TECHNICAL SPECIFICATIONS

Concrete Exposure Classes

RMCAO

Determination of the minimum concrete performance properties is based upon identifying the following key requirements:

- **Applicable Exposure Conditions** – The designer must assess the environmental conditions that the concrete will be exposed to during its service life. Direct input is also required from the owner regarding possible future uses since they can significantly affect the exposure class selection.
- **Structural Requirements** – The designer must determine the minimum concrete properties required to meet the applicable loading conditions.
- **Architectural Requirements** – The designer must consider the effects of selecting various architectural finishes on concrete material properties.
- **Minimum Durability Requirements** – Based upon the designer's assessment of the exposure conditions, the CSA A23.1 standard sets minimum concrete properties.

In cases where these various factors result in differing material properties, the designer must select the most stringent requirement as the minimum concrete performance requirement.

CSA A23.1-09 – Concrete Materials and Methods of Concrete Construction, Tables 1 – 4, outline the minimum durability requirements.

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CSA A23.1 – TABLE 1

Definitions of C, F, N, A, and S exposure classes

(See Clauses 4.1.1.1.1, 4.1.1.5, 4.4.4.1.1.1, 4.4.4.1.1.2, 6.6.7.5.1, 8.4.1.2 and Tables 2 and 12.)

C-XL	Structurally reinforced concrete exposed to chlorides or other severe environments with or without freezing and thawing conditions, with higher durability performance expectations than the C-1, A-1 or S-1 classes.
C-1	Structurally reinforced concrete exposed to chlorides with or without freezing and thawing conditions. Examples: bridge decks, parking decks and ramps, portions of marine structures located within the tidal and splash zones, concrete exposed to seawater spray, and salt water pools.
C-2	Non-structurally reinforced (i.e. plain) concrete exposed to chlorides and freezing and thawing. Examples: garage floors, porches, steps, pavements, sidewalks, curbs, and gutters.
C-3	Continuously submerged concrete exposed to chlorides but not to freezing and thawing. Examples: underwater portions of marine structures.
C-4	Non-structurally reinforced concrete exposed to chlorides but not to freezing and thawing. Examples: underground parking slabs on grade.
F-1	Concrete exposed to freezing and thawing in a saturated condition but not to chlorides. Examples: pool decks, patios, tennis courts, freshwater pools, and freshwater control structures.
F-2	Concrete in an unsaturated condition exposed to freezing and thawing but not to chlorides. Examples: exterior walls and columns.
N	Concrete not exposed to chlorides nor to freezing and thawing. Examples: footings and interior slabs, walls and columns.
A-1	Structurally reinforced concrete exposed to severe manure and/or silage gases, with or without freeze-thaw exposure. Concrete exposed to the vapour above municipal sewage or industrial effluent, where hydrogen sulphide gas may be generated. Examples: reinforced beams, slabs and columns over manure pits and silos, canals, pig slats, access holes, enclosed chambers, and pipes that are partially filled with effluents.
A-2	Structurally reinforced concrete exposed to moderate to severe manure and/or silage gases and liquids, with or without freeze-thaw exposure. Examples: reinforced walls in exterior manure tanks, silos and feed bunkers, exterior slabs.
A-3	Structurally reinforced concrete exposed to moderate to severe manure and/or silage gases and liquids, with or without freeze-thaw exposure in a continuously submerged condition. Concrete continuously submerged in municipal or industrial effluents. Examples: interior gutter walls, beams, slabs and columns, sewage pipes that are continuously full (e.g., force mains), and submerged portions of sewage treatment structures.
A-4	Non-structurally-reinforced concrete exposed to moderate manure and/or silage gases and liquids, without freeze-thaw exposure. Examples: interior slabs on grade.
S-1	Concrete subjected to very severe sulphate exposure (Tables 2 and 3).
S-2	Concrete subjected to severe sulphate exposure (Tables 2 and 3).
S-3	Concrete subjected to moderate sulphate exposure (Tables 2 and 3).

Notes:

1. *"C" classes pertain to chloride exposure.*
2. *"F" classes pertain to freezing and thawing exposure without chlorides.*
3. *"N" class is exposed to neither chlorides nor freezing and thawing.*
4. *"A" class pertains to agricultural, municipal or industrial projects exposed to human or animal wastes.*
5. *All classes of concrete, exposed to sulphates, shall comply with the minimum requirements of "S" class noted in Tables 2 and 3.*

CSA A23.1 TABLE 2

Definitions of C, F, N, R, S and A classes of exposure

(See Clauses 4.1.1.1.1, 4.1.1.3, 4.1.1.4, 4.1.1.5, 4.1.1.6, 4.1.2.1, 4.3.1, 7.4.1.1, 8.8.3, and 8.8.6.1, and Table 1.)

Requirements for specifying concrete

Class of exposure *	Maximum water-to-cementing materials ratio †	Minimum specified compressive strength (MPa) and age (d) at test †	Air content category as per Table 4	Curing Type (see Table 20)			Chloride ion penetrability test requirements and age at test ‡
				Normal Concrete	HVSCM 1	HVSCM 2	
C-XL	0.4	50 within 56 d	1 or 2§	3	3	3	< 1,000 coulombs within 56 d
C-1 or A-1	0.40	35 at 28 d	1 or 2§	2	3	2	<1,500 coulombs within 56 d
C-2 or A-2	0.45	32 at 28 d	1	2	2	2	
C-3 or A-3	0.50	30 at 28 d	2	1	2	2	
C-4** or A-4	0.55	25 at 28 d	2	1	2	2	
F-1	0.50	30 at 28 d	1	2	3	2	
F-2	0.55	25 at 28 d	2††	1	2	2	
N ††	For structural design	For structural design	None	1	2	2	
S-1	0.40	35 at 56 d	2	2	3	2	
S-2	0.45	32 at 56 d	2	2	3	2	
S-3	0.50	30 at 56 d	2	1	2	2	

* *See Table I for description of classes of exposure*

† *The minimum specified compressive strength may be adjusted to reflect proven relationships between strength and the water-to-cementing materials ratio. The water-to-cementing materials ratio shall not be exceeded for a given class of exposure.*

‡ *In accordance with ASTM C 1202. An age different from that indicated may be specified by the owner. Where calcium nitrite corrosion inhibitor is to be used, the same concrete mixture, but without calcium nitrite, shall be prequalified to meet the requirements for the permeability index in his Table.*

§ *Use Category 1 for concrete exposed to freezing and thawing. Use air content Category 2 for concrete not exposed to freezing and thawing.*

** *For class of exposure C-4, the requirement for air entrainment should be waived when a steel trowelled finish is required. The addition of supplementary cementing materials may be used to provide reduced permeability in the long term, if that is required.*

†† *Interior ice rink slabs and freezer slabs with a steel trowelled finish have been found to perform satisfactory without entrained air.*

‡‡ *See Clause 8.12 for concrete mixes for concrete floors.*

CSA A23.1 TABLE 3

Additional requirements for concrete subjected to sulphate attack*

(See Clauses 4.1.1.1.1, 4.1.1.6.2, 4.1.1.6.3, Tables 1 and 6, and Annex L.)

Class of exposure	Degree of exposure	Water soluble sulphate (SO_4) † in soil sample, %	Sulphate (SO_4) in groundwater sample, mg/L ‡	Water soluble sulphate (SO_4) in recycled aggregate sample, %	Cementing materials to be used §††	Performance requirements § Maximum expansion when testing using CSA A3004-c8, % At 6 months	At 12 months ††
S-1	Very severe	> 2.0	> 10,000	> 2.0	HS or HSb	0.05	0.10
S-2	Severe	0.20 – 2.0	1,500 – 10,000	0.60 – 2.0	HS or HSb	0.05	0.10
S-3	Moderate	0.10 – 0.20	150 – 1,500	0.20 – 0.60	MS, MSb, LH, HS or HSb	0.10	

* *For sea water exposure, see Clause 4.1.1.5*

† *As per CSA A23.2-3B*

‡ *As per CSA A23.2.B*

§ *Where combinations of supplementary materials and Portland or blended hydraulic cements are to be used instead of the cementing materials listed, the performance requirements shall be used to demonstrate performance against sulphate exposure (see Clauses 4.1.1.6.2, 4.2.1.1, and 4.2.1.3, and 4.2.1.4). Such combinations shall not be designated as blended cements.*

** *Type HS cement shall not be used in reinforced concrete exposed to both chloride and sulphates. Refer to Clause 4.1.1.6.3.*

†† *If the expansion is greater than 0.05% at 6 months but less than 0.10% at 1 year, the cementing materials combination under test shall be considered to have passed.*

CSA A23.1 TABLE 4

Requirements for the air content categories

(See Clauses 4.1.1.1.1, 4.1.1.3, 4.1.1.4, 4.1.1.5, 4.3.1, 4.3.3.1, 4.3.3.2, and 4.4.4.1.1.1 and Table 2.)

Air content category	Range in air content * for concretes with indicated nominal maximum sizes of coarse aggregate, % 10 mm	14 – 20 mm	28 – 40 mm
1 †	6 – 9	5 – 8	4 - 7
2	5 – 8	4 – 7	3 - 6

* *At the point of discharge from the delivery equipment, unless otherwise specified.*

† *For hardened concrete, see Clause 4.3.3.2.*

Notes:

(1) The above difference in air contents has been established based upon the difference in mortar fraction volume required for specific coarse aggregate sizes.

(2) Air contents measured after pumping or slip forming may be significantly lower than those measured at the end of the chute.

References

1 *CSA A23.1-09 – Concrete Materials and Methods of Concrete Construction, Canadian Standards Association International*

THE Power of Concrete

Technical information prepared by:
Ready Mixed Concrete Association of Ontario
#3 - 365 Brunel Road
Mississauga, ON L4Z 1Z5
T: 905.507.1122
F: 905.890.8122
info@rmcao.org
RMCAO.org