

# REVISION OF EN 206-1: WHAT WILL BE MODIFIED?

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## **Abstract**

The paper describes the main aspects of the current revision of EN 206-1. After about 10 years of experience with EN 206-1, CEN TC 104 decided to revise this first European Concrete Standard. Three main fields were identified for a general review, performed by adequate Task Groups: A) Durability, B) Use of additions and C) conformity criteria.

The general rules for the use of additions have been adapted: Besides the already practiced k-value-concept, two alternative concepts - the Equivalent Concrete Performance Concept (ECPC) and the Equivalent Performance of Combinations Concept (EPCC) - will be further incorporated.

For assessing conformity of concrete mean strength within the continuous production an alternative method by using control-charts (method C) will be incorporated. Furthermore the conformity procedure for fresh concrete properties (consistence and air-content) will be modified.

Further aspects will be considered within the revision (e.g. concrete with fibres, use of recycled aggregates). Also the special regulations for self-compacting concrete (SCC) will also be implemented in the new EN 206. Within a Joint-Working-Group between TC 104 and TC 288 it was agreed to regulate the additional aspects for concretes for special geotechnical works (bore-piles, diaphragm-walls) in future also in EN 206.

## **Keywords**

Additions, conformity, durability, k-value, performance concept, combinations concept, control charts,

## **Biographical notes**

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## 1. INTRODUCTION

In accordance with the CEN regulations, CEN standards have to be reviewed every five years. Thus in 2005 it had to be decided to start with a revision of the Concrete Standard EN 206-1 or to postpone such. At this point of time the application of this standard had been very different in the various Member States. While in a lot of them this standard has just been applied for only a few years in some others it was not applied at all. Consequently, in 2005 the experience with EN 206-1 was quite different and mostly just little. This in mind CEN/TC 104 "Concrete and related products" decided to shift its revision to earliest 2010. This point of view was confirmed by a resolution of the CEN meetings in Larnaca in November 2005. In context with a meeting in Stockholm in June 2007 CEN/TC 104/SC1 defined the roadmap for the revision of the European Concrete Standard EN 206-1. In June 2008 this roadmap was specified more in detail. The focus has to be on a rapid revision. This in mind CEN/TC 104/SC 1 decided in June 2007 that the general structure and the most important elements should be kept. Only a few major modifications should be taken, where real need for actions has been detected. These modifications have been discussed in the meantime in various Task Groups. The aim of these Task Groups is to prepare proposals to certain questions. The main focus is on equivalent durability concepts, the use of additives in concrete, the conformity control and the incorporation of special rules (e.g. for concrete in geotechnical works). These preparatory papers had been discussed within various meetings of CEN/TC 104/SC 1 and were the basis for the current draft of EN 206 which has just been send for enquiry to the Standardization Bodies of the Member States.

## 2. DURABILITY

### 2.1 Comparison of actual national application rules

A Task Group of CEN/TC 104/SC 1 "Concrete" developed a synopsis of the actual national application documents (NAD) of the European Concrete Standard EN 206-1 with respect to durability regulations. Considering the factsheets it becomes obvious that some countries neither have a restriction for the maximum w/c ratio nor for the minimum cement content of inside building elements. A majority of the NAD defines limit values, but the requirements can be very different. A lot of countries defined a minimum compressive strength of concrete. Five countries have no requirements at all. For inside building elements mostly exposure class XC1 has been defined. Nevertheless, some countries chose the classes X0 or XC3 for this exposure. For external construction elements a combination of exposure classes XC4 and XF1 is used in some countries. Requirements on the minimum compressive strength are unknown or differ considerably. The maximum w/c ratio is settled between 0.60 and 0.50, while the minimum cement content is defined between 150 and 320 kg/m<sup>3</sup>. Mostly 300 kg/m<sup>3</sup> are in use. Following conclusions have been drawn from this compilation:

- In the majority of cases most mentioned values of maximum w/c ratio and minimum cement content are related to EN 206-1, Table F.1
- In five cases (XC1, XC2, XC4, XD1 und XD3) the most used values of the minimum compressive strength class, maximum w/c ratio and minimum cement content is exactly the mentioned value in EN 206-1, Table F.1

There are also sometimes significant differences in the use of cements according to the exposure class. This is the result of different markets, construction practice and philosophy of making rules. So e.g. in the German application standard DIN 1045-1 an application guide exists for all 27 types of cement and some CEM-II-M cements. In other NAD's only the use of a few cements is regulated. Normally these cements are the most important ones in the respective national markets. Moreover also the rules for using additions are not consistent in the various Member States, sometimes there are significant differences.

## 2.2 General Procedure

So the synopsis showed clearly, that it is not possible to standardize the relevant durability aspects consistently and obligatory within all the CEN Member States. Nevertheless it must be the aim of EN 206, that at least the general procedure is regulated also in this metier. As for real performance criteria the necessary specific test methods are still missing, in principle durability also in the revised EN 206 has to be defined by indirect descriptive parameters as maximum w/c-ratio and minimum cement content etc. In this context especially the consideration of additions and their impact on the durability are of importance. Thus these aspects play a dominant role within the current EN 206-revision.

## 3. USE OF ADDITIONS

### 3.1 General Suitability

In CEN/TC 104/SC 1/TG 5 the regulations for concrete additions has been discussed very intensely. The general suitability of additions for concrete according to EN 206 is proved for mineral powder according to EN 12620 and pigments according to EN 12878 (nearly inert additions Type I) as well as for the pozzolanic concrete additions fly ash according to EN 450-1 and silica fume according to EN 13263-1 (Type II). In the revised EN 206 an additional link has to be made to the European product standard for blast furnace slag (GGBS, EN 15167-1) which has been published in the meantime.

The rules for the use of type II additions in concrete according to EN 206 are described in clause 5.2.5 "Use of additions". For two additions, fly ash and silica fume, specific requirements for their use with k-values are set. In this prescriptive concept for concrete mix design, the defined rules are on the safe side and cover all possible variations for the possible permutations of cement and addition.

Currently the specifications with respect to durability (k-values, w/c-ratio, cement content etc.) only refer to CEM I cements. Within the review those will be expanded also to CEM II/A type cements.

### 3.2 k-value Concept

With respect to the k-value concept in the revised EN 206, it was agreed that for fly ash and silica fume prescriptive k-values and cement substitution rates further will be set which have been proven to be on the safe side. These k-values allow the use of these additions in concrete throughout Europe with a restricted range of cement types within the requirements of the standard without any further verification procedure, i.e. without further testing except for the normal quality control for the concrete. This is because in a prescriptive concept for concrete mix designs, the defined rules must be on the safe side and cover all possible combinations of materials and variation for the given addition.

Because of only very limited experience in using the k-value concept for GGBS only a recommended value will be given. In national provisions, however, modifications to the rules of the k-value concept may be applied where their suitability has been established, e.g. higher k-values, increased proportions of additions, other additions (including type I), combinations of additions and other cements than those normally permitted. In this report the derivation of the prescriptive k-value approach is explained as well as options for modifications. It also describes how the k-value concept should be applied by the users such as the concrete producers.

### **3.3 Alternative Concepts (Equivalent Performance Concepts)**

Alternative options to the k-value concept are the Equivalent Concrete Performance Concept (ECPC) and Equivalent Performance of Combination Concept (EPCC). These methods are briefly described in EN 206 clause 5.2.5.3 and 5.2.5.4 while the principles for the assessment using this procedure are given in a CEN/TR. The rules for these performance concepts must also be safe and lead to a more efficient use of additions. Both equivalent performance concepts for the use of additions in concrete may be applied where suitability has been established as a result of a European Technical Approval, a relevant national standard or a provision valid in the place of use. Where GGBS has been used in the past as an concrete addition, this was performed nearly always under the ECPC or EPCC concepts.

#### **3.3.1 Equivalent Concrete Performance Concept (ECPC)**

The Equivalent Concrete Performance Concept (ECPC) permits amendments to the requirements for minimum cement content and maximum w/c-ratio when a combination of a specific addition and a specific cement source is used, for which the manufacturing source and characteristics of each are clearly defined and documented. This concept shall be used only for cements conforming to EN 197-1 with type II additions according specified for EN 206 application. It shall be proven that the concrete has an equivalent performance especially with respect to its interaction with the environment and to its durability when compared with a reference concrete in accordance with the requirements for the relevant exposure class. The ECPC is used in the Netherlands for more than 10 years already for combinations of fly ash as well as GGBS and cement. In the case that the durability aspects of the test concrete are equal or better than those of the reference concrete, the performance of the test concrete is assessed as equivalent to the reference concrete.

#### **3.3.2 Equivalent Performance of Combinations Concept (EPCC)**

The Equivalent Performance of Combinations Concept (EPCC) equates the performance of a combination of cement and an addition (or additions) with the performance of a standardized cement of the same nominal composition. This concept may permit a defined range of combinations to count fully towards the requirements for maximum w/c-ratio and minimum cement content, which are specified for the standardized cement.

In Europe there are three methods to establish the equivalence in performances of combinations: the UK method, the Irish method and the Portuguese method.

The main principles are:

- An addition added at the concrete mixer may be considered to perform in the same way, as would the same material incorporated into concrete as a constituent of cement.
- This is only permitted when a continuous program of control testing of the specific addition with the specific cement is carried out.

When applying this concept, it is recommended to

- identify a cement type, which complies with a European cement standard and, which has the same (or very similar) composition to the intended combination, and to
- assess whether the combination can be assumed to have adequate strength as well as the relevant physical and chemical properties, which the cement standard requires for the identified cement type.

In the case where the specification for the concrete includes a minimum requirement for strength, it can be assumed that if the concrete meets this strength requirement, then the combination has adequate strength; otherwise, a suitable testing program should be

established. The physical/chemical requirements in the addition standard will generally ensure that the combination has equivalent physical and chemical properties to the cement type and further testing will not normally be necessary. However, if there is concern that the combination may not satisfy any essential physical or chemical property or if special properties (e. g. heat of hydration or pozzolanicity) are required, a suitable testing program should be established. Any necessary testing should be carried out at least monthly using representative samples of the cement and addition(s) that are being combined.

### 3.4 Procedure

It was not possible to standardize the Equivalent Performance Concepts as harmonized rules within EN 206. Thus only the principles will be explained in the standard. For practicing these concepts guidance will be given in a separate CEN Technical Report. Main reasons for this are on one side, that experiences with these concepts are available only in a few Member States. On the other hand the basic requirements for durability parameters are so different – see above – that also the definition of one general reference concrete was impossible. So this can be kept only in hand of each Member State. The reference concrete shall conform to the provisions valid in the place of use for the selected exposure class. The proportions of the test concrete may vary from those of the reference concrete.

Summarizing the following principles for the use of additions have been considered within the EN 206 revision:

- The k-value concept and the equivalent concrete performance concept will remain.
- General aspects of the Equivalent Concrete Performance Concept and the Equivalent Performance of Combination Concept will be added.
- The reference to blast furnace slag (GGBS) shall be made in combination with the concepts that are mentioned above.
- The concepts for application of concrete additives will be described in general manner and combined with CEM I- and CEM II- cements. The regulations in detail for the application will be continued to run at national levels.

## 4. CONFORMITY CONTROL

CEN/TC 104/SC 1/TG 10 focuses on modifications in the conformity control, identification test and factory production control system (FPC). In the actual conformity control the conformity of compressive strength is assessed while current production at the age of 28 days by “n” not overlapping or overlapping, consecutively test results regarding to mean results  $f_{cm}$  (criterion 1) as well as individual test result  $f_{ci}$  (criterion 2). These principles will be kept furthermore.

For the case of a largely continuous production, an alternative method C with so called “Control charts” will be considered for the mean strength  $f_{cm}$  in the revised EN 206. Concrete production is based on the assumption that when the same quantities of constituents of the same type are batched and mixed, the concrete will have the same properties. Control charts use past production data to check if that assumption is valid by comparing what is actually achieved with what is expected. They detect where there has been a significant change in properties that requires corrective action(s). For production control also strength results of earlier age (e.g. 7 days) can be implemented additionally. This allows an earlier intervention in case of diverging strength.

For this, special evaluation-combined methods (Cu(mulative)sum, Shewart Charts) are admitted. For practising this, special tools, e.g. the evaluation by a V-mask (see fig. 1), can be

helpful. However, this verification is only allowed to be used combined with a certification by an external control (Third Party Control).

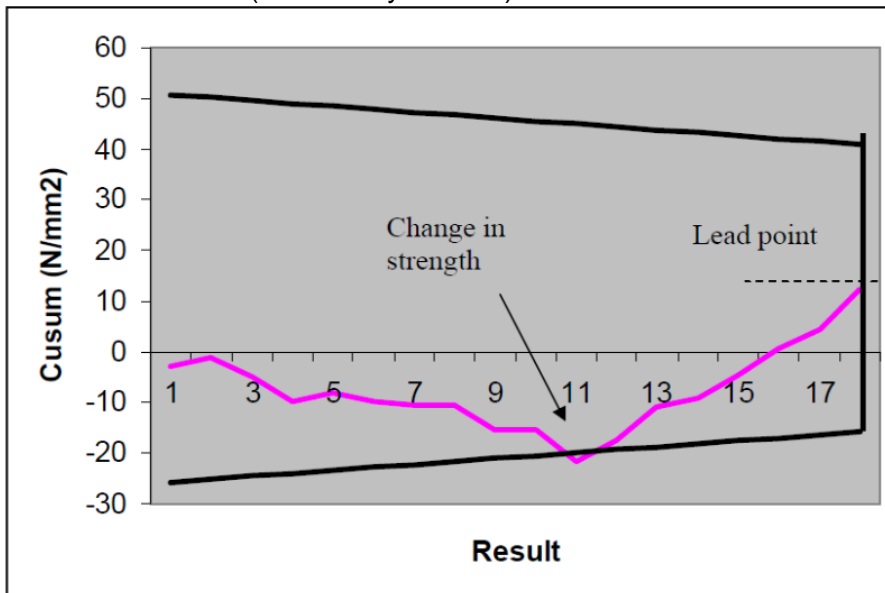


Fig. 1: V-Mask for evaluation of test-results within the Cu-sum method

Additionally rules for the application of fibres will be adopted in EN 206. Thereby it has to be differentiated between fibre addition in the mixing plant and the addition of them afterwards into the truck mixer.

Furthermore, fresh concrete tests (consistency, air content, homogeneous mixing of fibres), where the test results are immediately available and the rejection of a supply is directly possible – if necessary – , in future the conformity will be controlled only by individual test results. I.e. that for this characteristics the previous deviation limits in connection with acceptance numbers will be deleted.

## 5. FURTHER MODIFIKATIONS

Within the EN 206 revision also further aspects will be taken into consideration. So it is intended to implement the special rules for Self-Compacting Concrete (SCC), which currently are regulated in EN 206-9, in the future EN 206.

Furthermore the rules for the application of aggregates have to be adapted to the actual EN 12620. Especially the application of recycled aggregates has to be regulated as those are also considered now in the actual aggregate standard EN 12620. For the use of these recycled aggregates in concrete according EN 206 maximum replacement percentages in relation to exposure classes as well as categories for these aggregates will be recommended. According to the revised EN 12620 in the same manner modifications in the current regulations for natural aggregates have to be conducted.

Although the standards for special geotechnical works (EN 1536: bored piles and EN 1538: diaphragm walls) refer to EN 206 some special aspects for concrete are handled separately in those geotechnical standards. This is not very convenient, especially within the production control and the certification of concrete mixes for these applications inconsistencies with respect to the relevant standards can become relevant. Within a Joint-Working-Group between CEN TC104 / SC 1 and CEN TC 288 it could be found a compromise, that EN 206 considers the specific aspects for concretes for special geotechnical works (normative Annex D). On the other side in the next revision of the two standards EN 1536 and EN 1538 these regulations will be deleted, so that than with respect to concrete only reference will be made to EN 206.