

Common rules for precast concrete products

ICS 91.100.30

National foreword

This British Standard is the UK implementation of EN 13369:2004+A1:2006, incorporating corrigenda December 2006 and October 2007. It supersedes BS EN 13369:2004 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by A1 A1.

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

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English version

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 19 March 2004.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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Foreword

This document (EN 13369:2004) 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of an identical text or by endorsement, at the latest by January 2005, and conflicting national standards shall be withdrawn at the latest by January 2005.

This document supersedes EN 13369:2001.

This document includes a Bibliography.

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

Foreword to amendment A1

This European Standard (EN 13369:2004/A1:2006) has been prepared by Technical Committee CEN/TC 229 “Precast concrete products”, the secretariat of which is held by AFNOR.

This Amendment to the European Standard EN 13369:2004 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2006, and conflicting national standards shall be withdrawn at the latest by September 2006.

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

Introduction

This European Standard is intended to outline the general common requirements applicable to a large variety of precast concrete products manufactured in a factory environment. It will act as a reference standard for other standards to enable a more consistent approach to standardisation in the field of precast concrete products and to reduce the variations brought about by a large number of standards being 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 is in phase with associated standards EN 206-1 for concrete and EN 1992 for the design of concrete structures. As it is not a harmonized standard it may not be used in isolation for the purpose of CE marking of concrete products.

The design of structural 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 terminology, requirements, basic performance criteria, test methods and evaluation of conformity that will be referred to by specific product standards unless they are not appropriate. 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 products.

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

The precast 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.

This standard applies to compact concrete with no appreciable amount of entrapped air other than entrained air and with a dry density equal to or greater than 800 kg/m³. It does not cover prefabricated reinforced components of lightweight aggregate concrete with open structure.

2 Normative references

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

2.1 General references

National documents take precedence until Eurocodes are published as European Standards.

EN 1990, *Eurocode - Basis of structural design*.

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

2.2 Concrete

EN 206-1:2000, *Concrete - Part 1: Specification, performance, production and conformity*.

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

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

[AC1] 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*. **[AC1]**

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

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.*

2.3 Steel

prEN 10080:1999, *Steel for the reinforcement of concrete - Weldable reinforcing steel - Part 1: General requirements.*

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: Bars.*

2.4 Fire performance

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

EN 1991-1-2, *Eurocode 1: Actions on structures - Part 1-2: General actions - Actions on structures exposed to fire.*

EN 1992-1-2, *Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design.*

2.5 Acoustic insulation

EN ISO 140-3, *Acoustics - Measurement of sound insulation in buildings and of building elements - Part 3: Laboratory measurements of airborne sound insulation of building elements (ISO 140-3:1995).*

EN ISO 140-6, *Acoustics - Measurement of sound insulation in buildings and of building elements - Part 6: Laboratory measurements of impact sound insulation of floors (ISO 140-6:1998).*

EN ISO 717-1, *Acoustics - Rating of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation (ISO 717-1:1996).*

EN ISO 717-2, *Acoustics - Rating of sound insulation in buildings and of building elements - Part 2: Impact sound insulation (ISO 717-2:1996).*

2.6 Thermal resistance

EN ISO 10456:1999, *Building materials and products - Procedures for determining declared and design thermal values (ISO 10456:1999).*

3 Terms and definitions

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

3.1 General

3.1.1

concrete product

mass produced concrete unit manufactured in accordance with a product standard or this standard

NOTE Examples of concrete products are roof tiles, blocks, flags, garden furniture, etc., as opposed to precast products which normally will be structural units.

3.1.2

precast element

concrete unit cast and cured in a place other than the final location in the works

3.1.3

precast product

precast element designed and manufactured in accordance with a product standard or this standard

3.1.4

(concrete) cover

distance from the surface of embedded reinforcement to the nearest concrete surface

3.1.5

design (nominal) cover

value of the cover quoted in the project documentation (equal or greater to the minimum cover plus the permitted negative deviation)

3.1.6

minimum cover

minimum required value for actual cover

3.1.7

actual cover

cover measured on the finished product

3.1.8

type of concrete

concrete of a continuing factory production made with the same mix design and the same batching, casting and curing techniques, for the same strength class of the hardened material

3.2 Dimensions

3.2.1

principal dimensions

length, width, depth or thickness

3.2.2

critical dimension

dimension having a critical influence on an essential performance of the product, such as the product resistance and/or the building stability

3.2.3

design (nominal) dimension

dimension targeted in the project documentation

3.2.4

actual dimension (of the product)

dimension found by measurement (on the finished product)

3.3 Joints

3.3.1

joint

any type of interface between adjacent components

3.3.2

structural joint

any type of connection between products able to transmit forces (e.g. tensile, compressive, flexural or shear forces)

3.3.3

movement joint

joint that permits relative movement

3.3.4

expansion joint

movement joint for expansion (e.g. thermal) of the adjacent parts

3.4 Special devices

3.4.1

shear connector

connection device which transmits shear forces

3.4.2

anchorage (post-tensioned construction)

device to connect the end of a tendon to the concrete of a structural product and retain the force in the tendon

3.4.3

tie

tensile reinforcement for the connection of the parts of a structure

3.4.4

fastening

jointing device used for connecting one part to another

3.5 Supporting elements

3.5.1

bearing

support on which precast products are placed

3.5.2

bearing pad

element interposed between the supported product and the bearing

3.5.3

mortar bed

bearing pad composed of mortar

3.6 Tolerances

3.6.1

tolerance

permitted variation of dimension

3.6.2

deviation

difference between an actual dimension and the corresponding design dimension

3.6.3

production tolerance

tolerance on thickness, length, straightness, planarity, or other dimensions after production of a precast unit

3.6.4

erection tolerance

tolerance on local placing, verticality, horizontality, or other characteristics of the construction assembly after installation

3.6.5

construction tolerance

tolerance in a measure arising from a combination of production, setting out, site work and erection tolerances

3.7 Durability

3.7.1

durability

ability of a construction or a component to maintain adequate levels of stability and serviceability during its design working life under intended use with anticipated maintenance but without excessive unforeseen maintenance

3.7.2

working life

period of time during which the performance of the product in the works will be kept at a level compatible with the fulfilment of the performance requirements of the works, provided it is properly maintained

3.7.3

design working life

working life assumed for the design purposes

3.7.4

environmental condition

ambient actions on the construction affecting its durability

3.8 Mechanical properties

3.8.1

potential strength (of concrete)

concrete strength derived from tests on cubes or cylinders conforming to EN 12390-3 made and cured in laboratory conditions in accordance with EN 12390-2

3.8.2

structural (actual) strength (of concrete)

concrete strength derived from tests on specimens (drilled cores or cut prisms) extracted from the finished product (direct structural strength) or deduced from tests on standard specimens (as for potential strength) but cured in factory conditions as close as possible to the structural product (indirect structural strength)

3.8.3

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

3.8.4

design strength (of material)

value obtained by dividing the characteristic strength by the pertinent partial safety factor

3.9 Reinforcement (of precast concrete products)

3.9.1

prestressed reinforcement

prestressing steel (wire, strand or bars) subjected to pre- or post-tensioning

3.9.2

reinforcement

steel (bars, wire, strand, welded mesh or fabric, lattice girder) not subjected to pre- or post-tensioning

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 result from an European Standard which refers specifically to the use of this material in concrete or in concrete products; in absence of an European Standard it may also result, under the same conditions, from an ISO standard.

Where this material is not covered by an European or International Standard, or if it deviates from the requirements of these standards, the establishment of suitability may result from:

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

or

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

4.1.2 Constituent materials of concrete

EN 206-1:2000, 5.1.2 to 5.1.6 shall apply.

4.1.3 Reinforcing steel

Reinforcing steel (bars, coils and welded fabric) shall comply with prEN 10080, meet the requirements for the technical class specified for the precast product and, where applicable, shall comply with properties given by EN 1992-1-1, when this code is used in design.

Indented bars and wires, with diameters from 6 mm to 14 mm (included), complying with the properties given in annex N, may be used in conjunction with EN 1992-1-1 and national provisions as regards to crack width, transmission length and splitting failure.

Other types of reinforcing steel may be used according to relevant national standards or national provisions valid in the place of use of the product, provided they are fit for the intended purpose and have the required properties.

4.1.4 Prestressing steel

Prestressing steel (wire, bars and strand) shall comply with prEN 10138-1, prEN 10138-2, prEN 10138-3, prEN 10138-4 and, where applicable, with properties given by EN 1992-1-1, when this code is used in design.

Other types of prestressing steel may be used according to relevant national standards or national provisions valid in the place of use of the product.

Information on relaxation of the prestressing steel is given in EN 1992-1-1:2004, 3.3.2.

4.1.5 Inserts and connectors

Mechanical inserts and connectors shall:

- a) resist the design actions;
- b) have the necessary ductility;
- c) maintain these properties for the lifetime of the product.

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 and concrete temperature, EN 206-1:2000, 5.2 shall apply.

For specification of concrete EN 206-1:2000 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 of concrete

Concrete shall be placed as to retain no appreciable amount of entrapped air other than entrained air and to avoid detrimental segregation.

4.2.1.3 Curing (protection against drying out)

All surfaces of newly cast concrete shall be protected against drying out, by at least one of the methods listed in Table 2, unless it can be shown by tests on the product or otherwise, that no loss in strength or surface cracking will occur in the production environment.

The protection against drying out shall be maintained until the minimum concrete strength (expressed either by the degree of hardening or by the cylinder/cube strength at the end of curing) given in Table 1 is reached. For bridge elements, design working life more than 50 years, or specific to local environmental conditions, other values may be given following the requirements of their destination as indicated in the design documentation.

The concrete strength shall be measured by testing a concrete sample cured in the same manner as the product.

The degree of hardening may be measured either by testing a concrete sample or estimated by calculation using a hardening law based on an initial test and maturity concept.

Table 1 — Minimum concrete strength at the end of protection against drying out

Exposure conditions in the place of use (EN 206-1 exposure classes)	Minimum concrete strength at the end of protection against drying out		
	degree of hardening as % of required strength at 28 days		Cylinder/cube strength N/mm ²
For concrete without X0 reinforcement or embedded metal: all exposures except where there is freeze/thaw, abrasion or chemical attack. For concrete with reinforcement or embedded metal: Dry or Permanently wet X01	only the requirement on cylinder/cube strength applies		12/15
Wet, rarely dry XC2, XD2 Moderate humidity XC3 Moderate saturation Without deicing agent XF1	40	or	16/20
Other exposure conditions (cyclic wet and dry)	60	or	25/30

Table 2 — Protection against drying out

Method	Typical means of execution
A - Without addition of water	— keeping the concrete in an environment with a relative humidity above 75 %; — keeping the formwork in place; — covering the concrete surface with vapour-resistant sheets that are secured at the edges and joints to prevent through draughts.
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; — ponding the concrete surface with water.
C – Use of curing compounds	NOTE Effectiveness of this method should be estimated by initial testing showing that the strength reached with curing compounds is of the same order as the strength obtained by one of the above accepted means of curing.

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.

In order to avoid microcracking and/or durability defects, the following conditions shall be fulfilled unless previous positive experience has shown that these requirements are not necessary:

- a proper preheating period shall be applied when the heat treatment maximum mean temperature $\bar{T}$ exceeds 40 °C;
- where $\bar{T}$ exceeds 40 °C the temperature difference between adjacent parts of the elements during the heating and the cooling phases shall be limited to 20 °C.

The preheating period and the heating rate shall be documented.

During the full heating and cooling period the maximum mean temperature $\bar{T}$ 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 $\bar{T}$ ^a
Predominantly dry or moderate humidity	- $\bar{T} \leq 85$ °C ^b
Wet and cyclic wet	- $\bar{T} \leq 65$ °C.
^a $\bar{T}$ is the maximum mean temperature within the concrete, individual values may be 5 °C higher.	
^b When 70 °C < $\bar{T} \leq 85$ °C initial tests shall have demonstrated that the required strength is fulfilled at 90 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 Na₂O_{eq} content $\leq 3,5$ kg/m³, for cement SO₃ content $\leq 3,5$ % by mass.

In this case, depending on material and climatic conditions, more restricted requirements may apply to the heat treatment of outdoor elements in certain areas. These requirements shall be introduced in the National Annex of this standard.

The above limits for $\text{Na}_2\text{O}_{\text{eq}}$ 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. The latest knowledge should be taken into account.

4.2.2 Hardened concrete

4.2.2.1 Strength classes

For compressive strength classes of concrete 4.3.1 of EN 206-1:2000 applies. For design purposes the properties of concrete strength classes up to C90/105 are given in Table 3.1 of EN 1992-1-1:2004.

The producer can select intermediate classes, in $1,0 \text{ N/mm}^2$ steps of the characteristic cylinder strength. In this case the concrete properties are obtained by linear interpolation.

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

- C20/25 for reinforced products;
- C30/37 for prestressed 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 compressive strength of concrete is tested at 28 days. Supplementary tests of early strengths may be made before 28 days, when required by the production process (prestressing, demoulding, lifting, ...).

The manufacturer may perform tests before 28 days to evaluate the potential compressive strength.

For determination of potential strength EN 206-1:2000, 5.5.1.1 and 5.5.1.2 shall apply. 5.1.1 of this standard gives additional requirements.

4.2.2.2.3 Direct structural strength

Compressive direct structural strength shall be determined from the finished product by drilled cores in accordance with EN 12504-1 or by cut prisms converted to cube or cylinder with the appropriate correction factor.

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 product as possible, provided an initial test has determined the correspondence with direct structural strength.

4.2.2.2.5 Conversion factor

The deviation of direct structural strength from the potential strength is covered by the conversion factor $\eta = 0,85$ which is included in part of the value of the safety factor γ_c given in EN 1992-1-1:2004, 2.4.1.4, for ultimate limit states (see also annex C).

When structural strength is used, comparison with the required strength class is made by multiplying the test value by $1/\eta$.

4.2.3 Structural reinforcement

4.2.3.1 Processing of reinforcing steel

Reinforcing steel for structural purposes that is straightened or welded in the factory shall remain in compliance 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.

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 compliance 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 σ_{Omax} can be taken as:

$$\sigma_{Omax} = \min (0,85f_{pk} \text{ or } 0,95f_{p0,1k}) \text{ class 1}$$

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

$$\sigma_{Omax} = \min (0,80f_{pk} \text{ or } 0,90f_{p0,1k}) \text{ class 2}$$

4.2.3.2.2 Accuracy of tensioning

The deviation between the applied and target tensioning force (see annex K) at the active end, immediately after stressing, shall remain within the following tolerances:

Class A – normal tolerances

- single tendon/force: $\pm 7 \%$;
- total force: $\pm 5 \%$.

Class B – tightened tolerances

- single tendon/force: $\pm 4 \%$.

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 25 N/mm².

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 after transfer of the prestress force, shall be limited to the following values:

- for individual tendons (strands or wires): $1,3 \Delta L_0$;
- for the mean value of all tendons in 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:

$$\Delta L_0 = 0,4 l_{pt2} \frac{\sigma_{pmo}}{E_p}$$

where

- l_{pt2} is the upper bound value of transmission length = $1,2 l_{pt}$, in millimetres according to 8.10.2.2 of EN 1992 1-1;
- 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 is measured only on sawn products.

4.3 Finished product requirements

4.3.1 Geometrical properties

4.3.1.1 Production tolerances

Production tolerances of structural parameters, which affect load-bearing capacity of the element in its intended use, shall not exceed the values given in this clause. For other parameters, different tolerances may be specified.

For cross-sectional dimensions L , the permitted deviation is ΔL , and for position of reinforcing steel, prestressing steel and for the design cover c the permitted deviation is Δc .

Table 4 — Permitted deviations of cross-sections for structural elements

Target dimension of the cross-section in the direction to be checked	ΔL (mm)	Δc (mm)
$L \leq 150$ mm	+ 10 – 5	± 5
$L = 400$ mm	± 15	+ 15 – 10
$L \geq 2\,500$ mm	± 30	+ 30 – 10
Linear interpolation for intermediate values. NOTE 1 ΔL and the positive values for Δc (upper permitted deviation) are given to ensure that deviations in cross-sectional dimensions and in the position of the reinforcement do not exceed values covered by the relevant safety factors in the Eurocodes. NOTE 2 The negative values for Δc (lower permitted deviation) are given for durability purposes. NOTE 3 Particularly functional specificities of the products may require tighter tolerances. NOTE 4 The given values may be modified by product standards.		

[AC1] The upper permitted deviation for the location of the reinforcement may be determined as the mean value of the bars or strands in a cross-section or over a width of 1 m (e.g. slabs and walls). **[AC1]**

The design cover c of the reinforcement shall be at least the minimum cover $c_{\min}$ plus the lower permitted deviation $-\Delta c$ or the producer's guaranteed deviation, whichever is the lowest.

For principal dimensions other than cross-sectional dimensions:

$$\Delta L = \pm (10 + L / 1\,000) \leq \pm 40 \text{ mm}$$

where

L is the target size of the linear measure expressed in millimetres.

[AC1] Other types of tolerances may be given by product standards together with the values of the related permitted deviations (e.g. camber of beams, ...). **[AC1]** These values will not include the deformation effects of any applied load or of prestressing. In the verification of the measured deviations, such deformations shall be taken into account by computing their value for the test situation (including all the relevant time related effects).

4.3.1.2 **[A1]** Minimum nominal dimensions

The geometrical characteristics of precast structural products shall comply with the required minimum nominal dimensions.

The values of the minimum nominal dimensions shall be taken from relevant clauses of EN 1992-1-1:2004. These values may be reduced provided there is fully documented justification for the use of smaller values.

Product standards may specify different values of minimum nominal dimensions following the specific features of the products.

NOTE Concrete covers given in informative Annex A are minimum values (see 3.1.6). **[A1]**

4.3.2 Surface characteristics

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

4.3.3 Mechanical resistance

4.3.3.1 General

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 informative annex K, in cases specified in that annex.

NOTE 1 Actions and safety factors for actions are subject to national regulations or other rules valid in the place of use of the product. Design loads are assumed to be given values, depending on the intended use of the product.

NOTE 2 For precast elements with structural destination the structural design should be verified expressly to ensure their fitness for the particular application. Special attention should be given with regard to Public Safety and to the design co-ordination with the other parts of the construction and, where relevant, to conditions of transient periods.

4.3.3.2 Verification by calculation

Design values of capacities obtained by calculation shall be verified according to the relevant clauses of EN 1992 1-1, to the pertinent complementary rules given in the product standards or national rules valid in the place of use.

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 design conditions.

Physical testing is not required in case of reliable theoretical verification following the principles of EN 1992-1-1.

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 (e.g. EN 1990).

4.3.3.5 Safety factors

EN 1990 and EN 1992-1-1 give recommended values for partial safety factors. They also permit lower values under certain conditions. Annex C provides such information.

4.3.3.6 Transient situations

The following special cases of actions concerning transient situations of precast elements shall be considered.

Dynamic vertical effects during lifting, handling, transportation and erection shall be considered.

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.