BS EN 13369:2013

BSI Standards Publication

Common rules for precast concrete products

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National foreword

This British Standard is the UK implementation of EN 13369:2013. It supersedes BS EN 13369:2004+A1:2006 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/524, Precast concrete products.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Common rules for precast concrete products

Règles communes pour les produits préfabriqués en béton

Allgemeine Regeln für Betonfertigteile

This European Standard was approved by CEN on 21 January 2013.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 13369:2013) has been prepared by Technical Committee CEN/TC 229 “Precast concrete products”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2013, and conflicting national standards shall be withdrawn at the latest by October 2013.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13369:2004.

The main technical changes that have been made in this new edition are the following ones:

a) Scope: precast concrete product made of heavyweight, light and normal concrete; concrete using fibres (steel, polymer or other) is also covered;

b) Normative references have been updated while taking the Bibliography into account;

c) Terms and definitions have been reviewed;

d) Requirements;

e) New clause for reclaimed crushed and recycled coarse aggregates;

f) New wording and requirements for the subclause “Curing (protection against drying out)”;

g) New requirements: tensile strength, shrinkage, dry density;

h) Productions tolerances are revised;

i) New clause on Performance related design;

j) Evaluation of conformity;

k) Type testing, new Annex P, Survey of type testing;

l) Concrete strength, conformity criteria;

m) Annex G, Test of water absorption;

n) Annex Q, Use of reclaimed crushed and recycled coarse aggregates in concrete.

EN 13369 is a common reference for the following group of specific product standards prepared by Technical Committee CEN/TC 229:

— EN 1168, *Precast concrete products — Hollow core slabs*;

— EN 12737, *Precast concrete products — Floor slats for livestock*;

— EN 12794, *Precast concrete products — Foundation piles*;

— EN 12839, *Precast concrete products — Elements for fences*;

— EN 12843, *Precast concrete products — Masts and poles*;

— EN 13198, *Precast concrete products — Street furniture and garden products*;

— EN 13224, *Precast concrete products — Ribbed floor elements*;

— EN 13225, *Precast concrete products — Linear structural elements*;

— EN 13693, *Precast concrete products — Special roof elements*;

— EN 13747, *Precast concrete products — Floor plates for floor systems*;

— EN 13748-1, *Terrazzo tiles — Part 1: Terrazzo tiles for internal use*;

— EN 13748-2, *Terrazzo tiles — Part 2: Terrazzo tiles for external use*;

— EN 13978-1, *Precast concrete products — Precast concrete garages — Part 1: Requirements for reinforced garages monolithic or consisting of single sections with room dimensions*;

— EN 14843, *Precast concrete products — Stairs*;

— EN 14844, *Precast concrete products — Box culverts*;

— EN 14991, *Precast concrete products — Foundation elements*;

— EN 14992, *Precast concrete products — Wall elements*;

— EN 15037-1, *Precast concrete products — Beam-and-block floor systems — Part 1: Beams*;

— EN 15037-2, *Precast concrete products — Beam-and-block floor systems — Part 2: Concrete blocks*;

— EN 15037-3, *Precast concrete products — Beam-and-block floor systems — Part 3: Clay blocks*;

— EN 15037-4, *Precast concrete products — Beam-and-block floor systems — Part 4: Expanded polystyrene blocks*;

— EN 15050, *Precast concrete products — Bridge elements*;

— EN 15258, *Precast concrete products — Retaining wall elements*;

— EN 15435 *Precast concrete products — Normal weight and lightweight concrete shuttering blocks — Product properties and performances*;

— EN 15498, *Precast concrete products — Wood-chip concrete shuttering blocks — Product properties and performances*.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This document is intended to outline the general common requirements applicable to a large variety of precast concrete products manufactured in a factory environment. It acts as a reference standard for other standards to enable a more consistent approach to standardization in the field of precast concrete products and to reduce the variations brought about by a large number of standards produced in parallel by different groups of experts. At the same time, it allows those experts the flexibility to include variations in specific product standards where they are required.

This standard has been produced as part of the total CEN programme for construction and refers to the relevant specifications of associated standards EN 206 (all parts) for concrete and EN 1992 for the design of concrete structures. The installation of some precast concrete products is dealt with by EN 13670.

As it is not a harmonised standard, it may not be used on its own for the purpose of CE marking of precast concrete products.

The design of precast concrete products should be verified to ensure the fitness of their properties for the particular application, particular attention being paid to design co-ordination with other parts of the construction.

1 Scope

This European Standard specifies the requirements, the basic performance criteria and the evaluation of conformity for unreinforced, reinforced and prestressed precast concrete products made of compact light-, normal- and heavyweight concrete according to EN 206-1 with no appreciable amount of entrapped air other than entrained air. Concrete containing fibres for other than mechanical properties steel, polymer or other fibres is also covered. It does not cover prefabricated reinforced components of lightweight aggregate concrete with open structure.

It may also be used to specify products for which there is no standard. Not all of the requirements (Clause 4) of this standard are relevant to all precast concrete products.

If a specific product standard exists, it takes precedence over this standard.

The precast concrete products dealt with in this standard are factory produced for building and civil engineering works. This standard may also be applied to products manufactured in temporary plants on site if the production is protected against adverse weather conditions and controlled following Clause 6 provisions.

The analysis and design of precast concrete products is not within the scope of this standard but it does offer, for non-seismic zones, information about:

— the choice of partial safety factors defined by the pertinent Eurocode;

— the definition of some requirements for prestressed concrete products.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 206-1:2000[1)], *Concrete — Part 1: Specification, performance, production and conformity*

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

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

EN 1992-1-1:2004[2)], *Eurocode 2: Design of concrete structures — Part 1-1: General rules and rules for buildings*

EN 1992-1-2:2004[3)], *Eurocode 2: Design of concrete structures — Part 1-2: General rules — Structural fire design*

EN 10080:2005, *Steel for the reinforcement of concrete — Weldable reinforcing steel — General*

1) This document is impacted by the stand-alone amendments EN 206-1:2000/A1:2004 and EN 206-1:2000/A2:2005.

2) This document is impacted by the corrigendum EN 1992-1-1:2004/AC:2010.

3) This document is impacted by the corrigendum EN 1992-1-2:2004/AC:2008.

prEN 10138-1, *Prestressing steels — Part 1: General requirements*

prEN 10138-2, *Prestressing steels — Part 2: Wire*

prEN 10138-3, *Prestressing steels — Part 3: Strand*

prEN 10138-4, *Prestressing steels — Part 4: Bar*

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

EN 12390-1, *Testing hardened concrete — Part 1: Shape, dimensions and other requirements for 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 12390-7, *Testing hardened concrete — Part 7: Density of hardened concrete*

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

EN 13501-1, *Fire classification of construction products and building elements — Part 1: Classification using data from reaction to fire tests*

EN ISO 717-1, *Acoustics — Rating of sound insulation in buildings and of building elements — Part 1: Airborne sound insulation (ISO 717-1)*

EN ISO 717-2, *Acoustics — Rating of sound insulation in buildings and of building elements — Part 2: Impact sound insulation (ISO 717-2)*

EN ISO 10456, *Building materials and products — Hygrothermal properties — Tabulated design values and procedures for determining declared and design thermal values (ISO 10456)*

ASTM C173 / C173M - 10b, *Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 General

3.1.1
precast concrete product
product which is made of concrete and manufactured in accordance with this standard or a specific product standard in a place different from the final destination of use, protected from adverse weather conditions during production and which is the result of an industrial process under a factory production control system and with the possibility of sorting before delivery

Note 1 to entry: In relevant European Standards, the shorter term “Precast product” is often used.

3.1.2
(concrete) cover
distance between the surface of the reinforcement closest to the nearest concrete surface(including links and stirrups and surface reinforcement where relevant) and the nearest concrete surface

3.1.3
concrete family
group of concrete compositions for which a reliable relationship between relevant properties is established and documented

3.1.4
tendon
prestressing unit (wire, strand or bar) subjected to pre- or post-tensioning

3.1.5
lightweight concrete
concrete with a closed structure and with an oven-dry density of 800 kg/m^3 to 2 000 kg/m³

3.1.6
normal weight concrete
concrete with an oven-dry density of 2 000 kg/m^3 to 2 600 kg/m³

3.1.7
heavyweight concrete
concrete with an oven-dry density of more than 2 600 kg/m³

3.2 Dimensions

3.2.1
principal dimensions
length, width, depth or thickness

3.2.2
nominal dimension
dimension declared in the technical documentation and targeted at manufacture

3.3 Tolerances

3.3.1
tolerance
sum of the absolute values of the upper and the lower permitted deviation

3.3.2
deviation
difference between an actual measure and the corresponding nominal dimension

3.4 Durability

3.4.1
durability
ability of a precast concrete product to satisfy, with anticipated maintenance, the design performance requirements during its design working life under the influence of the expected environmental actions

3.4.2
design working life
assumed period for which a structure or part of it is to be used for its intended purpose with anticipated maintenance but without major repair being necessary

3.4.3
environmental conditions
physical or chemical impacts to which the precast concrete product is exposed and which result in effects on the concrete or reinforcement or embedded metal that are not considered as loads in structural design

3.4.4
ambient conditions
hygrothermic conditions in the factory which result in effects on the hardening process of the concrete

3.5 Mechanical properties

3.5.1
potential strength
compressive concrete strength derived from tests on cubes or cylinders moulded and cured in laboratory conditions in accordance with EN 12390-2

3.5.2
structural strength
compressive concrete strength derived from tests on specimens (drilled cores or cut prisms) taken from the precast concrete product (direct structural strength) or derived from tests on moulded specimens cured in the same ambient conditions as the product itself (indirect structural strength)

3.5.3
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

4 Requirements

4.1 Material requirements

4.1.1 General

Only materials with established suitability shall be used.

For a particular material, the establishment of suitability may be based on a European Standard which refers specifically to the use of this material in concrete or in precast concrete products; in absence of a European Standard, it may also result, under the same conditions, from an ISO Standard.

Where this material is not covered by a European or ISO Standard, or if it deviates from the requirements of these standards, the establishment of suitability may be based on:

— the provisions valid in the place of use of the precast concrete product which refer specifically to the use of this material in concrete or in precast concrete products; or

— a European Technical Approval specifically for the use of this material in concrete or precast concrete products.

4.1.2 Constituent materials of concrete

4.1.2.1 General

EN 206-1:2000, 5.1 shall apply.

4.1.2.2 Reclaimed crushed and recycled coarse aggregates

Reclaimed crushed and recycled coarse aggregates, mixed in concrete with other aggregates, shall not adversely alter the rate of setting and hardening of concrete, nor shall it be detrimental to the durability of the precast concrete product in the end use conditions.

The amount of crushed recycled aggregates obtained from precast concrete products manufactured in the same factory, can be used up to 10 % in weight of the total content of aggregates in the concrete mix with no further testing of the mechanical strength of the product or of hardened concrete properties other than testing of compressive concrete strength.

Where required and for specific applications, the amount of reclaimed aggregates might be limited to 5 % in weight.

More detailed recommendations on the use of reclaimed crushed and recycled coarse aggregates are given in Annex Q.

Alternative provisions are under development in the upcoming version of EN 206-1 and should be considered.

4.1.3 Reinforcing steel

Reinforcing steel (bars, coils and welded fabric) shall comply with EN 10080. Other types of reinforcing steel may be used according to provisions valid in the place of use of the product (e.g. EN 1992-1-1:2004, 3.2).

NOTE Recommendations on indented bars and wires are given in Annex N.

4.1.4 Prestressing steel

Prestressing steel (wire, bars and strand) shall comply with prEN 10138-1, prEN 10138-2, prEN 10138-3 and prEN 10138-4.

Other types of prestressing steel may be used according to provisions valid in the place of use of the product (e.g. EN 1992-1-1:2004, 3.3).

4.1.5 Inserts and connectors

Mechanical inserts and connectors shall:

a) resist the design actions;

b) have the necessary ductility.

Permanent connecting parts and fasteners shall maintain these properties for the design working life of the precast concrete product.

Provisions valid in the place of use of the product shall be taken into account.

NOTE Recommendations for the design of some anchors can be found in CEN/TS 1992-4 (all parts); recommendations for the design of lifting and handling devices, can be found in CEN/TR 15728.

4.2 Production requirements

4.2.1 Concrete production

4.2.1.1 General

For concrete composition, type of cement, use of aggregates, additions and admixtures, and for resistance to alkali-silica reaction, chloride content, air content and concrete temperature, EN 206-1:2000, 5.2 and 5.3 shall apply.

For specification of concrete EN 206-1 shall apply.

NOTE When concrete is specified by the manufacturer, basic requirements (EN 206-1:2000, 6.2.2) are given in the design documentation and additional requirements (EN 206-1:2000, 6.2.3) are normally not relevant for precast concrete.

4.2.1.2 Placing and compaction of concrete

Concrete shall be placed and compacted so as to retain no appreciable amount of entrapped air other than entrained air (e.g. to achieve sufficient frost resistance) to avoid detrimental segregation and to ensure that the reinforcement shall be properly embedded.

4.2.1.3 Curing (protection against drying out)

The concrete shall be protected during curing so that loss in strength and cracking due to temperature and shrinkage and that, if relevant, detrimental effects on durability, are avoided.

All surfaces of newly cast concrete may be protected by one of the methods listed in Table 1 or by any other method applicable in the place of use, unless it is shown by tests and inspection on the finished product or on representative samples, that other means are relevant in the production environment.

Table 1 — Protection against drying out

Method	Typical means of protection
A - Without addition of water	— keeping the concrete in an environment with a relative humidity above 65 % for CEM I and CEM II/A, 75 % for all the other types of binders; — keeping the formwork in place; — covering the concrete surface with vapour-resistant sheets
B - Keep the concrete moist by addition of water	— maintaining wet coverings on the concrete surface; — keeping the concrete surface visibly wet by spraying with water
C – Use of curing compounds	Curing compounds used shall conform to provisions valid in the place of use

For methods A and B, the protection shall be maintained until the compressive strength of the sample at the end of curing ($f_{c,cure}$) is equal to or greater than the smallest value of the parameters D_d;f_{ck} and $f_{c,L}$ (cylinders or cubes). The parameters D_d et $f_{c,L}$ are defined in Table 2.

$$f_{c,cure} \geq \text{MIN}\ (D_d;f_{ck}\ ;\ f_{c,L}) \qquad (1)$$

NOTE f_{ck} is the characteristic compressive strength of the concrete at the age of 28 days targeted by the manufacturer.

The measure of the mean compressive strength $f_{c,cure}$ shall be done on concrete samples that are submitted to the same protection against drying out as the product.

For design working life of more than 50 years, or for specific local environmental conditions, other values may be given following the requirements valid in the place of use.

The degree of hardening in Table 2 may either be measured by testing a concrete sample or estimated by calculation using a hardening law based on initial type testing or the maturity concept.

The test result shall be 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.

Table 2 — Minimum strength of the concrete at the end of protection against drying out

Exposure conditions in the place of use (EN 206-1 exposure classes)	**Degree of hardening D_d** %	**Cylinder/cube $f_{c,L}$** MPa
X0, XC1	only requirements on $f_{c,L}$ apply.	12/15
XC2, XC3, XC4, XD1, XD2, XF1	35	12/15[a]
All other exposure conditions (wetting/drying cycles)	50	16/20[b]
a This value has to be substituted by $0,25.f_{ck}$ if $0,25.f_{ck} \geq 12$ MPa (cylinder); 15 MPa (cube).		
b This value has to be substituted by $0,35.f_{ck}$ if $0,35.f_{ck} \geq 16$ MPa (cylinder); 20 MPa (cube).		

Other means than those defined in Table 2 may be employed if the value of the water absorption of the concrete, measured according to the test procedure defined in Annex G, does not exceed 10 % (in relative proportion) of the value of water absorption of the concrete complying with the requirements in Table 1. The water absorption test is run on (30 ± 1) mm thick samples that include the surface exposed to the environment.

4.2.1.4 Accelerated hydration by heat treatment

Where heat treatment at atmospheric pressure is applied to concrete during production in order to accelerate its hardening, it shall be demonstrated by initial testing that the required strength is achieved for each concrete family concerned.

— Depending on material and climatic conditions, more restricting requirements may apply to the heat treatment of outdoor products in certain areas according to provisions valid in the place of use. The following conditions shall be fulfilled when the maximum mean temperature T_{mean} within the concrete exceeds 40 °C during the curing process unless previous positive experience has shown that special measures are not necessary to avoid micro cracking and/or durability defects: a preheating period shall be applied during which T_{mean} does not exceeds 40 °C;

— the temperature difference between adjacent parts of the product during the heating and the cooling phases shall be limited to 20 °C.

The duration and heating rate of the full heating and cooling period (if appropriate) shall be documented.

During the full heating and cooling period T_{mean} shall be limited to the values of Table 3. However higher temperatures may be accepted provided the durability of concrete under the specified environment is demonstrated by long term positive experience.

Table 3 — Conditions for accelerated hydration

Product environments	**Maximum mean concrete temperature T_{mean}[a]**
Predominantly dry or moderate humidity	— $T_{mean} \leq 85$ °C [b]
Wet and cyclic wet	— $T_{mean} \leq 65$ °C
a Individual values may be 5 °C higher.	
b When 70 °C < $T_{mean} \leq 85$ °C initial tests shall have demonstrated that the structural strength at 90 d corresponds with normal evolution of hardening with respect to the structural strength obtained at 28 days.	

For wet and cyclic wet environments, in case of no long term positive experience, the suitability of the higher temperature treatment shall be demonstrated; the following limits may be a basis for this demonstration: for concrete: Na_2Oeq content $\leq$ 3,5 kg/m^3, for cement SO_3 content $\leq$ 3,5 % by mass.

The above limits for Na_2Oeq and SO_3 content may be changed in value, or limits on other constituents may be put, according to the results of scientific or technical experience.

4.2.2 Hardened concrete

4.2.2.1 Strength classes

For compressive strength classes of concrete EN 206-1:2000, 4.3.1 applies.

For design purposes, the properties of strength classes for normal and heavy weight concrete up to C90/105 are given in Table 3.1 of EN 1992-1-1:2004 and for lightweight concrete up to LC 80/88 in Table 11.3.1 of EN 1992-1-1:2004.

The manufacturer may select intermediate classes, in 1,0 MPa steps of the characteristic strengths. In this case, other concrete properties are obtained by linear interpolation.

For reinforced or prestressed precast concrete products, the minimum strength class of concrete shall be:

— C20/25 for reinforced precast concrete products;

— C30/37 for prestressed precast concrete products.

When lightweight concrete is used, the minimum strength class shall be LC 16/18 both for reinforced and prestressed precast concrete products.

4.2.2.2 Compressive strength

4.2.2.2.1 General

The compressive strength to verify the strength class of concrete is defined by the potential strength; the manufacturer may use direct structural strength or indirect structural strength to confirm it.

4.2.2.2.2 Potential strength

The potential strength shall be tested at 28 days.

Tests of potential strength may be performed before 28 days in order to evaluate the progression of potential strength or to estimate at early age the potential strength at 28 days by an appropriate hardening law. When relevant, tests may be performed at an age greater than 28 days.

For determination of potential strength EN 206-1:2000, 5.5.1.1 and 5.5.1.2 shall apply. Additional requirements are given in 5.1.1.

4.2.2.2.3 Direct structural strength

Compressive direct structural strength shall be determined from the finished product by drilling cores in accordance with EN 12504-1 or by cut prisms converted to cube or cylinder with the appropriate correction factor. Non-destructive tests on the finished product in accordance with EN 12504-2 may be used, but a correlation with tests as specified in 5.1.1 shall be established.

4.2.2.2.4 Indirect structural strength

For stabilised production processes where the composition of the concrete and curing methods are not changed, compressive indirect structural strength may be determined by test specimens, made from fresh concrete, cured and stored in factory conditions as close to the precast concrete product as possible, provided an initial test has determined the correlation with the direct structural strength.

Density may be used as a characteristic for the establishment of the correlation.

4.2.2.2.5 Conversion factor

The relation between the structural strength and the potential strength is established by dividing the structural strength by η = 0,85.

4.2.2.3 Tensile strength

If required, tensile strength should be determined according to EN 1992-1-1:2004, 3.1.2 in one of the following ways:

— by test (e.g. according to EN 12390-6);

— from the compressive strength at the same age;

— from the splitting tensile strength at the same age.

4.2.2.4 Shrinkage

For lightweight concrete, the drying shrinkage shall be declared by the manufacturer, according to EN 1992-1-1:2004, 11.3.3.

4.2.2.5 Dry density

If required, dry density shall be determined in accordance with EN 206-1:2000, 5.5.2.

4.2.2.6 Water absorption

If required for durability reasons or by provisions applicable in the place of use of the concrete product, water absorption shall be determined following Annex G.

4.2.3 Structural reinforcement

4.2.3.1 Processing of reinforcing steel

Reinforcing steel for structural purposes that is straightened, bent or welded in the factory shall remain in conformity with 4.1.3 after this treatment.

Welded connection of reinforcing bars may only be used when the weldability of the steel is fully documented.

Indications on welding process may be found in EN 1992-1-1:2004, 3.2.5.

4.2.3.2 Tensioning and prestressing

4.2.3.2.1 Initial tensioning stresses

The maximum prestressing force applied to a unit immediately after release of tendons shall satisfy the following conditions:

— absence of uncontrolled longitudinal cracking, spalling or bursting of the concrete;

— the stress in the concrete does not lead to excessive creep or deformation of the product.

When conformity of the product with the relevant requirements of the product standard is demonstrated by initial type testing and factory production control and the tightened tolerances of 4.2.3.2.2 are met, the maximum value of tensioning stress $\sigma_{O\max}$ can be taken as:

$$\sigma_{O\max} = \min (0{,}85 f_{\mathrm{pk}} \text{ or } 0{,}95 f_{\mathrm{p0{,}1k}}) \text{ class 1} \quad (2)$$

If the conditions mentioned in the previous paragraph are not met, EN 1992-1-1:2004, 5.10.2.1, shall apply:

$$\sigma_{O\max} = \min (0{,}80 f_{\mathrm{pk}} \text{ or } 0{,}90 f_{\mathrm{p0{,}1k}}) \text{ class 2} \quad (3)$$

4.2.3.2.2 Accuracy of tensioning

If class 1 according to 4.2.3.2.1 is applied, tightened tolerances on the prestressing force shall be applied with an accuracy of at least:

— single tendon/force: ± 5 %.

If class 2 according to 4.2.3.2.1 is applied, normal tolerances on the prestressing force shall be applied with an accuracy at least:

— single tendon/force: ± 10 %;

— total force: ± 7 %.

4.2.3.2.3 Minimum concrete strength at transfer

At transfer of the prestressing force, the concrete shall have a minimum strength $f_{cm,p}$ of 1,5 times the maximum compressive stress in the concrete and not less than 20 MPa (cylinder strength).

The requirements according to EN 1992-1-1:2004, 5.10.2.2 (5) shall be considered.

In any case the strength shall be adequate for the anchorage of the strands.

4.2.3.2.4 Slippage of tendons

Slippage, which is the shortening of the tendon at each end of the element after transfer of the prestress force, shall be limited to the following values:

— for individual tendons (strands or wires): 1,3 ΔL_0;

— for the mean value of all tendons on one end of an element: ΔL_0.

For strands the average value of three circumferentially positioned wires shall be taken into account.

The value of ΔL_0, in millimetres, shall be calculated from:

$$\Delta L_0 = 0{,}4\, l_{\mathrm{pt2}} \frac{\sigma_{\mathrm{pmo}}}{E_{\mathrm{p}}} \quad (4)$$

where

l_{pt2} is the upper bound value of transmission length = 1,2 l_{pt}, in mm according to EN 1992-1-1:2004, 8.10.2.2;

σ_{pmo} is the initial stress in the prestressing steel immediately after release, in MPa;

E_p is the modulus of elasticity of the prestressing steel, in MPa.

In general, slippage of tendons is measured except for one piece moulded products (see Table D.3). On sawn products, visual inspection alone may indicate no slippage and no further measurement is required.

4.3 Finished product requirements

4.3.1 Geometrical properties

4.3.1.1 Production tolerances

Recommendations for maximum deviations of cross-sectional dimensions [width (Δb) and height (Δh)], and for maximum deviation of concrete cover (Δc_{dev}) to bars, wires and strands are given in Table 4:

Table 4 — Deviations

Target dimension mm	**Cross-section Δb, Δh[a]** mm	**Concrete cover [a b] Δc_{dev}** mm
$L \leq 150$	+ 10/– 5	± 5
$L = 400$	+15/– 10	+ 15/– 10
$L \geq 2\,500$	± 30	+25/– 10

[a] Linear interpolation for intermediate values.

[b] According to EN 1992-1-1:2004, 4.4.1.1:

$c_{nom} = c_{min} + \Delta c_{dev}$ (use the numerical value for $-\Delta c_{dev}$). Δc_{dev} is a Nationally Determined Parameter; hence other values may be valid in the place of use. A manufacturer may achieve and declare smaller values for Δc_{dev} than given in the National Annex by taking the appropriate measures.

The structural design of the works shall take into account the tolerances on the supports as specified in the structural design for the works.

EN 1992-1-1:2004, 10.9.5.2 may be used as guidance to determine the assumed ineffective distances from the edge of the support and from the end of the precast concrete product. A combination of global tolerances may not be used to determine tolerances at the support, as in most cases they have to be stricter than tolerances achieved by such combinations.

For slabs and beams, the average deviation of concrete cover may be determined as the mean deviation of the individual bars, wires or strands in a beam cross-section or over a maximum width of 1 m in a slab. No individual bar, wire or strand shall have a negative deviation numerically larger than the recommended negative deviation.

NOTE Guidance on concrete cover can be found in Annex A.

Production tolerances of geometrical properties may be determined by measurements according to J.1 to J.3 of Annex J.

a) Recommendations for maximum deviations on length:

$$\Delta l = \pm (10 + \frac{L}{1000}) \leq \pm 40 \text{ mm} \quad (5)$$

where

L is the nominal length in millimetres.

b) Recommendations for maximum deviations on holes, openings, steel plates, inserts, etc:

1) Size of hole or opening ± 10 mm.

2) Location of holes, openings, steel plates, inserts, etc. ± 25 mm.

4.3.1.2 Minimum dimensions and detailing

The geometrical characteristics of precast concrete products shall comply with the required minimum dimensions and detailing.

The values of the minimum dimensions and detailing are based on the nominal dimensions and may be taken from the relevant Clauses 7, 8, 9 and 10 of EN 1992-1-1:2004.

4.3.2 Surface characteristics

For the specification of the surface characteristics of a finished product, reference should be made to J.4, where also recommended values are given.

Other maximum deviations may be specified.

For identification of concrete finishes, CEN/TR 15739 may be used.

4.3.3 Mechanical resistance

4.3.3.1 General

The compressive strength class of the concrete shall be declared unless both of the following conditions are fulfilled:

— mechanical resistance of the product is verified and declared on the basis of initial type testing and regular tests for this property during factory production control on the finished product;

— compressive strength class is not a relevant parameter to demonstrate durability of the finished product (see 4.3.7.1 and 4.3.7.5).

All relevant structural properties of the product shall be considered in both ultimate and serviceability limit states.

For prestressing losses, reference may be made to Annex K, in cases specified in that annex.

Mechanical resistance shall be verified by one of the following means:

— calculation (see 4.3.3.2);

— calculation aided by testing (see 4.3.3.3);

— testing (see 4.3.3.4).

The use of these means is submitted to provisions in the place of use.

4.3.3.2 Verification by calculation

Design values of mechanical resistance obtained by calculation shall be verified according to the relevant clauses of EN 1992 1-1, or to the rules valid in the place of use. Pertinent complementary rules given in this and in product standards apply.

4.3.3.3 Verification by calculation aided by physical testing

Physical testing on finished products is required to aid calculation in the following cases:

— alternative design rules with respect to 4.3.3.2;

— structural arrangements with unusual design models not covered by 4.3.3.2.

In these cases physical testing on a small number of full scale specimens is needed before starting production in order to verify the reliability of the design model assumed for calculation. This shall be done with load-tests up to ultimate limit state (design conditions).

Physical testing is not required in case of reliable theoretical verification following the principles of EN 1992-1-1. Relevant information is also found in EN 1990:2002, Annex D.

4.3.3.4 Verification by testing

In case of verification by testing, declared values shall be verified by direct load testing made on samples taken following proper statistical criteria.

Relevant information is also found in EN 1990:2002, Annex D.

4.3.3.5 Safety factors

Recommended values for partial safety factors can be found in EN 1990 and EN 1992-1-1. These standards also permit lower values under certain conditions. Annex C provides such information.

4.3.3.6 Transient situations

The following transient situations shall be considered:

— demoulding;

— transport to the storage yards;

— storage (support and load conditions);

— transport to site;

— erection (lifting);

— construction (assembly).

When relevant for the type of element, for transient situations a nominal transverse horizontal force to cover out of plane effects due to dynamic actions or verticality deviations shall be considered. This may be taken as 1,5 % of the self-weight of the element.

4.3.4 Resistance and reaction to fire

4.3.4.1 General

Resistance and reaction to fire shall be declared when relevant to the intended use of the product.

Resistance to fire is normally declared as standard fire resistance by means of classes. Alternatively, it may be declared as resistance to parametric fire.

Recommendations related to the use of EN 1992-1-2 are given in Annex O.

NOTE The required class for standard fire resistance, or alternatively resistance to parametric fire, depends on the national fire regulations.

4.3.4.2 Classification for standard fire resistance

For the verification of standard fire resistance one of the following methods can be chosen.

a) Classification by testing

Tests previously performed in accordance with the requirements of EN 13501-2 (i.e. same product, same or more demanding test method) may be taken into account.

The validity of test results can be extended to other spans, cross-sections and loads by appropriate calculation methods (see e.g. c) below).

b) Classification by tabulated data

Tabulated data can be found in EN 1992-1-2. When applicable complementary rules may be given in product standards.

c) Classification by calculation

For classification based on calculation methods, the relevant clauses of EN 1992-1-2 or the rules valid in the place of use apply. When applicable, complementary rules may be given in product standards

4.3.4.3 Verification of resistance to parametric fire

Actions due to parametric fire shall be as given in EN 1991-1-2. Resistance to parametric fire may be verified either by calculation methods in accordance to EN 1992-1-2, or by testing.

4.3.4.4 Reaction to fire

Concrete products made with maximum 1 % organic materials in the concrete composition (by mass or volume whichever is the more onerous) may be declared as reaction to fire class A1 without the need for testing.

Concrete products which include organic materials in the concrete composition greater than 1 % by mass or volume shall be tested and classified according to EN 13501-1.

NOTE See Commission Decision 96/603/EEC, Materials to be considered as reaction to fire Class A without the need for testing as amended by Commission Decision 2000/605/EC.

4.3.5 Acoustic properties

The acoustic properties are airborne sound insulation and impact sound insulation. These characteristics shall be declared when relevant for the intended use of the product.

The airborne sound insulation of a concrete product may be estimated by calculation following Annex B of EN 12354-1:2000 or measured according to EN ISO 140-3. In this case, it shall be expressed in the third octave bands 100 Hz to 3 150 Hz and as a single number quantity with spectrum adaptation terms according to EN ISO 717-1.

The impact sound insulation of a concrete product may be estimated by calculation following Annex B of EN 12354-2:2000 or measured according to EN ISO 140-6. In this case, it shall be expressed in the third octave bands 100 Hz to 3 150 Hz and as a single number quantity with spectrum adaptation terms according to EN ISO 717-2.

Complementary information may be found in the relevant product standards.

4.3.6 Thermal properties

Thermal properties shall be declared when relevant for the intended use of the product. The thermal properties of a concrete product shall be expressed in terms of one of the following sets of quantities:

a) the thermal conductivity of the material, together with the geometry of the product;

b) the thermal resistance of the product.

When relevant, the specific heat capacity of the material or the heat capacity of the finished product may be given.

The thermal conductivity of the material may be determined by testing in accordance with EN 12664. Determination of declared thermal values for dry state shall be according to EN ISO 10456, which also gives procedures to convert the declared thermal values into design thermal values.

The design thermal conductivity and the specific heat capacity of the materials may also be obtained from tabulated values in EN ISO 10456 and EN 1745.

The thermal resistance and thermal transmittance of concrete products may be calculated in accordance with EN ISO 6946 or measured in a hot box in accordance with EN ISO 8990 or EN 1934.

NOTE Tables with relevant data from EN ISO 10456 and EN 1745 are given in Annex L.

4.3.7 Durability

4.3.7.1 Durability requirements

The following specifications refer to concrete structural products with a design working life consistent with EN 1992-1-1.

The durability of precast concrete products is ensured by the following requirements as relevant:

— adequate content of cement and additions (see 4.2.1.1);

— maximum water/binder ratio (see 4.2.1.1);

— maximum chloride content (see 4.2.1.1);

— maximum alkali content (see 4.2.1.1);

— protection of newly cast concrete against drying out (see 4.2.1.3);

— minimum concrete strength (see 4.2.2.1);

— minimum concrete cover and concrete quality of cover (see 4.3.7.4);

and, where applicable:

— air content (see 4.2.1.1);

— adequate hydration by heat treatment (see 4.2.1.4);

— specific requirements to ensure internal integrity (see 4.3.7.2);

— specific requirements to ensure surface integrity (see 4.3.7.3);

— water absorption (see 4.3.7.5);

— use of performance design methods (e.g. EN 206-1).

Durability requirements may be found in EN 1992-1-1:2004, 4.2.

In case of non-structural concrete products or when the design working life of the concrete product is shorter or longer than the corresponding value in EN 1992-1-1 (50 years), the durability specifications may be adapted to the specific field of application of the product.

4.3.7.2 Internal integrity

The potential properties concerning resistance and durability of the concrete mix shall be safeguarded during production by adequate hydration, possibly by heat treatment (where applicable) and limitation of early cracking of concrete; see 4.2.1.3 and 4.2.1.4.

4.3.7.3 Surface integrity

When relevant, the surface resistance of concrete against deterioration processes such as chemical reactions, freeze-thaw effects, mechanical abrasion, etc. shall be ensured by proper provisions.

The technical requirements for surface integrity may follow EN 206-1:2000, 5.3 and, as far as possible, the performance related design method (EN 206-1:2000, 5.3.3 and Annex J) should be used to facilitate performance checking.

Depending on the provisions valid in the place of use of the product, one of these methods may be the combination of limiting values for each exposure class related to maximum water/binder ratio, minimum strength class and maximum water absorption of the concrete from the finished product.

EXAMPLE For class XC3 (moderate humidity, concrete inside buildings with moderate or high air humidity, external concrete sheltered from rain) the combination could be: maximum water/binder ratio 0,50, minimum strength class 35/45, maximum water absorption 6 %.

4.3.7.4 Steel corrosion resistance

Resistance against steel corrosion shall be obtained by following the principles of 4.1 of EN 1992-1-1:2004. To fulfil these principles, Annex A of this standard gives a scale of ambient conditions related to the concrete covers adopted in the design of the precast concrete product.

Corrosion resistance may also be obtained by protection of reinforcement or by using stainless steel.

4.3.7.5 Water absorption

When water absorption is specified it shall be measured according to 5.1.2.

4.3.7.6 Equivalent durability procedure

Performances of a precast concrete product may be determined by equivalent durability procedures.

4.3.8 Other requirements

4.3.8.1 Safety in handling

The concrete product shall be designed and manufactured so that it can be handled safely, with no detrimental effect on the product itself. Provisions for handling and storage during transport and on site shall be given and documented by the manufacturer. Additional information can be found in EN 13670:2009, 9.4.

NOTE General guidance is given in CEN/TR 15728. For specific applications, further guidance might be given in the insert suppliers' technical documentation.

4.3.8.2 Safety in use

The properties of a concrete product, regulatory related to safety in its intended final use, should be considered if required (e.g. surface regularity, slip resistance, sharp edges, etc.).

4.3.8.3 Self-weight

If required, the self-weight of the finished product shall be declared.

If C.5 is applied, the manufacturer shall control the self-weight.

5 Test methods

5.1 Tests on concrete

5.1.1 Compressive strength

The concrete strength shall be tested according to EN 12390-3:

— on representative moulded specimens according to EN 12390-1 and EN 12390-2;

— or on representative cores according to EN 12504-1.

For the determination of structural strength, the curing conditions of EN 12390-2 do not apply.

NOTE 1 The different shapes and dimensions of test specimens give different values for the concrete strength.

Proper shape factors shall be applied to give the standard cylinder or cube strength.

Cubes with a nominal size of at least 100 mm and not more than 150 mm and cylinders or cores with equal nominal length and diameter from 100 mm up to 150 mm can be assumed to give a strength value equivalent to the standard cube strength value obtained under the same ambient conditions.

Cylinders and cores with a nominal diameter of at least 100 mm and not larger than 150 mm and with a nominal length to diameter ratio equal to 2 can be assumed to give a strength value equivalent to the standard cylinder strength value obtained under the same ambient conditions.

For other shapes and sizes of specimens, conversion factors shall be established by initial testing according to EN 206-1:2000, 5.5.1.1.

Cores with a nominal diameter less than 50 mm and/or a nominal length less than 0,7 times the diameter shall not be used. Cubes with a nominal size less than 50 mm shall not be used.

NOTE 2 Annex H provides information on shape correlation factors.

Conversion factors for the relationship between indirect structural strength and direct structural strength shall be established by initial testing. Depending on the shape and/or size of the specimens to be considered this conversion factor may or may not include a shape and/or size conversion factor.

5.1.2 Water absorption

When the water absorption of concrete is measured, the test method given in normative Annex G shall apply.

5.1.3 Dry density of concrete

When the dry density of concrete is required, the test shall be carried out on representative specimens in accordance with EN 12390-7.

5.2 Measuring of dimensions and surface characteristics

When not defined in the specific product standard, information on measuring of dimensions are given in Annex J.

Dimensions are assumed at reference temperatures between 10 °C and 30 °C, and at the reference age of 28 days. If necessary, theoretical corrections shall be made for inherent deviations of the dimensions when measuring at other temperatures or ages.

The equipment used to check deviations shall be read with an accuracy of at least 1/5 of the deviation to be checked.

Angular deviation of a plane surface shall be measured in two perpendicular directions.

For wide elements, such as ribbed elements and special roof elements, the length should be measured at three locations, for example at 100 mm from both edges and in the centre.

If considered necessary, the width and height shall also be measured at least at three locations along the length of the element. For dimensions that may be difficult to measure directly on the element, leveling rods or leveling instruments may be used to aid in the measuring.

Lateral bow and camber shall be measured at midspan.

5.3 Weight of the products

When the reduction of γ_G according to C.5 is applied, the self-weight of the precast concrete product shall be determined by weighing with an accuracy of ± 3 % or estimated by calculation.

Estimated weight shall be calculated from:

— the nominal dimensions of the finished product;

— the mean value of concrete density representative for the finished product considered, and measured from the test specimen used for potential strength according to EN 12390-3;

— the amount of reinforcement of the finished product.

6 Evaluation of conformity

6.1 General

6.1.1 General

The assignment of tasks for the manufacturer and for the notified body in consideration of CE marking is defined in the relevant Annex ZA of the product standard. Care should be taken in respect of the fact that some tasks described in this clause are not relevant for CE marking.

6.1.2 Demonstration of conformity

Conformity of the concrete product with the relevant requirements of this standard and with the specified or declared values (levels or classes) for the product properties shall be demonstrated by carrying out both of the following tasks:

a) type testing including calculation when relevant (see 6.2);

b) factory production control (see 6.3), including product inspection.

6.1.3 Assessment of conformity

6.1.3.1 General

In addition to the requirements of 6.1.2, conformity may be assessed by a first, second or third party (see Annex E) whose tasks will depend on the product family.

6.1.3.2 Assessment of factory production control

If carried out, the third party assessment should be based on both the following tasks:

a) initial inspection of the factory and of factory production control;

b) continuing surveillance, assessment and approval of factory production control (including supervision of measurements and tests on materials, processes and finished products).

6.1.3.3 Assessment of the product

If carried out, the third party assessment should be based on one or both of the following tasks, which are additional to tasks a) and b) of 6.1.3.2:

a) supervision, assessment and approval of type testing of the product (see 6.2);

b) audit testing on samples taken at the factory or possibly from the construction site.

6.1.4 Product families

Types of concrete products may be grouped into families for the purpose of demonstrating conformity with relevant requirements. Grouping may take place if the family is identified in the product standard or if:

— the property of a single type can be demonstrated by the manufacturer to represent reliably the property of other types in the family and;

— it is demonstrated by the manufacturer that the property is controlled by the same procedures of the factory production control.

6.2 Type testing

6.2.1 General

The purpose of type testing is to demonstrate that the product meets the requirements.

A special feature of precast concrete products is the possibility that full scale testing of the products may be carried out prior to delivery. However it is not the intent that full scale testing shall be carried out on a regular basis.

Type testing can be:

— physical type testing – Physical type testing consists in submitting a representative sample of the product and/or of specimens to the relevant tests for the properties to be proved;

— type calculation – Type calculation is the justification of the relevant properties of the product by calculation;

— a combination of both physical type testing and type calculation.

When the design of a product has been supplied by the purchaser, the determination of the product type is not required.

For properties of the product evaluated on the basis of generally accepted design methods (e.g. design rules of EN 1992-1-1 or product standards), with common arrangements and usual design models or based on documented long-term experience, physical type testing of the product is not required. In other cases, physical type tests shall be carried out to verify the reliability of the design method.

It shall not be necessary to type test both the product and the concrete.

If the manufacturer has access to appropriate and calibrated test equipment, physical type testing may be carried out with this equipment.

Results of type testing shall be recorded. Annex P gives a survey of type testing and/or calculations which shall be performed or may be required according to this standard.

Reference to type testing performed on another production line or in another factory (shared type testing) may be admitted provided that it is demonstrated to be representative and it is documented. Shared type testing is not accepted for concrete properties.

6.2.2 Initial type testing

Initial type testing shall be carried out to demonstrate the conformity to the requirement before a new type of product is put on the market. It shall also be carried out for products under production at the date of availability of the pertinent product standard. Previous type tests performed before this date on the same product may be considered if they comply with the requirements of the pertinent product standard.

For initial type testing of concrete, the relevant requirements of Annex A of EN 206-1:2000 shall apply.

Products shall not be delivered until the results of initial type testing show that they comply with the requirements.

Initial type testing of the product shall also be carried out whenever there is a change in design, concrete composition, type of steel, method of manufacture or other modifications which could significantly change some of the properties of the product.

6.2.3 Further testing of samples taken at the factory

Appropriate further testing of samples taken at the factory shall be carried out when it is necessary for the demonstration of the conformity.

6.3 Factory production control

6.3.1 General

The manufacturer shall establish, document, maintain and implement a factory production control (FPC) system to ensure that the product put on the market meets the requirements of this standard and complies with the specified or declared values and with the requirements on technical documentation.

NOTE A manufacturer that operates a quality system in accordance with EN ISO 9001:2008 and takes into account the requirements of this standard is deemed to satisfy the factory production control requirements as described hereafter.

6.3.2 Organisation

The tasks, competences, responsibilities and authority of the personnel involved in factory production control shall be defined, documented, maintained and implemented, including procedures for the following activities:

a) demonstration of conformity of the product at appropriate stages;

b) identification recording and dealing with any instance of non-conformity;

c) establishment of causes of non-conformity and possible corrective action (design, materials or production procedures).

An organisational scheme shall clarify the activities given in a) to c) of the personnel involved.

Special requirements regarding the competence level of various functions may be applicable.

6.3.3 Control system

The factory production control system shall consist of procedures, instructions, regular inspections, tests and the utilisation of the results to control equipment, raw materials, other incoming materials, production process and finished products.

6.3.4 Document control

Documents shall be controlled in such a way that only valid copies are available in the workplace. These documents are the procedures, instructions, standards, construction reports, drawings and the factory production control procedures.

The production drawings and documents shall provide the specifications and all data necessary for the manufacture (see 6.3.5) of the product. They shall be dated and approved for production by a person designated by the manufacturer.

6.3.5 Process control

The manufacturer shall identify the relevant features of the plant and/or the production process which affect the conformity of the product with the technical specification. He shall plan and perform the production process in such a manner that conformity of the product with the requirements of the product standard is ensured.

6.3.6 Inspection and testing

6.3.6.1 General

Inspection and testing shall be performed on equipment, raw materials, other incoming materials, production process and finished products. The subjects, criteria, methods and frequencies related to inspection and testing shall be laid down in inspection schemes. The frequency of checks and inspections and the methods which are not specified in this standard shall be defined in such a way as to achieve permanent conformity of the product.

The inspection schemes given in Tables D.1 to D.4 are reference schemes.

The manufacturer shall apply the relevant parts of these schemes unless he can demonstrate that any changes which he makes to them achieve equal confidence in the conformity of the product. For the conformity of the production of concrete, the relevant part of the production control procedures of EN 206-1 can be considered to achieve an equal confidence level.

Switching rules for the rate of inspection subjects indicated in the inspection schemes, are given in Table D.5.

If relevant, additional inspections may be carried out.

The results of inspection which are expressed in numerical terms, all inspection results requiring corrective action and test results, shall be recorded and be available.

The tests shall be carried out in accordance with the methods mentioned in the relevant standard or by applying alternative test methods with a proven correlation or a safe relationship to the standard methods.

The results of testing shall meet the specified conformity criteria and be available.

6.3.6.2 Equipment

The weighing, measuring and testing equipment used in the factory shall be calibrated and inspected following the reference schemes given in Table D.1.

6.3.6.3 Materials

Raw materials and other incoming materials shall be inspected for conformity with the technical documentation according to 6.3.4.

The reference schemes for inspections, measurements and tests are given in Table D.2.

6.3.6.4 Production process

The schemes for inspections, measurements and tests are given in Table D.3.

6.3.6.5 Finished products

A sampling and testing plan for the finished products shall be prepared and implemented for all properties (including marking) to be checked.

The reference inspection scheme for the finished product is given in Table D.4.

6.3.7 Non-conforming products

If the results of factory production control or complaints after delivery reveal non-conformity of one or more properties of the product with this standard or with the manufacturer’s technical specifications, the manufacturer shall take the necessary steps in order to rectify the shortcoming. If non-conformity occurs, the

possible relevant effects on resistance, serviceability, appearance durability and on installation and assembly compatibility shall be documented. The documentation shall evaluate the possibility of acceptance with or without remedial measures or after downgrading the product for suitable uses within the scope of the relevant product standard. If the faulty product is not acceptable and no satisfactory remedial measure or downgrading is found, the faulty product shall be rejected.

If non-conformity is identified after delivery, the manufacturer shall have the necessary registrations and procedures that allow him to trace the non-conformity and to assess it.

Products which do not comply with the requirements shall be set aside and marked accordingly.

Procedures dealing with non-conformity of the product, with complaints concerning the properties stated in the standard or in the specification and with corrective actions shall be documented.

6.3.8 Conformity criteria

6.3.8.1 Concrete strength

Conformity criteria for standard compressive strength at 28 days shall be taken from 8.2.1.1 and 8.2.1.3 of EN 206-1:2000. However:

— the period of continuous production to estimate the current statistical parameters (mean, standard deviation...) of a concrete type or the reference concrete type of a concrete family may be reduced to three calendar weeks of factory production control provided that a minimum of 15 consecutive inspection results is obtained spread over at least five production days;

— the initial value of the statistical parameters estimated in the first period of production, reduced to three calendar weeks as specified above, may be updated through a continuous system for the next assessment period;

— for the initial phase, before reaching the minimum production period specified above, conformity assessment shall be based on the following criteria:

$$f_{cm} \geq f_{ck} + 4\text{MPa and} \quad (6)$$

$$f_{ci} \geq f_{ck} - 4\ \text{MPa} \quad (7)$$

where

f_{ci} is each test result;

f_{cm} is the mean compressive strength of concrete and;

f_{ck} is the characteristic value of the compressive strength of concrete;

The same criteria should be used for non-continuing occasional productions;

— the conformity assessment of concrete strength during the period of continuous production may be checked using a control chart complying with EN 206-1 requirements provided the probability of acceptance is equivalent.

Concrete strength may be tested at an earlier age using the same conformity assessment procedures and criteria. Further recommendations are given in Annex B.

6.3.8.2 Concrete properties other than strength

EN 206-1:2000, 8.2.3 shall apply.

6.3.9 Indirect or alternative test method

Any indirect or alternative test method may be used for specific properties, e.g. rebound hammer and sound velocity for testing concrete properties, provided a safe correlation is established and maintained with the direct method.

6.3.10 Initial inspection of factory and of FPC

Initial inspection of factory and of FPC shall be carried out when the production process has been finalised and in operation. The factory and FPC documentation shall be assessed to verify that the requirements of subclauses 6.3.1 to 6.3.9 are fulfilled.

During the inspection it shall be verified:

a) that all resources necessary for the achievement of the product characteristics included in this European Standard are in place and correctly implemented; and

b) that the FPC-procedures in accordance with the FPC documentation are followed in practice; and

c) when relevant, that the product complies with the initial type testing, for which compliance of the product performance to the declaration of conformity has been verified.

All locations where final assembly or at least final testing of the relevant product is performed, shall be assessed to verify that the above conditions a) to c) are in place and implemented. If the FPC system covers more than one product, production line or production process, and it is verified that the general requirements are fulfilled when assessing one product, production line or production process, then the assessment of the general requirements does not need to be repeated when assessing the FPC for another product, production line or production process.

All assessments and their results shall be documented in the initial inspection report.

6.3.11 Continuous surveillance of FPC

Surveillance of the FPC shall be undertaken once per year. The surveillance of the FPC shall include a review of the FPC test plan(s) and production processes(s) for each product to determine if any changes have been made since the last assessment or surveillance. The significance of any changes shall be assessed.

Checks shall be made to ensure that the test plans are still correctly implemented and that the production equipment is still correctly maintained and calibrated at appropriate time intervals.

The records of tests and measurement made during the production process and to finished products may be reviewed to ensure that the values obtained still correspond with those values for the samples submitted to the determination of the product type and that the correct actions have been taken for non-compliant devices.

6.3.12 Procedure for modifications

Where relevant, a re-assessment of the factory and of the FPC system shall be performed for those aspects, which may be affected by the modification.

All assessments and their results shall be documented in a report.

7 Marking

Each produced unit shall be marked or labelled to show:

— identification of the manufacturer;

— identification of the place of production;

— number of the product standard;

— identification code of the unit when necessary, (e.g. to trace declared unit properties and performances and other relevant product data in the technical documentation or to trace production process data);

— date of casting;

— self-weight of the unit when required;

— other information relevant for installation in the work (e.g. location and orientation) when required.

For identical or serial units of a concrete product, the above procedure may be simplified or replaced by overall marking or labelling of packaged units or lots of units.

In addition to the above data, the following accompanying information shall be provided on the marking or labelling or in the accompanying documents:

— product identity (description according to the standard and/or commercial name);

— technical documentation where applicable.

NOTE Where applicable, for CE marking refer to Annex ZA of relevant product standard.

8 Technical documentation

At the latest at the time of delivery, technical documents shall be available, which are appropriate for the chosen method of declaration, and which:

— ensure traceability of design assumptions, methods, results and detailing of the element including construction data such as the dimensions, the tolerances, the layout of the reinforcement, the concrete cover, etc;

— meet national provisions on design documents in the place of use;

— give guidance on safe transportation, handling and storing;

— give specifications for the erection of the elements; and

— give supplementary information referred to in the marking labelled to the elements.

Different technical documents for structural concrete products meeting the requirements above are exemplified in the informative Annex M.

Annex A
(informative)

Concrete cover as regard to corrosion

A.1 Minimum concrete cover for base conditions

With reference to the durability of precast concrete products in terms of steel protection against corrosion, Table A.1 gives the scale of environmental conditions and corresponding exposure classes.

Table A.1 — Nominal scale of environmental conditions

Environmental conditions	Aggressivity	Exposure classes of EN 206-1:2000
A	Null	X0
B	Low	XC1
C	Moderate	XC2-XC3
D	Normal	XC4
E	High	XD1-XS1
F	Very high	XD2-XS2
G	Extreme	XD3-XS3

For precast concrete products intended for normal design working life (50 years), the recommended values of minimum concrete cover as given in Table A.2 can be used, provided that special quality control of the factory production is ensured.

Table A.2 — Minimum concrete cover

Dimensions in millimetres

				Slab reinforcing bars		Other reinforcing bars		Slab pretensioned tendons		Other pretensioned tendons	
Environmental conditions	C_{min}	C_0	Ambient conditions	$\geq C_0$	$< C_0$	$\geq C_0$	$< C_0$	$\geq C_0$	$< C_0$	$\geq C_0$	$< C_0$
A	C20/25	C30/37	A	10	10	10	10	10		10	
B	C20/25	C30/37	B	10	10	10	10	15		15	
C	C25/30	C35/45	C	10	15	15	20	20	25	25	30
D	C30/37	C40/50	D	15	20	20	25	25	30	30	35
E	C30/37	C40/50	E	20	25	25	30	30	35	35	40
F	C30/37	C40/50	F	25	30	30	35	35	40	40	45
G	C35/45	C45/55	G	30	35	35	40	40	45	45	50

In Table A.2, C_{min} is the minimum concrete class required for the given exposure class, and C_0 is the concrete class being two strength classes higher than C_{min}. Where freeze/thaw or chemical attack on concrete (Classes XF and XA of EN 206-1:2000) is expected, special attention should be given to the concrete composition. Covers in accordance with Table A.2 will normally be sufficient for such situations.

A.2 Alternative conditions

In applying EN 1992-1-1:2004, 4.4.1.2, the following alternative conditions are recommended unless other rules are given in the National Annex.

— For products with intended design working life of 100 years in environmental conditions C to G, the values of Table A.2 should be increased with 10 mm.

— When steel with protection against corrosion by coating is used, the concrete cover as given in Table A.2 may be reduced by 5 mm; when stainless steel is used the concrete cover could be reduced to the value required for bond, fire resistance or specific aggressive environment.

— When the concrete class is ≥ C40/50 and its water absorption is less than 6,0 % (characteristic value) the concrete cover as given in Table A.2 may be reduced by 5 mm.

— For concrete classes higher than C50/60 and water absorption less than 5,0 % (characteristic value) the reduction may be taken to 10 mm.

— For uneven surfaces (e.g. exposed aggregate) the minimum concrete cover should be increased with the maximum depth of the unevenness. When a sufficient protection of concrete exposed surface is ensured, the exposure class may be decreased and the concrete cover accordingly.

— For products with a design working life shorter than 50 years and/or for non-structural products, the values in Table A.2 may be reduced. Unless rules valid in the place of use specify other values, a reduction of 5 mm is recommended,

— The minimum concrete cover should be 10 mm.

Annex B
(informative)

Concrete quality control

B.1 Statistical representative values

The test strength results should be subjected to statistical analysis applied to a moving group of samples to evaluate the current characteristic value with reference to the continuing production.

If needed, supplementary tests made before the target age of curing (28 days) can be carried out in the same way for early statistics. The test values should be previously subjected to a uniform correlation to a given age on the basis of a proved hardening law.

This procedure applies for potential strength or structural strength (direct or indirect).

B.2 Conformity criteria for potential strength

6.3.8.1. should be applied.

B.3 Direct structural strength

For concrete quality control, direct structural strength may be chosen by the manufacturer as an alternative to potential strength. Strength tests on drilled cores may be performed in order to verify the conformity of the direct structural strength. As a rule the sampling should follow the procedure below:

— with reference to every production day, two cores are taken from different positions in one product (e.g. one end upper position and one middle lower position), each core representing one sample;

— the core strength is measured (see 5.1.1), obtaining the two values $f_1^\circ \leq f_2^\circ$.

Conformity criteria are applied, as specified in B.2 for potential strength, with:

$$\alpha\ f_k^\circ < f_{ck} \qquad \text{(B.1)}$$

where

f_k° is the characteristic value of the standard period;

α is 1/0,85 is the safety conversion factor according to 4.2.2.2.5;

f_{ck} is the characteristic value of compressive strength of concrete.

B.4 Indirect structural strength

Indirect structural strength should be correlated to direct structural strength with an initial calibration testing. Tests on drilled cores as specified in B.3 should be performed, for a minimum period of five production days,

in parallel to the corresponding tests performed on the moulded samples cured in the same conditions of the elements.

For the calibration of indirect to direct structural strength, comparison is made with reference to the test data of the same day of production and to the whole group of the last five test data.

The ratio between indirect and direct structural strength is assumed to be 1,0 if:

$$f_{\mathrm{m}}^{\circ} \geq 0{,}95\ f \tag{B.2}$$

$$f_{1}^{\circ} \geq f - 3{,}0\ \mathrm{MPa} \tag{B.3}$$

$$f_{m}^{\circ} = \left(f_{1}^{\circ} + f_{2}^{\circ}\right)/2 \tag{B.4}$$

where

f_{1}° and f_{2}° are direct structural strength measured on cored specimens;

f is the indirect structural strength of the moulded sample;

and if

$$f_{\mathrm{k}}^{\circ} \geq f_{\mathrm{k}} \tag{B.5}$$

where

f_{k} is the characteristic indirect structural strength of the moulded samples for the last five production days.

After this calibration the same conformity criteria of B.2 can be applied to indirect structural strength with:

$$\alpha f_{\mathrm{k}} \geq f_{\mathrm{ck}} \tag{B.6}$$

where

α is 1/0,85 is the safety conversion factor according to 4.2.2.2.5.

B.5 Direct assessment of possibly non-conforming units

When from testing it results that conformity verification of B.2, B.3 or B.4 is not satisfied, the units produced in the corresponding day can be submitted to a direct assessment.

This assessment should be made by means of testing of direct structural strength on cores drilled from the products themselves, with the following procedure:

— a representative unit is selected from the stock of products manufactured with the non-conforming concrete type;

— three cores are taken from different positions in the unit (i.e. one upper end position, one lower end position, one middle position);

— the standard direct structural strength is measured (see 5.1.1) obtaining the three values $f_{1}^{\circ} \leq f_{2}^{\circ} \leq f_{3}$;

— an equivalent design value $f_d = (f_m - \Delta f)/\gamma$
is computed from the mean $f_m = \left(f_1^\circ + f_2^\circ + f_3^\circ\right)/3$
and from the total deviation $\Delta f = f_3 - f_1$ (≥ 3,5 MPa);

— the product is accepted if

$$\alpha f_1^\circ > f_{ck} - 4\text{MPa} \quad \text{(B.7)}$$

and

$$\alpha f_d \geq f_{cd}/\alpha_{cc} \quad \text{(B.8)}$$

where

f_{cd} is the intended potential design cylinder strength assumed in resistance calculations (ultimate limit state);

α_{cc} is the related long term effect coefficient (see EN 1992-1-1:2004, 3.1.6(1));

γ is the additional confidence factor necessary to extend the result of the assessment from the selected unit to all the non-conforming stock of units (the value 1,2 is recommended);

otherwise the product is rejected, unless it can be appropriately strengthened, or downgraded for other suitable uses.

Rules valid in the place of use may define the deviation Δf differently and in that case the rule valid in the place of use should be used.

NOTE In accordance with EN 1992-1-1, α_{cc} is a Nationally Determined Parameter (NDP).

If the questionable stock is large or contains products manufactured with the same concrete type but with different production processes leading to different structural strengths, a single unit submitted to the procedure as described may not be representative for the whole stock. In that case the stock should be subdivided in appropriate batches and the procedure should be applied for a representative unit of each batch.

Annex C
(informative)

Reliability considerations

C.1 General

Following EN 1992-1-1:2004, A.3, the values of partial safety factors for materials may be assumed as given in C.2 to C.4.

If the recommended values in EN 1992-1-1:2004, Clause 2 are changed in the National Annex, the reduced safety factors given in C.2 and C.3 should be modified proportionally.

These values should be used only when factory production control is under third party assessment.

C.2 Reduction based on quality control and reduced tolerances

If factory production control (see 6.3 and Annex D) ensures that unfavourable deviations of cross sectional dimensions are within the tightened tolerances given in Table C.1, the partial safety factor for reinforcement may be reduced to:

$\gamma_s = 1{,}10$

Under the condition given above, *and* if the coefficient of variation of the concrete strength is shown not to exceed 10 %, the partial safety factor for concrete may be reduced to:

$\gamma_c = 1{,}4$

Table C.1 — Tightened tolerances

h or *b* (mm)	**Tightened tolerances** mm	
	Cross section dimension Δh, Δb mm	**Position of reinforcement** Δc mm
≤ 150	± 5	± 5
400	± 10	± 10
≥ 2 500	+ 25	+ 20/– 10
With linear interpolation for intermediate values. $+\Delta c$ refers to the mean value of reinforcing bars or prestressing tendons in the cross section or over a width of one meter (e.g. slabs and walls).		

C.3 Reduction based on using reduced or measured geometrical parameters in design

If the calculation of design resistance is based on critical dimensions, including effective depth (see Figure C.1), which are either:

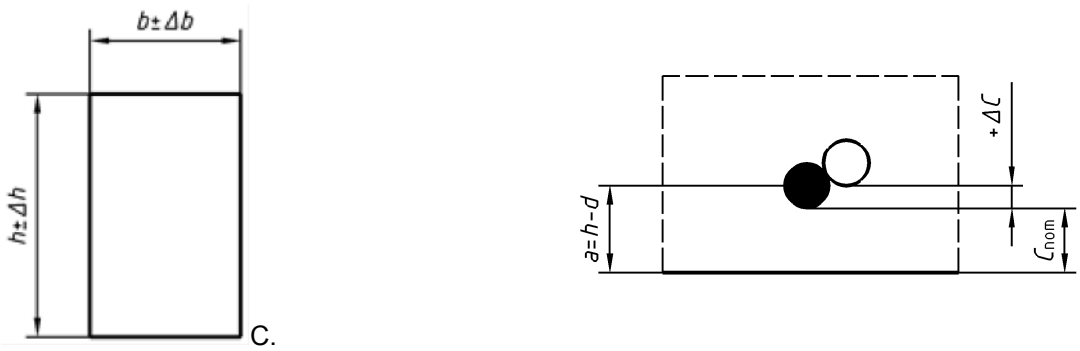
— reduced by tolerances, or

— measured in the finished structure,

the following values may be used:

γ_S = 1,05, γ_C = 1,45

Under the condition given above and provided that the coefficient of variation of the concrete strength is shown not to exceed 10 %, the partial factor for concrete may be reduced to γ_C = 1,35.



C.

a) Cross section

b) Position of reinforcement
(unfavourable direction for effective depth)

Figure C.1 — Cross-section tolerances

C.4 Reduction based on assessment of concrete strength in finished structure

For concrete strength values based on testing of direct structural strength as defined in 4.2.2, γ_C may be reduced with the conversion factor η; normally η = 0,85 may be assumed.

The value of γ_C to which this reduction is applied may already be reduced according to C.2 or C.3. However, the resulting value of γ_C should not be less than 1,30.

C.5 Reduction of γ_G based on control of self-weight

Partial safety factor for self-weight of precast concrete product γ_G may be reduced by factor 0,95 when the measured weight or the estimated weight of the product does not exceed that used in design calculations. The weight is determined according to 5.3.

Partial safety factor for self-weight of precast concrete product γ_G may be reduced by factor 0,90 when statistical 95 % fractile of weighted or evaluated weight does not exceed that used in design calculations.

If the reduction of γ_G is applied, tightened tolerances shall be used and controlled systematically, see Table C.1.

Annex D
(normative)

Inspection schemes

D.1 General

Inspection subjects do not apply if they are not relevant for the specific product or if their purpose is fulfilled by other appropriate inspection.

D.2 Equipment inspection

Table D.1 — Equipment inspection

	SUBJECT	METHOD	PURPOSE	FREQUENCY[a]
D.1.1 - Testing and measuring equipment				
1	Strength testing equipment	Except as indicated in the test method, calibrating against equipment which has been calibrated to National Specifications and is used exclusively for this purpose	Correct functioning and accuracy	— On (re) installation or after major repair — Once per year
2	Weighing equipment			
3	Dimension measuring equipment			
4	Temperature and humidity measuring equipment			
D.1.2 - Storage and production equipment				
1	Storage of materials	Visual inspection or other appropriate method	Absence of contamination	— On installation — Weekly
2	Weighing or volumetric batching equipment	Visual inspection	Correct functioning and cleanliness	Daily
3		Calibrating against equipment which has been calibrated to National Standards and is used exclusively for this purpose	Manufacturer declared accuracy	— On (re)installation or after major repair — Weighing: once a year — Volumetric: twice a year — In case of doubt

To be continued

Table D.1 (*concluded*)

	SUBJECT	METHOD	PURPOSE	FREQUENCY
4	Equipment for continuous measurement of water content of fine aggregates [a]	Comparison of the actual amount with the reading of the meter	Manufacturer declared accuracy	— On (re)installation — Twice a year — In case of doubt
5	Mixers	Visual inspection	Wear and correct functioning	Weekly
6	Moulds	Visual inspection	Condition (e.g. wear and deformation)	Regularly depending on the type of material and frequency of use
7	Prestressing equipment	Calibrating against equipment which has been calibrated to National Standards and is used exclusively for this purpose	Correct functioning and accuracy	— On (re) installation — Twice per year — In case of doubt
8		Visual inspection	Wear of anchorage equipment	Weekly for each equipment used
9	Casting machine/equipment	Manufacturer inspection instructions	Correct compaction of concrete	Manufacturer inspection instructions and at least monthly
10	Storage of reinforcing steel	Visual inspection	To ascertain separate and clean storage, absence of contamination and of strongly rusted steel bars	Regularly
11	Storage of prestressing steel	Visual inspection	Dry, airy storage, absence of contamination	Regularly

[a] Only if the equipment is available and the purpose is not covered by appropriate inspection(s) under D.3.1 in Table D.3 or D.4.1 in Table D.4.

D.3 Materials inspection

Table D.2 — Materials inspection

	SUBJECT	METHOD	PURPOSE	FREQUENCY
D.2.1 - All materials				
1	All materials	Inspection prior to discharge of delivery ticket and/or label on the package showing conformity with the order[a]	To ascertain that the consignment is as ordered and from the correct source	Each delivery
D.2.2 - Materials not submitted to an assessment of conformity before delivery[b]				
1	Cement and other cementitious materials[c]	Appropriate test methods	Conformity with requirements (see 4.1.2)[d]	Each delivery

To be continued

Table D.2 *(continued)*

	SUBJECT	METHOD	PURPOSE	FREQUENCY
2	Aggregates	Visual inspection prior to discharge with respect to the grading shape and impurities	Conformity with requirements (see 4.1.2)[d]	— Each delivery — When delivery is by belt conveyor and from the same source, periodically depending on local or delivery conditions
3		Sieve analysis according to EN 933-1	Conformity with agreed grading	— 1st delivery from new source — In case of doubt, following visual inspection — Periodically depending on local or delivery conditions
4		Appropriate test method	Assessment of impurities or contamination	
5		Test for water absorption according to EN 1097-6[e]	Assessment of effective water content of concrete (see EN 206-1:2000, 5.4.2)[e]	— 1st delivery from new source — In case of doubt, following visual inspection
6	Admixtures[f]	Visual inspection	Conformity with normal appearance	Each delivery
7		Test to EN 934-2	Uniformity of density	
8		Tests for identification according to EN 934-2, e.g. density, infrared etc.	Conformity with suppliers stated data	In case of doubt
9	Additions/ pigments[f]	Visual inspection	Conformity with normal appearance	— Each delivery — Periodically during production of concrete
10		Appropriate test method[g]	Uniformity of density[g]	
11		Test of loss of ignition[g]	Identification of changes in carbon content which may affect air entrained concrete [h]	Each delivery to be used for air-entrained concrete
12	Water not taken from a public distribution system	Test according to EN 1008	To ascertain that the water is free from harmful constituents	— 1st use of new source — Water from open water course : Three times a year, or more depending on local conditions — Other sources : once a year — In case of doubt
13	Recycled water	Visual inspection	Check for solid content and contaminants (see 4.1.2)[d]	Weekly
14		Test to EN 1008		In case of doubt

To be continued

Table D.2 *(concluded)*

	SUBJECT	METHOD	PURPOSE	FREQUENCY
15	Steel	Visual inspection	Conformity with requirements (see 4.1.3 and 4.1.4)[d]	Each delivery
16		Appropriate test method		
17	Inserts and connections	Manufacturers method	Conformity with requirements (see 4.1.5)[d]	Each delivery

[a] The order shall mention the specification(s).

[b] Materials not certified before delivery by the precast concrete product manufacturer or by other means.

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

[d] The requirements of this standard may be completed by the manufacturers requirements.

[e] Not necessary if the purpose is fulfilled by other appropriated inspection(s) under D.3.1 in Table D.3 or D.4.1 in Table D.4.

[f] It is recommended that samples are taken at each delivery and stored for testing in case of doubt.

[g] Only for additions in suspension.

[h] Only for bulk powder additions to be used for air-entrained concrete.

D.4 Process inspection

Table D.3 — Process inspection

	SUBJECT	METHOD	PURPOSE	FREQUENCY
D.3.1 – Concrete[a]				
1	Mixture composition (except water content)	— Visual on weighing equipment — Checking against production documents	Conformity with intended composition (weight or volumetric batched)	— Daily for each composition used — After each change
2		Appropriate analysis	Conformity with intended mixture values (only volumetric batched)	Monthly for each composition used
3	Water content of fresh concrete	Appropriate method	To provide data for the water/binder ratio	— Daily for each composition used — After each change — In case of doubt
4	Chloride content of concrete	Calculation	To ensure that the maximum chloride content is not exceeded	In case of an increase in the chloride content of the constituents
5	Water/binder ratio of fresh concrete	Calculation (see EN 206-1:2000, 5.4.2)	To assess specified water/binder ratio	Daily, if specified
6	Air content of fresh concrete where specified[b]	Test according to EN 12350-7 for normal- weight and heavy-weight concrete ASTM C173 / C173M - 10b for light weight concrete	To assess conformity with the specified content of entrained air	First batch of each production day until values stabilise

To be continued

Table D.3 *(continued)*

	SUBJECT	METHOD	PURPOSE	FREQUENCY
7	Concrete mix	Visual check	Correct mixing	Daily for each mixture
8	Potential strength	Testing according to 5.1.1	To assess conformity with intended value[c]	Daily for each type of concrete[d]
9	Structural strength[e]		To assess conformity with intended value[f]	Each five production days per concrete family used[f]
10	Density of hardened light- or heavyweight concrete[e]	Test according to EN 12390-7	To assess specified density (see 4.2.2.5)	As frequently as potential strength test
11	Water absorption[e]	Testing according to Annex G	Intended value (see 4.3.7.5 and Annex G)	Each five production days per type of hardened concrete used and casting technique applied. D.5.2 may be applied after 5 positive results
D.3.2 - Other process subjects[g]				
1	Reinforcement and inserts (including lifting inserts)	Visual inspection[h]	Conformity with required type, quantity, shape, dimensions and position	Daily
2		Measuring[h]		Depending on manufacturer inspection instructions
3	Welding	Visual inspection	Quality of welds	Daily
4		Appropriate test method(s)	Conformity of welded steel (see 4.2.3.1)	Depending on manufacturer inspection instructions, but not less than every 400 t of steel
5	Straightening	Visual inspection	Quality of straightening	Daily
6		Appropriate test method(s)	Conformity of straightened steel (see 4.2.3.1)	Depending on manufacturer inspection instructions, but not less than every 400 t of steel
7	Bending	Visual inspection	Quality of bending	Daily
8		Appropriate test method(s)	Conformity of bended steel (see 4.2.3.1)	Depending on manufacturer inspection instructions, but not less than every 400 t of steel

To be continued

Table D.3 *(concluded)*

	SUBJECT	METHOD	PURPOSE	FREQUENCY
9	Moulds and beds	Visual inspection	Cleanliness and oiling	Daily
10			Check for wear and deformation	Depending on moulding material and frequency of use
11		Measuring	Determination of dimensions	Each new mould or after major modification
12	Prestressing	Measuring of force or elongation	Correct force (see 4.2.3.2)	Depending on manufacturer inspection instructions
13	Before casting	Visual inspection	Conformity with production drawings	Daily with frequency depending on moulding process
14	Concrete placing	Visual inspection	Correct compaction	Daily
15	Protection against drying out	Visual inspection	Conformity with specification (see 4.2.1.3) and documented factory procedures	Daily
16		Verification of relevant process conditions		Weekly
17	Accelerated hardening (by heat treatment)	Verification of relevant process conditions	Conformity with specification and documented factory procedures	Daily
18		Measuring temperatures		Depending on process
19	Postcasting processing	As appropriate	Conformity with specifications and documented factory procedures	Depending on process and specifications
20	Slippage of tendons	Appropriated check/ measurement	Conformity with specification (see 4.2.3.2)	Depending on product and/or process[i]
21	Temperature	When relevant, check the temperature (outdoor, in the production and storage areas)	Take appropriate measures	Daily

[a] The indicated tests and frequencies may be adapted or even deleted when equivalent information is obtained directly or indirectly from the product (see 6.3.9).

[b] Only for concrete containing entrained air (see Table F.1 of EN 206-1:2000).

[c] For example, required strength class in the case of compressive strength (see 4.2.2.1).

[d] Alternatively 8.2.1.2 of EN 206-1:2000 may apply.

[e] Only if the property is specified.

[f] According to the manufacturers process requirements.

[g] This inspection scheme may be adapted or completed for specific product purposes.

[h] Check against approved production drawings.

[i] Need and frequency of effective measurement may depend on the possibility of visual check on product sections.

D.5 Finished product inspection

Table D.4 — Finished product inspection

	SUBJECT	METHOD	PURPOSE	FREQUENCY
D.4.1 - Product Testing[a]				
1	Production tolerances (including concrete cover)	Testing according to J.1 to J.3 and/or other appropriate method	Conformity with the requirements of this standard and the requirements for the manufacturer declared properties	Depending on product and geometrical properties
2	Surface characteristics	Testing according to J.4 and/or other appropriate method	Conformity with the requirements for the manufacturer declared properties	Depending on product and surface properties
3	Mechanical resistance by testing [b]	Appropriate test method	Conformity with the requirements for the manufacturer's declared mechanical resistance properties	Depending on product and mechanical resistance properties
4	Marking/ Labelling	Visual check	Conformity with the requirements of this standard	Daily
5	Storage	Visual check	Conformity with the requirements of this standard	Daily
			Segregation of non-conforming products	
6	Delivery	Visual check	Correct delivery age, loading and loading documents	Daily
7	Final inspection	Visual check	To ascertain intactness	Daily

[a] This inspection may be adapted and/or completed for specific product purposes.

[b] Only if regular inspection by full scale testing is relevant in addition to type testing (e.g. if full scale testing of mechanical resistance replaces concrete strength inspection).

D.6 Switching rules

Switching rules only apply for inspection subjects of Tables D.1 to D.4 providing quantified results checked against specified declared or documented values.

Switching rules apply for each selected subject separately.

Depending on the subject, a result considered for applying switching rules may be an individual result or may be related to a group of results obtained from a sample.

Table D.5 — Switching rules

D.5.1 - Normal inspection
The inspection rate shall be in accordance with Tables D.1 to D.4.
D.5.2 - Normal to reduced inspection
Reduced inspection corresponds to half the rate of normal inspection. It may be used when normal inspection is effective and the ten preceding successive results had been accepted.
D.5.3 - Reduced to normal inspection
When reduced inspection is effective, normal inspection shall be reinstated if any of the following occurs: — a result is not accepted; — OR the production becomes irregular or delayed; — OR other conditions warrant that normal inspection shall be instituted.
D.5.4 - Normal to tightened inspection
Tightened inspection corresponds to double the rate of normal inspection. It shall be used when on normal inspection of five or less consecutive results, two have not been accepted.
D.5.5 - Tightened to normal inspection
Tightened inspection continues until five consecutive results have been accepted. Then normal inspection may be resumed.
D.5.6 – Stoppage of production
When inspection has to remain tightened for ten consecutive results, production shall be stopped. The cause of the failure shall be investigated and any necessary remedial action shall be taken to restore product conformity. Production shall be resumed using tightened inspection.

Annex E
(informative)

Assessment of compliance

E.1 General

E.1.1 General remark

The assignment of tasks for the manufacturer and for the notified body in consideration of CE marking is defined in the relevant Annex ZA of the product standard. Care should be taken in respect of the fact that some tasks described in this annex are not relevant for CE marking, but can be relevant for other purposes (mutual agreement…).

E.1.2 Compliance of factory quality system

When compliance of factory quality system is assessed, the tasks shall be:

a) initial inspection of the factory and of the factory quality system;

b) continuous surveillance and assessment of factory quality system.

E.1.3 Compliance of the product

When compliance of the product is assessed, additional tasks to E1.2 (initial inspection and continuous surveillance) shall be:

a) supervision and assessment of the tests of the product;

b) audit testing on samples taken at the factory or possibly from the construction site.

E.2 Initial inspection

Initial inspection of the factory and of the factory quality system is intended to determine whether the requirements are fulfilled.

All the results of the initial inspection, especially those related to the factory quality system and the assessment of the acceptability of the system shall be documented in a report.

E.3 Continuous surveillance

For the continuous surveillance and assessment of factory quality system, the principal objective is to check whether the compliance with the relevant requirements is maintained.

A schedule shall be defined and operated to ensure that all the relevant aspects of factory quality system are inspected at least once a year.

During continuous surveillance, the results of the production control shall also be examined to ensure that the required testing and factory quality system, including calibration and maintenance of the test equipment have

been carried out at the appropriate frequency, and that appropriate corrective actions have been undertaken. When relevant, the requirements of the marking clauses should be checked.

During continuous surveillance, the execution of routine strength tests on concrete samples and the checks on tolerances and other particular characteristics, which are part of the inspection schemes of the factory quality system, shall be carried out.

It shall be examined each year that the correlations or safe relationships established by the manufacturer such as indirect testing are still valid.

The results of continuous surveillance shall be reported.

E.4 Audit testing

The aim of audit testing is to check the reliability of the factory quality system results. The audit testing shall be performed only on products declared consistent with the relevant requirements. Unless otherwise specified, audit testing is normally carried out using the available calibrated equipment.

In case of necessity, undamaged samples from the site or from the market may be audited.

Annex F

This annex does not exist

Annex G
(normative)

Test of water absorption

G.1 Method

After conditioning, the test specimen shall be immersed in water to constant mass and then oven-dried to constant mass. The water absorption of the concrete by immersion is considered to be the loss of mass expressed as a percentage of the mass of the dry test specimen.

G.2 Sampling

The test may be carried out on a whole product unit, on a specimen either sawn or drilled from the product, or on a moulded specimen cast with the same concrete as for the product and stored under similar ambient conditions as the product.

As a reference, the test specimen shall be at least 28 days old when starting the test procedure (see G.6).

NOTE If the same test specimens are used for the determination of density, the minimum volume required by EN 12390-7 is 1 000 cm^3.

a) Test specimen consisting of a whole product unit

If the test specimen have a mass at least 1,5 kg and less or equal than 5,0 kg, the whole product unit is tested without protection of any surface with resin.

b) Test specimen cut by sawing or drilling

The test specimen may be either a cylindrical specimen cut by drilling or a prismatic specimen cut by sawing from a product unit.

The size of a cylindrical specimen having a diameter *D* and a height *H*, and a prismatic specimen with a square section having a side length *A* and a height *H*, shall fulfil the size requirements of Table G.1. in which two types of specimens have to be considered:

1) thin products (thickness *E* at least 30 mm and less than 100 mm);

2) thick products (thickness *E* at least 100 mm).

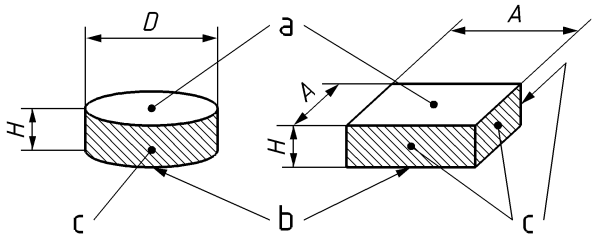
If no cylindrical or prismatic specimen satisfying the above conditions can be taken from the product unit, other shapes of specimen are admitted provided its volume *V* and its developed surface *S* fulfil the requirements of Table G.1.

— Thin products

The test specimen is cut (by sawing or drilling) through the full thickness of the product. The cut sides may be protected with a resin (see preparation in G.5). The two opposite sides which are not cut shall be left unprotected (Figure G.1).

— Thick products

The test specimen is cut (by sawing or drilling) through the full thickness of the product. This specimen can be shortened, if required, by cutting the sample, taking care that the exposed surface is included in the test specimen and that the size requirements of Table G.1. are fulfilled. The cut sides corresponding to the surrounding of the specimen may be protected with a resin (see preparation in G.5). The two remaining opposite faces shall be left unprotected (Figure G.1).



a) cylinder b) prism

Keys

A edge length
D diameter
H height
a unprotected exposed surfaces
b unprotected opposite side surface (exposed or cut surfaces)
c cut surfaces potentially protected

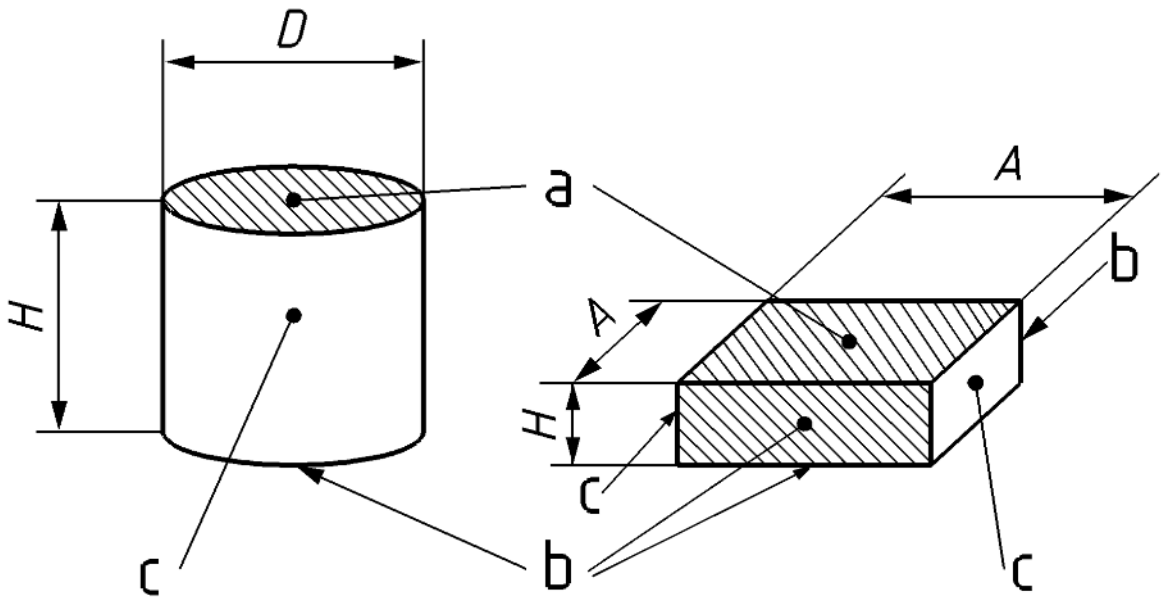
Figure G.1 — Test specimen cut from a product

c) Moulded test specimen (either cylinder or prism)

The moulded test specimen shall fulfil the size requirements of Table G.1. It may be either a cylinder having a diameter *D* and a height *H*, or a prism with a squared section having a side length *A* and a height *H*.

For cylinders, the top and bottom faces may be protected with a resin (see preparation in G.5). The surrounding of the test specimen shall be left unprotected. Unprotected surfaces should be moulded surfaces (Figure G.2).

For prisms, the surrounding of the test specimen may be protected with a resin (see preparation in G.5). The two remaining opposite sides shall be left unprotected. Unprotected faces should be two opposite moulded surfaces (Figure G.2).



a) cylinder b) prism

Key

A edge length
D diameter
H height
a possibly protected levelling surfaces
b possibly protected moulded surfaces
c unprotected moulded surfaces

Figure G.2 — Moulded test specimen

Whatever preparation method is chosen (i.e. with or without resin), the results shall fulfil the criteria.

d) Size requirements for test specimens

The requirements on the specimen size are indicated in the following Table G.1:

Table G.1 — Geometrical requirements for test specimens

		Product thickness	**Cylinder**		**Prism**		**Other shape**	
		E (mm)	***H*** (mm)	***D*** (mm)	***H*** (mm)	***A*** (mm)	***V*** (cm^3)	***S*** (cm^2)
Test specimen cut from a product unit	Thin product	$30 \le E < 50$	*E*	$200 \le D < 250$	*E*	$200 \le A < 250$	$800 \le V \le 2\,000$	$1{,}2 \le V/S \le 2$
		$50 \le E < 70$	*E*	$160 \le D < 200$	*E*	$160 \le A < 200$		
		$70 \le E < 100$	*E*	$140 \le D < 160$	*E*	$140 \le A < 160$		
	Thick product	$E \ge 100$	$½\ D \le H < D$	$100 \le D \le 160$	$½\ A \le H < A$	$100 \le A < 150$		
Moulded specimen			$½\ D \le H < D$	$100 \le D \le 160$	$½\ A \le H < A$	$100 \le A < 150$		

G.3 Materials

Potable water shall be used for immersing the specimen.

G.4 Apparatus

The following equipment shall be used:

G.4.1 Ventilated drying oven, with enforced ventilation or with a ratio of capacity in litres to area of natural ventilation channels in square millimetres less than 0,2 in which the temperature is controlled to (105 ± 5) °C; it shall have a volume at least 2½ times greater than the volume of test specimens to be dried at any one time.

G.4.2 Flat based vessel having a capacity at least 2½ times the volume of the test specimens to be immersed and a depth at least 50 mm greater than the height of the test specimens in the attitude that they will be soaked.

G.4.3 Balance reading in grams and accurate to 0,1 % of the reading.

G.4.4 Stiff brush.

G.4.5 Sponge or drying leather.

G.5 Preparation

Remove all dust, flashing, etc. with a brush and ensure that the test specimen is at a temperature of (20 ± 3) °C. The surfaces defined in G.2 may be protected with a resin. The choice of the resin and the way of sheltering shall ensure full protection of the treated surface during the whole testing procedure.

G.6 Procedure

Immerse the test specimen in potable water at a temperature of (20 ± 5) °C using the vessel. Test specimens shall be distanced from each other by at least 15 mm and have a minimum of 20 mm water above them. The minimum period of immersion shall be three days and continued until constant mass M1 is reached. Constant mass is deemed to be reached when two weighings performed at an interval of 24 h show a difference in mass of the test specimen of less than 0,1 %.

Before each weighing, wipe the test specimen with a drying leather or sponge which has been moistened and squeezed to remove any excess water. The condition is correct when the surface of the concrete is dull. The mass M1 of the test specimen is then recorded.

Then place the test specimen inside the oven in such a way that the distance between specimens is at least 15 mm. Dry the specimen at a temperature of (105 ± 5) °C to constant mass. The minimum period of drying shall be three days and continued until constant mass M2 is reached. Constant mass shall be deemed to be reached when two weighings performed at an interval of 24 h show a difference in mass of the specimen of less than 0,1°%. The specimen shall be allowed to cool down between 30 min to 1 h before it is weighed and the mass M2 is recorded.

The oven should not be filled with a new wet specimen when the cycle of already drying specimen has reached 48 h.

G.7 Results

Calculate the value of the water absorption 100 × (M1-M2)/M2 for each test specimen.

The test report shall indicate for each specimen tested the nature of the test specimen (moulded, sawn or drilled), the specimen dimensions, the conditions of preparation, the age of the test specimen when starting the test procedure, eventually the wet mass M1, the dry mass M2 and the value of water absorption of the test specimen.

NOTE If the test is made on more than one specimen from the same sample, the result is the average of the test results on these specimens.

Annex H
(informative)

Shape correlation factor for cores

When direct structural strength of concrete is tested in drilled cores, cores with $d \geq 50$ mm diameter should be employed; the length h should be not less than 0,7d; the end faces of the test sample should be ground. As a function of the size ratio h/d a proper shape correlation for the measured strength f' may be calculated from the formula:

$$f° = f' / \{1{,}20 - 0{,}20[1 - e^{-1{,}7(h/d-1)}]\} \quad \text{(H.1)}$$

in order to obtain the (cylinder) strength $f°$.

Annex I

This annex does not exist

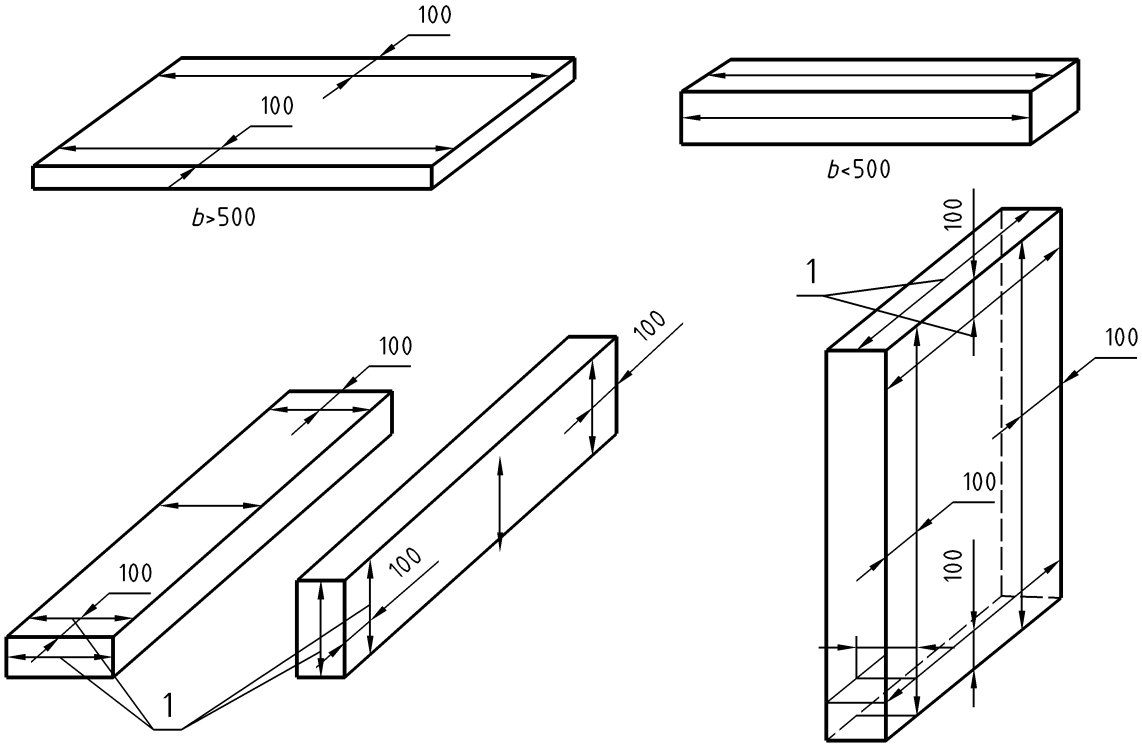
Annex J
(informative)

Measurement of dimensions

J.1 Length, height, width and thickness

Dimensions should not be measured along the edges.

Dimensions in millimetres



Key

b width
1 either - or

Figure J.1 — Measuring points for length, height, width and thickness

J.2 Warp and straightness

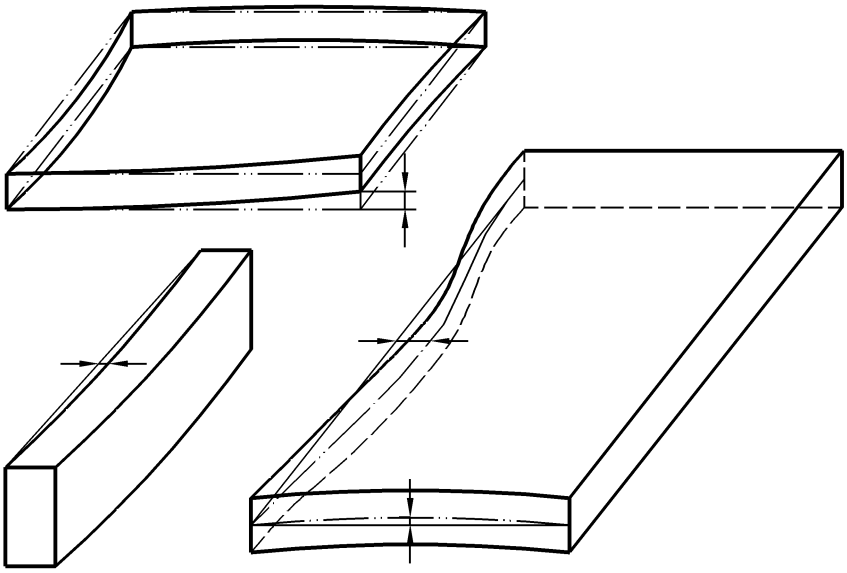


Figure J.2 — Measurement of warp and straightness

J.3 Out of squareness

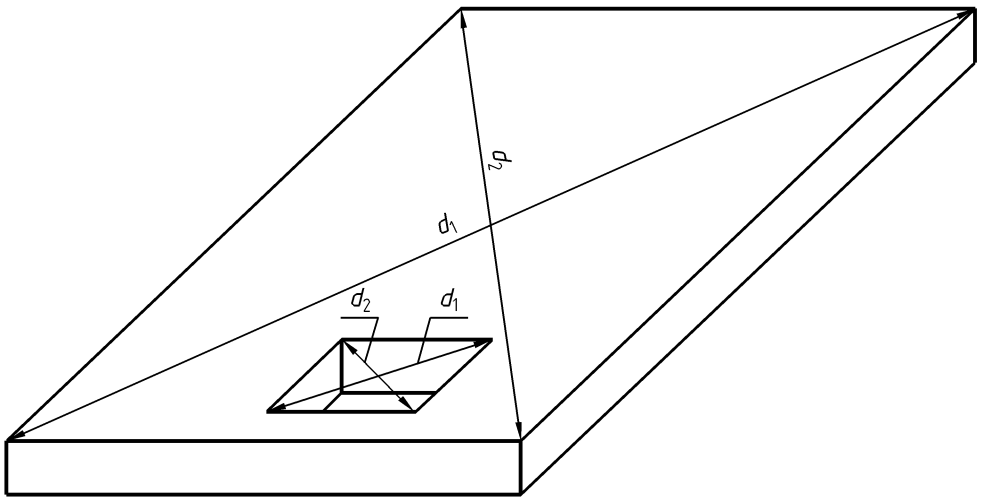


Figure J.3 — Measurement of diagonals

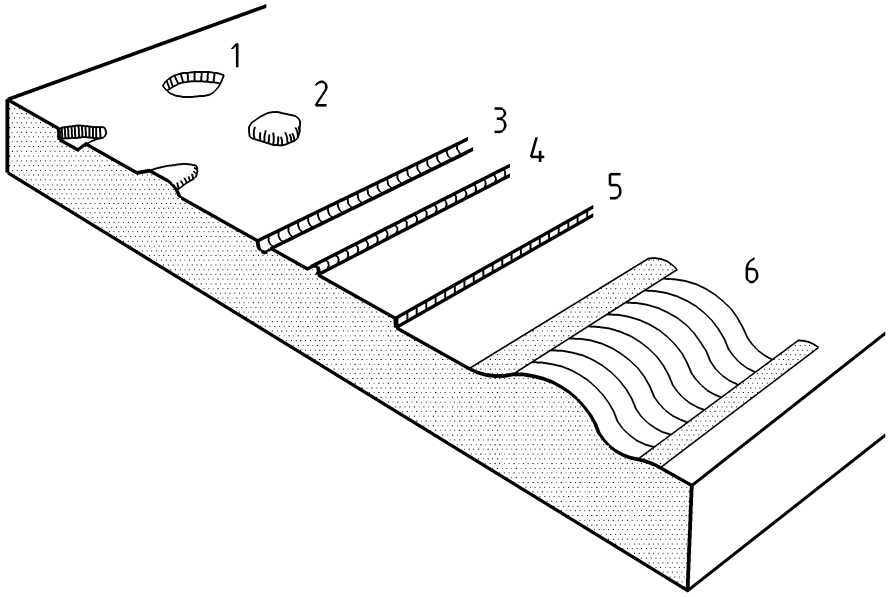
The tolerance requirement should be given as the difference in length between the two diagonals:

$$d_1 - d_2$$

J.4 Surface characteristics

For the specification of the surface characteristics of a finished product, reference should be made to the vocabulary defined in Figure J.4.

Specially treated surfaces, such as with exposed aggregate, polished, cast against a matrix, etc. are not covered by these tolerance recommendations.

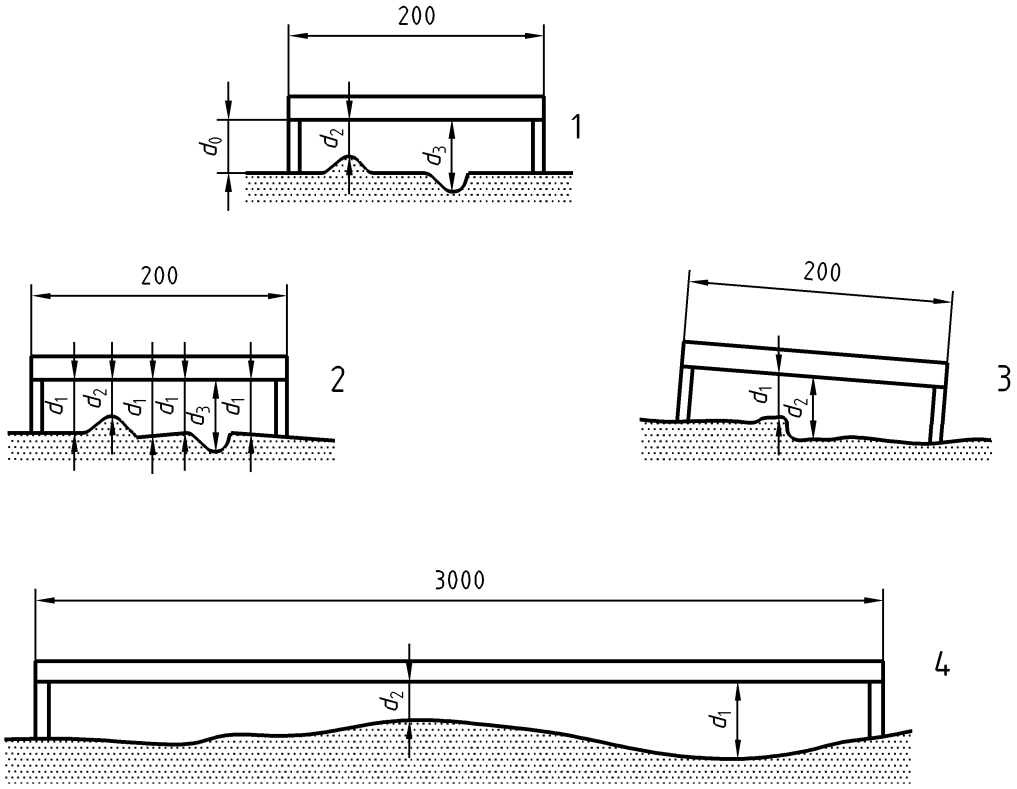


Key

1 recess
2 lump
3 groove
4 ridge
5 step discontinuity
6 undulation

Figure J.4 — Definitions of surface characteristics

Dimensions in millimetres



Key

1 lump: $d_0 - d_2$
recess: $d_3 - d_0$
The ruler should be shifted to find the largest lump and recess.

2 ridge: $d_1 - d_2$
groove: $d_3 - d_1$
The largest value of the differences is governing.

3 step discontinuity: $d_2 - d_1$

4 undulation: $d_1 - d_2$
To be measured at the highest and lowest point within the ruler.

Figure J.5 — Measurement of surface characteristics

The distance d_0 given in Figure J.5 is from the concrete surface at the location of the support of the reference ruler to the ruler. In most cases this will be the height of the supporting piece.

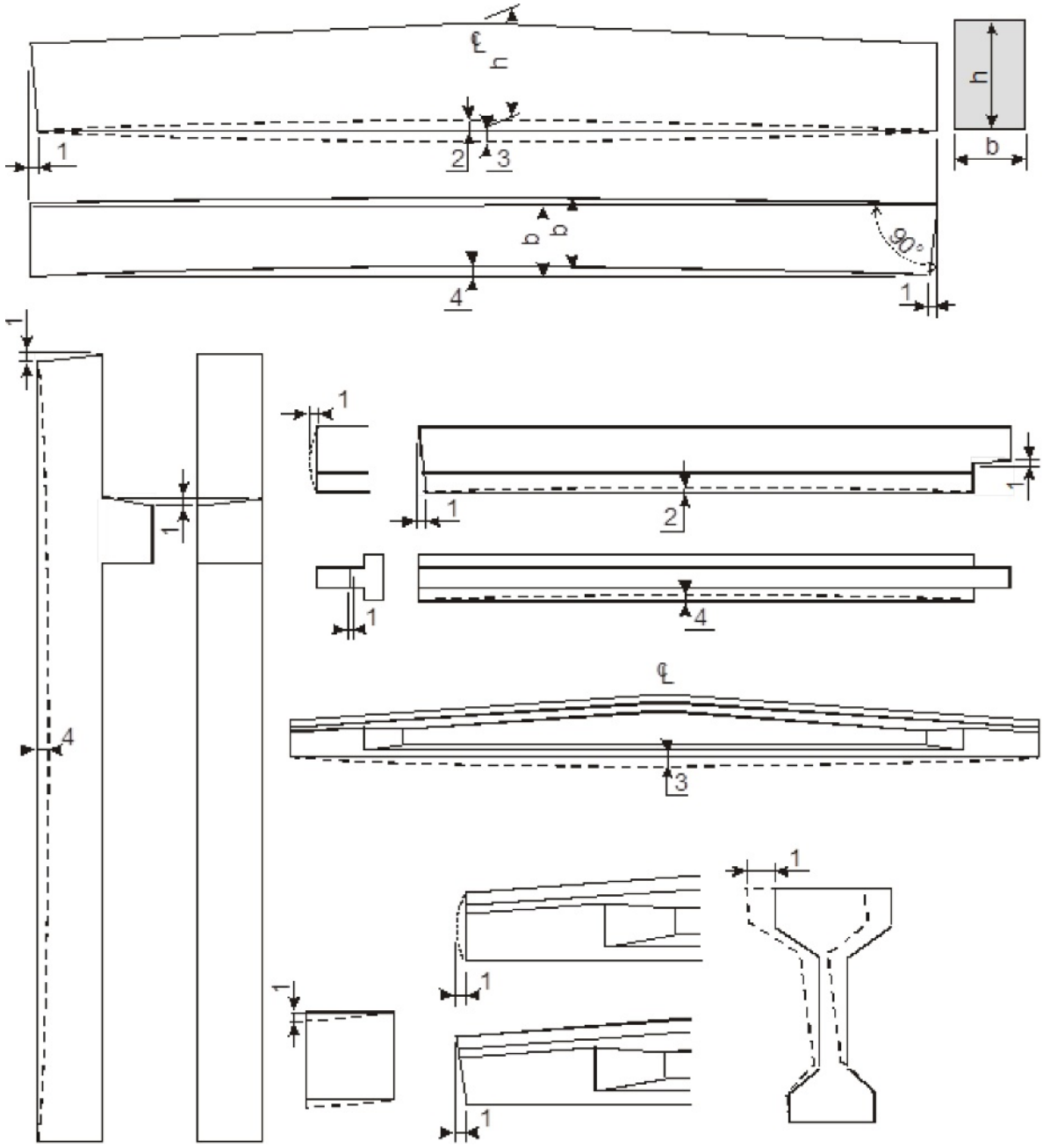
Recommended values for surface deviations are given in Table J.1.

Table J.1 — Surface deviations

Characteristic	Length of ruler	Recommended maximum deviation			
		Class 1		Class 2	
		Against form	Trowelled	Against form	Trowelled
Recess	200 mm	4 mm	3 mm	4 mm	3 mm
Lump	200 mm	2 mm	3 mm	2 mm	2 mm
Groove	200 mm	2 mm	2 mm	1 mm	1 mm
Ridge b	200 mm	5 mm	5 mm	3 mm	3 mm
Ridge h		3 mm	3 mm	2 mm	2 mm
Step discontinuity	200 mm	3 mm	2 mm	1 mm	2 mm
Undulation	3 000 mm	15 mm	8 mm	5 mm	4 mm

NOTE Requirements on surface tolerances cannot be used to describe the appearance of the surface.

J.5 Angular deviation lateral bow, camber and sag



Key

h height
b width
1 angular deviation
2 camber
3 sag
4 lateral bow

Figure J.6 — Measurement of angular deviation, lateral bow, camber and sag

Annex K
(informative)

Prestressing losses

K.1 General

NOTE This annex refers to pretensioning techniques and contains additional information for the calculation of prestressing losses.

Three stages should be considered for the calculation of the final loss in the case of pretensioned members:

— before the transfer of the prestressing force to the concrete;

— at transfer;

— after transfer.

K.2 Calculation of losses (general method)

K.2.1 Losses before transfer of the prestress force

Before transfer, the prestress loss is due to:

— The anchorage slip. This loss, ΔP_{s1}, is very small for long length casting beds.

— The short term steel relaxation. Where accelerated hardening is applied, this loss, ΔP_{P1}, is accelerated by the temperature of the treatment.

  Appropriate methods taking into account this acceleration should be applied. Otherwise, if the degree of hardening reached by the concrete after 10 h or less is at least 50 % of the required strength after 28 days, it may be assumed that this relaxation loss is equal to 75 % of the total relaxation at 20 °C of the tendon submitted to the same tension.

— The shrinkage of the concrete. This loss may be ignored when protection against drying out is maintained during manufacturing.

— The loss of tension in the tendons and the restrained dilatation of the concrete due to the temperature in the case of accelerated hardening. When a production inspection is applied this loss $[\Delta P_{\theta}]$ may be estimated by the following expression:

$$[\Delta P_{\theta}] = 0{,}5\ Ap\ E_{p}\ \alpha_{c}\ (\theta_{max} - \theta_{0}) \qquad \text{(K.1)}$$

where

Ap is the cross-section of tendons;

E_{p} is the elastic modulus of tendons;

α_{c} concrete thermal expansion (10×10^{-6}/°C);

$\theta_{max} - \theta_0$ is the difference between the maximum and initial temperature in the concrete near the tendons, in °C.

In case of compensation of the elongation due to thermal curing or preheating of the tendons before casting, the loss $[\Delta P_\theta]$ will be negligible;

— The possible friction on deflectors or guides. This loss $\Delta P_{\mu(x)}$ should be based on experimental data.

K.2.2 Loss at transfer of the prestress force

Before transfer, the force in the tendons is equal to:

$$P_o - \{\Delta P_{s1} + \Delta P_{p1} + [\Delta P_\theta] + [\Delta P_{\mu(x)}]\} \quad \text{(K.2)}$$

when neglecting shrinkage on the casting bed.

The loss at transfer of the prestress force ΔP_c is due to the elastic shortening of the concrete. Its value should be calculated by taking into account the elastic modulus of the concrete at the time of transfer in the ratio $n = E_p/E_{cm}$.

K.2.3 Losses after transfer of the prestressing force

After transfer, the loss ΔP is due to the combination of losses associated to the long-time properties of materials (creep, shrinkage, and remaining relaxation in the tendons). Its value should be calculated according to Formula (5.46) of EN 1992-1-1:2004 with the following consideration:

— in the case of accelerated hardening, if the degree of hardening reached by the concrete after 10 h or less is at least 50 % of the required strength after 28 days, the shrinkage and the creep of the concrete may be reduced 25 % and 15 % respectively and the rate of relaxation may be considered as reduced by the treatment.

K.2.4 Final prestress loss at infinite time

The final prestress loss at infinite time is equal to the sum of losses obtained before transfer, at transfer and after transfer at infinite time.

K.3 Simplified method

For current elements produced for stock (e.g. beams for beam and block systems with a length lower than 6 m, thin floor-plates, hollow core slabs with $h_t \leq 320$ mm, ...) the value of the final loss at infinite time may be estimated according to Table K.1 when all the following conditions a) to e) are met:

a) the concrete is a normal weight concrete and its consistency is stiff;

b) the relaxation of prestressing steel is very low: class 2;

c) the hardening of the concrete is accelerated by thermal treatment and reaches at least 50 % of the 28 days strength after 10 h or less;

d) the compressive stress in the concrete after transfer at the level of the tendons is not greater than 12 MPa;

e) the compressive stress in the concrete adjacent to the tendons due to the prestress, the self-weight and any other permanent action is not greater than 4 MPa.

Conditions c), d) and e) may be adapted for specific products.

Table K.1

Initial stress in the tendons (σ_{0max})	**Final loss at infinite time in percentage of initial prestress force** ($\Delta P/P_0$ %)
min (0,85 f_{pk}; 0,95 $f_{p0,1k}$)	22 %
0,80 f_{pk}	21 %
0,75 f_{pk}	20 %
0,70 f_{pk}	19 %
0,65 f_{pk}	17 %

Annex L
(informative)

This annex does not exist

Annex M
(informative)

Technical documentation

M.1 General

For precast concrete products, the technical documentation (including references to national requirements in the place of use) comprises the following items:

a) product documentation (see M.2);

b) production documentation (see M.3);

c) erection documentation (see M.4).

The documentation may refer unambiguously to product catalogues presented by the manufacturer, containing the general data describing the product and its destination for building and other civil engineering works as well as sketches with principal dimensions, indications about the relevant performances and any other information useful to define the use of the product.

M.2 Product documentation

The product documentation contains all the relevant product specifications.

When design calculations are requested, the load conditions and the consequent principal ultimate and serviceability verifications and safety factors used shall be given.

NOTE If CE marking applies, methods of declaration are given in Annex ZA of individual product standards.

Since the design of the product may be performed partly by the client and partly by the manufacturer, the documentation will usually be separated into:

a) client's specifications;

b) manufacturers specifications;

c) design calculations, with the load conditions and the consequent principal ultimate and serviceability verifications and safety factors used.

M.3 Production documentation

Production documentation consists of:

a) production drawings with the detailing of the precast concrete products (dimensions, reinforcing and prestressing steel, lifting devices, inserts, etc.);

b) production data with the required material properties and the product tolerances and weights.

M.4 Erection documentation

Erection documentation consists of:

a) installation drawings consisting of plans and sections showing the position and the connections of the products in the completed works;

b) installation data with the required in-situ material properties where applicable;

c) installation instructions with the necessary data for the handling, storing, setting, adjusting, connection and completion works.

Annex N
(informative)

Properties of indented bars and wire

Indented bars and wires, to be used in precast concrete products, should comply with Annex C of EN 1992-1-1:2004, excepted bond properties which are given in Table C.2N of that standard.

According to EN 10080, indented steel should present values of indentation parameters within the range given in Table N.1, where *d* is the nominal diameter of the bar or wire. Other values may be given in National Annex of EN 1992-1-1.

The indentations should form an angle of inclination with the longitudinal axis, β of at least 45°.

Sufficient bond strength may also be achieved (as an alternative to Table N.1) where bars or wires, tested using the beam test defined in Annex C of EN 10080:2005, present bond stresses compliant with expressions, see C.1 (1) of EN 1992-1-1:2004:

$$\tau_m \geq 0{,}098\ (80 - 1{,}2\ \phi) \qquad \text{(N.1)}$$

$$\tau_r \geq 0{,}098\ (130 - 1{,}9\ \phi) \qquad \text{(N.2)}$$

where

ϕ is the nominal bar size (mm);

τ_m is the mean value of bond stress (MPa) at 0,01 mm, 0,1 mm and 1 mm slip;

τ_r is the bond stress at failure by slipping.

Table N.1 — Limits for indentation parameters

Nominal diameter d mm	**Depth of indentations** t mm (mini)	**Width b** mm (mini)	**Indentation spacing c** mm (maxi)	**Sum of gap Σe** mm (maxi)
5	0,20	1,0	7,0	3,1
6	0,25	1,2	7,8	3,8
7	0,30	1,4	10,5	4,4
8	0,30	1,6	11,0	5,0
9	0,35	2,0	11,0	5,7
10	0,35	2,0	11,0	6,3
12	0,35	2,4	11,0	7,5
14	0,35	3,0	11,0	8,8
16	0,35	3,2	11,0	12,0

Annex O
(informative)

Resistance to fire: recommendations for the use of EN 1992-1-2

O.1 Use of tabulated data

Tabulated data is a recognised design solution for resistance to fire classification. Less conservative design may be achieved e.g. by using the actual design load level in fire situation μ_{fi} (columns and walls) or the actual steel stress $\sigma_{s,fi}$ (beams and slabs).

More specific tabulated data can be found in the product standards for some particular types of concrete products or developed on the basis of calculation methods (see EN 1992-1-2:2004, NOTE in 5.1).

O.2 Use of calculation methods

Use of lower limit of thermal conductivity (EN 1992-1-2:2004, 3.3.3) and temperature profiles in Annex A of EN 1992-1-2:2004 is recommended.

NOTE The lower limit of thermal conductivity has been derived from comparisons with temperatures measured in fire tests of different types of concrete structures. The lower limit gives more realistic temperatures for concrete structures than the upper limit, which has been derived from tests for steel/concrete composite structures.

Alternatively, thermal profiles may be derived from tests; see EN 1992-1-2:2004, 4.2.2.

Annex P
(informative)

Survey of type testing

Table P.1 — Type testing related to process items (hardened concrete properties included)

Nr	Aspect	Reference	Purpose
1	Potential compressive strength	4.2.2.1 A.4 and A.5 of EN 206-1:2000	Assessment that a new concrete type satisfies the intended strength class
2		A.4 and Annex K of EN 206-1:2000	Assessment that a multiple of concrete types belong to the same family
3	Structural strength	4.2.1.3	Acceptance of a hardening law for estimation of structural strength as an alternative for direct tests on specimens
4		Table 1, method C	Check of the effect of a curing compound on direct or indirect structural strength
5		Table 3, footnote b	Assessment that the required direct or indirect structural strength at 90 d is achieved if a concrete heat treatment is performed with $70\ ^{o}C \leq \bar{T} \leq 85\ ^{o}C$
6		4.2.2.2.4	Initial check relationship between direct and indirect structural strength
7	Concrete strength (general)	5.1.1	Assessment of the relationship between normalised (cylinder or cube) strength and the strength of test specimens which have sizes deviating from those mentioned in 5.1.1 and for which conversion factor given in 5.1.1 cannot be applied
8	Water absorption	4.2.2.6.	Assessment that a new concrete type satisfies the intended maximum water absorption level
9	Dry density	4.2.2.5.	Assessment that a new concrete type satisfies the intended minimum or maximum dry density level

Table P.2 — Type testing related to finished product properties

Nr	Properties	Reference	Purpose	Method (only one is used)	
				Testing	Calculation
11	Geometrical properties	4.3.1.1 5.2 Table C.1	Assessment of conformity with declared performances	X	
12	Surface characteristics	4.3.2 5.2	Assessment of conformity with declared performances	X	
13	Mechanical strength	4.3.3	Assessment of conformity with declared performances	X	X
14	Resistance and reaction to fire	4.3.4	Assessment of conformity with declared performances	X	X
15	Acoustic properties	4.3.5	Assessment of conformity with declared performances	X	X
16	Thermal properties	4.3.6	Assessment of conformity with declared performances	X	X
17	Concrete cover	Table A.2 Annex A	Assessment of conformity with declared performances	X	
18	Self-weight	5.3 Annex C	Assessment of conformity with declared performances	X	X

Annex Q
(informative)

Use of reclaimed crushed and recycled coarse aggregates in concrete

Q.1 General

When reclaimed crushed or recycled coarse aggregates are used in percentage up to 5 % in weight of the total content of aggregates in the concrete mix, no verification of the concrete properties other than concrete strength is required.

Q.2 Reclaimed crushed aggregates

The amount of crushed recycled aggregates obtained from precast concrete products manufactured in the same factory, can be used up to 10 % in weight of the total content of aggregates in the concrete mix with no further testing of the mechanical strength of the product or of hardened concrete properties other than testing of compressive concrete strength.

The amount may be increased up to 20 % if one of the following cases applies:

— the mechanical strength of the concrete product is determined by calculation aided or not by full scale testing and all of the hardened concrete properties relevant for calculation are determined by testing;

— the mechanical strength of the concrete product is determined by full scale testing.

Amounts above 20 % may be used when all the hardened concrete properties relevant for calculation are determined by testing and the mechanical strength of the precast concrete product determined by calculation is verified by initial full scale testing.

A maximum amount could be determined by provisions valid in the place of use.

Contamination of crushed recycled aggregates from internal source by impurities shall not be allowed.

Typical contaminations may be organic material, steel, plastic or insulation debris and oil.

Recycled aggregates should not be used in concrete for which durability requirements are higher than those for the concrete from which the recycled aggregates originate. This does not apply for concrete in exposure class X0, XC1 and XC2.

Q.3 Recycled coarse aggregates (aggregates from external source) assessed by the manufacturer

Recycled coarse aggregates from an external source made of pure concrete debris may be used under the same conditions as indicated in Q.2 provided the source and mix properties of the crushed concrete are known by the manufacturer.

Q.4 Other recycled coarse aggregates

Recycled coarse aggregates which do not satisfy the conditions of Q.3 should conform to the category of constituents RC90 according to EN 12620 and their amount in concrete mixes shall be limited to half of the percentages admitted for recycled aggregates of internal factory source as indicated in Q.2.

Provisions are under development in the upcoming version of EN 206-1 and should be considered.

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