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Precast concrete products - Ribbed floor elements

Produits préfabriqués en béton - Eléments de plancher nervurés

Betonfertigteile - Deckenplatten mit Stegen

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 13224:2011) 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of an identical text or by endorsement, at the latest by May 2012, and conflicting national standards shall be withdrawn at the latest by August 2013.

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

This document supersedes EN 13224:2004+A1:2007.

Significant technical changes compared to the previous version are:

a) change in the scope to also cover elements with bottom slab (as shown in Annex A);

b) deletion of the requirement on planarity (in 4.3.1.1 and 5.2);

c) deletion of the requirement on camber or sag (in 4.3.1.1 and 5.2);

d) addition of a rule for elements without shear reinforcement in 4.3.3.3;

e) adoption of the new template for Annex ZA.

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 the Construction Products Directive (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 EN 13670:2009 *Execution of concrete structures.* In all countries it can be accompanied by alternatives for national application.

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*

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

— EN 13978, *Precast concrete products — Precast concrete garages*

— EN 14843, *Precast concrete products — Stairs*

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

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

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

— EN 15037, *Precast concrete products — Beams for beam-and-block floor systems*

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, Croatia, 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 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 and resistance to fire, reference is made to EN 1992-1-1 and EN 1992-1-2. Additional complementary rules are provided where necessary.

4.3.3 and 4.3.4 include specific provisions resulting from the application of EN 1992-1-1, and EN 1992-1-2 rules made specific for the concerned product. The use of these provisions is consistent with a design of works made with EN 1992-1-1 and EN 1992-1-2.

1 Scope

This document identifies the requirements, the basic performance criteria and evaluation of conformity for precast ribbed elements made of reinforced or prestressed normal weight concrete, used in floors or roofs. The elements consist of a top and/or bottom slab and one or more (usually two) ribs; transverse ribs may also be present.

Some examples of precast elements considered in this document are shown in Annex A.

Specific requirements for minor floor elements are listed in Annex B.

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

This document does not cover load-bearing capacity determined by testing.

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 1990:2002, *Eurocode: Basis of structural design*

EN 1991-1-6:2005, *Eurocode 1 — Actions on structures — Part 1-6: General actions — Actions during execution*

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

3 Terms, definitions, and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1992-1-1:2004 and EN 13369:2004 and the following apply.

3.1.1
ribbed precast concrete element
precast unit consisting in a slab stiffened by one or more ribs

3.1.2
minor floor element
ribbed precast floor elements having limited dimensions, which are in compliance with Annex B

4 Requirements

4.1 Material requirements

For general aspects, reinforcing and prestressing steel, inserts and connectors, the relevant subclauses of EN 13369:2004, 4.1 shall apply. For constituent materials of concrete EN 206-1 applies. In particular, the ultimate tensile and tensile yield strength of steel shall be considered.

4.2 Production requirements

The production of precast ribbed elements shall comply with the requirements in EN 13369:2004, 4.2.

NOTE In addition to EN 13369:2004, 4.2.2 for cast-in-situ concrete considered to act compositely with precast units in the structural resistance (e.g. structural top layer), the minimum strength class is C 20/25.

In particular, the compressive strength of concrete shall be considered.

For minor floor elements, strength classes shall comply with B.2.3.

4.3 Finished product requirements

4.3.1 Geometrical properties

4.3.1.1 Production tolerances

Complementary to EN 13369:2004, 4.3.1.1 the following tolerances shall apply (Figure 1).

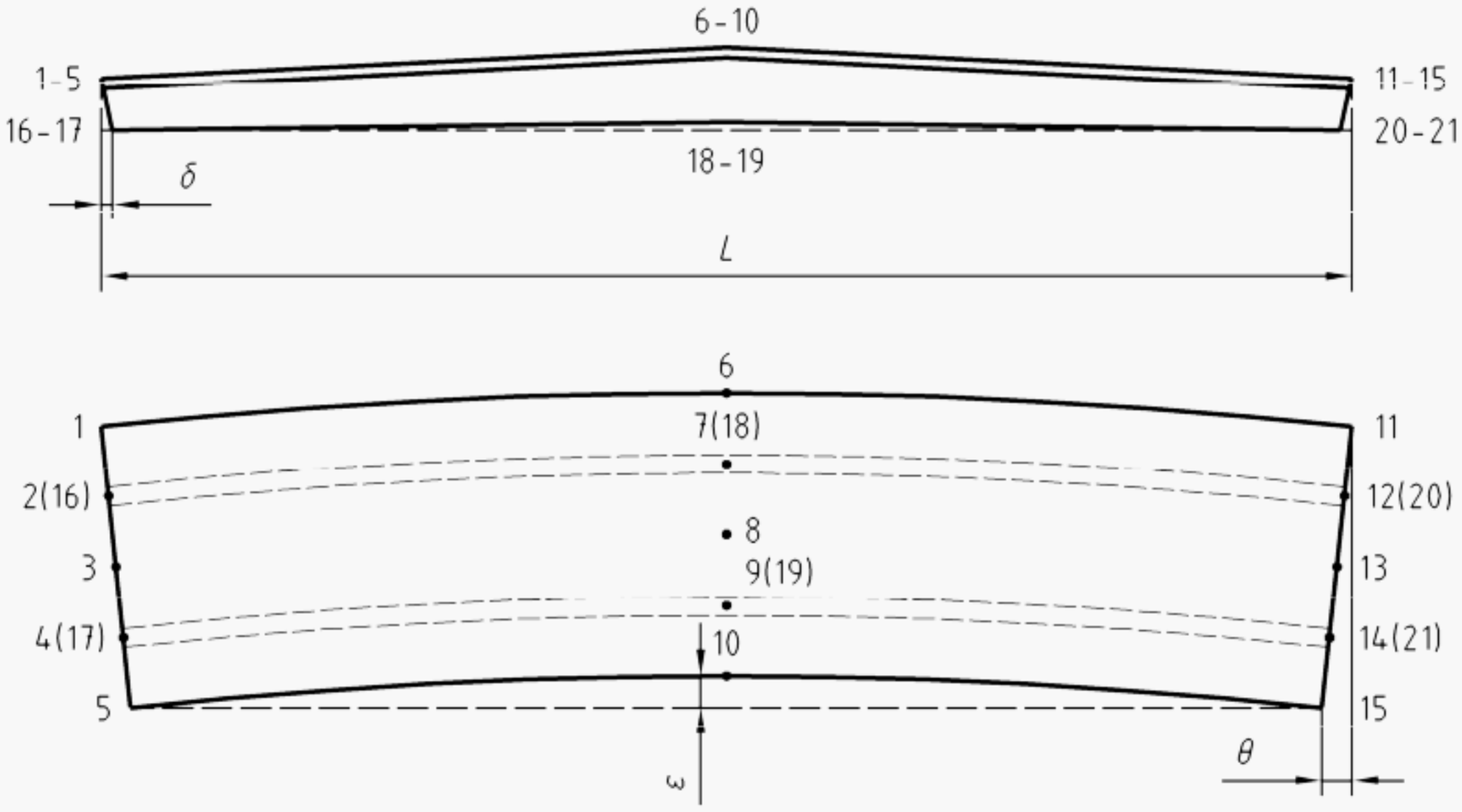


Figure 1 — Reference points for standard check of tolerances

DIMENSION	PERMITTED DEVIATION (mm)
Skewness (θ)	± 15
Lateral bow (ε)	± 10 or L/1 000 (whichever is greater)
Angular deviation of ribs (δ)	± 15

Methods of measurements are given in 5.3.

For prestressed elements the values of tolerance in lateral bow (ε) and angular deviation of ribs (δ) can be increased by 50 %; this includes the effect of prestressing tolerances.

For minor floor elements according to Annex B, the permitted deviation on length is ± 25 mm.

4.3.1.2 Minimum dimensions

EN 13369:2004, 4.3.1.2 shall apply.

4.3.1.3 Longitudinal connections

If the precast units are connected along their longitudinal edges by means of a cast in situ mortar or concrete joint, the minimum joint width shall be at least 30 mm at the top to allow satisfactory casting. The joint face shall be provided with at least one groove. The size shall be appropriate with regard to the shear resistance of the grout.

If tie bars are to be anchored within the joint, the joint width at the tie bar level shall be at least three times the diameter of the bar to enable a satisfactory bond and a complete encasing of the bar.

If welded connections are used, the connection devices should be designed in order to allow an easy compensation of camber and erection deviations and welding execution.

4.3.1.4 Concrete cover

For the protection against corrosion EN 13369:2004, 4.3.7 shall apply.

For minor floor elements see Annex B.

4.3.2 Surface characteristics

EN 13369:2004, 4.3.2 shall apply.

4.3.3 Mechanical resistance

4.3.3.1 General

EN 13369:2004, 4.3.3.1 to 4.3.3.5 shall apply except 4.3.3.4.

For minor floor elements see Annex B.

For transverse distribution of loads see Annex E.

For diaphragm actions see Annex F.

4.3.3.2 Transient situations

For transient situations, EN 13369:2004, 4.3.3.6 shall apply.

Unless compensating devices are used during lifting, each suspension point should be verified on the basis that only two are being active.

In the erection phases in which the access of workers on the elements can be expected, the construction loads of EN 1991-1-6 shall be considered and the supports for safety devices shall withstand the appropriate horizontal force, placed in the most unfavourable position of the upper side of the protection rail.

4.3.3.3 Shear reinforcement

It is allowed to omit the transversal shear reinforcement where it is not required by the resistance to loads or fire verification provided adjacent units are connected.

At least the minimum shear reinforcement according to EN 1992-1-1:2004, 9.2.2 shall be provided in the anchorage zone of prestressing tendons, unless a greater area is required by the relevant verification.

This minimum shear reinforcement is not required for ribbed elements used for roofs, provided the spalling stress in the webs is lower than the tensile strength of concrete at time of prestress release.

In ribs with a thickness not exceeding 120 mm the shear reinforcement may be shaped in one leg only, placed in the middle plane of the rib and properly anchored beyond the main reinforcement.

4.3.3.4 Shear and negative moments

In elements without shear reinforcement, negative moments and unintended restraining effects at the supports should be considered in the design of the elements and in the detailing of the connections at the supports in order to prevent possible restraint cracks which can initiate shear failure near the support.

Two methods to deal with negative or unintended fixing moments are applicable:

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

— design by calculations. Design methods to consider negative or unintended moments are given in Annex C.

4.3.3.5 Longitudinal shear

EN 1992-1-1:2004, 6.2.4 shall apply.

If the composite action with a cast on site topping is considered, the manufacturer shall declare the type of roughness of the surface according to EN 1992-1-1:2004, 6.2.5.

4.3.4 Resistance and reaction to fire

4.3.4.1 Resistance to fire

Fire resistance dealing with load bearing capacity R, integrity E and insulation I of ribbed floor elements, expressed in terms of classes, shall be declared following EN 13369:2004, 4.3.4.1 and 4.3.4.2.

Load bearing classification R by calculation can be carried out using the thermal maps given in Annex D.

Load bearing classification R by tabulated data may be made on the basis of data given in EN 1992-1-2 using beam data for the ribs and slab data for the slab, respectively.

NOTE If the option of tabulated data is selected, as they do not take into account the actual position of the reinforcement nor the actual load level, they usually lead to an over dimensioning of the cross section.

4.3.4.2 Reaction to fire

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

4.3.5 Acoustic properties

EN 13369:2004, 4.3.5 shall apply.

4.3.6 Thermal properties

EN 13369:2004, 4.3.6 shall apply.

4.3.7 Durability

EN 13369:2004, 4.3.7 shall apply.

4.3.8 Other requirements

4.3.8.1 Safety in handling

EN 13369:2004, 4.3.8.1 shall apply.

4.3.8.2 Safety in use

EN 13369:2004, 4.3.8.2 shall apply.

5 Test methods

5.1 General

EN 13369:2004, Clause 5 shall apply, with the following rules.

5.2 Tests on concrete

EN 13369:2004, 5.1 shall apply.

5.3 Measuring of dimensions and surface characteristics

EN 13369:2004, 5.2 shall apply with the following additional rules (see Figure 1):

Skewness (θ): (for elements having rectangular shape only): measure the distance of points 5 and 15 from straight lines normal to the straight line 1-11, containing respectively the points 1 and 11;

Lateral bow (ε): measure the distance of points 6 and 10 from straight lines respectively 1-11 and 5-15;

Angle deviation of the rib (δ): measure the distance of points 2 and 12 (4 and 14) from straight lines normal to the lines 16-20 (17-21), containing respectively the points 16 and 20 (17 and 21).

6 Evaluation of conformity

6.1 General

EN 13369:2004, 6.1 shall apply.

6.2 Type testing

EN 13369:2004, 6.2 shall apply.

6.3 Factory production control

NOTE The missing numbers correspond to the clauses of EN 13369 included in the general references made in this subclause.

EN 13369:2004, 6.3 shall apply.

6.4 Finished products

In addition to items 3 to 5 of D.4.1 of Table D.4 of EN 13369:2004, the check of Table 1 shall be performed.

Table 1 — Finished product inspection

Subject	Method	Purpose	Frequency
Main dimensions	See 5.2	Conformity with drawings and specified tolerances	1 every 10 elements or 1 every casting line
Skewness Lateral bow Angle deviation of the rib	See 5.2	Conformity with drawings and specified tolerances	Every month
Slippage of tendons	Appropriated check /measurement	Conformity with EN 13369:2004, 4.2.3.2.4	Only if release is not gradual
Surface appearance	Visual inspection In case of doubt, check according to EN 13369:2004, J.4	Conformity with specified tolerances	Every element

7 Marking and labelling

EN 13369:2004, Clause 7 shall apply.

NOTE For CE marking see 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 surface characteristics (when relevant), 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
(informative)

Examples of elements

Some examples of cross-sections of precast elements considered in this document are shown in Figure A.1.

The elements can be simply supported, or connected longitudinally on or with the supports, achieving total or partial continuity. They can also be designed with half joints at the ends, in order to reduce the total thickness.

According to the different situations, the elements can be:

— placed on site without transversal connections, eventually supporting secondary elements between them (isolated members);

— provided with steel plates at their lateral edges to be connected together at their top flanges by welded shear connectors;

— shaped in form of shear keys at their lateral edges to be connected together by cast in situ shear joints, and/or be provided with steel plates for welded connections on site;

— provided with a cast in situ reinforced concrete topping. Such topping, if effectively restrained to the precast elements by bond, with or without steel reinforcement projecting from the elements, may be taken into account in the resistant section.

Combinations of the preceding cases are also possible.

According to the different arrangement of connections, the elements can be:

— able to act as a diaphragm in order to transfer horizontal forces to the bracing elements (cases b), c), d) and a) if the secondary elements are adequately connected);

— able to transfer vertical shear from heavier loaded elements to the surrounding ones (cases c), d) and b) if the welded connection is arranged in an appropriate way).

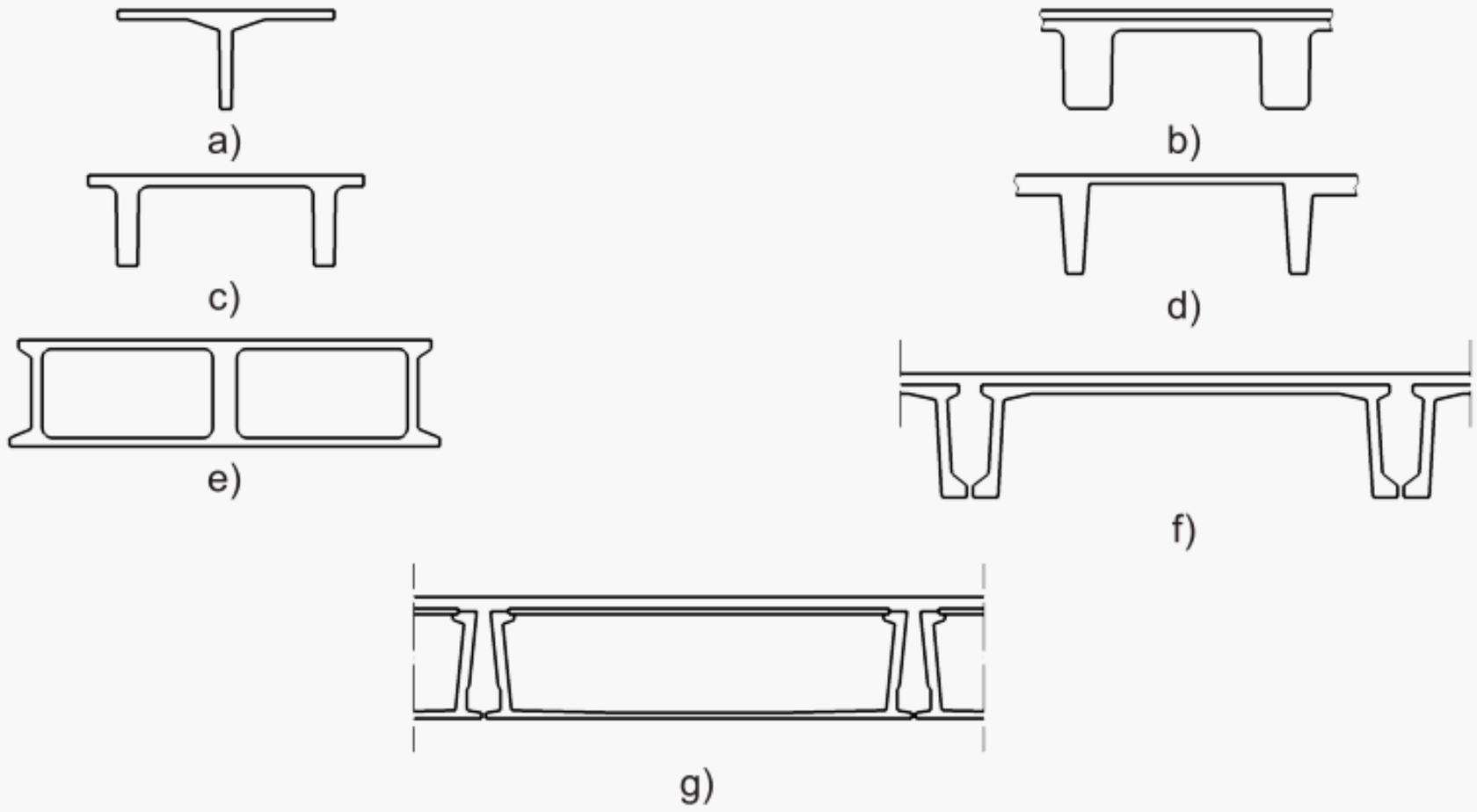


Figure A.1 — Examples of some forms of ribbed floor elements

Annex B
(normative)

Minor floor elements

B.1 General

In view of their use as specified in B.2.1, minor floor elements may be designed in the lower consequences class of EN 1990:2002, B.3.1. In this case, they shall be in compliance with the additional requirements and special rules of this annex.

Design, production and application of minor floor elements, according to these special rules, is only allowed if manufacturing takes place under strict production control.

B.2 Additional requirements for minor floor elements

B.2.1 General

Minor floor elements are ribbed precast floor elements with limited dimensions, used only for a suspended floor with a maximum below air space of 1 000 mm between the floor and the ground, which are in compliance with the additional requirements of B.2.2 and B.2.3.

NOTE According to consequences classes stated in 1990:2002, B.3.1, taking into account the use stated above, some special design rules are given for these products.

Examples of some forms of minor floor elements are given in Figure B.1.

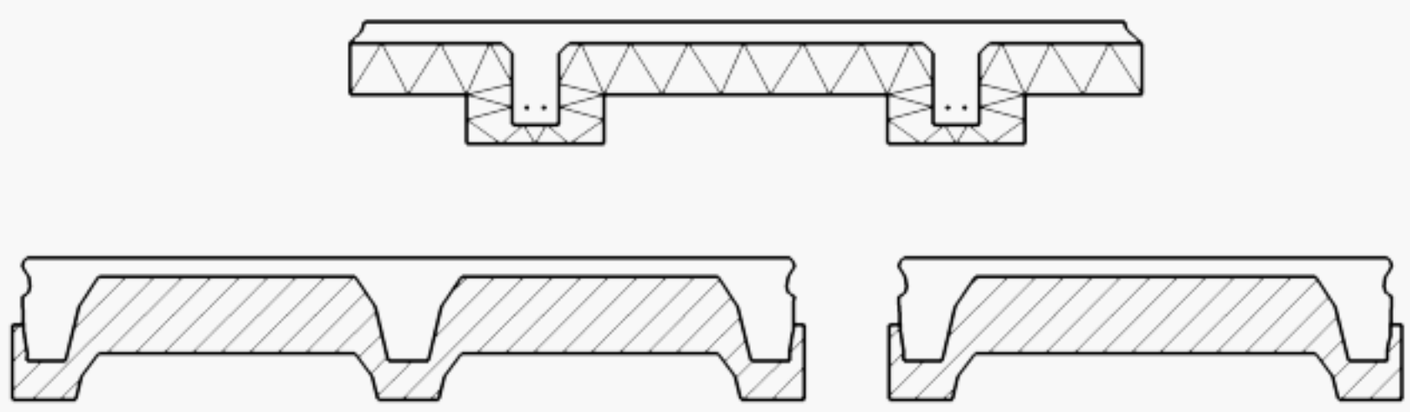


Figure B.1 — Possible forms of minor floor elements

B.2.2 Dimensions

Minor floor elements shall comply with the following dimensions (referred to the concrete-element, without thermal insulation):

span of the elements	≤ 8 000 mm;
height of the elements	≤ 400 mm;
width of the ribs	≥ 60 mm;
spacing between ribs	≤ 1 200 mm;

thickness of the slab:

— for $L_x \leq 950$ mm: ≥ 50 mm;

— for $L_x > 950$ mm: ≥ L_x/15;

cantilever (L_c) ≤ 600 mm;

thickness of cantilever slab ≥ L_c/8 or 50 mm;

for L_x and L_c: see Figure B.2.

The span/height ratio of minor floor elements shall be such that the time dependent deformation due to the quasi-permanent loads shall not exceed 3/1 000 of the span. In case of stone-like (plaster or brittle finish or other non-flexible) partitions, the additional deflection (after the execution of partitions) shall not exceed 2/1 000 of the span.

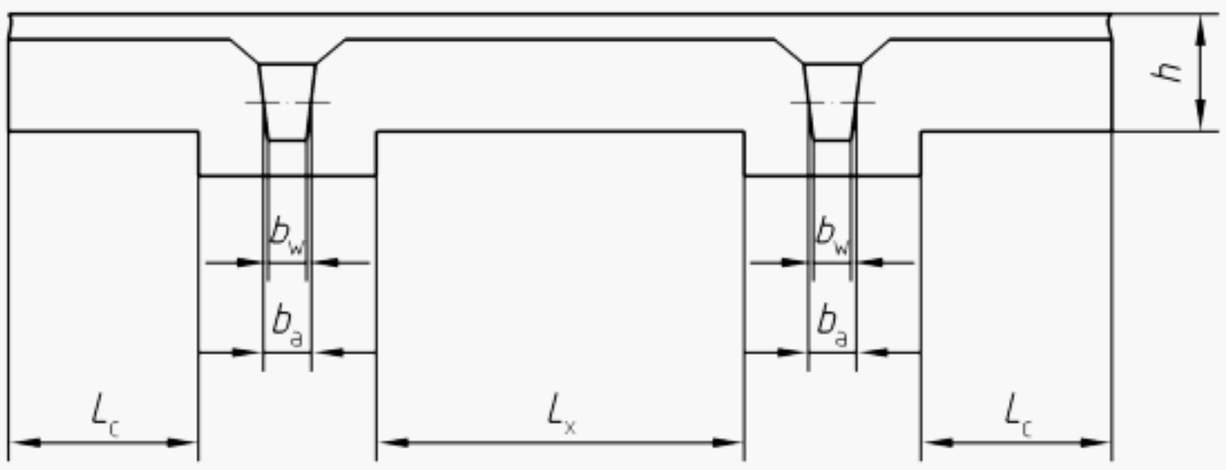


Figure B.2 — Notations

B.2.3 Minimum strength of concrete

The strength class of minor floor elements shall be not be less than C30/37 for reinforced elements and C40/50 for prestressed elements.

B.3 Special rules for minor floor elements

B.3.1 Bearing length

It may be assumed that the requirements of the bearing length are fulfilled if the minimum values of Table B.1 are adopted:

Table B.1 — Minimum bearing length for minor floor elements

support	prestressed elements	reinforced elements
masonry	90 mm	100 mm
concrete	80 mm	80 mm
steel	70 mm	70 mm

B.3.2 Transverse load distribution

The check of the connections between the elements is not necessary if they are shaped as indicated in Figure B.3 (or in a similar way) and each element is verified under the total load acting on it. However, such elements can be considered non isolated members as far as EN 1992-1-1:2004, 10.9.3 (10) and 4.3.3.3 of this European Standard are concerned.

In the case that the connections are shaped as indicated in Figure B.3 and minor floor elements are subjected only to an imposed load not exceeding 2,5 kN/m^2 and to line loads not exceeding 3,0 kN/m, a longitudinal line load not exceeding 3,0 kN/m may be replaced by a uniformly distributed load over a width equal to half of the span.

In the case that the imposed load is not exceeding 2,5 kN/m^2 and line loads are greater than 3,0 kN/m and not exceeding 6,0 kN/m, the line load has to be taken into account according to Figure B.4 a), b), c) and d).

Dimensions in millimetres

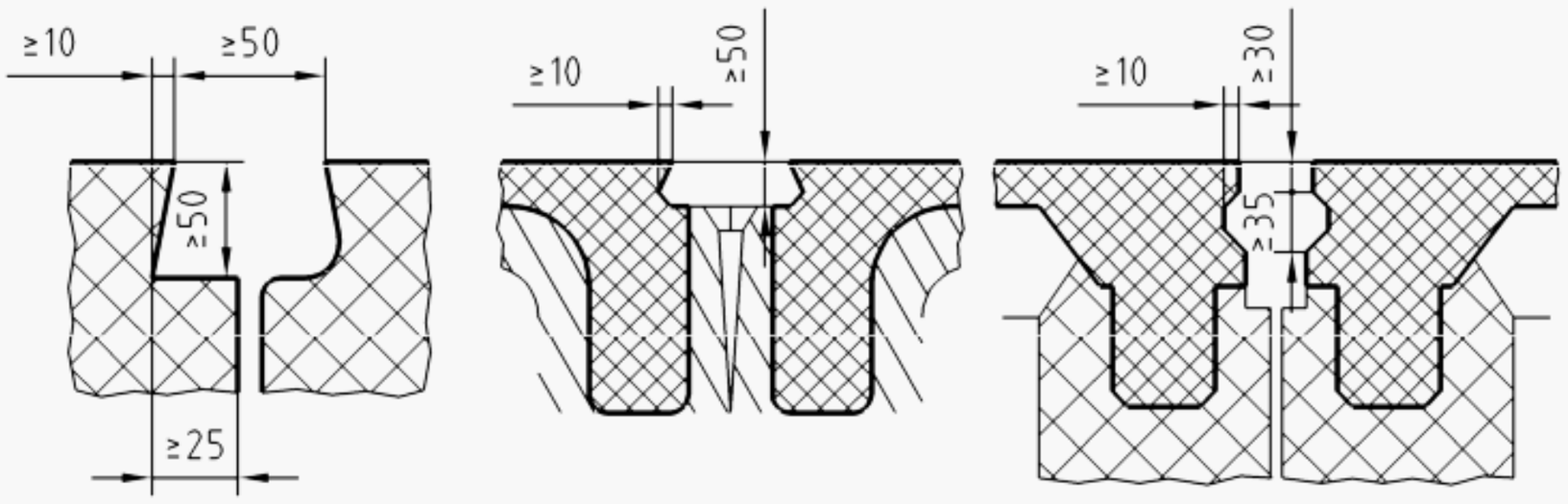


Figure B.3 — Joint shapes

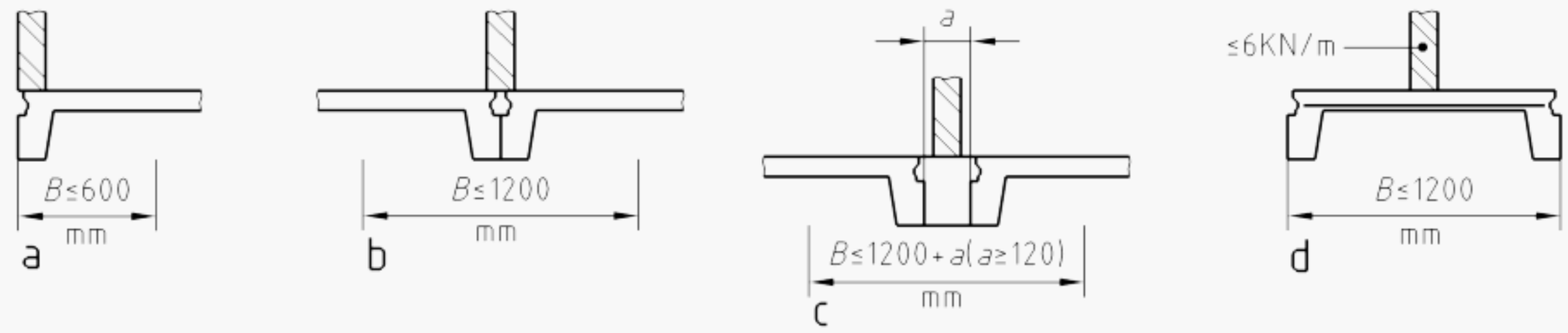


Figure B.4 — Transverse load distribution

B.3.3 Detailing

B.3.3.1 Shear reinforcement

In ribs having width not exceeding 125 mm the shear reinforcement, when required, may be shaped in one leg only, placed in the middle plane of the rib and properly anchored at each end.

B.3.3.2 Prestressed elements

Transversal reinforcement in the ribs can be omitted in the zone of anchorage of the prestressing tendons if it is not required by the resistance verification.

If all three following requirements are fulfilled:

— $A_p \leq 0{,}008\ h\ b_a$ (see Figure B.2), with $b_a \leq 1{,}25\ b_w$;

— strand diameter ≤ 12,5 mm;

— aggregate diameter ≤ 16 mm;

then the minimum clearance between the tendons is allowed to be 10 mm and there is no need for providing reinforcement against splitting.

B.3.3.3 Reinforced elements

The required anchorage zone can be assumed to be verified if the following detailing is provided:

— max. 2 bars in each rib, $\phi \leq 20$ mm; spacing of bars ≥ 20 mm; aggregate diameter ≤ 16 mm;

— for $\phi > 16$ mm the anchorage is assured by a properly welded cross-bar;

— for $\phi \leq 16$ mm the end of one bar is distant not more than 5 mm from the end of the rib, the second bar not more than 30 mm (for each bearing). If the distance is > 5 mm, the bearing length increases with the difference between the actual design distance and 5 mm.

Annex C
(informative)

Unintended negative moments

The following design by calculation may be adopted. The lower value from a) or b) may be taken.

a)

At end supports, which have been assumed as free supports, unless through the nature of the support no fixing moment can develop, the following unintended fixing moment may be taken into account:

$$M_{ds} = \frac{1}{3} M_{Eds}$$

where

M_{Eds} is the maximum span moment = $\gamma_G(M_{gs} - M_{ws}) + \gamma_Q M_{qs}$;

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 own weight of the elements;

γ_G, γ_Q are the partial factors for permanent and variable actions.

b)

The fixing moments may be calculated with the following equation:

$$M_{ds} = \frac{2}{3} N'_{Edt} \times a + \Delta M$$

where (see also Figure C.1):

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

a is the support length;

ΔM is the largest value of $\Delta M = f_{ctd} \cdot W$ and $\Delta M = f_{yd} \times A_y \times d + \mu_b \times N'_{Edt} \times h$;

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

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

f_{yd} is the design value of yield strength of reinforcement;

A_y is the cross sectional area of reinforcement;

d is the effective depth of the element cross section;

μ is the friction coefficient at the upper side of the element:

— 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;

h is the total depth of the element cross section.

If the joints between the ends of the element are smaller than 50 mm or if the joints are not filled, then:

ΔM is the smallest value of:

$$\Delta M = \mu_b \times N'_{Edt}\, h \text{ and } \Delta M = \mu_o \times N'_{Edb} \times h$$

where μ_0 is the friction coefficient at the underside of the element (same values as for μ_b).

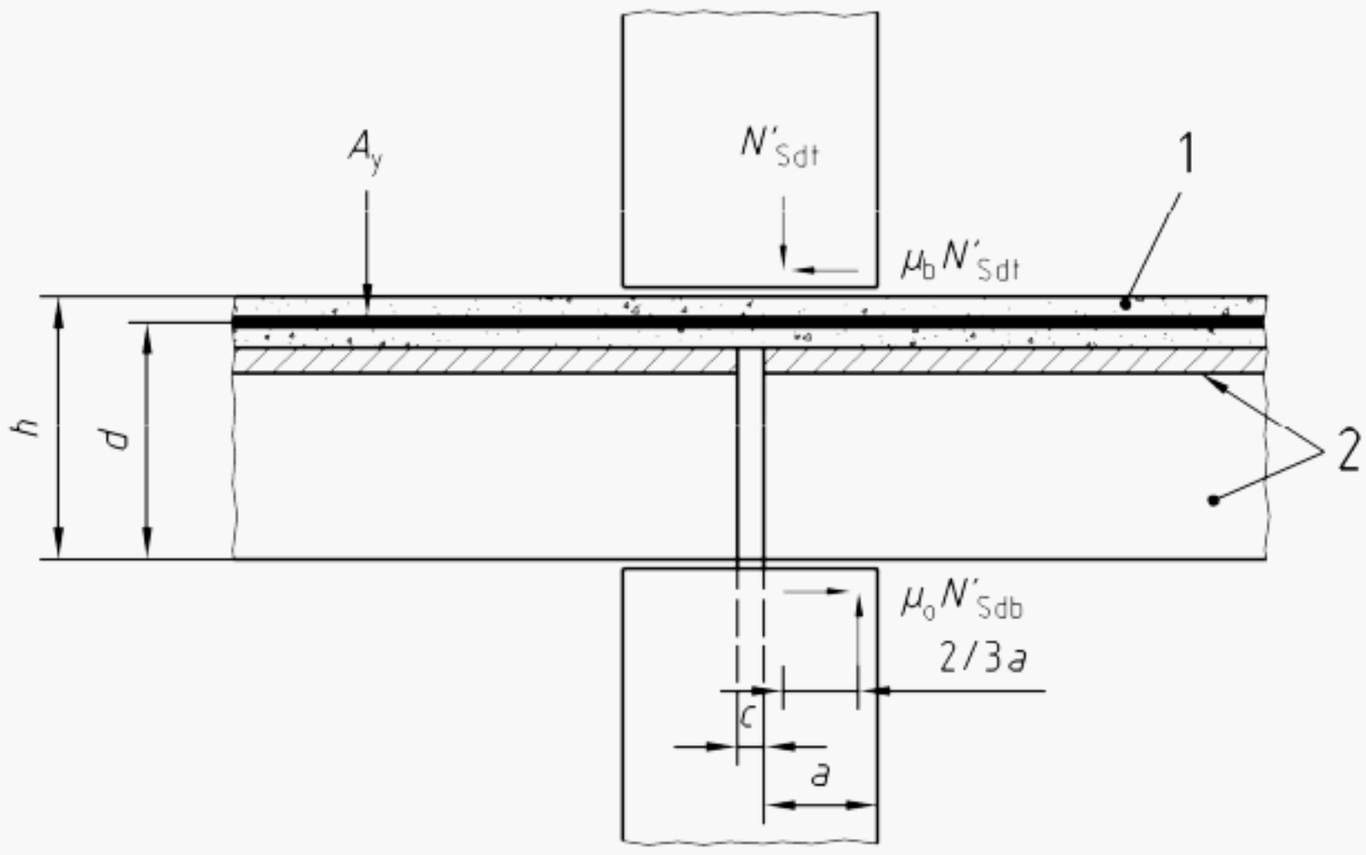
c)

Reinforcement for the unintended fixing moments may be omitted if:

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

in which the total depth is given in meter and:

W_t is the section modulus related to top side.



Key

1 cast in situ topping
2 precast element

Figure C.1 — Unintended fixing moments

d)

If, according to c), reinforcement for unintended fixing moments is required, or in case of negative design moments, then a top reinforcement shall be provided.

As a consequence, besides the check of shear in the elements related to positive moments and the corresponding positive reinforcement, a second check according to EN 1992-1-1:2004, 6.2.2 and 9.2.2 related to the negative moments and corresponding negative reinforcement should be carried out.

Annex D
(informative)

Thermal maps

A set of thermal maps for the bottom part of ribs is shown in the following. The ribs are supposed to be symmetrical by respect to a vertical axis, having the lateral sides inclined of 1:30. Small differences in the inclination of the lateral sides do not significantly affect the temperatures inside the rib (as demonstrated by the maps of 160 mm, 200 mm and 240 mm wide rib, having one vertical side).

The thermal maps have been computed by means of a Finite Elements procedure, starting from the following assumptions:

1) standard temperature-time curve according EN 1991-1-2:

$$\theta_g = 20 + 345 \log_{10}(8t + 1)$$

2) specific heat, thermal conductivity and density of concrete according to EN 1992-1-2:2004, Annex A:

$$c = 900 + 80\,(\theta_c/120) - 4\,(\theta_c/120)^2 \qquad \text{(calcareous and siliceous concrete)}$$

$$\lambda_c = 2 - 0{,}24\,\theta_c/120 + 0{,}012\,(\theta_c/120)^2 \qquad \text{(calcareous concrete)}$$

$$\rho_c = 2\,300 \text{ kg/m}^3$$

The effect of the moisture content of the concrete has been neglected.

The computed set of thermal maps is shown in Table D.1:

Table D.1 — Computed set of thermal maps

Width of the ribs (mm)	Fire exposure time (min)
80	30, 60, 90, 120
120	30, 60, 90, 120
160	60, 90, 120, 180
200	90, 120, 180
240	120, 180, 240

The thermal maps may be used for thermal properties given in EN 1992-1-2:2004, 3.3 both for upper and lower limit of thermal conductivity. They are conservative for the lower limit.

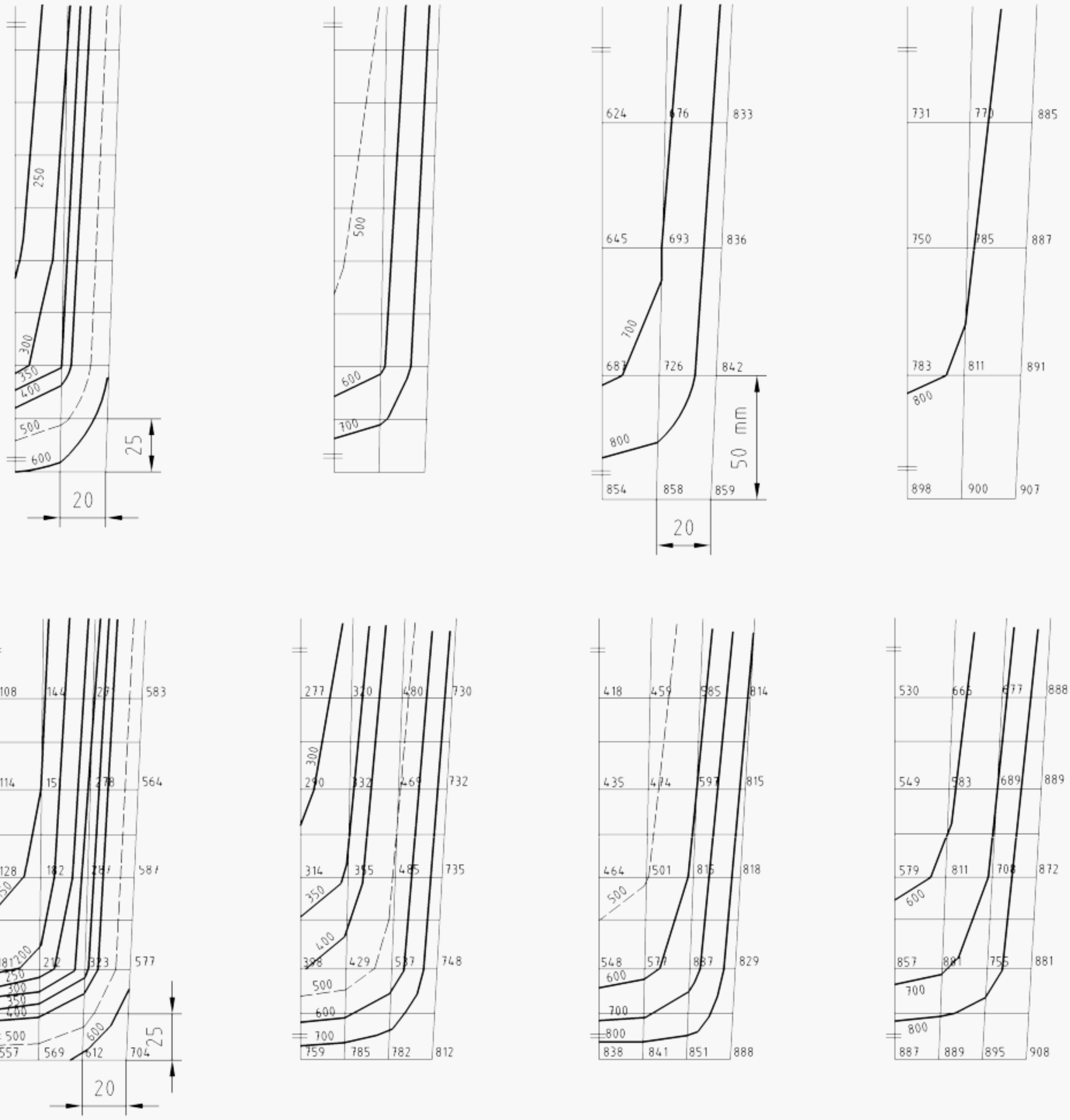
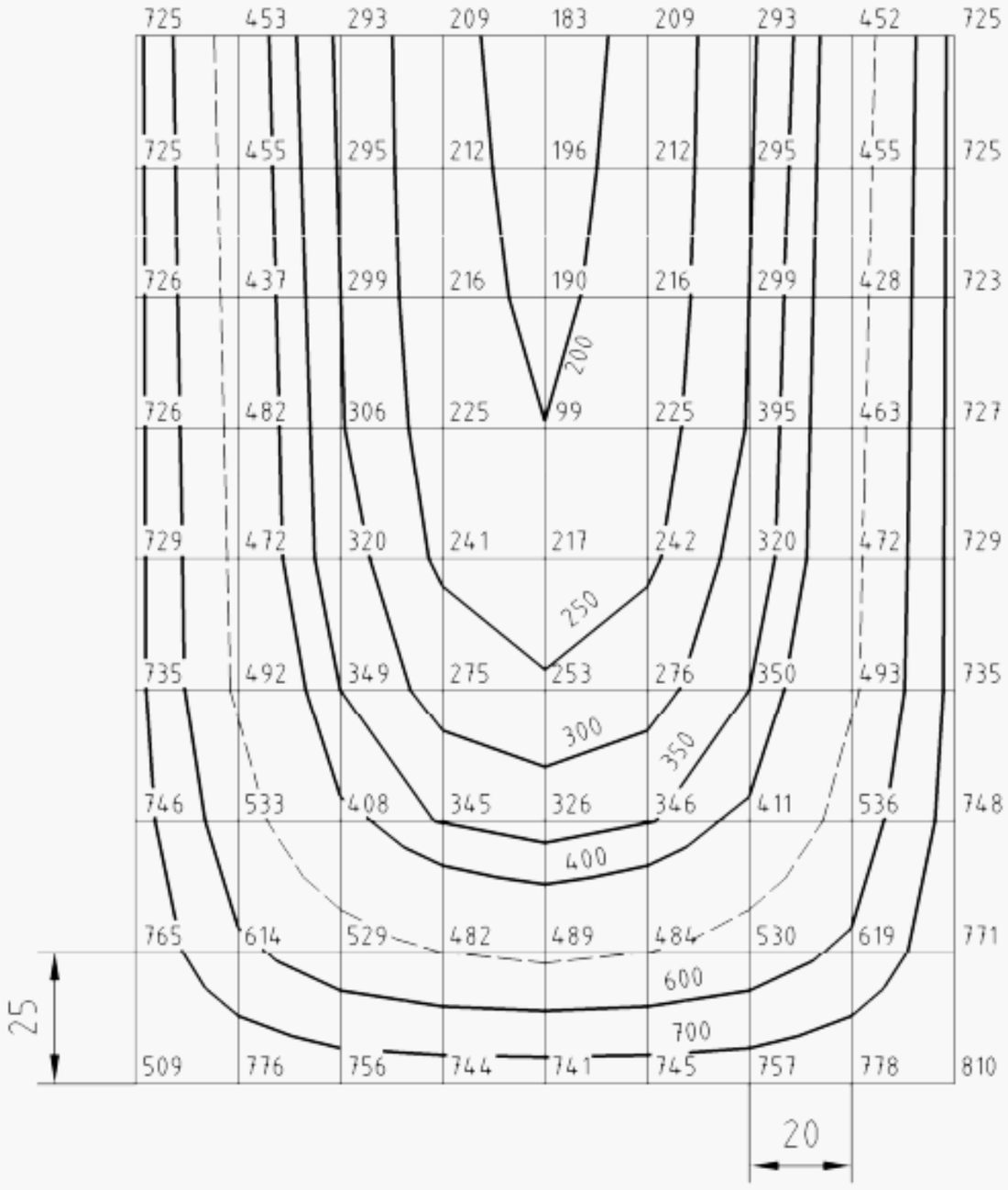
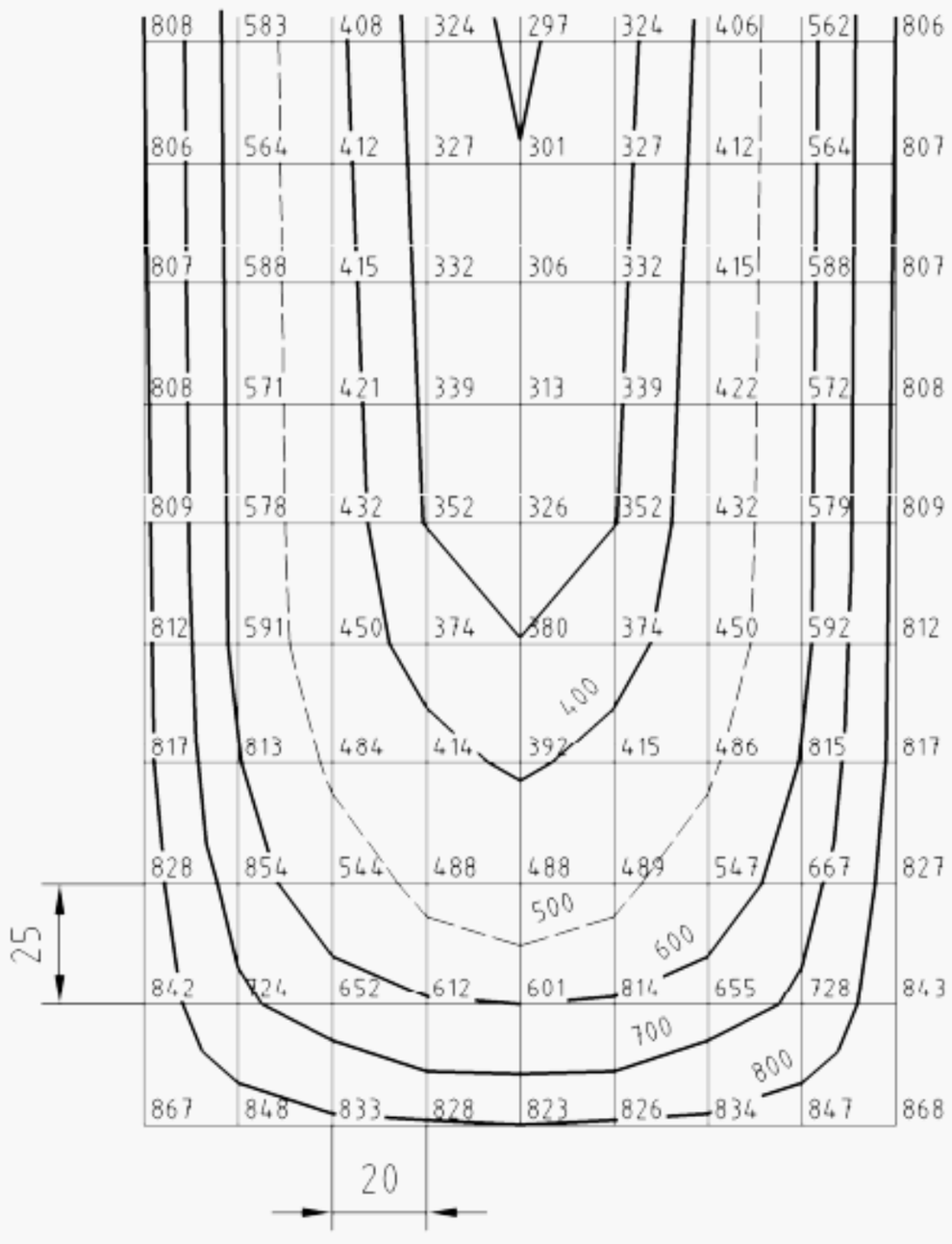
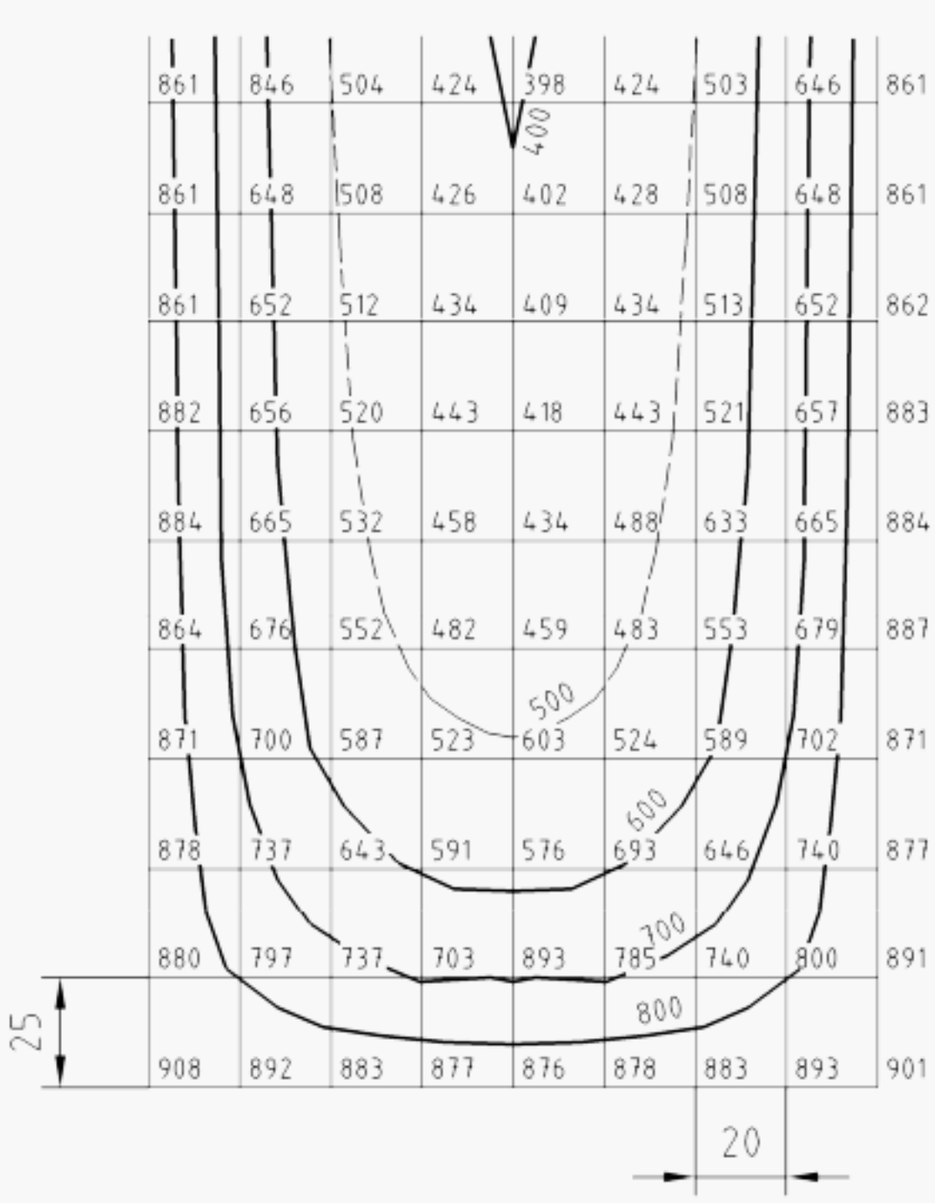


Figure D.1a — Thermal maps for width of ribs 80 mm and 120 mm (for exposure times see Table D.1)







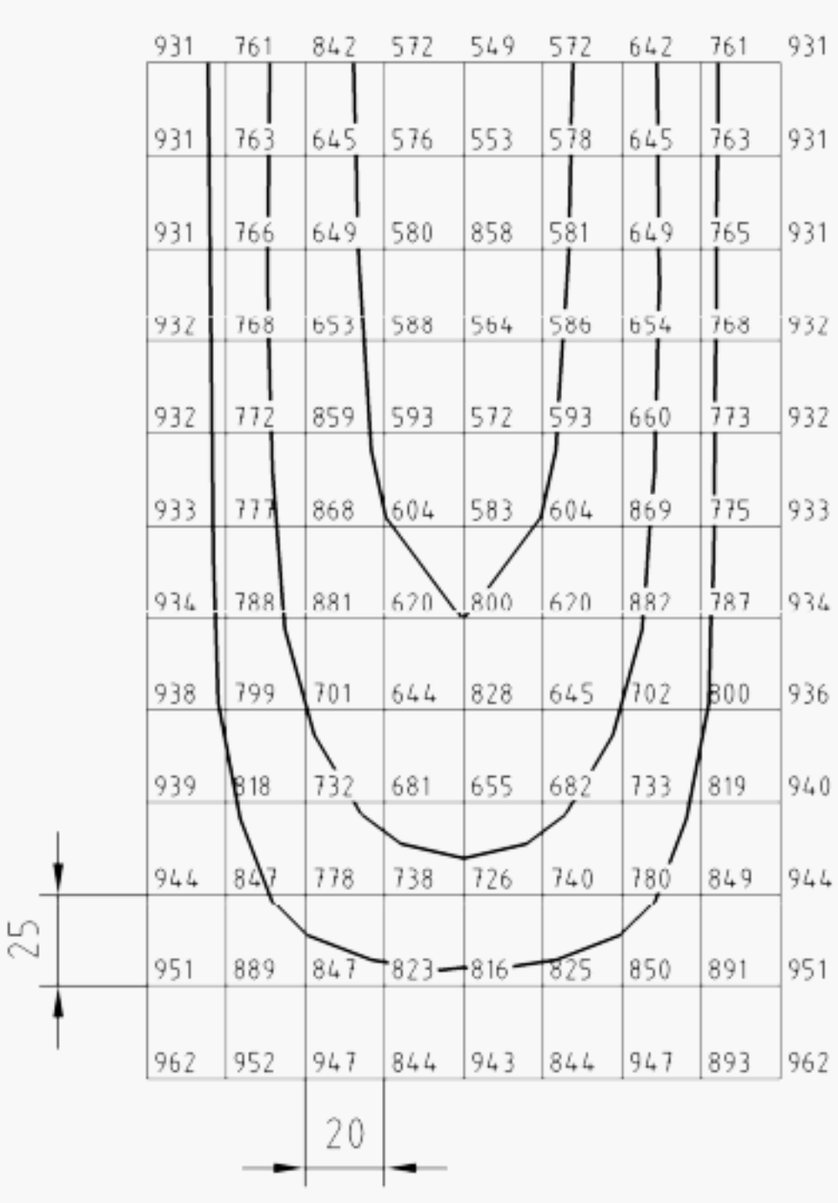


Figure D.1b — Thermal maps for width of ribs 160 mm (for exposure times see Table D.1)

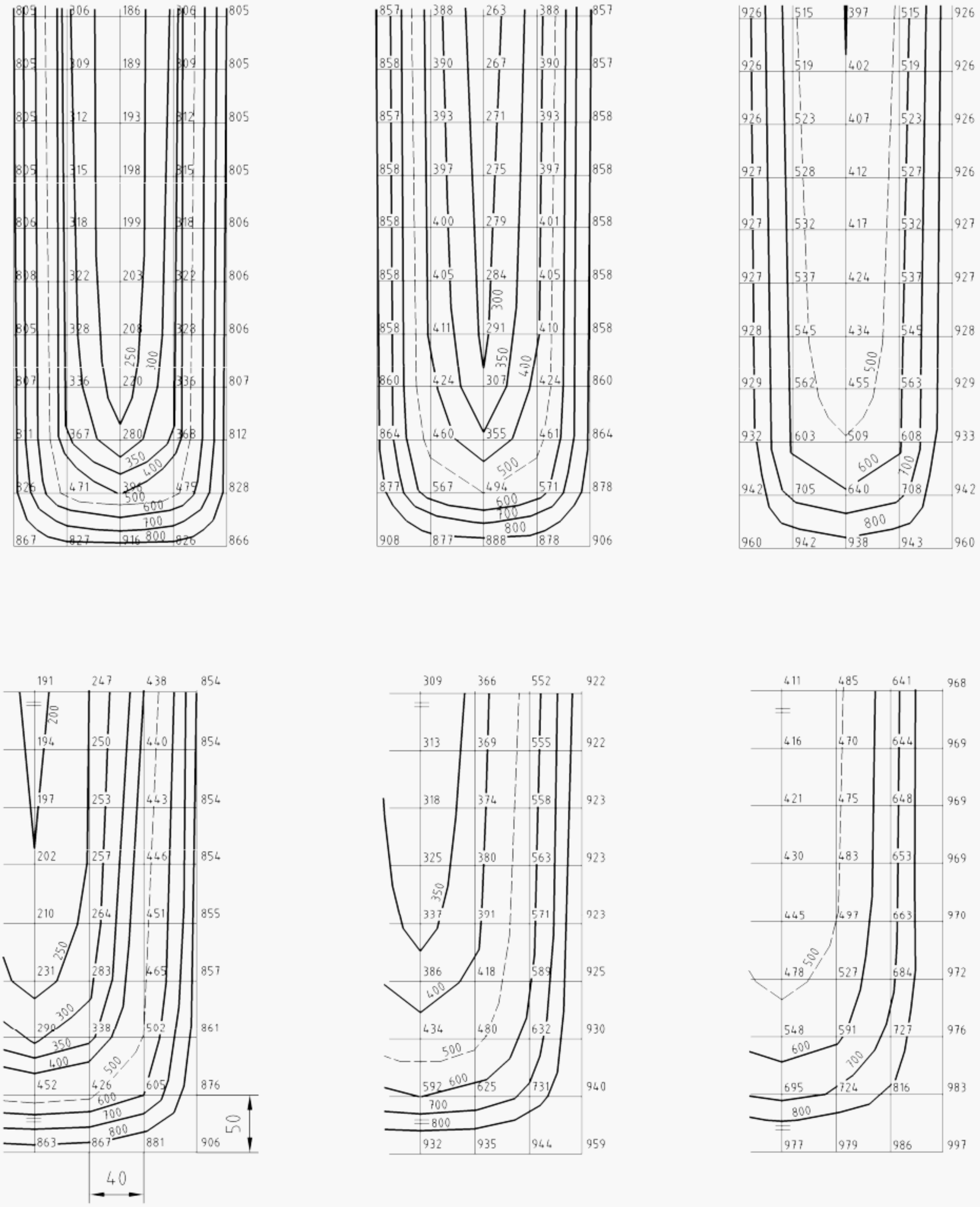


Figure D.1c — Thermal maps for width of ribs 200 mm and 240 mm (for exposure times see Table D.1)

Figure D.1 — Thermal maps

Annex E
(informative)

Transverse load distribution

Elements connected along the longitudinal edge with welded or cast in situ joints are not isolated members and may be designed to redistribute concentrated loading. The resistance of the connections and the transversal bending of the elements may be verified according to the actual shear forces between the elements. In case of cast in situ joins, lateral displacements should be limited by a horizontal resistant force at least equal to the total vertical shear force which has to be transmitted across the longitudinal joints. The horizontal force can be provided by one or more of the following provisions:

a) the surrounding parts of the structure;

b) the peripherical ties;

c) a transverse reinforcement;

d) a reinforced topping.

Alternatively, the same procedure as for isolated members may be applied, but the transverse bending of the elements should be verified under a shear force equal to the 40 % of the greatest possible difference in load between adjoining elements.

Elements connected by reinforced concrete cast on site topping are not isolated members and may be designed to redistribute concentrate loading through the shear and the bending moment in the topping. Alternatively, the same procedure as for isolated members may be applied, but the resistance of the topping and of the elements should be verified under a shear force in the joints equal to the 40 % of the greatest possible difference in load between adjoining elements.

Annex F
(informative)

Diaphragm action

The floors made of precast ribbed elements may act as a diaphragm in order to transfer horizontal actions to the vertical bracing elements. In this case, the design of the connections and, if relevant, of the elements should consider the internal forces due to the diaphragm action.

If there is a reinforced cast in situ topping, all the diaphragm actions can be attributed to the topping.

In the case of ribbed elements without bottom slab, the diaphragm action is mainly developed at the level of the top of the elements.

Annex ZA
(informative)

Clauses of this European Standard addressing the provisions of the EU Construction Products Directive

ZA.1 Scope and relevant characteristics

This European Standard has been prepared under the mandate M/100 "Precast Concrete Products"[1] 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 EU Construction Products Directive (89/106/EEC).

Compliance with these clauses confers a presumption of fitness of the precast ribbed floor elements 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 EU Directives, not affecting the fitness for intended uses, may be applicable to the precast ribbed floor elements 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/cpd-ds/)

This annex establishes the conditions for CE marking of precast ribbed floor elements made of reinforced or prestressed normal weight concrete, used for the construction of the structures of buildings and other civil engineering works, except bridges and shows the relevant clauses applicable.

This annex has the same scope as Clause 1 of this standard and is defined by Table ZA.1.

[1] As amended

Table ZA.1 — Relevant clauses for ribbed floor elements

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 4.2.3.2.1 of EN 13369 Initial tensioning stresses 4.2.3.2.4 of EN 13369 Slippage of tendons	None	kNm, kN, kN/m N/mm^2 mm
	Method 3	4.3.3 Mechanical resistance 4.2.3.2.1 of EN 13369 Initial tensioning stresses 4.2.3.2.4 of EN 13369 Slippage of tendons	None	Design specification
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	4.3.4 Resistance to fire	R	Design specification
Durability	All methods	4.3.7 Durability	None	Declared class
Detailing	All methods	4.3.1 Geometrical properties 8 Technical documentation	None	mm /

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).

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 Clause ZA.3) may be used. The NPD option may not be used, however, where the characteristic is subject to a threshold level.

ZA.2 Procedure for attestation of conformity of precast ribbed floor elements

ZA.2.1 System of attestation of conformity

The system of attestation of conformity of precast ribbed floor elements, for the essential characteristics indicated in Table ZA.1, in accordance with the decision of the Commission 99/94/EEC of 25 January 1999 (published the 3.02.1999 in the OJEU) 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.2 — System of attestation of conformity

Product(s)	Intended use(s)	Level(s) or class(es)	Attestation of conformity system(s)
Precast ribbed floor elements	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 precast ribbed floor elements, 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 ribbed floor elements under system 2+

Tasks		Content of the tasks	Evaluation of conformity clauses to apply
Tasks under the responsibility of the manufacturer	Initial type testing[1]	All characteristics of Table ZA.1[a]	6.2
	Factory production control	Parameters related to all characteristics of Table ZA.1	6.3
	Further testing of samples taken at the factory	All characteristics of Table ZA.1	6.2.3 of EN13369:2004
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[2]	— compressive strength (of concrete); — ultimate tensile and tensile yield strength; — mechanical resistance [3] — detailing; — durability; — resistance to fire R (in case of verification by testing).	6.3
	Continuous surveillance, assessments and approval of factory production control	— compressive strength (of concrete); — ultimate tensile and tensile yield strength; — mechanical resistance [3] — detailing; — durability; — resistance to fire R (in case of verification by testing).	6.3

[1] Initial Type testing (ITT) includes calculation and/or testing. ITT by calculation is not required when only methods 1 and 3a are used. ITT according to Annex J shall be performed irrespective of the declaration method, see 6.2.2.

[2] 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 (when assessed by calculation) can be omitted when only methods 1 and 3a) are used.

[3] 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, ...), 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;

— 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 identified in this standard or by the manufacturer himself and affect the content and/or procedures of the factory production control including the procedure 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/EEC and shall be shown on the product (or when not possible it may be on the accompanying label, the packaging or the accompanying commercial documents e.g. a delivery note).

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

— 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 factory production control certificate;

— reference to this European Standard with the date of the version;

— 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 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 subclauses 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 are given. For what concern 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).

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 factory production control certificate;

— reference to this European Standard with the date of the version.

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

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

Figure ZA.1 gives a 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
11	Last two digits of the year in which the marking was affixed
0123-CPD-0456	Number of the FPC certificate
EN 13224:2011	Number of this European Standard

Figure ZA.1 — Example of simplified label

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

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, the following properties shall be declared:

— compressive strength of concrete;

— ultimate tensile strength of reinforcing steel;

— tensile yield strength of reinforcing steel;

— ultimate tensile strength of prestressing steel;

— tensile 0,1 proof stress of prestressing steel;

— 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 ribbed element, the model 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.

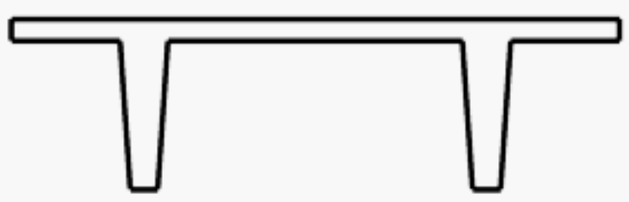
CE 0123	CE conformity marking consisting of the CE symbol given in directive 93/68/EEC Identification of the notified body
AnyCo Ltd, PO Bx 21, B-1050 11 0123-CPD-0456	Name or identifying mark and registered address of the manufacturer Last two digits of the year in which the marking was affixed Number of the FPC certificate
EN 13224:2011 Precast ribbed floor element RIBBED ELEMENTS (for floor) 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  Series TT/n Type 800 × 2 500 × 20 000 For detailing see Technical Information Technical Information: Product Catalogue ABC: 2002 – clause ii	Number of dated version and title of European Standard concerned Generic name and intended use Information on product geometry and material characteristics including detailing (to be adapted to the specific product by the manufacturer) NOTE The sketch may be omitted if equivalent information are available in clearly identified Technical Information (product catalogue) referred to.

Figure ZA.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, the following properties shall be declared (where relevant):

— compressive strength of concrete;

— ultimate tensile strength of reinforcing steel;

— tensile yield strength of reinforcing steel;

— ultimate tensile strength of prestressing steel;

— tensile 0,1 proof stress of prestressing steel;

— 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;

— resistance to fire R class;

— safety factors for concrete and steel used in calculation;

— other Nationally Determined Parameters NDPs used in calculation;

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

— geometrical data;

— detailing.

This information may be given by reference to the manufacturer's Technical Documentation for geometrical data, detailing, durability and other NDP's.

Figure ZA.3 gives, for ribbed floor elements, the model CE marking in the case in which the properties related to mechanical resistance and stability and resistance to fire including the aspects of durability and serviceability are determined by the manufacturer 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 EN 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 11 0123-CPD-0456	Name or identifying mark and registered address of the manufacturer Last two digits of the year in which the marking was affixed Number of the FPC certificate
EN 13224:2011 Precast ribbed floor element RIBBED ELEMENTS (for floor)	Number of dated version and title of European Standard concerned 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, 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 Technical documentation.

Figure ZA.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, the following properties shall be declared:

— compressive strength of concrete;

— ultimate tensile strength of reinforcing steel;

— tensile yield strength of reinforcing steel;

— ultimate tensile strength of prestressing steel;

— tensile 0,1 proof stress of prestressing steel;

— 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 precast ribbed floor elements, 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 0123	CE conformity marking consisting of the CE symbol given in directive 93/68/EEC Identification of the notified body
AnyCo Ltd, PO Bx 21, B-1050 11 0123-CPD-0456	Name or identifying mark and registered address of the manufacturer Last two digits of the year in which the marking was affixed Number of the FPC certificate
EN 13224:2011 Precast ribbed floor element RIBBED ELEMENTS (for floor) 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 and durability see the design specifications Design specification: Order code xxxxxx	Number of dated version and title of European Standard concerned Generic name and intended use Information on product mandated characteristics including detailing (to be adapted to the specific product by the manufacturer)

Figure ZA.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, the following properties shall be declared:

— compressive strength of concrete;

— ultimate tensile strength of reinforcing steel;

— tensile yield strength of reinforcing steel;

— ultimate tensile strength of prestressing steel;

— tensile 0,1 proof stress of prestressing steel;

— resistance to fire class;

— reference to the design specifications according to the client's order and dealing with geometrical data, detailing, mechanical strength, fire resistance, acoustic insulation parameters and durability.

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

Figure ZA.5 gives, for precast ribbed floor elements, an example of CE marking in the case the product is produced according to a design specification applied by the manufacturer according to the purchaser’s order.

CE 0123	CE conformity marking consisting of the CE symbol given in directive 93/68/EEC Identification of the notified body
AnyCo Ltd, PO Bx 21, B-1050 11 0123-CPD-0456	Name or identifying mark and registered address of the manufacturer Last two digits of the year in which the marking was affixed Number of the FPC certificate
EN 13224:2011 Precast ribbed floor element RIBBED ELEMENTS (for floors) 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, and durability see the design specifications Design specification: .....(client's order)	Number of dated version and title of European Standard concerned Generic name and intended use Information on product mandated characteristics including detailing (to be adapted to the specific product by the manufacturer)

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

In addition to any specific information relating to dangerous substances, the product should be also 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.

Bibliography

[1] EN ISO 9001:2008, *Quality management systems — Requirements (ISO 9001:2008)*

[2] EN 13670:2009, *Execution of concrete structures*

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