Unofficial translation into English of the Sections of Swiss Standard SIA 262/1:2013 referring to *in Situ* Air-Permeability Tests

Foreword

In the following, an unofficial translation of the following Sections of Swiss Standard SIA 262/1:2013 "Concrete Construction - Complementary Specifications" is presented:

- Section 4.3.4: Indicative limit values of Air-Permeability for different concrete types (exposure classes)
- Section 4.3.5: Conformity conditions
- Annex E: "Air-Permeability on the Structures", description of test method

A literal translation of the Sections has been attempted, present them in the same order as found in the original document. The official Swiss Standard in its German and French versions was taken as reference document. Whenever differences between both versions were found, the interpretation of the German version has been adopted.

Clarifying comments, not existing in the original document, have been inserted as footnotes in red characters. An Appendix has been included, explaining the meaning of the Exposure Classes defined in European Standard EN 206-1, for those not familiar with it.

For a more general overview of the scope of the entire Standard, a translation of its List of Contents has also been included.

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SIA 262/1:2013 Bauwesen Construction

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Construction en béton – Spécifications complémentaires
Costruzioni di calcestruzzo – Indicazioni complementari
Concrete Structures – Supplementary specifications

Betonbau – Ergänzende Festlegungen

Concrete Construction - Complementary Specifications

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LIST OF CONTENTS

Sections of the Standard Referring to the Measurement of Air-Permeability *in Situ*

4.3.4 For the evaluation of the results of Air-Permeability measurements, the requirements of Table 7, function of the concrete type and obtained at an age between 1 and 3 months, could be adopted. Details can be found in VSS-Report 641 (see Section E.11).

Table 7 : Indicative values for the evaluation of Air-permeability test results

Description	Concrete Type						
	A	B	C	D	E	F	G
Strength Classes[1]	C20/25	C25/30	C30/37	C25/30	C25/30	C30/37	C30/37
Exposure Classes[2]	XC1 XC2	XC3	XC4 XF1	XC4 XD1 XF2	XC4 XD1 XF4	XC4 XD3 XF2	XC4 XD3 XF4
Minimum Cement Content (kg/m^3)	280	280	300	300	300	320	320
Maximum water/cement ratio	0.65	0.60	0.50	0.50	0.50	0.45	0.45
Air-Permeability $\boldsymbol{k_{Ts}}$ (10^{-16} m^2)	-	-	2.0	2.0	2.0	0.5	0.5

4.3.5 For an evaluation according to Section 4.3.4, each Testing Area must fulfill the following conditions:

- Condition 1: Out of six (6) Air-permeability values k_{Ti} , measured on one Testing Area, not more than one (1) k_{Ti} value may exceed the specified limit value k_{Ts}. If just 2 out of 6 Air-permeability values, measured on one Testing Area, exceed the specified limit value k_{Ts}, a new series of 6 measurements will be conducted on different testing points within the same Testing Area.
- Condition 2: Not more than one (1) k_{Ti} value out of the six new Air-permeability measurements may exceed the specified limit value k_{Ts}.
- If neither Condition 1 nor Condition 2 are satisfied, the Testing Area is not in conformity with the requirements

[1] The indicated values correspond to the required characteristics strength (MPa) at 28 days, measured on cylinders/cubes.
[2] Correspond to the Exposure Classes defined in European Standard EN 206-1 (see Appendix). The combination of exposures are those typically found in Switzerland. The limits for XD classes can be applied to equivalent XS classes for marine environments, absent in Switzerland.

ANNEX E (normative)

AIR-PERMEABILITY ON THE STRUCTURE

E.1 Scope

The following Sections specify a non-destructive method to determine the Air-Permeability of concrete on the structure. The non-destructive determination of the Air-Permeability provides indications on the durability of the near-surface concrete layers.

E.2 References

None.

E.3 Definitions

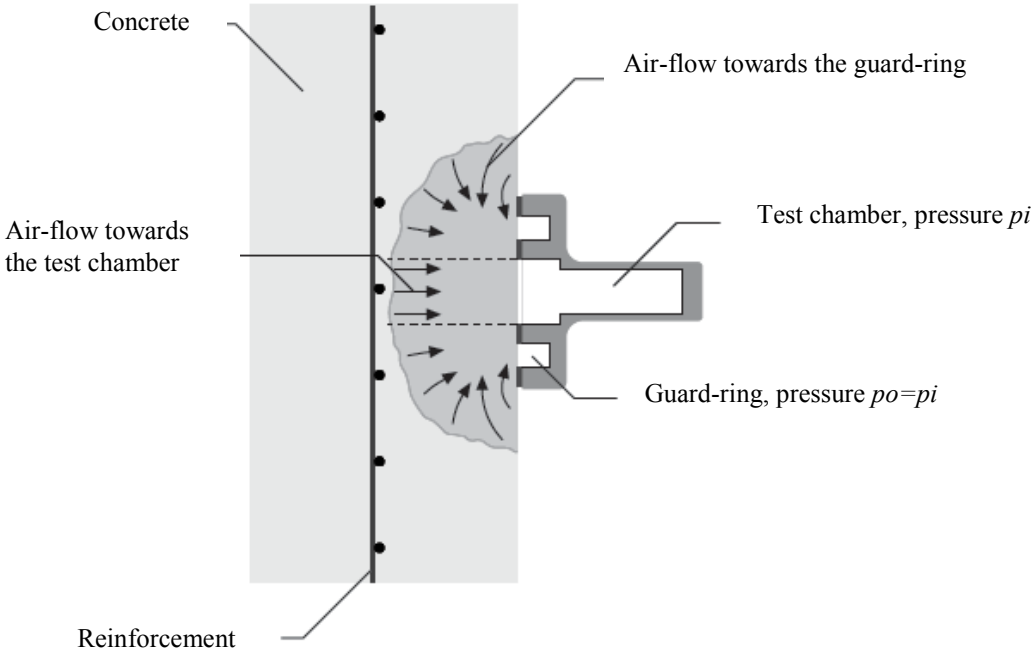
kT Coefficient of Air-Permeability or, in short, Air-Permeability [m^2]

E.4 Principle

By means of a vacuum pump, a vacuum is created in a test chamber and in a concentric guard-ring, both of which are open to the concrete surface. Then, the connection between the test chamber and the vacuum pump is air-tightly closed.

The pressure rise in the test chamber, due to the air flowing through the concrete, is measured in function of time. The Air-Permeability is computed as function of the change in pressure with time and other characteristic values.

Figure 3: Air-flow during the determination of the Air-Permeability



E.5 Test Equipment

- Instrument for the automatic control of the measurement, with a test chamber (minimum diameter 40 mm) and a surrounding concentric guard-ring. The pressure in the guard-ring must be regulated by the instrument so that the pressures in the test chamber and the guard-ring are always equal during the measurement
- Vacuum pump capable of creating a pressure below 20 mbar
- Instrument for determining the moisture of concrete based on electrical impedance

Note: more information on the necessary equipment can be found in Report VSS-641

E.6 Preparation of the Instrument and of Test Surface

- The testing instrument has to be conditioned before the measurements. For this, the instrument is applied on an impermeable material, evacuating it during at least 20 minutes.
- Then, the instrument has to undergo two successive calibrations. During this procedure, the pressure rise should not exceed 5 mbar and the difference between the pressure rise of both calibrations should not exceed 0.5 mbar.
- Before and during the measurement, the instrument shall be protected from direct exposure to sunlight.
- The surface of the concrete must be sufficiently smooth to generate adhesion of the vacuum chamber, preventing the infiltration of air in between the chamber and the concrete. Otherwise, the concrete surface is questionable and should be dry-polished with care.
- The cover depth to the reinforcement at the measurement point shall be at least of 2 cm; same for pipes, ducts, etc.
- At the measurement point no system to protect the concrete or similar should exist, unless it is proved that it has no influence on the measurement.
- The moisture content of the concrete has to be measured at the place where the Air-Permeability is to be determined and cannot exceed 5.5% by mass.
- The temperatures of the air and of the concrete have to be measured at the measurement point and should not be below 10°C.

E.7 Execution

- The measurement is performed at an age between 28 and 90 days; the temperature and moisture conditions must be respected.
- The test chamber and the guard-ring are placed on the concrete surface and a vacuum is automatically created by the instrument during 1 minute, by means of the vacuum pump. Next, the instrument automatically stops the evacuation of the test chamber and the pressure rise is measured in function of time, at least every 15 sec.
- On each Testing Area of a structural element, 6 to 12 measurements (see Evaluation[3]) have to be conducted on different locations. Care should be taken that the free distance, both horizontal and vertical, between measurement points as well as with the edges of the element should be at least 0.2 m.

[3] Sections 4.3.4 and 4.3.5

E.8 Test Results

On the basis of the measured values (pressure rise, test duration, other characteristic values), the instrument computes the Air-Permeability *kT* according to the following formula (see Report VSS 641):

$$k_T = \left(\frac{V_c}{A}\right)^2 \frac{\mu}{2\varepsilon p_a} \left(\frac{\ln\left(\frac{p_a + \Delta p}{p_a - \Delta p}\right)}{\sqrt{t} - \sqrt{t_0}}\right)^2$$

kT	Air-Permeability [m^2]
V_c	Volume of test chamber [m^3]
A	Cross-sectional area of the test chamber [m^2]
μ	Dynamic viscosity of air, assumed as constant at 2.0 10^{-5} Ns/m^2
$\mathcal{E}$	Air-filled porosity of the concrete, assumed as constant at 0.15
t	End of the measurement [s]
t_0	Initiation of the measurement (after evacuation of the test chamber) [s]
p_a	Atmospheric pressure [N/m^2]
Δ_p	Pressure difference in the test chamber between t_0 and t [N/m^2]

E.9 Report

Each test report must contain the following information:

- Name and Address of the order placer
- Name and Address of the Institution, as well as of the person responsible for the tests
- Reference to this Standard as well as to eventual deviations from it
- Date and time of the measurements
- Identification of the construction and element
- Casting date of the element tested
- Position of the measurement points
- Peculiarities of the element and measurement points, such as cracks, honeycombing, large blowholes, etc.
- In case of preparation of the measurement point (e.g. polishing), indicate the applied treatment
- Temperature of air and concrete
- Weather (e.g. cloudy, sunny)
- Moisture content in % by mass of each measurement point
- Instrument used (manufacturer and type)
- Pressure rise of all conducted calibrations
- Duration of the measurement (< 6, 6 or > 6 minutes per measurement)
- Individual measured values of Air-Permeability in 10^{-16} m^2.

E.10 Precision

Test results obtained by 5 laboratories on 2 to 3 elements of 2 jobsites, made of concretes with w/c ratios between 0.40 and 0.50, yielded the characteristic values shown in Table 13 (Report VSS 641).

Table 13: Uncertainties of the measurements for mean values

Jobsite	Geometric mean of Air-Permeability	Standard deviation of the logarithms of Air-Permeability	Repeatability standard deviation $\mathbf{S_r}$	Reproducibility standard deviation $\mathbf{S_R}$
	[10^{-16} m^2]	[log(m^2)]	[log(m^2)]	[log(m^2)]
1	0.17	0.43	0.44	0.45
2	0.19	0.79	0.55	0.58

E.11 Literature

F. Jacobs, A. Leemann, E. Denarié und T. Teruzzi: *Empfehlungen zur Qualitätskontrolle von Beton mit Luftpermeabilitätsmessungen*, Bundesamt für Strassenbau, Bericht VSS Nr. 641, Dez. 2009. The Report can be downloaded from http://www.tfb.ch/de/Publikationen.html[4].

[4] A partial English translation can be downloaded from http://www.m-a-s.com.ar/eng/documentation.php

APPENDIX (for clarification purposes, not included in Standard SIA 262/1:2013)

Definition of Exposure Classes according to European Standard EN 206-1 (Swiss Version SN EN 206-1):

Exposure Class	Environmental Influences	Examples
Reinforcement corrosion in carbonated concrete		
XC1	Dry or permanent wet	Structural members inside buildings at low humidity
XC2	Wet, rarely dry	Surfaces wetted with water over long periods
XC3	Moderately damp	Structural members inside buildings at moderate or high humidity, outdoor surfaces protected from rain
XC4	Alternatively wet and dry	Surfaces wetted with water which are not classified under class XC2
Reinforcement corrosion induced by chlorides (e.g. de-icing agents)		
XD1	Moderately damp	Structural members within spray range of road surfaces
XD2a	Wet, rarely dry.	Swimming pools, structural members in contact with industrial waste water containing chlorides; ≤ 0.5 g/l Cl
XD2b	Wet, rarely dry	Swimming pools, structural members in contact with industrial waste water containing chlorides; > 0.5 g/l Cl
XD3	Alternatively wet and dry	Parts of bridges, parking levels or retaining walls which are exposed to spray containing chlorides
Damage to concrete due to frost action, with or without de-icing agents		
XF1	Moderate water saturation, without de-icing agents	Vertical surfaces which are exposed to rain and frost
XF2	Moderate water saturation, with de-icing agents	Vertical surfaces which are exposed to spray containing de-icing agents
XF3	High water saturation, without de-icing agents	Horizontal surfaces which are exposed to rain and frost
XF4	High water saturation, with de-icing agents	Bridge slabs which are exposed to de-icing agents; surfaces which are exposed to spray or splash water and frost