Value Chain Analysis

CO2 Performance Ladder level 5 requirement

VEENIX EPCM

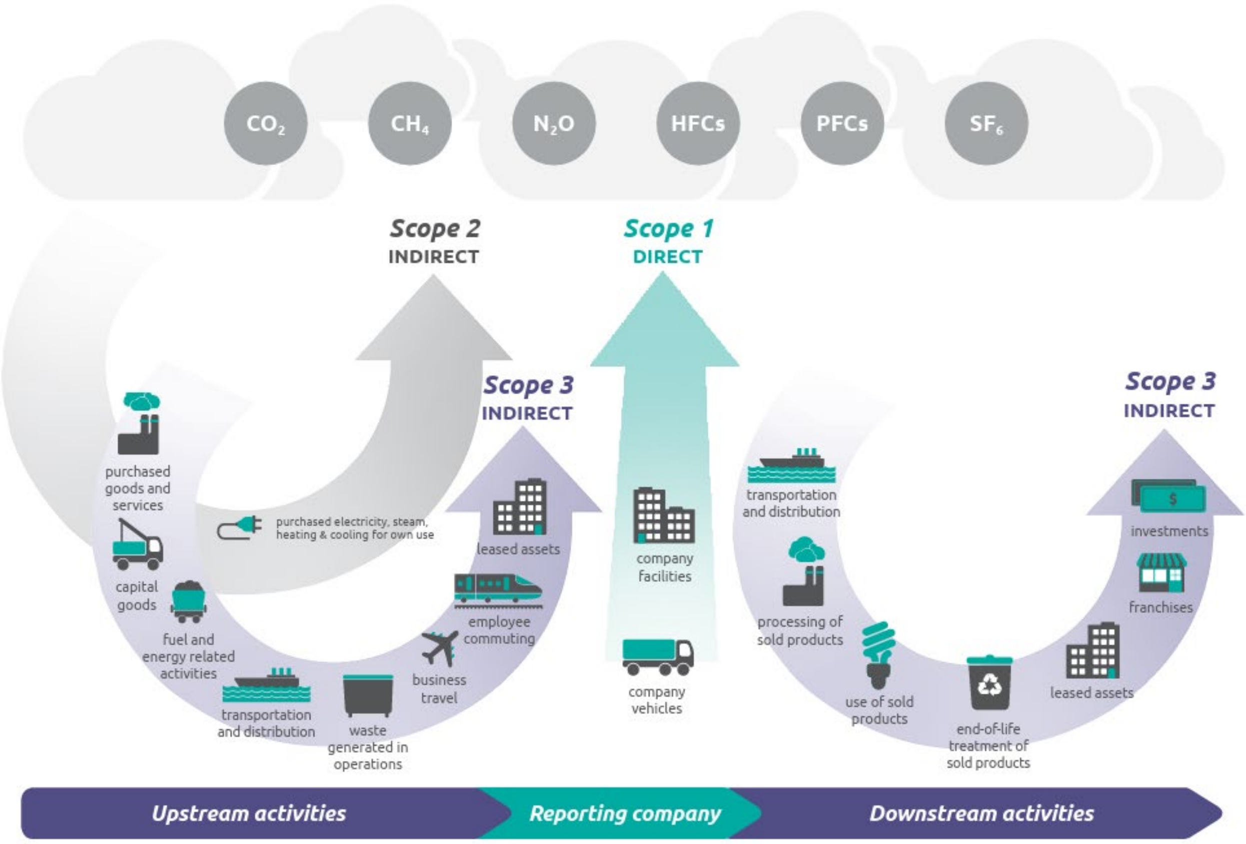
Table of Content

1 Introduction

1.1 What is a value chain analysis?

A value chain analysis is a way to assess every activity of a company or a project to understand the performance of each life cycle phase.

The value chain analysis of FCC Construcción NL is based on the GHG Protocol method Scope 3 Standard.



Regarding the GHG emissions in the value chain, a deep analysis of the activities of Scope 3 is carried out. The purpose of this scope 3 value chain analysis is to gain insight into the most material scope 3 emissions in tonnes of CO_2-eq (GWP) and where they occur in the chain. In order to identify effective opportunities to reduce scope 3 emissions and what so-called chain partners should be approached for this.

A value chain is defined as a certain line of supplying and purchasing companies and organisations. It represents a sequence of interconnected activities that contribute to the creation of a product or the delivery of a service. Value chain analysis is an analysis of CO2 emissions in one of the value chains that an organisation is active in. By understanding these emissions, companies can implement strategies to reduce their carbon footprint and enhance sustainability.

FCC Construcción NL has been considered a small company (base year 2020) up to 2024. Since 2025, the size of the organization is **medium**.

To comply with the CO2 performance ladder and to show the commitment and ambition, the company has executed three value chain analysis for the main materials, which are steel, asphalt and concrete.

1.2 Activities FCC Construcción SA (NL)

FCC Construcción, as per the KVK records, engages in general civil engineering and road construction. Their activities span a wide spectrum, including the design, planning, and execution of civil engineering projects. From constructing roads and bridges to managing infrastructure development, FCC Construcción plays a vital role in shaping our built environment. Their expertise contributes to the efficient transportation networks and essential infrastructure that underpin modern societies. By participating in these critical sectors, FCC Construcción demonstrates its commitment to enhancing connectivity, safety, and sustainable development.

The work by FCC Construcción S.A. (NL), VeenIX BaHo BV, contains study, contracting, construction, execution, management, maintenance and operation of all kinds of public or private works. FCC Construcción S.A. (NL) engages in thorough research and analysis.
They study the feasibility, environmental impact, and technical aspects of proposed projects. This initial phase lays the groundwork for informed decision-making.
As for the construction phase, FCC negotiates agreements with suppliers, subcontractors, and other stakeholders. This involves ensuring compliance with legal requirements, cost-effectiveness, and quality standards.

FCC Construcción S.A. (NL) is hands-on in the construction phase. They oversee the actual building process, coordinating various teams, materials, and equipment. Whether it's erecting buildings, bridges, or roads, their expertise ensures successful execution.
Effective project management is crucial. The company handles scheduling, resource allocation, risk mitigation, and quality control. Their skilled project managers keep everything on track.
Beyond construction, they take responsibility for the long-term well-being of the infrastructure. Maintenance involves regular inspections, repairs, and upgrades. Operation entails ensuring smooth functionality, whether it's a water treatment plant, a highway, or a public building.

In summary, FCC Construcción S.A. (NL) plays pivotal roles in shaping our built environment, from inception to ongoing operation. Their multifaceted contributions enhance our daily lives and drive sustainable development.

1.3 Main scope 3 activities

The value chain analysis encompasses several critical components. Firstly, it includes the procurement component, which involves discussions related to sourcing materials, services, and resources. Secondly, it covers materials processing, where raw materials are transformed into usable products. Lastly, transportation plays a pivotal role in moving goods efficiently within the value chain. All three components are integral to the work of FCC Construcción S.A. (NL) and are evident in the VeenIX BaHo A9 project.

FCC Construcción S.A. (NL) implements FCC Construcción S.A. materiality analysis to evaluate the scope 3 category emissions. For a construction company and its projects, the scope 3 category that has the main impact in GHG emissions is ***purchased goods and services.***

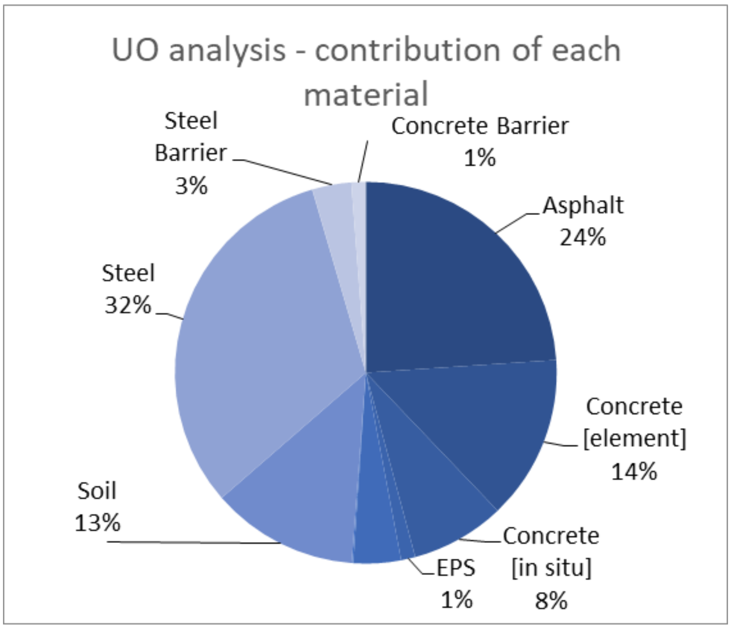
Scope *Based on GHG Protocol	Category *Based on ISO14064	Description	Status	Total CO2 emissions (ton)	Contribution to total Scope 3 emissions
Scope 1	Category 1	Direct emissions and removals	Relevant, calculated	2.528,25	3,5%
Scope 2	Category 2	Indirect emissions from imported electricity	Relevant, calculated	396,37	0,6%
Scope 3	Category 3	Employee Commuting (In-Itinere Travel)	Relevant, calculated	268,71	0,4%
Scope 3	Category 3	Business Travel	Relevant, calculated	59,76	0,1%
Scope 3	Category 3	Upstream Transportation	Relevant, calculated	6.504,32	9,0%
Scope 3	Category 4	Downstream Transportation	Not applicable to FCC Construcción	-	-
Scope 3	Category 4	Purchased Goods and Services	Relevant, calculated	62.211,71	86,4%
Scope 3	Category 3	Capital Goods	Not relevant	-	-
Scope 3	Category 4	Fuel- and Energy-Related Activities (not included in Scope 1 or 2)	Relevant, calculated	27,13	0,0%
Scope 3	Category 4	Waste Generated in Operations (Solid and Liquid Waste Disposal)	Relevant, calculated	21,72	0,0%
Scope 3	Category 3	Upstream Leased Assets	Not applicable to FCC Construcción	-	-
Scope 3	Category 4	Processing of Sold Products	Not applicable to FCC Construcción	-	-
Scope 3	Category 5	Use of Sold Products	Not applicable to FCC Construcción	-	-
Scope 3	Category 5	Downstream Leased Assets	Not applicable to FCC Construcción	-	-
Scope 3	Category 5	End-of-Life Treatment of Sold Products	Not applicable to FCC Construcción	-	-
Scope 3	Category 4	Franchises	Not applicable to FCC Construcción	-	-
Scope 3	Category 3	Investments	Not applicable to FCC Construcción	-	-
			Total	72.017,97	100%

1 Value chain of the A9 BaHo project

Focusing on the purchased goods and services category, an analysis of all the project's list of suppliers is done annually. Additionally, to accurately map CO_2 emissions, we identify key activities through the Work Breakdown Structure (WBS) and extract total material quantities from the Bill of Quantities (BoQ). This same approach is applied to calculate the Environmental Cost Indicator (MKI) by focusing on the most impactful materials.

This approach allows us to clearly determine which materials are most used in the project. As expected for a road construction project, asphalt, concrete, steel, and soil represent the most significant material groups.

The latest version of the MKI analysis brought the following results for the whole project:



As evidenced, there are four materials that represent 99% of the MKI, which also influences the carbon footprint of the project.

Additionally, when selecting the most impactful materials regarding CO2 emissions, FCC Construcción NL follows the methodology of FCC Construcción S.A., which carried out a materiality analysis, with the support of an external consultant, with the ultimate aim of improving the calculation of its carbon footprint and checking its response to the requirements of the UNE-EN ISO 14064-1:2019 Standard, in addition to the ENCORD priority categories, the proposed criteria of the Analysis being as follows:

Magnitude of emissions: those that are quantitatively substantial. It is established that it is significant and, therefore, necessary to include from 1%.
Level of influence on sources: the extent to which the organization has the capacity to monitor and reduce these emissions.
Access to information: ease of obtaining the data necessary for the calculation.
Data accuracy level.
Sector-specific guidelines: those emissions that are considered significant based on the guidelines of a business sector.

A more detailed analysis of asphalt, steel, and concrete is made, as these are the most impactful materials in terms of CO_2 emissions.

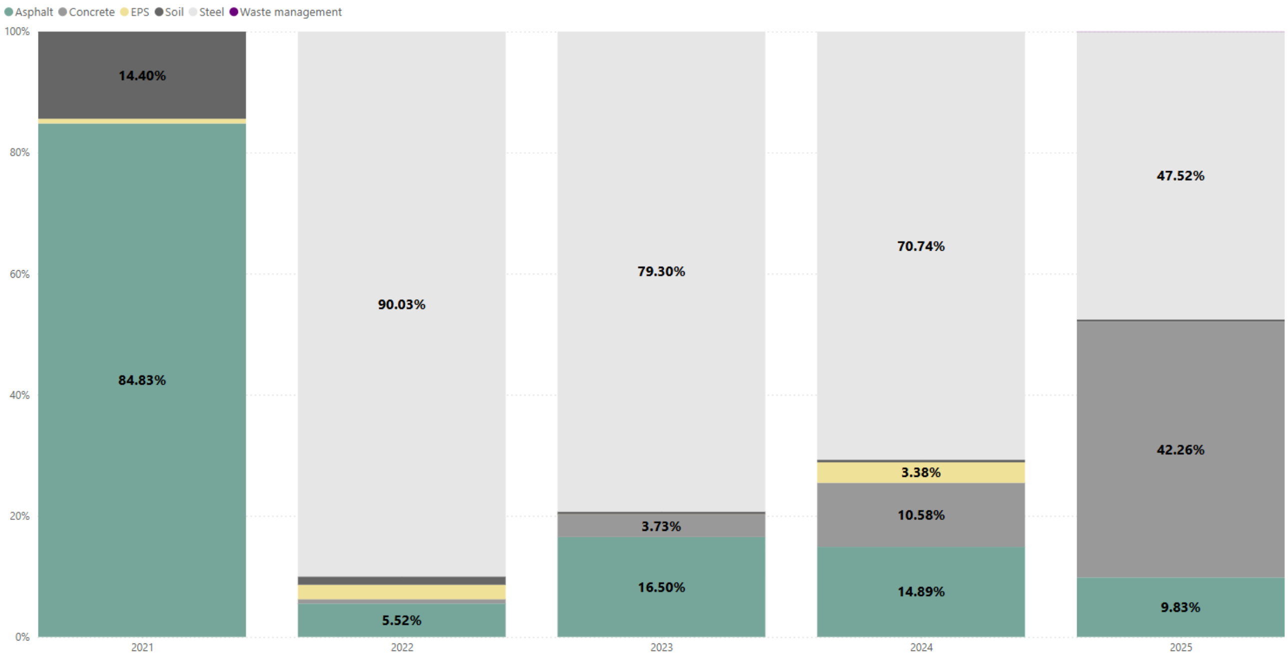
2 Scope 3 emissions and subject analyses

In accordance with the guidelines in the GHG protocol and the CO_2 Performance Ladder Handbook 3.1, the analysis of scope 3 was carried out on the basis of an analysis of 15 categories. Subsequently, the choice of the value chain is based on an identification of the most material scope 3 emissions done in Scope 3 Dominance Analysis document.

2.1 Choice for the value chain analysis

The VeenIX A9BAHO project is a large infrastructure construction project that is the entire scope of FCC Construcción (NL). Therefore, the majority of the project's emissions are related to upstream scope 3 activities, which are related to the purchasing of goods, capital goods, fuel and energy related activities and transportation.

To effectively address the project's emissions, we analysed the impact of each material individually. The relevance of materials varies depending on the construction phase.



Initially, preliminary works such as earthworks and paving the temporary roads were the primary activities. Subsequently, foundation activities for the structures commenced, such as the temporary retaining walls, involving sheet piles, anchors, and piles. In 2025, in situ concrete and reinforcement steel have become the most significant materials as they are used in mainly in the compression layers of the structures and the concrete parts in the Deep cut.

The decision of which materials are object to have a value chain analysis are the ones with more impact in the project.

3 Value chain analysis – Steel

3.1 Introduction

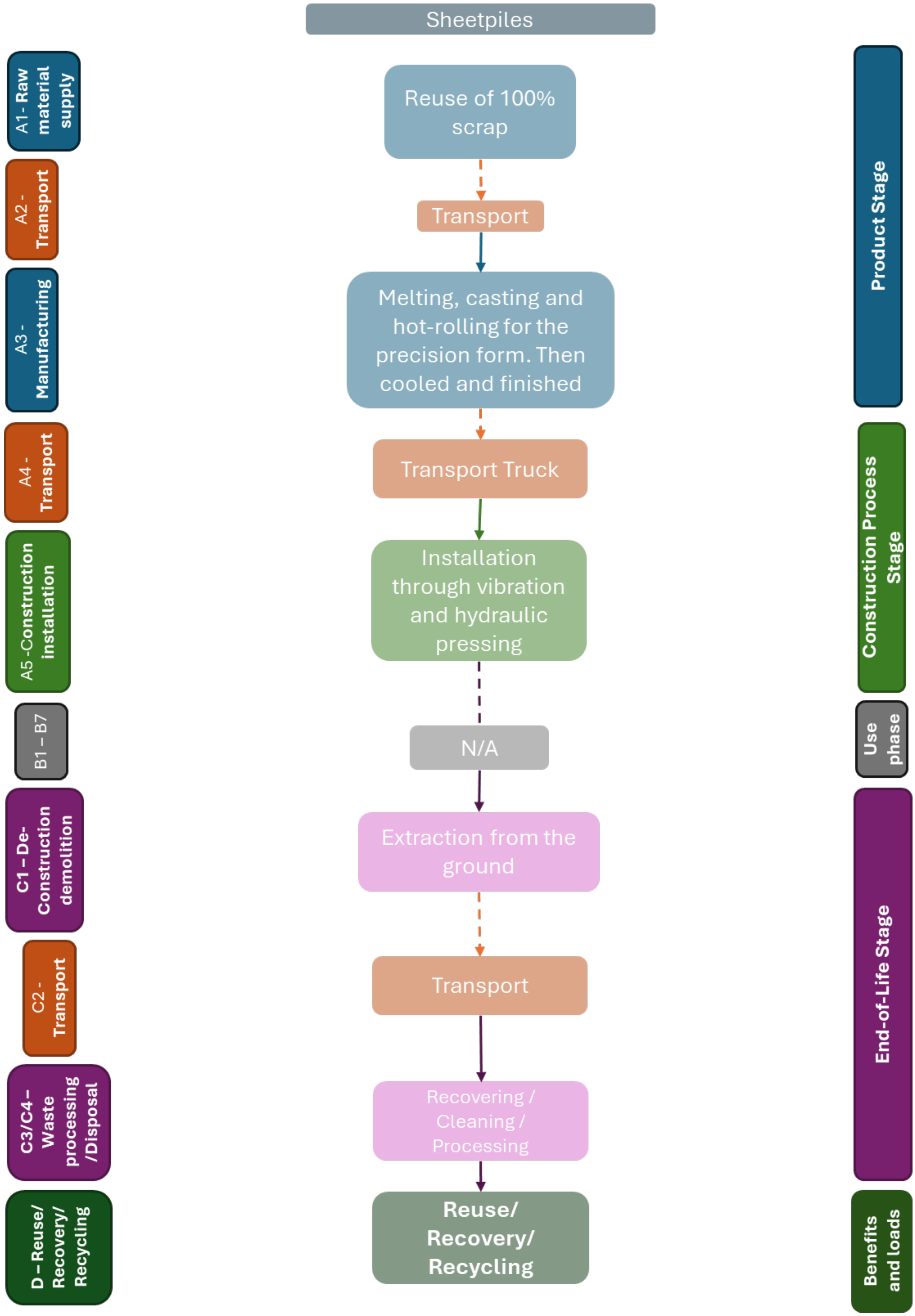
This Value Chain Analysis focuses on the steel products used in the A9 BaHo project, specifically sheet piles (new, reused, temporary) and reinforcement steel. The analysis is based on the Life Cycle Assessment (LCA) prepared by VeenIX and follows the SBK Bepalingsmethode 3.0 and EN15804. The functional unit is 1 ton of steel. The system boundaries include modules A1–A5, B1–B5, C1–C4 and D, covering raw material extraction, steel production, transport, installation, use, end-of-life and recycling/reuse potential.

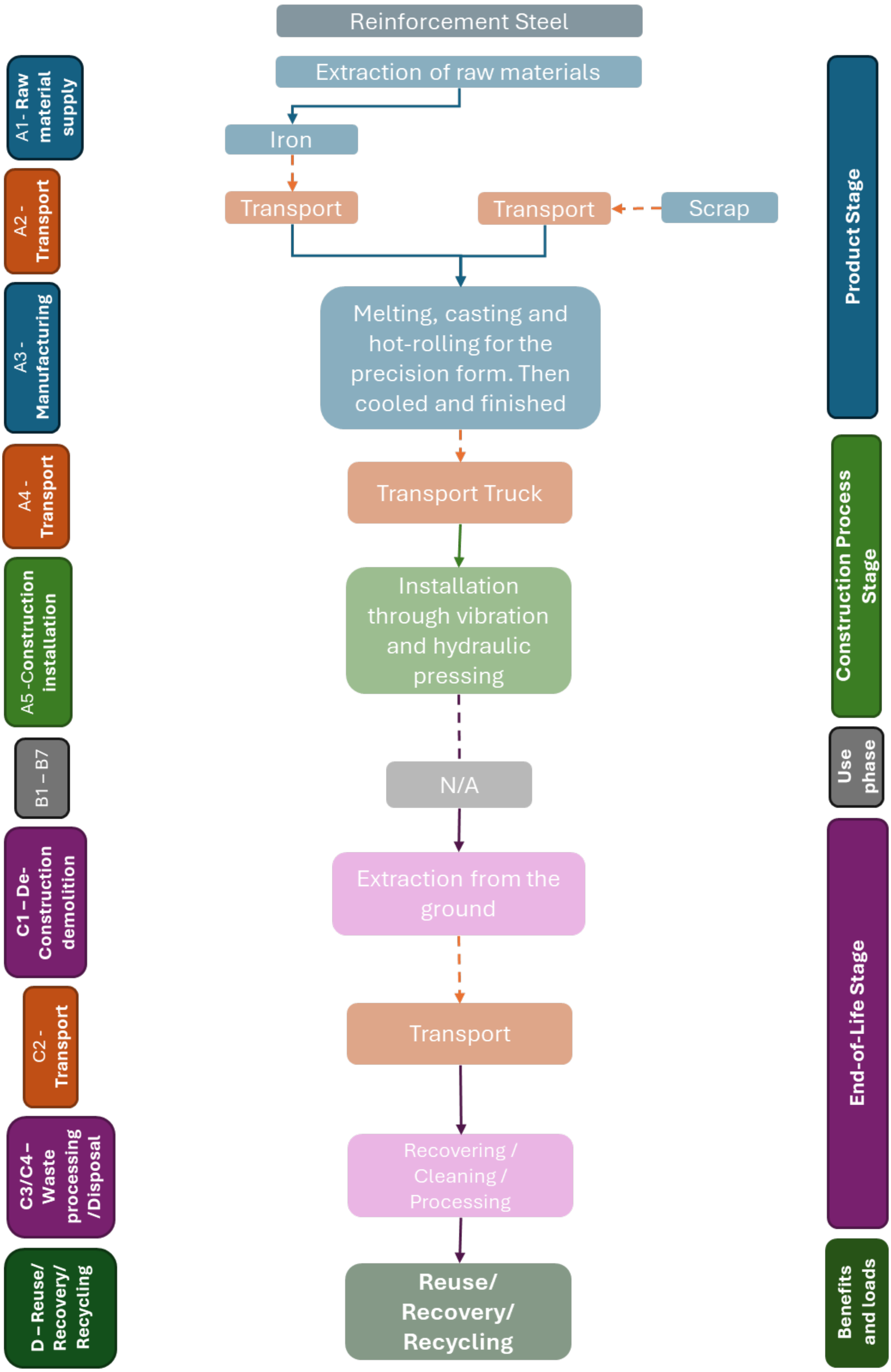
3.2 Value Chain description

Steel sheet piles (EcoSheetPiles™) and reinforcement steel are produced primarily from scrap steel via electric arc furnace (EAF) technology. Sheet piles are produced by ArcelorMittal in Luxembourg, while reinforcement steel is produced in the Netherlands by VWN-certified manufacturers. The value chain includes raw material sourcing, melting and rolling processes, transport to site, installation using heavy machinery, and finally dismantling, recycling and reuse scenarios.

- Scrap steel collection and preparation (A1).
- Melting in EAF and hot rolling into sheet piles or reinforcement bars (A2–A3).
- Transport to the A9 BaHo site by road and inland waterways (A4).
- Installation using piling rigs, cranes and handling equipment (A5).
- No activities during use phase (B1–B5).
- Demolition, extraction, transport and recycling (C1–C4).
- Recycling and reuse credits for secondary steel (D).

Below is the process diagram which describes which processes take place at each stage of the LCA for Sheetpiles and Reinforcement steel.


Sheetpiles
A1- Raw material supply
A2 - Transport
A3 - Manufacturing
A4 - Transport
A5 -Construction installation
B1 – B7
C1 – De-Construction demolition
C2 - Transport
C3/C4 – Waste processing /Disposal
D – Reuse/ Recovery/ Recycling
Reuse of 100% scrap
Transport
Melting, casting and hot-rolling for the precision form. Then cooled and finished
Transport Truck
Installation through vibration and hydraulic pressing
N/A
Extraction from the ground
Transport
Recovering / Cleaning / Processing
Reuse/ Recovery/ Recycling
Product Stage
Construction Process Stage
Use phase
End-of-Life Stage
Benefits and loads


Reinforcement Steel
Extraction of raw materials
Iron
Transport
Transport
Scrap
Melting, casting and hot-rolling for the precision form. Then cooled and finished
Transport Truck
Installation through vibration and hydraulic pressing
N/A
Extraction from the ground
Transport
Recovering / Cleaning / Processing
Reuse/ Recovery/ Recycling
A1 - Raw material supply
A2 - Transport
A3 - Manufacturing
A4 - Transport
A5 -Construction installation
B1 – B7
C1 – De-Construction demolition
C2 - Transport
C3/C4 – Waste processing /Disposal
D – Reuse/ Recovery/ Recycling
Product Stage
Construction Process Stage
Use phase
End-of-Life Stage
Benefits and loads

3.3 Quantitative analysis of scope 3 emissions

This chapter analyses the environmental impacts of sheet piles and reinforcement steel by describing phase contributions, key emission drivers and mixture/category differences.

Phase contributions (A1–D):
- A1–A3: Dominant phase for new steel, driven by electricity consumption in EAF, alloying and hot rolling.
- Reused sheet piles have no A1–A3 impact, significantly lowering total footprint.
- A4: Transport contributes CO2 emissions depending on transport mode and distance; sheet piles arrive via mixed truck and barge transport.
- A5: Installation impacts arise from diesel consumption of piling equipment; approx. 470 MJ/ton.
- C1–C4: Demolition and sorting contribute moderately; 51% of sheet piles are recycled, 49% reused.
- D: Module D provides large negative credits for steel recycling, especially for reinforcement steel (up to 26.7 € MKI/ton).

Global Warming Potential (GWP) ranges widely:
New sheet piles approx. 748 kg CO2-eq/ton;
reused sheet piles approx. 71 kg CO2-eq/ton;
Reinforcement steel approx. 900 kg CO2-eq/ton.

The emissions per phase of the life cycle in kg CO2 eq for category global warming GWP, are the following.

Product	Totaal	A1	A4	A5	C1	C2	C3	C4	D
New Sheetpiles	**7,48E+02**	4,27E+02	3,51E+01	5,62E+01	4,34E+01	4,22E+00	1,67E+01	8,01E-01	1,64E+02
Reused Sheetpiles	**7,17E+01**	0,00E+00	7,38E+00	4,43E+01	0,00E+00	6,58E+00	1,35E+01	0,00E+00	0,00E+00
Temporary sheetpiles	**1,52E+02**	4,27E+02	3,21E+01	5,62E+01	4,34E+01	6,58E+00	1,35E+01	0,00E+00	-4,27E+02
Reinforce-ment steel	**1,52E+02**	4,27E+02	3,21E+01	5,62E+01	4,34E+01	6,58E+00	1,35E+01	0,00E+00	-4,27E+02

3.4 Value chain partners

The value chain for sheet piles and reinforcement steel in the A9 BaHo project involves several key partners whose coordinated actions are essential to achieving further environmental impact reductions.

Upstream, steel producers play a central role: ArcelorMittal supplies the sheet piles, manufactured predominantly from scrap steel using electric arc furnaces, while members of the Vereniging Wapeningsstaal Nederland (VWN) produce reinforcement steel with a high recycled content. These producers strongly influence the life-cycle impacts, as the LCA shows that the product stage (A1–A3) is the dominant contributor to global warming and MKI scores.

Transport partners are responsible for moving materials from production and storage locations to the construction site, where logistics choices (transport modes, distances, and vehicle standards such as Euro 6 trucks and inland shipping) directly affect emissions. At the construction stage, FCC Construcción and its subcontractors (including installation specialists such as TerraFirm) determine impacts related to material efficiency, loss rates, and machinery fuel use during installation and deconstruction (A5 and C1).

Downstream, demolition contractors, recyclers, and reuse markets enable high recycling and reuse rates at end of life, which generate substantial benefits in Module D, particularly for sheet piles.

3.5 Implementation of GHG emissions reduction measures

The A9 BaHo project implements several reduction measures: use of high recycled-content steel (EcoSheetPiles™), maximising reuse of sheet piles (up to 100% reused), and ensuring high end-of-life recycling rates (51% recycling, 49% reuse for sheet piles; 95% recycling for reinforcement steel). Euro 6 trucks reduce transport emissions, while efficient piling equipment lowers fuel consumption. Closer collaboration across the value chain—such as aligning design choices with reuse potential, coordinating logistics to maximise low-carbon transport, sharing data on material losses, and developing take-back or reuse agreements with steel suppliers and recyclers—offers clear opportunities to further reduce environmental impacts beyond those already captured in the LCA. Together, these measures significantly reduce the scope 3 footprint of steel materials within the project.

4 Value chain analysis - Asphalt

4.1 Introduction

This Value Chain Analysis focuses on the **asphalt** used in the A9 BaHo project. This value chain is based on the Life Cycle Assessment (LCA) of the asphalt mixtures implemented in the project elaborated by VeenIX. The assessment includes the cradle-to-grave environmental impacts of asphalt mixtures, including ZOAB, AC bin base16, AC bin base 22, SMA and others.

The functional unit evaluated is 1 ton of asphalt.

The system boundaries follow modules A1–A5, B1–B5, C1–C4 and D, covering raw material extraction, manufacturing, transport, installation, use, end-of-life and recycling potential.

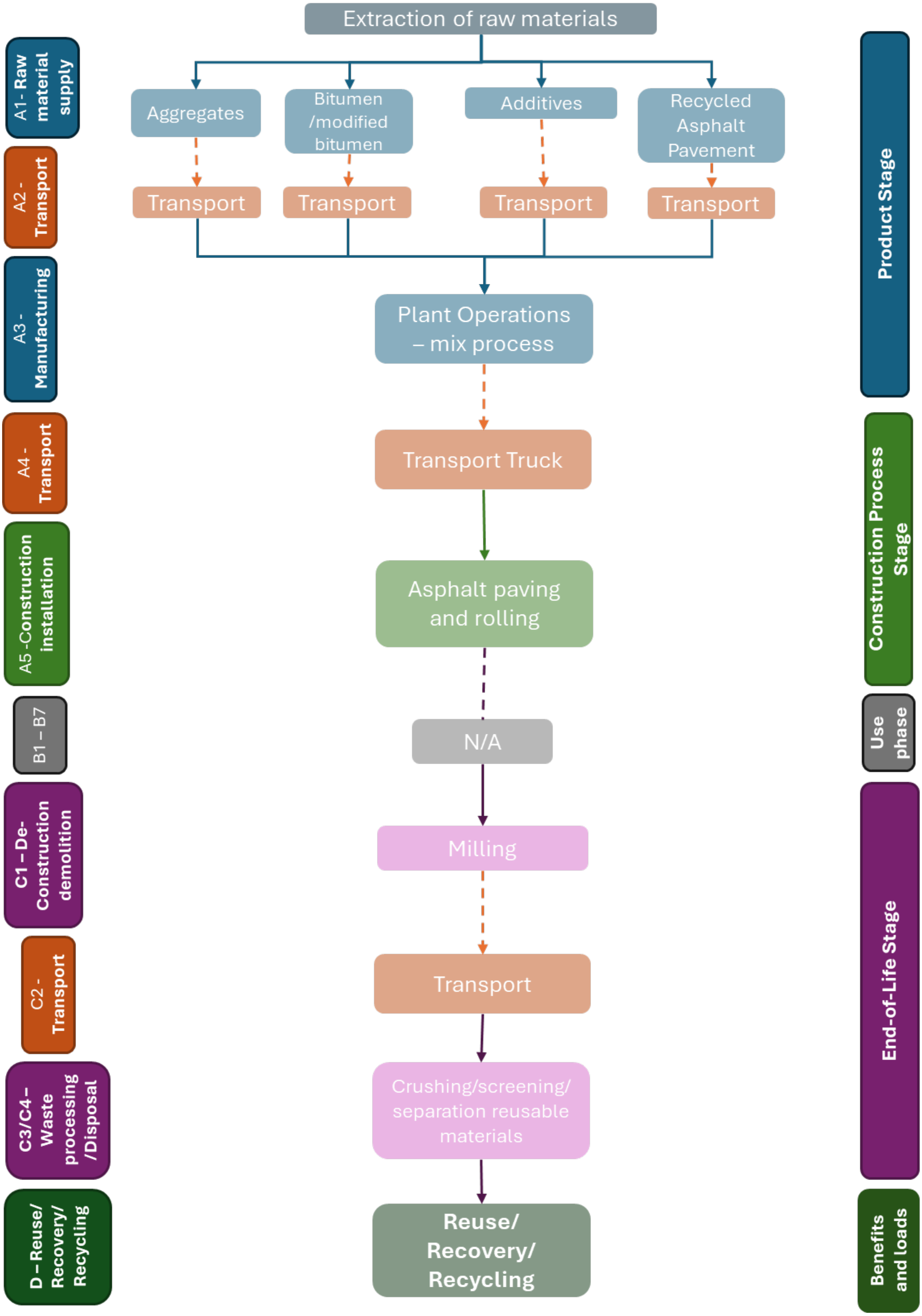
4.2 Value Chain description

Raw materials, including aggregates and bitumen, are transported to the Heijmans asphalt production plant in the industrial zone near Amsterdam. At the plant, aggregates are first dried and heated to remove moisture, while bitumen is maintained at the required temperature. These materials are then fed into a mixing system where they are combined under controlled conditions to produce asphalt mixtures tailored to project specifications.

The asphalt value chain includes:

- Extraction of aggregates and bitumen, including processing and energy-intensive heating steps (A1).
- Transport of raw materials to the production plants from Heijmans (A2).
- Manufacturing of asphalt mixtures with 30–70% RAP content depending on layer type (A3).
- Hot transport to construction site and paving/compaction operations (A4–A5).
- Limited maintenance during the use phase (B1–B5).
- Milling, transport, waste handling and recycling at end-of-life (C1–C4), with recovery credits modelled in Module D.

Below is the process diagram which describes which processes take place at each stage of the LCA.


Extraction of raw materials
Aggregates
Bitumen /modified bitumen
Additives
Recycled Asphalt Pavement
Transport
Transport
Transport
Transport
Plant Operations – mix process
Transport Truck
Asphalt paving and rolling
N/A
Milling
Transport
Crushing/screening/ separation reusable materials
Reuse/ Recovery/ Recycling
A1- Raw material supply
A2 - Transport
A3 - Manufacturing
A4 - Transport
A5 -Construction installation
B1 – B7
C1 – De-Construction demolition
C2 - Transport
C3/C4 – Waste processing /Disposal
D – Reuse/ Recovery/ Recycling
Product Stage
Construction Process Stage
Use phase
End-of-Life Stage
Benefits and loads

4.3 Quantitative analysis of scope 3 emissions

This chapter expands the quantitative analysis by describing impacts per life cycle phase, identifying emission drivers, and comparing mixture categories. The analysis uses MKI values, greenhouse gas emissions, and toxicity/energy indicators as provided in the LCA.

Phase Contributions (A1–D)

- A1–A3 (Raw material supply + production): This phase dominates environmental impact for all mixtures. The LCA shows that these modules generate the highest contributions to Global Warming Potential (GWP), Human Toxicity (HT) and Acidification Potential (AP). Heating and drying of aggregates and production of bitumen are the main emission sources.
- A4 (Transport to site): Although less dominant than A1–A3, transport contributes significantly due to heavy truck payloads and multiple delivery cycles. Impacts vary by mixture based on density and required volumes.
- A5 (Installation): Energy use from paving and compaction contributes to AP and POCP but is comparatively smaller. Surface courses such as SMA and ZOAB show slightly higher A5 impacts than base layers.
- B1–B5 (Use and maintenance): Mixtures such as AC base layers with long lifetimes (up to 60 years) show very low annualised environmental impact. ZOAB variants require more frequent replacement (10–14 years), increasing long-term impact.
- C1–C4 (End of life): Emissions arise from milling and transport. However, high recovery rates reduce contributions in C3 and C4.
- D (Recycling credit): Module D consistently gives negative values, reflecting the environmental benefit of RAP reintroduction into new asphalt mixtures. ZOAB and AC base layers show the highest recycling potential.

Global Warming Potential (GWP)

GWP across mixtures ranges from ~33 kg CO2-eq/ton (AC 16/22 base layers) up to ~90 kg CO2-eq/ton (ZOAB toplayer). Surface layers and porous asphalt show higher GWP because of more bitumen use and additional processing.

Drivers of GWP include:
- Bitumen production (petroleum-derived)
- Aggregate heating (energy intensive)
- Transport distances for raw material supply
- Lower RAP content increases emissions

The emissions per phase of the life cycle in kg CO2 eq for category global warming GWP, are the following.

Product	Totaal	A1-3	A4	A5	B1	B2-5	C1	C2	C3	C4	D
2L-ZOAB toplaag	8,60E+01	1,04E+02	1,44E+00	8,81E-01	0,00E+00	0,00E+00	1,86E+00	1,44E+00	0,00E+00	0,00E+00	-2,36E+01
ZOAB Regulier	6,84E+01	8,19E+01	3,72E+00	1,07E+00	0,00E+00	0,00E+00	3,40E+00	3,72E+00	0,00E+00	0,00E+00	-2,54E+01
2L-ZOAB 16	6,22E+01	7,74E+01	3,72E+00	8,81E-01	0,00E+00	0,00E+00	1,86E+00	3,72E+00	0,00E+00	0,00E+00	-2,54E+01
AC 11 surf	5,53E+01	6,73E+01	3,72E+00	1,92E+00	0,00E+00	0,00E+00	1,14E+00	3,72E+00	0,00E+00	0,00E+00	-2,25E+01
SMA	6,41E+01	8,58E+01	3,72E+00	1,92E+00	0,00E+00	0,00E+00	1,14E+00	3,72E+00	0,00E+00	0,00E+00	-3,22E+01
AC 16 surf	5,37E+01	6,57E+01	3,72E+00	1,92E+00	0,00E+00	0,00E+00	1,14E+00	3,72E+00	0,00E+00	0,00E+00	-2,25E+01
AC 16 Bin/Base	3,33E+01	3,17E+01	3,72E+00	1,07E+00	0,00E+00	0,00E+00	3,40E+00	3,72E+00	0,00E+00	0,00E+00	-1,03E+01
AC 16 Bin/Base	4,31E+01	5,53E+01	3,72E+00	1,07E+00	0,00E+00	0,00E+00	3,40E+00	3,72E+00	0,00E+00	0,00E+00	-2,41E+01
AC 16 Bin/Base	3,43E+01	3,62E+01	3,72E+00	1,07E+00	0,00E+00	0,00E+00	3,40E+00	3,72E+00	0,00E+00	0,00E+00	-1,38E+01
AC 22 Bin/Base	3,31E+01	3,15E+01	3,72E+00	1,07E+00	0,00E+00	0,00E+00	3,40E+00	3,72E+00	0,00E+00	0,00E+00	-1,03E+01
AC 22 Bin/Base	3,40E+01	3,59E+01	3,72E+00	1,07E+00	0,00E+00	0,00E+00	3,40E+00	3,72E+00	0,00E+00	0,00E+00	-1,38E+01
AC 22 Bin/Base	3,56E+01	3,75E+01	3,72E+00	1,07E+00	0,00E+00	0,00E+00	3,40E+00	3,72E+00	0,00E+00	0,00E+00	-1,38E+01

4.4 Value partners

The asphalt value chain for the A9 BaHo project involves several partners whose coordinated actions directly influence the environmental performance of the final product.

Heijmans, as the primary asphalt producer, plays a central role by sourcing raw materials, operating the production plants and determining the recipes, energy use, and recycled content of the mixtures used throughout the project. Their decisions regarding the incorporation of RAP (Recycled Asphalt Pavement) and the optimization of production processes represent one of the largest opportunities for environmental impact reduction.

Material suppliers, including aggregate producers and bitumen providers, influence upstream emissions through their extraction methods, material specifications, and transport distances.

Transport partners move both raw materials to the plant and finished asphalt to the construction site; they are critical to reducing emissions in modules A2 and A4, especially through route optimization, cleaner fuels, and efficient scheduling.

Construction teams have their impacts in modules A5 through on-site fuel consumption, installation practices, and adherence to quality requirements that influence pavement longevity.

Finally, recycling and end-of-life partners manage milling, material recovery, and reintegration of reclaimed asphalt into new mixtures, directly affecting the benefits captured in module D and the circularity of the system.

To achieve higher emission reductions, partners can collaborate in several ways: producers and suppliers can jointly explore higher-RAP formulations that still meet performance specifications; transporters and construction teams can synchronize logistics to minimize idle times and avoid unnecessary trips; producers can share real-time production data with construction teams to optimize paving temperatures and reduce energy use; and plant operators, recyclers, and designers can co-develop circular strategies that maximize the value and usability of reclaimed asphalt in future mixes.

4.5 Implementation of GHG emissions reduction measures

In the A9 BaHo project, several concrete measures have already been implemented to reduce greenhouse gas emissions associated with asphalt. A major achievement is the reuse of approximately 190,000 tons of asphalt, significantly lowering demand for virgin aggregates and bitumen while maximising the recycling benefits reflected in Module D of the LCA. This approach directly contributes to Scope 3 reductions by avoiding emissions linked to raw material extraction and processing.

5 Value chain Analysis - Concrete

5.1 Introduction

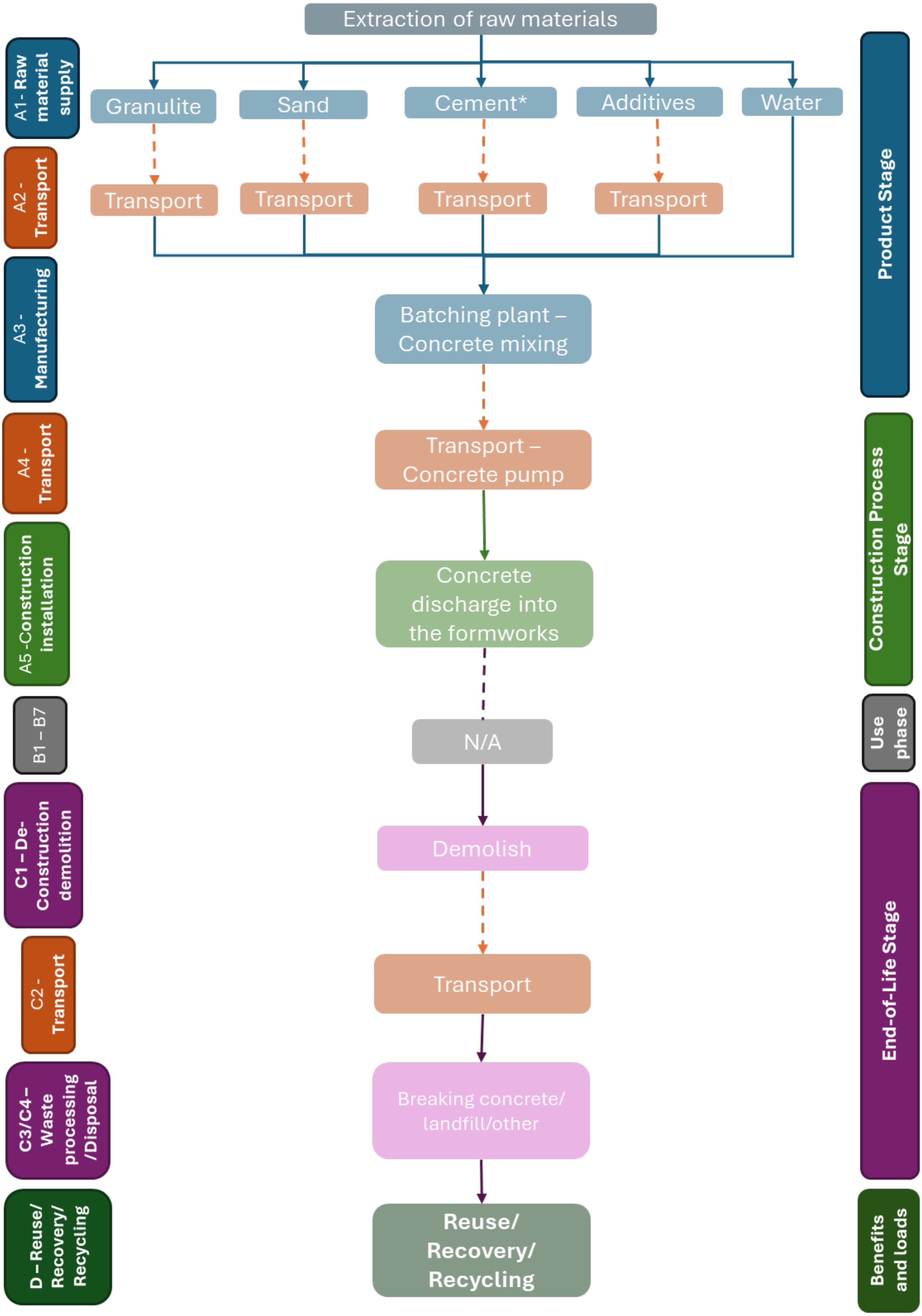
This Value Chain Analysis focuses on the in-situ concrete used in the A9 BaHo project. The analysis is based on the Life Cycle Assessment (LCA) elaborated by VeenIX, covering the cradle-to-grave environmental impacts of the main concrete mixtures applied in civil structures, including types 025-X0-2-32RV600, M37-XD3-16F4, S45-XF4-I-II-16F4 and S55-XF4-V-II-32F5. The functional unit evaluated is 1 m^3 of concrete. The system boundaries follow modules A1–A5, B1–B5, C1–C4 and D, covering raw material extraction, manufacturing, transport, installation, use, end-of-life and recycling potential.

5.2 Value chain description

Raw materials—including cement (CEM III/B 42.5 N), granite aggregates, sand, fly ash, water and superplasticisers—are transported to the Kijlstra concrete plant in the Amsterdam harbour. At the plant, materials are batched and mixed to produce high-performance in-situ concrete mixtures tailored to the structural requirements of the A9 BaHo project. The fresh concrete is then delivered using hybrid truck mixers and placed using concrete pumps and hydraulic diggers. After curing, the concrete forms the structural components of the project. During use, concrete requires no maintenance. At end-of-life, it is demolished, transported and processed, with 99% recycled as granulate and 1% landfilled.

- Extraction and processing of cement, aggregates, fly ash and admixtures (A1).
- Transport of raw materials to the Kijlstra concrete plant (A2).
- Batching, mixing and energy use at the plant (A3).
- Hybrid truck mixer transport and discharge at site, including pumping (A4–A5).
- No operational activities during use phase (B1–B5).
- Demolition, loading, transport and processing of concrete (C1–C4), with 99% recycled into granulates and 1% landfilled (D).

Below is the process diagram which describes which processes take place at each stage of the LCA.


Extraction of raw materials
Granulite
Sand
Cement*
Additives
Water
Transport
Transport
Transport
Transport
Batching plant – Concrete mixing
Transport – Concrete pump
Concrete discharge into the formworks
N/A
Demolish
Transport
Breaking concrete/ landfill/other
Reuse/ Recovery/ Recycling
A1- Raw material supply
A2 - Transport
A3 - Manufacturing
A4 - Transport
A5 -Construction installation
B1 – B7
C1 – De-Construction demolition
C2 - Transport
C3/C4 – Waste processing /Disposal
D – Reuse/ Recovery/ Recycling
Product Stage
Construction Process Stage
Use phase
End-of-Life Stage
Benefits and loads

5.3 Quantitative analysis of scope 3 emissions

This chapter expands the quantitative analysis by describing impacts per life cycle phase, identifying emission drivers and comparing mixture categories. The analysis uses MKI values, greenhouse gas emissions, and toxicity and energy indicators as reported in the LCA.

Phase Contributions (A1–D):

- A1–A3 (Raw material supply + production): This phase dominates environmental impact for all mixtures. Cement production and aggregate extraction generate the majority of Global Warming Potential (GWP), Human Toxicity (HT) and Acidification (AP).
- A4 (Transport to site): Hybrid truck mixers contribute to emissions mainly through diesel use. Variations depend on density and batching volumes.
- A5 (Installation): Concrete pumping and compaction create impacts in AP and POCP but remain considerably smaller than A1–A3.
- B1–B5 (Use and maintenance): Concrete structures require no maintenance, resulting in negligible environmental impact during the use phase.
- C1–C4 (End of life): Emissions arise from demolition and transport. High recycling rates reduce burdens in C3 and C4.
- D (Recycling credit): Module D consistently results in negative values, reflecting avoided impacts by delivering recycled granulate to substitute virgin gravel.

Global Warming Potential (GWP) across mixtures ranges from approximately 166–188 kg CO2-eq/m³, with higher values in mixtures with increased cement content (e.g., S55-XF4-V-II-32F5). GWP is primarily driven by cement production, aggregate processing, transport distances and electricity and gas consumption at the concrete plant. Lower fly-ash substitution ratios increase emissions.

The emissions per phase of the life cycle in kg CO2 eq for category global warming GWP, are the following.

Product	Totaal	A1-A3	A4	A5	C1	C2	C3	C4	D
025-X0-2-32RV600	**1,66E+02**	1,19E+02	3,99E+00	1,42E+01	2,04E+01	1,54E+01	3,66E+00	1,24E-01	-1,06E+01
M37-XD3-16F4	**1,72E+02**	1,24E+02	3,99E+00	1,45E+01	2,04E+01	1,55E+01	3,68E+00	1,24E-01	-1,07E+01
S45-XF4-I-II-16F4	**1,76E+02**	1,28E+02	3,99E+00	1,47E+01	2,04E+01	1,57E+01	3,73E+00	1,26E-01	-1,08E+01
S55-XF4-V-II-32F5	**1,88E+02**	1,39E+02	3,99E+00	1,52E+01	2,04E+01	1,56E+01	3,70E+00	1,25E-01	-1,07E+01

5.4 Value chain partners

The value chain for in-situ concrete in the A9 BaHo project involves multiple partners, each influencing different phases of the environmental footprint across the life cycle. Upstream, raw material suppliers—including producers of CEM III/B cement, granite aggregates, industry sand, and additives such as superplasticisers and fly ash—play a decisive role, as the LCA shows that A1 (raw materials) is by far the most impactful phase for all mixtures, contributing substantially to global warming, human toxicity, and acidification due to energy-intensive extraction and processing of cement and aggregates. The concrete producer Kijlstra acts as a central manufacturing partner, responsible for batching, mixing, and quality control at their Amsterdam plant; their process and energy inputs (electricity, natural gas, and minor diesel use) determine module A3 impacts. Transport partners, specifically the providers of hybrid truck mixers, influence emissions in A4 through both diesel and electricity consumption, while ZHBC, responsible for the concrete pumps, is a key partner at the construction stage (A5), where pumping, compacting, and formwork preparation add additional energy use and fuel consumption. At end-of-life, demolition contractors and recycling facilities contribute significantly to the overall reduction potential, given that 99% of concrete is assumed to be recycled according to the mandated end-of-life scenario, generating meaningful benefits in module D.

Opportunities for improvement arise among these partners. Upstream suppliers and Kijlstra could work together on increasing the use of low-carbon binders, optimizing mix designs, and reducing transport distances of heavy raw materials. Logistics partners can further reduce impacts by increasing the share of electric driving in hybrid mixers or optimizing delivery schedules to reduce idling and inefficiencies. On-site partners can minimize losses, optimize pumping operations, and coordinate formwork and installation activities to lower fuel consumption in A5. Finally, closer collaboration with demolition and recycling partners could strengthen circularity strategies, by maximizing recovery of high-quality granulate or exploring selective demolition techniques. Aligning all value chain actors behind shared reduction targets offers strong potential to further reduce the environmental burden of concrete beyond what is shown in the LCA.

5.5 Implementation of GHG emissions reduction measures

Several measures have been implemented within the A9 BaHo project to reduce greenhouse gas emissions associated with concrete. The use of CEM III/B cement significantly lowers CO_2 emissions due to its higher slag content, reducing clinker demand. Additionally, hybrid truck mixers decrease diesel use by operating the mixer drum electrically.

Another initiative implemented was the S*ustainable Concrete pilot,* which was a project to prove the behavior and feasibility of recycled sand and granulite generated by the demolition granulate extracted from existing constructions KW007 and KW009 and applied back into the structures as concrete. The demolitions of these structures gave the opportunity to the project to select suitable granulate that could be reused in new concrete. More information can be found in the *Sustainable Measures Catalogue 2025* of the project and in the CO2 Management Plan.