
Climate enhanced concrete
Erik Nordström
Vattenfall R&D
Thomas
Thomas

Agenda

Lilla Edet project

Climate enhanced concrete

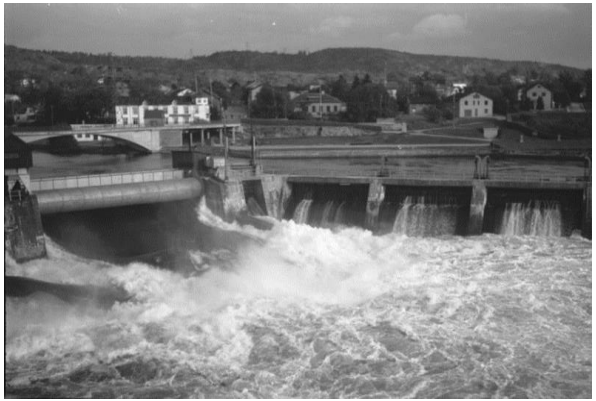
Concrete purchase guideline

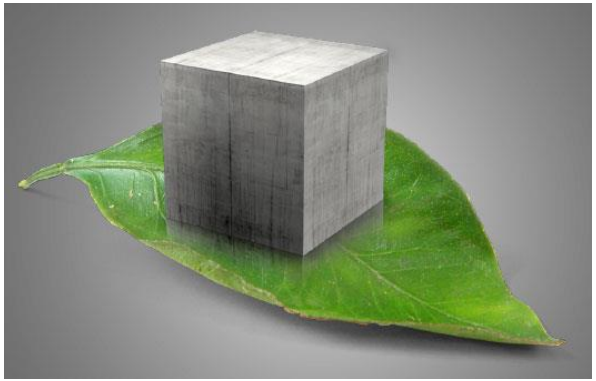
Lilla Edet dam safety project

- Increase discharge capacity
- Old spillway gates – maintenance costly
- Concrete partly degraded
- New concrete spillway dam – 8000 m^3 of concrete
- Four new gated spillways (3 segment + 1 flap)

The mission

- Reduce CO_2-footprint from the concrete mix
- Reduce the need for post-cooling to avoid early age thermal cracking
- Develop a robust and economically justifiable concept for implementation in Lilla Edet-project

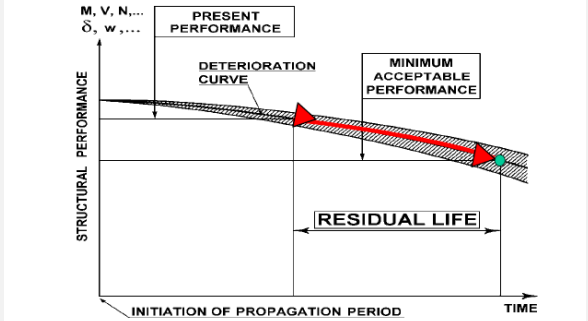




Requirements on Concrete

- High quality generally dependent on:
  - Fresh properties for constructability
  - Hardened properties for strength + load-bearing capacity
  - Durability properties

- Specific for hydropower concrete:
  - Large dimensions
  - Harsh exposure conditions (water, frost, erosion)
  - Limited access during operation



Concrete industry today

Environmental focus:

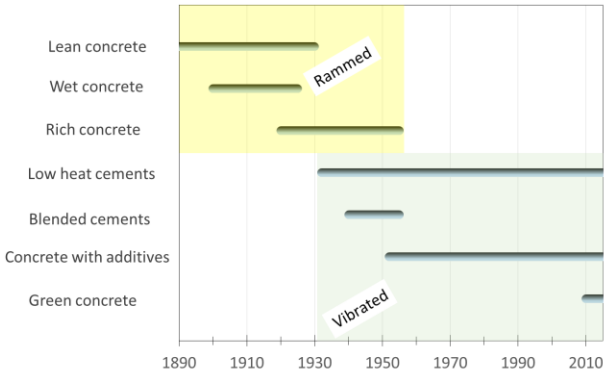
- Transition ongoing !

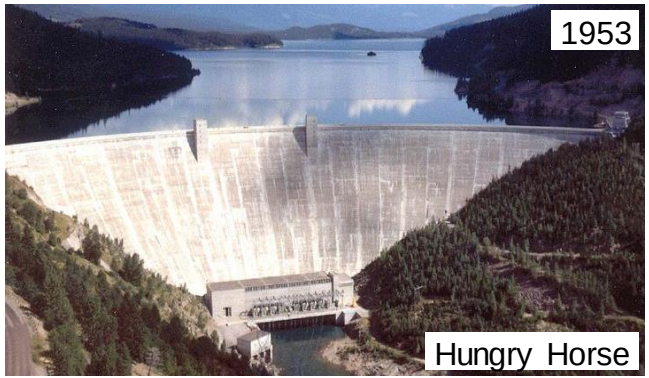
Material	GWP (kg CO_2/tonnes)
Cement	820-930
Silica fume	28
Fly ash	4
GGBS	52-67
Lime stone filler	32-75

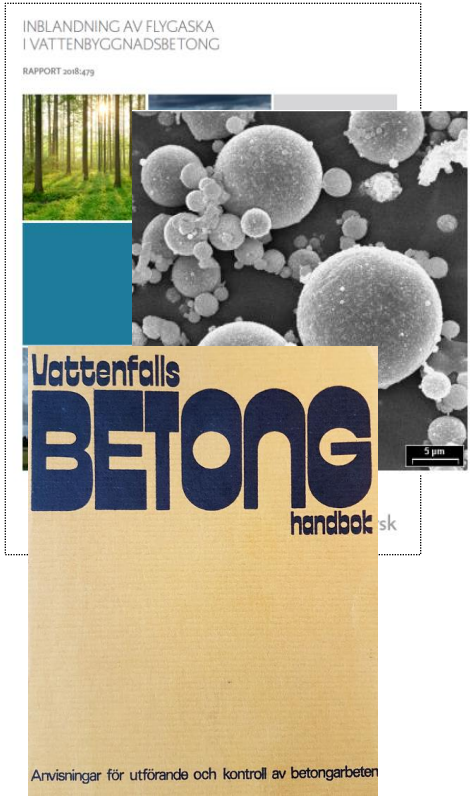
Potential for replacing cement= f (exposure environment) !!

Past and Present knowledge

- Use of Supplementary Cementitious Materials (SCMs)
- Changes in Mix-design concepts over the decades
- Measures for reduction of early-age thermal cracking
- Experience from construction and operation



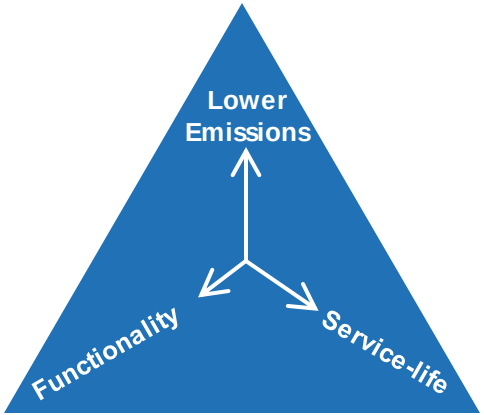




Definition of concept

- Replace parts of cement with fly ash
- Increase maximum aggregate size
- Replace parts of the mixing water with ice
- Optimize mix-design ~ Avoid ”overstrength”

- Reduced cement content
- Lowered CO_2-footprint
- Lowered risk for thermal cracking

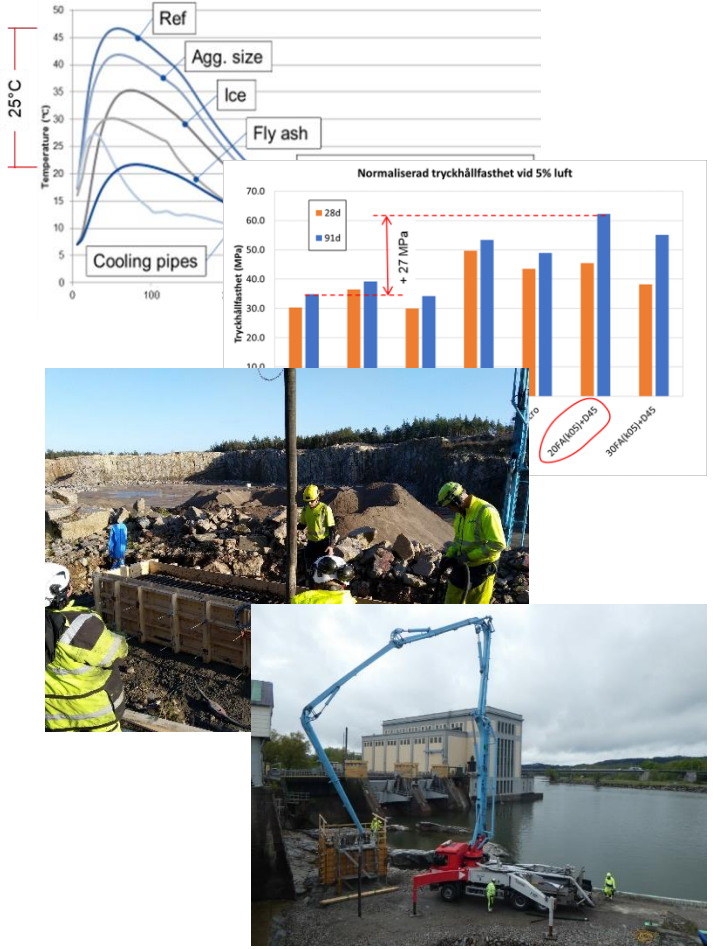


Development of concept

- Small scale trial mixing
  - Semi-adiabatic measurements (heat development)
  - Numerical modelling of crack risk
  - Fresh and hardened properties

- Full scale mixing and pumping + mock-up

- Co-operation with contractor + local ready-mix supplier
  - Mix-design optimized with local materials
  - Mock-up with reinforcement according to design
  - 1st pouring of crane foundation on site in Lilla Edet

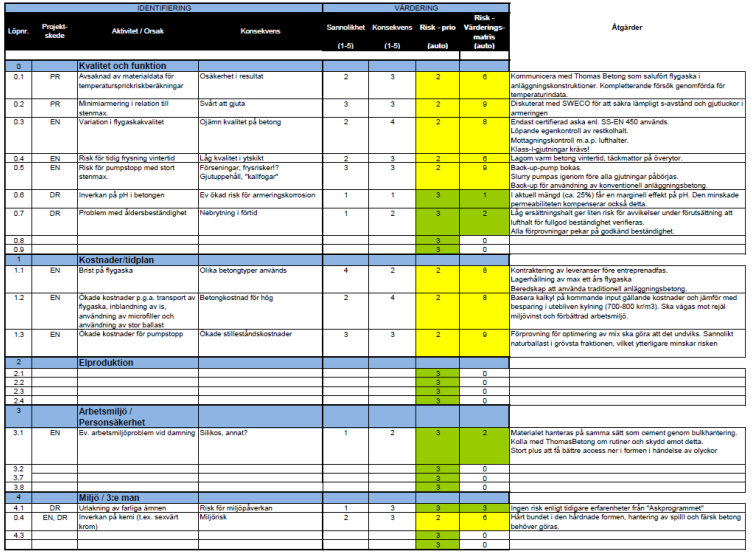


Implementation / Convince managers

- Risk analysis
  - Quality
  - Cost / Time
  - HSE

- Risk mitigation keys
  - Continous co-operation between parts
  - Pre-testing at early stage
  - On-site QA / QC

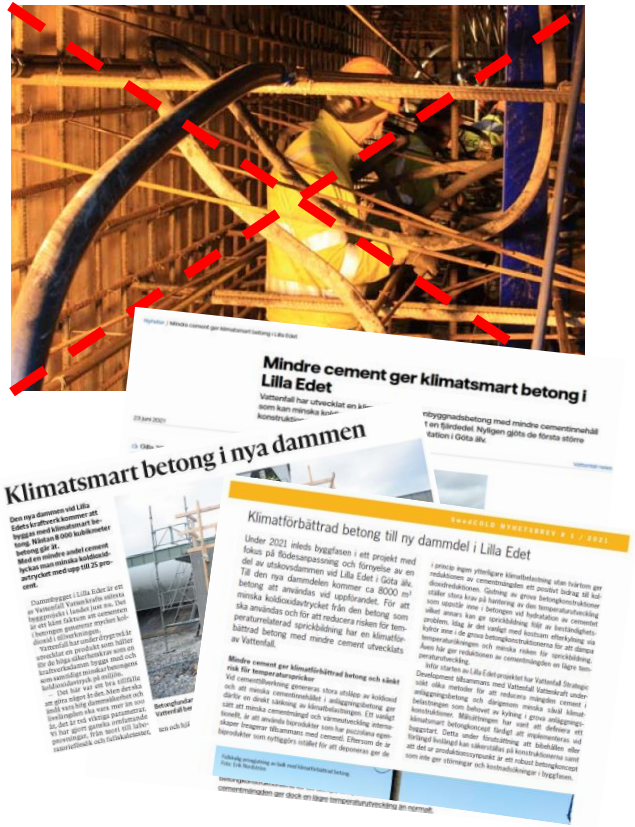
- ”Fall-back-solution” with traditional concrete



	IDENTIFIERING			VÄRDERING				
Löpnr.	Projekt-skede	Aktivitet / Orsak	Konsekvens	Sannolikhet (1-5)	Konsekvens (1-5)	Risk - prio (auto)	Risk - Värderings-matris (auto)	Åtgärder
0		**Kvalitet och funktion**						
0.1	PR	Avsaknad av materialdata för temperaturspricknskberäkningar	Osäkerhet i resultat	2	3	2	6	Kommunicera med Thomas Betong som saluförti flygaska i anläggningskonstruktioner. Kompletterande försök genomförda för temperaturindata.
0.2	PR	Miniminarmering i relation till stenmax.	Svårt att gjuta	3	3	2	9	Diskuterat med SWECO för att säkra lämpligt s-avstånd och gjutluckor i armeringen
0.3	EN	Variation i flygaskakvalitet	Ojämn kvalitet på betong	2	4	2	8	Endast certifierad aska enl. SS-EN 450 används. Löpande egenkontroll av restkolhalt. Mottagningskontroll m.a.p. lufthalter. Klass-I-gjutningar krävs!
0.4	EN	Risk för tidig frysning vintertid	Låg kvalitet i ytskikt	2	3	2	6	Lagom varm betong vintertid, täckmattor på överytor.
0.5	EN	Risk för pumpstopp med stort stenmax.	Försenningar, frysrisker!? Gjutuppehåll, "kallfogar"	3	3	2	9	Back-up-pump bokas. Slurry pumpas igenom före alla gjutningar påbörjas. Back-up för användning av konventionell anläggningsbetong.
0.6	DR	Inverkan på pH i betongen	Ev ökad risk för armeringskorrosion	1	1	3	1	I aktuell mängd (ca. 25%) får en marginell effekt på pH. Den minskade permeabiliteten kompenserar också detta.
0.7	DR	Problem med åldersbeständighet	Nebrytning i förtid	1	2	3	2	Låg ersättningshalt ger liten risk för avvikelser under förutsättning att lufthalt för fullgod beständighet verifieras. Alla förprovningar pekar på godkänd beständighet.
0.8						3	0	
0.9						3	0	
1		**Kostnader/tidplan**						
1.1	EN	Brist på flygaska	Olika betongtyper används	4	2	2	8	Kontraktering av leveranser före entreprenadfas. Lagerhållning av max ett års flygaska Beredskap att använda traditionell anläggningsbetong.
1.2	EN	Ökade kostnader p.g.a. transport av flygaska, inblandning av is, användning av microfiller och användning av stor ballast	Betongkostnad för hög	2	4	2	8	Basera kalkyl på kommande input gällande kostnader och jämför med besparing i utebliven kylning (700-800 kr/m3). Ska vägas mot rejäl miljövinst och förbättrad arbetsmiljö.
1.3	EN	Ökade kostnader för pumpstopp	Ökade ställeståndskostnader	3	3	2	9	Förprovning för optimering av mix ska göra att det undviks. Sannolikt naturballast i grövsta fraktionen, vilket ytterligare minskar risken
2		**Elproduktion**						
2.1						3	0	
2.2						3	0	
2.3						3	0	
2.4						3	0	
3		**Arbetsmiljö / Personsäkerhet**						
3.1	EN	Ev. arbetsmiljöproblem vid damning	Silikos, annat?	1	2	3	2	Materialet hanteras på samma sätt som cement genom bulkhantering. Kolla med ThomasBetong om rutiner och skydd emot detta. Stort plus att få bättre access ner i formen i händelse av olyckor
3.2						3	0	
3.7						3	0	
3.8						3	0	
4		**Miljö / 3:e man**						
4.1	DR	Urlakning av farliga ämnen	Risk för miljöpåverkan	1	3	3	3	Ingen risk enligt tidigare erfarenheter från "Askprogrammet"
0.4	EN, DR	Inverkan på kemi (t.ex. sexvärt krom)	Miljörisk	2	3	2	6	Hårt bundet i den hårdnade formen, hantering av spill och färsk betong behöver göras.
4.3						3	0	
						3	0	

Results

- CO_2-emissions reduced with ~700 tonnes
- Performance requirements fulfilled & verified in full scale
- Logistics for fly ash assured by ready-mix supplier
- All need for post-cooling eliminated
- H&S for craftsmen substantially improved
- Lilla Edet-project steering group approved implementation



Spin-off - Concrete guideline

- Set minimum requirements - use existing low emission products
- Stepwise lower the accepted level of emissions from concrete
- Open up for new ideas to encourage further improvement
- Valid for both ready-mix concrete and prefabricated concrete
- Two possible levels of requirements:
  - Basic level (minimum)
  - Advanced level (higher environmental ambition)

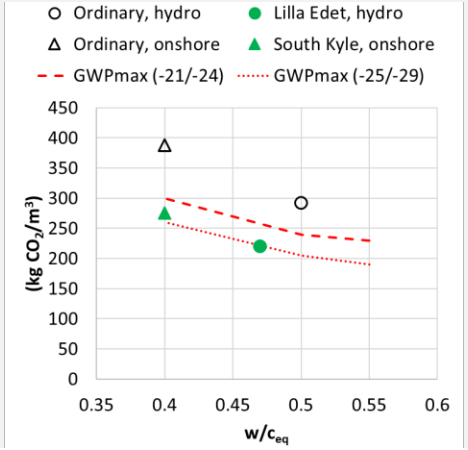
All improvements of concrete in terms of environmental aspects must be done under the prerequisite to fulfil specified requirements on structural **load-bearing capacity** and durability in relation to the **targeted service-life** of the final product. General requirements on constituents and concrete material properties in relation to relevant specified exposure class is given by the **European standard** EN 206-1 and, if available, **national** application standards or annexes.

Guideline: Environmental requirements on concrete suppliers

[Vattenfall ID]

Confidentiality class: C2 - Internal
Issue No. 1.0, valid from 2022-03-01

Exposure class according to EN-206-1	Type of structures (example)	Maximum GWP* (kg CO_2/m^3 of concrete)	
		2021-2024	2025-2029
XO, XC1	- Indoor structures - Foundations below ground water level, no frost action	< 230	< 190
XC3, XC4, XF3	- Foundations, frost action - Hydropower structures	< 240	< 205
XF4, XC4, XS3, XD3	- Foundations, bridges, frost, exposure to salts (thaw or marine)	< 300	< 260



First Movers Coalition

WORLD ECONOMIC FORUM

FMC cement & concrete commitment framework

Vattenfall commits to purchasing near-zero cement

Vattenfall will ensure that at least 10 percent of the cement/concrete procured for its projects is near-zero carbon cement/concrete, by 2030. The new commitment was made in connection to COP27 where the First Movers Coalition today launched a new sector - Cement and Concrete.

As a founding member of the First Movers Coalition (FMC), the global public-private partnership to scale new clean technologies to decarbonize the transport and materials sectors, Vattenfall now joins the latest sector launched.

"Vattenfall's goal is to enable fossil free living within one generation. We can only

First Movers Coalition

Cement & Concrete: Commitment scope

Construction & Engineering

"We commit to purchasing at least 10% (by volume) of our cement / concrete per year as near-zero cement / concrete[1] inclusive of any SCMs by 2030 and excluding fossil-based SCMs by 2035

Real Estate / Developers / Advisory

"We commit to ensuring / specifying that at least 10% (by volume) of the cement / concrete procured for our projects per year is near-zero carbon cement / concrete[1] inclusive of any SCMs by 2030 and excluding fossil-based SCMs by 2035

Out-of-scope technologies:

- [By 2035] Fossil-based SCMs (i.e., GGBS and fly ash)
- Carbon offsets

1. As per FMC definition

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First Movers Coalition

Cement & Concrete: Detailed commitment

Subject of demand signal

First Movers will make a commitment[1] for either cement or concrete:

1. Cement with embodied carbon below 184 kg CO_2e/ton[2,3]
2. Concrete that meets the embodied carbon limits below[4,5]

Specified compressive strength (f'_c in psi)[6]	Embodied carbon (kg CO_2e/m^3)
0 - 2500 psi	70
2501 - 3000 psi	78
3001 - 4000 psi	96
4001 - 5000 psi	117
5001 - 6000 psi	124
6001 - 8000 psi	144

Technological pathways

Solutions may include (but are not limited to):

- **CCUS**
- **Non-fossil-based SCMs**[7]
- **Fuel switching**
- Renewable electricity
- Energy efficiency improvements
- Decarbonated raw materials
- Alternative cement chemistries
- CO2 mineralization during curing

Out-of-scope:

- [By 2035] Fossil-based SCMs (i.e., GGBS and fly ash)
- Carbon offsets

Bolded abatement technologies seen as most critical to meeting FMC targets according to FMC research

1. Depending on locality-specific regulatory / technical requirements 2. Using 2021 baselines for US-based manufacturers with >80% clinker ratio chosen to avoid penalizing suppliers in countries with inherently low clinker ratios 3. Modules A1, A2, A3 in lifecycle analysis (cradle-to-gate) as per EPD standards for portland cement; Scope 1 and 2 emissions 4. Modules A1, A2, A3 in lifecycle analysis (cradle-to-gate) as per EPD standards for ready mix concrete; Scope 1 and 2 emissions 5. Standard applies to both RMC and precast concrete given that both are specified by compressive strength and do not present significantly different emissions profiles 6. Specified compressive strength of concrete using standard cylinders of six inches diameter and twelve inches height after 28 days of curing 7. Any supplementary cementitious materials from non-fossil-based processes (i.e., not GGBS and fly ash)
Sources: 2021 US-based NRMCA Member Industry-average EPD for Ready Mixed Concrete with 0-19% SCM; 2021 US-based Portland Cement Association Industry-average EPD for portland cement (91.4% clinker by weight); 2018 IEA Cement Low-Carbon Transition Technology Roadmap

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Thanks for your attention !