EUROPEAN EXPERIENCE WITH DURABILITY-RELATED PERFORMANCE TEST METHODS AND THE SPECIFICATION OF DURABILITY BY PERFORMANCE

BACKGROUND

(1) A JWG between CEN/TC250/SC2, CEN/TC104/SC1 and CEN/TC299 developed a framework for the specification of durability by performance. The Framework also includes the further possibility that a set of European deemed-to-satisfy limiting values for each performance level may also be derived. Currently this framework is limited to the following aspects of durability:

- resisting carbonation-induced corrosion;
- resisting chloride induced corrosion;
- resisting freeze-thaw damage.

(2) CEN/TC104/SC1/WG1 has identified the need for further work to try and turn this framework into a workable, reliable and cost-effective system.

(3) During and after the CEN/TC104/SC1/WG1 meeting held on the 17 March 2016 a series of questions were identified that need to be answered before a durability by performance system can be developed. It was stated that satisfactory answers may already exist to some of these questions.

(4) CEN/TC104/SC1/WG1 notes the existence of fib bulletin no 76: *Benchmarking of Deemed-to-satisfy provisions in standards*, but this does not address all the needs for confidence in a radically new system. WG1 is also aware that a significant amount of data on performance-related test methods is available in Europe and 'data mining' will be a key element in the expected research projects. This survey does not intend to collect such data, but the last question is aimed at identifying sources where this information is held.

(5) National mirror groups to CEN/TC104/SC1 are asked to persuade their experts, research organisations and universities to provide information to be collated at the national level and then submitted to

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for collating and the preparation of a CEN/TR**.**

Responses should be submitted before 15 September 2016
(CEN/TC104/SC1 Decision 449).

(6) To aid completing the questionnaire some Notes are provided.

(7) You are free to add any comments that may be relevant and helpful to others. Please add the comments to the relevant question or if general to the start of the Section.

(8) Please return the survey as a Word document to ease copying and pasting.

(9) This survey comprises a series of questions split into seven sections. Please complete Section 1 and other sections as appropriate.

A list of the questions is set out below in order for the reader to quickly see where it may be possible to make a response:

Section 1. Contact information and preliminary questions (Q1 to Q7)

Section 2. Overall schemes (Q8)

Section 3. Relationships between limiting value specifications (mix design and materials) and performance in existing structures:

Q9. Published data

Q10. Carbonation in existing structures and level of corrosion

Q11. Chloride ingress into existing structures and level of corrosion

Q12. Freeze-thaw damage to existing structures

Section 4. Relationships between durability-related performance test methods on test specimens and performance in structures or on natural exposure sites:

Q13. Published references

Q14. Comparison of type testing and in-situ testing

Section 5. Scope and extent of type testing and the period of validity of the type testing:

Q15. Scope, extent and purpose of type testing

Section 6. Additional testing for production:

Q16. Additional testing of production samples or site testing

Section 7. Sources of data on values achieved with durability-related performance test methods.

Q17. Contact details of organisation that have and are willing to provide data on the relationships between durability testing, constituent materials and mix proportions

Section 1: Contact information and preliminary questions

Response from the CEN member:

Contact person in case of questions on the response:

Contact person's e-mail address:

Preliminary questions

Q1. Do you have an overall scheme for any aspect of durability?

Yes	
No	

If yes, please complete Section 2 for each aspect of durability.

Q2. Do you have data on the relationships between limiting value specifications and performance in existing structures?

Yes	
No	

If yes, please complete Section 3.

Q3. Do you have information on the relationships between durability-related performance test methods on test specimens and performance in structures?

Yes	
No	

If yes, please complete Section 4.

Q4. Are you aware of any projects where a durability performance specification for concrete has been applied?

Yes	
No	

If yes, please complete Sections 5 and Section 6 for each example.

Q5. Are you aware of any projects where durability testing was undertaken prior to specifying concrete in the normal way?

Yes	
No	

If yes, complete Section 6 for each example.

Q7. Do you have organisations with data on the relationships between durability testing, constituent materials and mix proportions?

Yes	
No	

If yes, please complete Section 7.

Section 2: Overall schemes

Those essential components that are typically relevant in performance concepts are shown in the following figure:

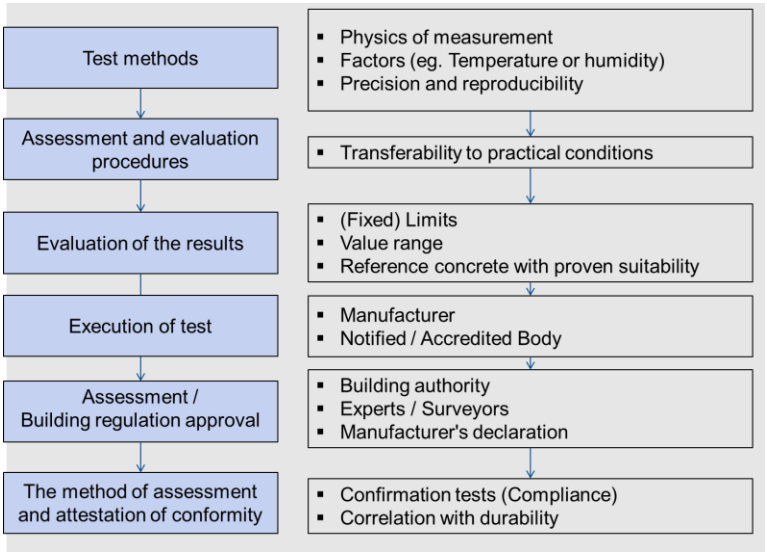

Figure 1: Essential components for implementation of performance concepts

Q8. If such systems are already implemented in your country, please describe them using the essential components given in Figure 1 and completing the Table 1:

Table 1: Essential components for implementation of performance concepts

Essential building regulation component	
Verification procedure / Test methods	
Assessment and evaluation procedures	
Assessment and attestation of conformity	
Execution of the test	
Assessment	
Building regulation approval	
Comments	

An example on how the table may be completed is given in Table 2.

Table 2: German examples for verification concepts for concrete durability

Essential building regulation component	CEN/TR 16563 - Annex B	ARS No. 04/2013 + Annex [1)]
Verification procedure / Test methods	• Carbonation acc. to RILEM CPC 18 • Chloride Migration acc. to NT Build 492 • Freeze-Thaw-Test acc. to CEN/TS 12390-9 (Cube-Test) or CF/CIF-Test acc. to CEN/TS 12390-9 and CEN/TR 15177 • Freeze-Thaw-Test with de-icing salts (CDF-Test) acc. to CEN/TS 12390-9	• ASR performance test with FIB-climate storage (Expert method) • ASR performance test with 60 °C-concrete prism and with alkali supply (modified acc. to RILEM and German Alkali Guidelines - Annex C) – VDZ test
Assessment and evaluation procedures	• Carbonation: Assessment background acc. to Fig. B.1-B.4 of CEN/TR 16563 Annex B • Chloride-Migration: limit value • Freeze-Thaw-Test: limit value • Freeze-Thaw-Test with de-icing salts: limit value and Reference concrete, if necessary	• Assessment background of experts (e. g. [1] for VDZ test)
Assessment and attestation of conformity	according to specifications of the national technical approval or the European Technical Assessment for • Factory production control (FPC) • Third party inspection (today mainly „strength-oriented“) • Application rules	• Performance test (expert report) • Incorporation Register of the BASt [2)] • Confirmation test (MBT [3)] + XFA/XRD on the aggregate)
Execution of the test	Experts acc. to notification by DIBt	Experts acc. to notification by BMVI
Assessment	Expert committee at DIBt	Experts acc. to notification by BMVI
Building regulation approval	DIBt	BASt [2)] register: „ASR-Performance-Test (Procedure V1)“

1) General Circular on Road Construction (ARS) No. 04/2013 by the Federal Ministry for Transport, Building and Urban Development

2) Federal Highway Research Institute

3) MBT: Mortar bar test

4) German Institute for Building Technology

[1] Müller, C.; Borchers, I.; Eickschen, E., “Experience with ASR test methods: advice on obtaining practical evaluation criteria for performance testing and aggregate testing”, In: Cement International 3/2013, Vol. 11.

Section 3: Relationships between limiting value specifications and performance in existing structures

Q9. If this information is already published, please give the reference and provide a summary and key data in English.

If these reports covers the questions in 10 to 12, go to Section 4.

Q10. Carbonation in existing structures and level of corrosion

Description of the structure(s) and its environment	
Average carbon dioxide concentration, ppm	
Average relative humidity, %	
Average temperature, ^{o}C	
Measurements taken from areas exposed or sheltered from direct rainfall	
Age(s) of structure	
Reason for investigation	
Average carbonation depth, mm	
Was carbonation > cover?	
Level of corrosion	
Comments	

Range of in-situ results[A)]							
Cement type[B)]	Addition, if any	If used, % addition by mass of (C+A)	Band of actual W/C ratio or W/(C+A) ratio[C), D)]	Coarse aggregate type	Aggregate absorption, if known	Average carbonation rates[E)], mm/√years	Number of test results

[A)] Add lines to the table as necessary.
[B)] Use EN 197 notations, e.g. CEMII/A-LL.
[C)] If no addition is used, provide W/C ratio; if addition is used provide W/(C+A) ratio. Use the following bands: 0.26 to 0.30, 0.31 to 0.35, 0.36 to 0.40, 0.41 to 0.45 etc.
[D)] If the actual w/c ratio is not known, give the specified w/c ratio or if you believe compressive strength controlled the mix design, the likely w/c ratio to achieve the specified strength.
[E)] Give the average per structure and where the data exists, split into exposed and sheltered areas.

Q11. Chloride ingress into existing structures and level of corrosion

Repeat tables below for different types of elements, locations and exposure solutions

Description of the structure(s)	
Type of structure[A)]	
Location of element[B)]	
Exposed to what type of chlorides[C)]	
Age(s) of structure	
Reason for investigation	
Surface concentration, if measured	
Average chloride concentration at rebar, %	
Level of corrosion	
Comments	

[A)] For example bridge abutment, seawall, swimming pool.
[B)] For example, permanently immersed, splash zone, tidal zone.
[C)] For example, North sea water, de-icing chemicals.

Range of in-situ results[A)]							
Cement type[B)]	Addition, if any	If used, % addition by mass of (C+A)	Band of W/C ratio or W/(C+A) ratio[C),D)]	Coarse aggregate type	Aggregate absorption, if known	Range of diffusion coefficients, $m^2/s \times 10^{-12}$	Number of test results

[A)] Add lines to the table as necessary.
[B)] Use EN 197 notations, e.g. CEMII/A-LL.
[C)] If no addition is used, provide W/C ratio; if addition is used provide W/(C+A) ratio. Use the following bands: 0.26 to 0.30, 0.31 to 0.35, 0.36 to 0.40, 0.41 to 0.45 etc.
[D)] If the actual w/c ratio is not known, give the specified w/c ratio or if you believe compressive strength controlled the mix design, the likely w/c ratio to achieve the specified strength.

Q12. Freeze-thaw damage in existing structures.

Description of the structure(s)	
Type of structure[A)]	
Location of element[B)]	
Age(s) of structure	
Number freeze-thaw cycles per year	
Number applications de-icing per year	
Typical lowest temperature per year, ^{o}C	
Reason for investigation	
Level of damage[C)]	
Comments	

[A)] For example bridge abutment, road.
[B)] For example, approximately horizontal, approximately vertical.
[C)] For example, slight surface scaling, 50% loss of cover.

Range of test results[A)]									
Cement type[B)]	Addition, if any	If used, % addition by mass of (C+A)	Band of W/C ratio or W/(C+A) ratio[C), D)]	% air[E)]	Coarse aggregate type	Aggregate absorption, if known	Type of failure[F)]	Signs of aggregate failure, yes or no?	% area damaged

[A)] Add lines to the table as necessary.
[B)] Use EN 197 notations, e.g. CEMII/A-LL.
[C)] If no addition is used, provide W/C ratio; if addition is used provide W/(C+A) ratio. Use the following bands: 0.26 to 0.30, 0.31 to 0.35, 0.36 to 0.40, 0.41 to 0.45 etc.
[D)] If the actual w/c ratio is not known, give the specified w/c ratio or if you believe compressive strength controlled the mix design, the likely w/c ratio to achieve the specified strength.
[E)] If the air was not the correct sizes for freeze-thaw resistance, add comment.
[F)] Scaling, internal damage, aggregate failure

Section 4. Relationship between laboratory test data and data from structures

Q13. If this information is already published, please give the reference and provide a summary and key data in English.

If these reports cover the questions in 14, go to Section 5.

Q14. What type testing was undertaken and how did the in-situ test values compare

14a) Carbonation

Type testing undertaken	
Type of test	
Standard	
Average value in type testing	
Description of the structure(s) and its environment	
Average carbon dioxide concentration, ppm	
Average relative humidity, %	
Average temperature, ^{o}C	
Measurements taken from areas exposed or sheltered from direct rainfall	
Age(s) of structure	
Reason for investigation	
Average carbonation depth, mm	
Was carbonation > cover?	
Level of corrosion	
Comments	

14b) Chlorides

Type testing undertaken	
Type of test	
Standard	
Average value in type testing	
Description of the structure(s) and its environment	
Type of structure[A)]	
Location of element[B)]	
Exposed to what type of chlorides[C)]	
Age(s) of structure	
Reason for investigation	
Surface concentration, if measured	
Average chloride concentration at rebar, %	
Level of corrosion	
Comments	
[A)] For example bridge abutment, seawall, swimming pool. [B)] For example, permanently immersed, splash zone, tidal zone. [C)] For example, North sea water, de-icing chemicals.	

14c) Freeze-thaw

Type testing undertaken	
Type of test	
Standard	
Average value in type testing	
Description of the structure(s) and its environment	
Type of structure[A)]	
Location of element[B)]	
Age(s) of structure	
Number freeze-thaw cycles per year	
Number applications de-icing per year	
Typical lowest temperature per year, ^{o}C	
Reason for investigation	
Level of damage[C)]	
Comments	

[A)] For example bridge abutment, road.
[B)] For example, approximately horizontal, approximately vertical.
[C)] For example, slight surface scaling, 50% loss of cover.

Section 5: Scope, extent and purpose of type testing for durability and the period of validity of the type testing

Q15. Extent, scope and purpose of type testing

If type testing for durability is a national requirement for all concretes, put in Row 1 'All structures in exposure classes ….. (add the exposure classes).

If the type testing is to check that a new constituent satisfies the current national limiting value specification (Row 6), put 'Not relevant' in Row 1.

For each example:

Type of structure	
What tests were undertaken?	
Number of test specimens per mix?	
Number of mixes tested?	
What was the period of validity for the type testing?[A)]	
To check that a new constituent satisfies the current national limiting value specification[B)] e.g. the equivalent durability procedure as given in CEN/TR 16563	
To prove that a specified limiting mix proportion specification gave the intended performance[B)]	
To provide input for a modelling exercise?	
To determine a mix design that gave the required performance and that this mix design became a specified requirement?	
To determine a mix design and that the supplied concrete was routinely subjected to the same performance testing?	
To determine a mix design and that the supplied concrete was routinely subjected to different (more rapid) performance testing?	
Comments	
[A)] If it was for the duration of the contract, say so, and give the contract duration in years. [B)] After proving this initial performance, conformity is based on conformity to the limiting value specification.	

Section 6: Production and conformity control of concretes where durability performance is a specified requirement

Q16. After proving the concrete by type testing, are there any requirements for additional durability testing of production samples or site testing. If so please provide details.

This is testing in addition to the normal testing of consistence, compressive strength and the assessment of the w/c ratio.

Section 7: Sources of data on values achieved with durability-related performance test methods

Q17. Contact details of organisation that have and are willing to provide data on the relationships between durability testing, constituent materials and mix proportions.

Organisation	Carbonation	Chlorides	Freeze-thaw	Other
Name of organisation				
Address				
Contact person				
E-mail				
Name of organisation				
Address				
Contact person				
E-mail				

Add more rows if necessary.