

## Recent advances on European cement standards prepared by CEN TC51 for more sustainable products

X. Guillot<sup>1\*</sup>, F. Van Rickstal<sup>2</sup>, and M. Schneider<sup>3</sup>

<sup>1</sup> CEN TC 51 Chairman, Paris, France

Email: [xavier.guillot@lafarge.com](mailto:xavier.guillot@lafarge.com)

<sup>2</sup> CEN TC 51 Secretary, Brussels, Belgium

Email: [f.vanrickstal@cric-occn.be](mailto:f.vanrickstal@cric-occn.be)

<sup>3</sup> CEN TC 51 / WG6 Convenor, Düsseldorf, Germany

Email: [martin.schneider@vdz-online.de](mailto:martin.schneider@vdz-online.de)

### ABSTRACT

In Europe, the CEN (European Committee for Standardization) Technical Committee 51 (CEN/TC51) is in charge for the last 50 years of the standardization activities about cements, building limes and other hydraulic binders in an extensive framework including testing methods and conformity control. Benefits expected from the work of CEN/TC 51 are mainly to address major issues within the framework of the European Green Deal and more especially concerns about hydraulic binders' carbon footprint and circular economy. Significant progress has been made in recent years in that direction with the preparation of new standards: EN 197-5 about Portland-composite cement CEM II/C-M and composite cement CEM VI and also EN 197-6 Cement with Recycled Building Materials. Portland-composite cement CEM II/C-M are ternary cements containing clinker in the range of 50% to 64% and two other main constituents. Composite cement CEM VI are made with less than 50% clinker, blast-furnace slag and a third constituent. Cements specified in EN 197-6 contain a new constituent designated as Recycled Concrete Fines, specially selected and prepared mineral material coming from Construction and Demolition Wastes. The content of these two standards and the way they have been developed are detailed in this paper. These new cements are adapted for most of the applications and for structural concrete in particular, allowing a significant reduction of the concrete carbon footprint. In standardization, this momentum to extend solutions will continue and be reinforced in order to support the European Strategy to put standards back at the core of a resilient, green, and digital EU single market and to strengthen the global role of the European standardisation system.

**KEYWORDS:** *cement standards, sustainable products, European context, circularity*

### 1. Introduction

All decarbonisation roadmaps rely on several levers of the construction value chain and the development of new more sustainable cements constitute a significant one. Inevitably, standardization of these products is an essential path towards the reduction of the construction sector's carbon footprint. But the valorisation of the results obtained from technical works or fruitful collaborative research into specifications of a product in a standard has many pitfalls. Several aspects have to be considered: regulations, technical performances, intended uses, relationships with other standards, health and environmental assessments.... Even though their application is voluntary, European harmonized standards are part of the European law. In particular, activities conducted within CEN (European Committee for Standardization) Technical Committee 51 (CEN/TC51) are covered by the European Construction Products Regulation (CPR). So, requirements of cements, building limes and other hydraulic binders are specified in accordance with this specific framework.

To address major issues linked to consequences of the Climate change, European Commission has initiated end of 2019 the Green Deal initiative with a set of Regulations, Directives and Strategies prepared since that time. Among them, the CPR revision but also the communication on Standardization Strategy have been released. To support the European Strategy to put standards at the core of a resilient, green and digital EU single market, CEN/TC51 has undertaken several works.

This paper presents the main content of the two last cement standards EN 197-5 and EN 197-6 that have been published respectively in 2021 and 2023. Perspectives in terms of development of new standards are also mentioned.

## 2. Recent advances

### 2.1 Methodology

To standardize a new cement or a new hydraulic binder, the fitness for intended use has to be demonstrated. For that purpose, a few years ago, the CEN/TC51 has developed guidance CEN TR 16912 (2017) for the procedure to be followed to support this standardization. A categorization of new cements (Table 1) has been developed and a list of corresponding requirements to be assessed has been established.

**Table 1. Categorization of new cements and the corresponding requirements**

<u>Category 1</u> Cement from a new combination of constituents according to EN 197-1	<u>Category 2</u> Cement containing a minor amount of one or more new constituents	<u>Category 3</u> Cement differing substantially from those types defined in existing standards
Assessment of mechanical, physical and chemical performances		
Assessment of durability related characteristics		
	Assessment of influence on environmental performance	
	Assessment of possible health impact	
		Relevant practical experience gained under approved conditions prior to European standardization

In order to prepare the two standards described hereafter, technical dossiers have been prepared according to these guidelines.

### 2.1 Ternary cements

During technical works, it has been demonstrated that some new combinations of well-known constituents with a limited amount of clinker were relevant for reducing the carbon footprint of cements while maintaining the required level of mechanical performance and durability necessary for current applications. As a consequence, EN 197-5 has been prepared then published in 2021. Portland-composite cement CEM II/C-M are ternary cements containing clinker in the range of 50% to 64% and two other main constituents (Table 2). Composite cement CEM VI are made with less than 50% clinker, blast-furnace slag and a third constituent. Another change about the requirements of limestone has been introduced into EN 197-5. As it has been demonstrated that dolomitic limestone was also suitable to be used into cement, the requirements have been extended accordingly. Cements covered by this standard shall fulfil the same mechanical, physical and chemical requirements as those specified into EN 197-1 for common cements. With such new cements, the carbon footprint can be significantly reduced, below 500 kg CO<sub>2eq.</sub> / t for CEM II/C and below 400 kg CO<sub>2eq.</sub> / t for CEM VI. Across Europe, National Annexes of concrete standard EN 206 are progressively introducing rules on the use of these cements depending the Exposure Classes.

**Table 2. Portland-composite cement CEM II/C-M and Composite cement CEM VI**

Main types	Notation of the products (types of cement)		Composition (percentage by mass a)										Minor additional constituents
			Main constituents										
			Clinker	Blast-furnace slag	Silica fume	Pozzolana		Fly ash		Burnt shale	Limestone		
	natural	natural calcined				siliceous	calcareous	L <sup>c</sup>	LL <sup>c</sup>				
Type name	Type notation	K	S	D <sup>b</sup>	P	Q	V	W	T	L <sup>c</sup>	LL <sup>c</sup>		
CEM II	Portland-composite cement <sup>d</sup>	CEM II/C-M	50-64	←----- 36-50 -----→								0-5	
CEM VI	Composite cement	CEM VI (S-P)	35-49	31-59	-	6-20	-	-	-	-	-	-	0-5
		CEM VI (S-V)	35-49	31-59	-	-	-	6-20	-	-	-	-	0-5
		CEM VI (S-L)	35-49	31-59	-	-	-	-	-	-	6-20	-	0-5
		CEM VI (S-LL)	35-49	31-59	-	-	-	-	-	-	-	6-20	0-5

<sup>a</sup> The values in the table refer to the sum of the main and minor additional constituents.  
<sup>b</sup> In case of the use of silica fume, the proportion of silica fume is limited to 6-10 % by mass.  
<sup>c</sup> In case of the use of limestone, the proportion of limestone (sum of L, LL) is limited to 6-20 % by mass.  
<sup>d</sup> The number of main constituents other than clinker is limited to two and these main constituents shall be declared by designation of the cement (for examples, see Clause 6).

**2.3 Cements with Recycled Building Materials**

A new breakthrough has been achieved in 2023 with the publication of a new standard EN 197-6 Cement with Recycled Building Materials. To start with, the Recycled Building Materials specified are Concrete Recycled Fines (F) which are defined as a specially selected and prepared mineral material coming from plants or units producing recycled concrete aggregates (coarse and/or fine); it can be also reclaimed from concrete production operations. As Recycled Concrete Fines are mainly non-reactive, they can be treated as a limestone. The standard precisely states the requirements to be fulfilled on the Total Organic Carbon (TOC) content, sulfate content and clay content (Table 3).

**Table 3. Requirements of Recycled Concrete Fines**

Requirements	Limit
TOC content	≤ 0,8 % by mass
Sulfate content (as SO <sub>3</sub> )	≤ 2,0 % by mass
Assessment of fines determined by the methylene blue test	≤ 1,20 g/100 g

Possible compositions of cement containing Recycled Concrete Fines are indicated in Table 4.

**Table 4. Cement with Recycled Concrete Fines**

Main types	Notation of the products (types of cement)		Composition (percentage by mass) <sup>a</sup>										Minor additional constituents
			Main constituents										
			Clinker	Recycled concrete fines	Blast-furnace slag	Silica fume	Pozzolana		Fly ash		Burnt shale	Limestone	
	natural	natural calcined					siliceous	calcareous	L <sup>c</sup>	LL <sup>c</sup>			
Type name	Type notation	K	F	S	D <sup>b</sup>	P	Q	V	W	T	L <sup>c</sup>	LL <sup>c</sup>	
CEM II	Portland-recycled-fines cement	CEM II/A-F	80-94	6-20	-	-	-	-	-	-	-	-	0-5
		CEM II/B-F	65-79	21-35	-	-	-	-	-	-	-	-	0-5
	Portland-composite cement <sup>d</sup>	CEM II/A-M	80-88	6-14	←----- 6-14 -----→								0-5
		CEM II/B-M	65-79	6-29	←----- 6-29 -----→								0-5
		CEM II/C-M	50-64	6-20	←----- 16-44 -----→								0-5
CEM VI	Composite cement	CEM VI	35-49	6-20	31-59	-	-	-	-	-	-	-	0-5

<sup>a</sup> The values in the table refer to the sum of the main and minor additional constituents.  
<sup>b</sup> In case of the use of silica fume, the proportion of silica fume is limited to 6 % to 10 % by mass.  
<sup>c</sup> In case of the use of limestone, the proportion of the sum of limestone and recycled concrete fines (sum of L, LL and F) is limited to 35 % by mass.  
<sup>d</sup> The number of main constituents other than clinker is limited to two and these main constituents shall be declared by designation of the cement (for examples, see Clause 6). In case of the use of both F and (L or LL) in the composition, the number of main constituents other than clinker is limited to three and these main constituents shall be declared by designation of the cement.

Up to 35% of Recycled Concrete Fines are allowed in the composition of these cements, enabling a truly circular economy of Construction and Demolition Materials and reducing the use of natural resources. Despite the long process to elaborate new standards, it took only two years to prepare and publish it from the time CEN/TC51 received officially the request. In a near future, it will be also possible to introduce Recycled Concrete Fines into other hydraulic binders' standards such as Hydraulic Road Binders' ones. Investigations will also continue to identify additional promising materials coming from construction and demolition that could be considered suitable as cement constituents.

### **3. Perspectives**

On the short term, the deployment of these new sustainable cements will be possible only by endorsement of EN 197-5 and EN 197-6 into application standards (concrete and mortar mainly). It will be beneficial for the construction sector to promote these new standards at international level in order to implement similar standards in other regions of the world.

Within CEN/TC51, a new momentum for the development of standards covering more sustainable hydraulic binders is given and different areas are investigated such as : identification of new promising construction and demolition materials and alternative Supplementary Cementitious Materials (SCMs), further investigations on CO<sub>2</sub>-efficient cements and support in test methods development and validation.

It is worth to mention also that in the next two years and in the framework of the revision of the European Construction Product Regulation, a huge activity will be conducted between European Commission, Member States and CEN experts. The outcome will be a new Standardization Request from the European Commission, a binding document for CEN/TC51 on the basis of which experts will elaborate harmonized standards of tomorrow.

### **4. Conclusions**

In the last two years, new standards specifying more sustainable cements have been published in Europe by CEN/TC51. This is the result of several years of work, based on a robust methodology and this despite some legal issues due to the complexity of the European law.

EN 197-5 specifies new combinations of constituents and a reduced amount of clinker and EN 197-6 introduces a new constituent coming from Construction and Demolition Materials. Both standards will be beneficial to reduce the carbon footprint of products and to promote circular economy.

Many considerations to transform a promising product from the technical point of view into specifications in a product standard have to be tackled: among others, regulations, technical performances, intended uses, relationships with other standards and building codes, health and environmental assessments, assessment and verification of constancy of performance, certification. Awareness of all stakeholders on these issues will shorten the time to market of more sustainable products necessary to achieve the net zero targets.

In a near future, additional paths to extend possibilities within hydraulic binders and building limes' standards will be followed once new solutions will be technically validated.

### **Acknowledgements**

Authors acknowledge all CEN/TC51 experts for their valuable contributions in the development of standards.

### **References**

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- EN 197-6 (2023) Cement - Part 6: Cement with recycled building materials