SLOVENSKI STANDARD
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Montaģni betonski izdelki ï Votle ploģļ e

Precast concrete products - Hollow core slabs

Betonfertigteile - Hohlplatten

Produits préfabriqués en béton - Dalles alvéolées

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ICS:

91.100.30	Beton in betonski izdelki	Concrete and concrete products

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Precast concrete products - Hollow core slabs

Produits préfabriqués en béton - Dalles alvéolées

Vorgefertigte Betonerzeugnisse - Hohlplatten

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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

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.

Foreword

This document (EN 1168:2005) has been prepared by Technical Committee CEN/TC 229 “Precast concrete products”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2005, and conflicting national standards shall be withdrawn at the latest by May 2007.

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 – Part1 : 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 :

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

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

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

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

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

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

— prEN 13747, *Precast concrete products – Floor plates for floor systems*

— prEN 13978, *Precast concrete products – Precast concrete garages*

— prEN 14843, *Precast concrete products - Stairs*

— prEN 14844, *Precast concrete products – Box culverts*

— prEN 14991, *Precast concrete products – Foundation elements*

— prEN 14992, *Precast concrete products – Wall elements : Production properties and performances*

— prEN 15258, *Precast concrete products – Retaining wall elements*

— prEN 15050, *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, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and the 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; in Annex J (Normative) a test method is given for confirmation of design model for shear resistance.

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 450 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 EN 1991-2 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.*

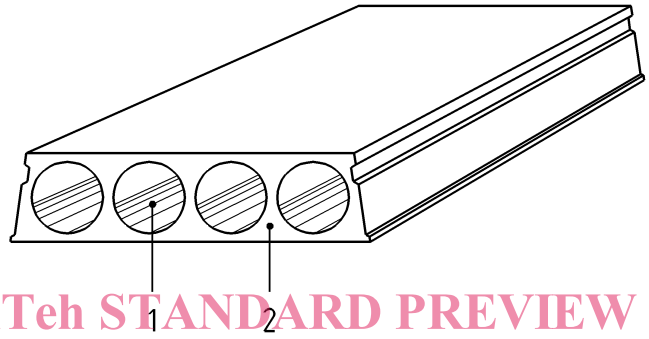
prEN 13791:2003, *Assessment of concrete compressive strength in structures or in structural elements.*

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

Complementary to 4.2 of EN 13369:2004 the following subclauses shall apply. In particular the compressive strength of concrete shall be considered.

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 $\geq \varnothing$;

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

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

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

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;

— $150\ \text{mm} < h < 250\ \text{mm}$: 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.

4.3.1.1.1 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.

4.3.1.1.2 Tolerances for concrete cover

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.

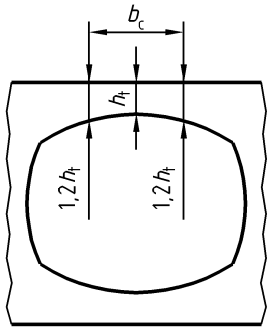


Figure 2 — Minimum thickness of upper flange

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:

  — when the nominal centre to centre distance of the strands ≥ 3 $\varnothing$: c_{min} = 1,5 $\varnothing$;

  — when the nominal centre to centre distance of the strands < 2,5 $\varnothing$: c_{min} = 2,5 $\varnothing$;

  — c_{min} may be derived by linear interpolation between the values calculated in a) and b);

where

$\varnothing$ is the strand or wire diameter, in millimetres (in the case of different diameters in a strand, the average value shall be used for $\varnothing$).

For ribbed wires, the concrete cover shall be increased with 1 $\varnothing$.

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).

For confirmation of design model for shear resistance a test method is given in Annex J.

4.3.3.2 Verification by calculation

4.3.3.2.1 Resistance to splitting for prestressed hollow core slabs

Visible horizontal splitting cracks in the webs are not allowed.

Applying one of the requirements in a) or b) hereafter prevents splitting cracks:

a) for the web in which the highest splitting 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 splitting stress σ_{sp} shall satisfy the following condition:

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

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

$$\text{and } \alpha_e = \frac{(e_o - k)}{h}$$

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 splitting cracks will not develop.

4.3.3.2.2 Shear and torsion capacity

4.3.3.2.2.1 General

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 Shear capacity – Torsion capacity

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).

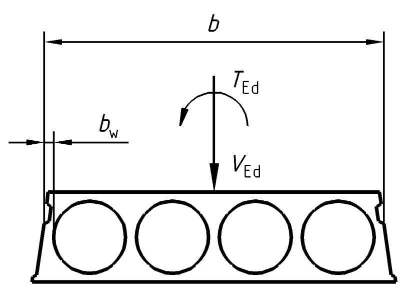


Figure 3 — Eccentric shear force

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} :

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