Madrid, España.

Tel: (+34) 902 102 201
Mail: aenordap@aenor.com
Web: www.aenor.com

UNE 36904-2:2018. CEN standard EN 15804:2012+A2:2020 serves as the core for the RCP

Independent verification of the declaration and data, according to EN ISO 14025:2010

☐ Internal ☑ External

Verification Body: AENOR Confía


global steel wire
MEL SHOP
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ROLLING MILL
TYCSA

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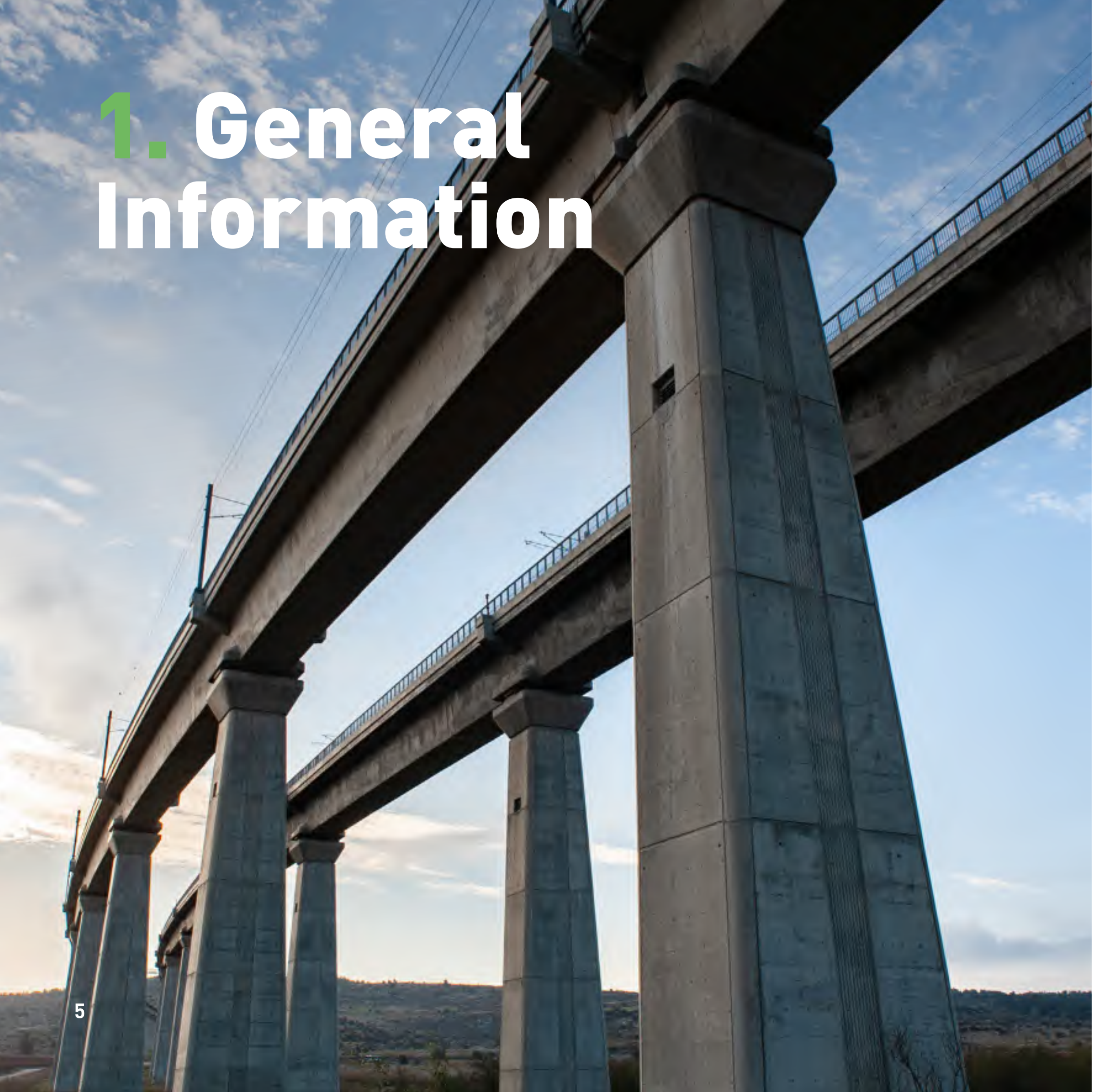
1. General Information



1.1. The organization

Tycsa PSC is the largest manufacturer of wires and high elastic limit steel strands for construction and the company in the sector with the largest presence in the international market, offering a long experience in manufacturing your products, with the contribution of a highly qualified human team and a global comercial presence.

Tycsa PSC began its journey in Barberá del Vallès (Barcelona) in the 1950s as one of the largest national producers of wires, strands and cables for different applications industrial, but with a strong export profile, with contact already at the time on a regular basis with different international markets.

Today, the extensive experience in combination with advanced production processes and rigorous control mechanisms make the quality of Tycsa PSC its best presentation.

Within Tycsa PSC's environmental policy, the protection and improvement of the Environment is set as an objetive within the manufacturing and commercialization of their products.

Both the steel and the production process used for the manufacture of the drawn products stand outfor its ecological values and for its ability torecycling compared to other products and technologies.

1.2. Scope of the Declaration

This environmental product declaration describes environmental information related to the life cycle of production from cradle to gate with modules A4, C1-C4 and D (A1-A3, A4, C and D), of five types of products of drawn steel:

- Prestressed Wire (smooth or indented), PF4.
- 7-wire bare strand, P61 and P62.
- 3-wire strand, PC4.
- 7-wire sheathed strand, P63.

The role played by the product system studied is the production of drawn steel products to be used in the construction sector as constructive elements.

1.3. Lyfe cycle and conformity

This EPD has been drawn up and verified according to the standards EN ISO 14025:2010, EN 15804:2012+A1:2013, UNE 36904-2:2018.

This EPD includes the life cycle stages listed in Table 1-1. This DAP is of the cradle to door type with modules A4, C and D.

System boundary. Information modules included			
Product stage	A1	Raw material supply	X
	A2	Transport to the manufacturer	X
	A3	Manufacturing	X
Construction	A4	Transport to Work site	X
	A5	Installation / Construction	MNE
Use stage	B1	Use	MNE
	B2	Maintenance	MNE
	B3	Repair	MNE
	B4	Replacement	MNE
	B5	Refurbishment	MNE

System boundary. Information modules included			
Use stage	B6	Operational energy use	MNE
	B7	Operational wáter use	MNE
End of life	C1	De-construction / demolition	NR
	C2	Transport	X
	C3	Waste processing	X
	C4	Disposal	X
	D	Reuse, recovery and/or recycling potentials	x

X = Module included in the LCA; NR = Not relevant module; MNE = Module not assessed

This EPD may not be comparable to others developed in other Programs or according to documents of different reference; specifically can not be comparable to EPDs not developed and verified according to the EN 15804 Standard.

Similarly, the EPDs may not be comparable if the source of the data is different (for example, databases), if all relevant information modules are not included or if they are not based on the same scenarios.

The comparison of construction products must be done on the same function, applying the same functional unit and at the level of the building or infrastructure, which means, including the behavior of the product throughout its entire life cycle, as well as the specifications of the section 6.7.2. of the EN ISO 14025 Standard.

1.4. Differences compared to previous versions of this EPD

In 2020, an EPD for Tycsa products was published. In it, to represent the production of wire rod, the results of a sectorial EPD of wire rod production in Spain were used. In the current version, a specific EPD for GSW wire rod has been used, carried out with data from the year 2021.

2. The Product

2.1. Identification of the product

This EPD is applicable to drawn steel products manufactured by Tycsa PSC: prestressed wire PF4, bare 7-wire strands P61 and P62, 3-wire strands PC4 and 7-wire sheathed strand P63.

CPC Code: 4126.

2.2. Product Performance

Specifically, the manufacturer declares the following information on the technical specifications of the product:

Mechanical characteristics	
Young Modulus	195 GPa ± 10% (strand) 205 GPa ± 10% (wire)
Elongation	≥ 3,5% L > 500 m
Very low relaxation	≤ 2,5% after 1.000 h to 70% Fm

2.3. Composition of the product

The composition and properties of the wires and strands are established in the UNE 36094:1997 standard Steel wires and strands for prestressed concrete reinforcement or in the international reference standard depending on the client.

In the production of wire and strands (3 and 7 wires), steel wire rod is used as the main raw material. The composition declared by the manufacturer for each of the products is as follows:

Composition of drawn products in %			
	Steel	Polyethylene (HDPE)	Grease
Wire PF4	100%	-	-
3-wire strand PC4	100%	-	-
7-wire strand P61	100%	-	-
7-wire strand P62	100%	-	-
Stheathed Strand P63	89,4 - 90,1%	6,8 - 9,1%	3,8 - 0,8%

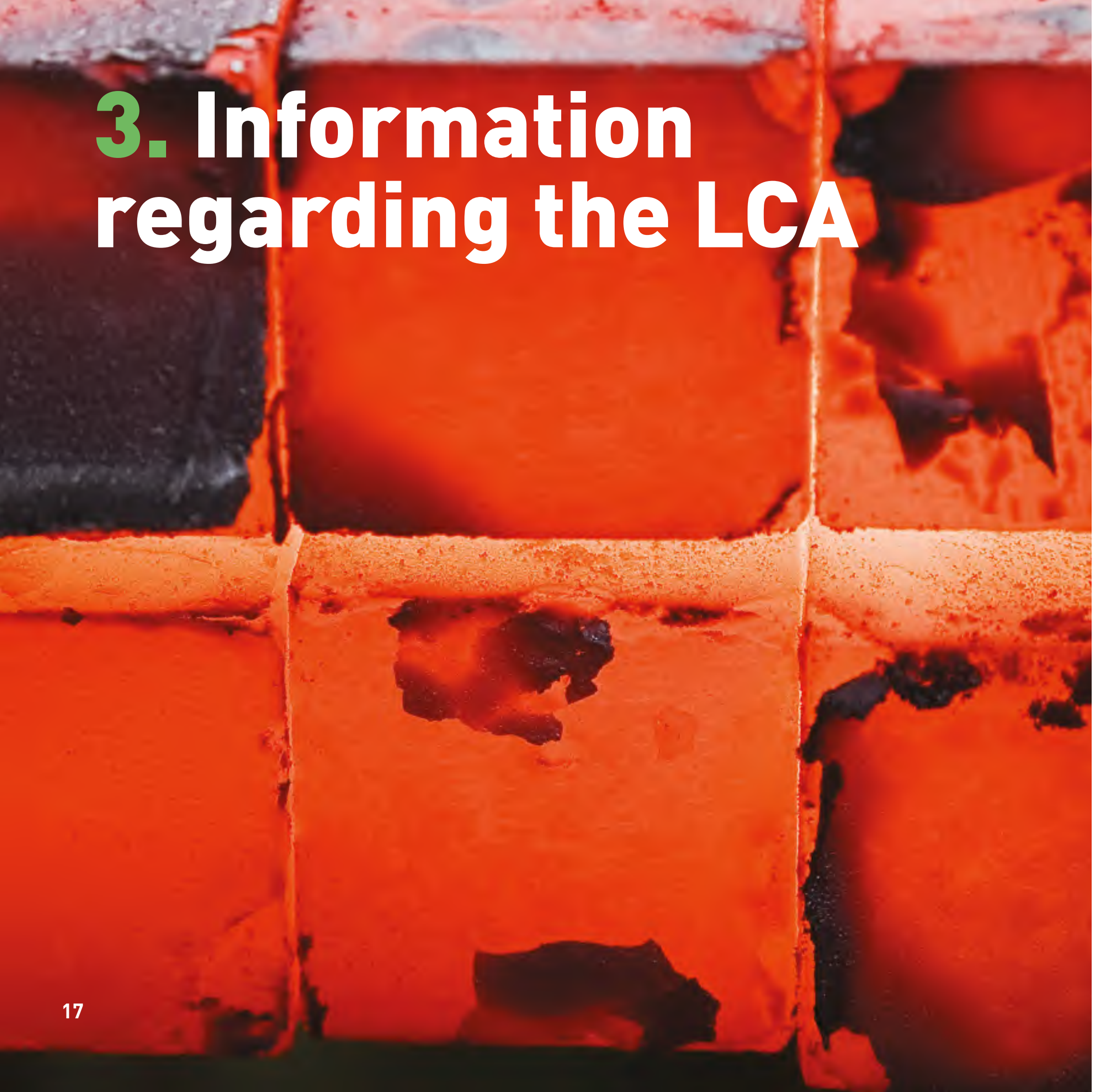
The steel wire rod used in the production of Tycsa PSC wires and strads, manufactured by Global Steel Wire S.A., has the following average composition:

Average composition of the wire rod used as raw material	
Material	Quantity
Post-consumer scrap	27,42%
Pre-consumer scrap	62,45%
Recycled Pig Iron	7,114%
pre-reduced iron	3,016%

The content of recycled raw material is 96.984%.

The manufacturer declares that some families of products manufactured by Tycsa PSC use substances listed in the "CandidateList of Substances of Very High Concern (SVHC) for authorization" in a percentage greater than 0.1% and less than 0.3% of the weight of the product.

3. Information regarding the LCA



3.1. Life cycle analysis

The life cycle analysis report for the EPD of the production of Tycsa PSC's drawn steel products, of July 2022, has been carried out by the company Abaleo S.L. with the Ecoinvent 3.8 database (November 2021) and the SimaPro 9.3.0.3 software, which is the most updated version available at the time of the LCA.

To carry out the study, data from Tycsa PSC factory located in Poligono Industrial Nueva Montaña s/n, 39011 Santander (Cantabria) was available.

The LCA study follows the recommendations and requirements of international standards ISO 14040:2006, ISO 14044:2006 and the European Standard UNE-EN 15804:2012 + A2:2020.

3.2. Stydy Scope

The scope of this EDP is the cradle-to-gate production with modules A4, C1-C4 and D (A1-A3, A4, C and D), of the five drawn steel products (steel wire, 3-wire strand and the 7-wire bare strand and black sheathed strand) for use in the construction of structures.
The specific data on the manufacturing process of the products come from Tycsa PSC facilities at Polígono Industrial Nueva Montaña s/n factory, 39011 Santander (Spain), corresponding to year 2021.

The LCA does not include:

- The production of auxiliary materials used in the plant, which account for 0.014% of the total weight of Tycsa PSC's production in 2021.
- All equipment whose useful life is greater than 3 years.
- The construction of the factory buildings, or other capital goods. Nor have the products used in the maintenance of buildings been considered..
- Transport of product returned to the factory has not been considered.
- Staff work trips.
- Travel to or from work by staff.

3.3. Declared Unit

The declared unit for Tycsa PSC's drawn steel products is 1 ton of product, including its packaging:

- Prestressed wire PF4.
- 3-wire strand PC4.
- 7-wire bare strand P61.
- 7-wire bare strand P62.
- 7-wire sheathed strand P63.

3.4. Allocation criteria.

According to the criteria of the reference standard:

- Whenever possible it has been expanded the product system to avoid assigning the environmental impacts to the co-products of multi-unit unit processes, within the process of production.
- When it has not been possible to avoid the assignment, an assignment of the inputs and outputs of the system has been made, based on mass.

It has not been necessary to apply economic allocation criteria.

3.5. Reference Service Life (RSL)

The Reference Service Life (RSL) of drawn steel products is the RSL of the structure in which they are installed.

A medium RSL of 50 years can be accepted. The assembly and/or installation processes of drawn steel products are outside the scope of this EPD.

3.6. Cut off criteria

The LCA includes the gross weight/volume of all the materials used in the production process of the drawn steel products studied, except for auxiliary materials that account for 0.014% of the total weight of production in 2021. Consequently, the criteria of including at least 99% of the total weight of the products used for the declared functional unit.

There has been no exclusion of energy consumption.

3.7. Representativeness, quality and selection of data

To model the manufacturing process of the different drawn steel products, the production data of the Tycsa PSC factory in Santander, from the year 2021, which is a representative year of average production, have been used. Data from this factory have been obtained for material and energy consumption; air emissions, discharges and waste generation; and transport distances.

To represent the production of GSW wire rod used as raw material in the manufacture of Tycsa PSC products, the supplier's EPD has been considered: "Special steel wire rod produced in electric arc furnace" (S-P-06129 EPD International AB; publication date 2022-06-01; validity date: 2027-05-31).

When necessary, the Ecoinvent 3.8 database (November 2021) was used, which is the latest version available at the time of the LCA. For the inventory data, to model the LCA and to calculate the environmental impact categories requested by the Product Category Rule, the SimaPro 9.3.0.3 software has been used, which is the most updated version available at the time of carrying out the study.

For the choice of the most representative processes, the following criteria have been applied:

- That they are representative data of the technological development actually applied in the manufacturing processes. In case of not having information, a representative data of an average technology has been chosen.
- That they be geographical data as close as possible and, where appropriate, regionalized means.
- That the data be as up-to-date as possible.

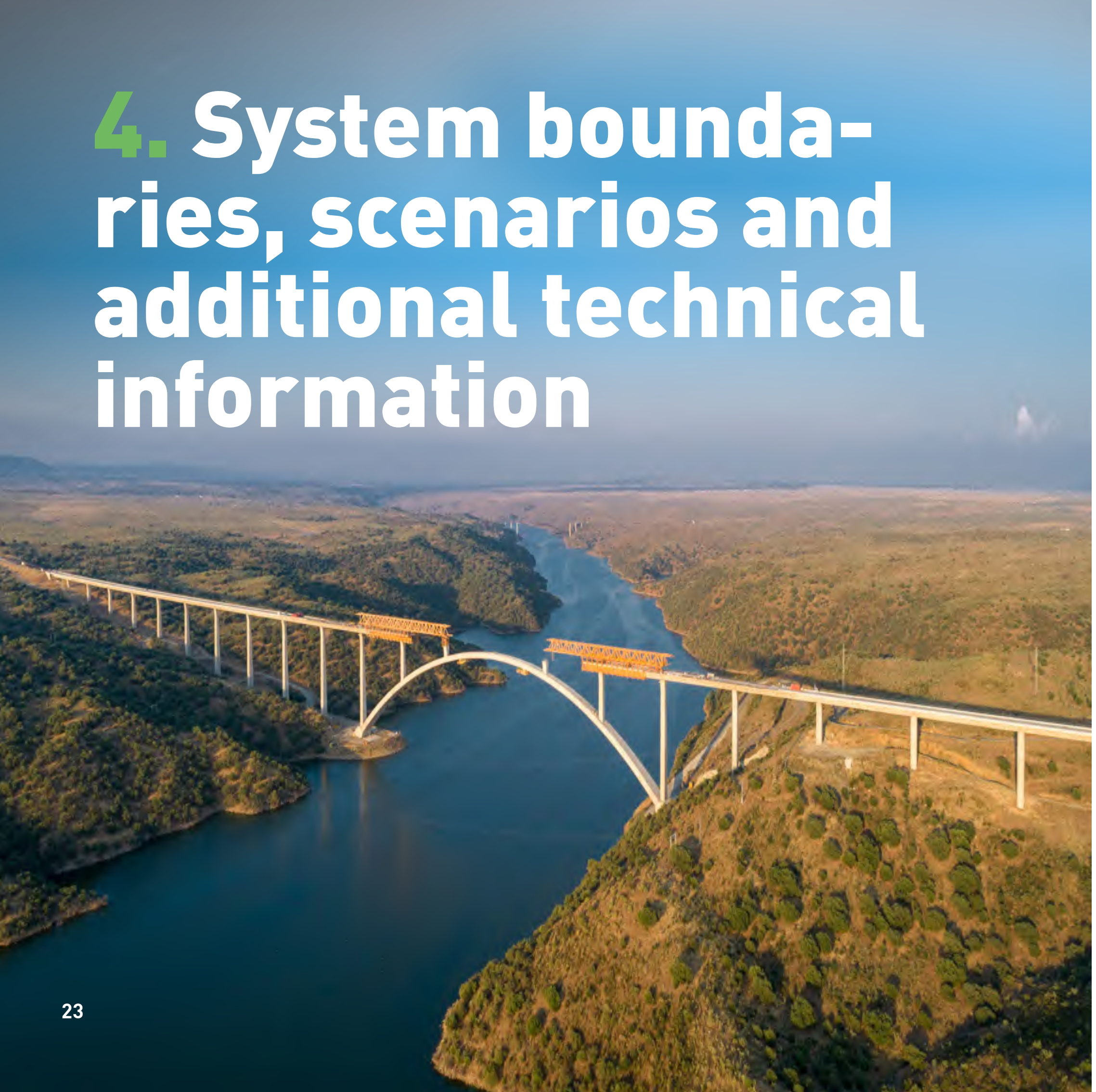
To assess the quality of the primary data on the production of Tycsa PSC's drawn steel products, the criteria for semi-quantitative evaluation of the quality of the data are applied, proposed by the European Union in its Guide to the Environmental Footprint of Products and Organizations. The results obtained are the following:

- Very good integrity. Score 1.
- Good methodological suitability and coherence. Score 2.
- Very good temporal representation. Score 1.
- Good technological representativeness. Score 2.
- Very good geographical representation. Score 1.
- Very low data uncertainty. score 1.

According to the above data, the Data Quality Rating (DQR) takes the following value: 8/6= 1.33, which indicates that the quality of the data is excellent.

To better understand the evaluation of the quality of the data carried out, it is indicated that the score of each of the criteria varies from 1 to 5 (the lower the score, the better the quality) and that the following table is applied to obtain the final score:

Overall data quality score (DQR)	Overall quality level of data
≤ 1,6	Excellent quality
1,6 a 2,0	Very good quality
2,0 a 3,0	Good quality
3 a 4,0	Reasonable quality
> 4	Insufficient quality



4. System boundaries, scenarios and additional technical information

The product system studied in the Life Cycle Analysis of the production of Tycsa PSC drawn steel products (wire, 3-wire strand, 7-wire bare strand and 7-wire sheathed strand) is from the cradle to the gate with the A4 modules, C1-C4 and D. Assembly processes and/or product installation are excluded. The following phases of production have been studied:

Product stage:

- A1 from production of the raw material used in the manufacture of the wire, 3-wire strand, 7-wire bare strand and 7-wire sheathed strand and the energy consumption of the production process.

- A2, from transportation of materials to the plant.

- A3, from manufacturing wire, 3-wire strand, 7-wire bare strand and 7-wire sheathed strand in Santander: production of parts including water and fuel consumption; production of auxiliary materials; packaging production; and transport and management of waste generated.

Installation stage:

- A4, transportation from the door of the Tycsa PSC factory to the construction site.

End of life stage:

- C1, deconstruction or demolition.

- C2, transportation of disassembled materials to the place of waste treatment or final disposal.

- C3, waste treatment for reuse, recovery and/or recycling.

- C4, of waste disposal, including physical pre-treatment and management at the disposal site and associated energy and water use.

Benefits and burdens beyond the system:

D, of reuse, recovery and/or recycling potential, expressed as net charges and benefits.

4.1. Processes prior to manufacturing (upstream) and product manufacturing (modules A1-A3)

The components necessary for their manufacture are received at the drawn steel products factory: the wire rod used as raw material and the auxiliary products used in each stage of the process.

The manufacturing process consists of the following production stages:

- Pickling. Hot rolled products have a thin layer of iron oxides on their surface that must be removed before cold drawing. This process is carried out in the pickling line where the steel product is immersed in successive acid baths to remove the iron oxide from the surface, as well as the calamine that forms in the hot rolling of the wire rod. Once pickled, they are washed for further processing and prepared with a coating of products that reduce friction during the following stages and improve resistance to corrosion.
- Wire drawing. In cold drawing, the wire rod is passed through some dies, producing a reduction in the section and a modification of the physical characteristics. To facilitate passage through the dies, lubricating soaps and emulsions are used. By passing the wire rod through successive dies, it is possible to reduce the section to a predetermined size, also achieving a hardening of the material and a smooth surface.
- Indentation. To improve adherence with the concrete, the wires are passed through rollers that, applied to the passage on the surface of these, produce the indentations.
- Stabilization: To releases the tensions produced in the forming processes, a thermomechanical treatment is carried out under established temperature conditions to subsequently be cooled first by means of water by controlled temperature and finally by air drying to prevent the strand from arriving wet.
- Coiling. The wires and strand are wound into coils.
- Stranding (only 3-wire and 7-wire strand). In this stage the wires are wound helically to form the different types of strands.
- Sheathing. The sheathed strands are covered with a polyethylene sheath, injecting specific materials between the steel and the sheath: (grease or wax)

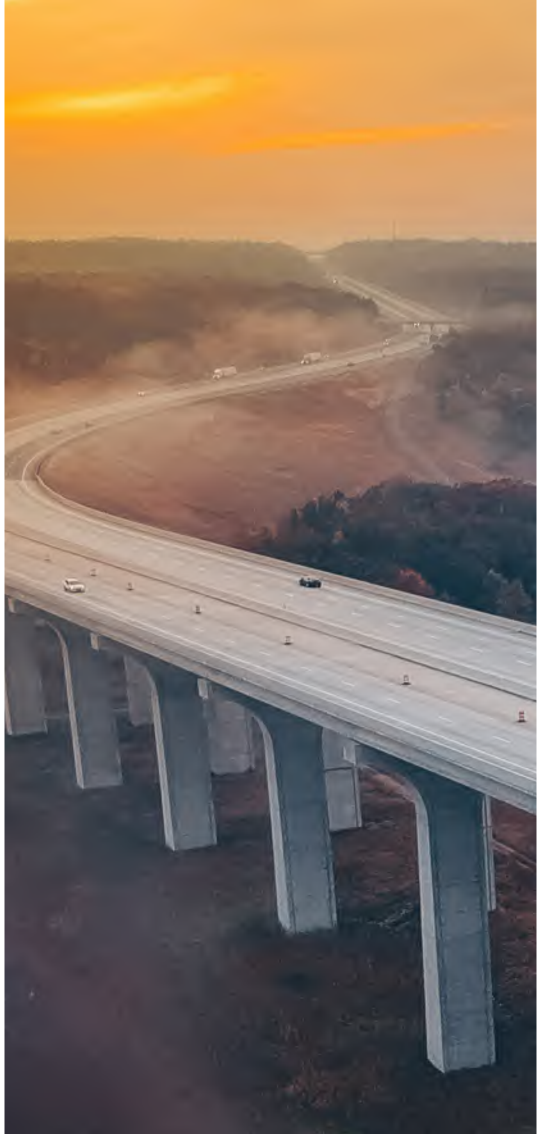
Stages and information modules for the evaluation of buildings. Building life cycle. Building Life Cycle Information.					
Building Life Cycle Information.	A1 a 3 (Production stage)	A1	X	Supply of raw materials	-
		A2	X	Transport	-
		A3	X	Production	-
	A4 - 5 (Construction stage)	A4	X	Transport	Scenario
		A5	MNE	Construction / installation process	Scenario
	B1 a 7 (Use stage)	B1	MNE	Use	Scenario
		B2	MNE	Maintenance	Scenario
		B3	MNE	Repair	Scenario
		B4	MNE	Substitution	Scenario
		B5	MNE	Rehabilitation	Scenario
		B6	MNE	Energy use in service	Scenario
		B7	MNE	Use of water in service	Scenario
	C1 a 4 (End of life stage)	C1	NR	Deconstruction, demolition	Scenario
		C2	X	Transport	Scenario
		C3	X	Waste treatment	Scenario
		C4	X	Waste disposal	Scenario
Additional Information	Benefits and burdens beyond the system	D	X	Potential for reuse, recovery and recycling	-

X Assessed module. **MNE** Module not evaluated. **NR** Not relevant.

4.2. Transport to site and construction process (A4-A5)

Module A4. The transport of drawn steel products from the Tycsa PSC production plant in Santander to the facilities where they are used has been considered, distinguishing the mode of transport used: ship and truck. Transport distances to the customer have been provided by Tycsa PSC.

Module parameters A4 – PF4	
Parameter	Quantity (per functional unit)
Liters of fuel: - Diesel in truck EURO 5 (carga útil de 29,96t) - Heavy diesel in transoceanic ship (50.000 TPM)	- 0,02255 l/tkm - 0,00269 l/tkm
Average distance: - Truck - Ship	- 1.021,03 km - 4.262,19 km
Capacity utilization (including empty return)	-
Apparent density of transported products	7.850kg/m³
Useful capacity factor	0,98 t



Module parameters A4 – PC4	
Parameter	Quantity (per functional unit)
Liters of fuel: - Diesel in truck EURO 5 (carga útil de 29,96t) - Heavy diesel in transoceanic ship (50.000 TPM)	- 0,02255 l/tkm - 0,00269 l/tkm
Average distance: - Truck - Ship	- 706,90 km - 10.588,66 km
Capacity utilization (including empty return)	-
Apparent density of transported products	7.850kg/m³
Useful capacity factor	0,98 t

Module parameters A4 – P62	
Parameter	Quantity (per functional unit)
Liters of fuel: - Diesel in truck EURO 5 (carga útil de 29,96t) - Heavy diesel in transoceanic ship (50.000 TPM)	- 0,02255 l/tkm - 0,00269 l/tkm
Average distance: - Truck - Ship	- 1.205,01 km - 5.173,26 km
Capacity utilization (including empty return)	-
Apparent density of transported products	7.850kg/m³
Useful capacity factor	0,98 t

Module parameters A4 – P61	
Parameter	Quantity (per functional unit)
Liters of fuel: - Diesel in truck EURO 5 (carga útil de 29,96t) - Heavy diesel in transoceanic ship (50.000 TPM)	- 0,02255 l/tkm - 0,00269 l/tkm
Average distance: - Truck - Ship	- 1.378,31 km - 2.216,32 km
Capacity utilization (including empty return)	-
Apparent density of transported products	7.850kg/m³
Useful capacity factor	0,98 t

Module parameters A4 – P63	
Parameter	Quantity (per functional unit)
Liters of fuel: - Diesel in truck EURO 5 (carga útil de 29,96t) - Heavy diesel in transoceanic ship (50.000 TPM)	- 0,02255 l/tkm - 0,00269 l/tkm
Average distance: - Truck - Ship	- 1.185,48 km - 4.793,80 km
Capacity utilization (including empty return)	-
Apparent density of transported products	7.850kg/m³
Useful capacity factor	0,98 t

Module A5: Not Evaluated

4.3. Use linked to the building structure

Module B1-B5: Not Evaluated

4.4. Use linked to the operation of the building

Module B6-B7: Not Evaluated

4.5. Module C - End of life stage

Module C1 – Deconstruction / demolition. It has been considered that the deconstruction module (C1) is not considered relevant for the quantitative analysis. Material and energy consumption for the deconstruction and extraction of drawn steel products are not relevant within the framework of the building or civil works of which they are part.

Module C2 – Transportation to the waste treatment/recovery site. Waste from Tycsa PSC's drawn steel elements at the end of their useful life is considered to be transported an average distance of 50km to the nearest waste management point, with EURO5 trucks of more than 32 tons.

Module C3-C4 – Waste treatment and waste disposal. To determine the percentages of recycling and sending to landfill and incineration of the products studied, the criteria of Part C of Annex 2 V2.1 (May 2020) of the Circular Footprint Formula of the Union's Environmental Footprint methodology are applied. European (RECOMMENDATION (EU) 2021/2279 OF THE COMMISSION of December 15, 2021, on the use of environmental footprint methods to measure and communicate the environmental behavior of products and organizations throughout their life cycle).

Applying the indicated values to the composition of Tycsa PSC's drawn steel products, the following end-of-life scenarios result:

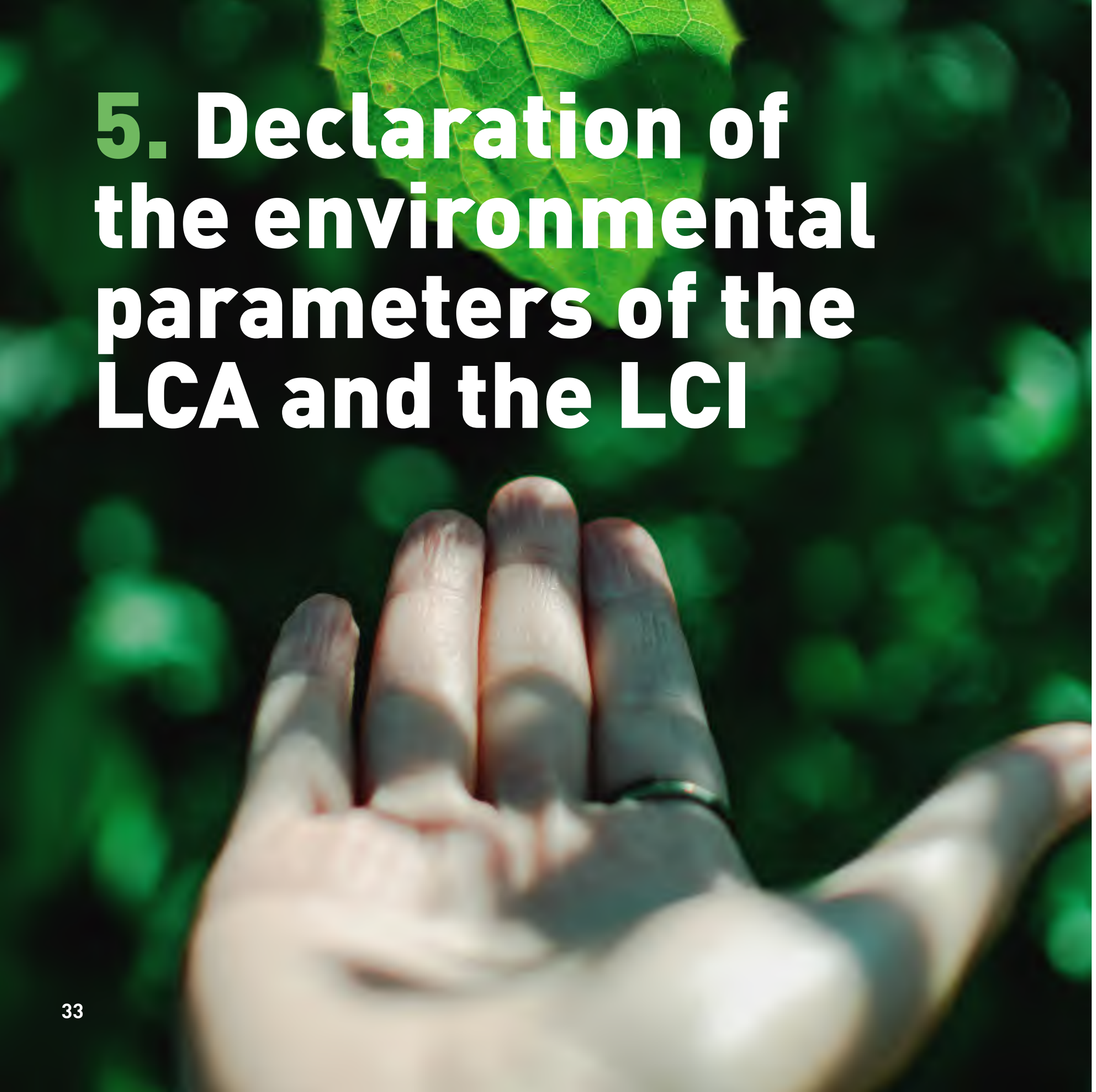
Module C parameters – PF4 wire / PC4 3-wire strand / P61 7-wire strand / P62 7-wire strand	
Parameter	Value (per unit declared)
Demolition	It is considered that, during the process of deconstruction and disassembly of the products studied, material and energy consumption are included in the framework of the building or civil works of which they are a part.
Collection process, specified by type	- 1,000 kg collected separately. - 0 kg collected with mixed construction waste.
Recovery system, specified by type	- 0 kg for reuse - 850 kg of steel for recycling - 21 kg of steel for energy recovery
Elimination, specified by type	129 kg of product or material for final disposal in landfill.
Assumptions for scenario development (transport)	Transport of waste by EURO5 truck of >32 tons: average distance of 50 km from the work to the management points.

Parameters of module C – Sheathed strand P63	
Parameter	Value (per unit declared)
Demolition	It is considered that, during the process of deconstruction and disassembly of the products studied, material and energy consumption are included in the framework of the building or civil works of which they are a part.
Collection process, specified by type	- 1,000 kg collected separately. - 0 kg collected with mixed construction waste.
Recovery system, specified by type	- 0 kg for reuse - 759 9 kg of steel and 23.85 kg of PP for recycling - 18.77 kg of steel and 11.50 kg of PP for energy recovery
Elimination, specified by type	185.98 kg of product or material for final disposal in landfill.
Assumptions for scenario development (transport)	Transport of waste by EURO5 truck of >32 tons: average distance of 50 km from the work to the management points.

4.6. Module D - Benefits beyond the system

The recovery coefficient has been applied to the waste that is sent for recycling, indicated in the criteria of Part C of Annex 2 V2.1 (May 2020) of the Circular Footprint Formula of the methodology of the Environmental Footprint of the European Union (RECOMMENDATION (EU) 2021/2279 OF THE COMMISSION of December 15, 2021, on the use of environmental footprint methods to measure and communicate the environmental behavior of products and organizations throughout their life cycle):

- 100% of the steel sent for recycling.
- 90% of the PE sent to recycling.



5. Declaration of the environmental parameters of the LCA and the LCI

Below are the different environmental parameters obtained from the Life Cycle Assessment (LCA) for the production of 1 ton of each of Tycsa PSC's drawn steel products.

The estimated impact results are relative and do not indicate the final value of the impact categories, nor do they refer to threshold values, safety margins or risks.

Environmental impact parameters:

Prestressed Wire PF4. Functional Unit: 1.000 kg						
Parameter	Unit	A1	A2	A3	A1-A3	A4
GWP-fossil	kg CO2 eq	5,47E+02	1,44E+00	2,63E+01	5,74E+02	4,18E+00
GWP-biogenic	kg CO2 eq	6,04E+00	8,40E-05	1,21E-01	6,16E+00	2,37E-04
GWP-luluc	kg CO2 eq	1,95E+00	1,16E-05	1,87E+00	3,82E+00	4,30E-05
GWP-total	kg CO2 eq	5,55E+02	1,44E+00	2,83E+01	5,84E+02	4,18E+00
ODP	kg CFC-11 eq	5,93E-05	3,41E-07	1,51E-05	7,47E-05	9,46E-07
AP	mol H+ eq	2,28E+00	4,99E-03	2,27E-01	2,51E+00	5,08E-02
EP-freshwater	kg PO4 eq	2,59E-01	6,59E-04	3,12E-02	2,91E-01	4,81E-03
EP-marine	kg N eq	5,88E-01	1,60E-03	4,77E-02	6,37E-01	1,32E-02
EP-terrestrial	mol N eq	5,73E+00	1,76E-02	2,88E-01	6,04E+00	1,47E-01
POCP	kg NMVOC eq	1,69E+00	4,79E-03	8,12E-02	1,78E+00	3,79E-02
ADP-minerals&me-tals 2	kg Sb eq	2,94E-03	6,25E-08	1,49E-05	2,95E-03	1,41E-07
ADP-fossil 2	MJ, v.c.n.	6,82E+03	2,03E+01	3,22E+02	7,16E+03	5,69E+01
WDP 2	m3 eq	3,06E+02	-1,94E-03	7,48E+01	3,80E+02	-5,51E-03

GWP - total (kg CO2 eq): Global warming potential ; GWP - fossil (kg CO2 eq): Global warming potential of fossil fuels; GWP - biogenic (kg CO2 eq): Potencial de calentamiento global biogénico; GWP - luluc (kg CO2 eq): Global warming potential of land use and land use change; ODP (kg CFC-11 eq): Stratospheric ozone layer depletion potential; AP (mol H+ eq): Acidification potential, accumulated surplus; EP-freshwater (kg PO4 eq): Eutrophication potential, fraction of nutrients reaching the final freshwater compartment;

Parameters that describe the environmental impacts defined in the UNE-EN 15804 Standard for the production of 1 ton of PF4 prestressed wire.

Prestressed Wire PF4. Functional Unit: 1.000 kg						
Parameter	Unit	C1	C2	C3	C4	D
GWP-fossil	kg CO2 eq	NR	3,59E+00	7,88E-02	3,26E-01	-1,77E+02
GWP-biogenic	kg CO2 eq	NR	2,07E-04	3,42E-04	4,39E-05	-1,30E-01
GWP-luluc	kg CO2 eq	NR	2,86E-05	1,22E-06	1,11E-05	-6,38E-02
GWP-total	kg CO2 eq	NR	3,59E+00	7,92E-02	3,26E-01	-1,77E+02
ODP	kg CFC-11 eq	NR	8,39E-07	1,77E-08	6,76E-08	-7,15E-06
AP	mol H+ eq	NR	1,21E-02	5,60E-04	3,35E-03	-7,02E-01
EP-freshwater	kg PO4 eq	NR	1,58E-03	8,54E-05	5,14E-04	-7,50E-02
EP-marine	kg N eq	NR	3,82E-03	2,34E-04	1,46E-03	-1,38E-01
EP-terrestrial	mol N eq	NR	4,20E-02	2,56E-03	1,60E-02	-1,59E+00
POCP	kg NMVOC eq	NR	1,15E-02	7,72E-04	4,45E-03	-7,60E-01
ADP-minerals&me-tals 2	kg Sb eq	NR	1,54E-07	3,55E-09	1,57E-08	-2,35E-03
ADP-fossil 2	MJ, v.c.n.	NR	5,00E+01	1,08E+00	4,33E+00	-1,66E+03
WDP 2	m3 eq	NR	-4,78E-03	-3,83E-01	2,08E-03	-3,77E+01

EP-marine (kg N eq): Eutrophication potential, fraction of nutrients that reach the final compartment of seawater; EP-terrestrial (mol N eq): Eutrophication potential, accumulated surplus; POCP (kg NMVOC eq): Tropospheric ozone formation potential; ADP-minerals&metals (kg Sb eq): Abiotic resource depletion potential for non-fossil resources; APD-fossil (MJ, v.c.n): Abiotic resource depletion potential for fossil resources; WDP (m3 eq): Water deprivation potential (user), weighted water deprivation consumption.

Environmental impact parameters:

Prestressed Wire PF4. Functional Unit: 1.000 kg						
Parameter	Unit	A1	A2	A3	A1-A3	A4
PM	Disease Incidence	2,48E-05	1,07E-07	1,19E-06	2,61E-05	3,29E-07
IRP 1	kBq U235 eq	1,09E+02	8,85E-02	3,32E+00	1,12E+02	2,48E-01
ETP-fw 2	CTUe	7,05E+03	8,26E+00	6,85E+02	7,74E+03	2,32E+01
HTP-c 2	CTUh	3,12E-06	1,16E-10	7,62E-08	3,20E-06	4,49E-10
HTP-nc 2	CTUh	6,11E-06	1,35E-08	6,88E-06	1,30E-05	3,99E-08
SQP 2	Pt	1,56E+03	5,47E-02	7,26E+02	2,28E+03	1,52E-01

PM (disease incidence): Potential incidence of diseases due to emissions of particulate matter; IRP (kBq U235 eq): Exposure efficiency of human potential relative to U235; ETP-fw (CTUe): Comparative toxic unit potential for ecosystems - freshwater; HTP-c (CTUh): Comparative potential of toxic unit for ecosystems - carcinogenic effects; HTP-nc (CTUh): Comparative toxic unit potential for ecosystems - non-cancer effects; SQP (Pt): Soil quality potential index.

Additional environmental impact parameters defined in the UNE-EN 15804 Standard for the production of 1 ton of PF4 prestressed wire.

Prestressed Wire PF4. Functional Unit: 1.000 kg						
Parameter	Unit	C1	C2	C3	C4	D
PM	Disease Incidence	NR	3,58E-07	4,28E-08	8,98E-08	-1,26E-05
IRP 1	kBq U235 eq	NR	2,18E-01	4,67E-03	1,82E-02	-3,07E+00
ETP-fw 2	CTUe	NR	2,20E+01	7,12E+00	2,20E+00	-4,68E+03
HTP-c 2	CTUh	NR	3,08E-10	3,25E-10	2,69E-11	-1,13E-06
HTP-nc 2	CTUh	NR	4,30E-08	3,51E-09	3,26E-09	-4,02E-06
SQP 2	Pt	NR	1,35E-01	1,78E+00	5,32E+00	-2,91E+02

Warning 1. This impact category deals primarily with the eventual impacts of low doses of ionizing radiation on human health from the nuclear fuel cycle. It does not consider the effects due to possible nuclear accidents or occupational exposure due to the disposal of radioactive waste in underground facilities. The ionizing radiation potential of the soil, due to radon or some construction materials, is not measured in this parameter either.

Warning 2. The results of this environmental impact indicator should be used with caution as the uncertainties of the results are high and experience with this parameter is limited.

Environmental impact parameters:

(1) 3-wire strand PC4; (2) 7-wire strand P61; (3) 7-wire strand P62

3-w Strand PC4 / 7-w Strand P61 / P62. Functional Unit: 1.000 kg								
Parameter	Unit	A1	A2	A3	A1-A3	A4(1)	A4(2)	A4(3)
GWP-fossil	kg CO2 eq	5,71E+02	1,33E+00	2,67E+01	5,99E+02	3,56E+00	9,93E+00	8,57E+00
GWP-biogenic	kg CO2 eq	6,19E+00	7,80E-05	1,26E-01	6,32E+00	2,03E-04	5,69E-04	4,88E-04
GWP-luluc	kg CO2 eq	2,13E+00	1,08E-05	1,85E+00	3,99E+00	3,62E-05	8,75E-05	8,45E-05
GWP-total	kg CO2 eq	5,79E+02	1,34E+00	2,87E+01	6,09E+02	3,56E+00	9,94E+00	8,57E+00
ODP	kg CFC-11 eq	6,18E-05	3,17E-07	1,50E-05	7,71E-05	8,08E-07	2,30E-06	1,95E-06
AP	mol H+ eq	2,39E+00	4,64E-03	2,31E-01	2,63E+00	4,13E-02	6,49E-02	9,02E-02
EP-freshwater	kg PO4 eq	2,69E-01	6,12E-04	3,41E-02	3,04E-01	3,93E-03	6,92E-03	8,73E-03
EP-marine	kg N eq	6,10E-01	1,48E-03	5,22E-02	6,63E-01	1,08E-02	1,81E-02	2,38E-02
EP-terrestrial	mol N eq	5,97E+00	1,63E-02	2,93E-01	6,28E+00	1,20E-01	2,00E-01	2,63E-01
POCP	kg NMVOC eq	1,76E+00	4,45E-03	8,23E-02	1,84E+00	3,10E-02	5,28E-02	6,84E-02
ADP-minerals&metals 2	kg Sb eq	2,98E-03	5,80E-08	1,49E-05	3,00E-03	1,22E-07	3,93E-07	3,04E-07
ADP-fossil 2	MJ, v.c.n.	7,15E+03	1,89E+01	3,26E+02	7,50E+03	4,86E+01	1,37E+02	1,17E+02
WDP 2	m3 eq	3,26E+02	-1,81E-03	9,22E+01	4,18E+02	-4,70E-03	-1,32E-02	-1,13E-02

GWP - total (kg CO2 eq): Global warming potential ; GWP - fossil (kg CO2 eq): Global warming potential of fossil fuels; GWP - biogenic (kg CO2 eq): Potencial de calentamiento global biogénico; GWP - luluc (kg CO2 eq): Global warming potential of land use and land use change; ODP (kg CFC-11 eq): Stratospheric ozone layer depletion potential; AP (mol H+ eq): Acidification potential, accumulated surplus; EP-freshwater (kg PO4 eq): Eutrophication potential, fraction of nutrients reaching the final freshwater compartment;

Parameters that describe the environmental impacts defined in the UNE-EN 15804 Standard for the production of 1 ton of 3-wire strand PC4 , and 7-wire strand P61 & P62.

3-w Strand PC4 / 7-w Strand P61 / P62. Functional Unit: 1.000 kg						
Parameter	Unit	C1	C2	C3	C4	D
GWP-fossil	kg CO2 eq	NR	3,59E+00	7,88E-02	3,26E-01	-1,77E+02
GWP-biogenic	kg CO2 eq	NR	2,07E-04	3,42E-04	4,39E-05	-1,30E-01
GWP-luluc	kg CO2 eq	NR	2,86E-05	1,22E-06	1,11E-05	-6,38E-02
GWP-total	kg CO2 eq	NR	3,59E+00	7,92E-02	3,26E-01	-1,77E+02
ODP	kg CFC-11 eq	NR	8,39E-07	1,77E-08	6,76E-08	-7,15E-06
AP	mol H+ eq	NR	1,21E-02	5,60E-04	3,35E-03	-7,02E-01
EP-freshwater	kg PO4 eq	NR	1,58E-03	8,54E-05	5,14E-04	-7,50E-02
EP-marine	kg N eq	NR	3,82E-03	2,34E-04	1,46E-03	-1,38E-01
EP-terrestrial	mol N eq	NR	4,20E-02	2,56E-03	1,60E-02	-1,59E+00
POCP	kg NMVOC eq	NR	1,15E-02	7,72E-04	4,45E-03	-7,60E-01
ADP-minerals&metals 2	kg Sb eq	NR	1,54E-07	3,55E-09	1,57E-08	-2,35E-03
ADP-fossil 2	MJ, v.c.n.	NR	5,00E+01	1,08E+00	4,33E+00	-1,66E+03
WDP 2	m3 eq	NR	-4,78E-03	-3,83E-01	2,08E-03	-3,77E+01

EP-marine (kg N eq): Eutrophication potential, fraction of nutrients that reach the final compartment of seawater; EP-terrestrial (mol N eq): Eutrophication potential, accumulated surplus; POCP (kg NMVOC eq): Tropospheric ozone formation potential; ADP-minerals&metals (kg Sb eq): Abiotic resource depletion potential for non-fossil resources; APD-fossil (MJ, v.c.n): Abiotic resource depletion potential for fossil resources; WDP (m3 eq): Water deprivation potential (user), weighted water deprivation consumption.

Environmental impact parameters:

(1) 3-wire strand PC4; (2) 7-wire strand P61; (3) 7-wire strand P62

3-w Strand PC4 / 7-w Strand P61 / P62. Functional Unit: 1.000 kg								
Parameter	Unit	A1	A2	A3	A1-A3	A4(1)	A4(2)	A4(3)
PM	Disease Incidence	2,54E-05	9,97E-08	1,20E-06	2,67E-05	2,86E-07	9,16E-07	7,09E-07
IRP 1	kBq U235 eq	1,18E+02	8,22E-02	3,38E+00	1,21E+02	2,12E-01	5,98E-01	5,11E-01
ETP-fw 2	CTUe	7,31E+03	7,67E+00	7,79E+02	8,10E+03	1,99E+01	5,89E+01	4,86E+01
HTP-c 2	CTUh	3,17E-06	1,08E-10	7,75E-08	3,25E-06	3,78E-10	9,30E-10	8,86E-10
HTP-nc 2	CTUh	6,30E-06	1,25E-08	6,99E-06	1,33E-05	3,46E-08	1,10E-07	8,57E-08
SQP 2	Pt	1,68E+03	5,08E-02	7,26E+02	2,41E+03	1,30E-01	3,69E-01	3,14E-01

PM (disease incidence): Potential incidence of diseases due to emissions of particulate matter; IRP (kBq U235 eq): Exposure efficiency of human potential relative to U235; ETP-fw (CTUe): Comparative toxic unit potential for ecosystems - freshwater; HTP-c (CTUh): Comparative potential of toxic unit for ecosystems - carcinogenic effects; HTP-nc (CTUh): Comparative toxic unit potential for ecosystems - non-cancer effects; SQP (Pt): Soil quality potential index.

Additional environmental impact parameters defined in the UNE-EN 15804 Standard for the production of 1 ton of 3-wire strand PC4 , and 7-wire strand P61 & P62.

3-w Strand PC4 / 7-w Strand P61 / P62. Functional Unit: 1.000 kg						
Parameter	Unit	C1	C2	C3	C4	D
PM	Disease Incidence	NR	3,58E-07	4,28E-08	8,98E-08	-1,26E-05
IRP 1	kBq U235 eq	NR	2,18E-01	4,67E-03	1,82E-02	-3,07E+00
ETP-fw 2	CTUe	NR	2,20E+01	7,12E+00	2,20E+00	-4,68E+03
HTP-c 2	CTUh	NR	3,08E-10	3,25E-10	2,69E-11	-1,13E-06
HTP-nc 2	CTUh	NR	4,30E-08	3,51E-09	3,26E-09	-4,02E-06
SQP 2	Pt	NR	1,35E-01	1,78E+00	5,32E+00	-2,91E+02

Warning 1. This impact category deals primarily with the eventual impacts of low doses of ionizing radiation on human health from the nuclear fuel cycle. It does not consider the effects due to possible nuclear accidents or occupational exposure due to the disposal of radioactive waste in underground facilities. The ionizing radiation potential of the soil, due to radon or some construction materials, is not measured in this parameter either.

Warning 2. The results of this environmental impact indicator should be used with caution as the uncertainties of the results are high and experience with this parameter is limited.

Environmental impact parameters:

Sheathed Strand P63. Functional Unit: 1.000 kg						
Parameter	Unit	A1	A2	A3	A1-A3	A4
GWP-fossil	kg CO2 eq	6,68E+02	1,89E+01	2,25E+02	9,12E+02	5,81E+00
GWP-biogenic	kg CO2 eq	6,36E+00	1,11E-03	4,74E-01	6,84E+00	3,31E-04
GWP-luluc	kg CO2 eq	3,28E+00	1,53E-04	1,83E+00	5,11E+00	5,61E-05
GWP-total	kg CO2 eq	6,78E+02	1,89E+01	2,27E+02	9,24E+02	5,81E+00
ODP	kg CFC-11 eq	7,22E-05	4,49E-06	5,31E-05	1,30E-04	1,33E-06
AP	mol H+ eq	2,88E+00	6,57E-02	1,03E+00	3,97E+00	5,67E-02
EP-freshwater	kg PO4 eq	3,06E-01	8,67E-03	1,02E-01	4,17E-01	5,56E-03
EP-marine	kg N eq	6,84E-01	2,10E-02	1,82E-01	8,87E-01	1,51E-02
EP-terrestrial	mol N eq	6,88E+00	2,31E-01	1,69E+00	8,81E+00	1,67E-01
POCP	kg NMVOC eq	1,98E+00	6,30E-02	1,66E+00	3,71E+00	4,34E-02
ADP-minerals&me-tals 2	kg Sb eq	2,83E-03	8,22E-07	9,76E-05	2,93E-03	2,10E-07
ADP-fossil 2	MJ, v.c.n.	8,61E+03	2,67E+02	7,46E+03	1,63E+04	7,96E+01
WDP 2	m3 eq	4,36E+02	-2,56E-02	2,14E+02	6,50E+02	-7,68E-03

GWP - total (kg CO2 eq): Global warming potential ; GWP - fossil (kg CO2 eq): Global warming potential of fossil fuels; GWP - biogenic (kg CO2 eq): Potencial de calentamiento global biogénico; GWP - luluc (kg CO2 eq): Global warming potential of land use and land use change; ODP (kg CFC-11 eq): Stratospheric ozone layer depletion potential; AP (mol H+ eq): Acidification potential, accumulated surplus; EP-freshwater (kg PO4 eq): Eutrophication potential, fraction of nutrients reaching the final freshwater compartment;

Parameters that describe the environmental impacts defined in the UNE-EN 15804 Standard for the production of 1 ton of sheathed strand P63.

Sheathed Strand P63. Functional Unit: 1.000 kg						
Parameter	Unit	C1	C2	C3	C4	D
GWP-fossil	kg CO2 eq	NR	3,59E+00	2,73E+01	1,03E+01	-1,99E+02
GWP-biogenic	kg CO2 eq	NR	2,07E-04	8,18E-04	5,11E-04	-1,77E-01
GWP-luluc	kg CO2 eq	NR	2,86E-05	8,66E-05	2,76E-05	-6,47E-02
GWP-total	kg CO2 eq	NR	3,59E+00	2,73E+01	1,03E+01	-1,99E+02
ODP	kg CFC-11 eq	NR	8,39E-07	6,97E-08	1,26E-07	-7,02E-06
AP	mol H+ eq	NR	1,21E-02	6,22E-03	6,17E-03	-7,61E-01
EP-freshwater	kg PO4 eq	NR	1,58E-03	1,47E-03	1,96E-03	-7,68E-02
EP-marine	kg N eq	NR	3,82E-03	3,03E-03	4,48E-03	-1,47E-01
EP-terrestrial	mol N eq	NR	4,20E-02	3,12E-02	2,96E-02	-1,68E+00
POCP	kg NMVOC eq	NR	1,15E-02	7,58E-03	1,04E-02	-8,13E-01
ADP-minerals&me-tals 2	kg Sb eq	NR	1,54E-07	1,91E-07	3,09E-08	-2,10E-03
ADP-fossil 2	MJ, v.c.n.	NR	5,00E+01	4,17E+00	7,90E+00	-2,90E+03
WDP 2	m3 eq	NR	-4,78E-03	-2,17E-01	5,82E-03	-6,62E+01

EP-marine (kg N eq): Eutrophication potential, fraction of nutrients that reach the final compartment of seawater; EP-terrestrial (mol N eq): Eutrophication potential, accumulated surplus; POCP (kg NMVOC eq): Tropospheric ozone formation potential; ADP-minerals&metals (kg Sb eq): Abiotic resource depletion potential for non-fossil resources; APD-fossil (MJ, v.c.n): Abiotic resource depletion potential for fossil resources; WDP (m3 eq): Water deprivation potential (user), weighted water deprivation consumption.

Environmental impact parameters:

Sheathed Strand P63. Functional Unit: 1.000 kg						
Parameter	Unit	A1	A2	A3	A1-A3	A4
PM	Disease Incidence	2,55E-05	1,41E-06	8,55E-06	3,55E-05	4,91E-07
IRP 1	kBq U235 eq	1,71E+02	1,16E+00	1,66E+01	1,89E+02	3,47E-01
ETP-fw 2	CTUe	8,17E+03	1,09E+02	2,70E+03	1,10E+04	3,32E+01
HTP-c 2	CTUh	3,00E-06	-1,53E-09	1,55E-07	3,16E-06	5,90E-10
HTP-nc 2	CTUh	6,76E-06	1,77E-07	8,10E-06	1,50E-05	5,93E-08
SQP 2	Pt	6,76E-06	7,20E-01	2,06E+03	4,47E+03	2,13E-01

PM (disease incidence): Potential incidence of diseases due to emissions of particulate matter; IRP (kBq U235 eq): Exposure efficiency of human potential relative to U235; ETP-fw (CTUe): Comparative toxic unit potential for ecosystems - freshwater; HTP-c (CTUh): Comparative potential of toxic unit for ecosystems - carcinogenic effects; HTP-nc (CTUh): Comparative toxic unit potential for ecosystems - non-cancer effects; SQP (Pt): Soil quality potential index.

Additional environmental impact parameters defined in the UNE-EN 15804 Standard for the production of 1 ton of sheathed strand P63.

Sheathed Strand P63. Functional Unit: 1.000 kg						
Parameter	Unit	C1	C2	C3	C4	D
PM	Disease Incidence	NR	3,58E-07	5,93E-08	1,65E-07	-1,26E-05
IRP 1	kBq U235 eq	NR	2,18E-01	1,13E-02	4,43E-02	-3,59E+00
ETP-fw 2	CTUe	NR	2,20E+01	6,45E+01	8,06E+00	-4,26E+03
HTP-c 2	CTUh	NR	3,08E-10	1,68E-09	6,45E-11	-1,01E-06
HTP-nc 2	CTUh	NR	4,30E-08	7,61E-08	6,90E-09	-3,70E-06
SQP 2	Pt	NR	1,35E-01	1,97E+00	1,72E+01	-2,70E+02

Warning 1. This impact category deals primarily with the eventual impacts of low doses of ionizing radiation on human health from the nuclear fuel cycle. It does not consider the effects due to possible nuclear accidents or occupational exposure due to the disposal of radioactive waste in underground facilities. The ionizing radiation potential of the soil, due to radon or some construction materials, is not measured in this parameter either.

Warning 2. The results of this environmental impact indicator should be used with caution as the uncertainties of the results are high and experience with this parameter is limited.

Use of resources:

Prestressed Wire PF4. Functional Unit: 1.000 kg						
Parameter	Unit	A1	A2	A3	A1-A3	A4
PERE	MJ, v.c.n.	1,40E+03	3,12E-02	2,27E+02	1,62E+03	8,43E-02
PERM	MJ, v.c.n.	0	0	0	0	0
PERT	MJ, v.c.n.	1,40E+03	3,12E-02	2,27E+02	1,62E+03	8,43E-02
PENRE	MJ, v.c.n.	1,18E+04	2,04E+01	4,83E+02	1,23E+04	5,70E+01
PENRM	MJ, v.c.n.	0	0	0	0	0
PENRT	MJ, v.c.n.	1,18E+04	2,04E+01	4,83E+02	1,23E+04	5,70E+01
SM	kg	9,11E+02	0	0	9,11E+02	0
RSF	MJ, v.c.n.	0	0	0	0	0
NRSF	MJ, v.c.n.	0	0	0	0	0
FW	m3	6,53E+00	1,03E-03	1,41E+00	7,94E+00	2,79E-03

PERE (MJ, v.c.n.): Use of renewable primary energy excluding renewable primary energy resources used as raw material; PERM (MJ, v.c.n.): Use of renewable primary energy used as raw material; PERT (MJ, v.c.n.): Total use of renewable primary energy; PENRE (MJ, v.c.n.): Non-renewable primary energy use, excluding non-renewable primary energy resources used as raw material; PENRM (MJ, v.c.n.): Use of non-renewable primary energy used as raw material; PENRT (MJ, v.c.n.): Total use of non-renewable primary energy; SM (kg): Use of secondary materials; RSF (MJ, v.c.n.): Use of renewable secondary fuels; NRSF (MJ, v.c.n.): Use of non-renewable secondary fuels; FW (m3): Net use of fresh water resources.

Parameters that describe the use of resources for the production of 1 ton of prestressed wire PF4.

Prestressed Wire PF4. Functional Unit: 1.000 kg						
Parameter	Unit	C1	C2	C3	C4	D
PERE	MJ, v.c.n.	NR	7,68E-02	2,01E-03	1,82E-02	-1,69E+02
PERM	MJ, v.c.n.	NR	0	0	0	0
PERT	MJ, v.c.n.	NR	7,68E-02	2,01E-03	1,82E-02	-1,69E+02
PENRE	MJ, v.c.n.	NR	5,01E+01	1,08E+00	4,34E+00	-1,76E+03
PENRM	MJ, v.c.n.	NR	0	0	0	0
PENRT	MJ, v.c.n.	NR	5,01E+01	1,08E+00	4,34E+00	-1,76E+03
SM	kg	NR	0	0	0	0
RSF	MJ, v.c.n.	NR	0	0	0	0
NRSF	MJ, v.c.n.	NR	0	0	0	0
FW	m3	NR	2,53E-03	5,54E-05	2,38E-04	-5,65E-01

Use of resources:

(1) 3-wire strand PC4; (2) 7-wire strand P61; (3) 7-wire strand P62

3-w Strand PC4 / 7-w Strand P61 / P62. Functional Unit: 1.000 kg								
Parameter	Unit	A1	A2	A3	A1-A3	A4(1)	A4(2)	A4(3)
PERE	MJ, v.c.n.	1,54E+03	2,90E-02	2,27E+02	1,77E+03	7,22E-02	2,08E-01	1,75E-01
PERM	MJ, v.c.n.	0	0	0	0	0	0	0
PERT	MJ, v.c.n.	1,54E+03	2,90E-02	2,27E+02	1,77E+03	7,22E-02	2,08E-01	1,75E-01
PENRE	MJ, v.c.n.	1,25E+04	1,89E+01	4,89E+02	1,30E+04	4,87E+01	1,38E+02	1,17E+02
PENRM	MJ, v.c.n.	0	0	0	0	0	0	0
PENRT	MJ, v.c.n.	1,25E+04	1,89E+01	4,89E+02	1,30E+04	4,87E+01	1,38E+02	1,17E+02
SM	kg	9,49E+02	0	0	9,49E+02	0	0	0
RSF	MJ, v.c.n.	0	0	0	0	0	0	0
NRSF	MJ, v.c.n.	0	0	0	0	0	0	0
FW	m3	6,76E+00	9,54E-04	1,73E+00	8,49E+00	2,39E-03	6,86E-03	5,78E-03

PERE (MJ, v.c.n.): Use of renewable primary energy excluding renewable primary energy resources used as raw material; PERM (MJ, v.c.n.): Use of renewable primary energy used as raw material; PERT (MJ, v.c.n.): Total use of renewable primary energy; PENRE (MJ, v.c.n.): Non-renewable primary energy use, excluding non-renewable primary energy resources used as raw material; PENRM (MJ, v.c.n.): Use of non-renewable primary energy used as raw material; PENRT (MJ, v.c.n.): Total use of non-renewable primary energy; SM (kg): Use of secondary materials; RSF (MJ, v.c.n.): Use of renewable secondary fuels; NRSF (MJ, v.c.n.): Use of non-renewable secondary fuels; FW (m3): Net use of fresh water resources.

Parameters that describe the use of resources for the production of 1 ton of 3-wire strand PC4 , and 7-wire strand P61 & P62.

3-w Strand PC4 / 7-w Strand P61 / P62. Functional Unit: 1.000 kg						
Parameter	Unit	C1	C2	C3	C4	D
PERE	MJ, v.c.n.	NR	7,68E-02	2,01E-03	1,82E-02	-1,69E+02
PERM	MJ, v.c.n.	NR	0	0	0	0
PERT	MJ, v.c.n.	NR	7,68E-02	2,01E-03	1,82E-02	-1,69E+02
PENRE	MJ, v.c.n.	NR	5,01E+01	1,08E+00	4,34E+00	-1,76E+03
PENRM	MJ, v.c.n.	NR	0	0	0	0
PENRT	MJ, v.c.n.	NR	5,01E+01	1,08E+00	4,34E+00	-1,76E+03
SM	kg	NR	0	0	0	0
RSF	MJ, v.c.n.	NR	0	0	0	0
NRSF	MJ, v.c.n.	NR	0	0	0	0
FW	m3	NR	2,53E-03	5,54E-05	2,38E-04	-5,65E-01

Use of resources:

Sheathed Strand P63. Functional Unit: 1.000 kg						
Parameter	Unit	A1	A2	A3	A1-A3	A4
PERE	MJ, v.c.n.	2,44E+03	4,11E-01	5,67E+02	3,01E+03	1,19E-01
PERM	MJ, v.c.n.	0	0	0	0	0
PERT	MJ, v.c.n.	2,44E+03	4,11E-01	5,67E+02	3,01E+03	1,19E-01
PENRE	MJ, v.c.n.	1,64E+04	2,68E+02	7,98E+03	2,46E+04	7,97E+01
PENRM	MJ, v.c.n.	0	0	0	0	0
PENRT	MJ, v.c.n.	1,64E+04	2,68E+02	7,98E+03	2,46E+04	7,97E+01
SM	kg	8,49E+02	0	0	8,49E+02	0
RSF	MJ, v.c.n.	0	0	0	0	0
NRSF	MJ, v.c.n.	0	0	0	0	0
FW	m3	7,49E+00	1,35E-02	2,28E+00	9,79E+00	3,94E-03

PERE (MJ, v.c.n.): Use of renewable primary energy excluding renewable primary energy resources used as raw material; PERM (MJ, v.c.n.): Use of renewable primary energy used as raw material; PERT (MJ, v.c.n.): Total use of renewable primary energy; PENRE (MJ, v.c.n.): Non-renewable primary energy use, excluding non-renewable primary energy resources used as raw material; PENRM (MJ, v.c.n.): Use of non-renewable primary energy used as raw material; PENRT (MJ, v.c.n.): Total use of non-renewable primary energy; SM (kg): Use of secondary materials; RSF (MJ, v.c.n.): Use of renewable secondary fuels; NRSF (MJ, v.c.n.): Use of non-renewable secondary fuels; FW (m3): Net use of fresh water resources.

Parameters that describe the use of resources for the production of 1 ton of sheathed strand P63.

Sheathed Strand P63. Functional Unit: 1.000 kg						
Parameter	Unit	C1	C2	C3	C4	D
PERE	MJ, v.c.n.	NR	7,68E-02	1,80E-01	4,57E-01	-1,70E+02
PERM	MJ, v.c.n.	NR	0	0	0	0
PERT	MJ, v.c.n.	NR	7,68E-02	1,80E-01	4,57E-01	-1,70E+02
PENRE	MJ, v.c.n.	NR	5,01E+01	4,35E+00	8,28E+00	-3,07E+03
PENRM	MJ, v.c.n.	NR	0	0	0	0
PENRT	MJ, v.c.n.	NR	5,01E+01	4,35E+00	8,28E+00	-3,07E+03
SM	kg	NR	0	0	0	0
RSF	MJ, v.c.n.	NR	0	0	0	0
NRSF	MJ, v.c.n.	NR	0	0	0	0
FW	m3	NR	2,53E-03	4,43E-02	5,35E-04	-5,81E-01

Waste categories:

Parameters that describe the waste categories for the production of 1 ton of prestressed wire PF4.

Prestressed wire PF4. Functional Unit: 1.000 kg						
Parameter	Unit	A1	A2	A3	A1-A3	A4
HWD	kg	7,86E-03	5,35E-05	1,04E-03	8,96E-03	1,19E-04
NHWD	kg	7,51E+01	1,07E-03	1,25E+01	8,76E+01	3,09E-03
RWD	kg	7,81E-02	1,46E-04	2,94E-03	8,11E-02	4,09E-04

Parameters that describe the categories of waste for the production of 1 ton of 3-wire strand PC4 , and 7-wire strand P61 & P62.

3-w strand PC4 / 7-w strand P61 / P62. Functional Unit: 1.000 kg								
Parameter	Unit	A1	A2	A3	A1-A3	A4 (1)	A4 (2)	A4 (3)
HWD	kg	8,20E-03	4,97E-05	9,77E-04	9,23E-03	1,03E-04	3,35E-04	2,57E-04
NHWD	kg	7,65E+01	9,92E-04	1,27E+01	8,92E+01	2,63E-03	7,30E-03	6,33E-03
RWD	kg	8,40E-02	1,35E-04	2,98E-03	8,71E-02	3,49E-04	9,84E-04	8,41E-04

Parameters that describe the categories of waste for the production of 1 ton of sheathed strand P63.

Sheathed Strand P63. Functional Unit: 1.000 kg						
Parameter	Unit	A1	A2	A3	A1-A3	A4
HWD	kg	9,54E-03	7,04E-04	6,53E-03	1,68E-02	1,78E-04
NHWD	kg	7,53E+01	1,41E-02	1,72E+01	9,25E+01	4,28E-03
RWD	kg	1,18E-01	1,92E-03	2,11E-02	1,41E-01	5,71E-04

HWD (kg): Hazardous waste disposed ; NHWD (kg): Non hazardous waste disposed; RWD (kg): Radioactive waste disposed.

Prestressed wire PF4. Functional Unit: 1.000 kg						
Parameter	Unit	C1	C2	C3	C4	D
HWD	kg	NR	1,32E-04	2,81E-06	1,09E-05	-1,38E-02
NHWD	kg	NR	2,63E-03	1,16E+01	1,29E+02	-7,00E+01
RWD	kg	NR	3,58E-04	7,68E-06	2,99E-05	-3,01E-03

(1) 3-wire strand PC4; (2) 7-wire strand P61; (3) 7-wire strand P62

3-w strand PC4 / 7-w strand P61 / P62. Functional Unit: 1.000 kg						
Parameter	Unit	C1	C2	C3	C4	D
HWD	kg	NR	1,32E-04	2,81E-06	1,09E-05	-1,38E-02
NHWD	kg	NR	2,63E-03	1,16E+01	1,29E+02	-7,00E+01
RWD	kg	NR	3,58E-04	7,68E-06	2,99E-05	-3,01E-03

Sheathed Strand P63. Functional Unit: 1.000 kg						
Parameter	Unit	C1	C2	C3	C4	D
HWD	kg	NR	1,32E-04	5,97E-05	2,03E-05	-1,24E-02
NHWD	kg	NR	2,63E-03	1,10E+01	1,86E+02	-6,29E+01
RWD	kg	NR	3,58E-04	1,46E-05	6,09E-05	-3,46E-03

Outflows:

Parameters that describe the output flows for the production of 1 ton of prestressed wire PF4.

Prestressed wire PF4. Functional Unit: 1.000 kg						
Parameter	Unit	A1	A2	A3	A1-A3	A4
CRU	kg	0	0	0	0	0
MFR	kg	0	0	1,68E+01	1,68E+01	0
MER	kg	0	0	0	0	0
EE	MJ	0	0	0	0	0

Parameters that describe the output flows for the production of 1 ton of 3-wire strand PC4 , and 7-wire strand P61 & P62.

3-w strand PC4 / 7-w strand P61 / P62. Functional Unit: 1.000 kg								
Parameter	Unit	A1	A2	A3	A1-A3	A4 (1)		A4 (2)
CRU	kg	0	0	0	0	0	0	0
MFR	kg	0	0	3,08E+01	3,08E+01	0	0	0
MER	kg	0	0	0	0	0	0	0
EE	MJ	0	0	0	0	0	0	0

CRU (kg): Components for re-use; MFR (kg): Materials for recycling; MER (kg): Materials for energy recovery; EE (MJ): Exported electric energy.

Prestressed wire PF4. Functional Unit: 1.000 kg						
Parameter	Unit	C1	C2	C3	C4	D
CRU	kg	NR	0	0	0	0
MFR	kg	NR	0	8,50E+02	0	0
MER	kg	NR	0	2,10E+01	0	0
EE	MJ	NR	0	0	0	0

(1) 3-wire strand PC4; (2) 7-wire strand P61; (3) 7-wire strand P62

3-w strand PC4 / 7-w strand P61 / P62. Functional Unit: 1.000 kg						
Parameter	Unit	C1	C2	C3	C4	D
CRU	kg	NR	0	0	0	0
MFR	kg	NR	0	8,50E+02	0	0
MER	kg	NR	0	2,10E+01	0	0
EE	MJ	NR	0	0	0	0

Outflows:

Parameters that describe the output flows for the production of 1 ton of sheathed strand P63.

Sheathed Strand P63. Functional Unit: 1.000 kg						
Parameter	Unit	A1	A2	A3	A1-A3	A4
CRU	kg	0	0	0	0	0
MFR	kg	0	0	7,82E+01	7,82E+01	0
MER	kg	0	0	0	0	0
EE	MJ	0	0	0	0	0

CRU (kg): Components for re-use; MFR (kg): Materials for recycling; MER (kg): Materials for energy recovery; EE (MJ): Exported electric energy.

Sheathed Strand P63. Functional Unit: 1.000 kg						
Parameter	Unit	C1	C2	C3	C4	D
CRU	kg	NR	0	0	0	0
MFR	kg	NR	0	7,84E+02	0	0
MER	kg	NR	0	3,03E+01	0	0
EE	MJ	NR	0	0	0	0

Information on biogenic carbon content:

The manufacturer declares that the drawn steel products do not contain materials with biogenic carbon.

Following the indications of the reference standard, the declaration of the biogenic carbon content of the packaging is omitted because the mass of the materials that contain biogenic carbon in the packaging is less than 5% of the total mass of the product.

6. Additional environmental information

6.1. Indoor air emissions

The use in the construction of drawn steel products, prestressed wire, bare strand, and sheathed strand, does not produce emissions into the indoor air during its useful life.

6.2. Release to soil and water

The use in the construction of drawn steel products, prestressed wire, bare strand and sheathed strand, does not generate emissions to the ground or water, during its useful life.

6.3. Results of the EF 3.0 Methodology

As additional information, the results of appl-ying the EF 3.0 Method (adapted) V1.00 / EF 3.0 normalization and weighting set methodology to the product stage (A1-A3) of Tycsa PSC's drawn steel products have been calculated..

All results refer to the declared unit, which is without 1,000 kg (1 ton) of product. The values for the environmental impact categories consi-dered in the applied methodology are shown.

The estimated impact results are relative and do not indicate the final value of the impact ca-tegories, nor do they refer to threshold values, safety margins or risks.

Potential environmental impacts resulting from the application of the EF 3.0 Method for the production of 1 ton of PF4 prestressed wire.

Impact Categories	Unit	A1	A2	A3	Total
Climate change	kg CO2 eq	5,55E+02	1,44E+00	2,83E+01	5,84E+02
Ozone depletion	kg CFC11 eq	5,93E-05	3,41E-07	1,51E-05	7,47E-05
Ionising radiation	kBq U-235 eq	1,09E+02	8,85E-02	3,32E+00	1,12E+02
Photochemical ozone formation	kg NMVOC eq	1,69E+00	4,79E-03	8,12E-02	1,78E+00
Particulate matter	disease inc.	2,48E-05	1,07E-07	1,19E-06	2,61E-05
Human toxicity, non-cancer	CTUh	6,11E-06	1,35E-08	6,88E-06	1,30E-05
Human toxicity, cancer	CTUh	3,12E-06	1,16E-10	7,62E-08	3,20E-06
Acidification	mol H+ eq	2,28E+00	4,99E-03	2,27E-01	2,51E+00
Eutrophication, fres-hwater	kg P eq	1,23E-02	7,35E-07	2,40E-03	1,47E-02
Eutrophication, marine	kg N eq	5,88E-01	1,60E-03	4,77E-02	6,37E-01
Eutrophication, terrestrial	mol N eq	5,73E+00	1,76E-02	2,88E-01	6,04E+00
Ecotoxicity, freshwater	CTUe	7,05E+03	8,26E+00	6,85E+02	7,74E+03
Land use	Pt	1,56E+03	5,47E-02	7,26E+02	2,28E+03
Water use	m3 depriv.	2,98E+02	-3,41E-03	7,53E+01	3,74E+02
Resource use, fossils	MJ	1,18E+04	2,04E+01	4,81E+02	1,23E+04
Resource use, mine-rals and metals	kg Sb eq	2,93E-03	6,24E-08	1,38E-05	2,94E-03

Potential environmental impacts resulting from the application of the EF 3.0 Method for the production of 1 ton of PC4 3-wire strand / P61 7-wire strand / P62 7-wire strand.

Impact Categories	Unit	A1	A2	A3	Total
Climate change	kg CO2 eq	5,79E+02	1,34E+00	2,87E+01	6,09E+02
Ozone depletion	kg CFC11 eq	6,18E-05	3,17E-07	1,50E-05	7,71E-05
Ionising radiation	kBq U-235 eq	1,18E+02	8,22E-02	3,38E+00	1,21E+02
Photochemical ozone formation	kg NMVOC eq	1,76E+00	4,45E-03	8,23E-02	1,84E+00
Particulate matter	disease inc.	2,54E-05	9,97E-08	1,20E-06	2,67E-05
Human toxicity, non-cancer	CTUh	6,30E-06	1,25E-08	6,99E-06	1,33E-05
Human toxicity, cancer	CTUh	3,17E-06	1,08E-10	7,75E-08	3,25E-06
Acidification	mol H+ eq	2,39E+00	4,64E-03	2,31E-01	2,63E+00
Eutrophication, fres-hwater	kg P eq	1,28E-02	6,83E-07	2,63E-03	1,54E-02
Eutrophication, marine	kg N eq	6,10E-01	1,48E-03	5,22E-02	6,63E-01
Eutrophication, terrestrial	mol N eq	5,97E+00	1,63E-02	2,93E-01	6,28E+00
Ecotoxicity, freshwater	CTUe	7,31E+03	7,67E+00	7,79E+02	8,10E+03
Land use	Pt	1,68E+03	5,08E-02	7,26E+02	2,41E+03
Water use	m3 depriv.	3,18E+02	-3,16E-03	9,18E+01	4,10E+02
Resource use, fossils	MJ	1,25E+04	1,89E+01	4,87E+02	1,30E+04
Resource use, mine-rals and metals	kg Sb eq	2,97E-03	5,79E-08	1,38E-05	2,98E-03

Potential environmental impacts resulting from the application of the EF 3.0 Method for the production of 1 ton of P63 sheathed strand.

Impact Categories	Unit	A1	A2	A3	Total
Climate change	kg CO2 eq	6,78E+02	1,89E+01	2,27E+02	9,24E+02
Ozone depletion	kg CFC11 eq	7,22E-05	4,49E-06	5,31E-05	1,30E-04
Ionising radiation	kBq U-235 eq	1,71E+02	1,16E+00	1,66E+01	1,89E+02
Photochemical ozone formation	kg NMVOC eq	1,98E+00	6,30E-02	1,66E+00	3,71E+00
Particulate matter	disease inc.	2,55E-05	1,41E-06	8,55E-06	3,55E-05
Human toxicity, non-cancer	CTUh	6,76E-06	1,77E-07	8,10E-06	1,50E-05
Human toxicity, cancer	CTUh	3,00E-06	1,53E-09	1,55E-07	3,16E-06
Acidification	mol H+ eq	2,88E+00	6,57E-02	1,03E+00	3,97E+00
Eutrophication, fres-hwater	kg P eq	1,50E-02	9,68E-06	6,36E-03	2,14E-02
Eutrophication, marine	kg N eq	6,84E-01	2,10E-02	1,82E-01	8,87E-01
Eutrophication, terrestrial	mol N eq	6,88E+00	2,31E-01	1,69E+00	8,81E+00
Ecotoxicity, freshwater	CTUe	8,17E+03	1,09E+02	2,70E+03	1,10E+04
Land use	Pt	2,41E+03	7,20E-01	2,06E+03	4,47E+03
Water use	m3 depriv.	4,26E+02	-4,48E-02	2,18E+02	6,45E+02
Resource use, fossils	MJ	1,64E+04	2,68E+02	7,98E+03	2,46E+04
Resource use, mine-rals and metals	kg Sb eq	2,81E-03	8,21E-07	9,40E-05	2,90E-03

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