BUILDING MATERIALS

LCA FROM CRADLE TO GATE
FOR TWO FLOORS WITH DIFFERENT VCT

SUMMARY

This Life Cycle Assessment (LCA) focuses on two types of solid floor structures, where one has a water-cement ratio (VCT) of 0.4 and the other of 0.5. The study is limited to modules A1 to A4 (A1-A4), which means that the analysis covers from raw material extraction to factory gate (cradle to gate). By carefully presenting concrete recipes, flow charts, specific reference flows and comparative results, it is identified which of the floor structures has the greatest climate impact. In this study, the impact is quantified solely through emissions of greenhouse gases, expressed in carbon dioxide equivalents. The results show that both floor structures with specific vct have a significantly lower climate impact than the generic values from the National Board of Housing, Building and Planning's climate database. At the same time, a marked difference emerges between the floor structures, where the floor structure with vct 0.4 has a higher climate impact than the floor structure with vct 0.5. The main reason for this difference is the amount of cement – the floor structure with VCT 0.4 contains more cement, which contributes to the increased climate impact.

TABLE OF CONTENTS

1. INTRODUCTION

The climate impact of the production of load-bearing building elements is a topic of great relevance in today's society, where most actors and institutions conduct studies in the field. Floor structures are the structural element that separates two floors and function as an essential load-bearing component in buildings. Dimensions and material choices for floor structures are not standardized, but are adapted to the requirements of the current construction and the client's specifications. Wooden floors and concrete floors are among the most common types.

For concrete floors, the water-cement ratio (vct) often varies, which is defined as the ratio of the mass of water to cement in the concrete mix. This ratio greatly affects the properties of the concrete – a lower VCT generally means higher strength and improved durability. Concrete slabs also contain reinforcement to meet the tensile strength requirements that the concrete itself does not meet.

The purpose of this report is to carry out a life cycle assessment (LCA) of two concrete slabs with a reinforcement percentage of 0.15% and different vct values, one with vct 0.4 and one with vct 0.5. The analysis covers the entire process from raw material extraction to finished product, with the intention of investigating which floor structure gives the best rise to the greatest climate impact and which life cycle phases contribute the most and which life cycle phases contribute the most and the least. The focus is on emissions of carbon dioxide equivalents, which constitute a collective unit of measurement for the impact of several greenhouse gases on the climate.

2. METHOD

LCA was used as a method. An LCA is often done in four steps:

I. Define goals and scope. Here you should think about what questions you want to ask and how you want to use the results you get. Among other things, it is decided which life cycle stages are to be included, which components are to be included in the analysis, how much of the resource compilation is to be included, specify the functional unit in a way that is in harmony with the purpose of the analysis, determine system boundaries (how the LCA calculation is to be delimited) so that it does not become too extensive. Then time limits need to be made, where the analysis period must correspond to the material or the entire life of the building. Geographical delimitations also need to be made, as the data must be representative of the Swedish market.

II. Inventory. Here, data is collected on the emissions that the material gives rise to during its life cycle. In this step, you need to decide whether to use 'specific data' or 'generic data', where both types of data collection are associated with different strengths and weaknesses. In simple terms, generic data is better for a general overview where it is not determined which constituent materials will be used in construction, while specific data is the best way to access product-specific data.

III. Assess the environmental impact. In this step, emissions and the use of resources are put in relation to various environmental problems.

IV. Interpret results. In the last step, the results are interpreted and then formulated so that you get answers to the questions you had in step 1.

This LCA analysis was performed in accordance with the standards that exist for LCA in the construction sector, which gives the analysis higher validity and credibility, as it increases the possibility for an external party to replicate the survey and obtain a similar result. This increases the reliability and credibility of the study.

3. PRODUCT DESCRIPTION

The floor structure has a dimension of 1000 x 220 x 1000 mm3. In addition to the concrete composition, they contain a reinforcement percentage of 0.15%, with a weight corresponding to approximately 12 kg/m2. The concrete mixes of both floors have a fineness modulus of 4.9 for the ballast. Table 1. and 2. Below is illustrated the constituent material of each floor structure and its density (kg/m3), weight (kg) and volume (m3). Both floors belong to different strength classes.

Table 1 shows the floor structure with vct 0.5 belongs to the strength class K40, with a compressive strength of 47 MPa and a density of 2356 kg/^{m3}.

Table 1: CONCRETE RECIPE VCT 0.5

DELMATERIAL	DENSITY [kg/m3]	WEIGHT [kg]	VOLUME [m3]
CEMENT	3100	350	0,113
WATER	1000	175	0,175
AIR	-	0	0,02
NATURGRUS	2650	898	0,339
MACADAM	2650	935	0,353
SUMMA		**2358**	**1**

Table 2 shows the floor structure with vct 0.4 belongs to the strength class K55, with the higher compressive strength of 62 MPa and a density of 2367 kg/^{m3}.

Table 2: CONCRETE RECIPE VCT 0.4

DELMATERIAL	DENSITY [kg/m3]	WEIGHT [kg]	VOLUME [m3]
CEMENT	3100	438	0,141
WATER	1000	175	0,175
AIR	-	0	0,02
NATURGRUS	2650	862	0,325
MACADAM	2650	898	0,339
SUMMA		**2373**	**1**

4. DEFINITION OF OBJECTIVES AND SCOPE

The aim of this analysis is to determine and compare the climate impact associated with two different floor structures with different water-cement values, where one shows a vct of 0.4 and the other a vct of 0.5. For each floor structure, the climate impact calculation covers the entire process from raw material procurement, including transport-specific flows for each material type, to finished assembly and commissioning.

4.1 FUNCTIONAL DEVICE

The functional unit, defined based on the function of the product system, is 1m². This choice is based on the task of the floor structure to cover an area between two floors and transfer the imposed loads according to the calculated capacity.

4.2 SIMPLIFIED FLOWCHART AND DATA QUALITY REQUIREMENTS

The system boundary of the study includes a building's first 4 roasts (according to the LCA method), A1A4; supply of raw materials (A1), transport (A1), manufacturing (A3) and A4 (transport) and ends before the next stage begins, the so-called construction and installation process (A5).

Figure 1 shows a simplified flow chart over the life cycle of a concrete slab, from raw material and manufacturing (A1-A4) to use and recycling or landfill.

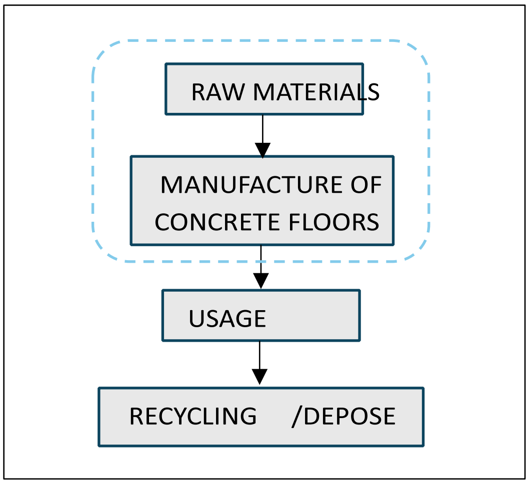

Figure 1: SIMPLIFIED FLOW HEMA

Table 3 shows an updated summary of the data that is central to the implementation of the study. Cement, Reinforcement and Crushed Rock have been evaluated based on their respective EPDs. The water values reflect an average for European tap water from 2018. The floor structure's data is an average from three Swedish producers, while Natural Gravel values continue to be based on the scientific study of *Stripple, H.* (2001), with an update from 2021. Additives have been excluded as they have been deemed to be of limited relevance. The data has been updated to reflect its reliability until 2024.

Table 3: DATA QUALITY AUDIT

TILLSATSMEDEL	VATTEN	CEMENT	ARMERING	NATURGRUS	BERGKROSS	BJÄLKLAG	TIDSMÄSSIG TÄCKNING
GILTIG FRÅN:	-	2018	11/12-2020	25/08-2021	2001	08/05-2017	2021
GILTIG TILL:	-	-	10/12-2025	26/07-2026	-	08/05-2022	-
GEOGRAFISK TÄCKNING	-	Europa	Europa	Sverige	Sverige	Sverige	Sverige
DATAKVALITET:	-	★★☆☆☆	★★★★☆	★★★☆☆	★☆☆☆☆	★★☆☆☆	★★★☆☆

4.3 ALLOCATIONS AND ASSUMPTIONS

The additives make up less than 1% of the total mass, which means that their impact on the climate impact, both for the individual modules and for the floor structures in total, is minimal. Due to the marginal impact that is less than 1% of the floor's total climate impact, the calculations for the additives have been excluded.

In the EPD
For crushed rock, the resource use has been divided between each crushed stone, with a focus on the actual crushing of rock rather than the gravel handling.

As for the reinforcement, the EPD has
used a "cut-off" method of allocation, where diesel consumption during loading and unloading trucks has been allocated based on the weight of the transported load. The allocations in this SPD have followed a certain order: first, allocation has been avoided where possible, then physical factors such as mass or volume have been used, and finally economic values have been used if the other methods have not been applicable.

5. LIFE CYCLE INVENTORY ANALYSIS

Figure 2 shows a detailed flowchart that clarifies the framework for the investigation. The defined boundary for this life cycle assessment study covers steps A1 to A4, which means that the analysis extends from the production of the various sub-materials up to the transport of the floor structure to the construction site.

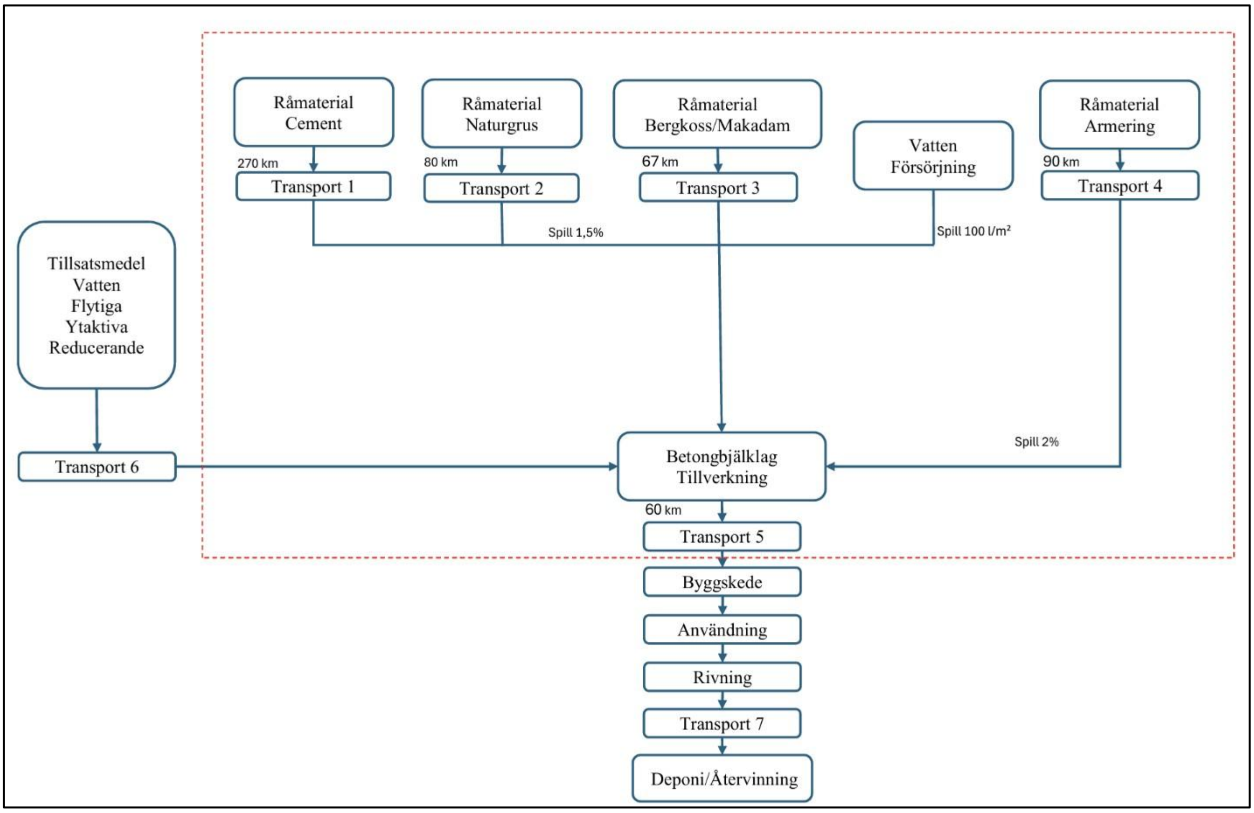

Figure 2: DETAILED FLOWCHART

Cement Manufacturing
Aalborg Portland A/S in Denmark produces Portland cement (CEM I), a hydraulic binder that hardens through a chemical reaction with water. Production begins with a mixture of limestone and quartz-rich sand (clay) in carefully balanced proportions. This mixture is heated in a rotating oven at temperatures around 1,450 °C, resulting in the formation of a material called clinker. After firing, the clinker is ground into a fine powder. To adjust the rate of reaction between the cement and the water, about 5% gypsum is added. The finished Portland cement from Aalborg Portland A/S is well-known for its high quality and durability and is used in a variety of construction projects.

Additives
Used in concrete mixes to optimize specific properties according to customer requirements. These can improve the concrete's workability, reduce water content, or influence other properties to meet the needs of the project.

Water
The quality of the water is crucial for the strength and durability of concrete. To be suitable for concrete production, the water must be fresh. Drinkable water is generally acceptable. Salt water, such as that from the Baltic Sea, can be used in unreinforced concrete but should be avoided in reinforced concrete due to the corrosive effect of chlorides on the reinforcement.

Ballast production
Ballast consists of a mixture of crushed rocks of different sizes to achieve a tight compaction. The different grain sizes fill the voids and the cement paste binds the ballast together. Macadam, which is produced by Skanska Industrial Solutions AB, undergoes three crushing steps to reach fractions between 0-32 mm. The grain size distribution is checked by sieving and weighing aggregate samples.

Reinforcement manufacturing
Stens Stål, located at Änghagsgatan 20 in Lidköping, manufactures high-quality reinforcing steel through a careful process. Production begins with the melting of scrap steel in an electric arc furnace to create a homogeneous steel mass. This pulp is alloyed to achieve the desired properties and then molded into bars or wire. Through rolling and drawing, the steel is formed into specific dimensions and surface qualities. Finally, the product undergoes rigorous quality checks to ensure that it meets the relevant building standards. Stens Stål is recognized for its reliable delivery and high product quality in the construction industry.

Manufacture of Concrete Floor Structures
Concrete is a mixture of cement, aggregate and water. The water must be drinkable if the concrete is reinforced. The ratio of water to cement (V/C) is critical to the strength of concrete; higher cement content gives lower V/C and thus higher strength. Concrete is vibrated during pouring to ensure that the aggregate is evenly distributed around the reinforcement, but self-compacting concrete can sometimes avoid this process. Admixtures can be used to improve the properties of concrete. Concrete floors, which are manufactured by UBAB Ulricehamns Betong AB, are prestressed and can have a span of up to 10 meters. The reinforcement is set up in a mold and the concrete is cast with a low V/C ratio to ensure

high strength. The reinforcement in the floor structure counteracts tensile and shear forces. After casting, the floor structure undergoes hardening and drying before being delivered to the construction site.

5.1 REFERENCE FLOW

Reference flows for the different floor structures, including inflows and outflows with regard to spillage, are presented in Table 4 and Table 5. The differences in the reference flow between floor structures with V/C 0.5 and 0.4 are shown, for example with larger amounts of natural gravel and aggregate in the former but a smaller amount of concrete. Example calculations for macadam and floor structures with V/C 0.4 illustrate how the amount of material per functional unit has been calculated.

Calculations:

Volume of concrete floors: $V_{joists\ 0.4}$: $B \times h \times L = 0.22$ m3

Density of concrete floors: $\rho_{\text{floor structure } 0.4} = 2373$ kg/m3

Mass flow for concrete slabs per functional unit: $2373 \times 0.22 = 522$ kg/m2

Volume of concrete excluding reinforcement:

$V_{btg} = V_{floor\ 0.4}$ – Heating ring: $0.22-(0.0015\times0.22) = 0.21967$m3

Volume of macadam per functional unit:

Vmacadam / (f. e) = $0.339\times0.21967 = 0.07446$ m^3/m2

Density of macadam: $\rho_{macadam} = 2650$ kg/m3

Spill factor of macadam: Spill factor macadam = $1/(1-\text{spillage}) = 1/(1-0.015) = 1.0152$

Mass flow of macadam per functional unit:

Mass flux macadam / (f. e) $=0.07446\times2650\times1.0152=200$ kg/m2

Table 4: REFERENCE FLOW FOR THE FLOOR STRUCTURE WITH VCT 0.5

MATERIAL	MÄNGD
Cement	79 kg/m²
Vatten	141 kg/m²
Naturgrus	198 kg/m²
Makadam	206 kg/m²
Armering	2.64 kg/m²
Bjälklag	518 kg/m²

Table 5: REFERENCE FLOW FOR THE FLOOR STRUCTURE WITH VCT 0.4

MATERIAL	MÄNGD
Cement	99 kg/m²
Vatten	141 kg/m²
Naturgrus	189 kg/m²
Makadam	197 kg/m²
Armering	2.64 kg/m²
Bjälklag	521 kg/m²

5.2 COMPILATION OF EMISSIONS

Table 6 illustrates the distances required for transport from the origin of the raw materials to the finished product and on to the customer. The transport routes include freight by boat as well as road transport with different types of trucks. Note that section 1 from Aalborg, has been omitted due to its minimal length. Transports are carried out with the following vehicles:

- **LASTBIL1**: 25-ton Euro 6 truck
- **LASTBIL2**: 40-ton Euro 6 truck

Table 6: TRANSPORT DISTANCES OF EACH UNIT PROCESS

	LEG 1		LEG 2		LEG 3	
	WITH	**DISTANCE**	**WITH**	**DISTANCE**	**WITH**	**DISTANCE**
CEMENT AALBORG	-	-	BOAT	**160 km**	TRUCK 2	**110 km**
REINFORCEMENT LIDKÖPING	LASTBIL1	**90 km**	-	-	-	-
BERGKROSS SKANSKA	LASTBIL2	**67 km**	-	-	-	-
NATURGRUS	LASTBIL1	**80**	-	-	-	-
SOFFIT	LASTBIL1	**60**	-	-	-	-

Table 7 shows the greenhouse gas emissions from the production of natural gravel and the total transports included in the production of the floor structure with vct 0.4 and vct 0.5. Information on transport distances and means of transport for each raw material is shown in Table 6. The large difference in emissions for Transport 1 compared to other transports is explained by the 160 km transport distance that takes place by boat. The calculations are based on emission data from VITT LIPASTO, which is illustrated in the calculations.

<u>Calculations:</u>

<u>Nature greetings</u>

$198\ \mathrm{kg/m2} -> 0.198\ \mathrm{tons/m2}$

In - Output $N2O$: $2.30 * 10^{-3}\ \mathrm{g/tonne}$

$N2O$ Emissions : $0.198 * 2.30 * 10^{-3} = 0.46 * 10^{-3}\ \mathrm{g/m2}$

<u>Transport 4</u> – 25t truck Euro 6

Quantity: 2.64 kg/m2

Distance: 90 km

Emission factor CO2: 35 g/tkm (fullastad)

Emission factor CO2: 613 g/km (tom retur)

$$\text{CO2 Emissions } = 35 * 90 * 2.64 * 10^{-3} + 613 * 90 * 2.64/25000 = 14,14\ \mathrm{g/m^2}$$

Table 7: GREENHOUSE GAS EMISSIONS

TRANSPORT:	1	2	3	4	5	NATURGRUS	UNIT
Vct 0.4							
$CH4$	0,00030	0,00045	0,00050	0,000041	0,0010	0,000071	$g/m2$
$N2O$	0,020	0,035	0,040	0,003	0,070	0,00043	$g/m2$
$CO2$	2750,0	590,0	1 050,0	14,14	900,0	0,0138	$g/m2$
Vct 0.5							
$CH4$	0,00032	0,00050	0,00055	0,000043	0,0011	0,000074	$g/m2$
$N2O$	0,022	0,037	0,045	0,004	0,073	0,00046	$g/m2$
$CO2$	2500,0	650,0	1120,0	15,20	950,0	0,0144	$g/m2$

6. CLIMATE IMPACT ASSESSMENT

The climate impact that arises during the transport and production of materials, such as concrete floors with different vct, is a complex issue where several factors come into play. The main greenhouse gases that contribute to this impact are nitrous oxide (N_2O), methane (CH_4) and carbon dioxide (CO_2). Each of these gases has a specific Global Warming Potential (GWP), which is a measure of their ability to amplify the greenhouse effect and thus contribute to global warming.

Figure 3 illustrates that the three types of emissions generated during transport and production of natural gravel show a certain value of GWP. This measure, which in Swedish is referred to as the potential to contribute to the greenhouse effect and global warming, illustrates the climate impact of emissions.

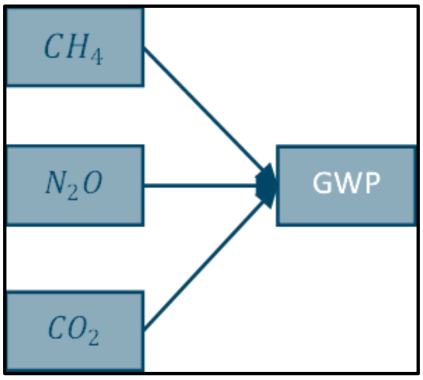

Figure 8: CLIMATE-IMPACTING EMISSIONS

The analysis of the various transports shows that carbon dioxide emissions account for the largest share of the total climate impact, especially when it comes to longer transports such as the 160 km long distance at sea. This mode of transport is energy-intensive and generates significant amounts of CO_2, which is clearly reflected in emission levels. On the other hand, the shorter transports by truck, although more frequent, contribute to a slightly lower climate impact, but their total emissions are still significant.

The production of natural gravel has relatively lower emissions, but the high GWP values for N_2O and CH_4 mean that even small amounts of these gases have a noticeable impact on the climate. This underlines the importance of focusing not only on the total amounts of emissions but also on the types of greenhouse gases emitted and their long-term effect on the climate.

In order to make an accurate assessment of climate impact, it is therefore crucial to take into account both the length of the transport and the type of means of transport, as well as to use reliable sources to calculate emissions. Data from established databases such as VTT LIPASTO are particularly valuable in this context, as they provide a scientifically based insight into how different factors contribute to total emissions.

6.1 GRADING

All GWP emissions (over a 100-year period) have been characterised in terms of carbon dioxide equivalents. A separate characterization has been carried out for the floor structure with vct 0.4 and 0.5 respectively. Below is an illustrative calculation showing the procedure for the calculations.

<u>Calculations:</u>

Characterization factor for N2O (Nitrous oxide): *298* kgCO2eq / m2

Emissions of N2O (Nitrous oxide) during transport 5 for vct 0.4: 0.070 g/m^2

The carbon dioxide equivalent of N2O will then be:

$$298 * 0{,}070 * 10^{-3} = 0{,}02086\ kgCO2eq\ /\ m2 = \mathbf{20{,}9}\ \boldsymbol{gCO2eq\ /\ m2}$$

Summing up all carbon dioxide equivalents for emissions from transport 5 then gives:

945,9 $\boldsymbol{gCO2eq\ /\ m2}$

Table 8 summarises the carbon dioxide equivalents for all transports and the production of natural gravel.

Table 8: CARBON DIOXIDE EQUIVALENTS FOR EMISSIONS FROM ALL TRANSPORT AND PRODUCTION OF NATURAL GRAVEL

TRANSPORT:	1	2	3	4	5	NATURGRUS	UNIT
Vct 0.4	2763,50	611,68	1074,42	16,06	945,86	0,1436	$gCO2eq\ /\ m2$
Vct 0.5	2514,56	673,53	1147,16	16,06	999,22	0,1534	$gCO2eq\ /\ m2$

6.2 CLIMATE IMPACT GWP

The climate impact caused by the various transports and production of materials for the floor structures with vct 0.4 and vct 0.5 has been analyzed and presented in both bar graphs and table 9. Based on the results in Figures 4 and 5, cement production is the unit process that contributes most to the total climate impact, regardless of which floor structure is used. Module A1, which covers the production and production of raw materials, turns out to be the most significant source of emissions, with a significantly greater impact compared to the other modules. This is clearly shown in Figures 6 and 7.

An examination of the specific transport routes shows that the long transport distances, in particular the 160 km long boat transport in Transport 1, contribute significantly to the total emissions. These transports generate significant amounts of carbon dioxide, which has a major impact on the climate. At the same time, the analysis shows that the production of natural gravel, although it has lower total emissions, still contributes to global warming due to the high GWP values of nitrous oxide and methane.

Table 9 presents the total climate impact GWP for both floor types with vct 0.4 and vct 0.5 respectively, from cradle to gate (modules A1-A4), and specifies the unit in which the impact is measured

Table 9: TOTAL CLIMATE IMPACT OF THE FLOOR STRUCTURE

TOTAL CLIMATE IMPACT (GWP) OF FLOOR STRUCTURE PRODUCTION	Vct 0.4	Vct 0.5	UNIT
A1-A3	91,0	73,8	kgCO2eq/m2
A4	1,27	1,26	kgCO2eq/m2
COMPLETELY	92,27	75,06	kgCO2eq/m2

Figure 4 illustrates the climate impact (GWP) from the various unit processes in the production of floor structures with vct 0.4. It is clear that cement has a significantly greater climate impact compared to other materials.

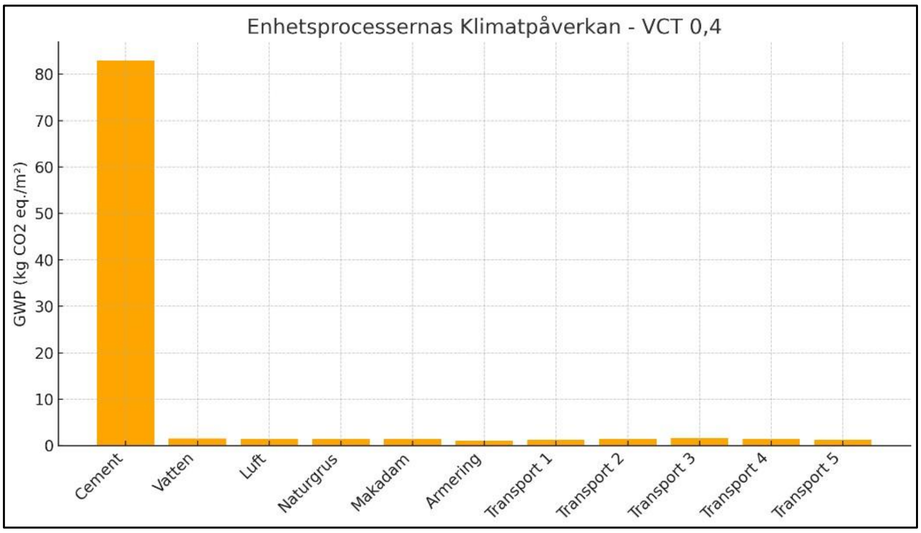

Figure 4: CLIMATE IMPACT (GWP) OF THE UNIT PROCESSES WITH VCT 0.4

Figure 5 illustrates the climate impact (GWP) of the various unit processes in the manufacturing phase of the floor structure with a vct of 0.5 visualized through a bar graph. In this case, too, a clear difference in climate impact between cement and other constituent materials emerges.

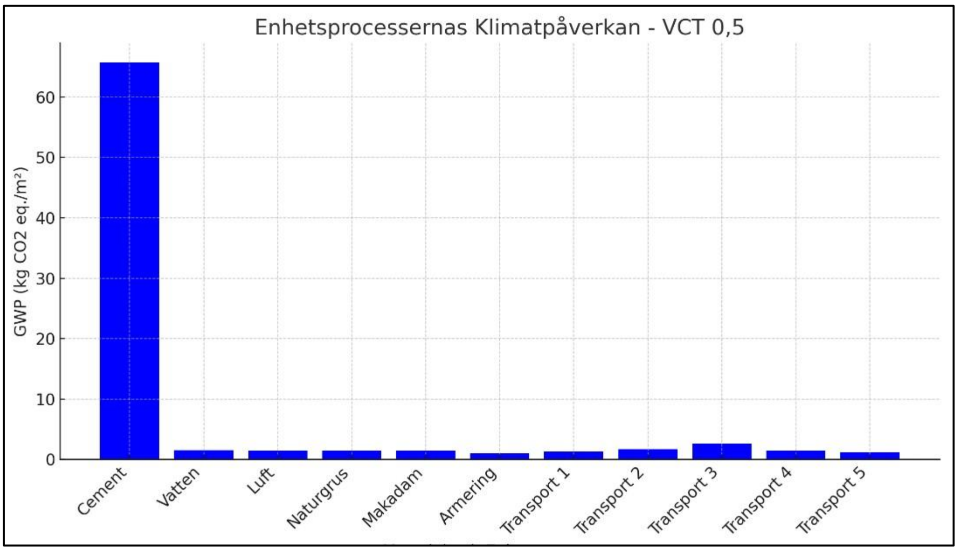

Figure 5: CLIMATE IMPACT (GWP) OF THE UNIT PROCESSES WITH VCT 0.5

Figure 6 describes the climate impact (GWP) distributed over modules A1-A4, which covers the life cycle stage from cradle to gate, for the floor structure with a vct of 0.4. The results show that the largest share of the climate impact is concentrated in module A1, where extraction, processing and production of the raw material required for the production of the floor structure takes place.

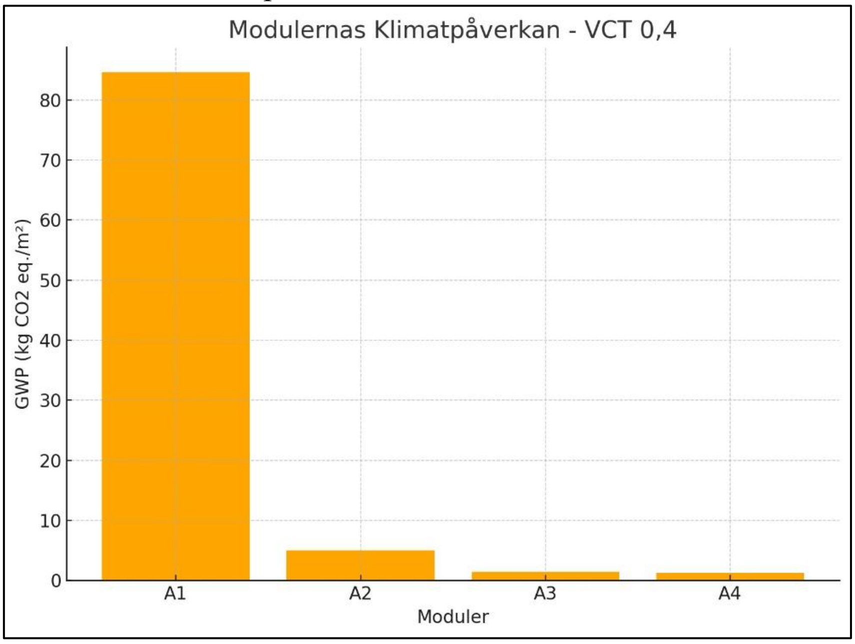

Figure 6: CLIMATE IMPACT OF MODULES A1-A4 WITH VCT 0.4

Figure 7 presents the corresponding climate impact GWP for modules A1-A4 for the floor structure with vct 0.5. Here, too, it appears that the majority of the emissions are found in module A1, which includes the initial process steps such as raw material extraction, processing and production related to the manufacture of the floor structure.

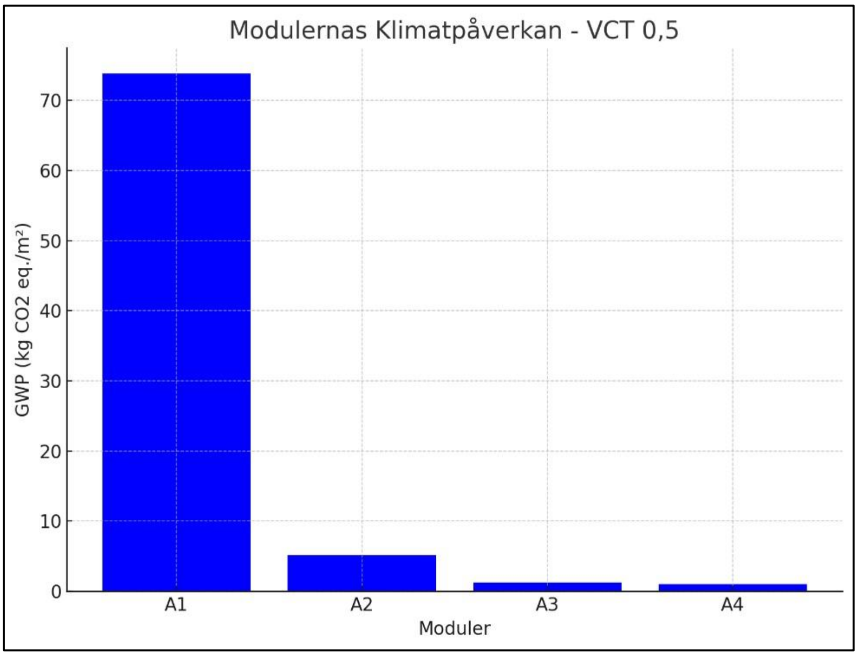

Figure 7: CLIMATE IMPACT OF MODULES A1-A4 WITH VCT 0.5

Based on data from EPDs

for all sub-materials, it is possible to calculate the climate impact in the form of carbon dioxide equivalents per square metre for each sub-material and module (A1-A4).

The mass flux of cement (vct 0.5) is estimated at 79 kg/m², and the global warming potential (GWP) of cement in modules A1-A3 amounts to 0.83 kg CO_2equivalent per kg of cement.

The calculated climate impact of cement in module A1, per functional unit, will thus be:

GWPA1 (Cement) per f. $e = 79 * 0{,}83 =$ 65.7 kgCO2eq/m2

Table 10 presents general values for solid floor structures, expressed per kg floor structure, with data taken from the National Board of Housing, Building and Planning's climate database (Boverket, 2021). The table also shows values for climate-improved floor structures, which have a lower climate impact. The values for the climate impact of the floor structures from the National Board of Housing, Building and Planning are given in a different unit than the one used in the report for the floor structures, which is taken into account in the subsequent example calculations.

Table 10: GENERIC DATA FROM THE NATIONAL BOARD OF HOUSING, BUILDING AND PLANNING'S CLIMATE DATABASE

Produkt	**A1-A3** (kg CO_{2e}/kg)	**A4** (kg CO_{2e}/kg)
Massivt bjälklag[1]	0,2288	0,045
Massivt bjälklag, klimatförbättrat[2]	0,1713	0,045

Calculations:

Climate impact of floor structure (vct 0.4), module A1-A3: 91.0 (kgCO2eq)/m²

Amount of floor structure (vct 0.4): 521 kg/m2

Climate impact (with the correct unit) in module A1-A3: $\frac{1}{521} * 91 = 0{,}1747$(kgCO2eq)/kg

Climate impact at A4 (vct 0.4): 1.27 kg(CO2e)/m²

Amount of floor structure (vct 0.4): 521 kg/m²

Climate impact at A4 (with correct unit): $\frac{1}{521} * 1{,}27 = 0{,}002438\ kg(CO_2eq)$/kg

Table 11 presents a comparison of the climate impact between the different modules and generic data for solid floor structures, retrieved from the National Board of Housing, Building and Planning's climate database. The table uses uniform measures to facilitate comparison.

Table 11: COMPARISON BETWEEN GENERIC VALUES AND CALCULATED VALUES FOR FLOOR STRUCTURES

	A1-A3	**A4**	**UNIT**
Bjälklag vct 0,4	0,175	0,0024	(kgCO2eq)/kg
Bjälklag vct 0,5	0,142	0,0024	(kgCO2eq)/kg
Generic value – National Board of Housing, Building and Planning Solid floor structure	0,2288	0,045	(kgCO2eq)/kg
Generic value – Boverket Solid floor structure Climate improved	0,1713	0,045	(kgCO2eq)/kg

7. INTERPRETATION

The results indicate that the manufacturing process and the procurement of raw materials are the most significant factors for the climate impact associated with the production of floors. A closer analysis shows that cement is the largest climate-impacting component. This is mainly due to the high carbon dioxide emissions generated by cement production, both through the combustion of fuels and in limestone decomposition, where the carbon dioxide is released.

The study has satisfactorily answered the questions about the climate impact from cradle to gate for solid concrete floors. However, it is important to note some uncertainties that have affected the results. Among these is the conversion of the amount of material in the concrete recipe from kg to kg/functional unit. In addition, the quality problems in some EPDs, where the data quality was not always clearly specified, have made the analysis more difficult.

To ensure the most accurate study possible, certain assumptions have been necessary. Initially, it was also a challenge to understand the differences between the system boundaries in the study and those specified in the EPD. However, this complexity has been clarified in the course of the report, which has contributed to a more accurate and useful analysis.

8. CONCLUSION AND RECOMMENDATIONS

The analysis shows that the climate impact of floor structures is strongly related to the choice of raw materials and manufacturing processes, where the contribution of cement to total carbon dioxide emissions is particularly significant. The results indicate that slabs with a higher water-cement ratio (VCT) show a lower climate impact, which is due to reduced cement use. For example, floor structures with vct 0.5 have a lower global warming potential (GWP) compared to floor structures with vct 0.4, which can be attributed to the reduced amount of cement required.

A study by *Alzuhairi, F., & Fatah, A*. (2020) that significant reductions in carbon dioxide emissions from concrete can be achieved by careful consideration of the amount of cement and the water-cement ratio (VCT) in the concrete mix as well as by the use of alternative binders that partially replace the cement. The study clarifies that concrete with higher strength and lower VCT can contribute to reduced climate impact. This provides valuable insight into how different concrete recipes affect sustainability and underlines the importance of choosing the right parameters when choosing concrete quality.

Despite the dominant impact of cement, the transport of cement is another important factor that contributes to the overall emissions. The long transport distance by heavy truck and boat results in significant carbon dioxide emissions. To optimize climate impact, construction projects should consider using local cement suppliers to reduce transport-related emissions. The choice of nearby suppliers and sustainable production methods are crucial to achieve a lower climate impact in future construction projects.

9. REFERENCE LIST

UBAB Ulricehamn Betong AB. (u.å). Floors. https://www.ubab.com/produkt/bjalklag/

Aalborg Portland A/S, Cementir Holding S.p.A. (2022). RAPID cement CEM I 52,5 N (LA). https://www.aalborgwhite.com/sites/default/files/documents/2022-08/Aalborg%20Portland%20Aalborg%20white%20epd%20-%2003.2021.pdf

The National Board of Housing, Building and Planning (2021). Generic values for a solid floor structure.
https://www.boverket.se/contentassets/eb39a37752af4f74a61ccf92ac21cd5b/lista-on-updates-of-the-climate-database-may-2022.pdfhttps:/www.boverket.se/contentassets/eb39a37752af4f74a61ccf92ac21cd5b/lista-pa updates-av-klimatdatabasen-maj-2022.pdf.

The National Board of Housing, Building and Planning (2021). Input data for transport.
https://www.boverket.se/sv/klimatdeklaration/gor-so-har/substrate/input-transport/

Bygg.se. (n.d.). Rebar, this is how it is used.
https://bygg.se/armeringsjarn-what-is-it /.(

Skanska Industrial Solutions AB. (2017). Rock crushing products. [EPD].
https://www.epd-norge.no/getfile.php/139362-1679571052/EPDs/Building Products/Asphalt/NEPD-1257-403_Crushed-Stone Bergkrossprodukter_1_1.pdf

Svensk Betong. (approx. Carbon dioxide emissions. https://www.svenskbetong.se/om-concrete/prefab/environment-and-sustainability/carbon emissions

Alzuhairi, F., & Fatah, A. (2020). Environmentally improved concrete is compared with ordinary concrete with regard to the estimated environmental impact.
https://www.diva-portal.org/smash/get/diva2:1561805/FULLTEXT01.pdf

BE GROUP. (approx. Handbook reinforcement in the basics.
https://www.begroup.se/storage/66432FA5BBC9C902E3CED709F7252614331BD3EC2A0970BACE011048E9ED190F/9433b4ef70334b30b972f1b81e8f42ba/pdf/media/467b82560DF244FFB21OR51B390A1448/BE_ArmouringShandBoken_2017_Web.pdf