european cement research academy

Performance-based specifications for low carbon and circular concrete structures (PerfCon)

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Workshop European Commission – Cembureau

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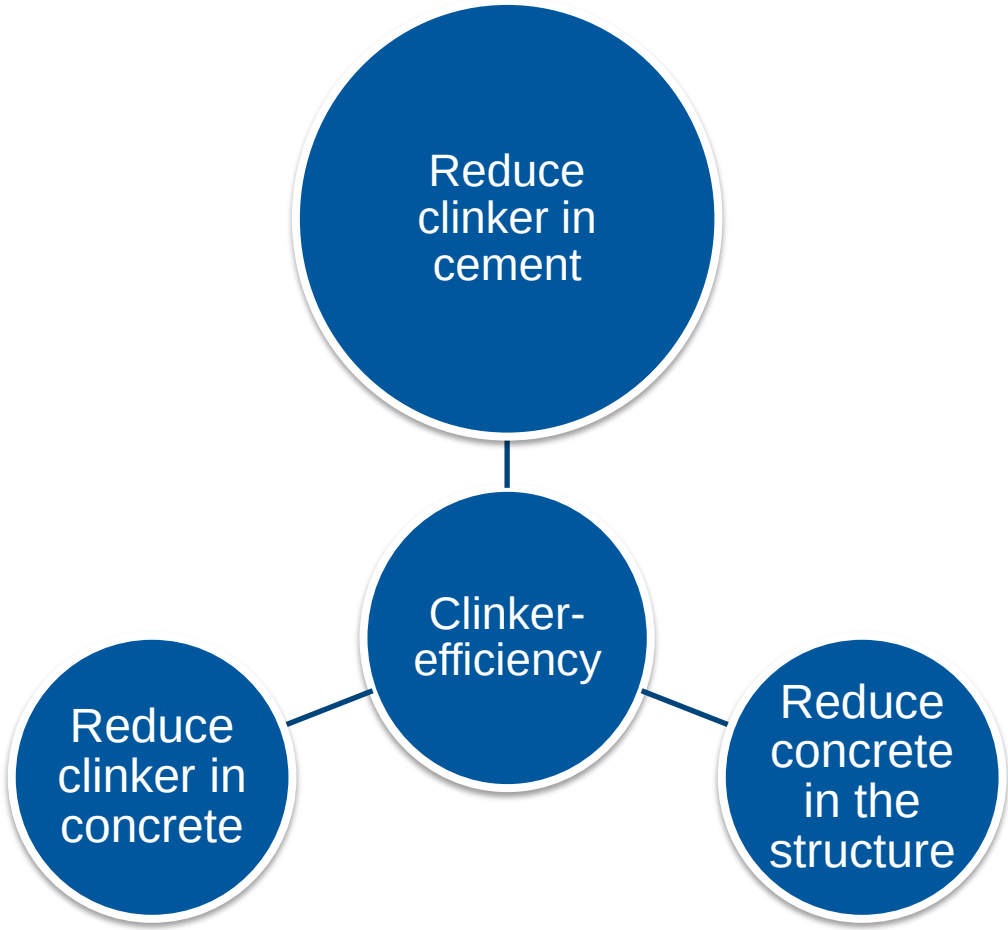
Ways to reduce the carbon footprint of concrete structures



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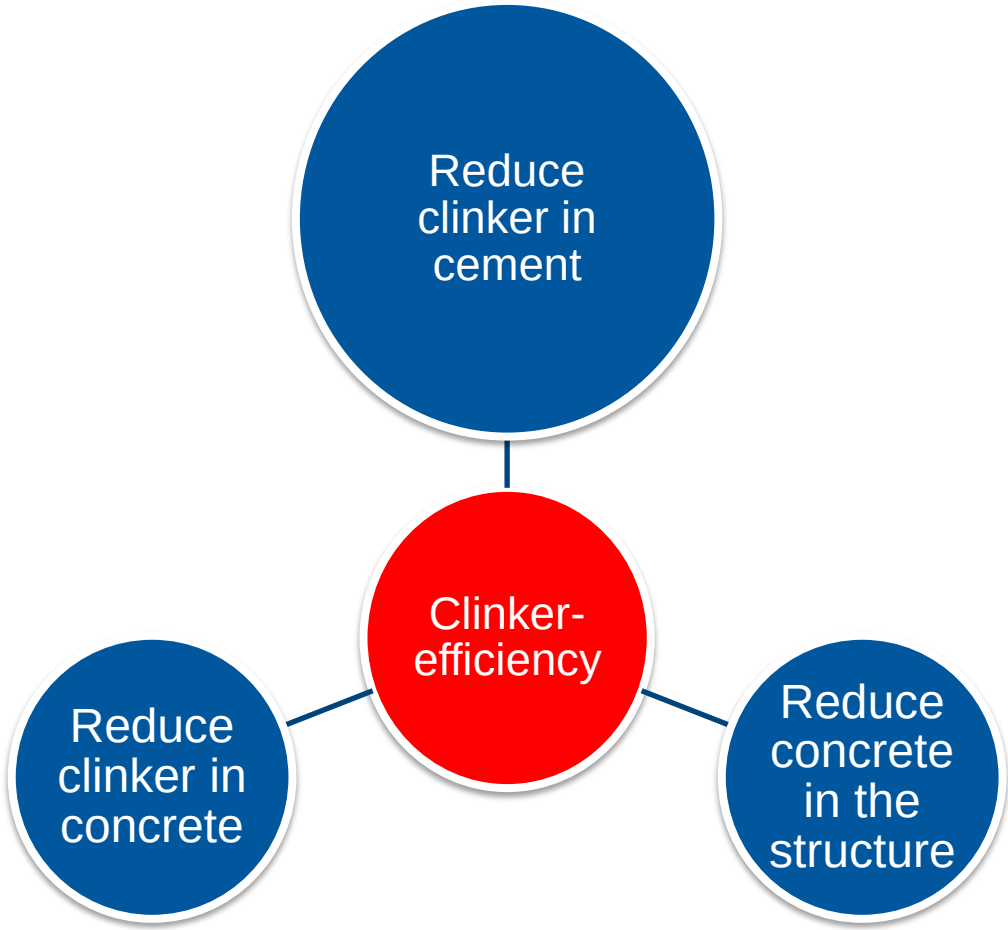


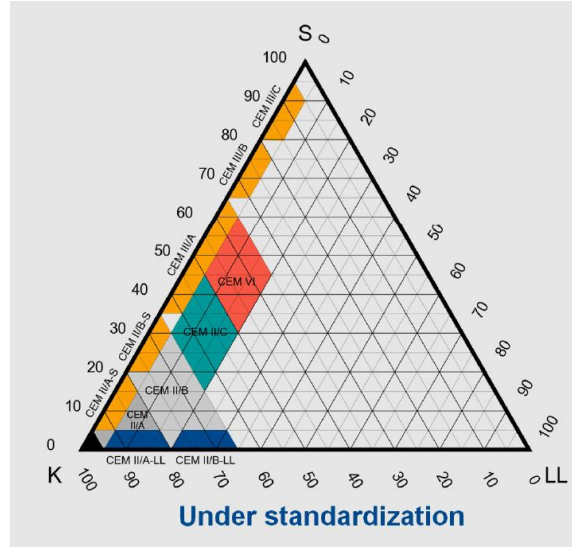
Ways to reduce the carbon footprint of concrete structures

Reduce clinker in cement

Clinker-efficiency

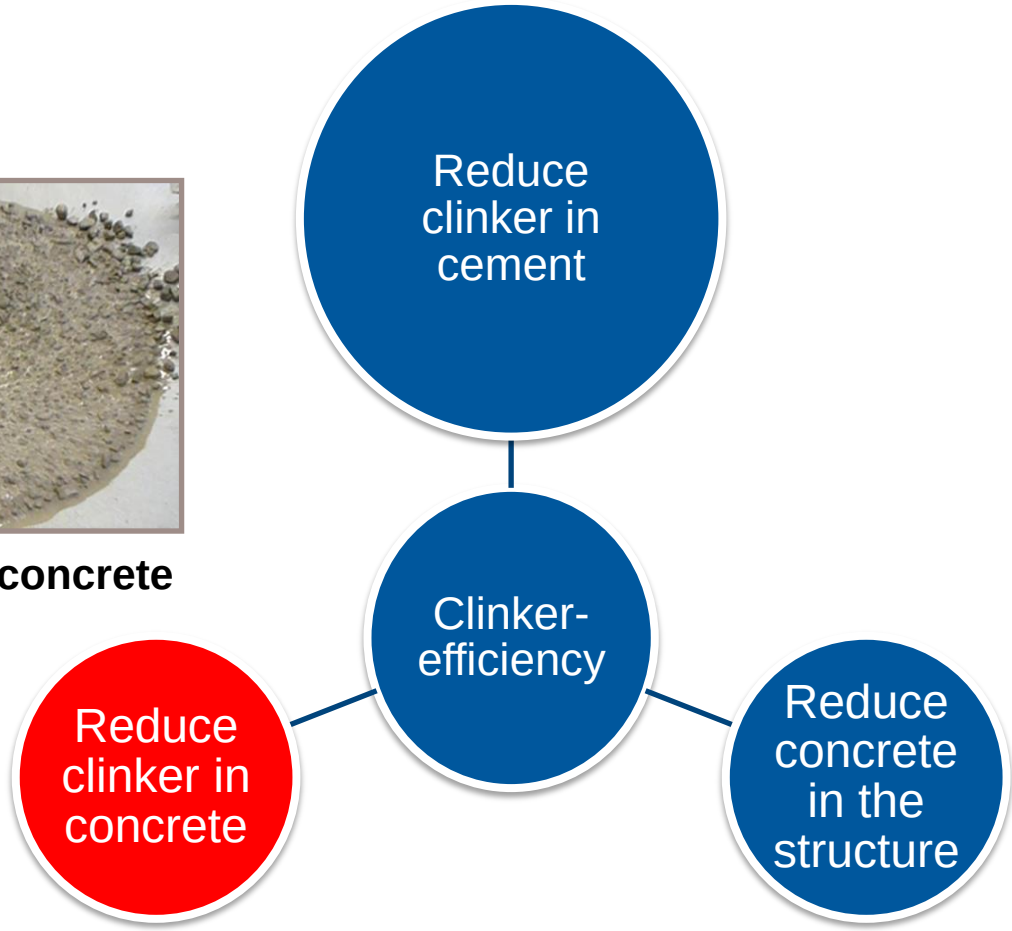
Reduce clinker in concrete

Reduce concrete in the structure



Ways to reduce the carbon footprint of concrete structures

Robust fresh concrete properties!



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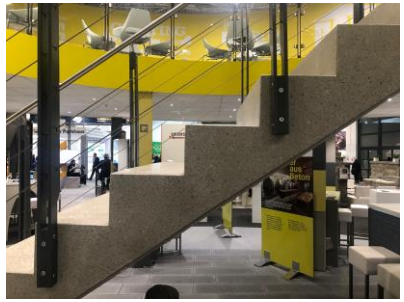

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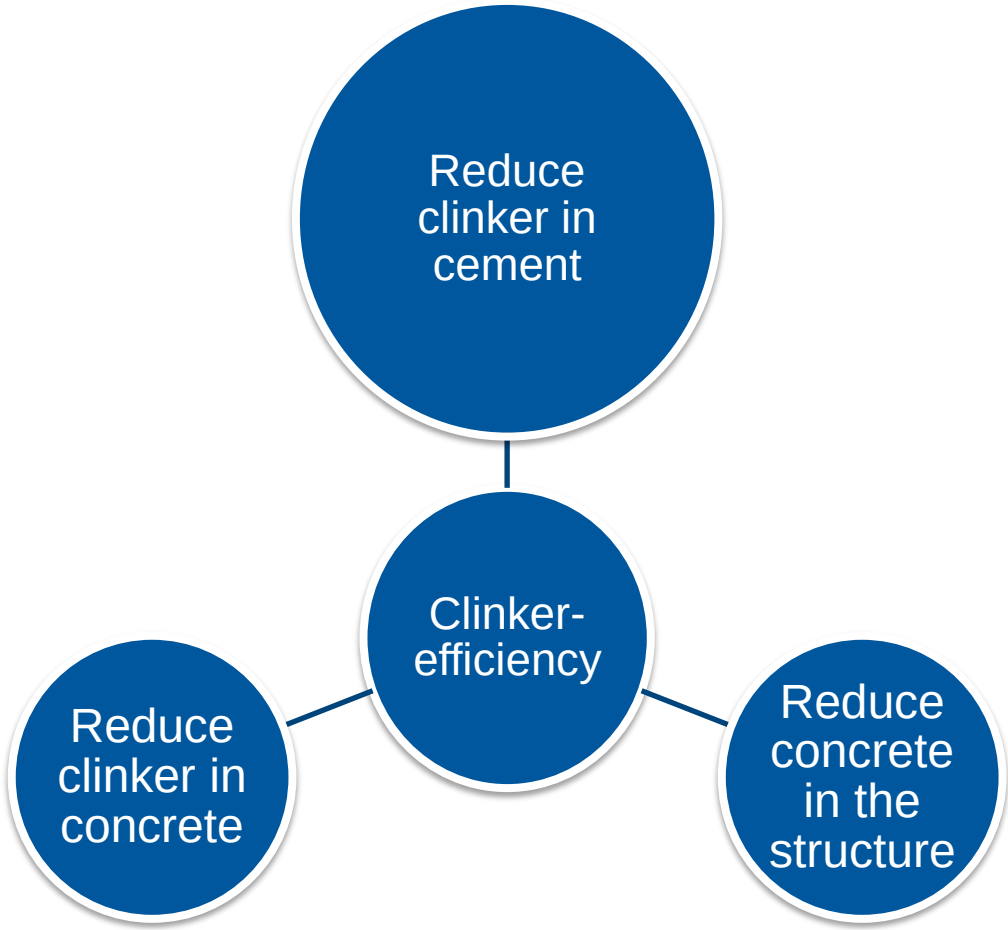


How far can we go?

How to measure clinker efficiency?

In cement:

- clinker content — clinker factor (kg/kg)

In concrete:

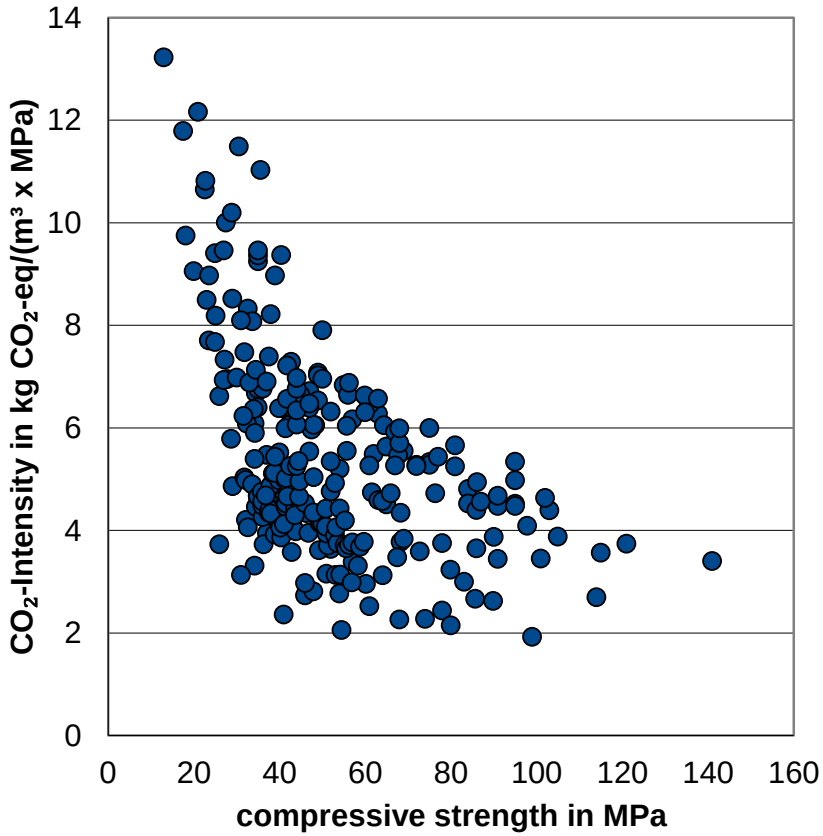
- clinker content: kg clinker / m³
- clinker intensity: kg clinker / (m³ MPa)
- CO_2 intensity: kg CO_2 / (m³ MPa)

In construction:

- CO_2 intensity per lifetime: kg clinker / (m³ MPa a)

Cement content and clinker efficiency in concrete

CO_2 intensity of concretes

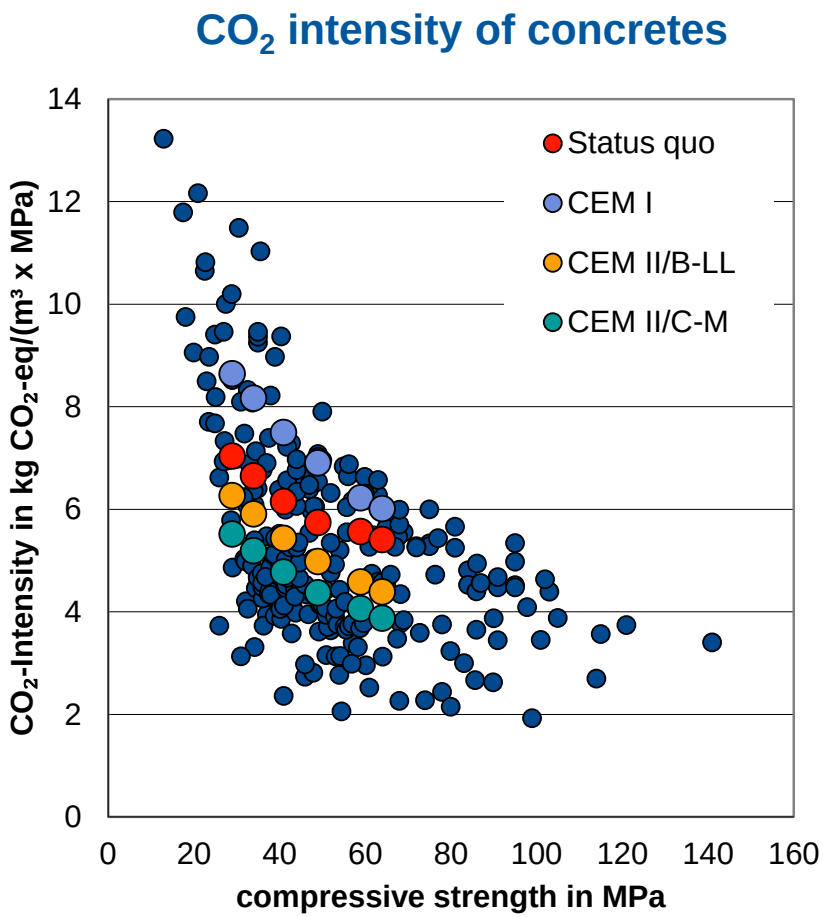


Concrete strength class	Marketshare % Germany 2016	min. in Exposure Class
C8/10	1.0	X0
C12/15	6.8	---
C16/20	1.9	**XC1**, XC2
C20/25	14.4	**XC3**
C25/30	39.8	**XC4, XF1**, XF2, XF3, XA1
C30/37	21.4	XS1, XD1, XF4
C35/45	11.2	XS/D 2, 3, XA 2,3
C45/55	0.6	---
C50/60	0.3	---

~ 64 % = 32 Mio m³

source: database and evaluation VDZ; strength class distribution BTB

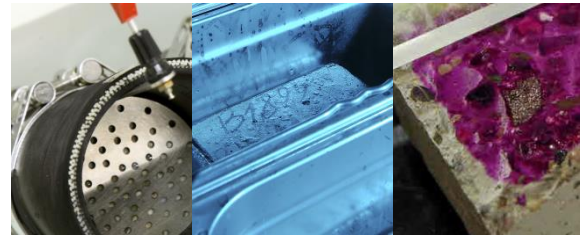
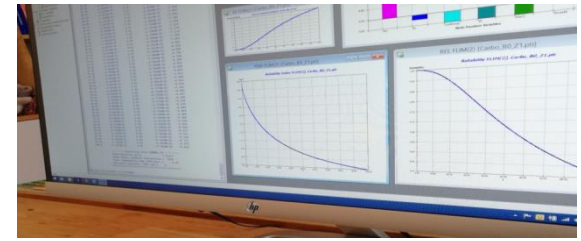
Cement content and clinker efficiency in concrete



- CEM II/B-LL cements and CEM II/C cements:
  - at least indoor and “normal” outdoor concretes (approx. 65% of all in-situ concrete in Germany)
- Reduction potential of the CO_2 intensity approx. 25%

Validation of durability performance for concrete

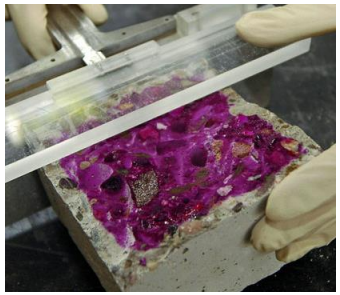
Performance based on

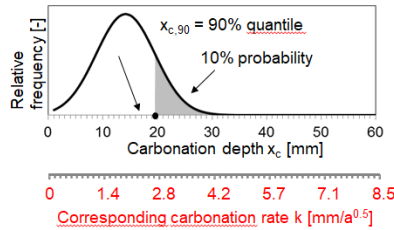
Experience	Testing (laboratory)	Calculation
		
Description/ deemed-to-satisfy rules	Assessment background/ limit values	Limit state
▪ EN 206 + NAR ▪ Exposure classes ▪ min c, max w/c ▪ c_{min} etc.	▪ Test procedures ▪ CEN/TR 16563 ▪ European technical assessment (EAD/ETA)	▪ Models ▪ fib Model Code „Service Life Design“ ▪ ISO 16204

Questions to be answered regarding testing and models

Are the test methods and models

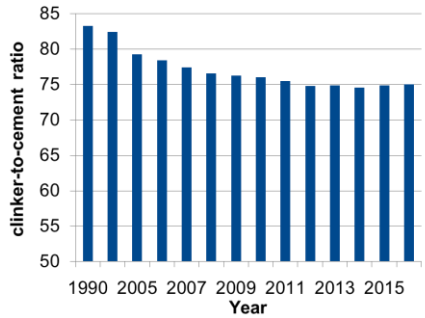
- in line with practical experience?
- fit for use for new eco-efficient concretes (low-clinker cements, new / higher amounts of main constituents, recycled aggregates…) ?

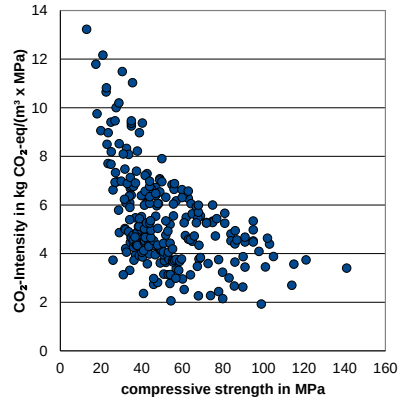


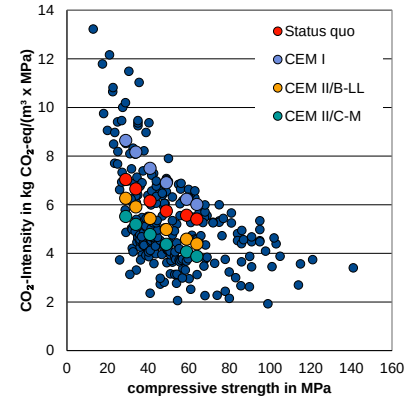


ERC	depth [mm] / rate [mm/a$^{0.5}$]
RC20	20 / 2.8
RC30	30 / 4.2
RC40	40 / 5.7
RC50	50 / 7.1
RC60	60 / 8.5

From clinker factor to embedded CO_2







Consequences

- Embedded CO_2 as KPI/benchmark for CO_2 performance
  - This transitions to be supported by all stakeholders
  - Finally CO_2 savings through less clinker production

The missing link

Cement
less clinker
in cement

- clinker efficient cements
- higher utilization of constituents of good availability

Concrete
less clinker
in concrete

- higher flexibility of concrete adapted to exposure classes
- combine CO_2 performance with lifetime durability parameters

Construction
intelligent use
of concrete

- optimize for CO_2 performance
- ensure best possible CO_2 performance at end of life time

We need to cooperate along the whole value chain

General project idea

- Use of clinker-efficient cements and recycled materials in concrete construction
- Covering the entire value chain:
  cement production – use in concrete – performance in constructions – new construction methods
- Incorporation of circular economy issues (use of recycled components in concrete and possibly in cement)
- Assessment of test methods and models with respect to practical application
- Developing indicators for technical and ecological performance
- **Ways to reduce the carbon footprint of concrete structures: Possibilities and limits**

General project idea

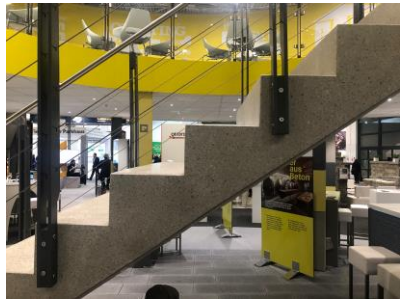
- Project idea was developed in CEN / TC 104 / SC1 / WG1
- European project, several project partners
- Budged: approx. 10 million € for 5 years
- Potential reduction of CO_2 intensity by 25 %
- Possible funding options in the field of circular economy, resource efficiency; advanced materials:
  - e.g. H2020-CE-SC5-07-2018-2019-2020, NMBP-Calls, ERA-MIN, Interreg & Innovation Fund: Less / low carbon cement
  - Future: Horizon Europe / Interreg, Joint Programing Initiatives (e.g. SPIRE) & Innovation Fund

From low carbon cements to CO_2 efficient structures

- After development of low-carbon cements and low-carbon concretes, looking on strategies to develop low-carbon construction elements
- Taking into account new construction technologies, for example
  - hollow-core slabs (partly already available)
  - gradient concrete
  - 3d-printing
- Analyse the effect on technical and ecological performance

- Build a demonstrator using all the above mentioned low-carbon technologies

Ways to reduce the carbon footprint of concrete structures



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- Taking into account new construction technologies, for example
  - hollow-core slabs (partly already available)
  - gradient concrete
  - 3d-printing
  - Carbon reinforced concrete
- Analyse the effect on technical and ecological performance

- Build a demonstrator using all the above mentioned low-carbon technologies
- **Possible funding programme**: **Innovation Fund for a demonstrator**

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