DEAS/131-1:2023
ICS 91.100.30
HS 3816.00.00

# EAST AFRICAN STANDARD

## Concrete —Part 1: Specification, performance, production and conformity

DRAFT DEAS FOR PUBLIC COMMENTS

# EAST AFRICAN COMMUNITY

## Introduction

This East African Standard will be applied under different climatic and geographical conditions, different levels of protection and under different, well established, regional traditions and experience. Classes for concrete properties have been introduced to cover these situations. Where such general solutions were not possible, the relevant clauses contain permission for the application of national standards or provisions valid in the place of use of the concrete.

During the development of this East African Standard, consideration was given to detailing a performance-related approach to the specification of durability. For this, a review of performance-related design and test methods has been undertaken. However, this standard permits the continuation and development of practices valid in the place of use of the concrete as an alternative to the prescriptive approach.

This East African Standard incorporates rules for the use of constituent materials that are covered by East African Standards. Other by-products of industrial processes, recycled materials etc. are in current use based on local experience. Until East African specifications for these materials are available, this standard will not provide rules for their use, but instead refers to national standards or provisions valid in the place of use of the concrete.

This East African Standard defines tasks for the specifier, producer and user. For example, the specifier is responsible for the specification of concrete, Clause 6, and the producer is responsible for conformity and production control, Clauses 8 and 9. The user is responsible for placing the concrete in the structure. In practice there may be several different parties specifying requirements at various stages of the design and construction process e.g. the client, the designer, the contractor, the concreting sub-contractor. Each is responsible for passing the specified requirements, together with any additional requirements, to the next party in the chain until they reach the producer. In the terms of this East African Standard, this final compilation is known as the “specification“. Conversely, the specifier, producer and user may be the same party (e.g. a contractor doing design and build). In the case of ready mixed concrete, the purchaser of the fresh concrete is the specifier and has to give the specification to the producer. This standard also covers the necessary exchange of information between the different parties. Contractual matters are not addressed. Where responsibilities are given for parties involved, these are technical responsibilities.

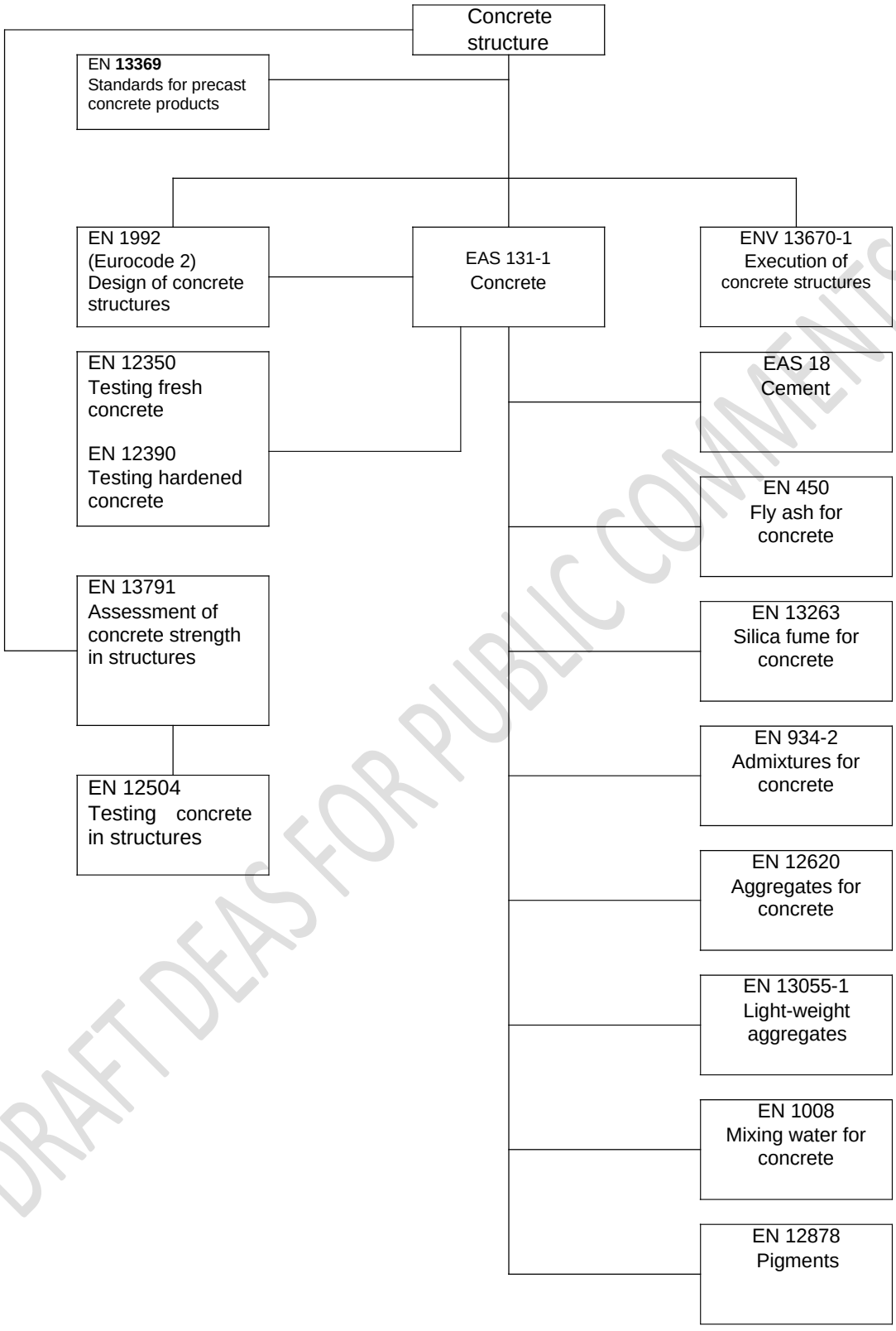
Notes and footnotes in tables of this standard are normative unless stated otherwise; other notes and footnotes are informative.

Conformity to this standard means conformity to the specification of the concrete to be assessed by application of the conformity criteria in Clause **8**. It also requires the producer to comply with the requirements for the production process and the production control.

Concerning the requirements on the production process and the production control, this standard gives sufficient flexibility to be adjusted to the size of production, the works, the particular equipment and procedures.

Where the producer has failed to comply with any requirements for production process and production control, the producer shall investigate the consequences of the non-compliance and when this results in a non-conformity with respect to Clause **8** or the requirements placed on the concrete, the producer shall declare the concrete as non-conforming. In all cases the cause of the non-compliance with the requirements on the production process and production control shall be investigated and corrected without delay.

DRAFT DEAS FOR PUBLIC COMMENTS




DRAFT DEAS FOR PUBLIC COMMENTS

**Figure 1 – Relationship between EAS 131-1 and standards for design and execution, standards for constituent materials and test standards**

# Concrete — Part 1: Specification, performance, production and conformity

## 1 Scope

This East African Standard applies to concrete for structures cast *in situ*, precast structures, and structural precast products for buildings and civil engineering structures.

The concrete may be mixed on site, ready-mixed concrete or produced in a plant for precast concrete products.

This standard specifies requirements for:

— the constituent materials of concrete;

— the properties of fresh and hardened concrete and their verification;

— the limitations for concrete composition;

— the specification of concrete;

— the delivery of fresh concrete;

— the production control procedures;

— the conformity criteria and evaluation of conformity.

This East African Standard applies to concrete compacted to retain no appreciable amount of entrapped air other than entrained air. This standard applies to normal-weight, heavy-weight and light-weight concrete.

Other East African Standards for specific products e.g. precast products or for processes within the field of the scope of this standard may require or permit deviations from this standard.

Additional or different requirements may be given in further parts of this standard or in other specific East African Standards, for example:

— concrete to be used in roads and other trafficked areas;

— concrete using other materials (e.g. fibres) or constituent materials not covered by 5.1;

— concrete with an upper aggregate size of 4 mm or less (mortar);

— special technologies (e.g. sprayed concrete);

— concrete for disposal of liquids and gaseous waste;

— concrete for vessels for storage of polluting substances;

— concrete for massive structures (e.g. dams);

— dry mixed concrete.

NOTE As long as these standards are not available, provisions valid in the place of use of the concrete may apply. East African Standards are under preparation for:

- concrete to be used in roads and other trafficked areas;
- sprayed concrete.

DRAFT DEAS FOR PUBLIC COMMENTS

This standard does not apply to:

— aerated concrete;

— foamed concrete;

— concrete with open structure ("no-fines" concrete);

— concrete with density less than 800 kg/m³;

— refractory concrete.

This standard does not cover health and safety requirements for the protection of workers during production and delivery of concrete.

## 2 Normative references

This East African Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this East African Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

In the case of reference to East African draft standards, provisions valid in the place of use of the concrete may be applied until the East African Standard is available.

EAS 18-1, *Cement — Part 1: Composition, specifications and conformity criteria for common cements*

EAS 18-2, *Methods of testing cement — Part 2: Chemical analysis of cement*

EN 450, *Fly ash for concrete — Definitions, requirements and quality control*

EN 933-1, *Tests for geometrical properties of aggregates — Part 1: Determination of particle size distribution — Sieving method*

EN 934-2, *Admixtures for concrete, mortar and grout — Part 2: Concrete admixtures — Definitions and requirements*

EN 1008:, *Mixing water for concrete — Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete*

EN 1097-3, *Tests for mechanical and physical properties of aggregates — Part 3: Determination of loose bulk density and voids*

EN 1097-6, *Tests for mechanical and physical properties of aggregates — Part 6: Determination of particle density and water absorption*

EN 12350-1, *Testing fresh concrete — Part 1: Sampling*

EN 12350-2, *Testing fresh concrete — Part 2: Slump test*

EN 12350-3, *Testing fresh concrete — Part 3: Vebe test*

EN 12350-4, *Testing fresh concrete — Part 4: Degree of compactability*

EN 12350-5, *Testing fresh concrete — Part 5: Flow table test*

EN 12350-6, *Testing fresh concrete — Part 6: Density*

DRAFT DEAS FOR PUBLIC COMMENTS

EN 12350-7, *Testing fresh concrete — Part 7: Air content of fresh concrete — Pressure methods*

EN 12390- 1, *Testing hardened concrete — Part 1: Shape, dimensions and other requirements for test specimens and moulds*

EN 12390-2, *Testing hardened concrete — Part 2: Making and curing specimens for strength tests*

EN 12390-3, *Testing hardened concrete — Part 3: Compressive strength of test specimens*

EN 12390-6, *Testing hardened concrete — Part 6: Tensile splitting strength of test specimens*

EN 12390-7, *Testing hardened concrete — Part 7: Density of hardened*

*concrete* EN 12620:, *Aggregates for concrete*

EN 12878, *Pigments for colouring of building materials based on cement and/or lime — Specifications and methods of test*

EN 13055-1:, *Lightweight aggregates — Part 1: Lightweight aggregates for concrete and mortar* EN

13263:, *Silica fume for concrete — Definitions, requirements and conformity control*

EN 13577:, *Water quality — Determination of aggressive carbon dioxide content* EN

45501:, *Metrological aspects of non-automatic weighing instruments*

ISO 2859-1:, *Sampling schemes for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 3951, *Sampling procedures and charts for inspection by variables by percent nonconforming*

ISO 4316, *Surface active agents — Determination of pH of aqueous solutions — Potentiometric method*

ISO 7150-1, *Water quality — Determination of ammonium — Part 1: Manual spectrometric method*

ISO 7150-2, *Water quality — Determination of ammonium — Part 2: Automated spectrometric method*

ISO 7980, *Water quality — Determination of calcium and magnesium — Atomic absorption spectrometric method*

DIN 4030-2, *Assessment of water, soil and gases for their aggressiveness to concrete — Part 2: Collection and examination of water and soil samples*

ASTM C 173, *Test method for air content of freshly mixed concrete by the volumetric method*

OIML R 117, *Measuring systems for liquids (Organisation Internationale de Métrologie Légale)*

Directive 90/384/EEC, *Directive of the Council of 20 June 1990 for the harmonization of the regulations of the Member States concerning non-automatic weighing equipment*

DRAFT DEAS FOR PUBLIC COMMENTS

# 3 Definitions, symbols and abbreviations

## 3.1 Terms and definitions

For the purposes of this standard, the following terms and definitions apply:

**3.1.1**
**concrete**
material formed by mixing cement, coarse and fine aggregate and water, with or without the incorporation of admixtures and additions, which develops its properties by hydration of the cement

**3.1.2**
**fresh concrete**
concrete which is fully mixed and still in a condition that is capable of being compacted by the chosen method

**3.1.3**
**hardened concrete**
concrete which is in a solid state and which has developed a certain strength

**3.1.4**
**site-mixed concrete**
concrete produced on the construction site by the user of the concrete for his own use

**3.1.5**
**ready-mixed concrete**
**concrete produced offsite by the supplier or user**

**3.1.6**
**precast concrete product**
concrete product cast and cured in a place other than the final location of use

**3.1.7**
**normal-weight concrete**
concrete having an oven-dry density greater than 2 000 kg/m$^3$ but not exceeding 2 600 kg/m$^3$

**3.1.8**
**light-weight concrete**
concrete having an oven-dry density of not less than 800 kg/m$^3$ and not more than 2 000 kg/m$^3$. It is produced using light-weight aggregate for all or part of the total aggregate

**3.1.9**
**heavy-weight concrete**
concrete having an oven-dry density greater than 2 600 kg/m$^3$

**3.1.10**
**high strength concrete**
concrete with a compressive strength class higher than C50/60 in the cases of normal-weight or heavy-weight concrete and LC50/55 in the case of light-weight concrete

**3.1.11**
**designed concrete**
concrete for which the required properties and additional characteristics are specified to the producer who is responsible for providing a concrete conforming to the required properties and additional characteristics

DRAFT DEAS FOR PUBLIC COMMENTS

**3.1.12**
**prescribed concrete**
**Concrete for which the composition of the constituent materials to be used are specified to the producer for compliance.**

**3.1.13**
**standardized prescribed concrete**
**pescribed concrete for which the composition is given in a standard valid in the place of use.**

**3.1.14**
**concrete family**
group of concrete compositions for which a reliable relationship between relevant properties is established and documented

**3.1.15**
**cubic metre of concrete**
quantity of fresh concrete which, when compacted in accordance with the procedure given in EN 12350-6, occupies a volume of one cubic metre

**3.1.16**
**truck mixer**
concrete mixer mounted on a self-propelled chassis capable of mixing and delivering a homogeneous concrete

**3.1.17**
**agitating equipment**
equipment generally mounted on a self-propelled chassis and capable of maintaining fresh concrete in a homogeneous state during transport

**3.1.18**
**non-agitating equipment**
equipment used for transporting concrete without agitation in the sense of definition 3.1.17, e.g. dump truck or transport hopper

**3.1.19**
**batch**
quantity of fresh concrete produced in one cycle of operations of a mixer or the quantity discharged during 1 min from a continuous mixer

**3.1.20**
**load**
quantity of concrete transported in a vehicle comprising one or more batches

**3.1.21**
**delivery**
process of handing over the fresh concrete by the producer

**3.1.22**
**admixture**
material added during the mixing process of concrete in small quantities related to the mass of cement to modify the properties of fresh or hardened concrete

**3.1.23**
**addition**
finely divided material used in concrete in order to improve certain properties or to achieve special properties. This standard deals with two types of inorganic additions:

— nearly inert additions (type I);

— pozzolanic or latent hydraulic additions (type II).

DRAFT DEAS FOR PUBLIC COMMENTS

**3.1.24**
**aggregate**
granular mineral material suitable for use in concrete. Aggregates may be natural, artificial or recycled from material previously used in construction

**3.1.25**
**normal-weight aggregate**
aggregate with an oven-dry particle density >2 000 kg/m$^3$ and <3 000 kg/m$^3$, when determined according to EN 1097-6.

**3.1.26**
**light-weight aggregate**
aggregate of mineral origin having an oven-dry particle density ≤2 000 kg/m$^3$ when determined according to EN 1097-6 or a loose oven-dry bulk density ≤1 200 kg/m$^3$ when determined according to EN 1097-3

**3.1.27**
**heavy-weight aggregate**
aggregate having an oven-dry particle density ≥ 3 000 kg/m$^3$ when determined according to EN 1097-6

**3.1.28**
**cement (hydraulic binder)**
finely ground inorganic material which, when mixed with water, forms a paste that sets and hardens by means of hydration reactions and processes and which, after hardening, retains its strength and stability even under water

**3.1.29**
**total water content**
added water plus water already contained in the aggregates and on the surface of the aggregates plus water in the admixtures and in additions used in the form of a slurry and water resulting from any added ice or steam heating

**3.1.30**
**effective water content**
difference between the total water present in the fresh concrete and the water absorbed by the aggregates

**3.1.31**
**water/cement ratio**
ratio of the effective water content to cement content by mass in the fresh concrete

**3.1.32**
**characteristic strength**
value of strength below which 5 % of the population of all possible strength determinations of the volume of concrete under consideration, are expected to fall

**3.1.33**
**entrained air**
microscopic air bubbles intentionally incorporated in concrete during mixing, usually by use of a surface active agent; typically between 10 µm and 300 µm in diameter and spherical or nearly so

**3.1.34**
**entrapped air**
air voids in concrete which are not purposely entrained

**3.1.35**
**site (construction site)**
area where the construction work is undertaken

DRAFT DEAS FOR PUBLIC COMMENTS

**3.1.36**
**specification**
final compilation of documented technical requirements given to the producer in terms of performance or composition

**3.1.37**
**specifier**
person or body establishing the specification for the fresh and hardened concrete

**3.1.38**
**producer**
person or body producing fresh concrete

**3.1.39**
**user**
person or body using fresh concrete in the execution of a construction or a component

**3.1.40**
**working life**
period of time during which the performance of the concrete in the structure will be kept at a level compatible with the fulfilment of the performance requirements of the structure, provided it is properly maintained

**3.1.41**
**initial test**
test or tests to check before the production starts how a new concrete or concrete family shall be composed in order to meet all the specified requirements in the fresh and hardened states

**3.1.42**
**identity test**
test to determine whether selected batches or loads come from a conforming population

**3.1.43**
**conformity test**
test performed by the producer to assess conformity of the concrete

**3.1.44**
**evaluation of conformity**
systematic examination of the extent to which a product fulfils specified requirements

**3.1.45**
**environmental actions**
those chemical and physical actions to which the concrete is exposed and which result in effects on the concrete or reinforcement or embedded metal that are not considered as loads in structural design

**3.1.46**
**verification**
confirmation by examination of objective evidence that specified requirements have been fulfilled

## 3.2 Symbols and abbreviations

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 chlorides other than from sea water

XS Exposure classes for risk of corrosion induced by chlorides from sea water

XF Exposure classes for freeze/thaw attack

DRAFT DEAS FOR PUBLIC COMMENTS

XA Exposure classes for chemical attack

S1 to S5 Consistence classes expressed by slump

V0 to V4 Consistence classes expressed by Vebe time

C0 to C3 Consistence classes expressed by degree of compactability

F1 to F6 Consistence classes expressed by flow diameter

C.../... Compressive strength classes in case of normal-weight and heavy-weight concrete

LC.../... Compressive strength classes in case of light-weight concrete

$f_{ck,cyl}$ Characteristic compressive strength of concrete determined by testing cylinders

$f_{c,cyl}$ Compressive strength of concrete determined by testing cylinders

$f_{ck,cube}$ Characteristic compressive strength of concrete determined by testing cubes

$f_{c,cube}$ Compressive strength of concrete determined by testing cubes

$f_{cm}$ Mean compressive strength of concrete

$f_{cm,j}$ Mean compressive strength of concrete at the age of ($j$) days

$f_{ci}$ Individual test result for compressive strength of concrete

$f_{tk}$ Characteristic tensile splitting strength of concrete

$f_{tm}$ Mean tensile splitting strength of concrete

$f_{ti}$ Individual test result for tensile splitting test of concrete

D Density class of light-weight concrete

$D_{max}$ Maximum nominal upper aggregate size

CEM Cement type according to the series EAS 18

σ Estimate for the standard deviation of a population

$s_n$

***AQL***

***w/c***

$k$ Factor which takes into account the activity of a type II addition

$e$ Verification scale interval of weighing equipment

$m$ Load exerted on weighing equipment

$n$ Number

# 4 Classification

## 4.1 Exposure classes related to environmental actions

The environmental actions are classified as exposure classes in Table 1. The given examples are informative.

NOTE The exposure classes to be selected depend on the provisions valid in the place of use of the concrete. This exposure classification does not exclude consideration of special conditions existing in the place of use of the concrete or the application of protective measures such as the use of stainless steel or other corrosion resistant metal and the use of protective coatings for the concrete or the reinforcement.

The concrete may be subject to more than one of the actions described in Table 1 and the environmental conditions to which it is subjected may thus need to be expressed as a combination of exposure classes.

DRAFT DEAS FOR PUBLIC COMMENTS

**Table 1 — Exposure classes**

| Class designation | Description of the environment | Informative examples where exposure classes may occur |
|---|---|---|
| **1 No risk of corrosion or attack** | | |
| X0 | For concrete without reinforcement or embedded metal: all exposures except where there is freeze/thaw, abrasion or chemical attack<br><br>For concrete with reinforcement or embedded metal: very dry | Concrete inside buildings with very low air humidity. |
| **2 Corrosion induced by carbonation** | | |
| Where concrete containing reinforcement or other embedded metal is exposed to air and moisture, the exposure shall be classified as follows:<br><br>NOTE The moisture condition relates to that in the concrete cover to reinforcement or other embedded metal, but in many cases, conditions in the concrete cover can be taken as reflecting that in the surrounding environment. In these cases classification of the surrounding environment may be adequate. This may not be the case if there is a barrier between the concrete and its environment. | | |
| XC1 | Dry or permanently wet | Concrete inside buildings with low air humidity.<br>Concrete permanently submerged in water. |
| XC2 | Wet, rarely dry | Concrete surfaces subject to long-term water contact.<br>Many foundations. |
| XC3 | Moderate humidity | Concrete inside buildings with moderate or high air humidity.<br>External concrete sheltered from rain. |
| XC4 | Cyclic wet and dry | Concrete surfaces subject to water contact, not within exposure Class XC2. |
| **3 Corrosion induced by chlorides other than from sea water** | | |
| Where concrete containing reinforcement or other embedded metal is subject to contact with water containing chlorides, including de-icing salts, from sources other than from sea water, the exposure shall be classified as follows:<br>NOTE Concerning moisture conditions, see also section 2 of this table. | | |
| XD1 | Moderate humidity | Concrete surfaces exposed to airborne chlorides. |
| XD2 | Wet, rarely dry | Swimming pools.<br>Concrete exposed to industrial waters containing chlorides. |
| XD3 | Cyclic wet and dry | Parts of bridges exposed to spray containing chlorides.<br>Pavements.<br>Car park slabs. |
| **4 Corrosion induced by chlorides from sea water** | | |
| Where concrete containing reinforcement or other embedded metal is subject to contact with chlorides from sea water or air carrying salt originating from sea water, the exposure shall be classified as follows: | | |
| XS1 | Exposed to airborne salt but not in direct contact with sea water | Structures near to or on the coast |
| XS2 | Permanently submerged | Parts of marine structures |
| XS3 | Tidal, splash and spray zones | Parts of marine structures |
| **5 Freeze/thaw attack with or without de-icing agents** | | |
| Where concrete is exposed to significant attack by freeze/thaw cycles whilst wet, the exposure shall be classified as follows: | | |
| XF1 | Moderate water saturation, without de-icing agent | Vertical concrete surfaces exposed to rain and freezing |
| XF2 | Moderate water saturation, with de-icing agent | Vertical concrete surfaces of road structures exposed to freezing and airborne de-icing agents |
| XF3 | High water saturation, without de-icing agent | Horizontal concrete surfaces exposed to rain and freezing |
| XF4 | High water saturation, with de-icing agent or sea water | Road and bridge decks exposed to de-icing agents.<br>Concrete surfaces exposed to direct spray containing de-icing agents and freezing.<br>Splash zones of marine structures exposed to freezing. |

DRAFT FOR PUBLIC COMMENTS

**Table 1 — Exposure classes** *(continued)*

| Class designation | Description of the environment | Informative examples where exposure classes may occur |
|---|---|---|
| **6 Chemical attack** | | |
| Where concrete is exposed to chemical attack from natural soils and ground water as given in Table 2, the exposure shall be classified as given below. The classification of sea water depends on the geographical location, therefore the classification valid in the place of use of the concrete applies.<br>NOTE A special study may be needed to establish the relevant exposure condition where there is:<br>— limits outside of Table 2;<br>— other aggressive chemicals;<br>— chemically polluted ground or water;<br>— high water velocity in combination with the chemicals in Table 2. | | |
| XA1 | Slightly aggressive chemical environment according to Table 2 | |
| XA2 | Moderately aggressive chemical environment according to Table 2 | |
| XA3 | Highly aggressive chemical environment according to Table 2 | |

**Table 2 — Limiting values for exposure classes for chemical attack from natural soil and ground water**

The aggressive chemical environments classified below are based on natural soil and ground water at water/soil temperatures between 5 °C and 25 °C and a water velocity sufficiently slow to approximate to static conditions.

The most onerous value for any single chemical characteristic determines the class.

Where two or more aggressive characteristics lead to the same class, the environment shall be classified into the next higher class, unless a special study for this specific case proves that it is not necessary.

| Chemical characteristic | Reference test method | XA1 | XA2 | XA3 |
|---|---|---|---|---|
| **Ground water** | | | | |
| $SO_4^{2-}$ mg/l | EAS 18-2 | ≥200 and ≤ 600 | >600 and ≤3000 | >3000 and ≤6000 |
| pH | ISO 4316 | ≤6.5 and ≥ 5.5 | <5.5 and ≥ 4.5 | <4.5 and ≥ 4.0 |
| $CO_2$ mg/l aggressive | PrEN 13577: | ≥ 15 and ≤ 40 | >40 and ≤ 100 | >100 up to saturation |
| $NH_4^+$ mg/l | ISO 7150-1 or ISO 7150-2 | ≥ 15 and ≤ 30 | >30 and ≤ 60 | >60 and ≤ 100 |
| $Mg^{2+}$ mg/l | ISO 7980 | ≥ 300 and ≤ 1000 | >1000 and ≤ 3000 | >3000 up to saturation |
| **Soil** | | | | |
| $SO_4^{2-}$ mg/kg[a] total | EAS 18-2[b] | ≥ 2000 and ≤ 3000[c] | >3000[c] and ≤ 12000 | >12000 and ≤ 24000 |
| Acidity ml/kg | DIN 4030-2 | >200 Bauman Gully | Not encountered in practice | |

[a] Clay soils with a permeability below $10^{-5}$ m/s may be moved into a lower class.

[b] The test method prescribes the extraction of $SO_4^{2-}$ by hydrochloric acid; alternatively, water extraction may be used, if experience is available in the place of use of the concrete.

[c] The 3000 mg/kg limit shall be reduced to 2000 mg/kg, where there is a risk of accumulation of sulfate ions in the concrete due to drying and wetting cycles or capillary suction.

DRAFT DEAS FOR PUBLIC COMMENTS

## 4.2 Fresh concrete

### 4.2.1 Consistence classes

Where the consistence of concrete is classified, Tables 3, 4, 5 or 6 apply.

NOTE The classes of consistence in Tables 3 to 6 are not directly related. In special cases, consistence may also be specified by target value. For earth moist concrete, i.e. concrete with low water content designed to be compacted in special processes, the consistence is not classified.

**Table 3 — Slump classes**

| Class | Slump in mm |
|---|---|
| S1 | 10 to 40 |
| S2 | 50 to 90 |
| S3 | 100 to 150 |
| S4 | 160 to 210 |
| S5[1)] | ≥220 |

**Table 4 — Vebe classes**

| Class | Vebe time in seconds |
|---|---|
| V0[1)] | ≥31 |
| V1 | 30 to 21 |
| V2 | 20 to 11 |
| V3 | 10 to 6 |
| V4[1)] | 5 to 3 |

**Table 5 — Compaction classes**

| Class | Degree of compactability |
|---|---|
| C0[1)] | 1.46 |
| C1 | 1.45 to 1.26 |
| C2 | 1.25 to 1.11 |
| C3 | 1.10 to 1.04 |

**Table 6 — Flow classes**

| Class | Flow diameter in mm |
|---|---|
| F1[1)] | 340 |
| F2 | 350 to 410 |
| F3 | 420 to 480 |
| F4 | 490 to 550 |
| F5 | 560 to 620 |
| F6[1)] | 630 |

### 4.2.2 Classes related to maximum aggregate size

Where concrete is classified according to the maximum size of aggregate, the nominal upper aggregate size of the coarsest fraction ($D_{max}$) in the concrete shall be used for classification.

NOTE *D* is the upper sieve size by which the aggregate size is defined in accordance with prEN 12620:

[1)] See note to 5.4.1.

DRAFT DEAS FOR PUBLIC COMMENTS

### 4.3 Hardened concrete

#### 4.3.1 Compressive strength classes

Where concrete is classified with respect to its compressive strength, Table 7 for normal-weight and heavy-weight concrete or Table 8 for light-weight concrete apply. The characteristic compressive strength at 28 days of 150 mm diameter by 300 mm cylinders ($f_{ck,cyl}$) or the characteristic compressive strength at 28 days of 150 mm cubes ($f_{ck,cube}$) may be used for classification.

NOTE In special cases intermediate strength levels between those in Table 7 or 8 may be used if this is permitted by the relevant design standard.

**Table 7 — Compressive strength classes for normal-weight and heavy-weight concrete**

| Compressive strength class | Minimum characteristic cylinder strength $f_{ck,cyl}$ N/mm$^2$ | Minimum characteristic cube strength $f_{ck,cube}$ N/mm$^2$ |
|---|---|---|
| C8/10 | 8 | 10 |
| C12/15 | 12 | 15 |
| C16/20 | 16 | 20 |
| C20/25 | 20 | 25 |
| C25/30 | 25 | 30 |
| C30/37 | 30 | 37 |
| C35/45 | 35 | 45 |
| C40/50 | 40 | 50 |
| C45/55 | 45 | 55 |
| C50/60 | 50 | 60 |
| C55/67 | 55 | 67 |
| C60/75 | 60 | 75 |
| C70/85 | 70 | 85 |
| C80/95 | 80 | 95 |
| C90/105 | 90 | 105 |
| C100/115 | 100 | 115 |

**Table 8 — Compressive strength classes for light-weight concrete**

| Compressive strength class | Minimum characteristic cylinder strength $f_{ck,cyl}$ N/mm$^2$ | Minimum characteristic cube strength [a] $f_{ck,cube}$ N/mm$^2$ |
|---|---|---|
| LC8/9 | 8 | 9 |
| LC12/13 | 12 | 13 |
| LC16/18 | 16 | 18 |
| LC20/22 | 20 | 22 |
| LC25/28 | 25 | 28 |
| LC30/33 | 30 | 33 |
| LC35/38 | 35 | 38 |
| LC40/44 | 40 | 44 |
| LC45/50 | 45 | 50 |
| LC50/55 | 50 | 55 |
| LC55/60 | 55 | 60 |
| LC60/66 | 60 | 66 |
| LC70/77 | 70 | 77 |
| LC80/88 | 80 | 88 |

[a] Other values may be used if the relationship between these and the reference cylinder strength is established with sufficient accuracy and is documented.

DRAFT DEAS FOR PUBLIC COMMENTS

### 4.3.2 Density classes for light-weight concrete

Where light-weight concretes are classified by density classes, Table 9 applies.

**Table 9 — Classification of light-weight concrete by density**

| Density class | D1.0 | D1.2 | D1.4 | D1.6 | D1.8 | D2.0 |
|---|---|---|---|---|---|---|
| Range of density kg/m$^3$ | ≥800 and ≤1000 | >1000 and ≤ 1200 | >1200 and ≤ 1400 | >1400 and ≤ 1600 | >1600 and ≤1800 | >1800 and ≤2000 |

NOTE The density of light-weight concrete may also be specified by target value.

## 5 Requirements for concrete and methods of verification

### 5.1Basic requirements for constituent materials

### 5.1.1 General

Constituent materials shall not contain harmful ingredients in such quantities as may be detrimental to the durability of the concrete or cause corrosion of the reinforcement and shall be suitable for the intended use in concrete.

Where general suitability is established for a constituent material, this does not indicate suitability in every situation and for every concrete composition.

Only constituents with established suitability for the specified application shall be used in concrete conforming to EAS 131-1.

NOTE Where there is no East African Standard for a particular constituent material which refers specifically to the use of this constituent material in concrete conforming to EAS 131-1, or where there is an existing East African Standard which does not cover the particular product or where the constituent deviates significantly from the East African Standard, the establishment of suitability may result from:

— a relevant national standard or provisions valid in the place of use of the concrete which refers specifically to the use of the constituent material in concrete conforming to EAS 131-1.

### 5.1.2 Cement

General suitability is established for cement conforming to EAS 18-1.

### 5.1.3 Aggregates

General suitability is established for:

— normal and heavy-weight aggregates conforming to EN 12620:

— lightweight aggregates conforming to EN 13055-1

NOTE Provisions for recycled aggregates are not yet included in these standards. Until provisions for recycled aggregates are given in East African technical specifications, suitability should be established according to the note in 5.1.1.

### 5.1.4 Mixing water

Suitability is established for mixing water and for recycled water from concrete production conforming to EN 1008

### 5.1.5 Admixtures

General suitability is established for admixtures conforming to EN 934-2.

DRAFT EAS FOR PUBLIC COMMENTS

### 5.1.6 Additions (including mineral fillers and pigments)

General suitability as type I addition, see 3.1.23, is established for:

— filler aggregate conforming to EN 12620

— pigments conforming to EN 12878.

General suitability as type II addition, see 3.1.23, is established for:

— fly ash conforming to EN 450;

— silica fume conforming to EN 13263

## 5.2 Basic requirements for composition of concrete

### 5.2.1 General

The concrete composition and the constituent materials for designed or prescribed concrete shall be chosen (see 6.1) to satisfy the requirements specified for fresh and hardened concrete, including consistence, density, strength, durability, protection of embedded steel against corrosion, taking into account the production process and the intended method of execution of concrete works.

Where not detailed in the specification, the producer shall select types and classes of constituent materials from those with established suitability for the specified environmental conditions.

NOTE 1 The concrete should be designed so as to minimize segregation and bleeding of the fresh concrete unless specified otherwise.

NOTE 2 The required properties of concrete in the structure will generally only be achieved if certain execution procedures on the fresh concrete are fulfilled at the place of use. Therefore, in addition to the requirements of this standard, the requirements for transportation, placing, compaction, curing and further treatment should be taken into account before specifying the concrete (see ENV 13670-1 or other relevant standards). Many of these requirements are often interdependent. If all these requirements are satisfied, any difference in concrete quality between the concrete in the structure and standardized test specimens will be adequately covered by the partial safety factor for the material (see ENV 1992-1-1).

For standardized prescribed concrete, the composition is restricted to:

— natural normal-weight aggregate;

— additions in powder form provided they are not taken into account for the cement content and water/cement ratio;

— admixtures except for air-entraining admixtures;

— compositions fulfilling the criterion for adoption of initial tests given in A.5.

NOTE 3 Provisions valid in the place of use may list types and classes of constituent materials with established suitability for the local environment.

### 5.2.2 Selection of cement

The cement shall be selected from those for which the suitability is established, taking into account the:

— execution of the work;

— end use of the concrete;

— curing conditions (e.g. heat treatment);

— dimensions of the structure (the heat development);

— environmental conditions to which the structure is to be exposed (see 4.1);

— potential reactivity of aggregate to the alkalis from the constituents.

DRAFT DEAS FOR PUBLIC COMMENTS

### 5.2.3 Use of aggregates

#### 5.2.3.1 General

Aggregate type, grading and categories, e.g. flakiness, freeze/thaw resistance, abrasion resistance, fines, shall be selected taking into account the:

— execution of the work;

— end use of the concrete;

— environmental conditions to which the concrete is to be exposed;

— any requirements for exposed aggregate or aggregate for tooled concrete finishes.

— The maximum nominal upper aggregate size ($D_{max}$) shall be selected taking into account the cover to reinforcement and the minimum section width.

#### 5.2.3.2 All-in aggregate

All-in aggregate conforming to EN 12620shall be used only in concrete with compressive strength classes ≤ C12/15.

#### 5.2.3.3 Recovered aggregate

Aggregate recovered from wash water or fresh concrete may be used as aggregate for concrete.

Undivided recovered aggregate shall not be added in quantities greater than 5 % of the total aggregate. Where the quantities of the recovered aggregates are greater than 5 % of the total aggregate, they shall be of the same type as the primary aggregate and shall be divided into separate coarse and fine fractions and conform to EN 12620

#### 5.2.3.4 Resistance to alkali-silica reaction

Where aggregates contain varieties of silica susceptible to attack by alkalies ($Na_2O$ and $K_2O$ originating from cement or other sources) and the concrete is exposed to humid conditions, actions shall be taken to prevent deleterious alkali-silica reaction using procedures of established suitability.

NOTE Precautions appropriate to the geological sources of the aggregates should be followed, taking into account long term experience with the particular combination of cement and aggregate.

### 5.2.4 Use of recycled water

Recycled water from concrete production shall be used in accordance with the conditions specified for its use in EN 1008

### 5.2.5 Use of additions

#### 5.2.5.1 General

The quantities of type I and type II additions to be used in concrete shall be covered by the initial tests (see Annex A).

NOTE 1 The influence of high quantities of additions on properties other than strength should be taken into account.

Type II additions may be taken into account in the concrete composition with respect to the cement content and the water/cement ratio if the suitability is established.

The suitability of the *k*-value concept is established for fly ash and silica fume (see 5.2.5.2). If other concepts e. g. the equivalent concrete performance concept (see 5.2.5.3), modifications of the rules

DRAFT DEAS FOR PUBLIC COMMENTS

of the *k*-value concept, higher *k*-values as defined in 5.2.5.2.2 and 5.2.5.2.3, other additions (including type I) or combinations of additions are to be used, their suitability shall be established.

NOTE 2 The establishment of the suitability may result from either:

— a East African Technical Approval which refers specifically to the use of the addition in concrete conforming to EAS 131-1;

— a relevant national standard or provision valid in the place of use of the concrete which refers specifically to the use of the addition in concrete conforming to EAS 131-1.

### 5.2.5.2 *k*-value concept

#### 5.2.5.2.1 General

The *k*-value concept permits type II additions to be taken into account:

— by replacing the term "water/cement ratio" (defined in 3.1.31) with "water/(cement + *k* × addition) ratio";

— in the minimum cement content requirement (see 5.3.2).

The actual value of *k* depends on the specific addition.

The application of the *k*-value concept for fly ash conforming to EN 450 or silica fume conforming to prEN 13263together with cement of type CEM I conforming to EAS 18-1 is given in the following clauses.

The *k*-value concept may be applied to fly ash or silica fume with other types of cement and to other additions if there is established suitability.

#### 5.2.5.2.2 *k*-value concept for fly ash conforming to EN 450

The maximum amount of fly ash to be taken into account for the *k*-value concept shall meet the requirement:

fly ash/cement ≤ 0.33 by mass.

If a greater amount of fly ash is used, the excess shall not be taken into account for the calculation of the water/(cement + *k* × fly ash) ratio, and the minimum cement content.

The following *k*-values are permitted for concrete containing cement type CEM I conforming to EAS 18-1:

| | |
|---|---|
| CEM I 32.5 | $k = 0.2$ |
| CEM I 42.5 and higher | $k = 0.4$ |

The minimum cement content required for the relevant exposure class (see 5.3.2) may be reduced by a maximum amount of *k* × (minimum cement content × 200) kg/m$^3$ and additionally the amount of (cement + fly ash) shall not be less than the minimum cement content required in accordance with 5.3.2.

NOTE The *k*-value concept is not recommended for concrete containing a combination of fly ash and sulfate resisting CEM I cement in the case of exposure Classes XA2 and XA3 when the aggressive substance is sulfate.

#### 5.2.5.2.3 *k*-value concept for silica fume conforming to EN 13263

The maximum amount of silica fume to be taken into account for the water/cement ratio and the cement content shall meet the requirement:

silica fume/cement ≤ 0.11 by mass.

DRAFT DEAS FOR PUBLIC COMMENTS

If a greater amount of silica fume is used, the excess shall not be taken into account for the *k*-value concept.

The following *k*-values are permitted to be applied for concrete containing cement type CEM I conforming to EAS 18-1:

| | |
|---|---|
| for specified water/cement ratio | ≤ 0.45 $k$ = 2.0 |
| for specified water/cement ratio | > 0.45 $k$ = 2.0 except for exposure Classes XC and XF, where $k$ = 1.0. |

The amount of (cement + $k$ × silica fume) shall be not less than the minimum cement content required for the relevant exposure class (see 5.3.2). The minimum cement content shall not be reduced by more than 30 kg/m$^3$ in concrete for use in exposure classes for which the minimum cement content is ≤ 300 kg/m$^3$.

**5.2.5.3 Equivalent concrete performance concept**

The equivalent concrete performance concept permits amendments to the requirements in this standard for minimum cement content and maximum water/cement ratio when a combination of a specific addition and a specific cement is used, for which the manufacturing source and characteristics of each are clearly defined and documented.

Within the requirements of 5.2.5.1, it shall be proven that the concrete has an equivalent performance especially with respect to its reaction to environmental actions and to its durability when compared with a reference concrete in accordance with the requirements for the relevant exposure class (see 5.3.2).

Annex E gives the principles for the assessment of the equivalent concrete performance concept. Where concrete is produced according to these procedures, it shall be subject to continual assessment which takes into account variations in the cement and the addition.

Subject to the above provisions, the equivalent concrete performance concept of established suitability may be applied (see note 2 in 5.2.5.1).

**5.2.6 Use of admixtures**

The total amount of admixtures, if any, shall not exceed the maximum dosage recommended by the admixture producer and not exceed 50 g of admixture (as supplied) per kg cement unless the influence of the higher dosage on the performance and the durability of the concrete is established.

Admixtures used in quantities less than 2 g/kg cement are only permitted if they are dispersed in part of the mixing water.

If the total quantity of liquid admixtures exceeds 3 l/m$^3$ of concrete, its water content shall be taken into account when calculating the water/cement ratio.

Where more than one admixture is used, the compatibility of the admixtures shall be checked in the initial tests.

NOTE Concrete with consistence ≥ S4, V4, C3 or ≥ F4 should be made with high range water reducing/super plasticizing admixture.

**5.2.7 Chloride content**

The chloride content of a concrete, expressed as the percentage of chloride ions by mass of cement, shall not exceed the value for the selected class given in Table 10.

DRAFT DEAS FOR PUBLIC COMMENTS

**Table 10 — Maximum chloride content of concrete**

| Concrete use | Chloride content class [a] | Maximum Cl content by mass of cement [b] |
|---|---|---|
| Not containing steel reinforcement or other embedded metal with the exception of corrosion-resisting lifting devices | Cl 1.0 | 1.0 % |
| Containing steel reinforcement or other embedded metal | Cl 0.20 | 0.20 % |
| | Cl 0.40 | 0.40 % |
| Containing prestressing steel reinforcement | Cl 0.10 | 0.10 % |
| | Cl 0.20 | 0.20 % |

[a] For a specific concrete use, the class to be applied depends upon the provisions valid in the place of use of the concrete.

[b] Where type II additions are used and are taken into account for the cement content, the chloride content is expressed as the percentage chloride ion by mass of cement plus total mass of additions that are taken into account.

Calcium chloride and chloride based admixtures shall not be added to concrete containing steel reinforcement, prestressing steel reinforcement or other embedded metal.

For the determination of the chloride content of the concrete, the sum of the contributions from the constituent materials shall be determined using one of, or a combination of, the following methods:

— calculation based on the maximum chloride content of the constituent either permitted in the standard for the constituent or declared by the producer of each constituent material;

— calculation based on the chloride content of the constituent materials calculated monthly from the sum of the means of the last 25 determinations of chloride content plus 1.64 × the calculated standard deviation for each constituent material.

NOTE The latter method is particularly applicable to sea-dredged aggregates and for those cases where there is no declared or standard maximum value.

#### 5.2.8 Concrete temperature

The temperature of fresh concrete shall not be less than 5 °C at the time of delivery. Where a requirement for a different minimum temperature or a maximum temperature of fresh concrete is necessary, they shall be specified giving also tolerances. Any requirement for artificial cooling or heating of the concrete prior to delivery has to be agreed between the producer and the user.

### 5.3 Requirements related to exposure classes

#### 5.3.1 General

Requirements for the concrete to withstand the environmental actions are given either in terms of limiting values for concrete composition and established concrete properties (see 5.3.2), or the requirements may be derived from performance-related design methods (see 5.3.3). The requirements shall take into account the intended working life of the concrete structure.

#### 5.3.2 Limiting values for concrete composition

In the absence of East African Standards for absolute performance testing of concrete, due to different long term experience, requirements for the method of specification to resist environmental actions are given in this standard in terms of established concrete properties and limiting values of composition.

NOTE 1 Due to the lack of experience on how the classification of the environmental actions on concrete reflect local differences in the same nominal exposure class, the specific values of these requirements for the applicable exposure classes are given in the provisions valid in the place of use.

DRAFT DEAS FOR PUBLIC COMMENTS

The requirements for each exposure class shall be specified in terms of:

— permitted types and classes of constituent materials;

— maximum water/cement ratio;

— minimum cement content;

— minimum concrete compressive strength class

(optional); and if relevant:

— minimum air-content of the concrete.

NOTE 2 In the provisions valid in the place of use, the maximum water/cement ratio should be given in increments of 0.05, the minimum cement content in increments of 20 kg/m$^3$, the concrete compressive strength in classes as given in Table 7 for normal -weight and heavy-weight concrete and Table 8 for light- weight concrete. A recommendation for the choice of limiting values for concrete composition and properties is given in Annex F (informative) when using CEM I cement.

NOTE 3 The provisions valid in the place of use of the concrete should include requirements under the assumption of an intended working life of at least 50 years under the anticipated maintenance conditions. For shorter or longer working life, less onerous or more severe requirements may be necessary. In these cases or for specific concrete compositions or specific corrosion protection requirements for the concrete cover of the reinforcement (e.g. in the case of cover less than that specified in the relevant parts of ENV 1992-1 for corrosion protection), special considerations should be made by the specifier for a specific site or by national provisions in general.

If the concrete is in conformity with the limiting values, the concrete in the structure shall be deemed to satisfy the durability requirements for the intended use in the specific environmental condition, provided:

— the concrete is properly placed, compacted and cured e.g. in accordance with ENV 13670-1 or other relevant standards;

— the concrete has the minimum cover to reinforcement in accordance with the relevant design standard required for the specific environmental condition, e.g. ENV 1992-1;

— the appropriate exposure class was selected;

— the anticipated maintenance is applied.

#### 5.3.3 Performance-related design methods

The requirements related to exposure classes may be established by using performance-related design methods for durability and may be specified in terms of performance-related parameters, e.g. scaling of concrete in a freeze/thaw test. Guidance on the use of an alternative performance-related design method with respect to durability is given in Annex J (informative). The application of an alternative method depends on the provisions valid in the place of use of the concrete.

### 5.4 Requirements for fresh concrete

#### 5.4.1 Consistence

Where the consistence of concrete is to be determined, it shall be measured either by means of:

— slump test conforming to EN 12350-2;

— Vebe test conforming to EN 12350-3;

— degree of compactability conforming to EN 12350-4;

— flow table test conforming to EN 12350-5;

— specific methods to be agreed upon between the specifier and the producer for concrete for special applications (e.g. earth moist concrete).

DRAFT DEAS FOR PUBLIC COMMENTS

NOTE Due to the lack of sensitivity of the test methods beyond certain values of consistence, it is recommended to use the indicated tests for:

— slump ≥ 10 mm and ≤ 210 mm;

— Vebe time ≥ 30 sec and > 5 sec;

— degree of compactibility ≥ 1.04 and < 1.46;

— flow diameter > 340 mm and ≤ 620 mm.

Where the consistence of concrete is to be determined, it shall be tested at the time of use of the concrete or in the case of ready-mixed concrete, at the time of delivery.

If concrete is delivered in a truck mixer or agitating equipment, the consistence may be measured using a spot sample obtained from the initial discharge. The spot sample shall be taken after a discharge of approximately 0.3 $m^3$ in accordance with EN 12350-1.

The consistence may be specified either by reference to a consistence class according to 4.2.1 or, in special cases, by a target value. For target values, the related tolerances are given in Table 11.

**Table 11 — Tolerances for target values of consistence**

| **Slump** | | | |
|---|---|---|---|
| Target value in mm | ≤40 | 50 to 90 | ≥100 |
| Tolerance in mm | ± 10 | ± 20 | ± 30 |
| **Vebe time** | | | |
| Target value in sec | ≥11 | 10 to 6 | ≤5 |
| Tolerance in sec | ± 3 | ± 2 | ± 1 |
| **Degree of compactability** | | | |
| Target value | ≥1.26 | 1.25 to 1.11 | ≤ 1.10 |
| Tolerance | ± 0.10 | ± 0.08 | ± 0.05 |
| **Flow diameter** | | | |
| Target value in mm all values | | | |
| Tolerance in mm | ± 30 | | |

### 5.4.2 Cement content and water/cement ratio

Where the cement, water, or addition content is to be determined, the cement content, addition content or added water shall be taken either as recorded on the print-out of the batch recorder or where recording equipment is not used, from the production record in connection with the batching instruction.

Where the water/cement ratio of concrete is to be determined, it shall be calculated on the basis of the determined cement content and the effective water content (for liquid admixtures see 5.2.6). The water absorption of normal-weight and heavy-weight aggregates shall be determined in accordance with EN 1097-6. The water absorption of coarse light-weight aggregate in the fresh concrete shall be taken as the value obtained at 1 hour based on the method given in Annex C of EN 1097-6, using the as-used moisture state instead of the oven-dry state.

NOTE 1 For fine light-weight aggregate, the test method and criteria should follow the provisions valid in the place of use of the concrete.

Where the minimum cement content is replaced by the minimum (cement + addition) content or the water/cement ratio is replaced by the water/(cement + $k$ × addition) ratio or water/(cement + addition) ratio, (see 5.2.5) the method is to be applied with appropriate modifications.

No single value of water/cement ratio determination shall be greater than 0.02 above the limiting value.

DRAFT DEAS FOR PUBLIC COMMENTS

Where the determination of the cement content, the addition content or water/cement ratio of fresh concrete by analysis is required, the test method and tolerances shall be agreed between the specifier and producer.

NOTE 2 See CEN Report CR 13902 "Determination of the water/cement ratio of fresh concrete".

#### 5.4.3 Air content

Where the air content of the concrete is to be determined, it shall be measured in accordance with EN 12350-7 for normal-weight and heavy-weight concrete and in accordance with ASTM C 173 for light-weight concrete. The air content is specified by a minimum value. The upper limit on air content is the specified minimum value plus 4 % absolute.

#### 5.4.4 Maximum aggregate size

Where the maximum nominal upper aggregate size of fresh concrete is to be determined, it shall be measured in accordance with EN 933-1.

The maximum nominal upper aggregate size as defined in EN 12620shall not be greater than specified.

### 5.5 Requirements for hardened concrete

#### 5.5.1 Strength

##### 5.5.1.1 General

Where the strength is to be determined, it shall be based on tests carried out on either 150 mm cubes or 150/300 mm cylinders conforming to EN 12390-1 and made and cured in accordance with EN 12390-2 from samples taken in accordance with EN 12350-1.

In assessing the strength, other sizes of moulded specimens and other curing regimes may be used provided the relationship to those standardized has been established with sufficient accuracy and has been documented.

##### 5.5.1.2 Compressive strength

Where the compressive strength is to be determined, it shall be expressed as $f_{c,cube}$ where determined using cubical specimens and $f_{c,cyl}$ where determined using cylindrical specimens, in accordance with prEN 12390-3

Whether the compressive strength is to be assessed on the basis of cube or cylinder tests shall be declared by the producer in due time before delivery. If a different method is to be used, this has to be agreed between the specifier and the producer.

Unless specified otherwise, the compressive strength is determined on specimens tested at 28 days. For particular uses, it may be necessary to specify the compressive strength at ages earlier or later than 28 days (e.g. for massive structural elements) or after storage under special conditions (e.g. heat treatment).

The characteristic strength of the concrete shall be equal to or greater than the minimum characteristic compressive strength for the specified compressive strength class, see Tables 7 and 8.

If the testing for compressive strength is expected to give non-representative values, e. g. when concrete of consistence Class C0 or stiffer than S1 or vacuum concrete is tested, either the test method shall be modified or the compressive strength may be assessed in the existing structure or structural component.

NOTE Assessing the strength in the structure or structural component should be based on EN 13791

DRAFT DEAS FOR PUBLIC COMMENTS

#### 5.5.1.3 Tensile splitting strength

Where the tensile splitting strength of concrete is to be determined, it shall be measured in accordance with EN 12390-6. Unless specified otherwise, the tensile splitting strength is determined on specimens tested at 28 days.

The characteristic tensile splitting strength of the concrete shall be equal to or greater than the specified characteristic tensile splitting strength.

### 5.5.2 Density

According to its oven-dry density, concrete is defined as normal-weight concrete, light-weight concrete or heavy-weight concrete (see definitions).

Where the oven-dry density of concrete is to be determined, it shall be measured in accordance with EN 12390-7.

For normal-weight concrete, the oven-dry density shall be greater than 2 000 kg/m$^3$ and not exceed 2 600 kg/m$^3$.

For light-weight concrete, the oven-dry density shall be within the limiting values for the specified density class, see Table 9. For heavy-weight concrete, the oven-dry density shall be greater than 2 600 kg/m$^3$. Where the density is specified as a target value, a tolerance of ± 100 kg/m3 applies.

### 5.5.3 Resistance to water penetration

Where resistance to water penetration on test specimens is to be determined, the method and conformity criteria shall be agreed between the specifier and producer.

In the absence of an agreed test method, resistance to water penetration may be specified indirectly by limiting values for concrete composition.

### 5.5.4 Reaction to fire

Concrete which is composed of natural aggregates conforming to 5.1.3, cement conforming to 5.1.2, admixtures conforming to 5.1.5, additions conforming to 5.1.6 or other inorganic constituent materials conforming to 5.1.1, is classified as Euro Class A and does not require testing.

# 6 Specification of concrete

## 6.1 General

The specifier of the concrete shall ensure that all the relevant requirements for concrete properties are included in the specification given to the producer. The specifier shall also specify any requirements for concrete properties that are needed for transportation after delivery, placing, compaction, curing or further treatment. The specification shall, if necessary, include any special requirements (e.g. for obtaining an architectural finish).

The specifier shall take account of:

— the application of the fresh and hardened concrete;

— the curing conditions;

— the dimensions of the structure (the heat development);

— the environmental actions to which the structure is to be exposed;

— any requirements for exposed aggregate or tooled concrete finishes;

DRAFT DEAS FOR PUBLIC COMMENTS

— any requirements related to the cover to reinforcement or minimum section width, e.g. maximum nominal upper aggregate size;

— any restrictions on the use of constituent materials with established suitability, e.g. resulting from exposure classes.

NOTE 1 The provisions valid in the place of use of the concrete may contain requirements for some of these considerations.

Concrete shall be specified either as designed concrete referring in general to classification given in Clause 4 and requirements given in 5.3 to 5.5 (see 6.2) or as prescribed concrete by prescribing the composition (see 6.3). The basis for designing or prescribing a concrete composition shall be results from initial tests (see Annex A) or information obtained from long-term experience with comparable concrete, taking into account the basic requirements for constituent materials (see 5.1) and concrete composition (see 5.2 and 5.3.2).

For prescribed concrete, the specifier is responsible for ensuring that the specification conforms to the general requirements in EAS 131-1 and the specified composition is capable of achieving the intended performance of the concrete in both the fresh and hardened states. The specifier shall maintain and update supporting documentation relating the prescription to the intended performance, see 9.5. In the case of standardized prescribed concrete, this is the responsibility of the national standards organization.

NOTE 2 For prescribed concrete, the assessment of conformity is based solely on the achievement of the specified composition and not on any performance intended by the specifier.

## 6.2 Specification for designed concrete

### 6.2.1 General

Designed concrete shall be specified by means of basic requirements from 6.2.2, to be indicated in all cases, and additional requirements from 6.2.3, to be indicated where required.

For abbreviations to be used in specifications, see Clause 11.

### 6.2.2 Basic requirements

The specification shall contain:

a) a requirement to conform to EAS 131-1;

b) compressive strength class;

c) exposure classes (see Clause 11 for the abbreviated format);

d) maximum nominal upper aggregate size;

e) chloride content class in accordance with Table 10.

In addition, for light-weight concrete:

f) density class or target density.

In addition, for heavy-weight concrete:

g) target density.

In addition, for ready-mixed concrete and site-mixed concrete:

h) consistence class or, in special cases, a target value for consistence.

DRAFT DEAS FOR PUBLIC COMMENTS

#### 6.2.3 Additional requirements

The following items may be specified using performance requirements and test methods where they are appropriate:

— special types or classes of cement (e.g. cement with low heat of hydration);

— special types or classes of aggregate;

NOTE 1 In these cases, concrete composition to minimize deleterious alkali-silica reaction is the responsibility of the specifier (see 5.2.3.4).

— characteristics required to resist freeze/thaw attack (e.g. air content, see 5.4.3);

NOTE 2 Before specifying the air content at delivery, the possible loss of air during pumping, placing, compacting etc. subsequent to the delivery should be taken into account by the specifier.

— requirements for the temperature of the fresh concrete where different from those in 5.2.8;

— strength development (see Table 12);

— heat development during hydration;

— retarded stiffening;

— resistance to water penetration;

— resistance to abrasion;

— tensile splitting strength (see 5.5.1.3);

— other technical requirements (e.g. requirements related to the achievement of a particular finish or special method of placing).

### 6.3 Specification for prescribed concrete

#### 6.3.1 General

Prescribed concrete shall be specified by basic requirements from 6.3.2, to be indicated in all cases, and additional requirements from 6.3.3 to be indicated where required.

#### 6.3.2 Basic requirements

The specification shall contain:

a) a requirement to conform to EAS 131-1;

b) cement content;

c) cement type and strength class;

d) either w/c ratio or consistence in terms of class or, in special cases, a target value;

NOTE The specified value of the (target) w/c ratio should be 0.02 less than any required limiting value.

e) type, categories and maximum chloride content of aggregate; in the case of light-weight or heavy-weight concrete the maximum or minimum density of aggregate as appropriate;

f) maximum nominal upper size of aggregate and any limitations for grading;

g) type and quantity of admixture or addition, if any;

DRAFT DEAS FOR PUBLIC COMMENTS

h) if admixtures or additions are used, sources of these constituents and of the cement as a substitute for characteristics that are not definable by other means.

#### 6.3.3 Additional requirements

The specification may contain:

— sources of some, or all, concrete constituents as a substitute for characteristics that are not definable by other means;

— additional requirements for aggregates;

— requirements for the temperature of the fresh concrete where different from those in 5.2.8;

— other technical requirements.

### 6.4 Specification of standardized prescribed concrete

Standardized prescribed concrete shall be specified by citing:

— the standard valid in the place of use of the concrete giving the relevant requirements;

— the notation of the concrete in that standard.

Standardized prescribed concrete shall be used only for:

— normal-weight concrete for plain and reinforced concrete structures;

— compressive strength classes for design ≤C16/20 unless strength Class C20/25 is permitted in provisions valid in the place of use of the concrete;

— exposure Classes X0 and XC1 unless provisions valid in the place of use of the concrete permit other exposure classes.

For restrictions on the composition of standardized prescribed concrete, see 5.2.1.

## 7 Delivery of fresh concrete

### 7.1 Information from the user of the concrete to the producer [1)]

The user shall agree with the producer the:

— delivery date, time and rate;

— and where appropriate inform the producer of:

— special transport on site;

— special methods of placing;

— limitation of delivery vehicle, e.g. type (agitating/non-agitating equipment), size, height or gross weight.

### 7.2 Information from the producer of the concrete to the user [1)]

The user may require information on the concrete composition to permit proper placing and curing of the fresh concrete as well as for estimating the strength development. Such information shall be given by the producer on request before delivery as appropriate. The following information shall be provided for designed concrete on request:

[1)] This standard does not require the information to be given in a specific format as this will depend on the relationship between the producer and the user, e.g. in the case of site-mixed concrete or precast concrete products, the producer and user of the concrete may be the same party.

DRAFT DEAS FOR PUBLIC COMMENTS

a) type and strength class of cement and type of aggregates;

b) type of admixtures, type and approximate content of additions, if any;

c) target water/cement ratio;

d) results of relevant previous tests for the concrete, e.g. from production control or from initial tests;

e) strength development;

f) sources of the constituent materials.

In the case of ready-mixed concrete, the information may also be provided, where requested, by reference to the producer's catalogue of concrete compositions in which details of strength classes, consistence classes, batch weights and other relevant data are given.

For the determination of curing time, information on the strength development of the concrete may be given either in terms of Table 12 or by a strength development curve at 20 °C between 2 and 28 days.

**Table 12 — Strength development of concrete at 20 °C**

| **Strength development** | **Estimate of strength ratio** $f_{cm,2} / f_{cm,28}$ |
|---|---|
| Rapid | ≥0.5 |
| Medium | ≥0.3 to < 0.5 |
| Slow | ≥0.15 to < 0.3 |
| Very slow | <0.15 |

The strength ratio to indicate the strength development is the ratio of the mean compressive strength after 2 days ($f_{cm,2}$) to the mean compressive strength after 28 days ($f_{cm,28}$), determined from initial tests or based on known performance of concrete of comparable composition. For these initial tests, specimens for strength determination shall be sampled, made, cured and tested in accordance with EN 12350-1, EN 12390-1, EN 12390-2 and EN 12390-3

The producer shall inform the user of health risks that may occur during handling the fresh concrete as required by the provisions valid in the place of use of the fresh concrete.

### 7.3 Delivery ticket for ready-mixed concrete

At delivery, the producer shall provide the user with a delivery ticket for each load of concrete on which is printed, stamped or written at least the following information:

— name of the ready-mixed concrete plant;

— serial number of ticket;

— date and time of loading, i.e. time of first contact between cement and water;

— truck number or vehicle identification;

— name of purchaser;

— name and location of the site;

— details or references to specifications, e.g. code number, order number;

— amount of concrete in cubic metres;

— declaration of conformity with reference to the specifications and to EAS 131-1;

DRAFT DEAS FOR PUBLIC COMMENTS

— name or mark of the certification body if relevant;

— time at which the concrete arrives at the site;

— time of the beginning of unloading;

— time of the end of unloading.

In addition, the delivery ticket shall give details of the following:

a) for designed concrete:

— strength class;

— exposure classes;

— chloride content class;

— consistence class or target value;

— limiting values of concrete composition, if specified;

— type and strength class of cement, if specified;

— type of admixture and addition, if specified;

— special properties, if required;

— maximum nominal upper aggregate size;

— in case of light-weight or heavy-weight concrete: density class or target density.

b) for prescribed concrete:

— details of the composition, e.g. cement content, and, if required, type of admixture;

— either w/c ratio, or consistence in terms of class or target value, as specified;

— maximum nominal upper aggregate size.

In the case of standardized prescribed concrete, the information to be given shall follow the provisions of the relevant standard.

### 7.4 Delivery information for site-mixed concrete

Appropriate information as required in 7.3 for the delivery ticket is also relevant for site-mixed concrete where the site is large or several types of concrete are involved or where the party producing the concrete is different from the party who is responsible for placing the concrete.

### 7.5 Consistence at delivery

In general, any addition of water and admixtures at delivery is forbidden. In special cases, water or admixtures may be added where this is under the responsibility of the producer and used to bring the consistence to the specified value provided that the limiting values permitted by the specification are not exceeded and the addition of admixture is included in the design of the concrete. The quantity of any additional water or admixture added to the truck mixer shall be recorded on the delivery ticket in all cases. For re-mixing, see 9.8.

NOTE If more water or admixtures are added to the concrete in a truck mixer on site than is permitted by the specification, the concrete batch or load should be recorded as "non- conforming" on the delivery ticket. The party who authorized this addition is responsible for the consequences and this party should be recorded on the delivery ticket.

DRAFT DEAS FOR PUBLIC COMMENTS

# 8 Conformity control and conformity criteria

## 8.1 General

Conformity control comprises the combination of actions and decisions to be taken in accordance with conformity rules adopted in advance to check the conformity of the concrete with the specification. Conformity control is an integral part of production control (see Clause 9).

NOTE The properties of concrete used for conformity control are those measured by the appropriate tests using standardized procedures. The actual values of the properties of the concrete in the structure may differ from those determined by the tests depending on, e.g. dimensions of the structures, placing, compaction, curing and climatic conditions.

The sampling and testing plan and conformity criteria shall conform to the procedures given in 8.2 or 8.3. These provisions apply also to concrete for precast products unless the specific product standard contains an equivalent set of provisions. If higher sampling rates are required by the specifier, this shall be agreed in advance. For properties not covered in these clauses, the sampling and testing plan, method of test and conformity criteria shall be agreed upon between the producer and the specifier.

The place of sampling for conformity tests shall be chosen such that the relevant concrete properties and concrete composition do not change significantly between the place of sampling and the place of delivery. In the case of light-weight concrete produced with unsaturated aggregates, the samples shall be taken at the place of delivery.

Where tests for production control are the same as those required for conformity control, they shall be permitted to be taken into account for the evaluation of conformity. The producer may also use other test data on the delivered concrete in the conformity assessment.

The conformity or non-conformity is judged against the conformity criteria. Non-conformity may lead to further action at the place of production and on the construction site (see 8.4).

## 8.2 Conformity control for designed concrete

### 8.2.1 Conformity control for compressive strength

#### 8.2.1.1 General

For normal-weight and heavy-weight concrete of strength classes from C8/10 to C55/67 or light-weight concrete from LC8/9 to LC 55/60, sampling and testing shall be performed either on individual concrete compositions or on concrete families of established suitability (see 3.1.14) as determined by the producer unless agreed otherwise. The family concept shall not be applied to concrete with higher strength classes. Light-weight concrete shall not be mixed into families containing normal-weight concrete. Light-weight concrete with demonstrably similar aggregates may be grouped into its own family.

NOTE For guidance for the selection of concrete families, see Annex K. More detailed information for the application of the concrete family concept is given in CEN Report (13901).

In the case of concrete families, the producer shall achieve control over all family members and sampling shall be carried out across the whole range of concrete compositions produced within the family.

Where conformity testing is applied to a concrete family, a reference concrete is selected which is either that most commonly produced or one from the mid-range of the concrete family. Relationships are established between each individual concrete composition of the family and the reference concrete in order to be able to transpose test results for compressive strength from each individual concrete test result to the reference concrete. The relationships shall be reviewed on the basis of original compressive strength test data at every assessment period and when there are appreciable changes in the production conditions. In addition, when assessing conformity for the family, it has to be confirmed that each individual member belongs to the family (see 8.2.1.3).

In the sampling and testing plan and the conformity criteria of individual concrete compositions or concrete families, distinction is made between initial production and continuous production.

DRAFT DEAS FOR PUBLIC COMMENTS

Initial production covers the production until at least 35 test results are available.

Continuous production is achieved when at least 35 test results are obtained over a period not exceeding 12 months.

If the production of an individual concrete composition, or a concrete family, has been suspended more than 12 months, the producer shall adopt the criteria, sampling and testing plan given for initial production.

During continuous production, the producer may adopt the sampling and testing plan and the criteria for initial production.

If the strength is specified for a different age, the conformity is assessed on specimens tested at the specified age.

Where identity of a defined volume of concrete with a population verified as conforming to the characteristic strength requirements is to be assessed, e.g. if there is doubt about the quality of a batch or load or if in special cases required by the project specification, this shall be in accordance with Annex B.

**8.2.1.2 Sampling and testing plan**

Samples of concrete shall be randomly selected and taken in accordance with EN 12350-1. Sampling shall be carried out on each family of concrete (see 3.1.14) produced under conditions that are deemed to be uniform. The minimum rate of sampling and testing of concrete shall be in accordance with Table 13 at the rate that gives the highest number of samples for initial or continuous production, as appropriate.

Notwithstanding the sampling requirements in 8.1, the samples shall be taken after any water or admixtures are added to the concrete under the responsibility of the producer, but sampling before adding placticizer or superplasticizer to adjust the consistence (see 7.5) is permitted where there is proof by initial testing that the plasticizer or superplasticizer in the quantity to be used has no negative effect on the strength of the concrete.

The test result shall be that obtained from an individual specimen or the average of the results when two or more specimens made from one sample are tested at the same age.

Where two or more specimens are made from one sample and the range of the test values is more than 15 % of the mean then the results shall be disregarded unless an investigation reveals an acceptable reason to justify disregarding an individual test value.

**Table 13 — Minimum rate of sampling for assessing conformity**

| **Production** | **Minimum rate of sampling** | | |
|---|---|---|---|
| | **First 50 $m^3$ of production** | **Subsequent to first 50 $m^3$ of production [a]** | |
| | | concrete with production control certification | concrete without production control certification |
| Initial (until at least 35 test results are obtained) | 3 samples | 1/200 $m^3$ or 2/production week | 1/150 $m^3$ or 1/production day |
| Continuous [b] (when at least 35 test results are available) | | 1/400 $m^3$ or 1/production week | |

[a] Sampling shall be distributed throughout the production and should not be more than 1 sample within each 25 $m^3$.

[b] Where the standard deviation of the last 15 test results exceeds 1.37 $\sigma$, the sampling rate shall be increased to that required for initial production for the next 35 test results.

DRAFT DEAS FOR PUBLIC COMMENTS

#### 8.2.1.3 Conformity criteria for compressive strength

Conformity assessment shall be made on test results taken during an assessment period that shall not exceed the last twelve months.

Conformity of concrete compressive strength is assessed on specimens tested at 28 days[1)] in accordance with 5.5.1.2 for:

— groups of *n* non-overlapping or overlapping consecutive test results $f_{cm}$ (Criterion 1);

— each individual test result $f_{ci}$ (Criterion 2).

NOTE The conformity criteria are developed on the basis of non-overlapping test results. Application of the criteria to overlapping test results increases the risk of rejection.

Conformity is confirmed if both the criteria given in Table 14 for either initial or continuous production are satisfied.

Where conformity is assessed on the basis of a concrete family, Criterion 1 is to be applied to the reference concrete taking into account all transposed test results of the family; Criterion 2 is to be applied to the original test results.

To confirm that each individual member belongs to the family, the mean of all non-transposed test results ($f_{cm}$) for a single family member shall be assessed against Criterion 3 as given in Table 15. Any concrete failing this criterion shall be removed from the family and assessed individually for conformity.

**Table 14 — Conformity criteria for compressive strength**

| Production | Number *n* of test results for compressive strength in the group | Criterion 1 | Criterion 2 |
|---|---|---|---|
| | | Mean of *n* results ($f_{cm}$) N/mm$^2$ | Any individual test result ($f_{ci}$) N/mm$^2$ |
| Initial | 3 | $\geq f_{ck} + 4$ | $\geq f_{ck} - 4$ |
| | 15 | $f_{ck} + 1.48\ \sigma$ | $\geq f_{ck} - 4$ |

**Table 15 — Confirmation criterion for family members**

| Number *n* of test results for compressive strength for a single concrete | Criterion 3 |
|---|---|
| | Mean of *n* results ($f_{cm}$) for a single family member N/mm² |
| 2 | $\geq f_{ck} - 1.0$ |
| 3 | $\geq f_{ck} + 1.0$ |
| 4 | $\geq f_{ck} + 2.0$ |
| 5 | $\geq f_{ck} + 2.5$ |
| 6 | $\geq f_{ck} + 3.0$ |

Initially, the standard deviation shall be calculated from at least 35 consecutive test results taken over a period exceeding three months and which is immediately prior to the production period during which conformity is to be checked. This value shall be taken as the estimate of the standard deviation ($\sigma$) of the population. The validity of the adopted value has to be verified during the subsequent production. Two methods of verifying the estimate of the value of $\sigma$ are permitted, the choice of the method shall be made in advance:

1) If the strength is specified for a different age the conformity is assessed on specimens tested at the specified age.

DRAFT DEAS FOR PUBLIC COMMENTS

**Method 1**

The initial value of standard deviation may be applied for the subsequent period during which conformity is to be checked, provided the standard deviation of the latest 15 results ($s_{15}$) does not deviate significantly from the adopted standard deviation. This is considered valid provided:

— $0.63\ \sigma \leq s15 \leq 1.37\ \sigma$

— Where the value of $s_{15}$ lies outside these limits, a new estimate of $\sigma$ shall be determined from the last available 35 test results.

**Method 2**

— The new value of $\sigma$ may be estimated from a continuous system and this value is adopted. The sensitivity of the system shall be at least that of Method 1.

The new estimate for $\sigma$ shall be applied to the next assessment period.

### 8.2.2 Conformity control for tensile splitting strength

#### 8.2.2.1 General

Clause 8.2.1.1 applies, but the concept of concrete families is not applicable. Each concrete composition shall be assessed separately.

#### 8.2.2.2 Sampling and testing plan

Clause 8.2.1.2 applies.

#### 8.2.2.3 Conformity criteria for tensile splitting strength

Where tensile splitting strength of concrete is specified, conformity assessment shall be made on test results taken during an assessment period that shall not exceed the last twelve months.

Conformity of concrete tensile splitting strength is assessed on specimens tested at 28 days, unless a different age is specified in accordance with 5.5.1.3 for:

— groups of $n$ non-overlapping or overlapping consecutive test results $f_{tm}$ (Criterion 1);

— each individual test result $f_{ti}$ (Criterion 2).

Conformity with the characteristic tensile splitting strength ($f_{tk}$) is confirmed if the test results satisfy both the criteria in Table 16 for either initial or continuous production as appropriate.

**Table 16 — Conformity criteria for tensile splitting strength**

| Production | Number $n$ of results in the group | Criterion 1 | Criterion 2 |
|---|---|---|---|
| | | Mean of $n$ results ($f_{tm}$) in N/mm$^2$ | Any individual test results ($f_{ti}$) in N/mm$^2$ |
| Initial | 3 | $\geq f_{tk} + 0.5$ | $\geq f$tk – 0.5 |
| Continuous | 15 | $\geq f_{tk} + 1.48\ \sigma$ | $\geq f$tk – 0.5 |

The provisions for the standard deviation given in Clause 8.2.1.3 shall be applied accordingly.

### 8.2.3 Conformity control for properties other than strength

#### 8.2.3.1 Sampling and testing plan

Samples of concrete shall be randomly selected and taken in accordance with EN 12350-1. Sampling shall be carried out on each family of concrete produced under conditions that are deemed to be uniform. The minimum number of samples and the methods of test shall be in accordance with Tables 17 and 18.

DRAFT DEAS FOR PUBLIC COMMENTS

#### 8.2.3.2 Conformity criteria for properties other than strength

Where properties of concrete other than strength are specified, conformity assessments shall be made on running production over the assessment period that shall not exceed the last twelve months.

Conformity of concrete is based on counting the number of results obtained in the assessment period that lie outside the specified limiting values, class limits or tolerances on a target value and comparing this total with the maximum permitted number (method of attributes).

Conformity with the required property is confirmed if:

— the number of test results outside the specified limiting value, class limits or tolerances of target values, as appropriate, are not greater than the acceptance number in Tables 19a or 19b as given in Table 17 and 18. Alternatively in case of (AQL = 4 %), the requirement may be based on testing by variables in accordance with ISO 3951:1989 Table II-A (AQL = 4 %) where the acceptance number relates to Table 19a;

— all individual test results are within the maximum allowed deviation given in Table 17 or Table 18.

**Table 17 — Conformity criteria for properties other than strength**

| Property | Test method or method of determination | Minimum number of samples or determinations | Acceptance number | Maximum allowed deviation of single test results from the limits of the specified class or from the tolerance on the target value | |
|---|---|---|---|---|---|
| | | | | Lower limit | Upper limit |
| Density of heavy-weight concrete | EN 12390-7 | as Table 13 for compressive strength | see Table 19a | -30 kg/m$^3$ | no limit [a] |
| Density of lightweight concrete | EN 12390-7 | as Table 13 for compressive strength | see Table 19a | -30 kg/m$^3$ | +30 kg/m$^3$ |
| Water/cement ratio | see 5.4.2 | 1 determination per day | see Table 19a | no limit a | +0.02 |
| Cement content | see 5.4.2 | 1 determination per day | see Table 19a | -10 kg/m$^3$ | no limit [a] |
| Air content of air-entrained fresh concrete | EN 12350-7 for normal-weight and heavy-weight concrete and ASTM C 173 for light-weight concrete | 1 sample/production day when stabilized | see Table 19a | -0.5 % absolute value | +1.0 % absolute value |
| Chloride content of concrete | see 5.2.7 | the determination shall be made for each concrete composition and shall be repeated if there is an increase in the chloride content of any of the constituents | 0 | no limit [a] | no higher value permitted |

[a] Unless limits are specified.

DRAFT FOR PUBLIC COMMENTS

**Table 18 — Conformity criteria for consistence**

| Test method | | Minimum number of samples or determinations | Acceptance number | Maximum allowed deviation [a] of single test results from the limits of the specified class or from the tolerance on the target value | |
|---|---|---|---|---|---|
| | | | | Lower limit | Upper limit |
| Visual inspection | Comparison of the appearance with the normal appearance of concrete with the specified consistence | Each batch; for vehicle deliveries, each load | — | — | — |
| Slump | EN 12350-2 | i) frequency as given in Table 13 for compressive strength<br>ii) when testing air content<br>iii) in case of doubt following visual inspection | see Table 19b | -10 mm | +20 mm |
| | | | | -20 mm [b] | +30 mm [b] |
| Vebe time | EN 12350-3 | | | -4 sec | +2 sec |
| | | | | -6 sec [b] | +4 sec [b] |
| Degree of compactability | EN 12350-4 | | | -0.05 | +0.03 |
| | | | | -0.07 [b] | +0.05 [b] |
| Flow | EN 12350-5 | | | -15 mm | +30 mm |
| | | | | -25 mm [b] | +40 mm [b] |

[a] Where there is no lower or upper limit in the relevant consistence class, these deviations do not apply.

[b] Only applicable for consistence testing from initial discharge from truck mixer (see 5.4.1).

### 8.3 Conformity control of prescribed concrete including standardized prescribed concrete

Each batch of a prescribed concrete shall be assessed for conformity with the cement content, maximum nominal size and proportions of aggregates if specified and, where relevant, water/cement ratio, quantity of admixture or addition. The amount of cement, aggregate (each specified size), admixture and addition as recorded in the production record or the printout from the batch recorder shall be within the tolerances given in Table 21, and the water/cement ratio shall be within ±0.04 of the specified value. In the case of standardized prescribed concrete, the equivalent tolerances may be given in the relevant standard.

Where conformity of concrete composition is to be assessed by analysis of fresh concrete, the test methods and conformity limits shall be agreed between the user and the producer in advance, taking account of the above limits and the precision of the test methods.

Where conformity of the consistence is to be assessed, the relevant paragraphs of 8.2.3 and Table 18 apply.

For the:

— cement type and strength class;

— types of aggregates;

— type of admixture or addition, if any;

— sources of concrete constituents, where specified;

the conformity shall be assessed by comparison of the production record and the delivery documents for the constituents with the specified requirements.

DRAFT DEAS FOR PUBLIC

**Tables 19a and 19b — Acceptance numbers for conformity criteria for properties other than strength**

| Table 19a AQL=4% | |
|---|---|
| **Number of test results** | **Acceptance number** |
| 1-12 | 0 |
| 13-19 | 1 |
| 20-31 | 2 |
| 32-39 | 3 |
| 40-49 | 4 |
| 50-64 | 5 |
| 65-79 | 6 |
| 80-94 | 7 |
| 95 - 100 | 8 |
| Where the number of test results exceeds 100, the appropriate acceptance numbers may be taken from Table 2-A of ISO 2859-1:1999 | |

| Table 19b AQL=15% | |
|---|---|
| **Number of test results** | **Acceptance number** |
| 1-12 | 0 |
| 3 - 4 | 1 |
| 5 - 7 | 2 |
| 8-12 | 3 |
| 13-19 | 5 |
| 20-31 | 7 |
| 32-49 | 10 |
| 50-79 | 14 |
| 80 - 100 | 21 |

### 8.4 Actions in the case of non-conformity of the product

The following actions shall be taken by the producer in the event of non-conformity:

— check test results and if invalid, take action to eliminate errors;

— if non-conformity is confirmed e.g. by retesting, take corrective actions including a management review of relevant production control procedures;

— where there is confirmed non-conformity with the specification that was not obvious at delivery, give notice to the specifier and user in order to avoid any consequential damage;

— record actions on the items above.

If non-conformity of concrete results from addition of water or admixtures on site (see 7.5), the producer has to take actions only if he has authorized this addition.

NOTE If the producer has given notice of non-conformity of the concrete or if the results of conformity tests do not fulfill the requirements, supplementary testing according to EN 12504-1 on cores taken from the structure or components may be required or a combination of tests on cores and non-destructive tests on the structure or components, e.g. according to EN 12504-2 or EN 12504-4. Guidance for assessing the strength in the structure or in structural components is given in EN 13791.

## 9 Production control

### 9.1 General

All concrete shall be subject to production control under the responsibility of the producer. Production control comprises all measures necessary to maintain the properties of concrete in conformity to specified requirements. It includes:

— selection of materials;

— concrete design;

— concrete production;

— inspections and tests;

— the use of the results of tests on constituent materials, fresh and hardened concrete and equipment;

— where relevant, inspection of equipment used in transporting fresh concrete;

— conformity control for which provisions are given in Clause 8.

DRAFT DEAS FOR PUBLIC COMMENT

The requirements for other aspects of production control are given in the following subclauses. These requirements shall be considered taking account of the kind and size of the production, the works, the particular equipment, procedures and rules in use at the place of production and use of the concrete. Additional requirements may be necessary for special circumstances at the production place or for specific requirements for particular structures or structural elements.

NOTE Clause 9 takes account of the principles of ISO 9001.

## 9.2 Production control systems

The responsibility, authority and the interrelation of all personnel who manage, perform and verify work affecting the quality of the concrete shall be defined in a documented production control system (production control manual). This particularly concerns personnel who need the organizational freedom and authority to minimize the risk of non-conforming concrete and to identify and record any quality problem.

The production control system shall be reviewed at least every two years by the management of the producer to ensure the suitability and effectiveness of the system. Records of such reviews shall be retained for at least 3 years unless legal obligations require a longer period.

The production control system shall contain adequately documented procedures and instructions. These procedures and instructions shall, where relevant, be established in respect of the control requirements as given in the Tables 22, 23 and 24. The intended frequencies of tests and inspections by the producer shall be documented.

The results of tests and inspections shall be recorded.

## 9.3 Recorded data and other documents

All relevant data from the production control shall be recorded, see Table 20. The records of the production control shall be retained for at least 3 years unless legal obligations require a longer period.

**Table 20 — Recorded data and other documents, where relevant**

| Subject | Recorded data and other documents |
|---|---|
| Specified requirements | Contract specification or summary of requirements. |
| Cements, aggregates, admixtures, additions | Name of suppliers and sources. |
| Tests on mixing water (not required for potable water) | Date and place of sampling.<br>Test results. |
| Tests on constituent materials | Date and test results. |
| Composition of concrete | Concrete description.<br>Record of masses of constituents in batch or load (e.g. cement content).<br>Water/cement ratio.<br>Chloride content.<br>Code of family member. |
| Tests on fresh concrete | Date and place of sampling.<br>Location in structure, if known.<br>Consistence (method used and results).<br>Density, where required.<br>Concrete temperature, where required.<br>Air content, where required.<br>Volume of concrete batch or load tested.<br>Number and codes of specimens to be tested.<br>Water/cement ratio, where required. |
| Tests on hardened concrete | Date of testing.<br>Code and ages of specimens.<br>Test results for density and strength.<br>Special remarks (e.g. unusual failure pattern of specimen). |
| Evaluation of conformity | Conformity/ non-conformity with specifications. |
| Additionally for ready mixed concrete | Name of purchaser.<br>Location of work, e.g. the construction site.<br>Numbers and dates of delivery tickets related to tests.<br>Delivery tickets. |
| Additionally for precast concrete | Additional or different data may be required by the relevant product standard. |

DRAFT DEAS FOR PUBLIC COMMENTS

## 9.4 Testing

The testing shall be performed in accordance with the test methods given in this standard (reference test method) or other test methods may be used if the correlation or safe relationship between the results of these test methods and the reference methods have been established. The correctness of the safe relationship or correlation shall be examined at appropriate intervals.

The examination shall be carried out separately for each place of production that operates under different conditions, unless the relationship is given in national standards or provisions valid in the place of use.

## 9.5 Concrete composition and initial testing

In the case of using a new concrete composition, initial testing shall be performed to provide a concrete that achieves the specified properties or intended performance with an adequate margin (see Annex A). Where long term experience with a similar concrete or family is available, initial testing is not required. The concrete design and design relationships shall be re-established when there is a significant change in constituent materials. No initial testing by the producer is necessary in the case of a prescribed concrete or a standardized prescribed concrete.

New concrete compositions obtained by interpolation between known concrete compositions or extrapolations of compressive strength not exceeding 5 N/mm2 are deemed to satisfy the requirements for initial testing.

Concrete compositions shall be reviewed periodically to provide assurance that all concrete designs are still in accordance with the actual requirements, taking account of the change in properties of the constituent materials and the results of conformity testing on the concrete compositions.

## 9.6 Personnel, equipment and installation

### 9.6.1 Personnel

Knowledge, training and experience of personnel involved in production and production control shall be appropriate to the type of concrete, e.g. high strength concrete, light-weight concrete.

Appropriate records of the training and experience of the personnel involved in production and production control shall be maintained.

NOTE In some countries, there are special requirements regarding the level of knowledge, training and experience for the different tasks.

### 9.6.2 Equipment and installation

#### 9.6.2.1 Storage of materials

Constituent materials shall be stored and handled so that their properties do not change significantly, e.g. by action of climate, intermingling or contamination, and that the conformity with the respective standard is maintained.

Storage compartments shall be clearly marked in order to avoid errors in use of the constituent materials.

Special instructions from the suppliers of the constituent materials shall be taken into account. Facilities shall be provided to enable representative samples to be taken e.g. from stockpiles, silos and bins.

#### 9.6.2.2 Batching equipment

The performance of the batching equipment shall be such that under practical conditions of operation the tolerances stated in 9.7 can be obtained and maintained.

DRAFT DEAS FOR PUBLIC COMMENTS

After 2003-01-01, the accuracy of the weighing equipment shall conform to the accuracy requirements given in Directive 90/384/EEC, measured in accordance with EN 45501, for at least Class (IIII) for cement, aggregates, water, admixtures and additions. The number of verification scale intervals (*n*) of the weighing equipment shall be:

— for admixtures, at least 1 000;

— for cement, aggregates, water and additions, at least 500.

NOTE For further information see Annex G (informative).

The accuracy of the volumetric measuring equipment shall conform to the accuracy requirements in OIML R 117.

Notwithstanding the requirements given above, existing batching equipment which does not conform to the requirements of this clause may be used until 2003-01-01, if the equipment conforms to the provisions valid in the place of production at the date of publication of this standard.

#### 9.6.2.3 Mixers

The mixers shall be capable of achieving a uniform distribution of the constituent materials, and a uniform consistence of the concrete within the mixing time and at the mixing capacity.

Truck mixers and agitating equipment shall be so equipped as to enable the concrete to be delivered in a homogeneous state. In addition, the truck mixers shall be provided with suitable measuring and dispensing equipment, if water or admixtures are to be added on the site under the responsibility of the producer.

#### 9.6.2.4 Testing equipment

All necessary facilities, equipment and instructions for its proper use shall be available when required for inspections and tests on equipment, constituent materials and concrete.

Relevant test equipment shall be in calibration at the time of testing and the producer shall operate a calibration programme.

### 9.7 Batching of constituent materials

A documented batching instruction giving details of the type and quantity of the constituent materials shall be available at the place of batching of the concrete.

The tolerance of batching constituent materials shall not exceed the limits given in Table 21 for all quantities of concrete of 1 $m^3$ or more. Where a number of batches is mixed or re-mixed in a truck mixer, the tolerances in Table 21 apply to the load.

**Table 21 — Tolerances for the batching process of constituent material**

| Constituent material | Tolerance |
|---|---|
| Cement | ±3 % of required quantity |
| Water | |
| Total aggregates | |
| Additions used at > 5 % by mass of cement | |
| Admixtures and additions used at ≤ 5 % by mass of cement | ±5 % of required quantity |
| NOTE The tolerance is the difference between the target value and the measured value. | |

Cements, aggregates and additions in the form of powders shall be batched by mass; other methods are permitted if the required batching tolerance can be achieved and this is documented.

The mixing water, light-weight aggregates, admixtures and liquid additions may be batched by mass or by volume.

DRAFT DEAS FOR PUBLIC COMMENTS

## 9.8 Mixing of concrete

Mixing of the constituent materials shall be carried out in a mixer conforming to 9.6.2.3 and be continued until the concrete is of uniform appearance.

Mixers shall not be loaded in excess of their rated mixing capacity.

Admixtures, where used, shall be added during the main mixing process, except for high range water reducing admixtures or water reducing admixtures that may be added after the main mixing process. In the latter case, the concrete shall be re-mixed until the admixture has been completely dispersed throughout the batch or load and has become fully effective.

NOTE In a truck mixer, the duration of re-mixing after the main mixing process should not be less than 1 min/$m^3$ and not less than 5 minutes after adding the admixture.

For light-weight concrete batched with unsaturated aggregates, the period from initial mixing to the end of final-mixing (e.g. re-mixing in a truck mixer) shall be prolonged till the water absorption of the aggregates and subsequent evacuation of air from the light-weight aggregates does not have any significant negative impact on the hardened concrete properties.

The composition of the fresh concrete shall not be altered after leaving the mixer.

## 9.9 Production control procedures

The constituent materials, equipment, production procedures and concrete shall be controlled with regard to their conformity with the specifications and the requirements of this standard. The control shall be such that significant changes that influence the properties are detected and appropriate corrective action taken.

The types and frequency of inspections/tests for constituent materials shall be as given in Table 22.

NOTE This table is based on the assumption that there is adequate production control by the producer of the constituent materials at the places where the materials are produced and that the constituent materials are delivered with a declaration or a certificate of conformity with the relevant specification. If not, the producer of the concrete should check the conformity of the materials to the relevant standards.

The control of equipment shall ensure that the storage facilities, the weighing and gauging equipment, the mixer and control apparatus (e.g. the measuring of water content of the aggregates) are in good working condition and that they conform to the requirements of this standard. Frequency of inspections and tests for equipment (where used) are given in Table 23.

Plant, equipment and transport facilities shall be subject to a planned maintenance system and shall be maintained in efficient working condition so that the properties and the quantity of concrete are not adversely affected.

The properties of designed concrete shall be controlled to the specified requirements as given in Table 24.

The proportions of prescribed concrete, its consistence and temperature, where specified, shall be controlled to the specified requirements as given in Table 24 (lines 2 to 4, 6, 7 and 9 to 14).

The control shall include production, transport to the point of delivery and delivery.

For some concretes, additional requirements for production control may be necessary. For the production of high strength concrete, special knowledge and experience are required. These are not defined in the standard. Annex H gives some guidance. If the contract has defined special requirements for the concrete, the production control shall include appropriate actions in addition to those in Tables 22 to 24.

The actions foreseen in Tables 22 to 24, in special cases, may be adapted to the conditions of the specific production place and be replaced by actions which provide an equivalent level of control.

DRAFT DEAS FOR PUBLIC COMMENTS

**Table 22 — Control of constituent materials**

| | Constituent material | Inspection / test | Purpose | Minimum frequency |
|---|---|---|---|---|
| 1 | Cements [a] | Inspection of delivery ticket [d] prior to discharge | To ascertain if the consignment is as ordered and from the correct source | Each delivery |
| 2 | Aggregates | Inspection of delivery ticket [b d] prior to discharge | To ascertain if the consignment is as ordered and from the correct source | Each delivery |
| 3 | | Inspection of the aggregate prior to discharge | For comparison with normal appearance with respect to the grading, shape and impurities | Each delivery<br>Where delivery is by belt conveyor, periodically depending on local or delivery conditions |
| 4 | | Test by sieve analysis according to EN 933-1 | To assess compliance with standard or other agreed grading | First delivery from new source where this information is not available from the aggregate supplier<br>In case of doubt following visual inspection<br>Periodically depending on local or delivery conditions [e] |
| 5 | | Test for impurities | To assess the presence and quantity of impurities | First delivery from new source where this information is not available from the aggregate supplier<br>In case of doubt following visual inspection<br>Periodically depending on local or delivery conditions [e] |
| 6 | | Test for water absorption to EN 1097-6 | To assess the effective water content of concrete, see 5.4.2 | First delivery from new source where this information is not available from the aggregate supplier.<br>In case of doubt. |
| 7 | Additional control for light-weight or heavy-weight aggregates | Test according to EN 1097-3 | To measure the loose bulk density | First delivery from new source where this information is not available from the aggregate supplier.<br>In case of doubt following visual inspection.<br>Periodically depending on local or delivery conditions [e] |
| 8 | Admixtures [c] | Inspection of delivery ticket and label on container [d] prior to discharge | To ascertain if the consignment is as ordered and properly marked | Each delivery. |
| 9 | | Tests for identification according to EN 934-2, e.g. density, infrared | For comparison with manufacturer's stated data | In case of doubt. |
| 10 | Additions [c] bulk powder | Inspection of delivery ticket [d] prior to discharge | To ascertain if the consignment is as ordered and from the correct source | Each delivery. |
| 11 | | Test of loss of ignition of fly ash | To identify changes in carbon content which may effect air-entrained concrete | Each delivery to be used for air-entrained concrete where this information is not available from the supplier. |
| 12 | Additions in suspension [c] | Inspection of delivery ticket [d] prior to discharge | To ascertain if the consignment is as ordered and from the correct source | Each delivery. |
| 13 | | Test for density | To ascertain uniformity | Each delivery and periodically during production of concrete. |
| 14 | Water | Test to EN 1008 | To ascertain that the water is free from harmful constituents if the water is not potable. | Where a new non-potable source is used for first time.<br>In case of doubt. |

[a] It is recommended that samples are taken once per week from each cement type and stored for testing in case of doubt.

[b] The delivery ticket or the product data sheet shall also contain information on the maximum chloride content and should identify classification with respect to alkali silica reaction in accordance with the provisions valid in the place of use of the concrete.

[c] It is recommended that samples are taken at each delivery and stored.

[d] The delivery ticket shall contain or be accompanied by a declaration or certificate of conformity as required in the relevant standard or specification.

[e] This is not necessary where the production control for the aggregate is certified.

DRAFT DEAS FOR PUBLIC COMMENTS

**Table 23 — Control of equipment**

| | Equipment | Inspection / test | Purpose | Minimum frequency |
|---|---|---|---|---|
| 1 | Stockpiles, bins, etc. | Visual inspection | To ascertain conformity with the requirements | Once per week |
| 2 | Weighing equipment | Visual inspection of the performance | To ascertain that the weighing equipment is in a clean condition and functions correctly | Daily |
| 3 | | Test of weighing accuracy | To ascertain the accuracy according to 9.6.2.2 | On installation.<br>Periodically [a] depending on national provisions.<br>In case of doubt. |
| 4 | Admixtures dispenser (including those mounted on truck mixers) | Visual inspection of performance | To ascertain that the measuring equipment is in a clean condition and functions correctly | First use of the day for each admixture. |
| 5 | | Test of accuracy | To avoid inaccurate dispensing | On installation.<br>Periodically [a] after installation.<br>In case of doubt. |
| 6 | Water meter | Test of measuring accuracy | To ascertain accuracy according to 9.6.2.2 | On installation.<br>Periodically [a] after installation.<br>In case of doubt. |
| 7 | Equipment for continuous measurement of water content of fine aggregates | Comparison of the actual amount with the reading of the meter | To ascertain accuracy | On installation.<br>Periodically a after installation.<br>In case of doubt. |
| 8 | Batching system | Visual inspection | To ascertain that the batching equipment is functioning correctly | Daily |
| 9 | | Comparison (by a suitable method depending on the batching system) of the actual mass of the constituents in the batch with the target mass and in the case of automatic batch recording with the recorded mass | To ascertain batching accuracy according to Table 21 | On installation.<br>In case of doubt.<br>Periodically [a] after installation. |
| 10 | Testing apparatus | Calibration according to relevant national or EN Standards | To check the conformity | Periodically [a].<br>For strength testing apparatus, at least once per year. |
| 11 | Mixers (including truck mixers) | Visual inspection | To check the wear of the mixing equipment | Periodically [a]. |

[a] The frequency depends on the kind of equipment, its sensitivity in use and the production conditions of the plant.

DRAFT DEAS FOR PUBLIC COMMENTS

**Table 24 — Control of production procedures and of concrete properties**

| | Type of test | Inspection / test | Purpose | Minimum frequency |
|---|---|---|---|---|
| 1 | Properties of designed concrete | Initial test (see annex A) | To provide proof that specified properties are met by the proposed design with an adequate margin | Before using a new concrete composition. |
| 2 | Water content of fine aggregates | Continuous measuring system, drying test or equivalent | To determine the dry mass of aggregate and the water to be added | If not continual, daily, depending on local and weather conditions more or less frequent tests may be required. |
| 3 | Water content of coarse aggregates | Drying test or equivalent | To determine the dry mass of aggregate and the water to be added | Depending on local and weather conditions. |
| 4 | Water content of fresh concrete | Check of the quantity of water added [a] | To provide data for the water/cement ratio | Every batch |
| 5 | Chloride content of concrete | Initial determination by calculation | To ensure that the maximum chloride content is not exceeded | When performing initial test.<br><br>In case of an increase in the chloride content of the constituents. |
| 6 | Consistence | Visual inspection | For comparison with normal appearance | Each batch |
| 7 | | Consistence test according to EN 12350-2, -3, -4 or -5 | To assess the achievement of the specified values of consistence and to check possible changes of water content | Where consistence is specified, as Table 13 for compressive strength.<br>When testing air content.<br>In case of doubt following visual inspections. |
| 8 | Density of fresh concrete | Density test according to EN 12350-6 | For light-weight and heavy-weight concrete for supervision of batching and density control | Daily |
| 9 | Cement content of fresh concrete | Check the mass of cement batched [a] | To check the cement content and to provide data for the water/cement ratio | Every batch |
| 10 | Additions content of fresh concrete | Check the mass of additions batched [a] | To check the additions content and to provide data for the w/c ratio (see 5.4.2) | Every batch |
| 11 | Admixture content of fresh concrete | Check the mass or volume of admixture batched [a] | To check the admixture content | Every batch |
| 12 | Water/cement ratio of fresh concrete | By calculation or by test method, see 5.4.2 | To assess the achievement of the specified water/cement ratio | Daily, where specified |
| 13 | Air content of fresh concrete where specified | Test according to EN 12350-7 for normal-weight and heavy-weight concrete ASTM C 173 for light-weight concrete | To assess the achievement of the specified content of entrained air | For concretes containing entrained air: first batch or load of each production day until values stabilize. |
| 14 | Temperature of fresh concrete | Measure temperature | To assess the achievement of the minimum temperature of 5 °C or specified limit | In case of doubt. |
| 15 | Density of hardened light-weight or heavy-weight concrete | Test according to EN 12390-7[b] | To assess the achievement of the specified density | Where temperature is specified:<br>— periodically, dependent on the situation;<br><br>— each batch or load where the concrete temperature is close to the limit. |
| 16 | Compressive strength test on moulded concrete specimen | Test according to EN 12390-3 | To assess the achievement of the specified strength | Where compressive strength is specified, as frequently as for conformity control, see 8.1 and 8.2.1 |

[a] Where recording equipment is not used and the batching tolerances for the batch or load are exceeded, record the batched quantity in the production record.

[b] May also be tested in saturated conditions, where a safe relationship to oven-dry density is established.

DRAFT FOR PUBLIC COMMENTS

# 10 Evaluation of conformity

## 10.1 General

The producer is responsible for the evaluation of conformity for specified requirements of the concrete. For this purpose, the producer shall carry out the following tasks:

a) initial tests, when required (see 9.5 and Annex A);

b) production control (see Clause 9), including conformity control (see Clause 8);

Whether approved inspection and certification bodies are recommended to inspect the production control and certify its conformity depends on the level of performance requirements for the concrete, its intended use, the kind of production and the margin of safety in the concrete composition.

In general, the inspection and certification of the production control by approved inspection and certification bodies is recommended. This is not considered to be necessary for standardized prescribed concrete with a high margin of safety in the composition (see Annex A.5), limited intended use and low concrete strength class (see 6.4).

For precast concrete products, the requirements and provisions for the evaluation of conformity are given in the relevant technical specifications (product standards and technical approvals).

## 10.2 Assessment, surveillance and certification of production control

Where it is required either in a contract or by provisions valid in the place of use of the concrete, that the producer's production control shall be assessed and surveyed by an approved inspection body and then certified by an approved certification body, the provisions for assessment, surveillance and certification given in Annex C apply.

# 11 Designation for designed concrete

Where the essential characteristics of designed concrete are to be given in an abbreviated form, the following format shall be applied:

— reference to this East African Standard: EAS 131-1;

— compressive strength class: compressive strength class as defined in Table 7 or 8, e.g. C25/30;

— for limiting values according to the exposure class: the class designation of Table 1, followed by the abbreviation of the country name[1)], that issued the provisions for the limiting values, concrete composition and concrete properties or other set of requirements, e.g. XD2(F) where the French provisions apply;

— maximum chloride content: the class defined in Table 10, e.g. Cl 0.20;

— maximum nominal upper aggregate size: the value $D_{max}$ as defined in 4.2.2, e.g. $D_{max}$ 22;

— density: the class designations as given in Table 9 or the target value, e.g. D1.8;

— consistence: by class as defined in 4.2.1 or by a target value and method.

[1)] In accordance with the internationally recognized car plate code. To the abbreviation of the country name, further information concerning the provisions may be added.

DRAFT EAS FOR PUBLIC COMMENTS

# Annex A
# (normative)
# Initial test

## A.1 General

This annex provides details of initial testing as indicated in 5.2.1, 5.2.5.1, 6.1 and 9.5.

The initial test shall establish a concrete that satisfies all specified requirements for fresh and hardened concrete.

Where the producer or specifier can demonstrate an adequate design, based on data from previous tests or long-term experience, this may be considered as an alternative to initial tests.

## A.2 Party responsible for initial tests

Initial tests shall be the responsibility of the producer for designed concrete, the specifier for prescribed concrete and the standardization body for standardized prescribed concrete.

## A.3 Frequency of initial tests

Initial tests shall be performed before using a new concrete or concrete family.

Initial tests shall be repeated if there has been a significant change either in the constituent materials or in the specified requirements on which the previous tests were based.

## A.4 Test conditions

In general, initial tests shall be carried out on fresh concrete with a temperature of 15 °C to 22 °C.

NOTE If concreting on the site will be done under widely divergent temperature conditions, or if heat treatment is applied, the producer should be informed about this, so that he can consider the concerning effects on the properties of the concrete and the need for any additional tests.

For the initial test of a single concrete, at least three specimens from each of three batches shall be tested. Where the initial test is for a concrete family, the number of concretes to be sampled shall encompass the composition range of the family. In this case, the number of batches per concrete may be reduced to one.

The strength of a batch or load shall be taken to be the average of the test results. The result of the initial test on the concrete is the average strength of the batches or loads.

The time between mixing and consistence testing, and the results shall be recorded.

A significantly higher number of tests is necessary for prescribing the composition of a standardized prescribed concrete to encompass all the permitted constituent materials, which are foreseen to be used on a national level.

The results of the initial tests shall be documented at the responsible standard organization.

## A.5 Criteria for adoption of initial tests

For assessing the properties of concrete, in particular those of fresh concrete, the differences between the type of mixer and mixing procedure applied during the initial test and those applied during actual production shall be taken into account.

The compressive strength of the concrete with the composition to be adopted for the actual case shall exceed the values $f_{ck}$ of Table 7 or 8 by an adequate margin. This margin shall be at least that needed to satisfy the conformity criteria given in 8.2.1. The margin should be about twice the expected

DRAFT DEAS FOR PUBLIC COMMENTS

standard deviation, that means at least a margin of 6 N/mm$^2$ to 12 N/mm$^2$ depending on the production facilities, the constituent materials and the available background information about the variation.

The criterion for adoption of initial tests for standardized prescribed concrete is:

$$f_{cm} \geq f_{ck} + 12$$

The consistence of the concrete shall be within the limits of the consistence class, at the time at which the concrete is likely to be placed or in the case of ready mixed concrete, delivered.

For other properties that are specified, the concrete shall meet the specified values with an appropriate margin.

DRAFT DEAS FOR PUBLIC COMMENTS

# Annex B
# (normative)
# Identity testing for compressive strength

## B.1 General

This annex provides details for identity testing as indicated in 8.2.1.1.

Identity testing indicates whether the defined volume of concrete in question belongs to the same population as that verified as conforming with the characteristic strength via conformity assessment by the producer.

## B.2 Sampling and testing plan

Where identity testing is to be performed, the particular volume of concrete shall be defined, e.g.:

— single batch or load where there is doubt as to the quality;

— the concrete supplied for each storey of a building or group of beams/slabs or columns/walls of a storey of a building or comparable parts of other structures;

— the concrete delivered to a site within one week, but not more than 400 m³.

The number of samples to be taken from a particular volume of concrete shall be defined.

Samples shall be taken from different batches or loads in accordance with EN 12350-1.

Test specimens shall be prepared and cured in accordance with EN 12390-2. The compressive strength of the specimens shall be determined in accordance with EN 12390-3. The test result shall be that obtained from the average of the results of two or more specimens made from one sample for testing at the same age. Where the range of the test values is more than 15 % of the mean, the results shall be disregarded unless an investigation reveals an acceptable reason to justify disregarding an individual test value.

## B.3 Identity criteria for compressive strength

### B.3.1 Concrete under production control certification

Identity of concrete is assessed for each individual strength test result and the average of *n* non-overlapping discrete results as identified in Table B1.

Concrete is deemed to come from a conforming population if both the criteria in Table B.1 are satisfied for *n* results derived from strength tests on samples taken from the defined volume of concrete.

**Table B.1 — Identity criteria for compressive strength**

| **Number *n* of test results for compressive strength from the defined volume of concrete** | **Criterion 1** | **Criterion 2** |
|---|---|---|
| | **Mean of *n* results** ($f_{cm}$) N/mm² | **Any individual test result** ($f_{ci}$) N/mm² |
| 1 | Not applicable | $f_{ck}$ - 4 |
| 2-4 | $f_{ck}$ + 1 | $f_{ck}$ - 4 |
| 5-6 | $f_{ck}$ + 2 | $f_{ck}$ - 4 |

NOTE The identity criteria of Table B.1 give a probability of 1 % that a conforming concrete volume is rejected.

### B.3.2 Concrete not under production control certification

From the defined volume of concrete, at least 3 samples shall be taken for testing.
The concrete is deemed to come from a conforming population if the conformity criteria in 8.2.1.3 and Table 14 for initial production are satisfied.

DRAFT DEAS FOR PUBLIC COMMENTS

# Annex C
# (normative)
# Provisions for assessment, surveillance and certification of production control

## C.1 General

Where required for the production control (see Clause 9), the provisions for assessment, surveillance and certification of production control by an approved body are given in this annex.

## C.2 Tasks for the inspection body

### C.2.1 Initial assessment of the production control

An initial inspection of the concrete plant and its production control shall be performed by the approved inspection body. The initial inspection is for the purpose of determining whether the prerequisites, in terms of staff and equipment for orderly production and for the corresponding production control, appear to be suitable.

The inspection body shall at least check:

— the producer's production control manual and assess the provisions of it and in particular whether it conforms with the requirements for production control in Clause 9 and whether it takes account of the requirements of this standard;

— the availability of current documents essential for plant inspections at the relevant places and if these are available to the relevant persons;

— if all necessary facilities and equipment are available to carry out the necessary inspections and tests on equipment, constituent materials and concrete;

— the knowledge, training and experience of the staff for production and production control;

— if initial testing is performed according to Annex A of this standard and if this is reported in an adequate manner.

If indirect testing is performed or if conformity for strength is based on the transposed results of the family concept, the producer shall prove the correlation or safe relationship between the direct and indirect testing to the satisfaction of the inspection body.

To provide confidence in the results of the production control, the inspection body shall perform spot tests in parallel to those of the producer's. Such testing may be replaced by an in-depth surveillance of the producer's data and control system where the producer's testing laboratory is accredited and under the surveillance of an accreditation body.

All the relevant facts from the initial inspection, especially the equipment at the production place, the production control system and the assessment of the system, shall be documented in an assessment report.

When a production unit has passed the initial inspection to the satisfaction of the inspection body, the inspection body shall issue an assessment report that the production control conforms to Clause 9 of this standard. This report shall be passed to the producer and to the approved certification body.

NOTE On the basis of this report the approved certification body will decide on the certification of the production control (see C.3.1).

### C.2.2 Continuous surveillance of the production control

#### C.2.2.1 Routine inspection

The principal objective of the routine inspection by the inspection body is to check whether the prerequisites for production and agreed production control are being maintained. For this purpose, the assessment report of the initial inspection is used as a statement of the agreed production control.

DRAFT DEAS FOR PUBLIC COMMENTS

The producer is responsible for the maintenance of the production control system. When significant changes are made at the facilities at the production place, to the production control system or to the production control manual, the producer shall notify the changes to the inspection body which may request a re-inspection.

During the routine inspection, the inspection body shall at least assess:

— the production, sampling and testing procedures;

— the recorded data;

— the test results obtained for production control during the inspection period;

— that the required tests or procedures have been carried out with appropriate frequency;

— that the production equipment has been checked and maintained as scheduled;

— that the test equipment has been maintained and calibrated as scheduled;

— the actions taken with respect to any non-conformity;

— the delivery tickets and the declarations of conformity, where relevant.

To provide confidence in the sampling and testing of the producer's production control the inspection body shall, during the routine inspection, take spot samples from the running production for testing. Sampling for this purpose shall not be announced in advance. The inspection body shall determine the appropriate frequency for each production unit, in which testing on the concrete should be conducted, taking account of the individual circumstances. Such testing may under special individual circumstances be replaced by an in-depth surveillance of the producer's data and control system when the producer's testing laboratory is accredited and under the surveillance of the accreditation body.

Designed concretes shall be tested for the specified properties, e.g. strength, consistence. For prescribed concrete, testing shall cover consistence and composition only.

Comparison shall be made between the producer's routine test results and the results of testing by the inspection body.

The inspection body shall periodically examine the safe relationship between the direct and indirect testing and the relationships between the members of a concrete family.

The results of the routine inspection shall be documented in a report to be passed to the producer and the certification body.

The routine inspections shall be performed, at least, twice a year, except where the verification or the certification scheme defines conditions for decreasing or increasing that frequency.

**C.2.2.2 Extraordinary inspections**

An extraordinary inspection is necessary:

— if severe discrepancies are detected during a routine inspection (re-inspection);

— when there has been no production for a period of more than six months;

— where requested by the producer, e.g. because of changes in the production conditions;

— if requested by the certification body, giving due justification.

The scope, type and timing of the extraordinary inspection depends on the particular situation.

DRAFT DEAS FOR PUBLIC COMMENTS

### C.3 Tasks for the certification body

#### C.3.1 Certification of production control

The certification body shall certify the production control on the basis of a report from the inspection body, that states the production unit has passed the initial assessment of the production control to the satisfaction of the inspection body.

The certification body shall decide on the further validity of the certificate on the basis of the reports of the continuous surveillance of the production control.

#### C.3.2 Measures in case of non-conformity

Where the inspection body identifies non-conformity with the specification or where defects have been revealed in the production process or in the production control on which the producer has not reacted properly in due time (see 8.4), the certification body shall request the producer to rectify the defects within an appropriately short period. The actions of the producer shall be verified by the inspection body.

If appropriate, an extraordinary inspection and additional tests shall be arranged in the case of non-conformity with:

— strength;

— water/cement ratio;

— basic limits on the composition;

— density, where specified for designed light-weight and heavy-weight concrete;

— specified composition in the case of prescribed concrete.

If the results of the extraordinary inspection are not satisfactory or if the additional tests failed the set criteria, the certification body shall suspend or withdraw the certificate of conformity of the production control without undue delay.

NOTE After the suspension or the withdrawal of the certificate of the conformity of the production control, the producer is no longer permitted to refer to the certificate.

In case of other faults, the certification body may consider an extraordinary inspection unnecessary and may accept documentary evidence that the fault has been rectified. Such evidence shall be confirmed during the next routine inspection.

DRAFT DEAS FOR PUBLIC COMMENTS

# Annex D
# (informative)
# Bibliography

ENV 1992-1-1, *Eurocode 2: Design of concrete structures — Part 1-1: General rules and rules for buildings*

EN 12390-4, *Testing hardened concrete — Part 4: Compressive strength — Specification for compression testing machines*

EN 12390-5, *Testing hardened concrete — Part 5: Flexural strength of test specimens*

EN 12390-8, *Testing hardened concrete — Part 8: Depth of penetration of water under pressure*

EN 12504-1, *Testing concrete in structures — Part 1: Cored specimens — Taking, examining and testing in compression*

EN 12504-2, *Testing concrete in structures — Part 2: Non-destructive testing — Determination of rebound number*

EN 12504-3, *Testing concrete in structures — Part 3: Determination of pull-out force*

EN 12504-4, *Testing concrete in structures — Part 4: Determination of ultrasonic pulse velocity*

ENV 13670-1, *Execution of concrete structures — Part 1: Common rules*

EN 13791, *Assessment of concrete compressive strength in structures or in structural elements*

ISO 9001, *Quality systems — Model of quality assurance in design/development, production, installation and servicing*

CR 1901, *Regional specifications for the avoidance of damaging alkali-silica reactions in concrete*

CR 13901, *The use of the concept of concrete families for production and conformity control of concrete*

CR 13902, *Determination of water/cement ratio of fresh concrete*

CEB Bulletin of Information 197 — FIP, High strength concrete — State of the art report; SR 90/1-1990

DRAFT DEAS FOR PUBLIC COMMENTS

# Annex E
# (informative)
# Guidance on the application of the equivalent performance concept of concrete properties

This annex provides details of the equivalent concrete performance concept in 5.2.5.1 and 5.2.5.3.

Testing should show that the performance of the concrete containing the addition should be at least equivalent to that of the reference concrete.

The reference concrete should:

— contain a cement conforming to EAS 18-1 of the type and having the constituents corresponding to the combination of cement and addition;

— conform to the requirements of 5.3.2 for the relevant exposure class.

Where there is no corresponding cement available, CEM I cement should be used.

The test program should cover all tests required to demonstrate that the concrete containing the addition performs in an equivalent manner compared with the reference concrete in respect to the specific effects resulting from the environmental action of the specific exposure class.

Testing should be carried out at the same time and in the same laboratory that should be experienced and accredited for the relevant tests. The test result should provide a similar degree of reliability in the performance of the concrete as concrete containing cement conforming to EAS 18-1 and conforming to the requirements of 5.3.2 for the relevant exposure class.

The range of compositions for which this method applies should be limited to:

— the total amount of addition, including that already contained as a constituent in the cement, should be within the limits given EAS 18-1 for a corresponding permitted type of cement;

— the sum of cement and addition should be at least equal to the cement content requirement in 5.3.2 for the relevant exposure class;

— the water/(cement + addition) ratio should not be greater than the requirement in 5.3.2 for the maximum water/cement ratio for the relevant exposure class.

DRAFT DEAS FOR PUBLIC COMMENTS

# Annex F
# (informative)
# Recommendation for limiting values of concrete composition

This annex provides recommendations for the choice of the limiting values of concrete composition and properties in relation to exposure classes according to 5.3.2.

The values in Table F.1 are based on the assumption of an intended working life of the structure of 50 years.

The values in Table F.1 refer to the use of cement type CEM I conforming to EAS 18-1 and aggregate with maximum nominal upper size in the range of 20 mm to 32 mm.

The minimum strength classes were derived from the relationship between water/cement ratio and the strength class of concrete made with cement of strength Class 32.5.

The limiting values for the maximum water/cement ratio and the minimum cement content apply in all cases, whilst the requirements for concrete strength class may be additionally specified.

DRAFT DEAS FOR PUBLIC COMMENTS

**Table F.1 — Recommended limiting values for composition and properties of concrete**

| | Exposure classes | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No risk of corrosion or attack | Carbonation-induced corrosion | | | | Chloride-induced corrosion | | | | | | Freeze/thaw attack | | | | Aggressive chemical environments | | |
| | | | | | | Sea water | | | Chloride other than from sea water | | | | | | | | | |
| | X0 | XC 1 | XC 2 | XC 3 | XC 4 | XS 1 | XS 2 | XS 3 | XD 1 | XD 2 | XD 3 | XF 1 | XF 2 | XF 3 | XF 4 | XA 1 | XA 2 | XA 3 |
| Maximum w/c | — | 0.65 | 0.60 | 0.55 | 0.50 | 0.50 | 0.45 | 0.45 | 0.55 | 0.55 | 0.45 | 0.55 | 0.55 | 0.50 | 0.45 | 0.55 | 0.50 | 0.45 |
| **minimum** strength class | C12/15 | C20/25 | C25/30 | C30/37 | C30/37 | C30/37 | C35/45 | C35/45 | C30/37 | C30/37 | C35/45 | C30/37 | C25/30 | C30/37 | C30/37 | C30/37 | C30/37 | C35/45 |
| Maximum cement content ($kg/m^3$) | — | 260 | 280 | 280 | 300 | 300 | 320 | 340 | 300 | 300 | 320 | 300 | 300 | 320 | 340 | 300 | 320 | 360 |
| Maximum air content (%) | — | — | — | — | — | — | — | — | — | — | — | — | 4.0[a] | 4.0[a] | 4.0[a] | — | — | — |
| Other requirements | | | | | | | | | | | | Aggregate in accordance with EN 12620:2000 with sufficient freeze/thaw resistance | | | | | Sulfate-resisting cement [a] | |

[a] Where the concrete is not air entrained, the performance of concrete should be tested according to an appropriate test method in comparison with a concrete for which freeze/thaw resistance for the relevant exposure class is proven.

[b] When $SO_4^{2-}$ leads to exposure Classes XA2 and XA3, it is essential to use sulfate-resisting cement. Where cement is classified with respect to sulfate resistance, moderate or high sulfate-resisting cement should be used in exposure Class XA2 (and in exposure Class XA1 when applicable) and high sulfate-resisting cement should be used in exposure Class XA3.

DRAFT DEAS FOR PUBLIC COMMENTS

# Annex G
# (informative)
# Accuracy requirements for batching equipment

## G.1 General

This annex summarizes the application of EN 45501as required in 9.6.2.2 of this standard.

In line with the CEN rules, EN 45501should have been implemented as the national standard in all CEN member countries at the latest by 1993, together with the withdrawal of the existing conflicting national standards at the latest by December, 1995.

EN 45501specifies the metrological and technical requirements for non- automatic weighing instruments. A East African Standard for automatic weighing equipment is not yet available. However, it is expected that it will refer to EN 45501. Therefore, EAS 131-1 requires an application of EN 45501for both non-automatic and automatic weighing equipment. Non-automatic weighing instruments require the intervention of an operator during the weighing process e.g. to deposit in, or remove from the receptor (hopper) the load to be measured. The instrument enables direct observation of the weighing results either on display or as a print-out.

## G.2 Accuracy classes

In EN 45501, accuracy is classified into 4 classes:

Class (I), Special accuracy

Class (II), High accuracy

Class (III), Medium accuracy

Class (IIII), Ordinary accuracy

For concrete production, at least Class (IIII) for weighing cement, aggregates, water, admixtures and additions has been selected for this standard.

## G.3 Classification of instruments

The verification scale interval, the number of verification scale intervals and the minimum capacity for Class (IIII) are given in the following table. The verification scale interval for graduated instruments without auxiliary indicating devices is equal to the actual scale interval. Where instruments have auxiliary indicating devices or are non-graduated, the verification scale interval is selected by the manufacturer in accordance with guidance in EN 45501:1992.

**Table G.1 — (Extract from Table 3 of EN 45501)**

| Accuracy class | Verification scale interval (*e*) | Number (*n*) of verification scale intervals (*e*) $n = \frac{\text{max. capacity}}{e}$ | Minimum capacity of equipment to avoid excessive error |
|---|---|---|---|
| Ordinary (IIII) | 5 g ≤ *e* | 100 ≤ *n* ≤ 1000 | 10 *e* |

The number (*n*) of verification scale intervals (*e*) should be:

— for admixtures, at least 1 000;

— for cement, aggregate, water and additions, at least 500 (see 9.6.2.2).

DRAFT EAS FOR PUBLIC COMMENTS

EXAMPLE A weighing equipment for cement has a capacity of 3 000 kg while the scale interval is 5 kg.

The number ($n$) of verification scale intervals ($e$) is ($n$) = 3 000/5 = 600 which is within the permitted range of column 3 of Table G.1 and ≥ 500.

Maximum permissible errors:

A distinction is made between the maximum permissible errors at the initial verification after installation and in service as shown in Table G.2.

**Table G.2 — (Extract from Table 6 of EN 45501)**

| For loads ($m$) expressed in verification scale intervals ($e$) | Maximum permissible errors | |
|---|---|---|
| **Class (IIII)** | **Initial verification** | **In service** |
| $0 \leq m \leq 50e$ | ±0.5$e$ | ±1.0$e$ |
| $50e \leq m \leq 200e$ | ±1.0$e$ | ±2.0$e$ |
| $200e \leq m \leq 1000e$ | ±1.5$e$ | ±3.0$e$ |

## G.4 Other Requirements in EN 45501

Full details of the testing for verification are described in detail within the standard that also describes general technical requirements for the design and construction of suitable instruments.

Normative annexes of EN 45501give testing procedures for:

— non-automatic weighing instruments;

— additional tests for electronic instruments.

DRAFT DEAS FOR PUBLIC COMMENTS

# Annex H
# (informative)
# Additional provisions for high strength concrete

This annex gives some recommendations on provisions for production control additional to those given in Tables 22, 23 and 24 when high strength concrete is produced.

Numbers for the rows in the following Tables H.1, H.2 and H.3 are related to those in Tables 22, 23 and 24 respectively and replace or amend the equivalent requirements.

**Table H.1 — Control of constituent materials**

| | Constituent material | Inspection / test | Purpose | Minimum frequency |
|---|---|---|---|---|
| 4 | Aggregates | Test by sieve analysis according to EN 933-1 or aggregate supplier information | To assess compliance with agreed grading | Each delivery, unless the aggregates are delivered with restricted tolerances and with a certificate of the production control. |
| 9a | Admixtures [a] | Test for dry material content | For comparison with the declared value on the data sheet | Each delivery, unless the test data for this delivery are provided by the supplier. In case of doubt. |
| 9b | | Test for density | For comparison with nominal density | Each delivery |
| 11 | Additions bulk powder | Test of loss of ignition | To identify changes in carbon content that may effect the fresh concrete properties | Each delivery, unless the test data for this delivery are provided by the supplier. |
| [a] It is recommended that samples are taken from each delivery and stored. | | | | |

NOTE Additional information for production control for high strength concrete may be taken from the relevant literature, e.g. CEB Bulletin of Information 197 — FIP, High strength concrete — State of the art report; SR 90/1-1990.

**Table H.2 — Control of equipment**

| | Equipment | Inspection / test | Purpose | Minimum frequency |
|---|---|---|---|---|
| 1 | Stockpiles, bins, etc. | Visual inspection | To ascertain conformity with the requirements | Daily |
| 3a | Weighing equipment | Test of weighing accuracy | Confirmation of accuracy at single point | Weekly |
| 5 | Admixture dispensers (including those mounted on truck mixers) | Test of accuracy | To achieve accurate dispensing | On installation. Weekly after installation. In case of doubt. |
| 6a | Water meter | Comparison of the measured value with the target value | To ascertain accuracy according to Clause 9.7 | On installation. Weekly after installation. In case of doubt. |
| 7 | Equipment for continuous measurement of water content of fine aggregates | Comparison of the measured value with the reading of the meter | To ascertain accuracy | On installation. Weekly after installation. In case of doubt. |
| 9 | Batching system | Comparision (by a suitable method depending on the batching system) of the measured value of the constituents in the batch with the target value and in the case of automatic batch recording also with the recorded value. | To ascertain batching accuracy according to Table 21 | On first installation. In case of doubt at subsequent installations. Monthly after installation. |

DRAFT DEAS FOR PUBLIC COMMENTS

**Table H.3 — Control of production procedures and of concrete properties**

| | Type of test | Inspection / test | Purpose | Minimum frequency |
|---|---|---|---|---|
| 3 | Water content of the coarse aggregates | Drying test or equivalent | To determine the mass of aggregates and the water to be added | Daily.<br>Depending on local and weather conditions more or less frequent test may be required. |
| 4 | Added water content of fresh concrete | Record [a] of the quantity of water added | To provide data for the water/cement ratio | Every batch |
| 9 | Cement content of fresh concrete | Record [a] of the quantity of cement added | To check the cement content and to provide data for the water/cement ratio | Every batch |
| 10 | Additions content of the fresh concrete | Record [a] the quantity of additions added | To check the additions content | Every batch |
| [a] For production of high strength concrete automatic recording weighing equipment is recommended. | | | | |

DRAFT DEAS FOR PUBLIC COMMENTS

# Annex J
# (informative)
# Performance-related design methods with respect to durability

## J.1 Introduction

This annex gives brief details of the approach and principles for a performance-related design method with respect to durability as referred to in 5.3.3.

## J.2 Definition

The performance-related method considers each relevant deterioration mechanism, the working life of the element or structure, and the criteria that define the end of this working life, in a quantitative way.

Such a method may be based on satisfactory experience with local practices in local environments, on data from an established performance test method for the relevant mechanism, or on the use of proven predictive models.

## J.3 Applications and general guidance

a) Some aggressive actions are best dealt with by a prescriptive approach, e.g. alkali-silica reaction, sulfate attack, or abrasion.

b) Performance-related design methods are more relevant to corrosion resistance and possibly, freeze-thaw resistance of concrete. This approach may be appropriate where:

— a working life significantly differing from 50 years is required;

— the structure is "special" requiring a lower probability of failure;

— the environmental actions are particularly aggressive, or are well defined;

— standards of workmanship are expected to be high;

— a management and maintenance strategy is to be introduced, perhaps with planned upgrading;

— significant populations of similar structures, or elements, are to be built;

— new or different constituent materials are to be used;

— method according to 5.3.2 has been used in design, but there has been a failure to conform.

c) In practice, the level of durability achieved depends on a combination of design, materials and execution.

d) The sensitivity of the design concept, the structural system, the shape of members and structural/architectural detailing are all significant design parameters for all methods of durability design.

e) Compatibility of materials, the construction method, the quality of workmanship, levels of control and quality assurance are significant parameters for all methods of durability design.

f) The required durability performance depends on the required working life, on the possible future use of the structure, on the particular protective measures, on the planned maintenance in service, and on the consequences of failure, in the particular local environment.

g) For any required level of performance, it is possible to derive alternative equivalent solutions from different combinations of design, material and construction factors.

DRAFT DEAS FOR PUBLIC COMMENTS

h) The level of knowledge of the ambient and local micro-climate is important in establishing the reliability of performance-related design methods.

### J.4 Performance-related methods with respect to durability

In applying the methods listed below, it is important to define in advance, at least the following:

— type of structure and its form;

— local environmental conditions;

— level of execution;

— required working life.

Some assumptions and judgements on these issues will usually be necessary to reduce the chosen method to a pragmatic and practical level.

The methods that may then be used include:

a) The refinement of the method according to 5.3.2, based on long-term experience of local materials and practices, and on detailed knowledge of the local environment.

b) Methods based on approved and proven tests that are representative of actual conditions and have approved performance criteria.

c) Methods based on analytical models that have been calibrated against test data representative of actual conditions in practice.

The concrete composition and the constituent materials should be closely defined to enable the level of performance to be maintained.

DRAFT DEAS FOR PUBLIC COMMENTS

# Annex K
# (informative)
# Concrete families

## K.1 General

This annex provides details on the use of concrete families as indicated in 8.2.1.1.

## K.2 Selection of the concrete family

When selecting the family for production and conformity control, the producer must achieve control over all the family members. Where there is little experience of using the concrete family concept, the following is recommended for a family:

— cement of one type, strength class and source;

— demonstrably similar aggregates and type I additions;

— concretes with or without a water reducing/plasticizing admixture;

— full range of consistence classes;

— concretes with a limited range of strength classes.

Concretes containing a type II addition, i.e. a pozzolanic or latent hydraulic addition, should be put into a separate family.

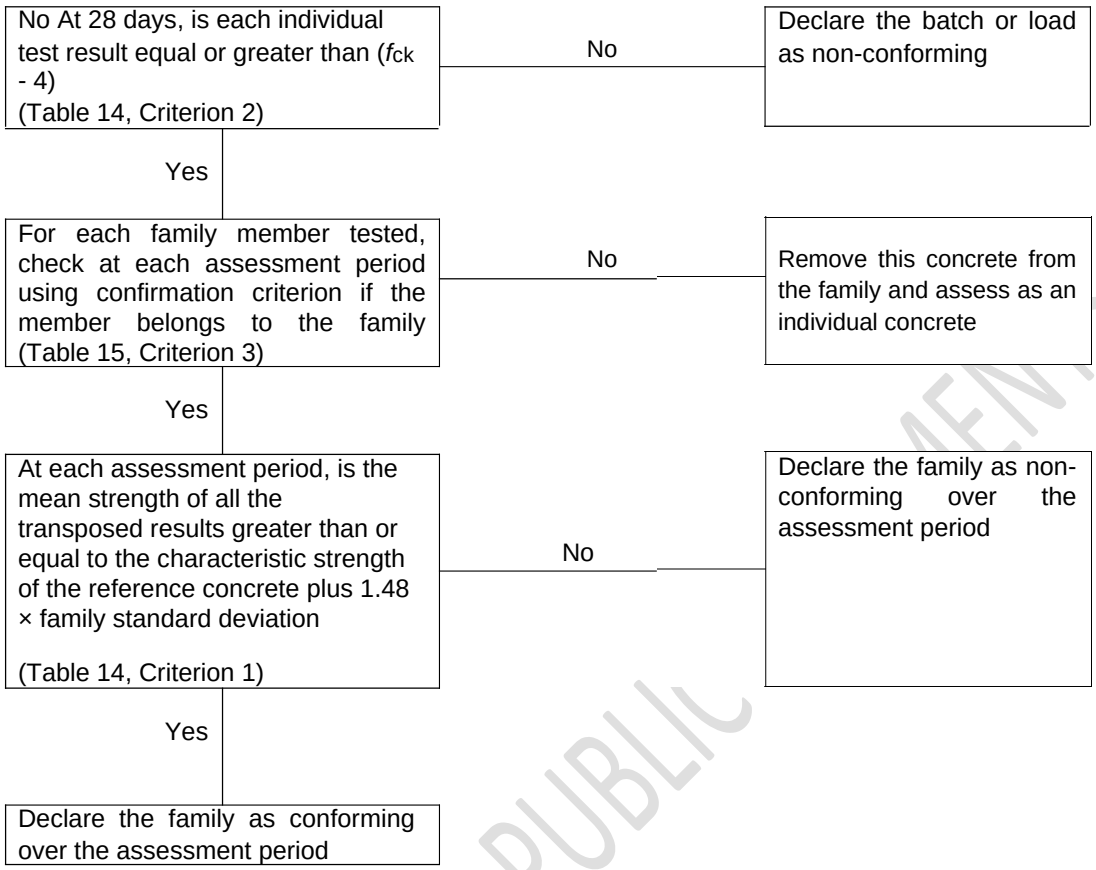
Concretes containing admixtures that may have an impact on compressive strength, e.g. high range water reducing/superplasticizing, accelerators, retarding or air entraining admixture should be treated as individual concretes or separate families.

To be demonstrably similar, aggregates should be from the same geological origin, be of the same type, e.g. crushed, and have a similar performance in concrete.

Before using the family concept or extending the families given above, the relationships should be tested on previous production data to prove that they give adequate and effective production and conformity control.

DRAFT DEAS FOR PUBLIC COMMENTS

### K.3 Flow chart for the assessment of membership and conformity of a concrete family




DRAFT DEAS FOR PUBLIC COMMENTS