



Concrete materials and methods of concrete construction/Test methods and standard practices for concrete





Standards Council of Canada Conseil canadien des normes

Legal Notice for Standards

Canadian Standards Association (operating as "CSA Group") develops standards through a consensus standards development process approved by the Standards Council of Canada. This process brings together volunteers representing varied viewpoints and interests to achieve consensus and develop a standard. Although CSA Group administers the process and establishes rules to promote fairness in achieving consensus, it does not independently test, evaluate, or verify the content of standards.

Disclaimer and exclusion of liability

This document is provided without any representations, warranties, or conditions of any kind, express or implied, including, without limitation, implied warranties or conditions concerning this document's fitness for a particular purpose or use, its merchantability, or its non-infringement of any third party's intellectual property rights. CSA Group does not warrant the accuracy, completeness, or currency of any of the information published in this document. CSA Group makes no representations or warranties regarding this document's compliance with any applicable statute, rule, or regulation.

IN NO EVENT SHALL CSA GROUP, ITS VOLUNTEERS, MEMBERS, SUBSIDIARIES, OR AFFILIATED COMPANIES, OR THEIR EMPLOYEES, DIRECTORS, OR OFFICERS, BE LIABLE FOR ANY DIRECT, INDIRECT, OR INCIDENTAL DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES, HOWSOEVER CAUSED, INCLUDING BUT NOT LIMITED TO SPECIAL OR CONSEQUENTIAL DAMAGES, LOST REVENUE, BUSINESS INTERRUPTION, LOST OR DAMAGED DATA, OR ANY OTHER COMMERCIAL OR ECONOMIC LOSS, WHETHER BASED IN CONTRACT, TORT (INCLUDING NEGLIGENCE), OR ANY OTHER THEORY OF LIABILITY, ARISING OUT OF OR RESULTING FROM ACCESS TO OR POSSESSION OR USE OF THIS DOCUMENT, EVEN IF CSA GROUP HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES.

In publishing and making this document available, CSA Group is not undertaking to render professional or other services for or on behalf of any person or entity or to perform any duty owed by any person or entity to another person or entity. The information in this document is directed to those who have the appropriate degree of experience to use and apply its contents, and CSA Group accepts no responsibility whatsoever arising in any way from any and all use of or reliance on the information contained in this document.

CSA Group is a private not-for-profit company that publishes voluntary standards and related documents. CSA Group has no power, nor does it undertake, to enforce compliance with the contents of the standards or other documents it publishes.

Intellectual property rights and ownership

As between CSA Group and the users of this document (whether it be in printed or electronic form), CSA Group is the owner, or the authorized licensee, of all works contained herein that are protected by copyright, all trade-marks (except as otherwise noted to the contrary), and all inventions and trade secrets that may be contained in this document, whether or not such inventions and trade secrets are protected by patents and applications for patents. Without limitation, the unauthorized use, modification, copying, or disclosure of this document may violate laws that protect CSA Group's and/or others' intellectual property and may give rise to a right in CSA Group negroes all intellectual property rights in this document.

Patent rights

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. CSA Group shall not be held responsible for identifying any or all such patent rights. Users of this standard are expressly advised that determination of the validity of any such patent rights is entirely their own responsibility.

Authorized use of this document

This document is being provided by CSA Group for informational and non-commercial use only. The user of this document is authorized to do only the following:

If this document is in electronic form:

- load this document onto a computer for the sole purpose of reviewing it;
- search and browse this document; and
- print this document if it is in PDF format.

Limited copies of this document in print or paper form may be distributed only to persons who are authorized by CSA Group to have such copies, and only if this Legal Notice appears on each such copy.

In addition, users may not and may not permit others to

- alter this document in any way or remove this Legal Notice from the attached standard;
- sell this document without authorization from CSA Group; or
- · make an electronic copy of this document.

If you do not agree with any of the terms and conditions contained in this Legal Notice, you may not load or use this document or make any copies of the contents hereof, and if you do make such copies, you are required to destroy them immediately. Use of this document constitutes your acceptance of the terms and conditions of this Legal Notice.



Standards Update Service

CSA A23.1:19/CSA A23.2:19 June 2019

Title: Concrete materials and methods of concrete construction/Test methods and standard practices for concrete

To register for e-mail notification about any updates to this publication

- go to store.csagroup.org
- click on CSA Update Service

The List ID that you will need to register for updates to this publication is 2425145.

If you require assistance, please e-mail techsupport@csagroup.org or call 416-747-2233.

Visit CSA Group's policy on privacy at **www.csagroup.org/legal** to find out how we protect your personal information.

Canadian Standards Association (operating as "CSA Group"), under whose auspices this National Standard has been produced, was chartered in 1919 and accredited by the Standards Council of Canada to the National Standards system in 1973. It is a not-forprofit, nonstatutory, voluntary membership association engaged in standards development and certification activities.

CSA Group standards reflect a national consensus of producers and users — including manufacturers, consumers, retailers, unions and professional organizations, and governmental agencies. The standards are used widely by industry and commerce and often adopted by municipal, provincial, and federal governments in their regulations, particularly in the fields of health, safety, building and construction, and the environment.

Individuals, companies, and associations across Canada indicate their support for CSA Group's standards development by volunteering their time and skills to Committee work and supporting CSA Group's objectives through sustaining memberships. The more than 7000 committee volunteers and the 2000 sustaining memberships together form CSA Group's total membership from which its Directors are chosen. Sustaining memberships represent a major source of income for CSA Group's standards development activities.

CSA Group offers certification and testing services in support of and as an extension to its standards development activities. To ensure the integrity of its certification process, CSA Group regularly and continually audits and inspects products that bear the CSA Group Mark.

In addition to its head office and laboratory complex in Toronto, CSA Group has regional branch offices in major centres across Canada and inspection and testing agencies in eight countries. Since 1919, CSA Group has developed the necessary expertise to meet its corporate mission: CSA Group is an independent service organization whose mission is to provide an open and effective forum for activities facilitating the exchange of goods and services through the use of standards, certification and related services to meet national and international needs.

For further information on CSA Group services, write to CSA Group 178 Rexdale Boulevard Toronto, Ontario, M9W 1R3 Canada



6

Standards Council of Canada Conseil canadien des normes

Cette Norme Nationale du Canada est disponible en versions française et anglaise.

Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users to judge its suitability for their particular purpose. *A trademark of the Canadian Standards Association, operating as "CSA Group"

A National Standard of Canada is a standard developed by a Standards Council of Canada (SCC) accredited Standards Development Organization, in compliance with requirements and guidance set out by SCC. More information on National Standards of Canada can be found at <u>www.scc.ca</u>.

SCC is a Crown corporation within the portfolio of Innovation, Science and Economic Development (ISED) Canada. With the goal of enhancing Canada's economic competitiveness and social wellbeing, SCC leads and facilitates the development and use of national and international standards. SCC also coordinates Canadian participation in standards development, and identifies strategies to advance Canadian standardization efforts.

Accreditation services are provided by SCC to various customers, including product certifiers, testing laboratories, and standards development organizations. A list of SCC programs and accredited bodies is publicly available at <u>www.scc.ca</u>.

Standards Council of Canada 600-55 Metcalfe Street Ottawa, Ontario, K1P 6L5 Canada National Standard of Canada

CSA A23.1:19/CSA A23.2:19 Concrete materials and methods of concrete construction/Test methods and standard practices for concrete



 A trademark of the Canadian Standards Association, operating as "CSA Group"



Published in June 2019 by CSA Group A not-for-profit private sector organization 178 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3

To purchase standards and related publications, visit our Online Store at **store.csagroup.org** or call toll-free 1-800-463-6727 or 416-747-4044.

ICS 91.080.40; 91.100.30 ISBN 978-1-4883-0744-7

© 2019 Canadian Standards Association All rights reserved. No part of this publication may be reproduced in any form whatsoever without the prior permission of the publisher.

Contents

Technical Committee on Concrete Materials and Construction 9

Preface 15

- CSA A23.1:19, Concrete materials and methods of concrete construction
- 0 Introduction 18
- **1 Scope** 18
- 1.1 General 18
- 1.2 Exclusions 18
- 1.3 Precasting of concrete in the field 18
- 1.4 Parking garages 19
- 1.5 Supplementary specifications 19
- 1.6 Terminology 19
- 2 Reference publications 19
- 3 Definitions 47

4 Materials and concrete properties 55

- 4.1 Requirements for concrete and alternative methods for specifying concrete 55
- 4.1.1 Durability requirements 55
- 4.1.2 Alternatives for specifying concrete 59
- 4.2 Materials 60
- 4.2.1 Cements and supplementary cementitious materials 60
- 4.2.2 Water 61
- 4.2.3 Aggregates 61
- 4.2.4 Admixtures 66
- 4.2.5 Fibres 67
- 4.2.6 Pigments for integrally coloured concrete 67
- 4.3 Concrete properties 67
- 4.3.1 Mix proportions 67
- 4.3.2 Workability 68
- 4.3.3 Air entrainment *69*
- 4.3.4 Density 70
- 4.3.5 Strength 70
- 4.3.6 Volume stability considerations 70
- 4.3.7 Chloride ion penetrability 71
- 4.4 Quality control 71
- 4.4.1 Responsibilites 71
- 4.4.2 Concrete acceptance 73

5 Production and delivery 75

- 5.1 Storage of materials 75
- 5.1.1 General 75
- 5.1.2 Cementitious materials 75

© 2019 Canadian Standards Association

5.1.3 Aggregate 76 5.1.4 Admixtures 76 5.2 Production of concrete 76 5.2.1 General 76 5.2.2 Measurement of materials 77 Batching plant 5.2.3 78 5.2.4 Mixing 79 5.2.5 Delivery 81 6 Formwork, reinforcement, and prestressing 84 6.1 Reinforcement 84 6.1.1 Reinforcing steel 84 6.1.2 Bend test 84 6.1.3 Special reinforcement 85 6.1.4 **Dissimilar metals** 85 6.1.5 Prestressing steel 85 6.1.6 Surface condition of reinforcement 85 6.1.7 Protective coating 86 6.2 Hardware and miscellaneous materials 86 6.2.1 Hardware and ferrous inserts 86 6.2.2 Nonferrous inserts 86 6.2.3 Protective coating 86 6.2.4 Miscellaneous materials 86 6.2.5 Vapour retarder 87 6.3 Storage of reinforcement 87 6.3.1 General 87 6.3.2 Special storage requirements 87 6.4 Construction tolerances for cast-in-place concrete 6.4.1 General 88 6.4.2 Cross-sectional dimensions and tolerances 88 6.4.3 Plumbness 89 6.4.4 Relative alignment 90 6.4.5 Levelness 90 6.4.6 Variations from a reference system and general dimensions 6.5 Formwork 91 6.5.1 General 91 6.5.2 Drawings for formwork 91 6.5.3 Construction 91 Fabrication and placement of reinforcement 6.6 93 6.6.1 General 93 6.6.2 Hooks and bends 93 6.6.3 Spirals 94 6.6.4 Ties 95 6.6.5 Spacing of reinforcement 96 6.6.6 Concrete cover 96 6.6.7 Support of reinforcement 97 6.6.8 Tolerances for location of reinforcement 99 6.6.9 Splices of reinforcement 100

6.6.10 Welding of reinforcement 100

© 2019 Canadian Standards Association

88

90

- 6.6.11 Inspection 100 6.7 Fabrication and placement of hardware and other embedded items 100 6.7.1 General 100 Placing of hardware 6.7.2 100 6.7.3 Tolerances for placing anchor bolts and hardware 101 Welding of hardware 6.7.4 101 6.7.5 Conduits and pipes embedded in concrete 102 6.8 Post-tensioning 103 6.8.1 General 103 6.8.2 Unbonded tendons 104 6.8.3 Bonded tendons 106 Cement grout for bonded tendons 107 6.8.4 6.8.5 Preparation for post-tensioning 109 6.8.6 Application and measurement of prestressing force 112 6.8.7 Grouting 113 7 Placing, finishing, and curing concrete 115 7.1 Preconstruction quality planning 115 7.1.1 General 115 7.1.2 Concrete mixes for interior concrete floors 115 7.2 Hot and cold weather concreting 116 7.2.1 Hot weather concreting — Job preparation 116 7.2.2 Cold weather concreting 116 7.3 Jointing 117 7.3.1 Construction joints 117 7.3.2 Contraction joints 118 7.3.3 Isolation joints 119 7.3.4 Expansion joints 120 7.3.5 Joint filling 120 7.4 Storage of materials used for placing, finishing, and curing 120 7.4.1 General 120 7.4.2 Fabricated and proprietary materials 120 7.5 Placing of concrete 120 7.5.1 General 120 7.5.2 Handling 121 Depositing 7.5.3 122 7.5.4 Consolidation 124 7.5.5 Concreting underwater 124 7.5.6 Concrete placed by tremie 125 7.5.7 Concreting tubular piles and drilled shafts 125 7.6 Protection of plastic concrete 126 7.6.1 General 126 7.6.2 Initial curing for high-strength and high-performance concrete 127 7.6.3 Mass concrete 127 7.7 Finishing of concrete floor surfaces 129 7.7.1 Surface tolerances 129 7.7.2 Correction of floor flatness deficiencies 130 7.7.3 Initial finishing of horizontal surfaces 130
- 7.7.4 Final finishing 131

© 2019 Canadian Standards Association

142

143

7.7.5 Abrasion and wear resistance 133 7.7.6 Nonslip surfaces 133 7.7.7 Scratch finish 133 7.7.8 Grinding 133 7.7.9 Moisture condition of concrete floors 134 Curing 7.8 134 7.8.1 General 134 7.8.2 Methods and materials 134 7.8.3 Curing for special requirements 135 7.9 Bonded toppings 136 7.9.1 Types 136 7.9.2 Special concrete mixtures for toppings 136 7.9.3 Monolithic toppings 137 7.9.4 Bonding systems 137 7.9.5 Bonding fresh concrete to rock 138 7.9.6 Tensile bond 138 7.9.7 Testing frequency 138 7.9.8 Finishing bonded toppings 138 7.9.9 Curing 139 7.10 Finishing of formed surfaces 139 7.10.1 General 139 7.10.2 Formed surface finishes 139 7.10.3 Patching 140 Rubbed finishes 7.10.4 141 8 Concrete with special performance or material requirements 8.1 General 142 8.1.1 Application 142 Purpose 8.1.2 142 8.1.3 Criteria 142 8.1.4 Relevant clauses 142 8.1.5 Performance evaluation 143 8.1.6 Materials 143 8.1.7 Mix proportions 143 8.1.8 Placing and curing 143 8.2 High-performance concrete and ultra-high performance concrete 8.3 Architectural concrete 143 8.3.1 General 143 8.3.2 Reference samples 144 8.3.3 Mock-up field samples 144 8.3.4 Formwork for special architectural finishes 144 8.3.5 Placing of architectural cast-in-place concrete 145 8.3.6 Special finishes 146 8.4 Pervious concrete 146 8.5 High-strength concrete 147 8.5.1 General 147 8.5.2 Aggregate 147 8.5.3 Mixing 147

8.5.4 Trial mixes 147

© 2019 Canadian Standards Association

8.5.5 Temperature 147 8.5.6 Consolidation 147 8.5.7 Curing and protection 147 148 8.5.8 Strength testing 8.6 Self-consolidating concrete 148 General 148 8.6.1 8.6.2 149 Materials 8.6.3 Performance requirements for SCC 149 8.6.4 Mixture proportions 149 8.6.5 Delivery and placing 150 8.6.6 Finishing 150 8.6.7 Formwork 150 8.6.8 Curing 150 8.7 Concrete made with high-volume supplementary cementitious materials 150 8.7.1 Proportion of SCM 150 8.7.2 Materials 151 8.7.3 Trial mixes 151 8.7.4 Curing requirements 151 8.8 Low-shrinkage concrete 152 8.8.1 General 152 8.8.2 Qualification testing 152 8.8.3 Qualification of the mixture proportions 152 8.9 No-slump concrete 152 8.9.1 General 152 8.9.2 Trial mixtures 153 8.9.3 Concrete mix design 153 8.9.4 Field testing of no-slump concrete 153 Consolidation 8.9.5 153 8.9.6 Slump and air content tests 153 8.9.7 Contractor co-operation 153 8.9.8 Pre-construction meeting 154 Roller-compacted concrete 154 8.10 Controlled low-strength materials (CLSM) 8.11 154 8.11.1 General 154 8.11.2 Unshrinkable fill 154 8.12 Concrete made with alternative supplementary cementitious materials 156 8.12.1 General 156 8.12.2 Materials 156 8.12.3 Use in concrete 156 8.13 Shotcrete 156 8.13.1 General 156 8.13.2 Materials 157 Performance requirements for shotcrete 8.13.3 157 8.13.4 Mixture proportions 158 8.13.5 Delivery 159 159 8.13.6 Placing Consolidation considerations 8.13.7 159

8.13.8 Hardened shotcrete testing 160