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Validation testing program on chloride penetration and carbonation standardized test methods

Programme d'essai de validation des méthodes d'essai normalisées relatives à la pénétration des chlorures et à la carbonatation

Validierungs-Prüfprogramm für genormte Prüfverfahren der Chlorideindringung und der Karbonatisierung

This Technical Report was approved by CEN on 1 January 2018. It has been drawn up by the Technical Committee CEN/TC 104.

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European foreword

This document (CEN/TR 17172:2018) has been prepared by Technical Committee CEN/TC 104 “Concrete and related products”, the secretariat of which is held by DIN.

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.

This document reports the data obtained in the Validation Testing Program (VTP) on chloride penetration and carbonation organized by WG 12 starting from 2009 as from document CEN/TC 51/WG 12 – Doc. N 229/2009, where the preparation of specimens the collection of results and the statistical analysis were performed by the Institute of Construction Sciences “Eduardo Torroja” of the CSIC of Spain, IETcc–CSIC, under the managing activities of Prof. Carmen Andrade.

Introduction

The procedure for the determination of chloride penetration is described in EN 12390-11:2015, "*Testing hardened concrete — Determination of the chloride resistance of concrete — Unidirectional diffusion*" and it has been published by CEN. The method is based on natural diffusion; a concentration profile after 90 days of contact with the chloride solution is used to fit Fick's law in order to calculate the chloride surface concentration, C_S and the non-steady-state chloride diffusion coefficient, D_{nss}. The method specifies three different modes of contact of the salt solution with one face of the specimen, immersion (DCL1), ponding (DCL2) and inversion (DCL3).

CEN/TC 51/WG 12 has also produced two methods addressed to the determination of the carbonation resistance of the concrete, the first one refers to natural condition and has been published as CEN/TS 12390-10, "*Testing hardened concrete — Part 10: Determination of the relative carbonation resistance of the concrete*", the second one, referring to accelerated condition, has been prepared by CEN/TC 51/WG 12/TG 5, but it has been disapproved by National Members at Formal Vote CEN TCA[1)].

The upgrading to EN standard of the aforesaid documents should require as first step the evaluation of robustness and precision data.

Having in mind these needs, CEN/TC 51/WG 12 organized a "Validation Testing Program (VTP) on chloride penetration and carbonation" for the preliminary evaluation of the robustness and the precision data of the test methods.

For the scope of the present work as robustness is intended the sensitivity of the test method to a composition change of concrete that are expected to produce an appreciable change in related performance.

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1) FprCEN/TS 12390-12:2010, *Testing hardened concrete — Part 12: Determination of the potential carbonation resistance of concrete: Accelerated carbonation method.*

1 Scope

The objective of the document consists in testing concrete mixes complying with EN 206 for particular aggressive environments with the test methods being standardized by TC 51/WG 12 on chloride penetration and carbonation in order to verify their robustness and coherence.

2 Concretes and specimens

For the VTP four concrete mixes were designed considering the limiting values indicated in Table F1 of EN 206 and the scope of assessing the robustness of the methods.

Three composition parameters (cement type, w/c ratio and cement content) were suitably chosen.

The following cement type and class were chosen: CEM II/A-LL 42.5 R and CEM II/B-V 32.5 R.

The w/c ratio was intentionally changed to substantially affect the concrete performances.

Two cement contents were used, the first one (300 kg/m^3) for carbonation, the second one (350 kg/m^3) for chloride penetration.

Aggregate “round shaped” of siliceous nature and with a maximum diameter of 14 mm was used. In Table 1 the composition of concrete mixes is shown.

The use of superplasticizer admixture was modulated, were necessary, to obtain a slump class S3 (100 mm – 150 mm). Table 1 gives the nominal proportions of the mixes used.

Table 1 — Proportions and cement types of the mixes prepared

	CARBONATION				CHLORIDE			
	MIX 1	**MIX 2**	**MIX 3**	**MIX 4**	**MIX 5**	**MIX6**	**MIX7**	**MIX8**
Cement type	CEM II/A-LL 42.5R		CEM II/B-V 32.5R		CEM II/A-LL 42.5R		CEM II/B-V 32.5R	
Cement amount (kg/m^3)	295	296	296	300	345	351	349	357
Water (l/m^3)	144	173	144	175	137	173	138	176
w/c ratio	0,49	0,58	0,49	0,58	0,4	0,49	0,4	0,49
Gravel (kg/m^3)	1 049	1 011	1 054	1 025	1 005	977	1 019	993
Sand (kg/m^3)	857	827	861	838	816	793	827	806
Superplasticizer (% cement weight)	0,60	0,20	0,50	0,15	0,79	0,23	0,57	0,10
Density (kg/dm^3)	2 260	2 265	2 294	2 285	2 273	2 313	2 330	2 330
Air content (%)	5,75	4,9	5,15	3,75	5,7	3,8	4,4	2,3
Slump (cm)	11	10	12	10	10	10	13,5	10

For each laboratory and test method 2 cubes (150 mm) were produced.

In Annex A a summary of the experimental details of the preparation of the specimens and their submission is described. It is worth noting that the specimen preparation was centralized in one laboratory (IETcc) in order to have a better homogeneity.