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Öndökümlü beton mamuller - Boşluklu döşeme elemanları

Precast concrete products - Hollow core slabs

Produits préfabriqués en béton - Dalles alvéolées

Vorgefertigte Betonerzeugnisse - Vorgefertigte Hohlplatten

TÜRK STANDARDLARI ENSTİTÜSÜ
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Milli Önsöz

Bu standard, CEN/TC 229 “Precast concrete products”(Dökümle üretilen imalatlar) Teknik Komitesi tarafından hazırlanmış, CEN tarafından 04.01.2009 tarihinde onaylanmış ve Türk Standardları Enstitüsü Teknik Kurulu'nun 19.01.2010 tarihli toplantısında Türk Standardı olarak kabul edilerek yayımına karar verilmiştir.

Bu standardda kullanılan bazı kelimeler ve/veya ifadeler patent haklarına konu olabilir. Böyle bir patent hakkının belirlenmesi durumunda TSE sorumlu tutulamaz.

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EUROPEAN STANDARD

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Precast concrete products - Hollow core slabs

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Vorgefertigte Betonerzeugnisse - Vorgefertigte Hohlplatten

This European Standard was approved by CEN on 1 July 2004 and includes Amendment 1 approved by CEN on 14 January 2008 and Amendment 2 approved by CEN on 4 January 2009.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Management Centre: Avenue Marnix 17, B-1000 Brussels

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The numbering of clauses is strictly related to EN 13369: Common rules for precast concrete products, at least for the first three digits. When a clause of EN 13369 is not relevant or included in a more general reference of this standard, its number is omitted and this may result in a gap on numbering.

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Foreword

This document (EN 1168:2005+A2:2009) has been prepared by Technical Committee CEN/TC 229 "Precast concrete products", the secretariat of which is held by AFNOR [A2⟩ and was examined by and agreed with a joint working party appointed by the Liaison Group CEN/TC 229 – CEN/TC 250, particularely for its compatibility with structural Eurocodes ⟨A2].

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of an identical text or by endorsement, at the latest by September 2009, and conflicting national standards shall be withdrawn at the latest by December 2010.

[A1⟩ This European Standard was examined by and agreed with a joint working party appointed by the Liaison Group CEN/TC 229 – TC 250, particularly for its compatibility with structural Eurocodes. ⟨A1]

This document includes Amendment 1 approved by CEN on 2008-01-14 and Amendment 2 approved by CEN on 2009-01-04.

This document supersedes [A2⟩ EN 1168:2005+A1:2008 ⟨A2].

The start and finish of text introduced or altered by amendment is indicated in the text by tags [A1⟩ ⟨A1] and [A2⟩ ⟨A2].

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 has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of Construction Products Directives (89/106/EEC) of the European Union (EU).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

This standard is one of a series of product standards for precast concrete products.

For common aspects reference is made to EN 13369: *Common rules for precast products*, from which also the relevant requirements of the EN 206-1: *Concrete – Part 1: Specification, performances, production and conformity* are taken.

The references to EN 13369 by CEN/TC 229 product standards are intended to make them homogeneous and to avoid repetitions of similar requirements.

Eurocodes are taken as a common reference for design aspects. The installation of some structural precast concrete products is dealt with by ENV 13670-1: *Execution of concrete structures – Part 1: Common rules*, which has at the moment the status of an European Prestandard. In all countries it can be accompanied by alternatives for national application and it shall not be treated as a European standard.

The programme of standards for structural precast concrete products comprises the following standards, in some cases consisting of several parts:

— [A1⟩ EN 1168:2005+A1 ⟨A1], *Precast concrete products – Hollow core slabs*

— [A1⟩ EN 12794:2005+A1 ⟨A1], *Precast concrete products – Foundation piles*

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

— [A1⟩ EN 13224:2004+A1 ⟨A1], *Precast concrete products – Ribbed floor elements*

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

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

— A1⟩ EN 13747 ⟨A1, *Precast concrete products – Floor plates for floor systems*

— A1⟩ EN 13978-1, *Precast concrete products - Precast concrete garages - Part 1: Requirements for reinforced garages monolithic or consisting of single sections with room dimensions* ⟨A1

— A1⟩ EN 14843 ⟨A1, *Precast concrete products - Stairs*

— A1⟩ EN 14844 ⟨A1, *Precast concrete products – Box culverts*

— A1⟩ EN 14991 ⟨A1, *Precast concrete products – Foundation elements*

— A1⟩ EN 14992, *Precast concrete products – Wall elements* ⟨A1

— A2⟩ 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*

— prEN 15037-4, *Precast concrete products – Beam-and-block floor systems – Part 4: Polystyrene blocks*

— prEN 15037-5, *Precast concrete products – Beam-and-block floor systems – Part 5: Lightweight blocks* ⟨A2

— A1⟩ EN 15258 ⟨A1, *Precast concrete products – Retaining wall elements*

— A1⟩ EN 15050 ⟨A1, *Precast concrete products – Bridge elements*

This standard defines in Annex ZA the application methods of CE marking to products designed using the relevant EN Eurocodes (EN 1992-1-1 and EN 1992-1-2). Where, in default of applicability conditions of EN Eurocodes to the works of destination, design Provisions other than EN Eurocodes are used for mechanical strength and/or fire resistance, the conditions to affix CE marking to the product are described in ZA.3.4.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, 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

The evaluation of conformity given in this standard refers to the completed precast elements which are supplied to the market and covers all the production operations carried out in the factory.

For design rules reference is made to EN 1992-1-1. Additional complementary rules are provided where necessary.

The verification of the mechanical resistance of hollow core slabs is, at this stage of standardisation, only fully accepted by calculation; (A2) however, concrete properties adopted as input for calculation of shear resistance depend on the proper functioning of the production machine; therefore a full scale test method to confirm both the shear resistance obtained by calculation and the proper functioning of the production machine, is given in Annex J (normative). (A2)

Special rules for structures with hollow core elements are presented in annexes about load distribution (Annex C), diaphragm action (Annex D), negative moments (Annex E), shear capacity of composite members (Annex F) and design of connections (Annex H).

Because of some specialities of the product, e.g. the absence of transverse reinforcement, some complementary design rules to EN 1992-1-1 are necessary. Furthermore, research on hollow core slabs has resulted in special, widely used, design rules which are not incorporated in the design rules of EN 1992-1-1. According to subclause 1.2 of EN 1992-1-1:2004 the complementary rules, given in informative annexes in this standard, comply with the relevant principles given in EN 1992-1-1.

Because of the fact that the experimental evidence is mainly based on elements with limited depth and width, this standard is applicable to elements with these limited dimensions. This limitation is not intended to prohibit the application of elements with larger sizes, but the experience is not yet wide enough to draw up standardised design rules.

1 Scope

This European Standard deals with the requirements and the basic performance criteria and specifies minimum values where appropriate for precast hollow core slabs made of prestressed or reinforced normal weight concrete according to EN 1992-1-1:2004.

This European Standard covers terminology, performance criteria, tolerances, relevant physical properties, special test methods, and special aspects of transport and erection.

Hollow core elements are used in floors, roofs, walls and similar applications. In this European Standard the material properties and other requirements for floors and roofs are dealt with; for special use in walls and other applications, see the relevant product standards for possible additional requirements.

The elements have lateral edges provided with a longitudinal profile in order to make a shear key for transfer of vertical shear through joints between contiguous elements. For diaphragm action the joints have to function as horizontal shear joints.

The elements are manufactured in factories by extrusion, slipforming or mouldcasting.

The application of the standard is limited for prestressed elements to a maximum depth of [A1⟩ 500 ⟨A1] mm and a maximum width of 1 200 mm. For reinforced elements the maximum depth is limited to 300 mm and the maximum width without transverse reinforcement to 1 200 mm and with transverse reinforcement to 2 400 mm.

The elements may be used in composite action with an in situ structural topping cast on site.

The applications considered are floors and roofs of buildings, including areas for vehicles in the category F and G of [A2⟩ EN 1991-1-1 ⟨A2] which are not subjected to fatigue loading. For building in seismic zones additional provisions are given in EN 1998-1.

This European Standard does not deal with complementary matters. E.g. the slabs should not be used in roofs without additional protection against water penetration.

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.

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

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

EN 1992-1-2:2004, *Eurocode 2: Design of concrete structures – Part 1-2: General rules – Structural fire design*

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 12390-4:2000, *Testing hardened concrete – Part 4: Compressive strength – Specification for testing machines*

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

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

EN 13369:2004, *Common rules for precast concrete products*

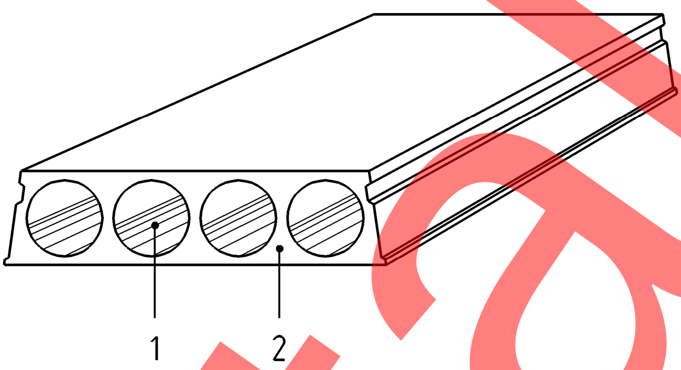
[A1⟩ EN 13791, *Assessment of in-situ compressive strength in structures and precast concrete components* ⟨A1]

3 Terms and definitions

For the purposes of this European Standard, the following terms and definitions apply. For general terms EN 13369:2004 shall apply.

3.1 Definitions

3.1.1
hollow core slab
monolithic prestressed or reinforced element with a constant overall depth divided into an upper and a lower flange, linked by vertical webs, so constituting cores as longitudinal voids the cross section of which is constant and presents one vertical symmetrical axis (see Figure 1)



Key

1 Core

2 Web

Figure 1 — Example of hollow core slab

3.1.2
core
longitudinal void produced by specific industrial manufacturing techniques, located with a regular pattern and the shape of which is such that the vertical loading applied on the slab is transmitted to the webs

3.1.3
web
vertical concrete part between two adjacent cores (intermediate webs) or on the lateral edges of the slab (outermost webs)

3.1.4
lateral joint
lateral profile on the longitudinal edges of a hollow core slab shaped so to allow grouting between two adjacent slabs

3.1.5
topping
cast in situ concrete on the hollow core slab floor intended to increase its bearing capacity and so constituting a composite hollow core slab floor

3.1.6
screed
cast in situ concrete or mortar layer used to level the upper face of the finished floor

3.1.7
hollow core slab floor
floor made of hollow core slabs after the grouting of the joints

3.1.8
composite hollow core slab floor
hollow core slab floor complemented by a cast-in-situ topping

4 Requirements

4.1 Material requirements

Complementary to 4.1 of EN 13369:2004 the following subclauses shall apply. In particular the ultimate tensile and tensile yield strength of steel shall be considered.

4.1.1 Prestressing steel

4.1.1.1 Maximum diameter of prestressing steel

The diameter of prestressing steel is limited to a maximum of 11 mm for wires and 16 mm for strands. The use of prestressing bars is not allowed.

4.2 Production requirements

A2 4.2 of EN 13369:2004 shall apply.

Proper placing and compacting of concrete by the production machine shall be verified by initial type testing according to 6.2.2.

Complementary to 4.2.3 of EN 13369:2004 4.2.1 shall apply for structural reinforcement. A2

4.2.1 Structural reinforcement

4.2.1.1 Processing of reinforcing steel

4.2.1.1.1 Longitudinal bars

For the distribution of the longitudinal bars the following requirements shall be fulfilled:

a) the bars shall be distributed uniformly across the width of the elements;

b) the maximum centre to centre distance between two bars shall not exceed 300 mm;

c) in the outermost webs there shall be at least one bar;

d) the clear spacing between bars shall be at least:

— horizontally : $\geq (d_g + 5\text{ mm})$, ≥ 20 mm and $\geq Ø$;

— vertically : $\geq d_g$, ≥ 10 mm and $\geq Ø$.

4.2.1.1.2 Transversal bars

Transverse reinforcement is not required in slabs up to 1 200 mm wide. Slabs having a width greater than 1 200 mm must have transverse reinforcement designed to suit the loading requirements. The minimum transverse reinforcement shall be 5 mm diameter bars at 500 mm centres.

4.2.1.2 Tensioning and prestressing

4.2.1.2.1 Common requirements for the distribution of prestressing tendons

The following requirements shall be fulfilled:

a) the tendons shall be distributed uniformly across the width of the elements;

b) in every width of 1,20 m at least four tendons shall be applied;

c) in every element of a width greater than 0,60 m and less than 1,20 m, at least three tendons shall be applied;

d) in every element with a width of 0,60 m or less at least two tendons shall be applied;

e) the minimum clear spacing between tendons shall be:

— horizontally : $\geq (d_g + 5 \text{ mm})$, $\geq$ 20 mm and $\geq Ø$;

— vertically : $\geq d_g$, $\geq$ 10 mm and $\geq Ø$.

4.2.1.2.2 Transfer of prestress

Clause 8.10.2.2 of EN 1992-1-1:2004 shall apply:

NOTE "Good" bond conditions are obtained for extruded and slip-formed elements. For the description of "good" and "poor" bond conditions, see Figure 8.2 of EN 1992-1-1:2004.

4.3 Finished product requirements

4.3.1 Geometrical properties

4.3.1.1 Production tolerances

4.3.1.1.1 Dimensional tolerances related to structural safety

The maximum deviations, measured in accordance with 5.2, on the specified nominal dimensions shall satisfy the following requirements:

a) slab depth:

— $h \leq 150$ mm: – 5 mm, + 10 mm;

— $h \geq 250$: ± 15 mm;

— 150 mm $< h <$ 250 mm : linear interpolation may be applied;

b) nominal minimum web thickness:

— individual web (b_w): – 10 mm;

— total per slab (Σb_w): – 20 mm;

c) nominal minimum flange thickness (above and underneath cores):

— individual flange: – 10 mm, + 15 mm;

d) vertical position of reinforcement at tensile side:

— individual bar, strand or wire: $h \leq 200$ mm ± 10 mm;

$h \geq 250$: ± 15 mm;

200 mm < h < 250 mm: linear interpolation may be applied;

— mean value per slab: ± 7 mm;

— the requirement in this paragraph shall not conflict with subclause 4.3.1.2.3 of this standard.

A1) 4.3.1.1.2 (A1 Tolerances for construction purposes

The maximum deviations, unless declared otherwise by the manufacturer, shall satisfy the following:

a) slab length: ± 25 mm;

b) slab width: ± 5 mm;

c) slab width for longitudinally sawn slabs :± 25 mm.

A1) 4.3.1.1.3 (A1 Tolerances for concrete cover

A1) The maximum deviation for concrete cover shall be Δc = -10 mm. A more stringent tolerance may be declared by the manufacturer. (A1

4.3.1.2 Minimum dimensions

Complementary to 4.3.1.2 of EN 13369:2004 next subclauses shall apply.

4.3.1.2.1 Thickness of webs and flanges

The nominal thickness specified on the drawings shall be at least the minimum thickness increased by the maximum deviation (minus tolerance) declared by the manufacturer.

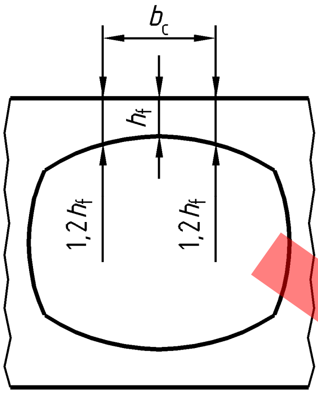
The minimum thickness shall be:

— for any web, not less than the largest of h/10, 20 mm and (d_g + 5 mm), where d_g and h are in millimetres;

— for any flange, not less than the largest value of $\sqrt{2h}$, 17 mm and (d_g + 5 mm), where d_g and h are in millimetres; however for the upper flange, not less than 0,25 b_c, where b_c is the width of that part of the flange in which the greatest thickness is not greater than 1,2 times the smallest thickness (see Figure 2).

Thickness of webs and flanges shall be measured in accordance with 5.2.1.1.

[A2>



<A2]

Figure 2 — Minimum thickness of upper flange

4.3.1.2.2 Minimum concrete cover and axis distances of prestressing steel

For indented wires or smooth and indented strands, the minimum concrete cover c_{min} to the nearest concrete surface and to the nearest edge of a core shall be at least:

— only with respect to the exposed face, the one determined in accordance with 4.4.1.2 of EN 1992-1-1:2004 shall apply;

— for preventing longitudinal cracking due to bursting and splitting and in the absence of specific calculations and/or tests:

[A1> a) when the nominal centre to centre distance of the strands is ≥ 3 Ø: c_{min} = 1,5 Ø;

b) when the nominal centre to centre distance of the strands is < 2,5 Ø: c_{min} = 2,5 Ø;

where Ø is the strand or wire diameter, in millimetres (in the case of different diameters, the average value shall be used for Ø).

For intermediate centre to centre distance, c_{min} may be derived by linear interpolation between the values defined in a) and b).

For ribbed wires, the concrete cover shall be increased by 1 Ø. <A1]

4.3.1.2.3 Minimum concrete cover of reinforcing steel

Clause 4.4.1.2 of EN 1992-1-1:2004 shall apply.

4.3.1.2.4 Longitudinal joint shape

The longitudinal joint width shall be:

— at least 30 mm at the top of the joint;

— greater than the larger value of 5 mm or d_g at the lower part of the joint, where d_g is the maximum aggregate size in the joint grout.

If tie bars, with a diameter of $\varnothing$, are to be placed and anchored in the longitudinal joint, the width of the joint at the tie bar level shall be at least equal to the larger of ($\varnothing + 20$ mm) or ($\varnothing + 2\,d_g$), where d_g and $\varnothing$ are in millimetres.

When the longitudinal joint has to resist vertical shear, the joint face shall be provided with at least one groove.

The size of the groove shall be appropriate with regard to the resistance of the grout against vertical shear.

The height of the groove shall be at least 35 mm, and its depth at least 8 mm. The distance between the top of the groove and the top of the element shall be at least 30 mm. The distance between the bottom of the groove and the bottom of the element shall be at least 30 mm.

Typical shapes of longitudinal joints are given in Annex B.

4.3.2 Surface characteristics

Requirements given in 6.2.5 of EN 1992-1-1:2004 shall apply for hollow core slabs intended to be used with an in situ topping.

4.3.3 Mechanical resistance

4.3.3.1 General

Complementary to 4.3.3 of EN 13369:2004 the following subparagraphs shall apply.

Where relevant, consideration should be given in the design to the effects of dynamic actions (e.g. impulse) during transient situations. In the absence of a more rigorous analysis this may be allowed for by multiplying the relevant static effects by an appropriate factor. For the effects of seismic actions, appropriate design methods should be used.

Special rules for structures with hollow core elements are presented in annexes about load distribution (Annex C), diaphragm action (Annex D), negative moments (Annex E), shear capacity of composite members (Annex F) and design of connections (Annex H).

[A2⟩ The test method for confirmation of the shear resistance is given in Annex J. ⟨A2]

4.3.3.2 Verification by calculation

4.3.3.2.1 Resistance to [A1⟩ spalling ⟨A1] for prestressed hollow core slabs

Visible horizontal [A1⟩ spalling ⟨A1] cracks in the webs are not allowed.

Applying one of the requirements in a) or b) hereafter prevents [A1⟩ spalling ⟨A1] cracks:

a) for the web in which the highest [A1⟩ spalling ⟨A1] stress will be generated, or, for the whole section if the strands or wires are essentially well distributed over the width of the element, the [A1⟩ spalling ⟨A1] stress σ_{sp} shall satisfy the following condition:

$$\sigma_{sp} \le f_{ct}$$

with $$\sigma_{sp} = \frac{P_o}{b_w e_o} \times \frac{15\,\alpha_e^{2,3} + 0{,}07}{1 + \left(\dfrac{\ell_{pt1}}{e_o}\right)^{1,5} \left(1{,}3\,\alpha_e + 0{,}1\right)}$$

and [A2⟩ $$\alpha_e = \frac{(e_o - k)}{h} \ge 0$$ ⟨A2] where

f_{ct} is the value of the tensile strength of the concrete deduced at the time that the prestress is released on the basis of tests;

P_o is the initial prestressing force just after release in the considered web;

b_w is the thickness of an individual web;

e_o is the eccentricity of the prestressing steel;

ℓ_{pt1} is the lower design value of the transmission length;

k is the core radius taken equal to the ratio of the section modulus of the bottom fibre and the net area of the cross section (W_b/A_c);

b) a fracture-mechanics design shall prove that [A1⟩ spalling ⟨A1] cracks will not develop.

4.3.3.2.2 Shear and torsion capacity

4.3.3.2.2.1 [A1⟩ Shear capacity ⟨A1]

[A1⟩ For hollow-core slabs without shear reinforcement, the shear resistance of the regions cracked by bending shall be calculated using expressions (6.2a) and (6.2b) of EN 1992-1-1:2004.

For prestressed single span hollow-core slabs without shear reinforcement, the shear resistance of the regions uncracked by bending (where the flexural tensile stress is smaller than $f_{ctk0,05}/\gamma_c$), the shear resistance should be calculated with the following expression:

$$V_{Rdc} = \frac{I b_w(y)}{S_c(y)} \left(\sqrt{(f_{ctd})^2 + \sigma_{cp}(y) f_{ctd}} - \tau_{cp}(y) \right)$$

where

$$\sigma_{cp}(y) = \sum_{t=1}^{n} \left\{ \left[\frac{1}{A_i} + \frac{(Y_c - y)(Y_c - Yp_t)}{I} \right] \cdot P_t(l_x) \right\} - \frac{M_{Ed}}{I} \cdot (Y_c - y) \quad \text{(positive if compressive)}$$

$$\tau_{cp}(y) = \frac{1}{b_w(y)} \cdot \sum_{t=1}^{n} \left\{ \left[\frac{A_c(y)}{A_i} - \frac{S_c(y) \cdot (Y_c - Yp_t)}{I} + Cp_t(y) \right] \cdot \frac{dP_t(l_x)}{dx} \right\}$$

This expression shall be applied with reference to the critical points of a straight line of failure rising from the edge of the support with an angle β = 35° with respect to the horizontal axis. The critical point is the point on the quoted line where the result of the expression of $V_{Rd,c}$ is the lowest.

The definition of symbols is given here below:

I is the second moment of area of the cross section;

$b_w(y)$ is the web width at the height y;

Y_c is the height of the centroidal axis;

$S_c(y)$ is the first moment of the area above height y and about the centroidal axis;

y is the height of the critical point on the line of failure;

l_x is the distance of the considered point on the line of failure from the starting point of the transmission length (= x);

$\sigma_{cp}(y)$ is the concrete compressive stress at the height y and distance l_x;

n is the number of tendon layers;

A_i is the fictive cross section surface;

$P_t(l_x)$ is the prestressing force in the considered tendon layer at distance l_x. The transfer of prestress shall be taken into account according to 8.10.2.2 of EN 1992-1-1:2004;

M_{Ed} is the bending moment due to the vertical load, for this expression the bending moment may be ignored (M_{Ed} = 0);

$\tau_{cp}(y)$ is the concrete shear stress due to transmission of prestress at height y and distance l_x;

$A_c(y)$ is the area above height y;

$Cp_t(y)$ is a factor taking into account the position of the considered tendon layer;

$Cp_t = -1$ when $y \leq y\ p_t$

$Cp_t = 0$ when $y > y\ p_t$

Yp_t is the height of the position of considered tendon layer.

As an alternative to the above expression, the following simplified expression may be applied:

$$V_{Rdc} = \varphi \frac{Ib_w}{S} \sqrt{(f_{ctd})^2 + \beta \alpha_\ell \sigma_{cp} f_{ctd}}$$

where

I/S is the second over first moment of area (= z lever arm);

$\alpha_\ell = l_x / l_{pt2}$ is the degree of prestressing transmission ($\alpha_l \leq 1,0$);

l_x is the distance of the considered section from the starting point of transmission length;

l_{pt2} is the upper value of transmission length (see Equation (8.18) of EN 1992-1-1:2004);

$\sigma_{cp} = N_{Ed}/A$ is the full concrete compressive stress at the centroidal axis;

$f_{ctd} = f_{ctk0,05}/\gamma_c$ is the design value of tensile strength of concrete;

$\varphi = 0,8$ is the reducing factor;

$\beta = 0,9$ is the reducing factor referred to transmission length.

For hollow-core slabs deeper than 450 mm the shear strength, both for regions cracked or uncracked by bending, shall be reduced by 0,9 with respect to the equations quoted above. A1

Sections between the edge of a support and the section at a distance 0,5h from this edge, need not to be checked. In case of flexible supports, the reducing effect of transversal shear stresses on the shear capacity shall be taken into account.

4.3.3.2.2.2 A1) Shear with torsion capacity (A1

If a section is subjected simultaneously to shear and torsion and if more accurate methods are not available, the shear capacity V_{Rdn} shall be calculated as follows:

$$V_{\mathrm{Rdn}} = V_{\mathrm{Rd,c}} - V_{\mathrm{ETd}}$$

with $V_{\mathrm{ETd}} = \frac{T_{\mathrm{Ed}}}{2b_{\mathrm{w}}} \times \frac{\Sigma b_{\mathrm{w}}}{b-b_{\mathrm{w}}}$

where

V_{Rdn} is the net value of the shear capacity;

$V_{\mathrm{Rd,c}}$ is the design value of shear capacity according to 6.2.2 of EN 1992-1-1:2004;

V_{ETd} is the design value of acting shear force caused by the torsional moment;

T_{Ed} is the design value of the torsional moment in the considered section;

b_{w} is the width of the outermost web at the level of the elastic gravity line (see Figure 3).

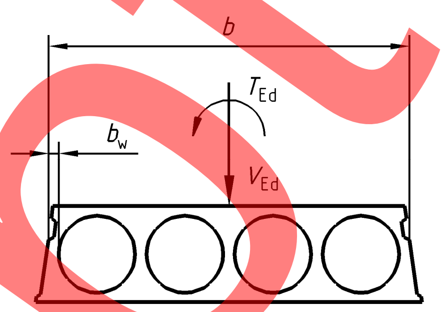


Figure 3 — Eccentric shear force

4.3.3.2.3 Shear capacity of the longitudinal joints

Load distribution from an element to the adjacent element will cause vertical shear forces in the joint and the elements at both sides of the joint.

The shear capacity in this case depends on the properties of the joint and of the elements.

This shear capacity v_{Rdj}, expressed as resisting linear load, is the smaller value of the flange resistance v'_{Rdj} or the joint resistance v_{Rdj} :

$$v'_{\mathrm{Rdj}} = 0{,}25\, f_{\mathrm{ctd}}\, \Sigma \mathrm{h_f}$$

and

$$v''_{Rdj} = 0{,}15\ (f_{ctdj}\ h_j + f_{ctdt}\ h_t)$$

where

f_{ctd} is the design value of the tensile strength of the concrete in the elements;

f_{ctdj} is the design value of the tensile strength of the concrete in the joints;

f_{ctdt} is the design value of the tensile strength of the concrete of the topping;

Σh_f is the sum of the smallest thicknesses of the upper and lower flange and the scaled thickness of the topping (see Figure 4); [A1⟩ where this scaled thickness is the nominal thickness of the topping multiplied by the ratio between the tensile strength of the topping and the tensile strength of the slabs; ⟨A1]

h_j is the net height of the joint (see Figure 4);

h_t is the thickness of the topping (see Figure 4).

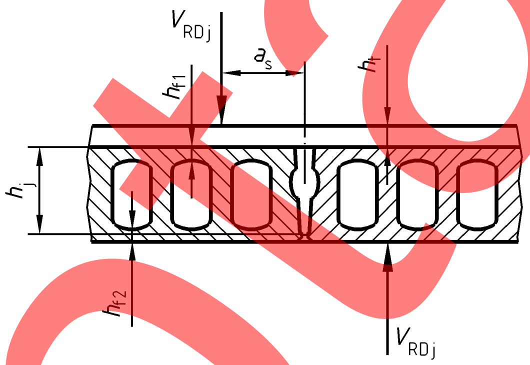


Figure 4 — Shear force in joints

The shear capacity V_{Rdj} expressed as resisting concentrated load, shall be calculated as follows:

$$V_{Rdj} = v_{Rdj}\ (a + h_j + h_t + 2\ a_s)$$

where

v_{Rdj} is the smaller value of v'_{Rdj} or v_{Rdj} ;

a is the length of the load parallel to the joint ;

a_s is the distance between the centre of the load and the centre of the joint.

4.3.3.2.4 Punching shear capacity

In the absence of particular justifications, the punching shear capacity of slabs without topping V_{Rd}, in newtons, expressed as resisting point load, shall be calculated as follows:

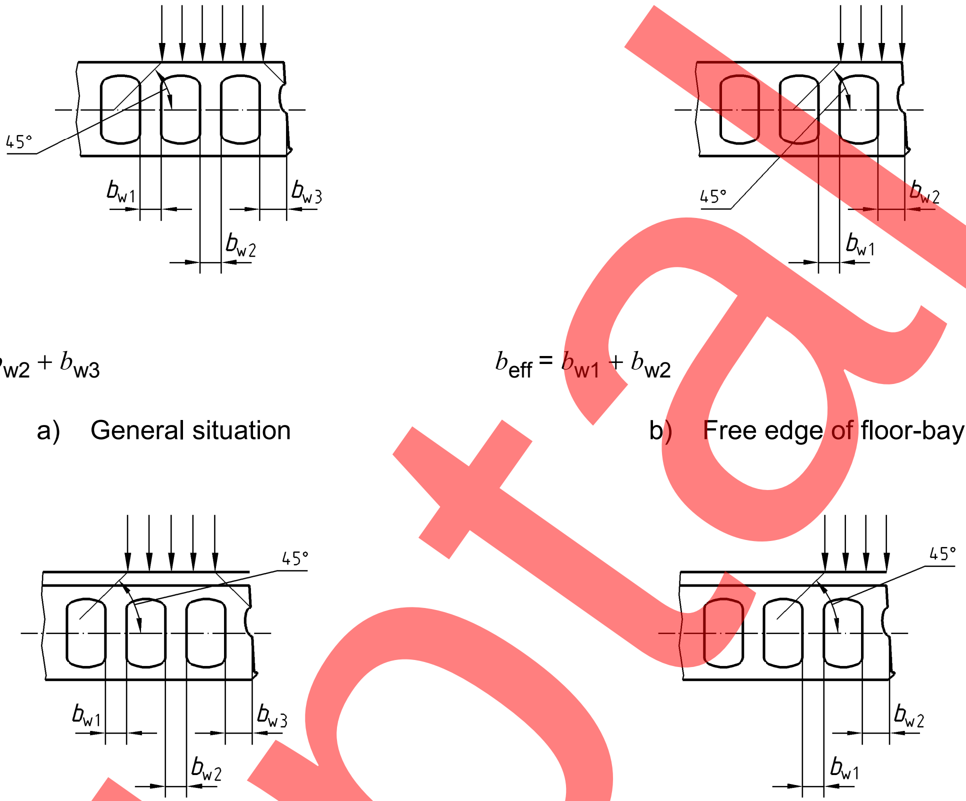
$$V_{Rd} = b_{eff}\ h\ f_{ctd} \left(1 + 0{,}3\alpha\ \frac{\sigma_{cp}}{f_{ctd}}\right)$$

with $\alpha = \frac{\ell_x}{\ell_{bpd}} \leq 1$ according to 6.2.2 of EN 1992-1-1:2004

where

b_{eff} is the effective width of the webs according to Figure 5 ;

σ_{cp} is the concrete compressive stress at the centroidal axis due to prestressing.



$b_{eff} = b_{w1} + b_{w2} + b_{w3}$

a) General situation

$b_{eff} = b_{w1} + b_{w2}$

b) Free edge of floor-bay

$b_{eff} = b_{w1} + b_{w2} + b_{w3}$

c) General situation with structural topping

$b_{eff} = b_{w1} + b_{w2}$

d) Free edge of floor-bay with structural topping

Figure 5 — Effective width

For concentrated loads of which more than 50 % is acting on outermost web (b_{w2} in Figures 5 b) and 5 d)) of a free edge of a floor bay, the resistance resulting from the equation is applicable only if at least one strand or wire in the outermost web and a transverse reinforcement are present. If one of these or both conditions are not satisfied, the resistance shall be divided by a factor of 2.

The transverse reinforcement shall be strips or bars at the top of the element or in the structural topping, with a length of at least 1,20 m and fully anchored, and shall be designed for a tensile force equal to the total concentrated load.

If a load above a core has a smaller width than half of the width of the core, a second resistance shall be calculated with the same equation, but in which h shall be replaced by the smallest thickness of the upper flange and b_{eff} by the width of the loading pad. The lowest value of the calculated resistances shall be applied.

If a structural topping is used, the thickness of the topping may be taken into account for calculation of punching shear capacity.

4.3.3.2.5 Capacity for concentrated loads

Concentrated loads will cause transverse bending moments. Since the elements have no transverse reinforcement the tensile stresses due to this bending moments shall be limited.

The limiting value depends on the basic design assumptions concerning load distribution.

If the elements are designed assuming no load distribution, which means that all loads acting on an element should be resisted by that element, the limiting value of the tensile stress is $f_{\mathrm{ctk}\ 0,05}$ in the serviceability limit state. In this case for elements without topping, in the serviceability limit state, the capacities for concentrated loads q_k and F_k are calculated in the absence of particular justifications as follows:

— for a linear load not on an edge of a floor area: $q_\mathrm{k} = \dfrac{20 W_{\ell \mathrm{b}} f_{\mathrm{ctk}0,05}}{\ell + 2b}$

— for a linear load on an edge of a floor area: $q_k = \dfrac{10 W_{\ell \mathrm{t}} f_{\mathrm{ctk}0,05}}{\ell + 2b}$

— for a point load anywhere on a floor area: $F_\mathrm{k} = 3\ W_\ell f_{\mathrm{ctk}\ 0,05}$

where

$W_{\ell\mathrm{b}}$ is the minimum section modulus in transverse direction per unit length related to the bottom fibre of the elements;

$W_{\ell\mathrm{t}}$ is the minimum section modulus in transverse direction per unit length related to the top fibre;

W_ℓ is the smaller of $W_{\ell\mathrm{b}}$ or $W_{\ell\mathrm{t}}$.

If the elements are designed by assuming load distribution according to the elastic theory, which means that a part of the loads acting on one element are distributed to adjacent elements, the limiting value of the tensile stress is f_ctd in the ultimate limit state.

The capacities for concentrated loads in this case, in the ultimate limit state, may be derived from the same equation, but in which q_k, F_k and $f_{\mathrm{ctk}\ 0,05}$ shall be replaced by q_d, F_d and f_ctd.

4.3.3.2.6 Load capacity of elements supported on three edges

Distributed imposed loads on an element of the floor with one supported longitudinal edge will cause torsional moments. The resulting support reaction due to this torsion shall be ignored in the design in the ultimate limit state.

The shear stresses due to these torsional moments shall be limited to $f_{\mathrm{ctk}\ 0,05}/1,5$ in the serviceability limit state.

The load capacity q_k for imposed load per unit area which is the total load minus the load due to the self weight of the elements, shall be calculated, in the serviceability limit state, as follows:

$$q_\mathrm{k} = \frac{f_{\mathrm{ctk}0,05} W_\mathrm{t}}{0,06 \ell^2}$$

with $W_t = 2t\,(h - h_f)(b - b_w)$

where

W_t is the torsional section modulus of an element according to the elastic theory;

t is the smallest of the values of h_f and b_w ;

h_f is the smallest value of the upper or lower thickness of the flange;

b_w is the thickness of the outermost web.

4.3.3.3 [A2) Verification by calculation aided by physical testing

The shear resistance obtained by calculation shall be confirmed by physical full scale testing according to Annex J. (A2]

4.3.4 Resistance and reaction to fire

4.3.4.1 Resistance to fire

Complementary to 4.3.4.1 to 4.3.4.3 of EN 13369:2004 the calculation method and tabulated data in Annex G of this standard may be used.

NOTE The topping or screed cast directly on the precast unit may be taken into account in the fire resistance of the floor for the separating function; the fire resistance given for a hollow core element is valid when installed in a floor structure with necessary tying system according to EN 1992-1-1:2004.

4.3.4.2 Reaction to fire

For reaction to fire, 4.3.4.4 of EN 13369:2004 shall apply.

4.3.5 Acoustic properties

Clause 4.3.5 of EN 13369:2004 shall apply.

NOTE The impact sound insulation of a building is influenced by the total floor structure, including floor-covering, support conditions, joint details and walls.

4.3.6 Thermal properties

Complementary to 4.3.6 of EN 13369:2004 the following rules may apply.

A rough approximation of the thermal resistance of hollow core slabs (height > 0,2 m) may be estimated as follows:

$$R_c = 0{,}35\,(h + 0{,}25)$$

where

R_c is the thermal resistance of the slabs (exclusive [A1) surface (A1] resistance), in square metres Kelvins per Watt;

h is the total height of the elements, in metres.

4.3.7 Durability

Clause 4.3.7 of EN 13369:2004 shall apply.

4.3.8 Other requirements

Clause 4.3.8 of EN 13369:2004 shall apply.

5 Test methods

5.1 Tests on concrete

Clause 5.1 of EN 13369:2004 shall apply.

5.2 Measuring of dimensions and surface characteristics

Complementary to 5.2 of EN 13369:2004 the following subclauses shall apply.

5.2.1 Element dimensions

5.2.1.1 Procedure

For the dimensions hereafter, the indicated procedures shall be applied:

a) slab depth h:

Take six measurements at one end of the slab (three at core and three at web centre lines): two near the middle, two near each edge of the slab. The result is the mean of these six measurements. Compare the result with the permissible values according to 4.3.1.1.1 a).

For elements not wider than 0,6 m, the number of measurements may be decreased to three.

b) web thickness b_w :

Take measurements of the minimum thickness of each web at one end of the slab.

Sum up the measurements.

Compare each individual value b_w and the total sum Σb_w with the permissible values according to 4.3.1.1.1 b).

c) flange thickness h_f :

Take six measurements at one end of the slab (three at lower flange, three at upper flange): two near the middle, two near each edge of the slab.

Calculate the mean value for lower flange and for upper flange values separately.

Compare each individual value and the two mean values with the permissible values according to 4.3.1.1.1 c).

For elements with a width smaller than 0,6 m, the number of measurements may be decreased to three.

d) slab length l :

Take two measurements: one near each edge.

Compare each individual value with the permissible values according to 4.3.1.1.2 a).

e) slab width b :

Take one measurement at one end of the slab where the cross-section is the widest.

Compare the value with the permissible value according to 4.3.1.1.2 b).

f) position of prestressing steel or reinforcing bars at tensile side:

Measure the vertical distance of the axis of each strand, wire or bar to the bottom of the slab or to the mould.

Compare each individual value and the mean value for the centre of gravity of the prestressing steel with the permissible values according to 4.3.1.2.2 and 4.3.1.2.3.

g) concrete cover c :

Measure the concrete cover of each strand, wire or bar at one end of the slab from the bottom of the slab and from the nearest core surface.

Compare each individual value with the permissible values according to 4.3.1.1.3.

5.3 Weight of the products

Clause 5.3 of EN 13369:2004 shall apply.

6 Evaluation of conformity

6.1 [A2⟩ General

6.1 of EN 13369:2004 shall apply.

6.2 Type testing

6.2.1 General

Consequently to 4.2 and 4.3.3.3, hollow core slabs shall be submitted to full scale type testing according to Annex J. Further full scale testing in the framework of the factory production control (see 6.3) is not required when the tests results are in accordance with the calculated values after J.5.

For the purpose of full scale type testing hollow core slabs made on the same type of production machines and with the same concrete strength with similar shape of cores may be grouped into a product family if the nominal depth h stays into a range of 50 mm and the nominal relative total web thickness $\sum b_{w\text{-}rel}$ of the cross sections stays into a range of 50 mm/m.

NOTE 1 The boarder of the range of 50 mm can be chosen by the producer, e.g. the depth of a product family can enclose 150 mm to 200 mm, but 175 mm to 225 mm is also possible. The same principle applies to the relative total web thickness.

NOTE 2 The relative total web thickness $\sum b_{w\text{-}rel}$ is equal to the total web thickness $\sum b_w$ (in mm) (see 4.3.1.1.1) divided by the slab width (in m).

If a production facility consists of two or more production machines of the same type, type testing may be limited to one machine as far as at least the same compaction level of concrete is demonstrated on the other machines by appropriate concrete strength tests on concrete specimen sampled from the production of each machine concerned as described in A.3, item 10.

Results of full scale testing shall be recorded after J.6.

6.2.2 Initial type testing

Complementary to 6.2.2 of EN 13369:2004 the following shall apply.

Initial type testing according to Annex J shall be performed at the start up of:

— one or more new cross sections to confirm the shear resistance obtained by calculation;

— a new production facility to confirm the proper functioning of the production machine(s).

Initial type testing shall be carried out for each singular cross section or if the sections are grouped into families (see 6.2.1), for a single section of each family.

For each cross section to be tested:

— the prestressing or reinforcement level shall be at least 75 % of the maximum level scheduled for the given cross section;

— three identical elements shall be tested and the reliability criteria of J.5 shall be checked for the individual and mean test results.

NOTE Even to confirm the proper functioning of the casting equipment, the check of the criteria of J.5 requires calculation of shear capacity, irrespective of the declaration of the mechanical resistance properties to the market or not by the manufacturer.

Cross sections belonging to the ongoing production legally put on the market at the date of publication of this amendment should not be considered as new and should be dispensed consequently from type testing.

6.2.3 Further type testing

Complementary to 6.2.3 of EN 13369:2004 the following shall apply.

Further full scale type testing according to Annex J shall be performed if there is a major change in the design of the cross sections, in concrete strength, in the type or operating principal of the production machine or if there is another change which could significantly affect shear resistance.

Further full scale type testing shall be made on at least one product-family to confirm the shear resistance obtained by calculation (see 6.2.2).

The change of concrete compressive strength by more than 1 class shall be considered as a major change of concrete strength.

Further type testing according to Annex J may also be required in case of doubt about proper functioning of the production machine on the base of the factory production control inspections (e.g. slippage of tendons or failing concrete compaction).

Depending on the nature of the change, 6.2.2 shall apply for the relevant sections and facilities.

6.3 Factory production control

Complementary to 6.3 of EN 13369:2004 following clause shall apply.

The inspection schemes of Annex D of EN 13369:2004 are completed as given in Annex A. A2

7 Marking

Complementary to 7 of EN 13369:2004 the following subclause shall apply.

7.1 General

Every individual delivered slab shall be definitely identifiable and traceable until erection with regard to its production site and data. For this purpose the manufacturer shall mark the products or the delivery documents so the relation to the corresponding quality records required in this standard can be secured. The manufacturer shall keep these records for the required period of archiving and make them available when required.

NOTE For CE marking refer to Annex ZA.

8 Technical documentation

The detailing of the element, with respect to geometrical data and complementary properties of materials and inserts, shall be given in technical documentation, which includes the construction data, such as the dimensions, the tolerances, the layout of reinforcement, the concrete cover, the expected transient and final support conditions and lifting conditions.

The composition of technical documentation is given in clause 8 of EN 13369:2004.

Annex A
(normative)

Inspection schemes

The relevant subjects of Annex D of EN 13369:2004 shall apply. Complementary to these subjects following schemes shall also apply.

A.1 Equipment inspection

Table A.1 is complementary to D.1.2 of Table D.1 of EN 13369:2004.

Table A.1 — Equipment inspection

	Subject	Method	Purpose	Frequency
Storage and production requirement				
9	Casting machine/equipment	Manufacturer inspection instructions	Correct compacting of concrete Correct core geometry	Manufacturer inspection instructions

A.2 Process inspection

Table A.2 is complementary to D.3.1 and. D.3.2 of Table D.3 of EN 13369:20004.

Table A.2 — Process inspection

	Subject	Method	Purpose[a]	Frequency*
Concrete and other process subjects				
19	Concrete mix	Visual inspection (see Table 18 of [A1) EN 206-1:2000 (A1])	Consistency	Every batch
20	Compressive strength of concrete	Strength test on moulded concrete specimens or maturity measurement or with rebound hammer or sound velocity meter after calibration by laboratory tests (see 6.3.8 of EN 13369:2004)	Detensioning strength	One specimen every day per casting bed
21	Accelerated hardening	Verification of relevant conditions Measuring temperatures	Conformity with intended factory procedures	Weekly Depending on process
22	Cross section	Visual inspection of deviations and imperfections	Accuracy	Every casting bed

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

A.3 Finished product inspection

Table A.3 is complementary to items 3 to 5 of D.4.1 of Table D.4 of EN 13369:2004.

Table A.3 — Finished product inspection

	Subject	Method	Purpose[a]	Frequency[a]
Product Testing				
		ⒶⅡ *deleted text* ⒶⅡ		
2	Initial slippage of strands	Measuring of slippage for non sawn elements	Conformity with maximum value according to 4.2.3.2.4 of EN 13369:2004	Three strands per bed per production day
		Visual inspection of sawn elements and measuring	Conformity with maximum value according to 4.2.3.2.4 of EN 13369:2004	Visual inspection of all elements and if there is no doubt measuring three strands per production day. In case of doubt measuring of all concerning strands
6	Cross section and length	Measuring according to 5.2	Dimensions	One element of every concrete cross section, including at least one element per machine every two production weeks
7	Ends of element	Visual inspection	Splitting cracks	Each sawn end
		Measuring at ends according to 5.2.1.1.g	Concrete cover	As for cross section
8	Upper surface characteristics of rough or indented interface in case of use with an in situ topping	Visual inspection	Roughness for shear resistance	As for cross section
9	Drainage holes where specified	Visual inspection	Accurate drilling	Daily
10	Concrete strength	On drilled cores from the product according to EN 12504-1 and EN 12390-3 and assessment according to [A1) EN 13791 (A1] or on cubes or cylinders according to EN 12390-2 and EN 12390-3 or On drilled cores from product according to EN 12390-6 and EN 12504-1	Compressive strength or tensile splitting strength[b]	At start of production or introduction of a new element type: three per full scale test At start of production or introduction of a new element type: three per full scale test

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

[A2) *delete text* (A2]

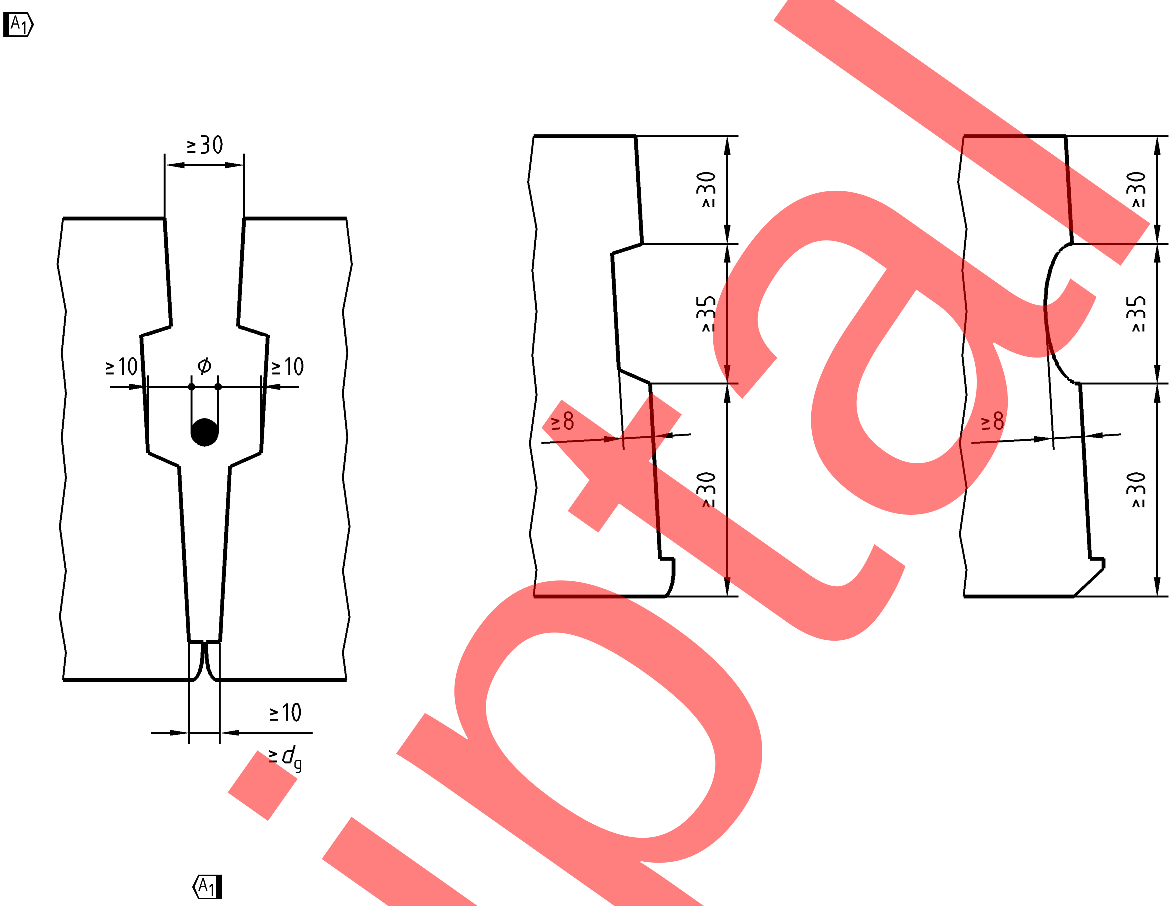
[b] Following the production process the producer can choose for one of the mentioned methods.

Annex B
(informative)

Typical shapes of joints

Examples of typical shapes of longitudinal joints are shown in Figure B.1.

Dimensions in millimetres



a) Joint with a tie bar   b) Trapezial groove   c) Semicircular groove

Key

d_g = Largest nominal maximum aggregate size of the mortar of the joint.

Figure B.1 — Typical shapes of longitudinal joints

Dimensions in millimetres

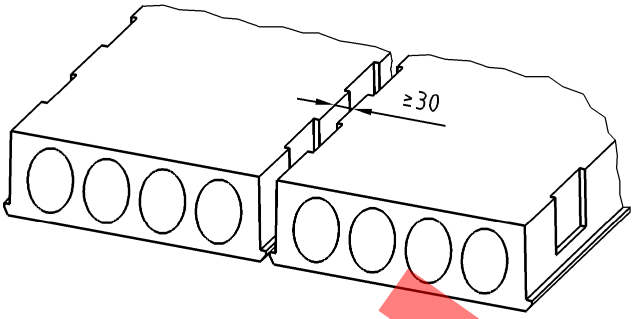


Figure B.2 — Example of indented joint profile of reinforced slabs

Annex C
(informative)

Transverse load distribution

C.1 Calculation method

The following two methods can be distinguished:

1) load distribution according to the theory of elasticity.

The elements should be regarded as isotropic or anisotropic slabs and the longitudinal joints as hinges.

The percentage of the load on the directly loaded element as obtained by the calculation, should in ultimate limit state be multiplied with 1,25 ; the total percentage share carried by the indirectly loaded elements may be decreased by the same amount according to the ratio of their loading percentages.

Instead of a calculation the load distribution may be determined by means of graphs based on the theory of elasticity. In C.4 and C.5 such graphs are given for elements with a width b = 1,20 m. For any other width such graphs may be elaborated.

The requirements of 4.3.3.2.5 shall be met.

2) No load distribution.

Every element should be designed with all loads acting directly on that element and assuming zero shear forces in the transverse joints. In this case, the transverse load distribution and the allied torsional moments may be ignored in ultimate limit state. In serviceability limit state, however, the requirements according to 4.3.3.2.5 and 4.3.3.2.6 should be met. The effective width shall be limited according to C.2.

The first method is only allowed if lateral displacements will be limited according to C.3 and, in absence of a structural topping, the joints are provided with longitudinal grooves according to Figure B.1.

If these conditions are not met, the load distribution should be ignored and the design should be based on the second method.

Line loads parallel to the span of the elements and not greater than 5 kN/m may be replaced by a uniformly distributed load over a width equal to a quarter of the span at both sides of the load. If the available width next to the load is smaller than a quarter of the span, the load should then be distributed over a width equal to the available width at one side plus a width equal to one quarter of the span at the other side.

C.2 Limitation of effective width

If the design analysis in ultimate limit state is based on the second method of C.1 for point loads, and for line loads with a characteristic value greater than 5 kN/m, the maximum effective width should be limited to the width of the load enlarged by:

— in the case of loads within the floorfield, twice the distance between the centre of the load and the support, but not greater than the width of the loaded element;

— in the case of loads on free longitudinal edges, once the distance between the centre of the load and the support, but not greater than half the width of the loaded element.

C.3 Lateral displacements

If the design is based on method 1 of C.1, lateral displacements of the units should be prevented by any of the following:

a) the surrounding parts of the structure;

b) the friction at the supports;

c) the reinforcement in the transverse joints;

d) the peripheral ties;

e) a reinforced topping.

Relying on friction at the supports is only allowed in non-seismic situations, if it can be proven that sufficient friction can be developed. Calculating the resistant friction forces, the actual bearing method should be taken in consideration.

The required resistance should be at least equal to the total vertical shear forces which have to be transmitted across the longitudinal joints.

C.4 Load distribution factors for centre and edge loads

Load distribution factors for centre and edge loads are the following:

a) in Figures C.1, C.2 and C.3, the loading percentages for a centre and an edge load have been given. A load may be considered as a centre load if the distance from the load to the edge of the floor area is at least 3 m (2,5 b). For loads between edge and centre the loading percentages may be derived from linear interpolation;

b) in Figures C.2 and C.3, the distribution factors for point loads at midspan ($\ell/x = 2$) have been given. For loads near to the support, $\ell/x \geq 20$, the loading percentages of the actual loaded slab should be taken 100 % and of the non-loaded slabs 0 %. For ℓ/x values between 2 and 20, the loading percentages may be derived from linear interpolation;

c) determining the loading percentages, linear loads with a length greater than half of the span should be considered as linear loads. Linear loads with a length smaller than half of the span should be considered as linear loads if the centre of the load is at midspan, and as point loads in the centre of the load if the centre is not at midspan;

d) in floors without a topping, the percentages of the loading, determined by the graphs, should in ultimate limit state be modified as follows:

— the percentage of the load on the directly loaded element should be multiplied by 1,25;

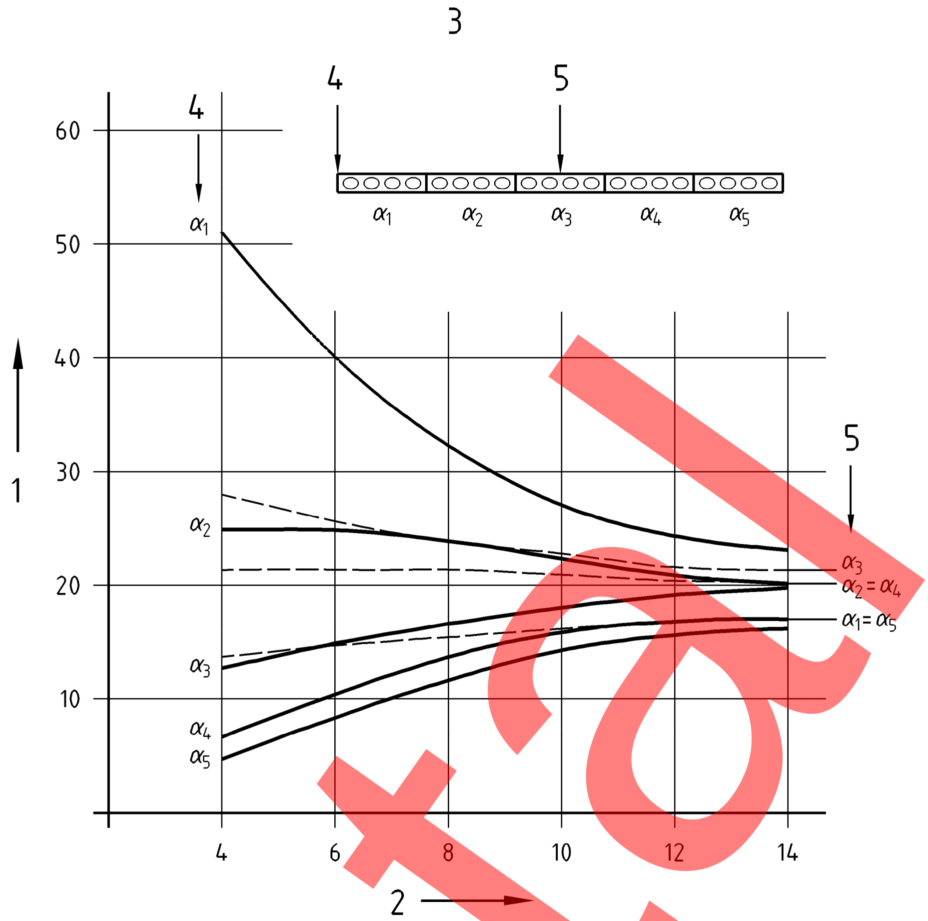
— the total percentages of the not directly loaded elements may be decreased by the same amount according to the ratio of their loading percentages;

e) the shear forces in the joints should be calculated from the loading percentages and should be considered as being linearly distributed:

— for point loads not at midspan and linear loads which, according to c), have to be considered as point loads, the effective length of the joint transmitting the shear force should be chosen equal to two times the distance from the centre of the load to the nearest support (see Figure C.4);

f) from the loading percentages, given in the graphs, the longitudinal shear forces in every joint and from that values the torsional moments in every element can be derived.

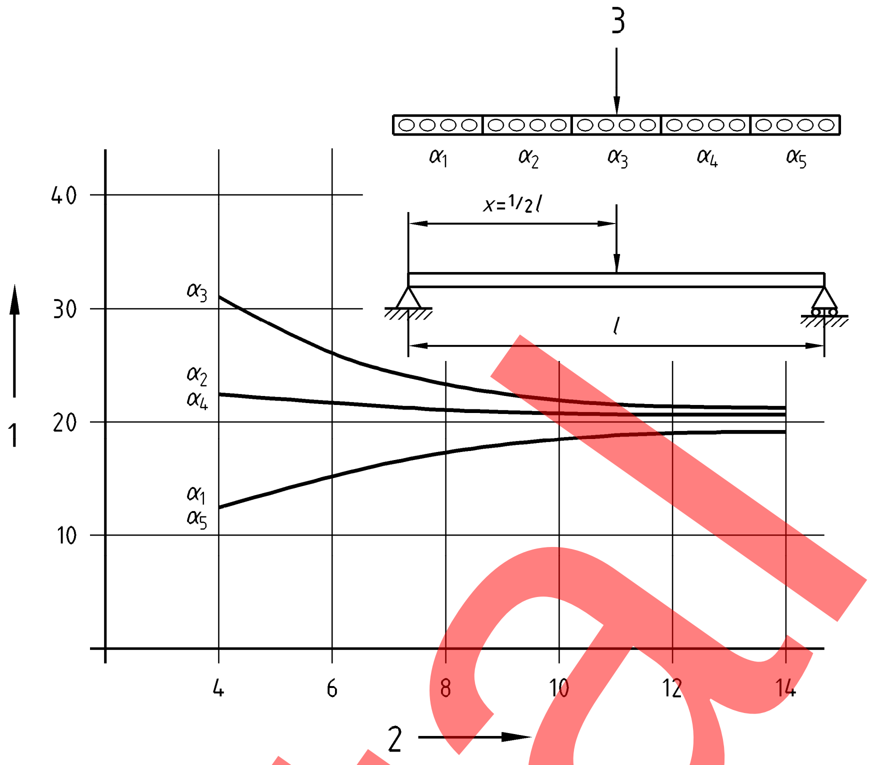
If lateral displacements are limited according to C.3, the torsional moments may be divided by a factor 2.



Key

1 Loading percentage (%)
2 Span (*l*) in m
3 Linear loads
4 Edge
5 Centre

Figure C.1 — Load distribution factors for linear loads



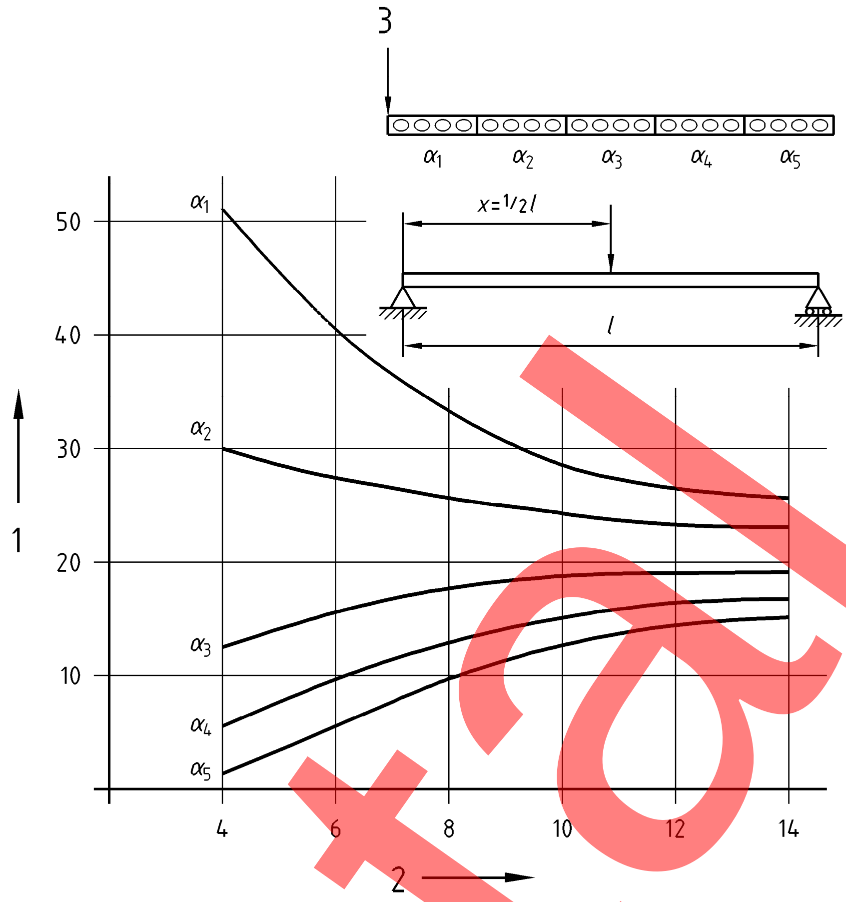
Key

1 Loading percentage (%)

2 Span (*l*) in m

3 Point load

Figure C.2 — Load distribution factors for point loads in centre



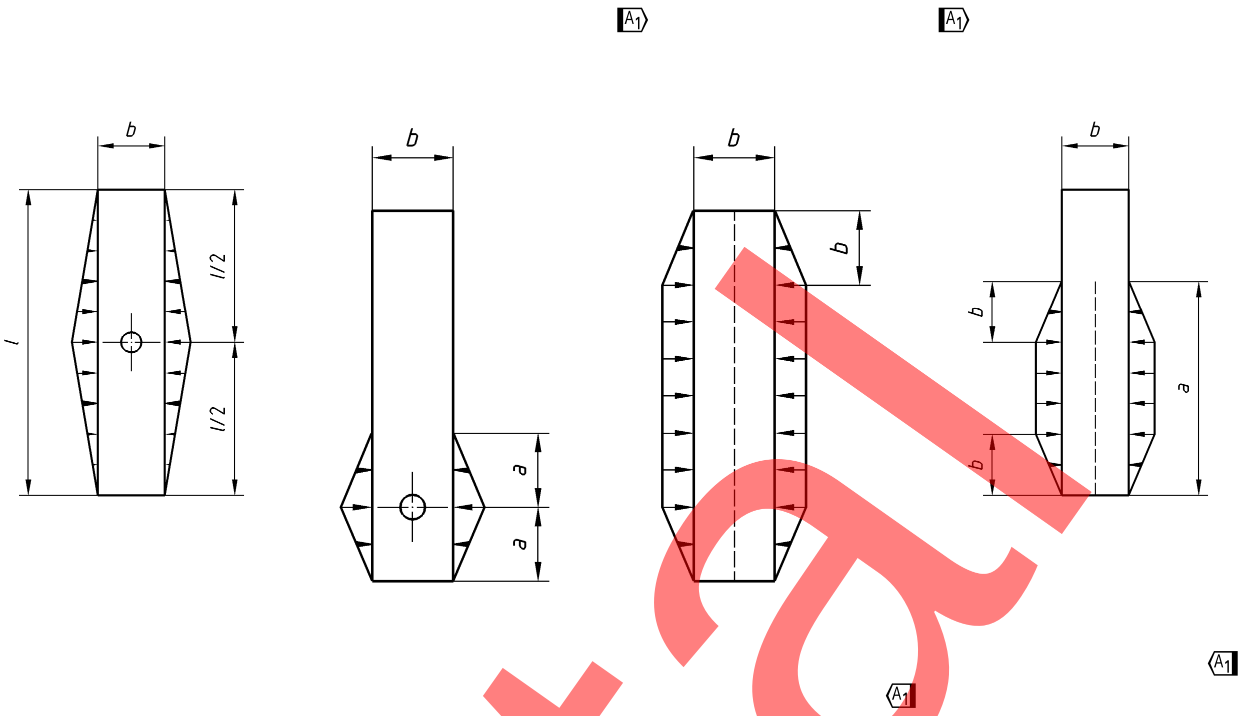
Key

1 Loading percentage (%)

2 Span (*l*) in m

3 Point load

Figure C.3 — Load distribution factor for point loads at edge



a) Point load in centre b) Point load between centre and support c) Linear load in centre d) Linear load not in centre

Figure C.4 — Assumed shape of vertical shear forces in joints

C.5 Load distribution factors for three or four supported edges

Load distribution factors for three or four supported edges are the following:

a) for linear loads and point loads, the reaction forces may be based on Figures C.5 and C.6.

Load distribution factors for three or four supported edges are the following.

If the number of elements (n) is larger than 5, the reaction force should be multiplied by the factor (see Figures C.5 and C.6):

$$1-\left(\frac{n-5}{50}\times\frac{s}{b}\right)$$

where

s is the distance of the load from the support, in millimetres;

b is the width of the slab in millimetres.

In the case of four supported edges, the reaction force of the support nearest to the force should be multiplied by the factor :

$$\frac{nb - s}{nb}$$

b) If the distance between the load and the longitudinal support is greater than 4,5 b, the reaction force may be taken as zero.

c) When determining the reaction forces, linear loads with a length greater than half the span should be considered as linear loads. Linear loads with a length smaller than half the span should be considered as linear loads if the centre of the load is at midspan, and as point loads if the centre of the load is not at midspan.

The reaction force of Figure C.5, may be multiplied by the ratio of the length of the load to the length of the span.

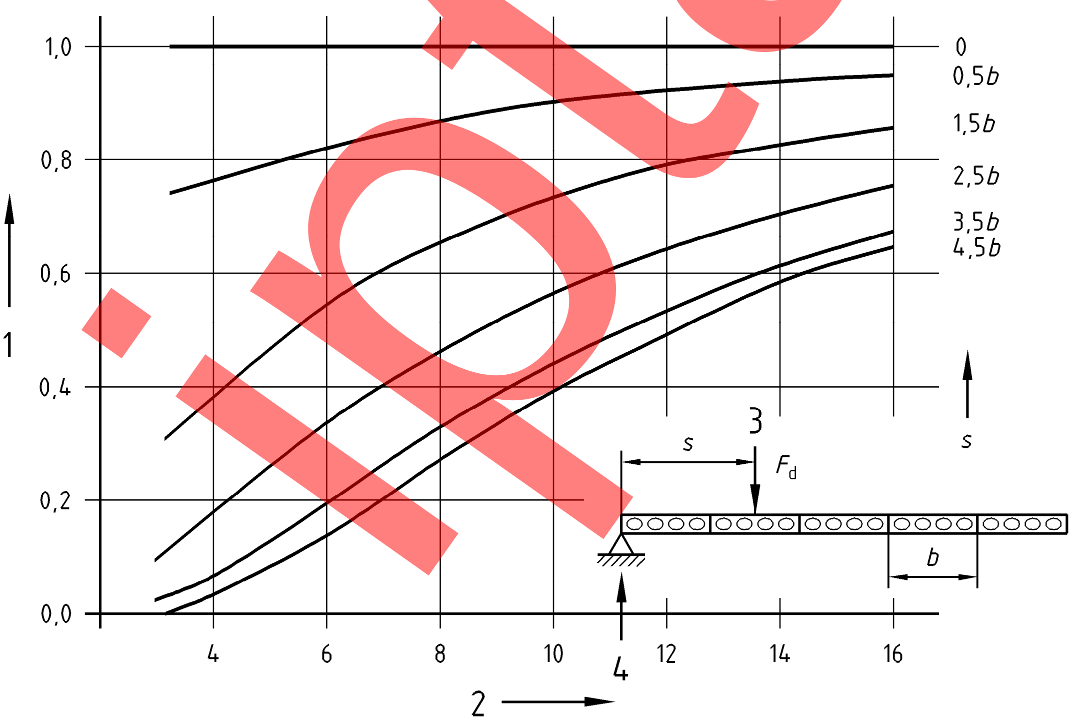
d) For point loads at midspan, ℓ/x = 2, the reaction forces can be taken from Figure C.6.

For loads near to the support, ℓ/x ≥ 20, the reaction force should be taken zero; for values of ℓ/x between 2 and 20 the reaction force should be calculated by linear interpolation.

The length of the reaction force should be chosen equal to two times the distance between the centre of the load and the nearest support.

The magnitude of the force is the value from Figure C.6 multiplied by 2x/ℓ.

e) The transverse distribution due to the reaction force should be calculated according to C.4 by considering the reaction force as a (negative) edge load.



Key

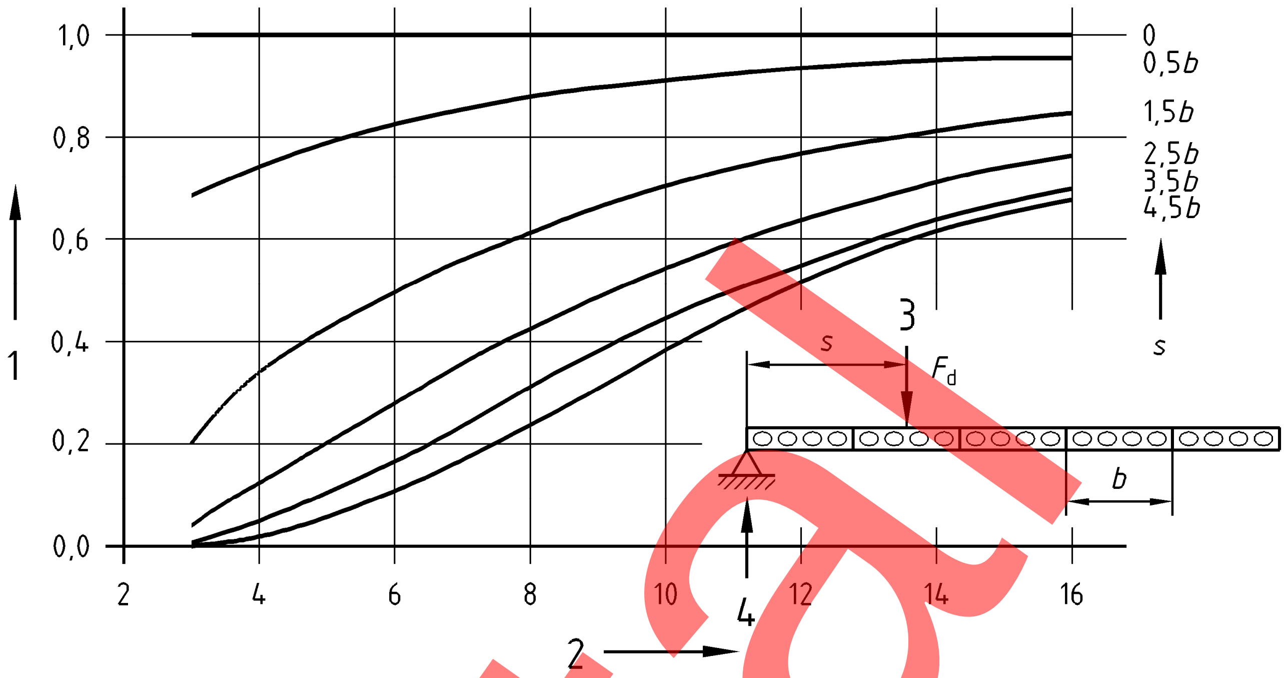
1 Reaction force/linear load

2 Span (l) in m

3 Linear load

4 Reaction force

Figure C.5 — Reaction force at longitudinal support due to linear load



Key

1 Reaction force x span/point load

2 Span (*l*) in m

3 Point load

4 Reaction force

Figure C.6 — Reaction force at longitudinal support due to a point load at midspan

Annex D
(informative)

Diaphragm action

Hollow core floors can act as diaphragms for the transfer of lateral forces to the bracing vertical structures if the following requirements are satisfied:

a) the shear forces should be resisted either by the joints parallel to the load or by special shear members along perpendicular joints or edges;

b) the calculation of the horizontal shear forces in longitudinal joints should be based on the theory of deep beams;

c) the model for a deep beam is usually a strut and tie model. The inner lever arm used for the determination of the force in the tensile tie should therefore be taken from code provisions pertaining to deep beams.

The resistance of the longitudinal joints to in-plane shear forces should be derived from 6.2.5 of EN 1992-1-1:2004.

If the design shear force exceeds this joint capacity, the capacity can be increased by:

— taking account of shear capacity of edge beams;

— application of special shear connectors.

If the diaphragm action is small, like in the case of low-rise housing, the tying system in non-seismic situations may be based on friction. Calculating the resistant friction forces, the actual bearing method should be taken into consideration.

In seismic zones, the design should be carried out considering the diaphragm behaviour of the hollow core floor with the longitudinal shear stress given in 10.9.3 (12) of EN 1992-1-1:2004, if one of the following requirements is satisfied:

— with a cast-in-situ topping of at least 40 mm for which shear at the interface is verified according to 6.2.5 of EN 1992-1-1:2004;

— in the absence of a cast-in-situ topping and all the hollow core slabs are provided with adapted indented lateral edges, as described in 6.2.5 of EN 1992-1-1:2004 (Figure 6.9);

— a system of horizontal appropriately designed ties is provided.

Annex E
(informative)

Unintended restraining effects and negative moments

E.1 General

Unintended restraining effects and negative moments at the supports should be considered in the design of the elements and detailing of the connections at the supports to prevent possible restraint cracks which can initiate shear failure near the support.

There are three methods to deal with negative or unintended fixing moments:

— detailing the connection in such a way that these moments will not occur;

— designing and detailing in such a way that cracks will not initiate unsafe situations;

— design by calculation.

E.2 Design by calculation

The following design by calculation may be adopted:

a) at end supports, which have been assumed as free supports, unless through the nature of the support no fixing moment can develop, the smaller of the two values calculated with E1 or E2 of M_{Edf} should be taken into account :

$$M_{\mathrm{Edf}} = \frac{M_{\mathrm{Eds}}}{3} \quad \text{... (E.1)}$$

where

M_{Eds} = $\gamma_{\mathrm{G}} (M_{\mathrm{gs}} - M_{\mathrm{ws}}) + \gamma_{\mathrm{Q}} M_{\mathrm{qs}}$;

M_{gs} is the maximum characteristic value of span moment due to permanent actions;

M_{qs} is the maximum characteristic value of span moment due to variable actions;

M_{ws} is the maximum characteristic value of span moment due to the self weight of the elements;

$\gamma_{\mathrm{G}}, \gamma_{\mathrm{Q}}$ = partial safety factors for permanent and variable actions;

A1) $$M_{\mathrm{Edf}} = \frac{2}{3} N_{\mathrm{Edt}} a + \Delta M \quad \text{(E.2)}$$ (A1

with ΔM taken equal to the largest value of:

$\Delta M = f_{\mathrm{ctd}} W$

and

$\Delta M = f_{\mathrm{yd}} A_{\mathrm{y}} d + \mu_{\mathrm{b}} N_{\mathrm{Edt}} h.$

If the joints between the ends of the element are smaller than 50 mm or if the joints are not filled, then ΔM is taken equal to the smallest value of:

$$\Delta M = \mu_b N_{Edt} h$$

and

$$\Delta M = \mu_0 N_{Edb} h$$

where (see also Figure E.1):

a is the support length as shown on Figure E.1;

A_y is the cross-section of possible connection reinforcement;

d is the distance from the lower fibre of slab to the position of connection reinforcement;

f_{yd} is the design yield strength of steel;

N_{Edt} is the design value of the total normal force in the structure above the floor;

N_{Edb} is the design value of the total normal force in the structure beneath the floor;

W is the section modulus of the in situ concrete between the ends of the elements;

μ_0 is the coefficient of friction at the underside of the slab;

μ_b is the coefficient of friction at the upperside of the slab;

μ_0 and μ_b being taken equal to 0,8 for concrete on concrete;

0,6 for concrete on mortar;

0,25 for concrete on rubber or neoprene;

0,15 for concrete on hair felt;

b) reinforcement for the unintended fixing moments may be omitted if:

$$M_{Edf} \leq 0{,}5\ (1{,}6 - h)\, f_{ctd}\, W_t$$

where

h is the height of the slab in *m*;

W_t is the section modulus related to the top fibre;

c) if, according to b), reinforcement for unintended fixing moments is required, or in case of negative design moments, then three possibilities may be considered:

1) applying top strands;

2) applying reinforcing bars in the longitudinal joints or in the cores;

3) applying a reinforced topping.

In all three cases, besides the check of shear in the elements related to positive moments and the corresponding positive reinforcement, a second check according 4.3.3.2.2 related to the negative moments and corresponding negative reinforcement should be carried out.

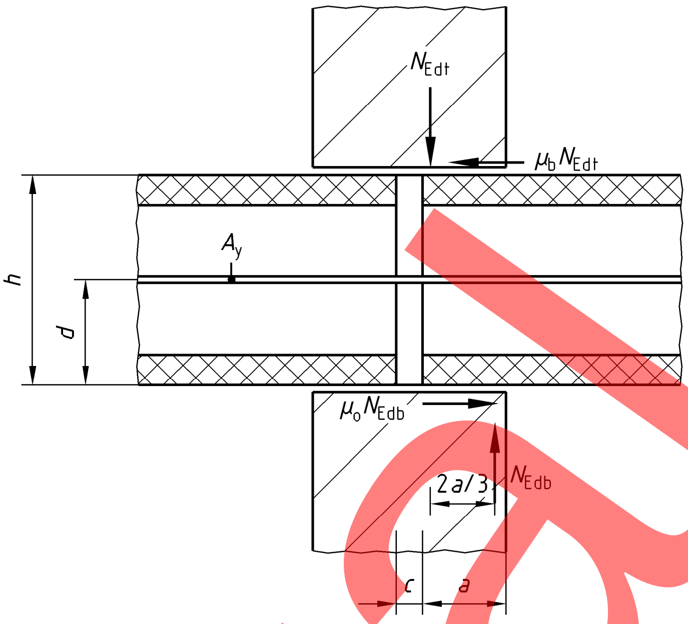


Figure E.1 — Unintended fixing moments

If reinforcing bars or a reinforced topping is used the second check should be carried out according to 6.2.2 of EN 1992-1-1:2004.

Annex F
(informative)

Mechanical resistance in case of verification by calculation: shear capacity of composite members

F.1 General

The shear resistance of precast hollow core slabs can be increased by applying an in-situ topping and/or filling a number of cores. The length of the filling should be at least the larger of the following two values:

— the transmission length for the prestressing force;

— the length necessary for the shear capacity plus the total depth of the cross section.

In general two loading conditions have to be considered:

Loading condition I, which refers to the self weight of the slab and of the in-situ topping. This load is carried by the precast element.

Loading condition II, which refers to the additional load on the composite structure. This load is carried by the composite structure.

F.2 Shear tension capacity of a hollow core slab with a topping

F.2.1 Failure types

Failure can principally occur in two ways:

— type a: the webs of the slab fail in shear;

— type b: the interface shear strength is exceeded and the topping shears off.

A check of failure type a should be carried out according to F.2.2 and a check of failure type b according to F.2.3.

F.2.2 Failure types *a*

The check of the shear tension capacity A1⟩ τ_{Rd} ⟨A1 according to EN 1992-1-1:2004 should be replaced by the following requirement:

$$\tau_{Ed} \leq \tau_{Rd}$$

With A1⟩ $\tau_{Ed} = \frac{V_{Edg} S}{\Sigma b_w I} + \frac{V_{Edq} S_o}{\Sigma b_w I_o}$ ⟨A1

and A1⟩ $\tau_{Rd} = \varphi \sqrt{f_{ctd}^2 + \beta \alpha \sigma_{cp} f_{ctd}}$ ⟨A1

in which A1⟩ $\alpha = \frac{\ell_x}{\ell_{pt2}} \leq 1$ ⟨A1 according to 6.2.2 of EN 1992-1-1:2004.

where

V_{Edg} is the design shear force due to dead load (element + topping);

V_{Edq} is the design shear force due to additional loads;

S, S_o is the first moment of area of element, respectively of (element + topping);

I, I_o is the second moment of area of element, respectively of (element + topping);

f_{ctd} is the design tensile strength of the concrete of the elements;

ℓ_x is the distance from the end of the element to the considered action;

l_{pt2} is the upper bound of the transmission length equal to 1,2 the transmission length ℓ_{pt} according to EN 1992-1-1:2004 equation (8.18);

σ_{cp} [A1⟩ is the concrete compressive stress at the centroidal axis due to ⟨A1] the fully developed effective prestressing force (lower value);

[A1⟩ (for φ and β see 4.3.3.2.2.1) ⟨A1].

F.2.3 Failure type b

It should be shown that the shear stress in the interface joint due to the additional loads meets the requirement of 6.2.5 of EN 1992-1-1:2004.

F.3 Shear tension capacity of a hollow core slab with a number of filled cores

When the shear tension capacity [A1⟩ V_{Rdt} ⟨A1] of hollow core slab without filling is equal to $V_{Rd,c}$ according to EN 1992-1-1:2004 equation (6.4), the shear tension capacity of a slab with n cores filled is:

[A1⟩ $V_{Rdt} = V_{Rd,c} + 2/3\, n\, b_c\, d\, f_{ctd}$ ⟨A1]

where

f_{ctd} is the design tensile strength of the filling concrete;

n is the number of filled cores;

b_c is the width of the cores (see Figure F.1).

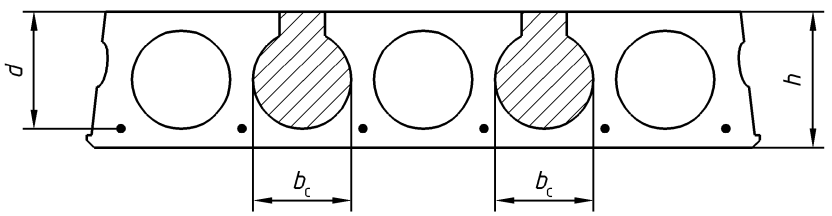


Figure F.1 — Slab with filled cores

F.3.1 Shear tension capacity of a hollow core slab with a topping and a number of filled cores

The shear tension capacity may be derived from the sum of the shear tension capacity according to F.2 and the shear tension capacity of the filled cores according to F.3.

F.4 Flexural shear capacity of a hollow core slab with a topping

For a slab with a topping, in the equation for the flexural shear capacity according to EN 1992-1-1:2004 equation (6.2 a + b), d may be replaced by d' and ρ_l by ρ'_l :

with $d' = d + h_t$

and $\rho'_1 = \dfrac{A_p}{b_w \, d'}$

where

h_t is the thickness of the topping;

A_s is the area of the tensile reinforcing steel;

A_p is the area of the prestressing steel.

In presence of filled cores a check must be carried out taking into account the characteristics of the composite section for the loading conditions I and II (see F.1).

Annex G
(informative)

Resistance to fire

G.1 Calculation method for load bearing conditions

Fire resistance (R) may be calculated according to 4.2 or 4.3 of EN 1992-1-2:2004 with the following additional information.

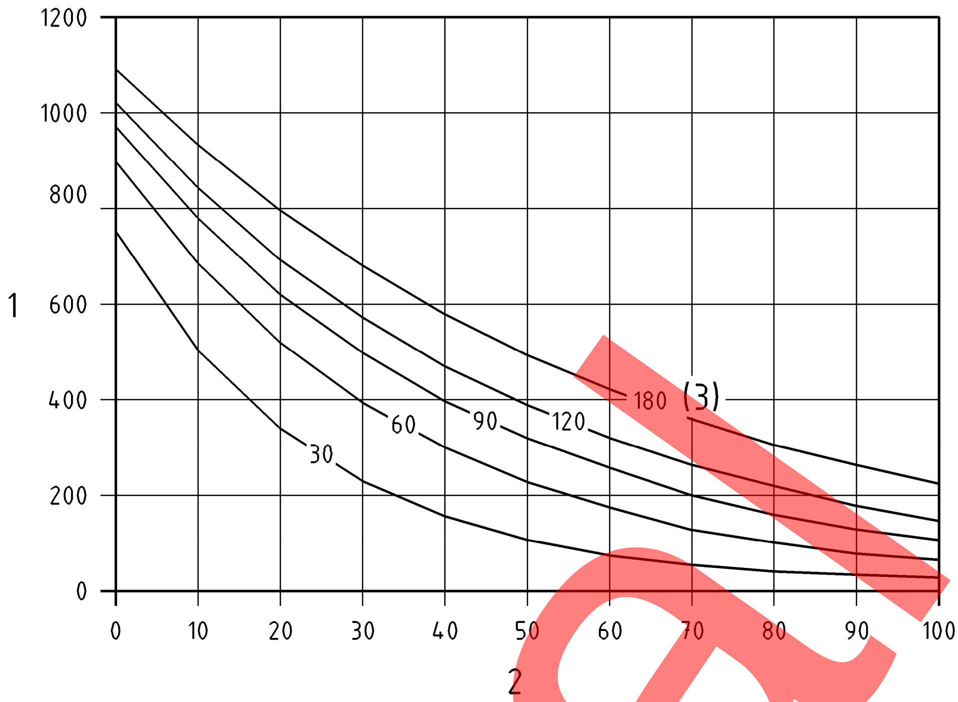
Temperature profiles given in Figure A.2. in EN 1992-1-2:2004 may be used (see Figure G.1), where a is the average axis distance of the steel from the soffit of the slab. The steel strength for the simplified calculation method is determined according to Figures 4.2 a), 4.2 b) or 4.3 of EN 1992-1-2:2004, and for the advanced calculation methods according to section 3 of EN 1992-1-2:2004.

The average axis distance may be decreased with 10 % in the case of concrete with calcareous aggregates.

Reduction of concrete strength and cross-section may be determined according to section 3 of EN 1992-1-2:2004.

When alternatively a simplified method is used to determine the fire resistance, it may be the one presented in Annex B, Annex D or Annex E of EN 1992-1-2:2004.

NOTE When topping or screed are cast directly on the precast unit, these ones may be taken into account, under particular conditions, in the fire resistance of the floor.



Key

1 Temperature θ (°C)

2 Distance from the exposed surface (mm)

3 Minutes

Figure G.1 — Temperatures within hollow core elements during fire for siliceous aggregate concrete

G.2 Tabulated data

When alternatively tabulated data are used, the fire resistance may be satisfied by the use of Table G.1 and the rules given in section 5 of EN 1992-1-2:2004, and for joints in separating structures the rules in 4.6 of EN 1992-1-2:2004. The table gives the thickness (h) of the slab, and values of axis distance (a) of reinforcing steel, to the soffit of simply supported slabs for normal weight concrete made with siliceous aggregates, which has to be met at least. If calcareous aggregates are used, the requirements of 5.1 of EN 1992-1-2:2004 apply.

Table G.1 — Nominal distance and slab thickness (see Figure G.2)

Dimensions in millimetres

	Required fire resistance class REI							
	REI 15	**REI 20**	**REI 30**	**REI 45**	**REI 60**	**REI 90**	**REI 120**	**REI 180**
Axis distance (a) reinforcing steel[b]	**10[a]**	**10[a]**	**10***	**15**	**20**	**30**	**40**	**55**
Slab thickness (h)	**100**	**100**	**100**	**100**	**120**	**140**	**160**	**200**

[a] Normally the cover required by EN 1992-1-1 will govern.

[b] For prestressed slabs the axis distance shall be increased according to 5.2(5) of EN 1992-1-2:2004.

When reinforcement is arranged in several layers similar to Figure G.2, the average axis distance should not be less than the distance given in the table (see equation (5.5) of EN 1992-1-2:2004). The axis distance for individual bars should not be less than 10 mm.

The slab thickness in Table G.1 corresponds with the minimum floor thickness given in Table 5.8 of EN 1992-1-2:2004 for solid slabs, and has been calculated according to the following conversion equation for hollow core slabs:

$$t_e = h\sqrt{A_c/(b \times h)}$$

where

t_e is the effective thickness;

h is the actual slab thickness;

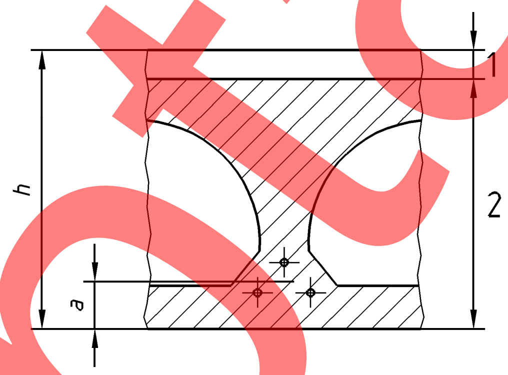
A_c is concrete area of the concrete section;

b is the width of the slab.

The minimum slab thickness given in Table G.1 is based upon a minimum concrete area of 55 %.

Where a concrete area in excess of this figure is provided, the overall depth may be decreased accordingly.

Where a concrete topping or a screed is used, the thickness of the non combustible layer may be taken into account in the fire resistance of the floor for the separating function.



Key

1 Topping and/or screed

2 Hollow-core precast unit

Figure G.2 — Definition of (a) and (h)

Annex H
(informative)

Design of connections

H.1 Connection at the supports

H.1.1 Design considerations

Connections should be designed:

a) to connect the hollow core units to the supporting structures;

b) to transfer tensile forces to the stabilising systems;

c) to establish sufficient shear capacity (shear friction effect) at longitudinal and transverse joint interfaces;

d) to balance the splitting effect from tie bars anchored in the joints;

e) to balance the effects of creep, shrinkage, temperature changes and differential settlements;

f) to prevent horizontal relative displacements of the hollow core units both in the longitudinal and the transverse directions and to prevent possible joint cracks from uncontrolled opening;

g) to balance the reaction on the support in case the reinforcement is protruding from the end of the element;

h) to minimise consequences on thermal or acoustical insulation, when necessary.

H.1.2 Tie arrangements

In order to limit the damage due to accidental actions and to prevent progressive collapse, the tie arrangements according to 9.10 of EN 1992-1-1:2004, should be adopted.

H.2 Connections at joints

H.2.1 Transverse reinforcement

The required reinforcement should be designed according to C.3 and Annex E.

Transverse reinforcement can be omitted in cases as indicated in these annexes.

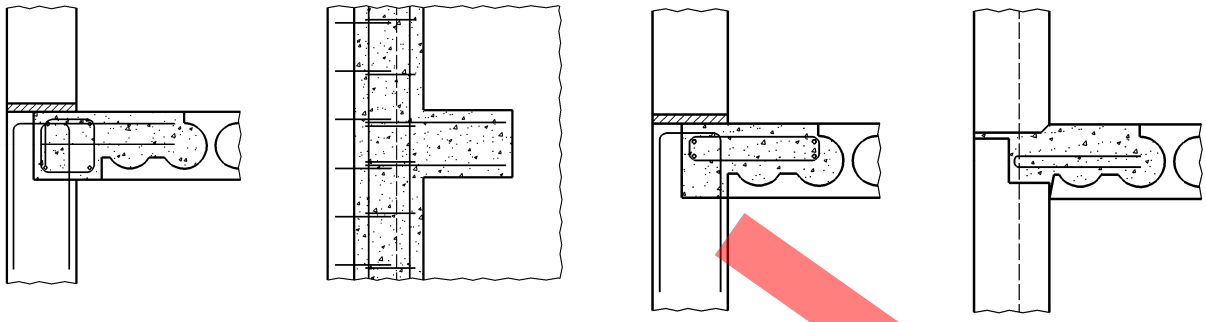
The transverse reinforcement can be concentrated in transverse tie beams at the edges of the floor and in the transverse joints.

H.2.2 Connections at side joints

The connections between the floor and the stabilising structures should be designed to transfer the stabilising forces by horizontal shear along the joint interfaces.

If necessary, (see C.3 and Annex E) the connections should be provided with transverse tie bars or stirrups, which should be distributed along the interface with the spacing not exceeding 4,8 m.

Tie arrangements in the form of closed stirrups should be placed preferably in cut-outs in the elements; the cut-outs should be as small as possible (Figure H.1).



cross section | plan view | rigid connection | flexible connection

a) With cast in situ edge beam | b) Without cast in situ edge beam

Figure H.1 — Principles of connection of floor to bracing element at side joints

H.2.3 Joint grout

If shear forces have to be transmitted by the joints the following requirements should be met:

a) the grade of the grout should be at least C12/15 according to 3.1.2 of EN 1992-1-1:2004;

b) the consistency of the fresh grout should be such that the joint gap will be filled completely and leakage and possible resulting settlements or cavities will be prevented;

c) the grout should be designed to prevent settlements and cracks due to shrinkage;

d) the aggregate diameter should be in balance with the average joint width;

e) the joints should be properly cleaned and the joints surfaces should not be too dry before grouting;

f) the joints should be filled to the entire height in one operation;

g) in cold weather, precautions should be taken in order to avoid snow and ice in the joints and freezing of the fresh grout.

Annex J
(normative)

A1⟩ Full scale test

J.1 General

The test elements shall be representative of the cross section or product family; total prestressing force for prestressed hollow core or reinforcement amount for reinforced hollow core shall be at least the 75 % of the maximum scheduled for the given cross section.

J.2 Apparatus

The testing machine shall be at least a class 3 machine according to 4.2 of EN 12390-4:2000.

J.3 Test arrangement

Tests shall be carried out by the manufacturer, at a testing laboratory or in the factory.

The test shall be performed at a temperature of 0 °C to 40 °C. This temperature shall be recorded.

In order to get reference values of the strength of the concrete (direct structural strength – see EN 13369:2004, 4.2.2.2.3), cylindrical cores shall be drilled out of the element. To obtain these cores, a slab segment of 200 mm ± 5 mm length shall be sawn out from the casting bed, directly adjacent to the test specimens. This segment shall be conserved under the same conditions as the test specimens. Shortly before testing, three cores shall be drilled out of the slab segment (see also Table A.3) and their strength shall be measured within ± 3 days from the date of the test. The mean of the three measured values gives the actual compressive strength f_c.

Instead of drilled cores, in order to get reference values of the strength of the concrete, 3 specimens (cubes or cylinders) may be made during the fabrication of the test element and submitted to the same heat treatment (indirect structural strength - see EN 13369:2004, 4.2.2.2.4). The specimens shall be conserved under the same conditions as the test element. The compressive strength of the specimens shall be measured within ± 3 days from the date of the test. The mean of the three measured values gives the actual compressive strength f_c.

The same type of test specimens (drilled cores or cubes/cylinders) shall be used as in factory production control to assess conformity of concrete strength.

In a similar way, when the actual tensile concrete strength f_{ct} is measured by splitting tensile tests (see 3.1.2 (8) of EN 1992-1-1:2004), it shall be taken as the mean of the 3 tests multiplied by 0,90.

The test element shall be a full-width slab element with a span of 4 m or 15 x h, whichever is bigger, with the tolerance of ± 100 mm.

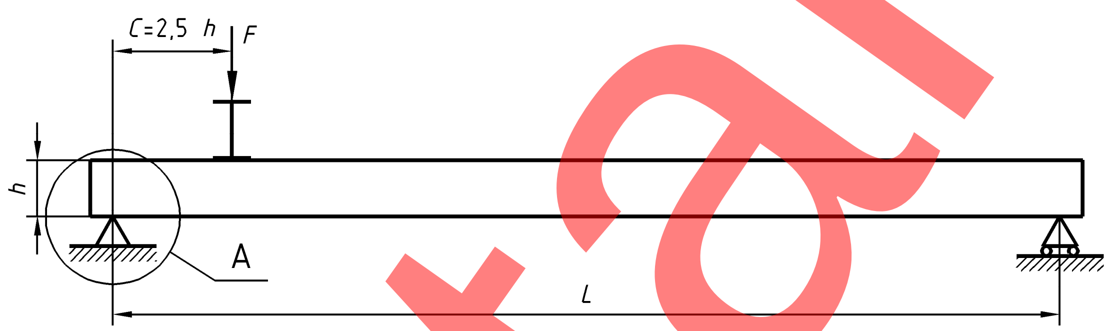
Initial type testing shall be done on three elements with the same prestressing reinforcement. The age of the test elements shall be at least 28 days.

The support which is the nearest to the load application point shall be a roller bearing, so that no axial forces are generated by a rotation of the element at the support. Between the element and the support beam, a load distributing material such as 10 mm masonite or neoprene or a bed of mortar or gypsum shall be applied. This material has to compensate for the unevenness of the element surface and a possible curvature of the element in the transverse direction. The load shall be applied at the distance from the roller support of 2,5 h, where h is the full depth of the cross-section, but not less than 600 mm with a tolerance of ± 25 mm. The support conditions shall be such that the support reaction is uniformly distributed over the width of the member. Figures J.1 a and b show the two possible testing arrangements.

The load shall be introduced by a stiff transverse steel beam. The stiffness of this beam shall be sufficient to prevent a non uniform distribution of the load over the width of the beam.

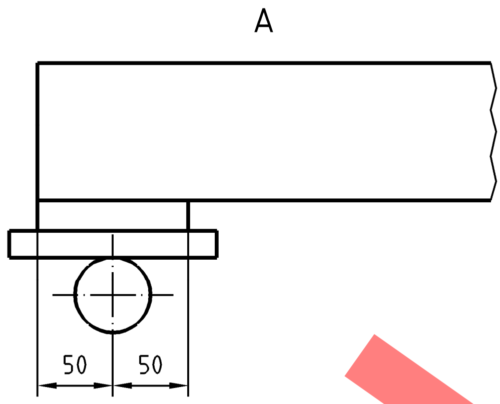
The depth of the steel beam shall be at least 150 mm, but when using one jack, preferably 250 mm.

Dimensions in millimetres



a) One line loading

b) Two lines loading



c) Detail of support in a) and b)

Figure J.1 — Testing arrangement

J.4 Loading procedure

The load shall be applied as repeated loading in 2 cycles. The amplitude of the loading of the first cycle shall be equal to at least 70 %, with a tolerance of –2 % and + 7 %, of the required design ultimate load. In the last cycle the load shall be increased up to the actual ultimate load at failure.

The required design ultimate load shall be evaluated using the design model for failure with the design values for material properties, nominal dimensions and with regard to the most unfavourable failure mode.

The speed of the loading of the element shall not exceed the following limits:

— for the first cycle:

 — two steps of equal amplitude in one minute each and subsequent withdrawal of the load;

— for the second cycle:

 — a first step up to 50 % of the calculated ultimate load in one minute;

 — a second step up to 75 % of the calculated ultimate load in one minute;

 — subsequent increase of the load with speed not exceeding 10 % of the calculated ultimate load per minute.

The calculated ultimate load F_{calc} shall be evaluated using the design model for failure, with the actual strength parameters of steel, with the actual strength parameters of concrete derived from its compressive strength such as measured in J.3, taking $\alpha_{cc} = \alpha_{ct}$ = 1.0 and γ_c = γ_s = 1.00, with the actual dimensions and with regard to the most unfavourable failure mode. Instead of derived from compressive strength, tensile strength of concrete may be measured by tests (see J.3).

The actual ultimate load corresponding to the failure of the test element shall be recorded together with the indication of the failure mode (shear tension, shear flexure, anchorage, cracking moment).

J.5 Interpretation of results

The failure mode observed in the test should correspond to the model assumed in calculation.

The results of the test shall be checked against the calculated ultimate load F_{calc}.

NOTE The design model for shear failure is represented by Equations (6.2.a) or (6.4) of EN 1992-1-1:2004 as modified in 4.3.3.2.2.1 of this standard, where the actual compressive strength f_c is used in place of f_{ck} and the actual tensile strength f_{ct} is used in place of f_{ctd}. Actual tensile strength f_{ct} may be measured directly by tests or derived by the correlations of Table 3.1 of EN 1992-1-1:2004, where f_{ck} is replaced by f_c and f_{ctk} is replaced by f_{ct} through the following calculations:

$f_{ctm} = 0{,}30\, f_c^{2/3}$ for concrete classes ≤ C50/60

or

$f_{ctm} = 2{,}12\ \ln[1+(f_c + 8)/10]$ for concrete classes > C50/60

and

$f_{ct} = 0{,}8\, f_{ctm}$

The stress σ_{cp} due to prestressing shall be calculated, with $\gamma_P = 1$, taking into account the prestressing losses developed at the test time and a linear increase over the transmission length l_{pt} as defined by expression (8.16) of EN 1992-1-1:2004. The first uncracked section to be checked for failure is placed at d/2 from the support (d = effective depth). The first possible section cracked by bending moment is placed at d from the support. The cracking bending moment is computed with f_{ct}. For these calculations the rules of EN 1992-1-1:2004 are applied.

The design model reliability is confirmed if the following requirements are fulfilled:

$F_{test}/\ F_{calc} \geq 0{,}95$ for each test

Average $(F_{test}/\ F_{calc}) \geq 1{,}00$ for the mean of the three tests

where

F_{calc} is the calculated ultimate load corresponding to the failure mode observed for each individual test element;

F_{test} is the actual ultimate load for each individual test element.

Average $(F_{test}/\ F_{calc})$ is the mean value of the three ratios between each actual ultimate load and the corresponding expected ultimate load.

If the test results do not comply with the two requirements above, one of the following actions shall be undertaken:

— improve production (machinery and/or concrete mix) and test again three new test elements;

— adjust the design model for the design of the product.

J.6 Test report

The test report shall include:

- the identification of the test element;
- the date of manufacture or any other code;
- the date and place of testing;
- the laboratory and the person in charge of testing;
- all the actual properties of materials used for the test element;
- the test method;
- the measuring equipment used;
- the temperature at the location of testing;
- the failure load value;
- the failure mode including written description and photos;
- any observations regarding the test and any disorders noted (cracks, etc.);
- a reference to this standard;
- a declaration that the test has been carried out in compliance with this standard, plus details of any amendment made. ⟨A1⟩

A2 *deleted text* A2

Annex ZA
(informative)

A2 Clauses of this European Standard addressing essential requirements or other provisions of EU Directives

ZA.1 Scope and relevant characteristics

This European Standard has been prepared under the mandate M/100 "Precast Concrete Products" given to CEN by the European Commission and the European Free Trade Association.

The clauses of this European Standard shown in this annex meet the requirements of the mandate given under the EC Construction Products Directive (89/106/EEC).

Compliance with these clauses confers a presumption of fitness of the hollow core slabs covered by this annex for the intended uses indicated herein; reference shall be made to the information accompanying the CE marking.

WARNING — Other requirements and other EC Directives, not affecting the fitness for intended uses, may be applicable to the hollow core slabs falling within the scope of this standard.

NOTE 1 In addition to any specific clauses relating to dangerous substances contained in this standard, there may be requirements applicable to the products falling within its scope (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the EU Construction Products Directive, these requirements need also to be complied with, when and where they apply.

NOTE 2 An informative database of European and national provisions on dangerous substances is available at the Construction web site on EUROPA, (accessed through http://ec.europa.eu/enterprise/construction/internal/dangsub/dangmain_en.htm).

This annex has the same scope as Clause 1 of this standard with regard to the production covered. It establishes the conditions for CE marking of hollow core slabs made of reinforced or prestressed concrete intended for the use indicated below and shows the relevant clauses applicable (see Table ZA.1).

Construction product: hollow core slabs made of reinforced or prestressed concrete.

Intended use: construction of the structures of buildings and other civil engineering works, except bridges.

The requirement on a certain characteristic is not applicable in those Member States (MSs) where there are no regulatory requirements for that characteristic for the intended use of the product. In this case, manufacturers placing their products on the market of these MSs are not obliged to determine nor to declare the performance of their products with regard to this characteristic and the option "No performance determined" (NPD) in the information accompanying the CE marking (see ZA.3) may be used. The NPD option may not be used, however, where the characteristic is subject to a threshold level.

Table ZA.1 — Relevant clauses for hollow core slabs

Essential characteristics		**Requirement clauses in this standard**	**Levels and/or class(es)**	**Notes and Unit**
Compressive strength (of concrete)	All methods	4.2 Production requirements	None	N/mm^2
Ultimate tensile and tensile yield strength (of steel)	All methods	4.1.3 Reinforcing steel and 4.1.4 Prestressing steel of EN 13369:2004	None	N/mm^2
Mechanical strength	Method 1	Information listed in ZA.3.2	None	Geometry and materials
	Method 2	4.3.3 Mechanical resistance	None	kNm, kN, kN/m
	Method 3	Design specification	None	
Resistance to fire (for load bearing capacity)	Method 1	Information listed in ZA.3.2	R	Geometry and materials
	Method 2	4.3.4 Resistance to fire	R	min
	Method 3	Design specification	R	
Airborne sound insulation and impact noise transmission	All methods	4.3.5 Acoustic properties	None	dB
Detailing	All methods	4.3.1 Geometrical properties 8 Technical documentation	None	mm /
Durability	All methods	4.3.7 Durability	None	Ambient conditions

The manufacturer or his authorized representative in the EEA shall select for CE marking the declaration method(s) he applies among the followings:

Method 1 = declaration of geometrical data and material properties (see ZA.3.2);

Method 2 = declaration of geometry, material properties and product properties determined following this standard and EN Eurocodes (see ZA.3.3);

Method 3 = declaration of product compliance with a given design specification distinguishing:

- Method 3a = declaration of product compliance with a given design specification provided by the client (ZA.3.4);
- Method 3b = declaration of product compliance with a given design specification provided by the manufacturer according to the client's order (ZA.3.5).

ZA.2 Procedure for attestation of conformity of hollow core slabs

ZA.2.1 System of attestation of conformity

The system of attestation of conformity of hollow core slabs, for the essential characteristics indicated in Table ZA.1, in accordance with the decision of the Commission 1999/94/EC of 25 January 1999 as given in Annex **III** of the Mandate M/100 ”Precast concrete products”, is shown in Table ZA.2, for the indicated intended use and relevant levels or classes.

Table ZA.I.2 — System of attestation of conformity

Product(s)	Intended use(s)	Level(s) or class(es)	Attestation of conformity system(s)
Hollow core slabs for floors	Structural	-	2+
System 2+ : See Directive 89/106 (CPD) Annex III-2 (ii) First possibility, including certification of the factory production control by an approved body on the basis of initial inspection of factory and of factory production control as well as of continuous surveillance, assessment and approval of factory production control.			

The attestation of conformity of hollow core slabs, for the essential characteristics indicated in Table ZA.1, shall be based on the evaluation of conformity procedure indicated in Table ZA.3, resulting from the application of the clauses of this or other European Standards indicated therein.

Table ZA.3 — Assignment of evaluation of conformity tasks for hollow core slabs under system 2+

Tasks			Content of the tasks	Evaluation of conformity clauses to apply
Tasks under the responsibility of the manufacturer		Initial type testing [b]	All characteristics of Table ZA.1 [a]	6.2 of EN 13369:2004
		Factory production control	Parameters related to all characteristics of Table ZA.1	6.3 of EN 13369:2004 and Annex A
		Further testing of samples taken at the factory	— mechanical strength; — all characteristics of Table ZA.1;	6.2.3 of EN 13369:2004
Tasks under the responsibility of the notified body	Certification of factory production control on the basis of:	Initial inspection of factory and of factory production control [c]	— compressive strength (of concrete); — ultimate tensile and tensile yield strength; — detailing; — durability; — resistance to fire *R* (in case of verification by testing).	6.1.3.2 a) and 6.3 of EN 13369:2004
		Continuous surveillance, assessments and approval of factory production control	— compressive strength (of concrete); — ultimate tensile and tensile yield strength; — detailing; — durability; — resistance to fire *R* [d] (in case of verification by testing).	6.1.3.2 b) and 6.3 of EN 13369:2004

[a] For fire resistance (when verified by testing) tests should be carried out by testing laboratory.

[b] Initial type testing (ITT) includes calculation and/or testing. ITT of mechanical strength and/or resistance to fire is not required when only methods 1 and 3a are used.

[c] Includes assessment that the factory production control system contains documented procedures related to ITT (calculation and/or testing) and that these procedures are followed. Reference to ITT of mechanical resistance and resistance to fire can be omitted when only methods 1 and 3a are used.

[d] Only for methods 2 and 3b.

ZA.2.2 EC Certificate and Declaration of conformity

When compliance with the conditions of this annex is achieved, and once the notified body has drawn up the certificate mentioned below, the manufacturer or his agent established in the EEA shall prepare and retain a declaration of conformity, which entitles the manufacturer to affix the CE marking. This declaration shall include:

— name and address of the manufacturer, or his authorised representative established in the EEA, and the place of production;

NOTE 1 The manufacturer may also be the person responsible for placing the product onto the EEA market, if he takes responsibility for CE marking.

— description of the product (type, identification, use etc.), and a copy of the information accompanying the CE marking;

NOTE 2 Where some of the information required for the Declaration is already given in the CE marking information, it does not need to be repeated.

— provisions to which the product conforms (e.g. Annex ZA of this EN);

— particular conditions applicable to the use of the product (e.g. provisions for use under certain conditions etc.);

— the number of the accompanying factory production control certificate;

- name of, and position held by, the person empowered to sign the declaration on behalf of the manufacturer or his authorised representative.

The declaration shall be accompanied by a factory production control certificate, drawn up by the notified body, which shall contain, in addition to the information above, the following:

- name and address of the notified body;
- name and address of the manufacturer;
- the number of the factory production control certificate;
- conditions and period of validity of the certificate, where applicable;
- name of, and position held by, the person empowered to sign the certificate;
- generic identification of the products covered by the Factory Production Control Certificate and for each product, identification of:
  - the method(s) of CE marking applied by the manufacturer;
  - whether the product is reinforced or prestressed;
  - other distinguished product families as far as they are identified in the product standard or by the manufacturer himself and affect the content and/or procedures of the factory production control including the procedures of type testing.

The above mentioned declaration and the certificate shall be presented in the official language or languages of the Member State in which the product is to be used.

ZA.3 CE marking and labelling

ZA.3.1 General

ZA.3.1.1 Affixing of CE marking

The manufacturer or his authorised representative established within the EEA is responsible for the affixing of the CE marking. The CE marking symbol to affix shall be in accordance with Directive 93/68/EC and shall be shown on the product (or when not possible it may be on the accompanying label, the packaging or on the accompanied commercial documents e.g. a delivery note).

The following information shall be added to the CE marking symbol:

- identification number of the certification body;
- name or identifying mark and registered address of the manufacturer;
- the last two digits of the year in which the marking is affixed;
- number of the EC factory production control certificate;
- reference to this European Standard;
- description of the product: generic name and intended use;
- information on those relevant essential characteristics taken from Table ZA.1 which are listed in the relevant sub-clause ZA.3.2, ZA.3.3, ZA.3.4 or ZA.3.5;

— "No performance determined" for characteristics where this is relevant.

The "No performance determined" (NPD) option may not be used where the characteristic is subject to a threshold level. Otherwise, the NPD option may be used when and where the characteristic, for a given intended use, is not subject to regulatory requirements in the Member State of destination.

In the following sub-clauses the conditions are given for the application of CE marking. Figure ZA.1 gives the simplified label to affix to the product, containing the minimum set of information and the link to the accompanying document where the other required information is given. For what concerns the information on essential characteristics, some of them may be given by an unambiguous reference to:

— technical information (product catalogue) (see ZA.3.2);

— technical documentation (ZA.3.3);

— design specification (ZA.3.4 and ZA.3.5).

The minimum set of information to be put directly in the affixed label or in the companying document is given in Figures ZA.1, ZA.2, ZA.3, ZA.4 and ZA.5.

ZA.3.1.2 Simplified label

In the case of simplified label the following information shall be added to the CE marking symbol:

— name or identifying mark and registered address of the manufacturer;

— identification number of the unit (to ensure traceability);

— the last two digits of the year in which the marking is affixed;

— number of the CE factory production control certificate;

— reference to this European Standard.

All other information defined by the relevant method of CE marking in one of the relevant sub-clauses ZA.3.2, ZA.3.3, ZA.3.4 and ZA3.5 shall be provided in the accompanying documents.

The same identification number shall mark, in the accompanying documents, the information related to the unit.

Figure ZA.1 gives the model for the simplified label for CE marking.

CE	CE conformity marking consisting of the CE symbol given in Directive 93/68/EEC
AnyCo Ltd, PO Bx 21, B-1050	Name or identifying mark and registered address of the manufacturer
45PJ76	Identification number of the unit
09	Last two digits of the year in which the marking was affixed
0123-CPD-0456	Number of the FPC certificate
EN 1168	Number of this European Standard

Figure ZA.I.1 — Example of simplified label

For small elements of for product stamping reasons, the size can be reduced by removing reference to EN and/or to FPC certificate.

ZA.3.2 Declaration of geometrical data and material properties (method 1)

Referring to Table ZA.1 and to the information quoted in the list of ZA.3.1.1, the following properties shall be declared:

— compressive strength of concrete;

— ultimate tensile strength of reinforcing steel (if used);

— tensile yield strength of reinforcing steel (if used);

— ultimate tensile strength of prestressing steel (if used);

— tensile 0,1 proof stress of prestressing steel (if used);

— geometrical data (only critical dimensions);

— conditions for durability;

— detailing.

This information may be given by reference to the manufacturer's technical information (product catalogue) for detailing, durability and geometrical data.

Figure ZA.2 gives, for a type of hollow core slab, an example of CE marking inclusive of the information needed to determine, according to design regulation valid in the place of use, the properties related to mechanical resistance and stability and resistance to fire, including aspects of durability and serviceability.

CE	CE conformity marking consisting of the CE symbol given in Directive 93/68/EEC
0123	Identification of the notified body
AnyCo Ltd, PO Bx 21, B-1050	Name or identifying mark and registered address of the manufacturer
09	Last two digits of the year in which the marking was affixed
0123-CPD-0456	Number of the FPC certificate
EN 1168	Number of European Standard concerned
Hollow core slabs for floors	Title of European Standard
PRESTRESSED HOLLOW CORE SLAB (for floors)	Generic name and intended use

Concrete:

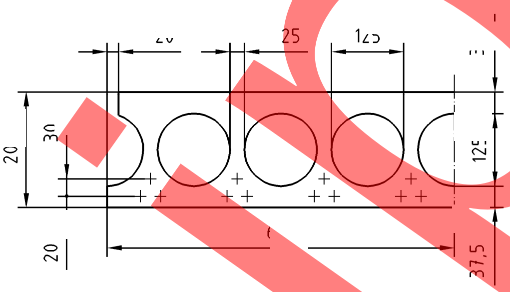
Compressive strength f_{ck} = 60 N/mm^2

Prestressing steel:

Ultimate tensile strength f_{pk} =1 860 N/mm^2

Tensile 0,1 % proof-stress $f_{p0,1k}$ = 1 580 N/mm^2

Dimensions in millimetres



length L = 4 800 mm ± 25 mm

strands 8 x 3 (3W Φ 5,2 – Fe 1 860)

low relaxation $\zeta_{1\,000}$ = 2,5 %

initial stress σ_{pi} = 1 420 N/mm^2

end protrusion of strands l = 0 mm

For detailing and durability see technical information

Technical information:

Product catalogue ABC: 2002 – clause ii

Information on product geometry and material characteristics including detailing (to be adapted to the specific product by the manufacturer)

NOTE 1 Numerical values are only as example.

NOTE 2 The sketch may be omitted if equivalent information is available in clearly identified technical information (product catalogue) referred to.

Figure ZA.I.2 — Example of CE marking with Method 1

ZA.3.3 Declaration of product properties (method 2)

For all design data, including models and parameters used in calculation, reference may be made to the technical (design) documentation.

Referring to Table ZA.1 and to the information quoted in the list of ZA.3.1.1, the following properties shall be declared:

— compressive strength of concrete;

— ultimate tensile strength of reinforcing steel (if used);

— tensile yield strength of reinforcing steel (if used);

— ultimate tensile strength of prestressing steel (if used);

— tensile 0,1 proof stress of prestressing steel (if used);

— mechanical ultimate strength of the element (design values for non-seismic situations) with axial compression capacity for some eccentricities or with bending moment capacity and shear capacity of critical sections;

— safety factors for concrete and steel used in calculation;

— resistance to fire R class;

— other Nationally Determined Parameters (NDPs) used in calculation;

— acoustic insulation parameters (airborne sound insulation and impact noise transmission);

— conditions for durability (exposure class(es));

— geometrical data;

— detailing.

This information may be given by reference to the manufacturer's technical information (product catalogue) for geometrical data, detailing, durability and other NDPs.

Figure ZA.3 gives, for prestressed or reinforced hollow core slabs, an example of CE marking in the case in which the properties related to mechanical resistance and stability and resistance to fire are determined by means of EN Eurocodes.

The design values of the mechanical ultimate strength of the element and the resistance to fire class shall be computed using, for the Nationally Determined Parameters, either the values recommended in EN 1992-1-1:2004 and EN 1992-1-2:2004 or the values given in the National Annex of the Eurocodes applicable to the works.

CE	CE conformity marking consisting of the CE symbol given in Directive 93/68/EEC
0123	Identification of the notified body
AnyCo Ltd, PO Bx 21, B-1050	Name or identifying mark and registered address of the manufacturer
09	Last two digits of the year in which the marking was affixed
0123-CPD-0456	Number of the FPC certificate
EN 1168	Number of European Standard
Hollow core slabs for floors	Title of European Standard concerned
PRESTRESSED/REINFORCED HOLLOW CORE SLAB (for floors)	Generic name and intended use
Concrete: Compressive strength f_{ck} = xx N/mm^2 Reinforcing steel: Ultimate tensile strength f_{tk} = yyy N/mm^2 Tensile yield strength f_{yk} = zzz N/mm^2 Prestressing steel: Ultimate tensile strength f_{pk} = uuu N/mm^2 Tensile 0,1 % proof-stress $f_{p0,1k}$ = www N/mm^2 Mechanical resistance (design values): Bending moment capacity (of the middle section) mmm kNm Shear capacity (of the end sections) vvv kN Material safety factors applied in strength calculation: For concrete γ_c = z,zz For steel γ_s = x,xx Resistance to fire RXX for η_{fi} = 0,xx RYY for η_{fi} = 0,yy For geometrical data, detailing, durability, acoustic insulation parameters, possible complementary information on fire resistance and other NDPs see the Technical documentation Technical documentation: Position number xxxxxx	Information on product mandated characteristics including detailing (to be adapted to the specific product by the manufacturer) NOTE 1 Mechanical resistance parameters refer to the precast element without any additional cast-in-situ part. NOTE 2 The values of resistance to fire may be replaced by a reference to the pertinent part of the Technical information.

Figure ZA.I.3 — Example of CE marking with Method 2

ZA.3.4 Declaration of compliance with a given design specification provided by the client (method 3a)

Referring to Table ZA.1 and to the information quoted in the list of ZA.3.1.1, the following properties shall be declared:

— compressive strength of concrete;

— ultimate tensile strength of reinforcing steel (if used);

— tensile yield strength of reinforcing steel (if used);

— ultimate tensile strength of prestressing steel (if used);

— tensile 0,1 proof stress of prestressing steel (if used);

— reference to the design documents provided by the client.

This method applies also in case of a design made with means other than EN Eurocodes.

Figure ZA.4 gives, for prestressed or reinforced hollow core slabs, an example of CE marking in the case the product is produced according to a design specification in which the properties related to mechanical resistance and stability and resistance to fire are determined by means of design provisions applicable to the works.

CE	CE conformity marking consisting of the CE symbol given in Directive 93/68/EEC
0123	Identification of the notified body
AnyCo Ltd, PO Bx 21, B-1050	Name or identifying mark and registered address of the manufacturer
09	Last two digits of the year in which the marking was affixed
0123-CPD-0456	Number of the FPC certificate
EN 1168	Number of European Standard
Hollow core slabs for floors	Title of European Standard concerned
PRESTRESSED/REINFORCED HOLLOW CORE SLAB (for floors)	Generic name and intended use
Concrete: Compressive strength f_{ck} = xx N/mm^2 Reinforcing steel: Ultimate tensile strength f_{tk} = yyy N/mm^2 Tensile yield strength f_{yk} = zzz N/mm^2 Prestressing steel: Ultimate tensile strength f_{pk} = uuu N/mm^2 Tensile 0,1% proof-stress $f_{p0,1k}$ = www N/mm^2 For geometrical data, detailing, mechanical strength, fire resistance, acoustic insulation parameters and durability see the design specifications Design specification provided by the client: Reference……………………….(file number)	Information on product mandated characteristics including detailing (to be adapted to the specific product by the manufacturer).

Figure ZA.I.4 — Example of CE marking with Method 3a

ZA.3.5 Declaration of compliance with a given design specification provided by the manufacturer according to the client's order (method 3b)

Referring to Table ZA.1 and to the information quoted in the list of ZA.3.1.1, the following properties shall be declared:

— compressive strength of concrete;

— ultimate tensile strength of reinforcing steel (if used);

— tensile yield strength of reinforcing steel (if used);

— ultimate tensile strength of prestressing steel (if used);

— tensile 0,1 proof stress of prestressing steel (if used);

— reference to the design document according to the client’s order and dealing, where required, with geometrical data, detailing, mechanical strength, resistance to fire, acoustic insulation and durability.

This method applies also in case of a design made with means other than EN Eurocodes.

Figure ZA.5 gives, for prestressed or reinforced hollow core slabs, an example of CE marking in the case the product is produced according to a design specification in which the properties related to mechanical resistance and stability and resistance to fire are determined by means of design provisions applicable to the works.

CE	CE conformity marking consisting of the CE symbol given in Directive 93/68/EEC
0123	Identification of the notified body
AnyCo Ltd, PO Bx 21, B-1050	Name or identifying mark and registered address of the manufacturer
09	Last two digits of the year in which the marking was affixed
0123-CPD-0456	Number of the FPC certificate
EN 1168	Number of European Standard
Hollow core slabs for floors	Title of European Standard concerned
PRESTRESSED/REINFORCED HOLLOW CORE SLAB (for floors)	Generic name and intended use
Concrete: Compressive strength f_{ck} = xx N/mm^2 Reinforcing steel: Ultimate tensile strength f_{tk} = yyy N/mm^2 Tensile yield strength f_{yk} = zzz N/mm^2 Prestressing steel: Ultimate tensile strength f_{pk} = uuu N/mm^2 Tensile 0,1% proof-stress $f_{p0,1k}$ = www N/mm^2 For geometrical data, detailing, mechanical strength, fire resistance, acoustic insulation parameters and durability see the design specifications Design specification:…………….(client's order)	Information on product mandated characteristics including detailing (to be adapted to the specific product by the manufacturer).

Figure ZA.I.5 — Example of CE marking with Method 3b

In addition to any specific information relating to dangerous substances, the product should also be accompanied, when and where required and in the appropriate form, by documentation listing any other legislation on dangerous substances for which compliance is claimed, together with any information required by that legislation. NOTE European legislation without national derogations need not be mentioned.

A2

Bibliography

[1] EN ISO 9001:2000, *Quality management systems – Requirements (ISO 9001:2000)*

[2] ENV 13670-1:2000, *Execution of concrete structures – Part 1: Common*

[3] ISO 1803:1997, *Building construction – Tolerances – Expression of dimensional accuracy – Principles and terminology*