

Evolving the well-established

Low Carbon Innovations in the Concrete sector

vdz

(Performance) Testing as a basis for application

Christoph Müller, VDZ concrete department and Chairman CEN/TC 104

EIC Portfolio Projects' Webinar

Advancing low-carbon cement and concrete through standardisation

September 3 2026 (online)

VDZ – Business units



Research and
innovation



Services and
consulting



Certification



Standardisation

VDZ Concrete Technology: From lab to building



Our services for performance, durability and sustainability



Performance testing



Special case: ASR Performance



Approval procedures



Product optimization



Building inspection



LCA and EPDs

Introduction of innovations in the concrete sector

Introduction of innovations in the concrete sector

Lab Performance Testing as a basis for approval procedures or standards



- Basis for CE-marking
- Germany: Needs national technical approval for the application

National technical approval for

- a product or
- the application of a standardized product

Application rules for cements in DIN 1045-2:2023 (NAD to EN 206), e. g.

- CEM II/B-M (S-LL) and
- CEM II/C-M (S-LL)

VDZ accepted as test lab and consultant by German Building Authorities (DIBt)

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"Next Base SR03" Calcium Sulphoaluminate based Cement

EAD 150001-00-0301 - CALCIUM
SULPHOALUMINATE
BASED CEMENT – January 2017



European Technical Assessment
ETA-13/0417 of 22 July 2018



National Technical Approval Z-3.15-2130
Concrete with Calcium Sulphoaluminate
based Cement "Next Base SR03" acc. to
ETA-13/0417

VDZ involvement

Development of the EAD

Product type testing

Testing in mortar and
concrete

Introduction of innovations in the concrete sector

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National technical approval for

- a product or
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Cement type	Number	Exposure classes	min K max LL in %
CEM II/B-M	30	all	65/20
CEM II/C (without F as HB)	12	all	50/20
CEM II/C + FA	4	all	
CEM IV and CEM V	4	¹⁾	40/0
Cements with F (NB) ²⁾	8	all	95-35/0-20
Cements with F (HB) ²⁾	8 ³⁾	all	80-50/20
Cements with F (HB) ²⁾ + FA	6/8 ³⁾		
CEM II/C	8	all except XF2, XF3, XF4	50/20
CEM II/C + FA	11/21		
CEM VI	1	all except XF2, XF3, XF4	35/20
CEM X	2	all except XF2, XF3, XF4, XA2/3, XM2/3	35/37

¹⁾ 1 x CEM IV all, 1 x CEM V all, 1 x CEM V without XF4, 1 x CEM V only XC4/XF1

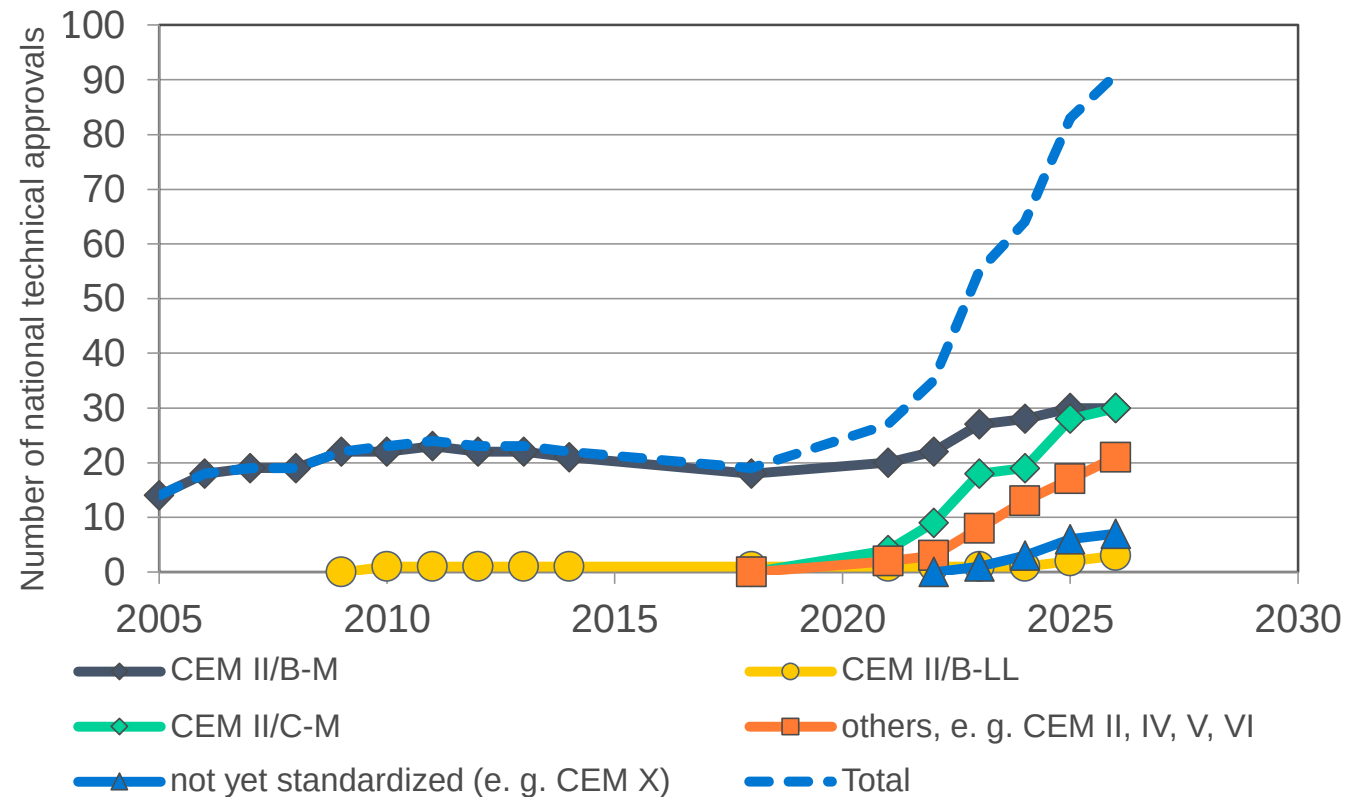
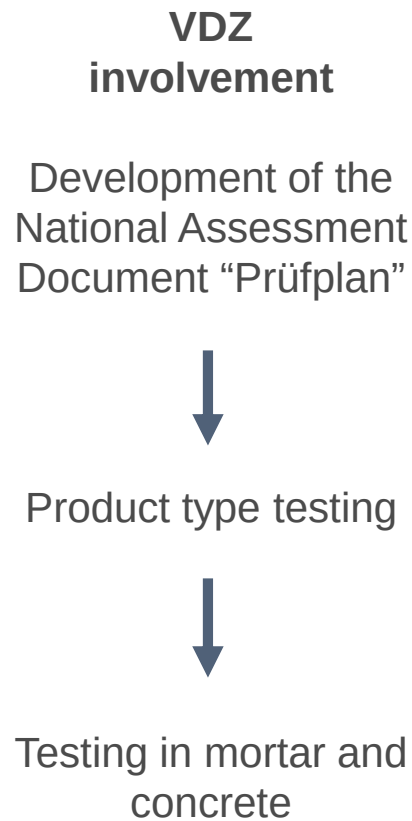
²⁾ NB = Minor constituent, HB = Main constituent ³⁾ 2 CEM II/A-F and 6 CEM II/C-M (X-F)

(see https://www.dibt.de/fileadmin/verzeichnisse/NAT_n/SVA_3.pdf)

K = Klinker, LL = Limestone, F = Recycled fines, FA = Fly ash

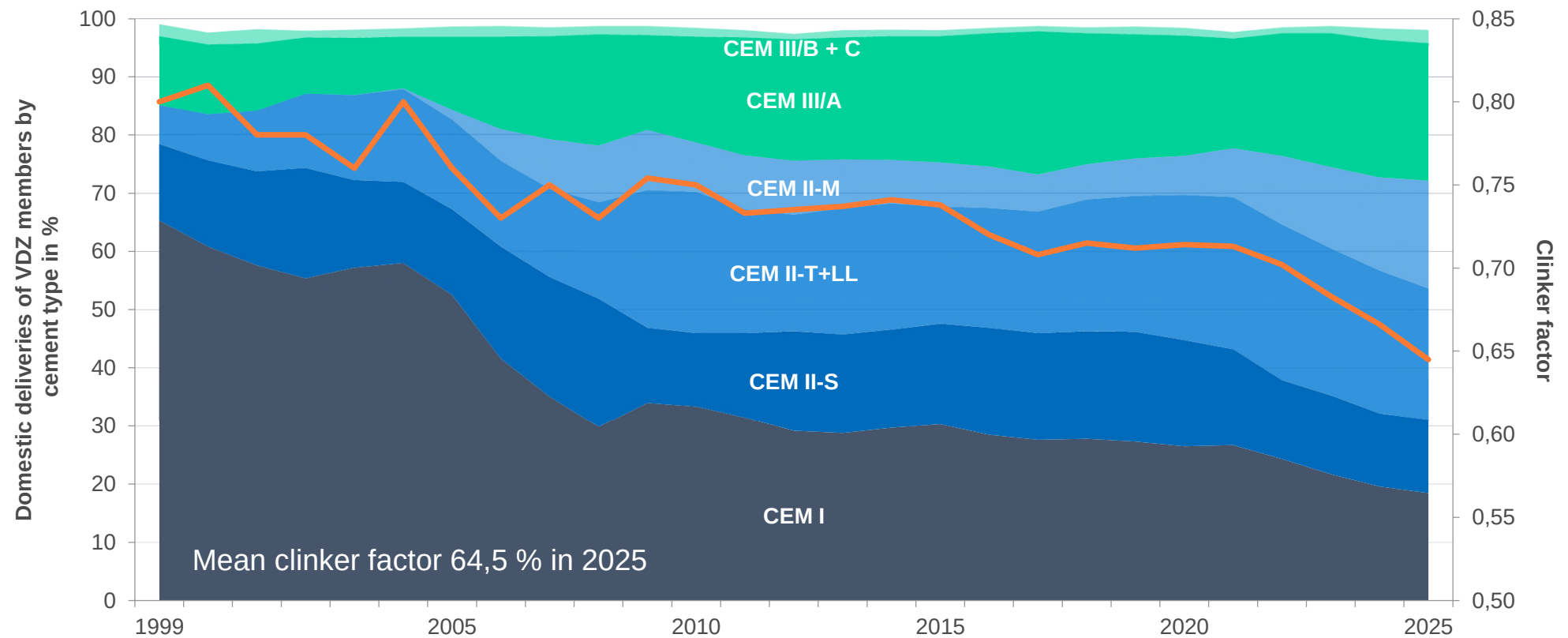
Introduction of innovations in the concrete sector

Lab Performance Testing as a basis for approval procedures or standards



Cement portfolio and clinker factor

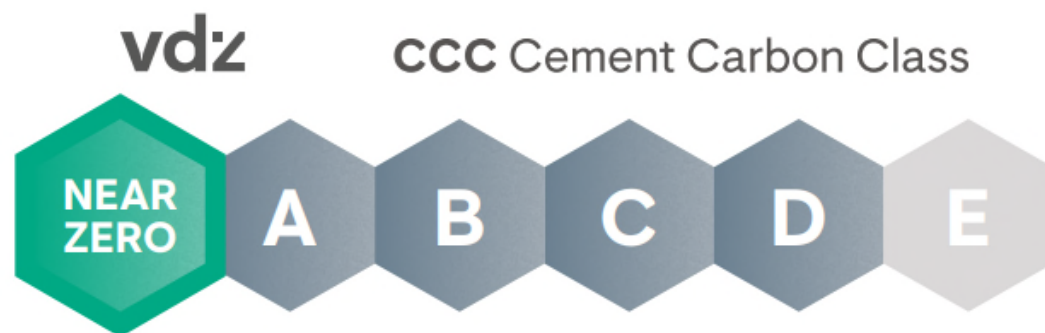
Development of the cement portfolio and the clinker factor in Germany from 1999 to 2025



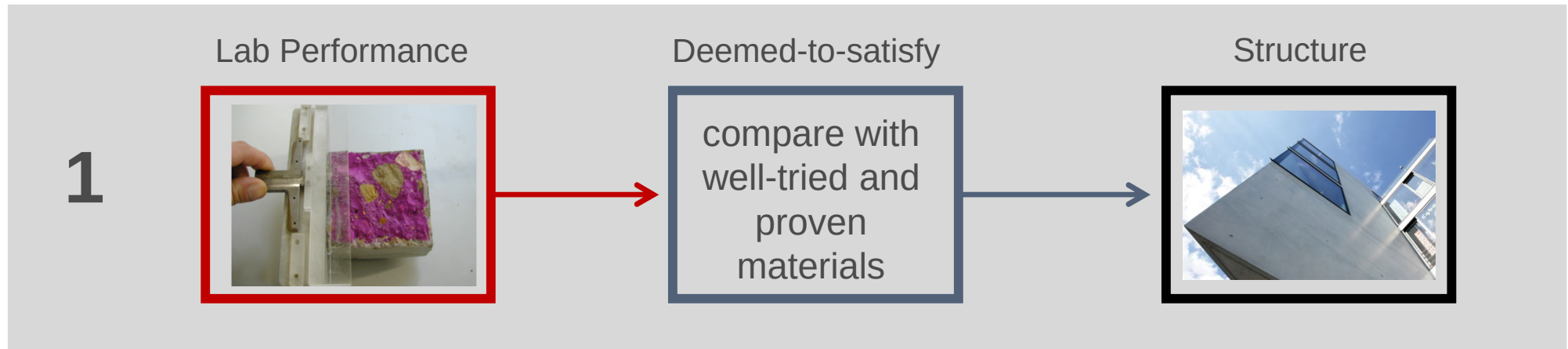
Source: VDZ

Note: The difference from 100 per cent is distributed across CEM IV, CEM V and other binders

Low carbon cement



CCC-Classes for cement			Limit (GWP) CO ₂ eq / tonne cement	Examples
Climate-friendly	Low emission	D	$400 \leq \text{GWP} < 500$	CEM II/B-S, CEM II/B-M
		C	$300 \leq \text{GWP} < 400$	CEM III/A, CEM II/C-M
		B	$200 \leq \text{GWP} < 300$	CEM III/B
		A	$100 \leq \text{GWP} < 200$	CEM III/C
	Near Zero	NZ	< 100	---

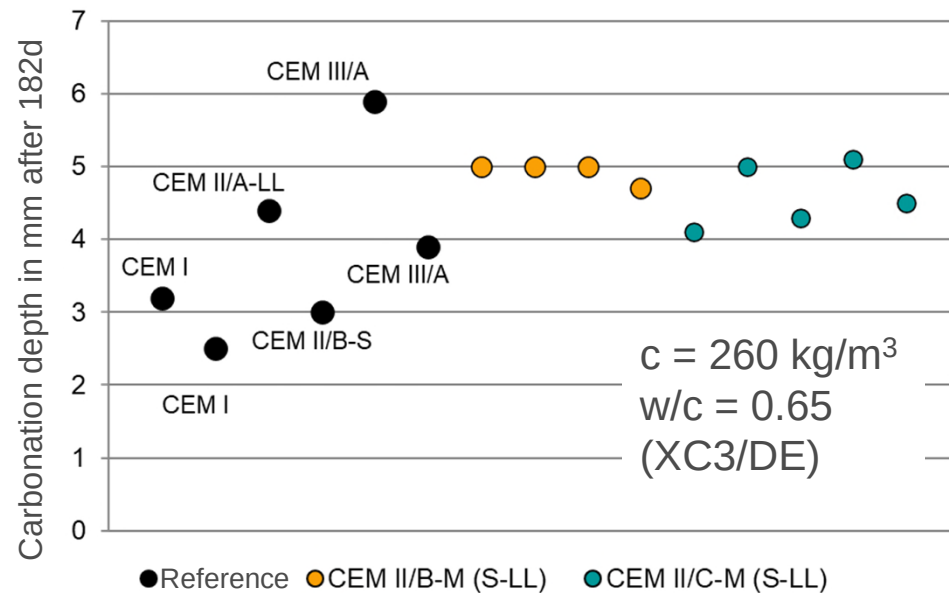


Durability: Carbonation as an example

A large proportion of concrete is used as reinforced concrete.
Sufficient resistance to carbonation-induced reinforcement corrosion can therefore used as a benchmark.

Carbonation of concrete with different cements

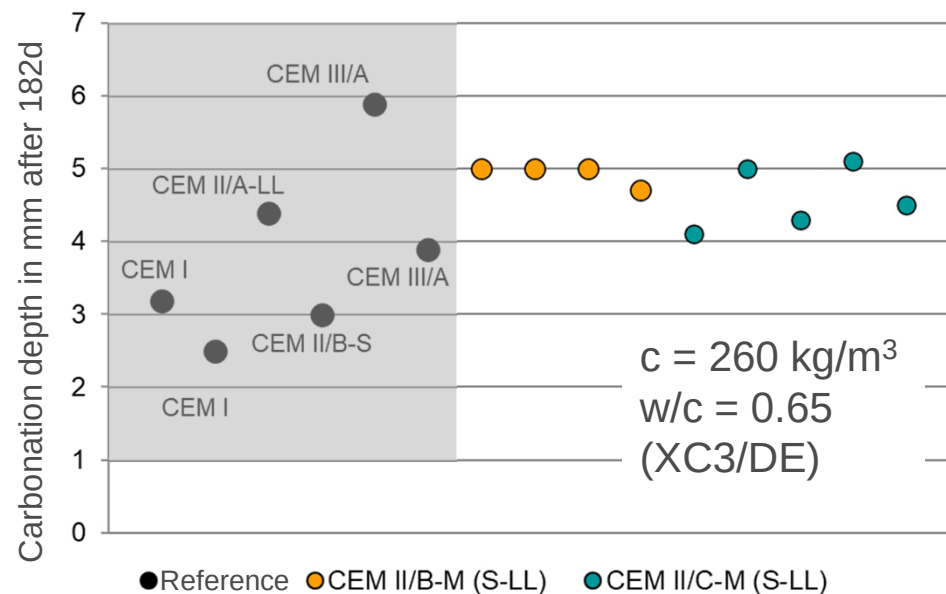
Example: Concrete for an exterior component, sheltered from rain (XC3) in Germany (DE)



Source: VDZ

Carbonation of concrete with different cements

Example: Concrete for an exterior component, sheltered from rain (XC3) in Germany (DE)



Today: no differentiation by cement type within the same exposure

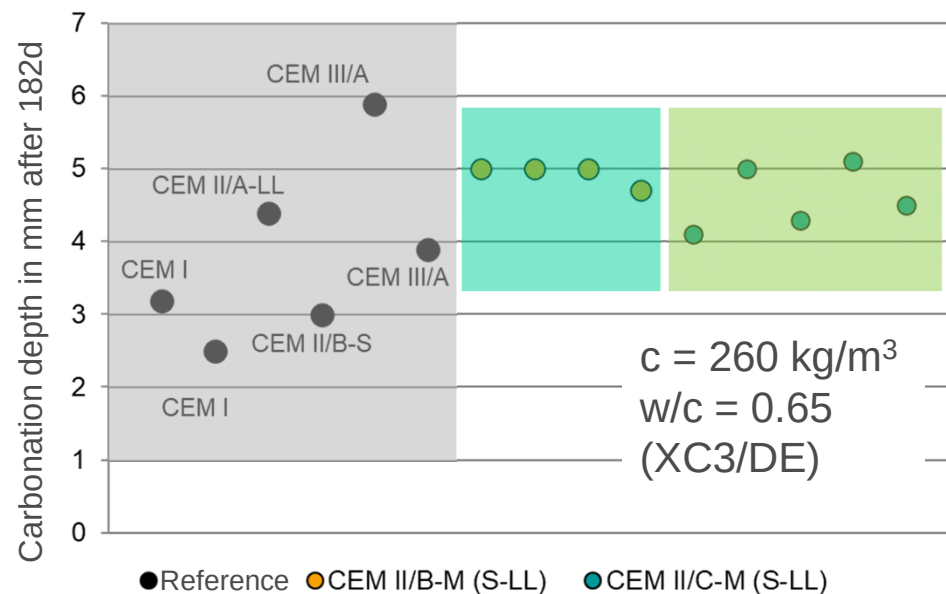
- Portland cement CEM I (≥ 94 % clinker)
- Slag cement CEM II/B-S (≥ 65 % clinker)
- Limestone cements CEM II/A-LL (≥ 80 % clinker)
- Slag cements CEM III/A (~ 35 -50 % clinker)

Well-tried and proven cements

Source: VDZ

Carbonation of concrete with different cements

Example: Concrete for an exterior component, sheltered from rain (XC3) in Germany (DE)



New cements CEM II-M comparable with well-tried and proven cements

Today: no differentiation by cement type within the same exposure

- Portland cement CEM I (≥ 94 % clinker)
- Slag cement CEM II/B-S (≥ 65 % clinker)
- Limestone cements CEM II/A-LL (≥ 80 % clinker)
- Slag cements CEM III/A (~ 35 - 50 % clinker)
- Ternary cements CEM II/B-M with ≥ 65 % clinker, ≤ 20 % limestone and slag
- Ternary cements CEM II/C-M with ≥ 50 % clinker, ≤ 20 % limestone and slag

Source: VDZ

Introduction of innovations in the concrete sector

Lab Performance Testing as a basis for approval procedures or standards

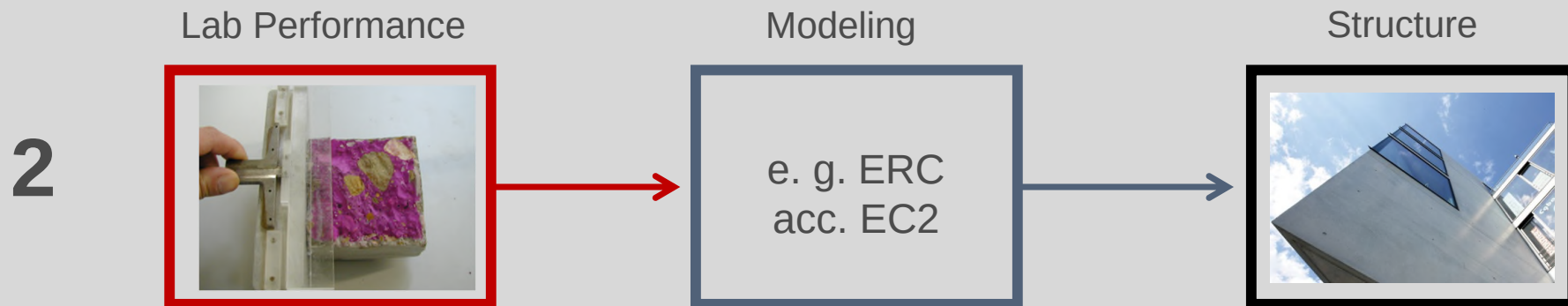
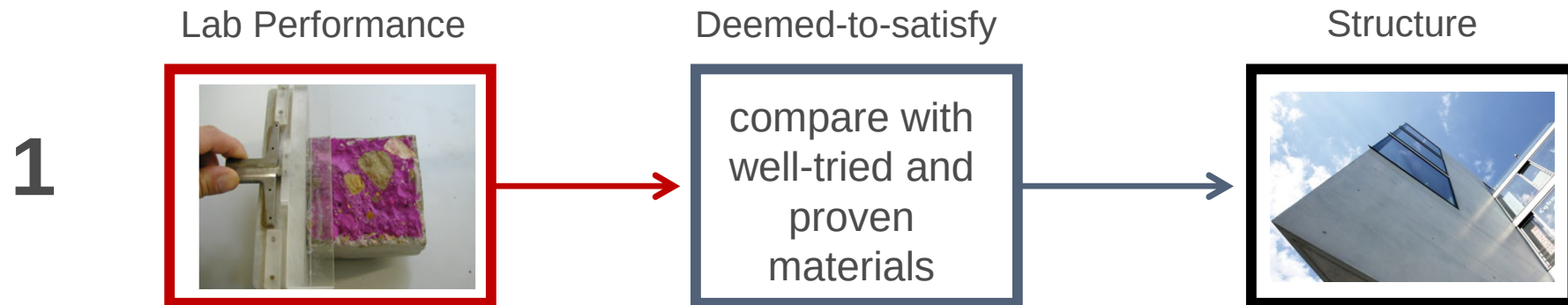
Cement type	Exposure classes	Minimum clinker content in %
CEM II/A and CEM II/B with Q as main constituent	all except XF2, XF4	80/65
CEM II/B-M (S-LL, V-LL, T-LL)	all except XF2, XF3, XF4	65
CEM II/C-M (S-LL)		50
CEM V/A (S-V)	all	40
CEM VI (S-V)	all	35
CEM VI (S-P)	all except XF2, XF4 and XM2/XM3	
CEM VI (S-LL)	XC0, XC1, XC2	



Application rules for cements in DIN 1045-2:2023 (NAD to EN 206), e. g.

- CEM II/B-M (X-LL) and
- CEM II/C-M (S-LL)

VDZ accepted as test lab and consultant by the concrete sector



Performance-based approach

Exposure Resistance Classes: Example Carbonation

ERC	Exposure class (Carbonation)							
	XC1		XC2		XC3		XC4	
	Design service life (years)							
	50	100	50	100	50	100	50	100
XRC 0,5	10	10	10	10	10	10	10	10
XRC 1	10	10	10	10	10	15	10	15
XRC 2	10	15	10	15	15	25	15	25
XRC 3	10	15	15	20	20	30	20	30
XRC 4	10	20	15	25	25	35	25	40
XRC 5	15	25	20	30	25	45	30	45
XRC 6	15	25	25	35	35	55	40	55
XRC 7	15	30	25	40	40	60	45	60

NOTE 1 The designation of XRC classes for resistance against corrosion induced by carbonation is derived from the carbonation depth [mm] (characteristic value 90 % fractile) assumed to be obtained after 50 years under reference conditions (400 ppm CO₂ in a constant 65 %-RH environment and at 20 °C). XRC has the dimension of a carbonation rate [mm/√(years)].

NOTE 2 The recommended minimum concrete cover values $c_{min,dur}$ assume execution and curing according to EN 13670 with at least Execution Class 2 and Curing Class 2.

NOTE 3 The minimum covers can be increased by an additional safety element $\Delta_{dur,y}$ considering special requirements (e.g. more extreme environmental conditions).

Optimization regards

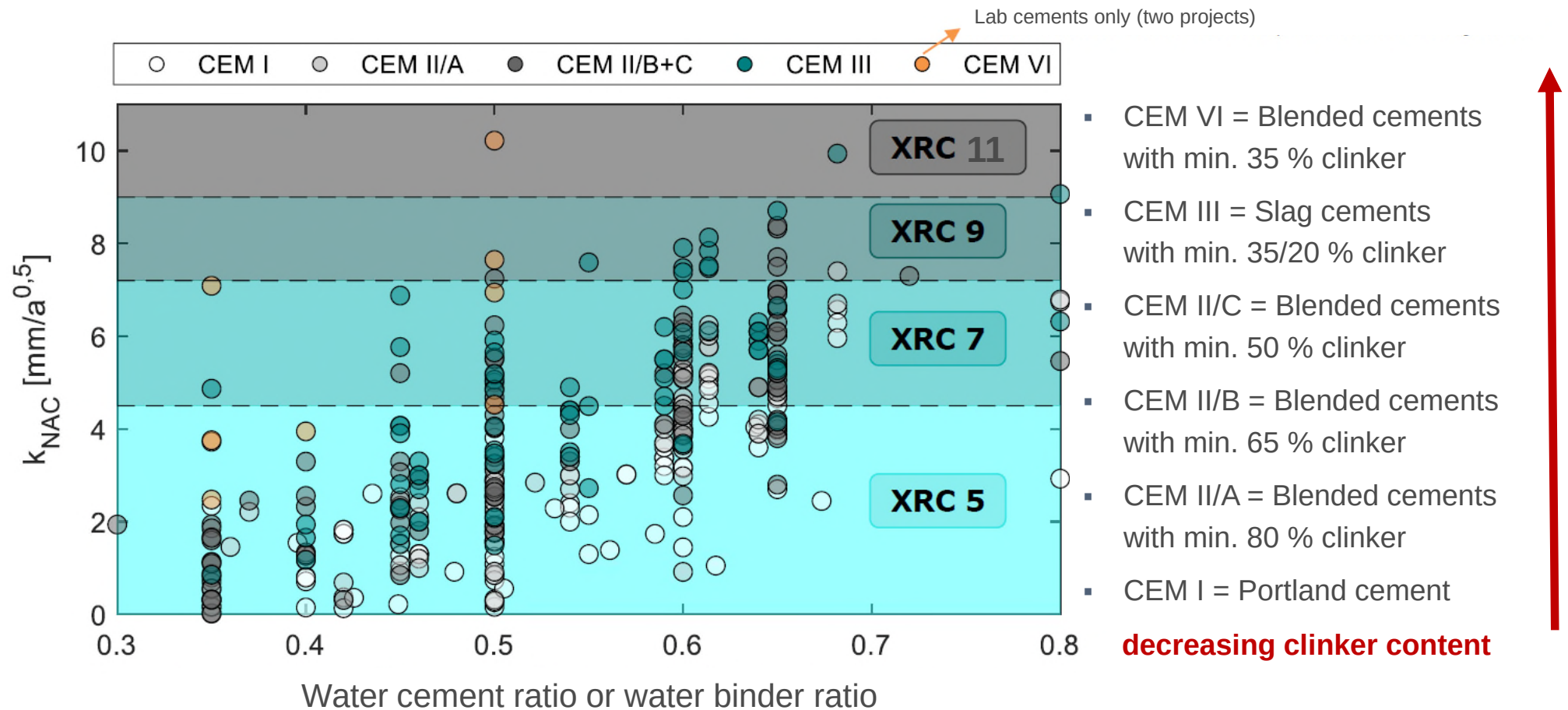
- concrete performance
- concrete cover
- service life

Increase in the **minimum concrete cover in mm** due to decrease in carbonation resistance

Definition of the carbonation behavior under reference conditions

Source: Eurocode 2: Design of concrete structures - Part 1-1: General rules - Rules for buildings, bridges and civil engineering structures - DRAFT FprEN 1992-1-1:2023

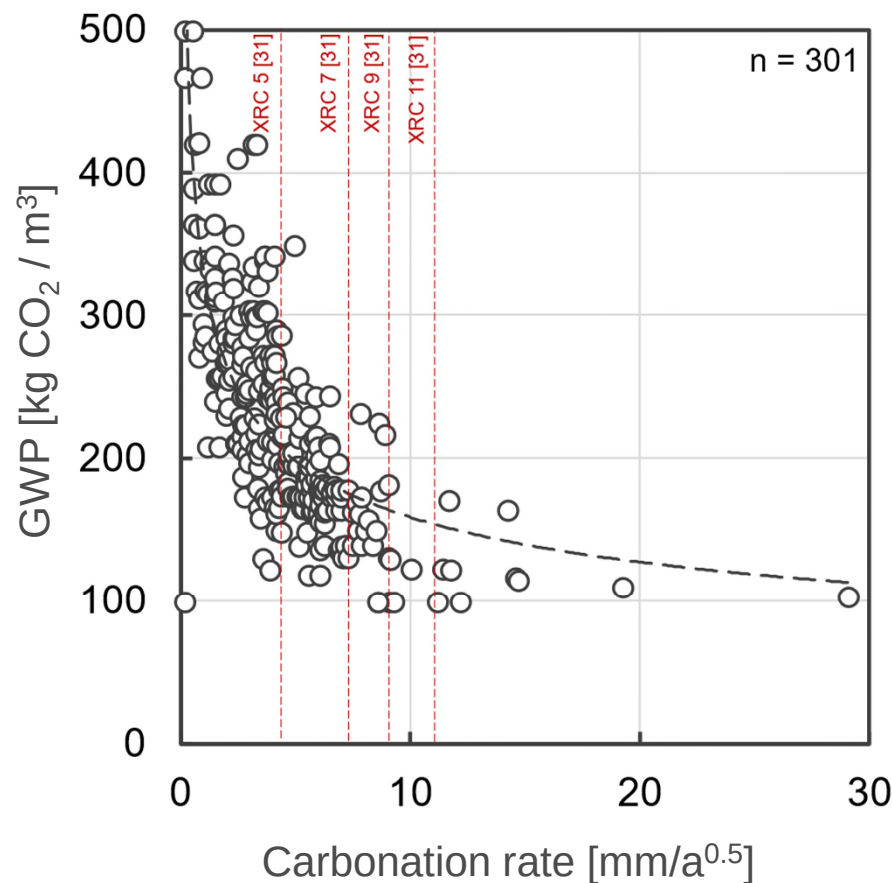
Example for a data-base on carbonation (n = 362)



Source: Carbonation data-base compiled by the German committee of reinforced concrete
Figure provided by Wibke Hermerschmidt, Issue 666 DAfStb

GWP potential = f (carbonation rate)

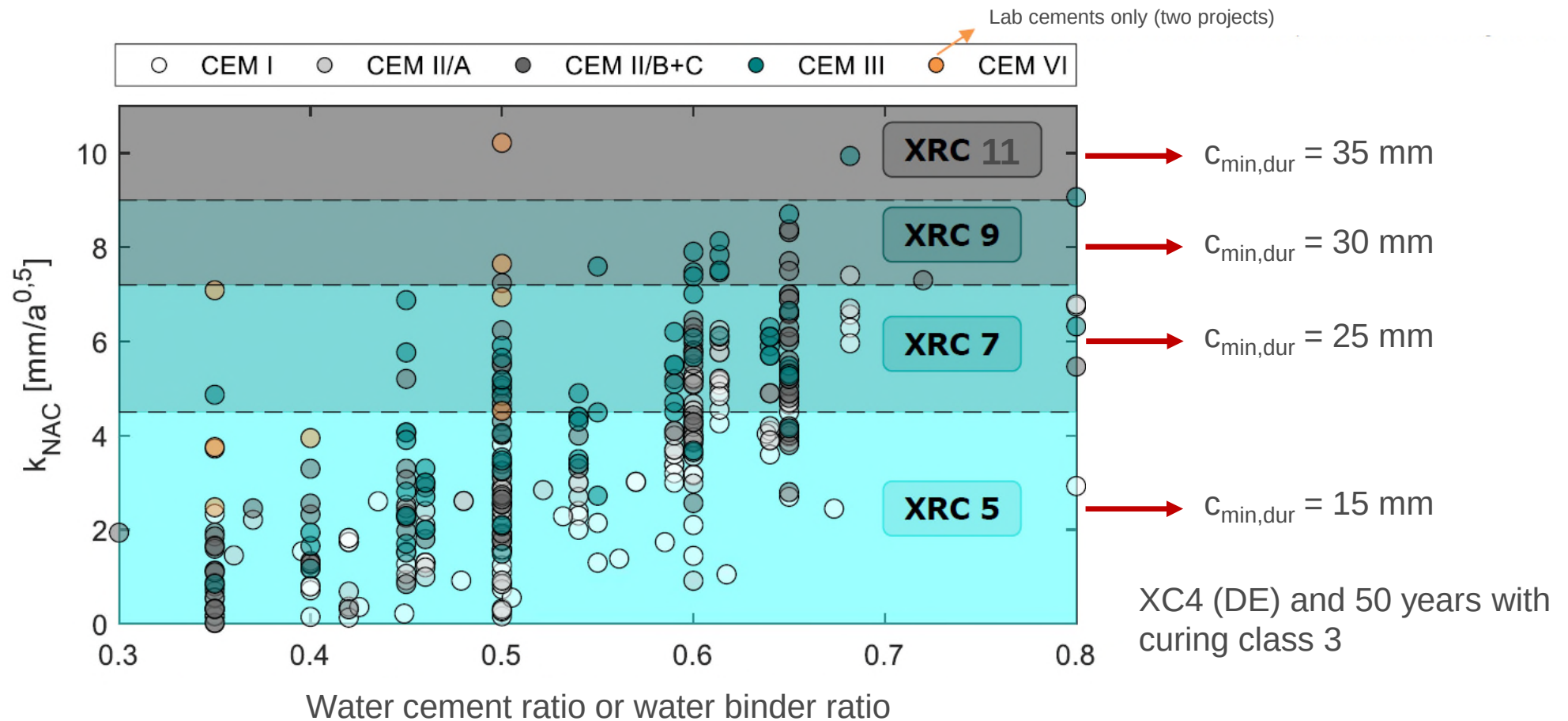
Source: Schack, Müller, Palm, Haist – Journal beton 7+8 2026



- The carbonation rate increases as GHG emissions decrease
- Concretes containing CEM I (with up to 500 kg CO₂/m³) have the lowest carbonation rates, partly less than 1.0 mm/a^{0.5}
- With GHG emissions of 130 kg CO₂/m³, a carbonation rate of less than 10 mm/a^{0.5} can be achieved
- Within the performance-based approach the targeted adjustment of the carbonation rate in combination with the resulting GHG emissions presents an optimisation challenge

[31] = German committee of reinforced concrete, ERC Guideline – DRAFT 2025

Example for a data-base on carbonation (n = 362)



Source: Carbonation data-base compiled by the German committee of reinforced concrete
Figure provided by Wibke Hermerschmidt, Issue 666 DAfStb

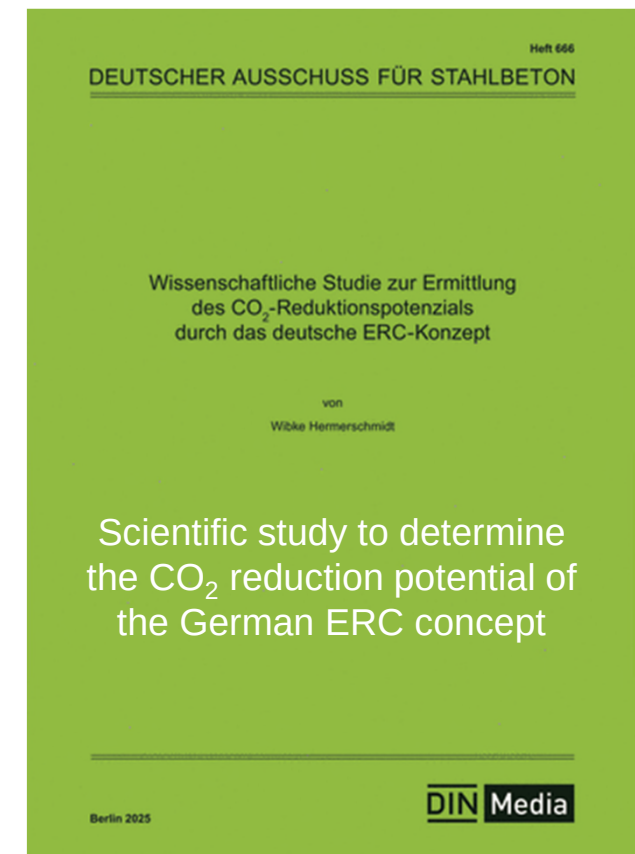
What is the CO₂ reduction potential of the (German) ERC performance concept compared to the current descriptive rules system of DIN 1045?

CO₂ savings (per m³ concrete): Description vs. ERC concept (DE)

DIN 1045-2 (descriptive) vs. ERC (performance):

+/- 20 % CO₂ per m³ of concrete

“In order to make the most of the ERC-performance-approach at the structural level (per m²), an integrated design is required, in which concrete technology and structural requirements (slenderness, concrete cover etc.) are coordinated.”



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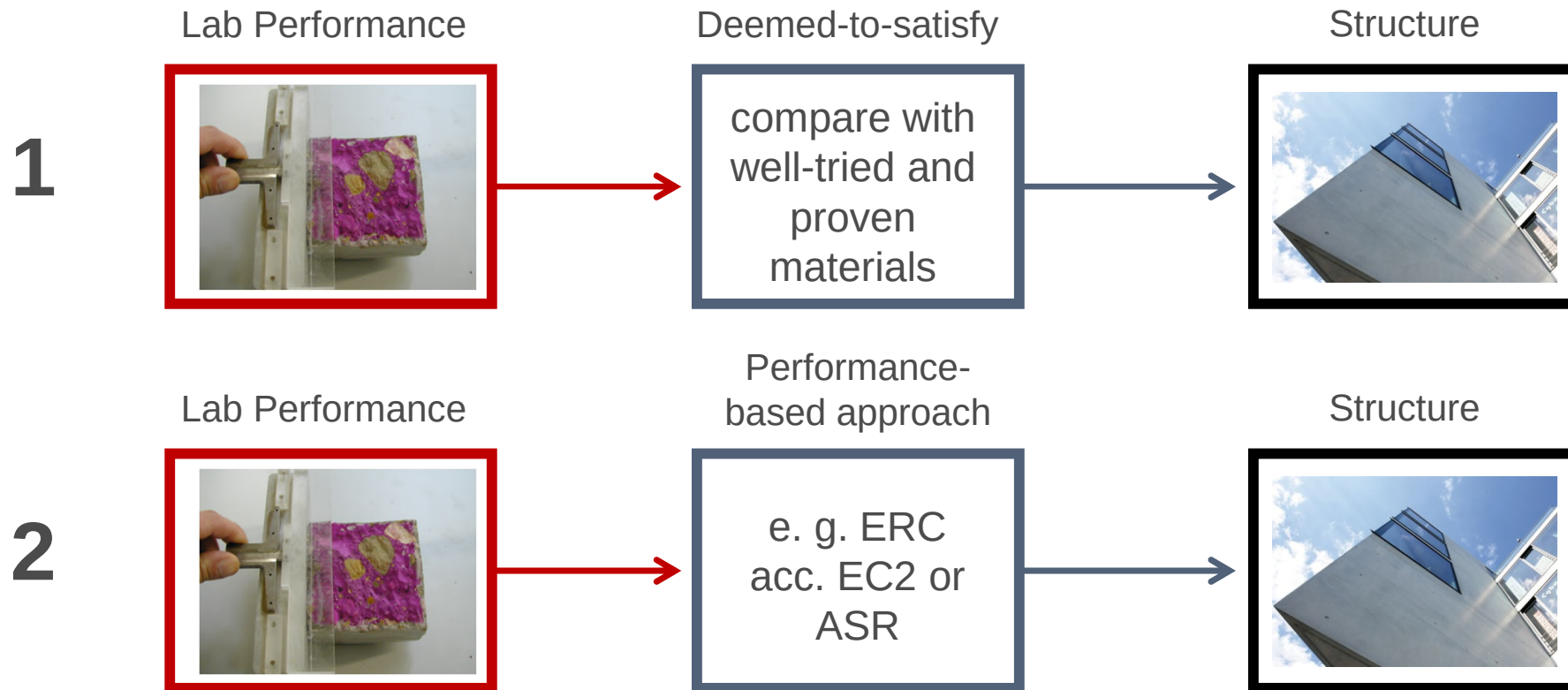


Application rules for cements in
DIN 1045-2:2023

(NAD to EN 206), e. g.

- CEM II/B-M (S-LL) and
- CEM II/C-M (S-LL)

Innovative, low carbon materials can be introduced to application by approval procedures and standards; based on lab performance testing



ERC = Exposure resistance classes acc. to Eurocode 2 (EC2)

ASR = Alkali-silica-reaction

Lab performance testing can be used to define deemed-to-satisfy rules or for performance-based approaches

CEN/TC 104 – Concrete and related products

Structure of CEN/TC 104 – Concrete and related products

CEN/TC 104 is the technical body which drafts the relevant standards for concrete and related products

CEN/TC 104 – Concrete and related products (Chair: Christoph Müller)

Subcommittees	
SC 1	Concrete - Specification, performance, production and conformity
	WG 1 Exposure Resistance Classes (ERC)
	WG 2 Use of digital tools and AI in FPC
	WG 3 Test methods
	WG 4 Concrete - Specification and conformity
	WG 5 ASR provisions for concrete
SC 2	Execution of concrete structures
	WG 4 Installation of post-tensioning kits for prestressing
	WG 5 Steel fibre reinforced concrete
	WG 6 FRP reinforcement and strengthening
	WG 7 Execution of ultra high performance fibre reinforced concrete (UHPFRC)
SC 3	Admixtures for concrete
SC 8	Protection and repairs of concrete structures
	WG 1 Surface protection systems
	WG 2 Repair
	WG 4 Injection products
	WG 5 Anchoring or fixing

Working groups	
WG 2	Aggregates for concrete
WG 4	Fly ash for concrete
WG 9	Silica fume for concrete
WG 10	Sprayed concrete
WG 11	Fibres for concrete
WG 14	Concrete in contact with drinking water
WG 15	Ground granulated blast furnace slag
WG 16	Joint Working Group CEN/TC 104/SC 1, CEN/TC 104/SC 2 and CEN/TC 288 - Concrete for special geotechnical works and foundations
WG 17	Curing Compounds
WG 18	Specification of ground calcium carbonate as an addition for concrete
WG 19	Decarbonisation, resource efficiency and sustainability
WG 20	Natural pozzolana and natural activated pozzolanic materials

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CEN/TR 18290 Sustainable construction with concrete



Practical guidance and further potential for optimisation

TECHNICAL REPORT

CEN/TR 18290-1

RAPPORT TECHNIQUE

TECHNISCHER REPORT

April 2026

ICS 13.020.20; 91.080.40

English Version

Sustainable construction with concrete - Part 1 - Practical guidance

Construction durable avec du béton - Partie 1 - Aide à la planification

Nachhaltig Bauen mit Beton - Teil 1 - Planungshilfe

This Technical Report was approved by CEN on 6 April 2026. It has been drawn up by the Technical Committee CEN/TC 104.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and United Kingdom.

- 1 Scope
 - 2 Normative references
 - 3 Terms and definitions
 - 4 Guidance for design
 - 5 Notes on the building material
 - 6 Effects of planning decisions on execution
 - 7 Summary
- Annexes

CEN/TR 18290 Sustainable construction with concrete



Practical guidance and further potential for optimisation

TECHNICAL REPORT

CEN/TR 18290-2

RAPPORT TECHNIQUE

TECHNISCHER REPORT

April 2026

ICS 13.020.20; 91.080.40

English Version

Sustainable construction with concrete - Part 2 - Further potential for optimisation

Construction durable avec du béton - Partie 2 -
Potentiel d'optimisation supplémentaire

Nachhaltig Bauen mit Beton - Teil 2 - Weitere
Optimierungswege

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- 1 Scope
 - 2 Normative references
 - 3 Terms and definitions
 - 4 Introduction
 - 5 Innovation in design and construction
 - 6 Continue to further innovate concrete
 - 7 New CO₂ -efficient cements and their use in concrete and their carbonation
 - 8 Water reduction/savings with respect to concrete manufacturing
 - 9 Tools to assess environmental/climate change performance
 - 10 Contribution by the execution on site
 - 11 More industrialized processes
(Digitalisation / Industry 4.0)
 - 12 Recarbonation
 - 13 Summary
 - 14 Proposals for further R&D (Innovation areas)
- Annexes

Generic specification for concrete constituents

Guideline (CEN/TR) and assessment scheme to facilitate the introduction of new concrete constituents

Category 1	Category 2	Category 3
• Materials and combinations of materials • Already covered in existing standards for common cement (EN 197 series) and concrete (to be listed)	• Emerging materials • Similar chemistry and reaction mechanisms as well-known concrete additions, demonstrated and specified in (local) standards	• All materials outside the scope of Category 1 & 2 • Unknown, different or additional reaction mechanisms • Different chemistry/phase composition of well-known concrete additions

- CEN/TR outline based on CEN/TR 16912 and FD P18-484
- Next steps
 - Develop initial categorization rules
 - Update list of essential characteristics/parameters for relevant basic requirements/fitness for use
 - Propose procedure to guide evaluation/pre-qualification

CEN/TC 104/WG19 Ad-hoc Group

- Blandine Albert
- Martin Cyr
- Ingemar Löfgren
- Thomas Matschei
- Ruben Snellings (Leader)

Structure of CEN/TC 104 – Concrete and related products

CEN/TC 104 is the technical body which drafts the relevant standards for concrete and related products

CEN/TC 104 – Concrete and related products (Chair: Christoph Müller)

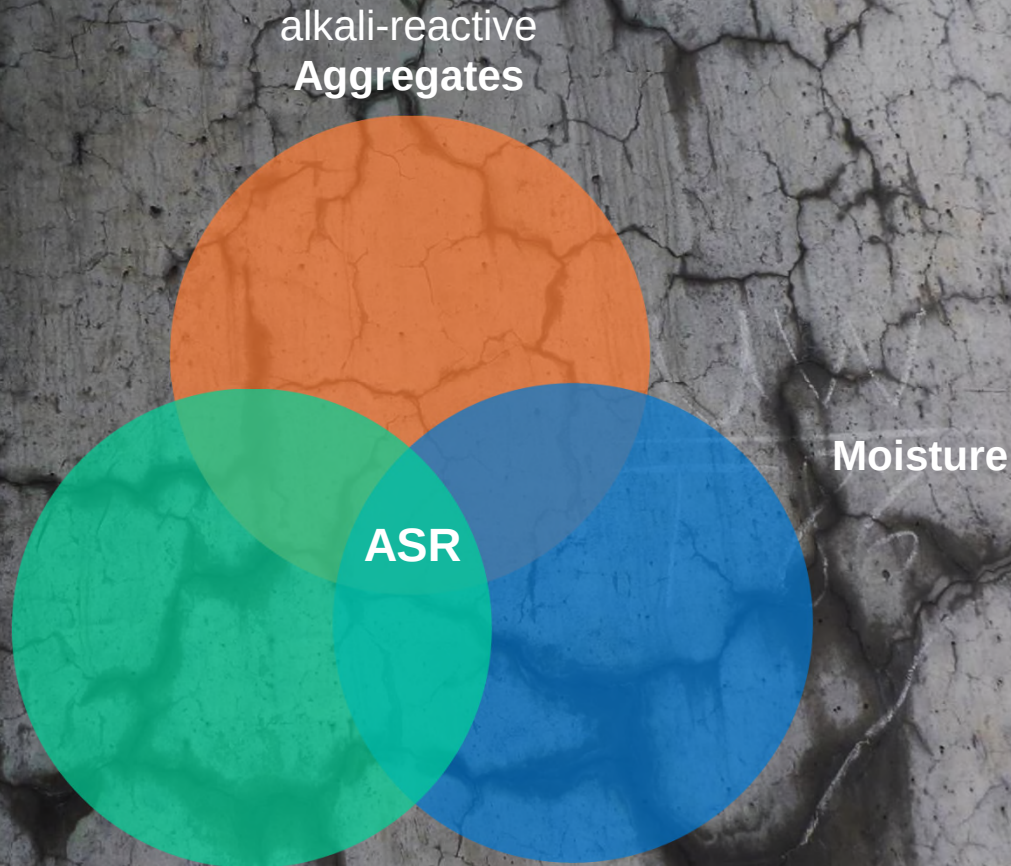
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Prevention of a damaging alkali-silica reaction (ASR)

Alkalies

- Alkalies from cement, additions, etc.
- Alkali supply from outside
- Alkalies from the aggregates





CEN/TR under preparation

Principles for risk assessment of alkali-silica reaction (ASR) in concrete

The document establishes a general framework for establishing provisions for assessing the risk of damaging alkali-silica reaction (ASR) in concrete and gives guidance on use of test methods and declaration of both concrete and concrete constituents.

6.4 Concrete mix design including performance testing



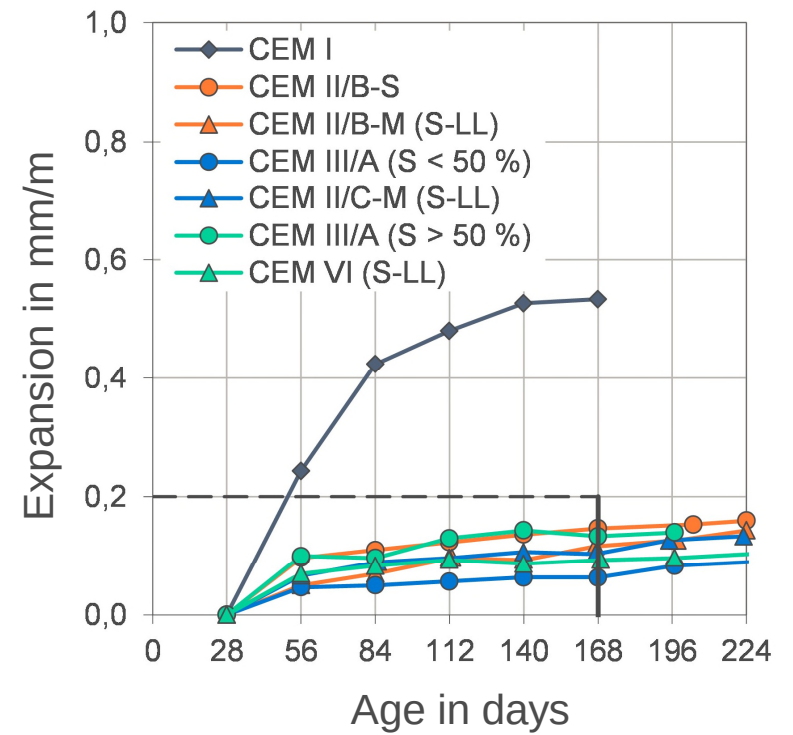
CEN/TR under preparation

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6.4 Concrete mix design including performance testing

ASR Performance Tests



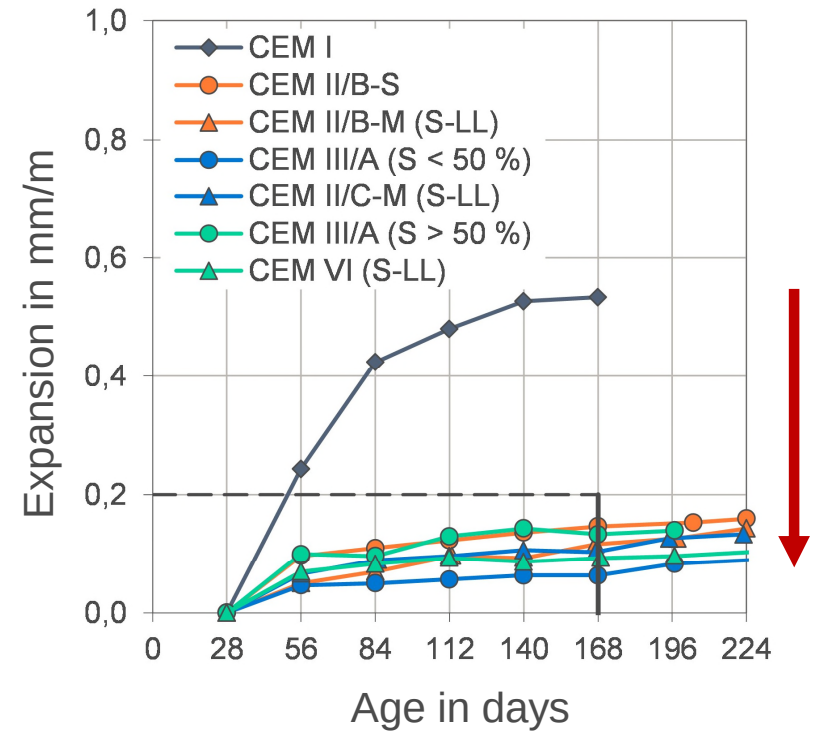
400 kg/m³ cement
w/c = 0.50

30 vol % sand 0/2
40 vol % gravel 4/8
15 vol % gravel 8/11
15 vol % gravel 11/16

Reactive
aggregate

ASR Performance Tests

Low clinker cements provide less CO₂, less alkalis and help to avoid damaging ASR



- less CO₂
- less Alkalis
- less/no ASR

The European Concrete Standard EN 206 today and tomorrow

EN 206 Concrete - Specification, performance, production and conformity

Part 1

Performance, requirements, factory production control and assessment criteria for individual values

Part 2

Conformity assessment and certification

Existing content of EN 206

New content of EN 206

Part 3

Additional requirements for specification and conformity of concrete for **special geotechnical works**

Part 4

Additional requirements for specification and conformity of concrete for **digital fabrication**

Part 5

Sustainability criteria for concrete

Part 6

Factory production control and assessment procedures using **digital tools and Artificial Intelligence**

Part 7

Information exchange for concrete with **digital tools**

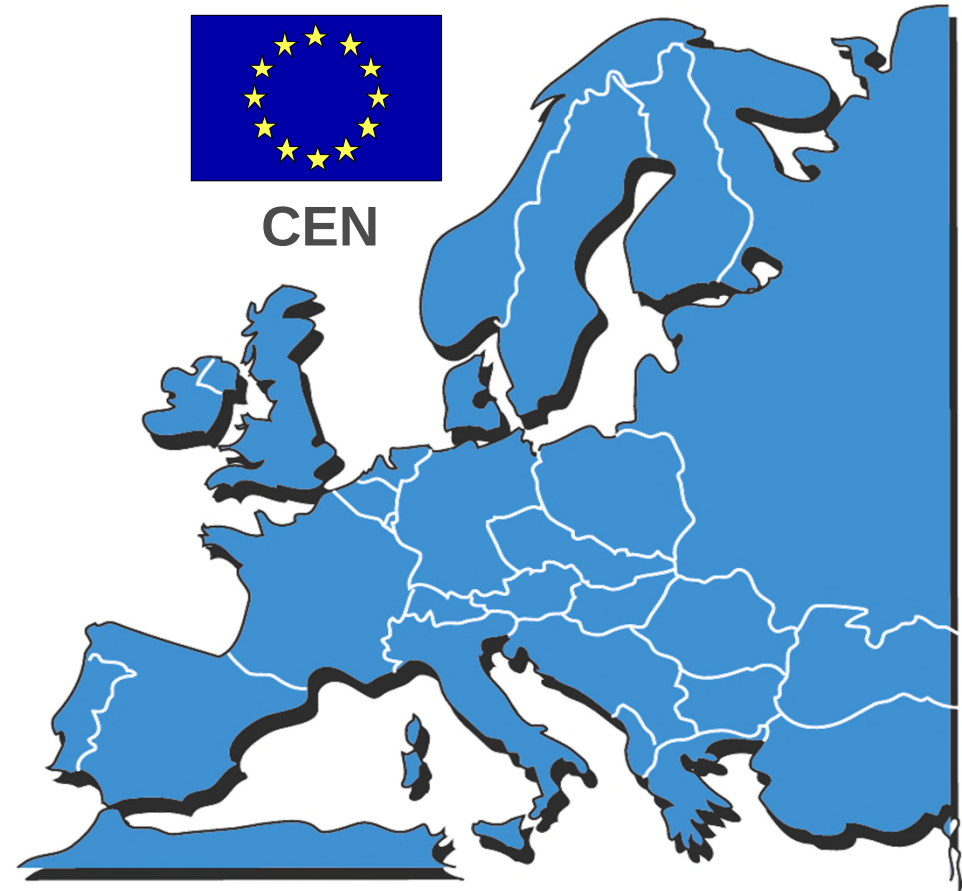
CEN TR (Part 100)

Exposure Resistance Class (ERC)
Concrete - specification and conformity criteria

recently revised

The European Concrete Standard EN 206 today

- „Non-harmonized“ standard (not under the CPR)
- „**Voluntary standard**“
- Mandatory through inclusion in contracts or establishment by national building authorities
- Recommendations / voluntary specification
- **No standardized durability requirements; only recommendations**
- **Allows / Requires national application rules**



Role of CEN/TC 104 in the CPR–Acquis Process (Subfamilies 1-3)

CEN/TC 104 observes the process, asks questions and give recommendations

CEN/TC 104 – Concrete and related products

Mirror committees for the CPR Acquis process			
TC Level	Horizontal Group	(Subfamilies 1-3)	Christoph Müller
SC 1	AHG hEN 206	(Subfamily 2)	Udo Wiens

- a) What kind of characteristics are essential for ready-mixed concrete under the framework of CPR2024 (e. g. for fresh and hardened concrete)?
- b) How will the need of essential characteristics from EN 1992-1-1 and EN 13670 including the wide range of NDPs in national annexes will be dealt with in a harmonized standard on ready-mixed concrete?
- c) Starting from the content of the latest version of EN 206-1:2026 what could be kept in a voluntary standard on ready-mixed concrete (e. g. parts of the FPC)?

CPR Acquis process

Sub-Group on Product Area 26

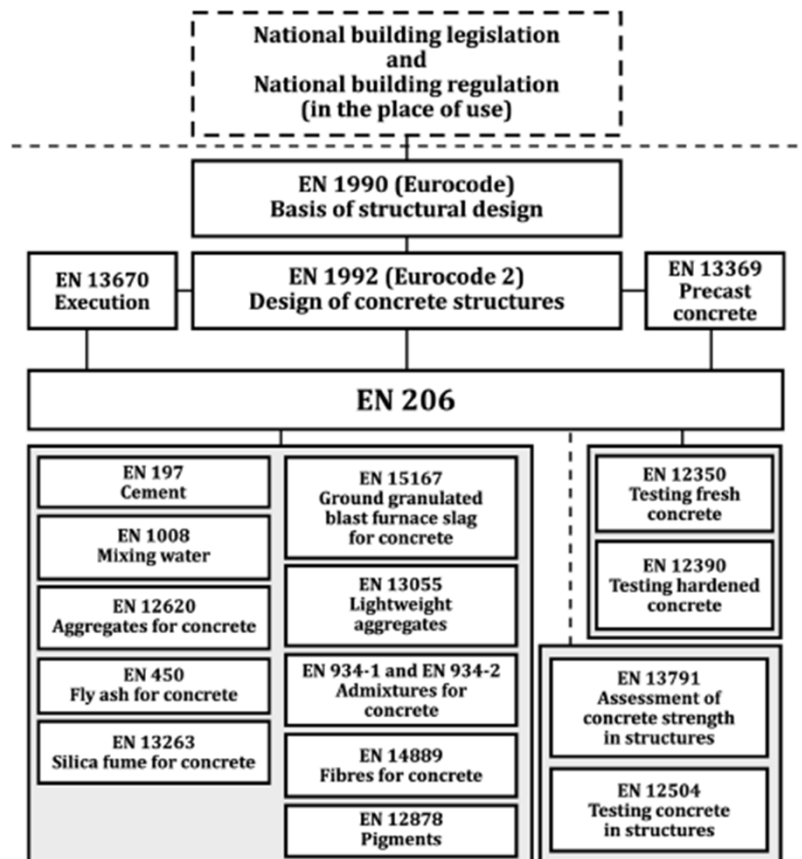
Products related to concrete, mortar and grout

Subfamily 2 Ready-mixed concrete

Milestone III Draft proposal 01

= MIIDP01

Circulated to the Sub-Group 1 April 2026



- The existing voluntary standard EN 206, together with EN 1992 (Eurocode 2) for design and EN 13670 for execution, forms a coherent and proven system of European standards ensuring safe, durable, and sustainable concrete structures across Europe.
- The EN 206 today allows and requires national application rules and is prepared for the future.
- For CEN/TC104 it is important that the coherent and proven system should only be changed for the good of the sector.
- Changes to the systematic approach in EN 206 might have (partly fundamental) implications for design, construction and the national regulations of all Member States.
- CEN/TC 104 recommends a partial/lean harmonization:
 - a new harmonized part of EN 206 addressing predetermined environmental essential characteristics
 - all other (technical) aspects in the non-harmonised zone.

Evolving the well-established

**Thank you for
your attention**

vdz

Christoph Müller

VDZ Technology gGmbH

T +49 (0)211 45 78-372

christoph.mueller@vdz-online.de

www.vdz-online.de