Harmonise to decarbonise

A review of European concrete standards

ALLIANCE for
LOW-CARBON CEMENT
& CONCRETE

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Executive summary

The cement and concrete industry represents one of the most carbon-intensive industries in Europe, responsible for up to 8% of global CO_2 emissions. As the demand for cement and concrete is expected to almost double by 2050, the need to decarbonise is even more urgent.

The challenge of decarbonising is not technological but regulatory. Safe, scalable, and low-carbon solutions exist - and standards have the potential to make them the norm. However, current standards are preventing these solutions from market entrance.

Standards are foundational to how the European internal market functions. Like all sectors, construction relies on standards to assess products placed and traded on the market. When standards are done right, clean technologies and innovation become a key vector for decarbonisation[1,2]. This is not yet the case for concrete standards in Europe.

It is widely accepted that shifting from recipe-based to performance-based cement and concrete standards is needed to ensure a level-playing field for all products and technologies. However, this report highlights another, possibly less well known, barrier to decarbonisation: the fragmented European market for concrete products.

PRESCRIPTIVE VS. PERFORMANCE-BASED APPROACH

A performance-based approach focuses on the performance characteristics of a product without imposing restrictions on the materials that can be used. In contrast, prescriptive standards are recipe-based by focusing on the material properties of a product. A prescriptive approach might be convenient but comes at the expense of eco-innovation and decarbonisation.

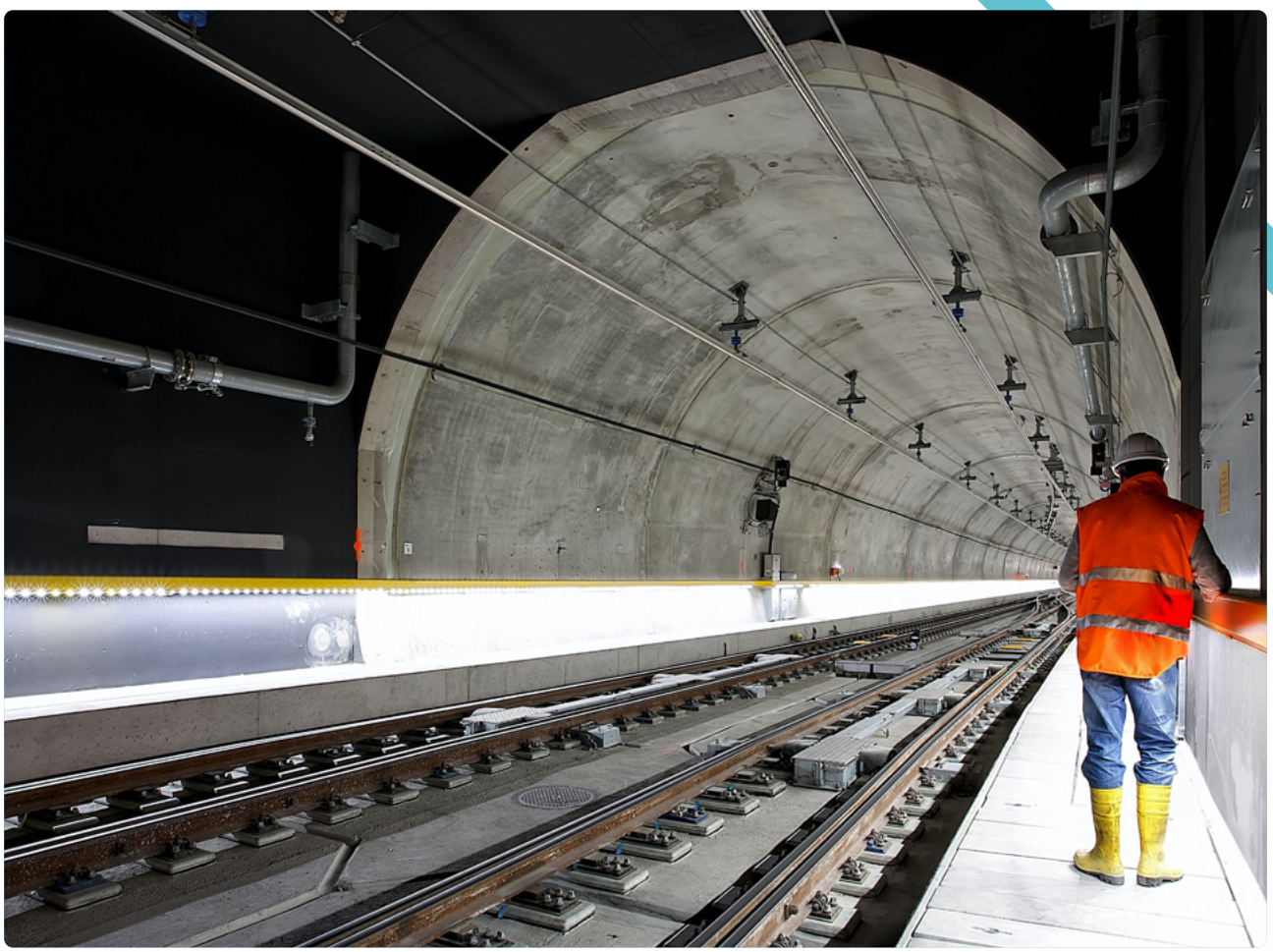
The lack of harmonisation of the main European concrete standard (EN 206) creates significant barriers to trade for low-carbon cement and concrete. This standard covers all types of concrete and nearly all types of precast concrete, providing recommendations on how to safely produce it. However, it's non-harmonised nature means that all national standardisation bodies can - and typically do - deviate from the general recommendations in their national concrete standards. This creates a flawed internal market and a significant barrier for rapid decarbonisation. A harmonised European concrete standard has the potential to fix this and make low-carbon concrete the norm, ensuring that solutions are deployed at a much faster rate.

WHAT IS A HARMONISED STANDARD?

Harmonised standards are a specific category of European standards developed by a European standardisation organisation following a request from the European Commission. They are widely used for construction products by providing common assessment methods for construction product performance. This supports access to the trade market and strengthens the competitiveness of the construction sector. Non-harmonised standards, on the contrary, do not provide a single framework for the assessment of products. These types of standards only suggest a common framework, which national standardisation bodies can deviate from in their national standards.

This is how we can get there:

- The European Commission and Member States should use the upcoming Construction Productions Regulation (CPR) acquis process[3] on concrete to issue a standardisation request to the CEN Technical Committee 104 for the development of a harmonised EN 206 standard.
- In line with the performance-based approach of the CPR, all prescriptive provisions should be removed from EN 206, and maximum alignment should be ensured with the European Commission's plans to move to a performance-based cement standard for common cements in Europe.



Introduction

Concrete is the most consumed human-made material on earth. It's not only buildings that are largely made of it, but also roads, bridges, wind turbine foundations, pavements, and marine construction. Most of us are so used to being surrounded by concrete that we no longer notice its ubiquity, nor are aware of its environmental impact.

Most of the environmental impact comes from the production of traditional Portland cement - the key binding ingredient of concrete - accounting for almost 8% of global CO_2 emissions. As the demand for cement and concrete is expected to double by 2050, the need to decarbonise is even more urgent.

The challenge of decarbonising is not technological, but regulatory.[4] A growing number of mature and scalable technologies exist - both at the level of cement and concrete - to significantly speed up the decarbonisation of the industry. However, at present, prescriptive standards prevent the large-scale market entrance of low-carbon technologies. Shifting to performance-based cement and concrete standards would ensure a level playing field for technologies. If implemented correctly, the industry's emissions could be slashed by half in the short-term.

While the benefits of performance-based standards are widely recognised, this report highlights the need to also harmonise national concrete standards (EN 206). Without harmonised standards, national standardisation bodies are free to introduce additional requirements or specifications. This results in a multitude of additional market entrance barriers for low-carbon solutions, creating a flawed internal European market and a significant hurdle for rapid decarbonisation. This could be remedied through the harmonisation of EN 206, allowing low-carbon concrete solutions to be deployed at a much faster scale throughout Europe.

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Europe's concrete standards conundrum

Standards play a key role in the placement of construction products on the European market. Not only is complying with standards essential for obtaining a European conformity (CE) marking, but they also serve as a guarantee for all actors in the value chain that the specific products are safe and durable for use. Being outside the scope of a standard is detrimental for a supplier, especially in a risk-averse sector such as construction.

In addition, the standardisation landscape for concrete is among the most complex ones in Europe. This stems from the fact that concrete standards sit at the interplay between European cement standards (i.e. EN 197 series) and the Eurocodes for the structural design of buildings and other civil engineering works (i.e. Eurocode 2 for the design of concrete structures).

While there is one overarching standard for all types of concrete (EN 206), it is complemented with specific (sub-)standards for precast concrete - both at general level - and at the level of individual precast concrete products. The relationship between these different standards can be visualised as shown in Figure 1.

Standard EN 206 is central to Europe's cement standards conundrum. It is the main European standard for concrete, applying to structures cast in situ, precast structures, and structural precast products for buildings and other civil engineering works.

However, EN 206 adds another layer of complexity because it is also a non-harmonised standard. This means that while the standard puts forward a common normative framework, individual standardisation bodies are free to deviate from it in the national annexes (or National Application Documents). This creates a very complex landscape for the marketing of cement and concrete technologies, especially since key European cement standards - including EN 197-1 as well as more than 20 other standards - for individual precast concrete products are harmonised following an official request of the European Commission to better integrate the internal market for construction products.

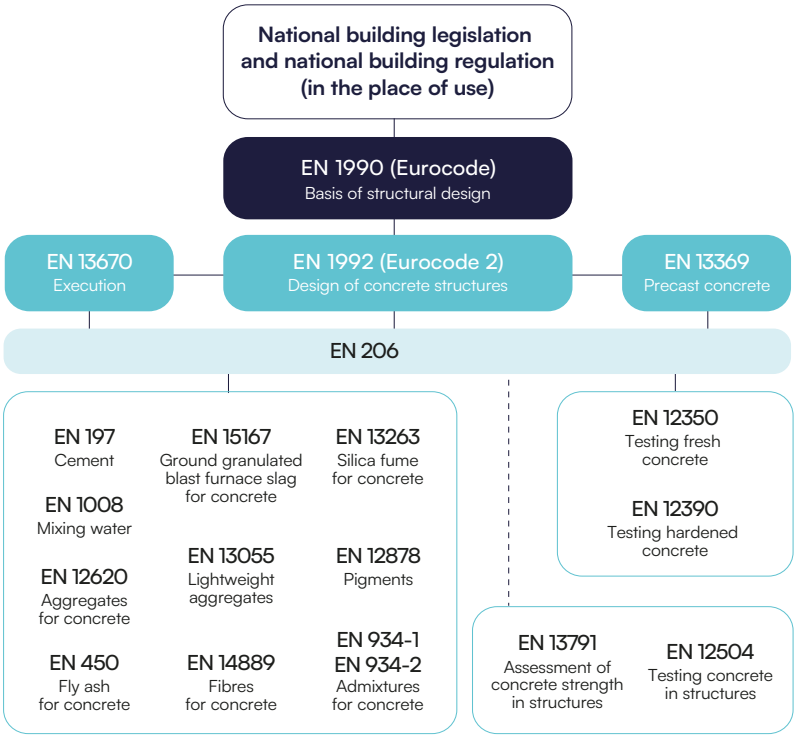


Figure 1: European standardisation landscape for cement and concrete

EN 206 — linchpin for decarbonisation?

The history of EN 206 goes back to the 1970s, when it was first introduced as a "Code of good practice for ready-mix concrete" by the European Ready-Mix Concrete Organisation (ERMCO). Ever since, it has been the main European standard for concrete. However, during this period, the standard has also been subject of much debate. Ultimately, its non-standardised nature has raised doubts as to if and how EN 206 has contributed to the overarching objective of the Construction Products Regulation (CPR) - or its predecessor, the Construction Products Directive (CPD).

The objective of the CPR is to strengthen the internal market for construction products through lifting trade barriers. The adoption of harmonised and performance-based standards is key to this, but EN 206 falls short. Several studies have pointed to the lack of alignment between cement types listed in the recipe-based European cement standard (EN 197-1) and a performance-based approach[5], while the non-harmonised status of EN 206 creates a plethora of national concrete standards.

However, attempts to harmonise EN 206 have consistently been opposed by traditional industry actors arguing that different European markets have different local manufacturing and building practices, as well as different climates[6]. It has also been claimed that a sufficient level of harmonisation would occur over time due to the mainstreaming of best practices. Yet, the periodic monitoring of national annexes by CEN TC 104 shows that this is far from true[7].

As a direct result, low-carbon cement and concrete technologies are confronted with a highly fragmented internal market with significant barriers to trade and market entrance. In combination with the prevalence of prescriptive provisions in the standard, this has a detrimental impact for the decarbonisation of the cement and concrete sector in Europe.

With the cement and concrete industry off-track to reach net zero by 2050[8], there is an urgent need for the harmonisation of EN 206. The example set by other key markets in the world — such as in Australia and the United States as well as for precast concrete products in Europe — show that it is possible to have a harmonised standard for large geographical markets with a wide range of different climate conditions and building traditions.

To demonstrate some of the existing barriers to trade, the remainder of this report will focus on the provision in different national annexes to EN 206. By focusing on the 6 largest producers of ready-mix concrete in Europe — France, Germany, Italy, Poland, Spain and the United Kingdom — the report will highlight the huge variety in how concrete is specified across Europe. For each of these countries, the report will elaborate on specific indicators, including minimum cement content, maximum water-to-cement ratio, and permitted cement types at national level. These cases offer a snapshot of the problematic and prevailing prescriptive approaches across Europe to concrete specification. Without a harmonised approach — and soon — the EU's climate goals will remain out of reach.

Minimum cement content

Historically, when concrete was produced with only Portland cement, it was common practice to specify a minimum cement content to ensure that the strength and durability requirements were met. Today, as both technologies and scientific insights have evolved, there is a much deeper understanding of factors affecting the performance of concrete. Minimum cement content requirements are simply no longer needed to ensure that concrete does its job well. It's time to shift the focus to concrete performance instead.

This is extremely relevant from a decarbonisation point of view, given that durable and safe concrete mixes can be made without cement (relying on alternative binding mechanisms) or using low-carbon cements (relying on high levels of clinker substitution). Despite all this, however, EN 206 still puts forward recommended values on minimum cement content for the different exposure classes of concrete (Table 1).

The selected national annexes show that while there is some degree of consistency in following the guidance of EN 206 - for example in the case of Italy and the UK - there are also significant deviations, such as in France and Spain. France deviates from EN 206 guidance with some exposure classes having higher or lower minimum cement contents. In Spain, concrete is divided into three types with different minimum cement contents for each category, including quite substantial thresholds for XO applications - which do not have any risk of corrosion or attack. This creates a very complex regulatory landscape for construction actor. These outdated requirements are creating and sustaining situations whereby certain types of low-carbon concrete have no (easy) route to market.

Exposure category		No risk of corrosion or attack	Carbonation-induced corrosion				Sea water			Chloride other than from sea water			Freeze/thaw attack				Aggressive chemical environments		
		X0	XC 1	XC 2	XC 3	XC 4	XS 1	XS 2	XS 3	XD 1	XD 2	XD 3	XF 1	XF 2	XF 3	XF 4	XA 1	XA 2	XA 3
EN 206	min. cement content (kg/m³)	-	260	280	280	300	300	320	340	300	300	320	300	300	320	340	300	320	360
France	Min. cement content (kg/m³)	150	260	260	280	280	330	330	350	280	330	350	280	300	315	340	330	350	360
Germany	Informative - Min. cement content (kg/m³)	-	260	280	280	300	300	320	340	300	300	320	300	300	320	340	300	320	360
	Normative - Min. cement content (kg/m³)	-	240	240	260	280	300	320	320	300	320	320	280	300	320	320	280	320	320
Italy	Min. cement content (kg/m³)	-	260	280	280	300	300	320	340	300	300	320	300	300	320	340	300	320	360
Poland	Min. cement content (kg/m³) - Mass	-	260	280	280	300	300	320	340	300	320	320	300	300	320	340	300	320	360
Spain	Min. cement content (kg/m³) - Mass	200	-	-	-	-	-	-	-	-	-	-	300	275	300	275	275	300	325
	Min. cement content (kg/m³) - Reinforced	250	275	275	275	300	300	325	350	300	325	325	300	325	300	325	325	350	350
	Min. cement content (kg/m³) - Prestressed	275	300	300	300	300	325	325	350	300	325	325	300	325	300	325	325	350	350
UK	Min. cement content (kg/m³)	-	260	280	280	300	300	320	340	300	300	320	300	300	320	340	300	320	360

Table 1: Recommended limiting values for composition and properties of concrete
Source: Jamcem, 2023.

Maximum water-to-cement ratio

The water-to-cement ratio is responsible for binding all constituents of concrete together. Once again, thresholds were designed around traditional Portland cement, where higher water-to-cement ratios resulted in greater spacing between the aggregates. This, in turn, could negatively affect the concrete's compressive strength and durability. Today, water-to-cement ratios are not fit for purpose as many low-carbon concrete mixes have a very different permeability.

Nonetheless, maximum water-to-cement ratios continue to be prescribed through standards, including EN 206. For the selected countries, the maximum water-to-cement ratio for each of the different exposure classes is described in the national annexes to EN 206 (Table 2). This table shows, again, a strong degree of deviation from the recommended values in EN 206, as well as a high level of variation across the selected countries. Importantly, seemingly small variations in ratio - of even 0,05 - can determine whether a low-carbon technology is aligned with or outside of the standards.

Exposure category		No risk of corrosion or attack	Carbonation-induced corrosion				Sea water			Chloride other than from sea water			Freeze/thaw attack				Aggressive chemical environments		
		X0	XC 1	XC 2	XC 3	XC 4	XS 1	XS 2	XS 3	XD 1	XD 2	XD 3	XF 1	XF 2	XF 3	XF 4	XA 1	XA 2	XA 3
EN 206	min. cement content (kg/m³)	-	0,65	0,60	0,55	0,50	0,50	0,45	0,45	0,55	0,55	0,45	0,55	0,55	0,50	0,45	0,55	0,50	0,45
France	Maximum w/c ratio	-	0,65	0,65	0,60	0,60	0,55	0,55	0,50	0,60	0,55	0,50	0,60	0,55	0,55	0,45	0,55	0,50	0,45
Germany	Informative - Maximum w/c ratio	-	0,65	0,60	0,55	0,50	0,50	0,45	0,45	0,55	0,55	0,45	0,55	0,55	0,50	0,45	0,55	0,50	0,45
	Normative - Maximum w/c ratio	-	0,75	0,75	0,65	0,60	0,55	0,50	0,45	0,55	0,50	0,45	0,60	0,55	0,55	0,50	0,60	0,50	0,45
Italy	Maximum w/c ratio	-	0,65	0,60	0,55	0,50	0,50	0,45	0,45	0,55	0,55	0,45	0,55	0,55	0,50	0,45	0,55	0,50	0,45
Poland	Maximum w/c ratio	-	0,70	0,65	0,60	0,55	0,50	0,45	0,45	0,55	0,50	0,45	0,55	0,55	0,50	0,45	0,55	0,50	0,45
Spain	Maximum w/c ratio - Mass	0,65	-	-	-	-	-	-	-	-	-	-	0,55	0,50	0,55	0,50	0,50	0,50	0,45
	Maximum w/c ratio - Reinforced	0,65	0,60	0,60	0,60	0,55	0,50	0,50	0,45	0,50	0,50	0,55	0,50	0,55	0,50	0,50	0,50	0,50	0,45
	Maximum w/c ratio - Prestressed	0,60	0,60	0,60	0,60	0,55	0,45	0,45	0,45	0,45	0,45	0,45	0,55	0,50	0,55	0,50	0,50	0,45	0,45
UK	Maximum w/c ratio	-	0,65	0,60	0,55	0,50	0,50	0,45	0,45	0,55	0,55	0,45	0,55	0,55	0,50	0,45	0,55	0,50	0,45

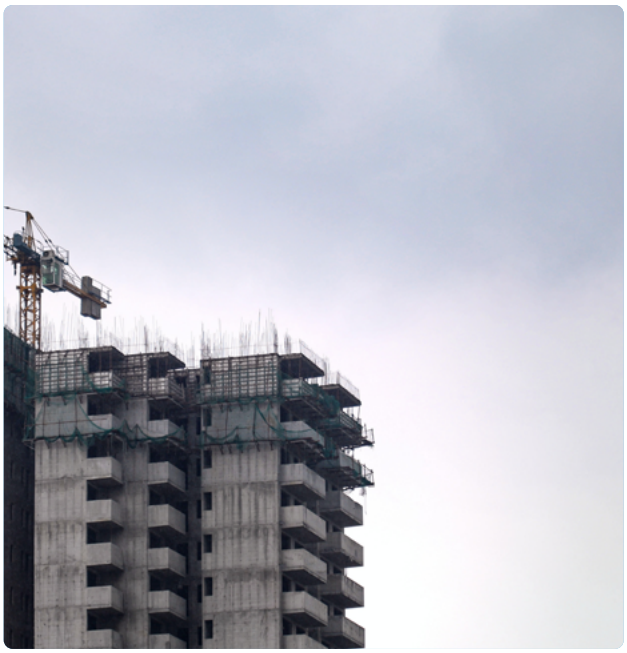
Table 2: Comparison of maximum water-to-cement ratio by exposure class for selected countries

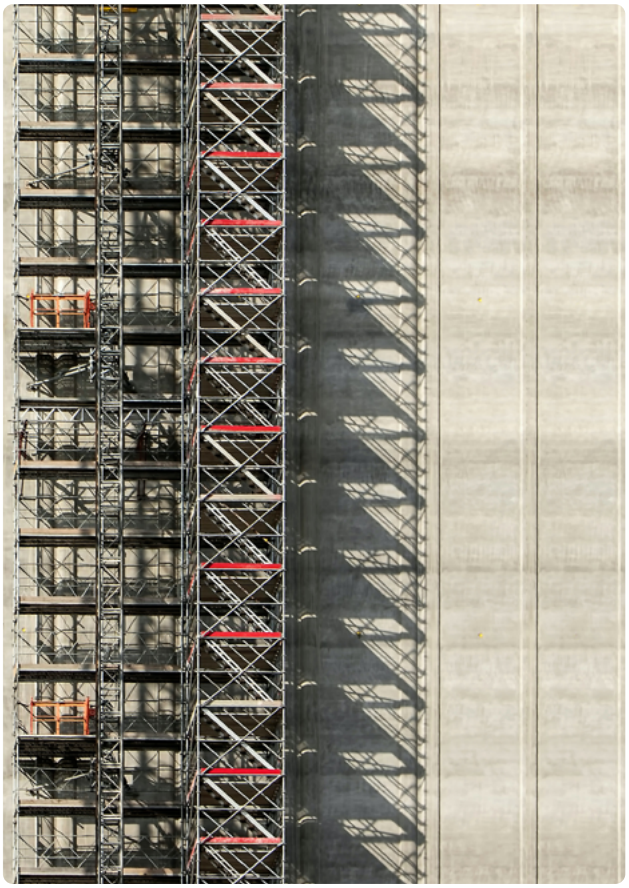
Source: Jamcem, 2023.

Permitted cement types and other constituents

Even though harmonised European standards for cements exist, virtually all national annexes to EN 206 contain additional provisions on the permitted cement types in concrete. This has been motivated by different building practices and regulatory traditions, but it also creates a very complex picture. Some national annexes provide specifications for all EN 197 cement types, whereas others only regulate cements that traditionally play a part in the national market. As a result, certain cement types are not eligible for certain exposure classes, while in other countries they are and can enter concrete mixes (Table 3).

Different national approaches to the approval of new constituents to concrete also exist throughout Europe (e.g. new types of supplementary cementitious materials). These vary both in process (duration, time) as well as scope (what short tracks exists for more popular constituents). While at a general level, growing attention is being paid to the issue by both the European Committee for Standardisation (CEN) and National Standards Bodies, progress is slow and fragmented throughout Europe. As a result, proven constituents — often within the scope of standards outside Europe — face a lengthy process in each individual European national context before they can be potentially deployed on the market. Sadly, this at the expense of decarbonising this extremely CO_2 intensive sector. At a fundamental level, a prescriptive approach to concrete constituents is also not aligned with the performance-based approach of the CPR.





> *With the cement and concrete industry off-track to reach net zero by 2050, there is an urgent need for the harmonisation of EN 206.*

Table 3: Summary of national recommendations for exposure class XC4 for an intended working life of at least 50 years

CEN MEMBER	MINIMAL COVER MM	COMP. STRENGTH CLASS	MAX W/C RATIO	MC	CE M I	II/A-S	II/A-D	II/A-P	II/A-Q	II/A-V	II/ A-W	II/A-T	II/A-L	II/A-LL
EN 206-1		C30/37	0,50	300	✓									
AT		NR	0,50	300	✓	✓	✓			✓	✓		✓	
BE	30	C30/37	0,50	320	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CZ		C30/37	0,50	300	✓	✓	✓	✓	✓	✓		✓	✓	✓
DK	20	C25/30	0,55	150	✓*					✓*			✓*	✓*
FI	25*	C28/35	NR	270	✓	✓	✓			✓				✓
FR		C25/30	0,60	280*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DE	25	C25/30	0,60	280	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IE	30	C30/37	0,55	320	✓									
IT	15	C32/40	0,50	340	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
LU	25*	C25/30	0,60	280	✓	✓	✓			✓		✓	✓	✓
NL	25*	NR	0,50	300	✓	✓	✓*	✓*	✓*	✓	✓*	✓*	✓*	✓*
NO	25*	NR		250	✓	✓	✓			✓		✓		
PT	30	C30/37	0,60	280	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓
SK		C30/37	0,50	300	✓	✓	✓	✓	✓	✓		✓	✓	✓
SE			0,55	300										
EN 206-1	15	NR	0,55	200	✓*	✓*	✓*			✓*				✓*
CH	40	NR	0,50	300	✓	✓	✓							✓
UK	25*	C32/40	0,55	300	✓	✓	✓			✓			✓	✓
		C40/50	0,45	340										
		NR to C32/40	NR to 0,45	150 to 340										

CEN MEMBER	II/A-M	II/B-S	II/B-P	II/B-Q	II/B-V	II/ B-W	II/B-T	II/B-L	IIB-LL	II/B-M	III/A	III/B	III/C	IV/A	IV/B	V/A	V/B
EN 206-1																	
AT	✓	✓			✓			✓*		✓*	✓*	✓*					
BE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓*	
CZ		✓	✓	✓	✓		✓				✓	✓					
DK					✓*												
FI	✓																
FR	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DE	✓ 1)	✓	✓	✓	✓	✓	✓	✓	✓	✓2)	✓	✓	✓	✓	✓ 3)	✓ 4)	✓ 5)
IE																	
IT	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
LU	✓	✓									✓	✓		✗	✗	✗	✗
NL	✓*	✓	✓*	✓*	✓	✓*	✓	✓*	✓*	✓*	✓	✓	✓*	✓*	✓*	✓*	✓*
NO																	
PT	✓					✗	✗					✗	✗				
		✓	✓	✓	✓	✗	✗	✓	✓	✓	✓*	✗	✗	✓	✓*	✓	✓*
SK		✓	✓	✓	✓		✓				✓	✓					
SE	✓*																
CH	✓*																
UK		✓			✓*						✓	✓		✓			
															✓		

✓ Permitted for this exposure class

✗ Not permitted for this exposure class

NR: No requirement

Blank: No guidance provided

* Indicated that there are qualifications, e.g. types of main constituents.

NOTE: The minimum cover to reinforcements in not part of the EN 206, but it has been included for information purposes.

Germany: 1) Applicable: CEM II/A-M (S-D; S-T; S-LL; D-T; D-LL, T-LL;S-P; S-V; D-P; D-V; P-V; P-T; P-LL; V-T; V-LL)

2) Applicable: CEM II/B-M (S-D; S-T; D-T; S-P; D-P; P-T; S-V; D-V; V-T)

3) Applicable: CEM IV/B (P) and valid on your for trass according to DIN 51043 used as main constituent up to a maximum of 40% (m/m)

4) Applicable: CEM IV/A (S-P) and valid on your for trass according to DIN 51043

5) Applicable CEM IV/B (S-P) and valid on your for trass according to DIN 51043

Endnotes

1 https://www.aldersgategroup.org.uk/publications/post/product-standards-crucial-to-deliver-a-strong-net-zero-industrial-base/

2 ALCCC-REPORT-FAST-TRACKING-CEMENT-DECARBONISATION.pdf (alliancelccc.com)

3 The CPR acquis revision is a broader process initiated by the European Commission, with the support and input of Member States and other stakeholders, to deliver better harmonised standards in Europe for construction products.

4 https://alliancelccc.com/wp-content/uploads/2023/05/ALCCC-REPORT-FAST-TRACKING-CEMENT-DECARBONISATION.pdf

5 See e.g. http://www.endurcrete.eu/filedelivery.php?docId=437 ; https://alliancelccc.com/wp-content/uploads/2023/05/ALCCC-REPORT-FAST-TRACKING-CEMENT-DECARBONISATION.pdf1

6 https://www.sciencedirect.com/science/article/pii/S1687404812000028

7 CEN TC 104 (2009) Survey on national provision in conjunction with EN 206 ; CEN TC 104 (2018) Survey on provision in place of use in conjunction with EN 206.

8 https://www.iea.org/reports/tracking-clean-energy-progress-2023

ALLIANCE for LOW-CARBON CEMENT & CONCRETE

Our Alliance was created to steer the sector towards viable decarbonisation pathways. Our members represent mature materials designers and producers, and also start-ups working in biotechnology, capturing carbon, and sustainable construction. We are all rooted in the circular economy and sustainable construction, and we all share the desire to change our industry — and prevent catastrophic climate change.

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