Notation

Latin Letters

A aggregate-content in concrete volume (kg/m^3)

A/C aggregate-to-cement ratio, by weight

AI activity index of SCM (%)

b parameter in Feret's formula

b_1 , b_2 parameters in Abrams' formula

c concrete cover: distance of reinforcement from the outer surface of concrete (m)

C initial cement-content in concrete volume (kg/m^3)

C_{eq} total equivalent cement-content in concrete (kg/m^3)

CAFH C_6AFH_{12} content in concrete (kg/m^3)

CAH C_4AH_{13} content in concrete (kg/m^3)

$CA\overline{S}H$ $C_4A\overline{S}H_{12}$ content in concrete (kg/m^3)

CH calcium hydroxide content in concrete volume (kg/m^3)

$[Cl^-(aq)]$ concentration of Cl^- in the aqueous phase of concrete (kg/m^3 pore solution)

$[Cl^-(s)]$ concentration of Cl^- in the solid phase of concrete (kg/m^3 concrete)

$[Cl^-(s)]_{sat}$ saturation concentration of Cl^- in the solid phase (kg/m^3 concrete)

CO_2 carbon dioxide content in the ambient air at the concrete surface (%)

$[CO_2]$ carbon dioxide concentration in the gaseous phase of concrete (kg/m^3 pore)

CS calcium sulphate content in concrete (kg/m^3 of concrete)

CSH calcium silicate hydrate content in concrete volume (kg/m^3)

d thickness of mortar coating (m)

d_A aggregate density (kg/m^3)

d_C cement density (kg/m^3)

d_{CON} fresh concrete density (kg/m^3)

d_D admixture (solids) density (kg/m^3)

d_F fly ash density (kg/m^3)

d_L lime density (kg/m^3)

d_{MOR} fresh mortar density (kg/m^3)

d_S silica fume density (kg/m^3)

d_W	water density (kg/m^3)
D	total admixture-content (solids) in concrete volume (kg/m^3)
D_{e,Cl^-}	intrinsic effective diffusivity of Cl^- in concrete (m^2/s)
$D_{e,CO2}$	effective diffusivity of CO_2 in carbonated concrete (m^2/s)
D_{max}	maximum nominal upper aggregate size
E	activation energy (J/gmol)
f_c	compressive strength of concrete (MPa)
$f_{c,cube}$	compressive strength of concrete determined by testing cubes (MPa)
$f_{c,cyl}$	compressive strength of concrete determined by testing cylinders (MPa)
f_{ci}	individual test result for compressive strength of concrete (MPa)
$f_{ck,cube}$	characteristic compressive strength of concrete determined by testing cubes (MPa)
$f_{ck,cyl}$	characteristic compressive strength of concrete determined by testing cylinders (MPa)
f_{cm}	mean compressive strength of concrete (MPa)
$f_{i,K}$	weight fraction of constituent i (i=C, Cf, S, A, F, $\overline{S}$, R) in portland clinker
$f_{i,P}$	weight fraction of constituent i in SCM
$F_{h,i}$	degree of hydration of portland clinker phase i
$F_{p,j}$	degree of pozzolanic reaction of SCM-oxide j
F	initial fly ash-content in concrete volume (kg/m^3)
H	chemically-bound water content in concrete volume (kg/m^3)
k	efficiency factor of SCM comparing to portland cement
K	clinker content in concrete (kg/m^3 of concrete)
KT	total production cost of concrete (€/m^3)
K_B	cost of concrete transportation and delivery (€/m^3)
K_{eq}	equilibrium constant for Cl^- binding (m^3 of pore solution/kg)
K_G	other fixed and general costs in concrete production (€/m^3)
K_M	mixing cost for concrete production (€/m^3)
K_P	purchase cost of materials for concrete production (€/m^3)
K_T	cost of concrete transportation (€/m^3)
L	lime content in mortar volume (kg/m^3)
L/C	lime-to-cement ratio, by weight
M	distance between outer surface and axis of symmetry (m)
MAC	mac content in concrete (kg/m^3 of concrete)
n	number of repairs of the protective coating in the total designed lifetime

p_1 , p_2 parameters in Bolomey's formula

p_{CS} percentage of calcium sulphate in the cement (%)

p_K percentage of clinker in the cement (minus calcium sulphate) (%)

p_{MAC} percentage of minor additional const. in the cement (minus calcium sulphate) (%)

p_{PO} percentage of other pozzol. materials in the cement CEM V (minus calc. sulph.) (%)

p_{SCM} percentage of SCM in the cement (minus calcium sulphate) (%)

p_{SL} percentage of slag in the cement CEM V (minus calcium sulphate) (%)

P SCM content in concrete (kg/m^3 of concrete)

P_B pumping power in concrete application (J/s)

P_M mixing power in concrete production (J/s.m^3)

q quantities in algebraic formulae

q_c rate of corrosion of the steel bar in concrete (10^{-4} g/cm^2/yr)

Q fresh-concrete flowrate (m^3/s)

Q_{cr} critical amount of corrosion that causes splitting of the cover (10^{-4} g/cm^2)

r degree of pozzolanic reaction of both slag and pozzolan in type CEM V cement

$r_{h,i}$ hydration rate of the portland clinker phase i (mol/m^3.s)

$r_{p,j}$ pozzolanic reaction rate of SCM-oxide j (mol/m^3.s)

R gas universal constant (8.314 J/gmol.K)

R rest constituents' content in concrete (kg/m^3)

RH ambient relative humidity (%)

S initial silica fume-content in concrete volume (kg/m^3)

SL slag content in concrete (kg/m^3 of concrete)

SS standard strength class of cement: compressive strength at 28 days (MPa)

t time (s)

t_a time of application of mortar coating (s)

$t_{cr,carb}$ critical time required for reinforcement depassivation due to carbonation (s)

$t_{cr,chlor}$ critical time required for reinforcement depassivation due to Cl^- penetration (s)

t_d time required for total carbonation of mortar coating (s)

$t_{pr,carb}$ critical time required for carbonation-induced corrosion to split the cover (years)

t_M mixing time in concrete production (s)

T period of the complete exposure-nonexposure cycle (years)

U value of concrete constituent C, SCM, A, W, or D per unit (€/kg)

U_E cost of energy (€/J, note: $2.773.10^{-7}$ kWh/J)

W initial water-content (effective) in concrete volume (kg/m^3)

W/C water-to-cement ratio, by weight

x distance from the outer surface of concrete (m)

x_c concrete carbonation depth measured from concrete surface (m)

$x_{c,a}$ intitial (without any coating) carbonation depth of concrete (m)

X_c carbonation depth measured from coating outer surface (m)

Z designed service life of a concrete structure (years)

Z_{carb} designed service life of a concrete structure regarding carbonation (years)

Greek Letters

$\gamma_{i,P}$ weight fraction of oxide i in SCM, which contributes to the pozzolanic reactions

$\Delta\varepsilon_c$ porosity reduction due to carbonation

$\Delta\varepsilon_h$ porosity reduction due to hydration of portland cement

$\Delta\varepsilon_p$ porosity reduction due to pozzolanic activity

$\Delta \overline{V}_j$ molar volume difference between solid products and reactants in j reaction (m^3/kg)

ε total concrete porosity (m^3 pore volume /m^3 concrete)

ε_0 porosity of fresh concrete

ε_{air} volume of entrained or entrapped air per concrete volume (m^3/m^3)

ε_C porosity of carbonated concrete

ε_{eff} effective porosity of concrete regarding chloride diffusion

λ correction factor of carbonation depth for RH<55%

ρ ratio of the exposure time to the total time of a complete cycle

Subscripts

0 quantities referring to x=0

A quantities referring to aggregates

ACT maximum part of SCM that may participate in the pozzolanic reactions

carb quantities reffering to concrete carbonation

cr critical quantities for steel depassivation

D quantities referring to chemical admixtures

F quantities referring to fly ash

i oxide C, Cf, S, A, F, $\overline{S}$ or R (see cement techn. not.; Cf: free CaO, R: other const.)

in quantities referring to t=0

j	age in days
K	quantities referring to portland clinker
opt	quantities calculated from an optimization technique
P	quantities referring to SCM
S	quantities referring to silica fume
W	quantities referring to water

Superscripts

*	required quantities
(1)	quantities referring to cement-lime mortar coating
(2)	quantities referring to concrete

Abbreviations

AASHTO	American Association of States Highway and Transportation Officials
ACI	American Concrete Institute
AFM	atomic force microscopy
ASTM	American Society for Testing and Materials
BET	Brunauer, Emmett and Teller (method of)
CCP	concrete compositional parameters
C…/…	compressive strength classes in case of normal-weight and heavy-weight concrete
CAL	calcareous
CEB	Comité Euro-international du Béton
CEM…	cement type according to the series EN 197
CEN	Comité Européen de Normalisation
CH	calcium hydroxide
CSH	calcium silicate hydrate
EN	European Standard
mac	minor additional constituent
OPC	ordinary (normal) portland cement
RH	relative humidity
RILEM	Réunion Intern. des Laborat. d'Essais et de Recherches sur les Mat. et les Constr.
SCM	supplementary cementing materials
SEM	scanning electron microscopy

SIL	siliceous
SRPC	sulphate-resistant portland cement
X0	exposure class for no risk of corrosion or attack
XC…	exposure classes for risk of corrosion induced by carbonation
XD…	exposure classes for risk of corrosion induced by Cl^- other than from sea water
XS…	exposure classes for risk of corrosion induced by Cl^- from sea water
XF…	exposure classes for freeze/thaw attack
XA…	exposure classes chemical attack

Cement Technology Notation

S: SiO_2

A: Al_2O_3

F: Fe_2O_3

C: CaO

M: MgO

H: H_2O

$\bar{S}$: SO_3

$\bar{C}$: CO_2

LOI: loss on ignition

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