EFCA AISBL:
ADMIXTURES AND SUSTAINABLE CONCRETE

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ADMIXTURES AND SUSTAINABLE CONCRETE

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Durability and Sustainability

Application area	Mix design	Porosity (theoretical)	Remarks
Reference Concrete for building components in interior zones	Cement: 300 kg/m^3 Water: 174 L/m^3 **W/C-ratio: 0.58**	In concrete: ~6% In hardened cement paste: ~22%	Can be manufactured with most types of aggregates
Watertight Concrete By the use of ≈ 0.8% Superplasticizer	Cement: 325 kg/m^3 Water: 156 L/m^3 **W/C-ratio: 0,48**	In concrete: ~3% In hardened cement paste: ~13%	Easily achievable with good aggregates
High durability Concr. By the use of ≈ 1.2% Superplasticizer	Cement: 360 kg/m^3 Water: 151 L/m^3 **W/C-ratio: 0,42**	In concrete: ~1% In hardened cement paste: ~5%	No longer achievable with fluctuating aggregates quality
High strength Concr. By the use of ≈ 1.6% Superplasticizer	Cement: 420 kg/m^3 Water: 147 L/m^3 **W/C-ratio: 0,35**	In concrete: ~0% In hardened cement paste: ~0%	Only achievable with carefully selected aggregates

Direct water savings by the use of admixtures

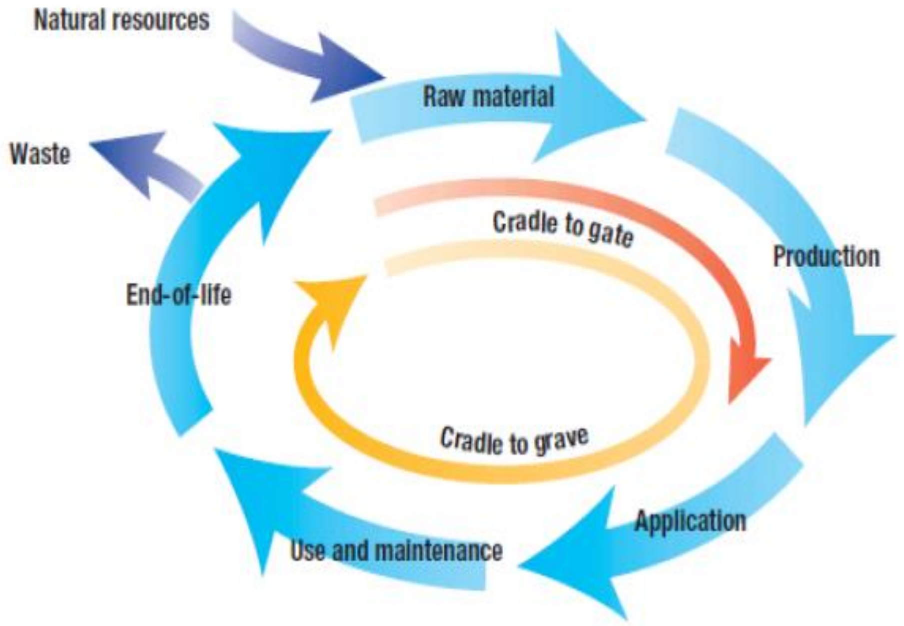
Mix design	Plasticizer use	Net water savings	Remarks
Cement: 325 kg/m^3 Water: 195 L/m^3 **W/C-ratio: 0,60**	No Water Reducer	**0 L/m^3**	Reference
Cement: 325 kg/m^3 Water: 163 L/m^3 **W/C-ratio: 0,50**	0.6 % Superplasticizer Water demand for manufacturing: ~ 12 l/kg	**9 L/m^3** **	Water demand for manufacturing of plasticizer includes all processes and raw materials (LCA)
Cement: 325 kg/m^3 Water: 130 L/m^3 **W/C-ratio: 0,40**	1.2 % Superplasticizer Water demand for manufacturing: ~ 12 l/kg	**18 L/m^3**	Water demand for manufacturing of plasticizer includes all processes and raw materials (LCA)

Life Cycle Analysis of concrete mix designs

Life Cycle Assessment (LCA) is a standardized method to assess and compare the inputs, outputs and potential environmental impacts of products and services over their life cycle

In a 'Cradle to Gate' approach, the LCA investigates the potential environmental impact of a product from raw material extraction to finished production.

In a 'Cradle to Grave' approach, the LCA investigates the potential environmental impact of a product from raw material extraction, production, application and use to final disposal at the end-of-life.



Life Cycle Analysis of concrete mix designs

The following example shows a LCA impact calculation of two different concrete mix designs. Recipe 1 with OPC only, Recipe 2 with 40 kg/m^3 limestone and 1.2% Superplasticizer to achieve same concrete quality (porosity).

Parameters of comparison	Concrete design mix reference	Optimized concrete design mix
Design mix comparison	Cement: 350 kg/m^3 Additive: 0 kg/m^3 Water content: (0.52) 182 L/m^3 Sand: 747 kg/m^3 Gravel: 1,121 kg/m^3	Cement: 280 kg/m^3 Additive: (Limestone) 40 kg/m^3 Water content: (0.48) 134.4 L/m^3 Sand: 804 kg/m^3 Gravel: 1,205 kg/m^3 Superplasticizer: 3.36 kg/m^3

Life Cycle Analysis of concrete mix designs

Parameters of comparison	Reference Concrete design mix	Optimized Concrete design mix
Concrete technology comparison	Fresh concrete consistency: Flow diameter 44 cm Compressive strength: 1-day: 22.3 N/mm^2 28-day: 40.0 N/mm^2 Porosity: 4.8 %	Fresh concrete consistency: Flow diameter 42 cm Compressive strength: 1-day: 22.4 N/mm^2 28-day: 46.9 N/mm^2 Porosity: 2.8 %
Economic comparison (relative assumptions)	Costs / m^3 76.50 €/m^3 Cost differences based on: cement and water	Costs / m^3 75.50 €/m^3 Cost differences based on: admixture, limestone, gravel & sand

Life Cycle Analysis of concrete mix designs

Parameters of comparison	Reference Concrete design mix		Optimized Concrete design mix	
Life Cycle Impact Assessment Cradle-to-gate (Method: CML2001 – Nov.09)				
Input net freshwater	**0.40**	m^3/m^3	**0.41**	m^3/m^3
Global warming potential (GWP 100 y)	**295.84**	kg CO_2-Equiv./m^3	**246.60**	kg CO_2-Equiv./m^3
Human toxicity potential (HTP inf.)	**0.50**	kg DCB-Equiv./m^3	** **9.58**	kg DCB-Equiv./m^3
Cumulative energy demand (CED)	**1486.67**	MJ/m^3	**1398.12**	MJ/m^3

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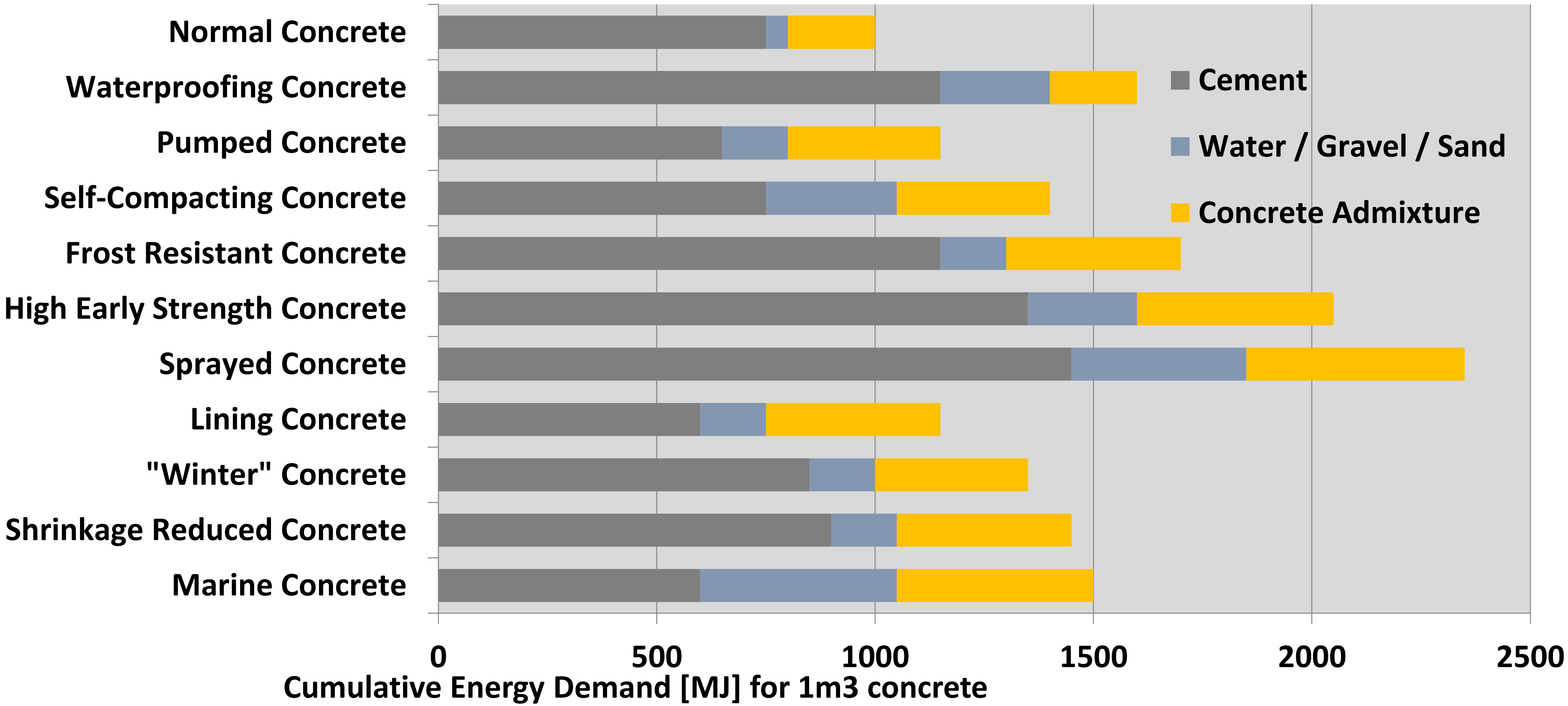
Cumulative Energy Demand [MJ] schematically



Life Cycle Impact of Superplasticizer type

Special concrete properties are required for the placement as slipped form concrete. To optimize that type of concrete recipe in respect to sustainability is a challenge

Height of the formwork is usually only around 1.20 m and the hourly production rate is 20 to 30 cm, the concrete underneath is 4 to 6 hours old and must be stiff enough to bear its own weight (green strength)

Therefore the temperature has a major influence, along with the requirement for the consistently optimum w/c-ratio.

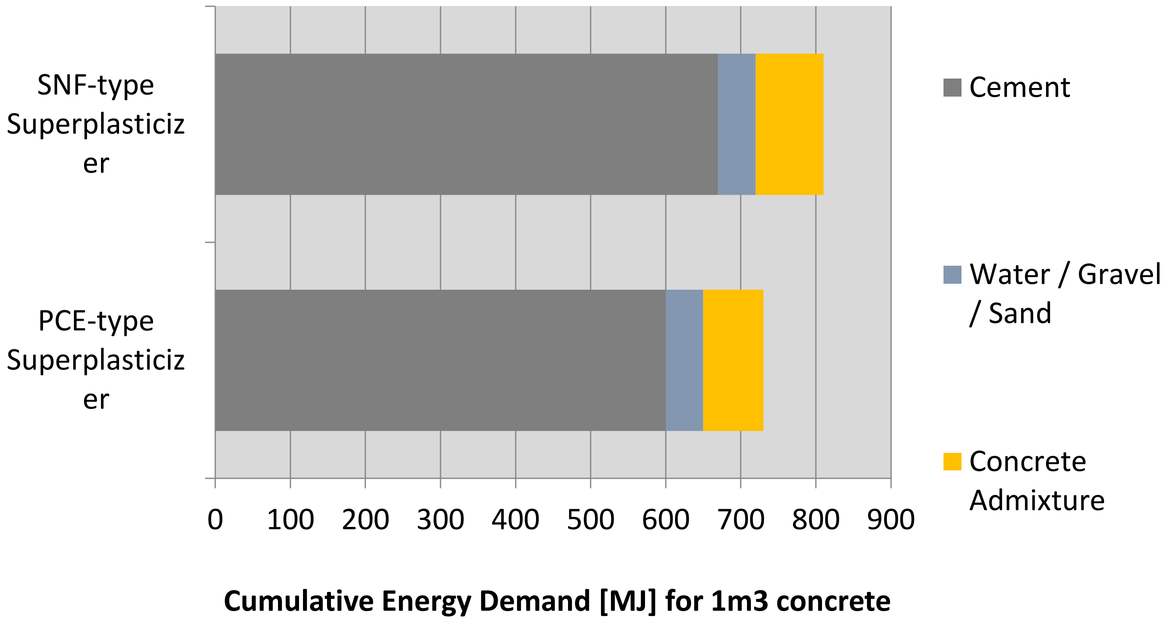
Life Cycle Impact of Superplasticizer type

two concrete systems to compare the impact of the use of PCE based superplasticizer

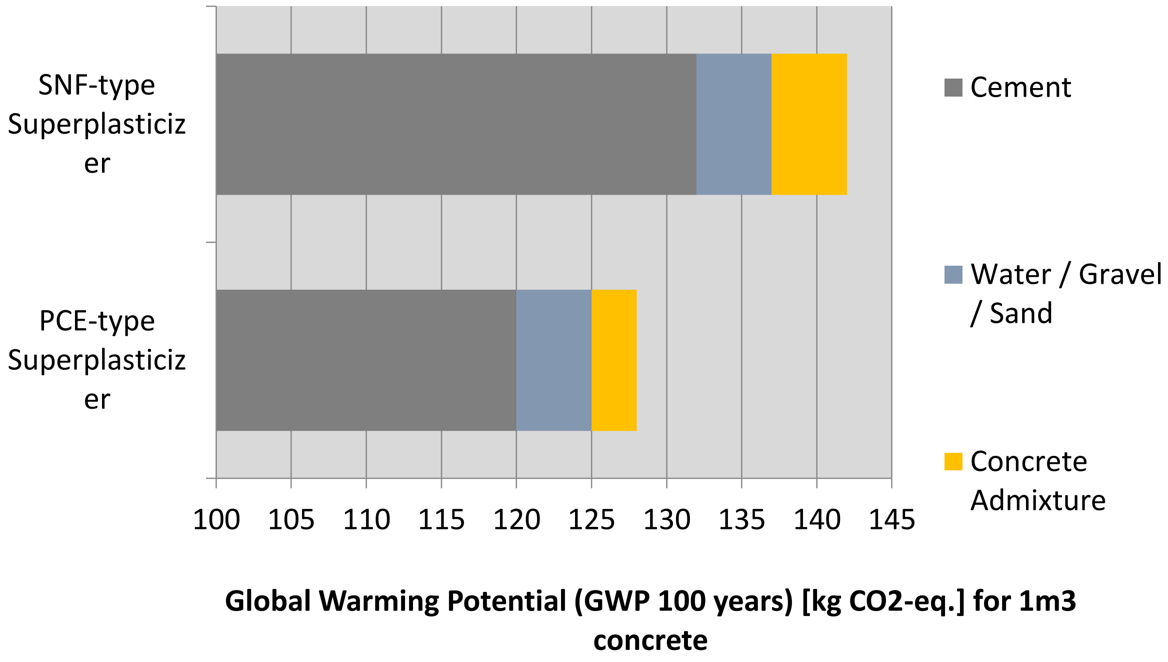
Concrete	Cement	Sand	Gravel	Water	Admix.
Paste Volume: 343 liter					
Traditional Superplasticizer	CEM III/A 42.5 N 442 kg/m³	Sand round 0/4 678 kg/m³	Gravel round 2/32 1’017 kg/m³	203 liter w/c=0,46	1% SNF type 4.4 kg/m³
Paste Volume: 310 liter					
New PCE-type Superplasticizer	CEM III/A 42.5 N 400 kg/m³	Sand round 0/4 712 kg/m³	Gravel round 2/32 1’068 kg/m³	184 liter w/c= 0,46	1% PCE type 4.0 kg/m³

Life Cycle Impact of Superplasticizer type

Cumulative Energy Demand [MJ]



Global Warming Potential [kg CO2-eq.], CML 2001



Life Cycle Impact of Concrete Accelerator type

Modern tunneling methods in weak rock conditions demand concrete segments which are immediately load bearing as linings to the fully excavated tunnel section

Striking takes place after only 5 – 6 hours and the concrete must already have a compressive strength of >15 N/mm^2, accelerated strength development is essential

In the autoclave (heat backflow) process, the concrete is heated to 28 – 30 °C during mixing (with hot water or steam), placed in the form and finished. It is then heated for about 5 hours in an autoclave at 50 – 60 °C to obtain the necessary strength for formwork removal

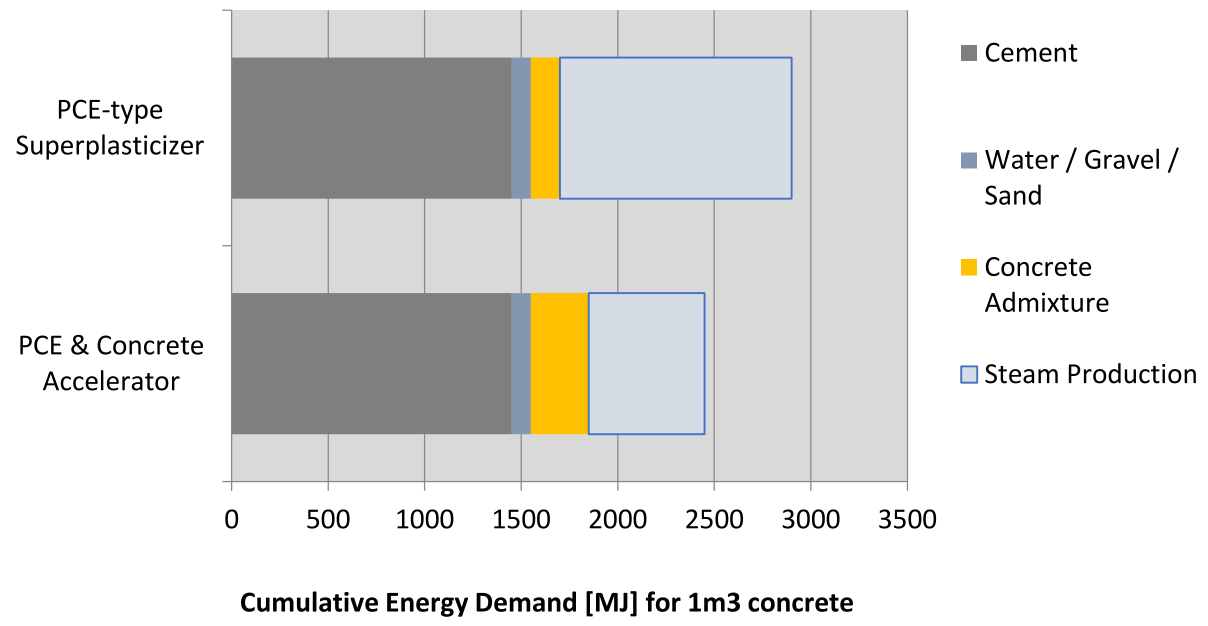
Life Cycle Impact of Concrete Accelerator type

Two concrete systems to compare the impact in steam reduction with concrete accelerators

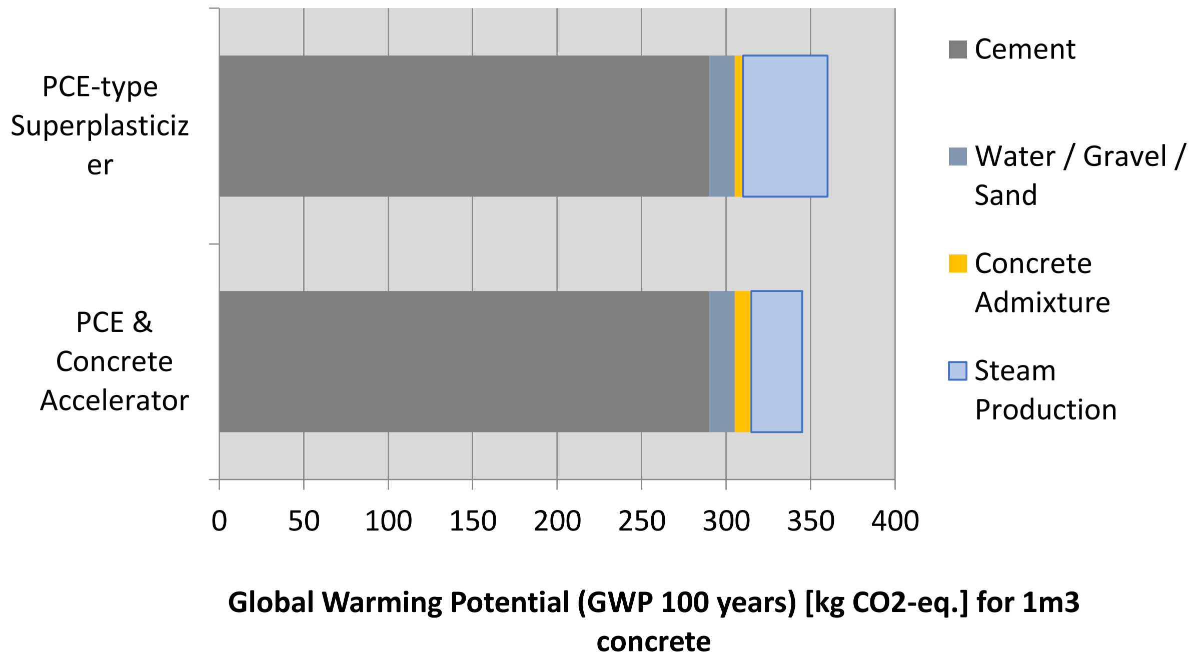
Concrete	Cement	Sand	Gravel	Water	Admix.
Steam Curing time: 300 minutes					
Superplasticizer	CEM I 52,5 350 kg/m³	Sand 900 kg/m³	Gravel 1'030 kg/m³	42 liter w/c=0,42	PCE type
Steam Curing time: 150 minutes					
Superplasticizer & Concrete Accelerator	CEM I 52,5 350 kg/m³	Sand 900 kg/m³	Gravel 1'030 kg/m³	42 liter w/c=0,42	PCE type + Accelerator

Life Cycle Impact of Concrete Accelerator type

Cumulative Energy Demand [MJ]



Global Warming Potential [kg CO2-eq.], CML 2001



Life Cycle Impact of Paste optimized mix design

PCE-type superplasticizer technology allowed to reduce the cement paste contents in the conventional concrete, breaking the traditional limits to obtain a better concrete (in fresh and hardened states)

Lower paste cement content will decrease the drying shrinkage, creep, abrasion erosion and liquid penetration (chlorides and sulphate penetration)

A part from economic benefit a smarter and more sustainable concrete is produced.

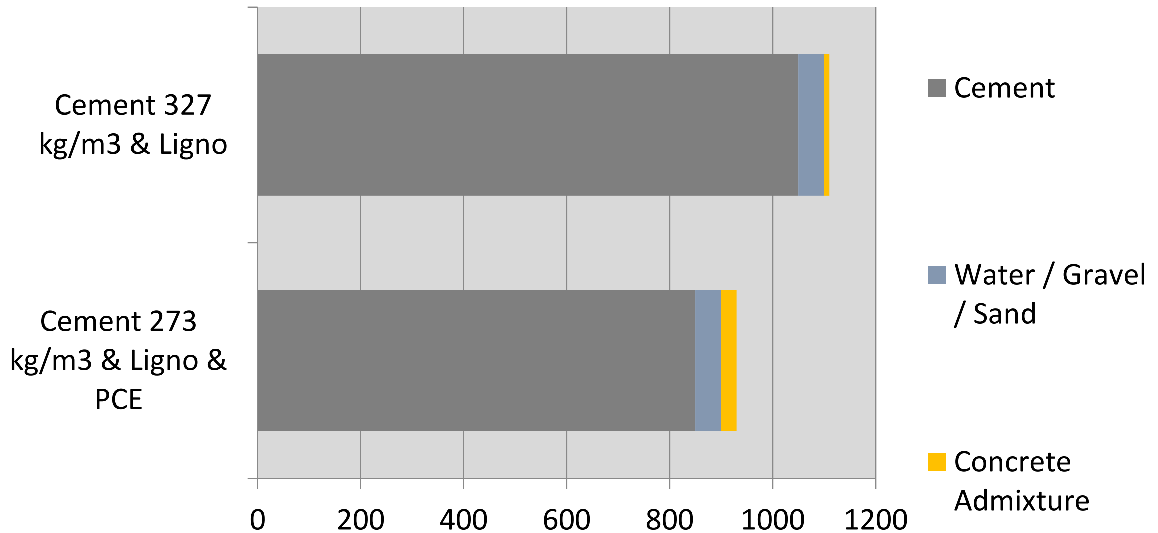
Life Cycle Impact of Paste optimized mix design

Two concrete systems to compare the impact of optimizing paste volume

Concrete	Cement	Sand	Gravel	Water	Admix.
Cement Paste Volume: 290 liter / Fine Paste Volume: 321 liter					
Traditional Superplasticizer	Cement Type 1 327 kg/m³	Sand 798 kg/m³	Gravel 916 kg/m³	187 liter w/c=0,57	0.6% Ligno-type
Cement Paste Volume: 242 liter / Fine Paste Volume: 275 liter					
New Superplasticizer	Cement Type 1 273 kg/m³	Sand 845 kg/m³	Gravel 952 kg/m³	155 liter w/c=0,57	0.4% Ligno-type 0.4% PCE-type

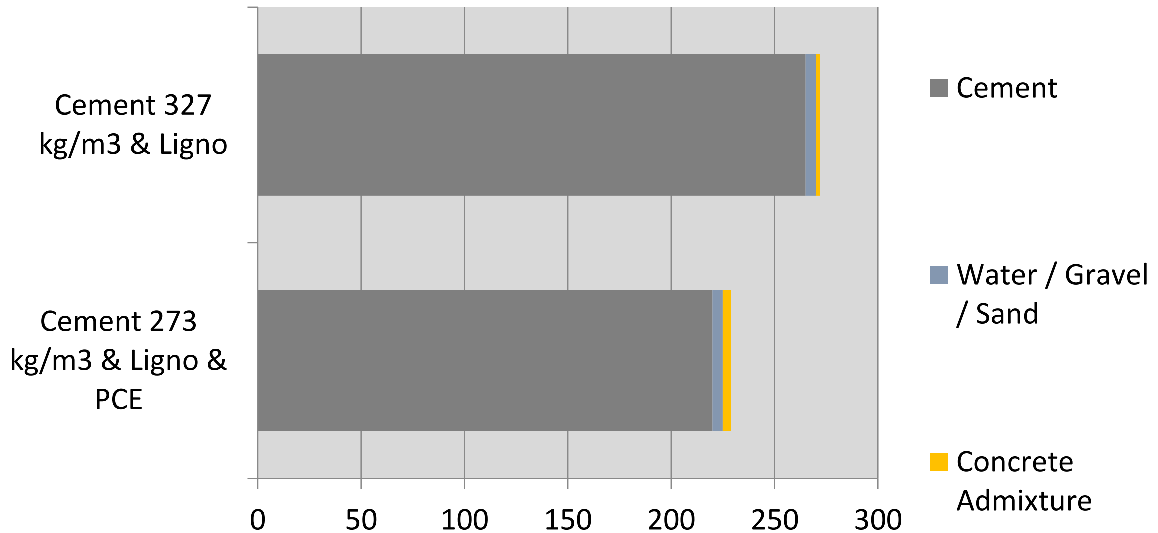
Life Cycle Impact of Paste optimized mix design

Cumulative Energy Demand [MJ]



Cumulative Energy Demand [MJ] for 1m3 concrete

Global Warming Potential [kg CO2-eq.], CML 2001



Global Warming Potential (GWP 100 years) [kg CO2-eq.] for 1m3 concrete

Summary

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THANK YOU
FOR YOUR ATTENTION!

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