



BSI Standards Publication

Carbonation and CO₂ uptake in concrete

National foreword

This Published Document is the UK implementation of CEN/TR 17310:2019.

The UK participation in its preparation was entrusted to Technical Committee B/517/1, Concrete production and testing.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2019
Published by BSI Standards Limited 2019

ISBN 978 0 580 99695 5

ICS 91.100.30

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 28 February 2019.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

ICS 91.100.30

English Version

Carbonation and CO₂ uptake in concrete

Carbonatation et absorption du CO₂ dans le béton

Karbonatisierung und CO₂-Aufnahme von Beton

This Technical Report was approved by CEN on 30 December 2018. 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, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Contents

Page

European foreword	iv
1 Scope	5
2 Normative references	5
3 Terms and definitions	5
4 Carbonation, the uptake of carbon dioxide	5
4.1 Compounds, chemistry and notation.....	5
4.2 Carbonation.....	6
4.2.1 Carbonation reactions.....	6
4.2.2 Process of carbonation.....	7
4.2.3 Degree of carbonation.....	7
4.2.4 Effect of carbonation on cement paste structure.....	9
4.2.5 Carbonation rate.....	10
4.2.6 Carbonation rate controlling factors.....	10
4.2.7 Carbonation rate of concrete with blended cements or with additions.....	14
4.3 CO ₂ binding capacity in concrete, Degree of carbonation.....	15
4.3.1 General.....	15
4.3.2 Theoretical binding capacity of Portland cement.....	15
4.3.3 Normal binding capacity of Portland cement.....	16
4.3.4 Normal binding capacity of blended cements.....	17
4.4 Carbonation in different environments.....	18
4.4.1 General.....	18
4.4.2 Dry indoor concrete.....	18
4.4.3 Concrete exposed to rain.....	18
4.4.4 Concrete sheltered from rain.....	18
4.4.5 Wet or submerged concrete.....	18
4.4.6 Buried concrete.....	19
5 Practical experiences of CO₂ uptake in concrete life stages	19
5.1 CO ₂ uptake during product stage (module A).....	19
5.2 CO ₂ uptake during use stage (module B).....	20
5.3 CO ₂ uptake during end of life stage.....	26
5.3.1 CO ₂ uptake during end of life stage – demolition, crushing and waste handling (module C1-C3).....	26
5.3.2 CO ₂ uptake during end of life stage — landfill (module C4).....	29
5.4 CO ₂ uptake beyond the system boundary (module D).....	29
6 Figures for "direct estimation" of CO₂ uptake in whole structures during use stage	30
6.1 General.....	30
6.1.1 General.....	30
6.1.2 CO ₂ uptake for a portal frame bridge.....	31
6.1.3 CO ₂ uptake for a residential building.....	32
6.2 Average CO ₂ uptake for construction types, strength classes and exposure.....	33
7 Additional information	34
7.1 CO ₂ uptake in the long term, beyond the service life of the structure.....	34
7.2 CO ₂ uptake of crushed concrete in new applications.....	34
8 Society perspective – Carbonation and CO₂ uptake in mortar	34
9 National calculation models and methods	35
9.1 General.....	35
9.2 Calculation of Carbonation of concrete in use phase (Swiss approach).....	35
9.2.1 General.....	35
9.2.2 Water/CaO.....	35
9.2.3 CO ₂ concentration, relative humidity and CO ₂ buffer capacity.....	35
9.2.4 A simple approach of assessing the CO ₂ uptake of concrete components.....	36

9.2.5	Ratio of CO ₂ uptake/CO ₂ emission as a function of thickness of concrete element.....	39
	Bibliography	40

Currently in preview, click buy full version

European foreword

This document (CEN/TR 17310:2019) has been prepared by Technical Committee CEN/TC 104 “Concrete and related products”, the secretariat of which is held by SN.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

Currently in preview, click buy full vers.

1 Scope

This document provides detailed guidance on the carbonation and carbon dioxide (CO₂) uptake in concrete. This guidance is complementary to that provided in EN 16757, *Product Category Rules for concrete and concrete elements*, Annex BB.

Typical CO₂ uptake values for a range of structures exposed to various environmental conditions are presented. These values can be incorporated into EPDs for the whole life cycle for either: a functional unit, one tonne or one m³ of concrete, without necessarily having any detailed knowledge of the structure to be built.

In the rest of the document, the data will be given per m³.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

4 Carbonation, the uptake of carbon dioxide

4.1 Compounds, chemistry and notation

4.1.1 Carbon dioxide: Chemically expressed as CO₂ and present in the atmosphere as a gas. When CO₂ is dissolved in water, H₂O, it may form carbonic acid, H₂CO₃, where this may release carbonate, CO₃²⁻, and bicarbonate, HCO₃⁻ ions.

4.1.2 Calcium hydroxide: Chemically expressed as Ca(OH)₂ and often called Portlandite. It is a product of the hydration of Portland cement and is always present in concrete. For simplicity, cement chemists often denote calcium hydroxide as CH. Calcium hydroxide is not very soluble in water but it does dissolve to the ions Ca₂⁺ and 2OH⁻. The presence of calcium hydroxide in concrete is largely responsible for maintaining its alkaline environment, which is at a pH around 12,5. Around 25 % of hardened hydrated cement is Ca(OH)₂.

4.1.3 Calcium oxide: Chemically expressed as CaO. Portland cement clinker contains 61 % to 67 % CaO by oxide analysis, and where typically the assumed value is 65 %. Nearly all the calcium oxide in Portland cement is not present as calcium oxide but as part of more complicated compounds such as di-calcium silicates, tri-calcium silicates, tri-calcium aluminate and tetra-calcium alumina ferrite. Fortunately using the oxide analysis figure of 65 % CaO is sufficient for the calculation of potential carbonation without going into the more complex chemistry.

4.1.4 Calcium silicate hydrates, and other hydration products: When Portland cement reacts with water, that is when it hydrates, it forms calcium hydroxide and a larger proportion of complex hydration products where the bulk of these are made up of calcium and silica. The hydration products, or gel as described by concrete technologists, are called calcium-silica-hydrates, often simplified to CSH. For a typical composition of hardened hydrated cement it is assumed 50 % is CSH, around 25 % is calcium hydroxide, 10% calcium monosulfoaluminate-AFm, 10 % ettringite-AFt leaving 5 % undefined.