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Authorised and notified according to Article 29 of the Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011

MEMBER OF EOTA

European Technical Assessment ETA-17/0330 of 2020/06/29

I General Part

Technical Assessment Body issuing the ETA and designated according to Article 29 of the Regulation (EU) No 305/2011: ETA-Danmark A/S

Trade name of the construction product:	Hi-Con Balcony elements
Product family to which the above construction product belongs:	Precast balcony elements made from ultra-high performance fibre reinforced concrete
Manufacturer:	Hi-Con A/S Hjallerup Erhvervspark 1 DK-9320 Hjallerup www.hicon.dk
Manufacturing plant:	Hi-Con A/S Hjallerup Erhvervspark 1 DK-9320 Hjallerup
This European Technical Assessment contains:	17 pages including 5 annexes which form an integral part of the document
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of:	EAD 010003-00-0301 Precast balcony elements made from ultra-high performance fibre reinforced concrete, edition May 2016
This version replaces:	The ETA with the same number issued on 2017-05-16

II SPECIFIC PART OF THE EUROPEAN TECHNICAL ASSESSMENT

1 Technical description of product and intended use

Technical description of the product

Hi-Con Balcony elements are precast balcony elements made from ultra-high performance fibre reinforced concrete (UHPFRC).

The precast UHPFRC balcony elements are made of variable size, shape, and design. The elements are cast in one operation and cured at the precast factory before they are transported to the building site and installed.

Common for all balcony types covered are:

- Constituent materials are generally according to EN 206 and especially the cement part is according to EN 197-1.
- They all consist of fibre reinforced concrete with a compressive strength above 110 MPa, which is outside the scope of EN 1992-1-1 (EC2).
- They are designed according to the principles of EC2, but with a few deviations based on UHPFRC material design. Examples of these deviations, made possible by the increased ductility of the UHPFRC compared to traditional concrete, are higher compressive design strength, lower rebar cover, shorter anchorage length and higher tensile strength. The specific composition of the concrete is deposited with ETA-Danmark A/S.
- The precast UHPFRC balcony elements are reinforced with conventional reinforcement mesh typically placed in two layers. Reinforcement shall be class B500 as minimum and comply with EN 10080 as well as EC2.
- Furthermore, the balcony elements are reinforced with steel fibres. The steel fibres provide ductility, anchorage capacity and improved cracking performance to the material. The steel fibres do not constitute structural reinforcement.
- Steel fibres comply with EN 14889-1. They may be stainless or carbon steel with a minimum tensile strength of 1200 MPa, a maximum length of 30 mm and a fibre diameter up to 0.4 mm.
- The precast UHPFRC balcony elements may contain structural ribs and/or integrated beams with localised reinforcement.
- The sizes of the precast elements are normally governed by the lifting and transport capacity during installation. There is no limit to the size from a structural point of view.

All brackets, fastenings, bannisters etc. are designed, produced and installed according to relevant standards (e.g. steel, aluminium, glass. etc.) and are not covered by this ETA. Anchorage of the precast balcony unit into the building facade, is designed according to principles in EC2 taking into account the provisions applying at place of use. The design for avoidance of thermal bridge between the precast element and the building is not covered by the ETA.

The design loads and the safety factors are provided in Eurocodes 0 and 1. The designer responsible for the structural design shall be experienced with this design basis.

The design of the fastenings between the product and the building façade shall be carried out according to the relevant Eurocodes, harmonized product standards, ETA´s, etc. taking into account the provisions applying at place of use. This also applies for any support columns including foundations. These elements are not included in this ETA.

The deviations from EC2 design principles and those valid for precast UHPFRC balcony elements are specified in annex A of this ETA.

Manufacturing of precast balcony elements shall be in accordance with EN 14650 and EN 13369 or similar standard – with the deviations specifically mentioned in this ETA.

Range

See annex B for examples of sizes, geometry and dimensions.

2 Specification of the intended use in accordance with the applicable EAD

The precast UHPFRC balcony element is used as outdoor balconies for houses subject to outdoor exposures. Environmental exposure classes given in EN 206 may be used to classify the exposure conditions. As minimum the exposure classes XC4 shall be applied.

The product is only intended to be used subjected to static or quasi-static load actions as cantilevered or simply supported exterior balconies. The product shall not be subjected to fatigue loading.

The provisions made in this European Technical Assessment are based on an assumed intended working life of the elements of 50 years.

The indications given on the working life cannot be interpreted as a guarantee given by the producer or Assessment Body, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

3 Performance of the product and references to the methods used for its assessment

Characteristic	Assessment of characteristic
3.1 Mechanical resistance and stability (BWR1)	
2.2.1 Compressive strength	**Minimum 110 MPa***
2.2.2 Compressive stress-strain curve	**At least 80% of the value of the compressive strength at 4 per mille**
2.2.3 E-modulus	**Minimum 42 GPa**
2.2.4 Tensile and bending strength (3-point bending curve)	**Minimum class 5b**
2.2.5 Uniaxial tensile strength	**Minimum 5 MPa**
2.2.6 Rebar anchorage length	**Formulas in annex C**
2.2.7 Creep and shrinkage behaviour	**Curves in annex D**
2.2.8 Freeze/thaw resistance	**m_{56}<10 g/m^2** **RDM>95%**
2.2.9 Chloride ingress (on cracked beams)	**< 5 x 10^{-14} m^2/s**
2.2.10 Carbonation depth	**Below 1 mm after 2 years**
2.2.11 Fibre distribution	**Minimum 5 MPa**
3.2 Safety in case of fire (BWR2)	
2.2.12 Reaction to fire	**A1**
2.2.13 Resistance to fire	The resistance to fire classification of a 100 mm thick balcony element in accordance with EN 13501-2 is **REI 60** The classification is valid for the following end use conditions: Loadbearing floor or roof with fire separating function. • The maximum moments and shear forces, which when calculated on the same basis as the test load, shall not be greater than those tested. The maximum moment and shear force is 5.89 kNm/m and 5.69 kN/m respectively (applied load + dead load). For tabulated design values for resistance to fire classification **RE 120** based on the Danish national annex to EC2; DS/EN 1992-1-2 DK NA2011 and for resistance to fire classification RE 60 based on the Finnish national annex to EC2; SFS/EN 1992-1-2, see annex E
2.2.14 Risk of explosive spalling	**NPA**

*****150x300 mm cylinders

3.10 Aspects related to the performance of the product

The European Technical Assessment is issued for the product on the basis of agreed data/information, deposited with ETA-Danmark, which identifies the product that has been assessed and judged. Changes to the product or production process, which could result in this deposited data/information being incorrect, should be notified to ETA-Danmark before the changes are introduced. ETA-Danmark will decide whether or not such changes affect the ETA and consequently the validity of the CE marking on the basis of the ETA and if so whether further assessment or alterations to the ETA, shall be necessary.

The supplementing statements of the manufacturer stated in the MTD for design and installation of the balcony elements shall be considered.

The performance of the balcony element can be assumed only, if the following aspects are considered:

- The declared performance for the rebar anchorage only applies when the boundary conditions for the formula are fulfilled, see annex C,
- The fibre index is higher or equal to 0.6.

It is the manufacturer's responsibility to make sure that all those who utilize the balcony element will be appropriately informed about the specific conditions according to this ETA and the not confidential parts of the MTD deposited to this ETA.

4 Attestation and verification of constancy of performance (AVCP)

4.1 AVCP system

According to the decision 99/94/EC of the European Commission1, as amended, the system(s) of assessment and verification of constancy of performance (see Annex V to Regulation (EU) No 305/2011) is 2+.

5 Technical details necessary for the implementation of the AVCP system, as foreseen in the applicable EAD

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited at ETA-Danmark prior to CE marking.

Issued in Copenhagen on 2020-06-29 by

Thomas Bruun
Managing Director, ETA-Danmark

Annex A
Design principles - deviations from EC2.

The design principles for Hi-Con balconies are based on the EC2 approach but with a number of deviations. Some deviations are trivial, but the most significant ones are mentioned in the present annex.

Concrete compressive strength:
A characteristic strength of 110 MPa is used. With a material safety factor of 1.4 this gives a design strength of 78.5 MPa.

Compressive strength – reduction factor:
Based on the ductility demonstrated by the UHPFRC used by Hi-Con (described in the evaluation document) it has been decided to deviate from the reduction factor η, described in section 3.1.7 in EC2. This factor is used to account for the increased brittleness of concrete at high strength compared to conventional concrete at 50 MPa levels and as demonstrated in the document, the Hi-Con UHPFRC has a much higher ductility. The value of η is taken as 1.0.

Anchorage:
The formula used for estimate of bond has been given in this ETA. In the evaluation report is also listed some of the test results that provide the basis for this formula as well as the additional tests that have been carried out over the years to further validate the use of a shorter development length in Hi-Con balconies than would be allowed according to EC2.

Cover to the reinforcement:
A minimum cover to the reinforcement of 10 mm is required. However, generally a cover to the reinforcement of 15 mm is used even in aggressive environment. To avoid reinforcement corrosion, it is necessary to have a very dense concrete, and this is documented in the evaluation report, where it is demonstrated that both carbonation and chloride intrusion is suitably slow – also in the loaded state. With slender structures with a comparatively high live load where the structure is exposed to significant bending tension, it is documented that the fibres provide effective crack control and that micro cracks at these levels do not affect carbonation and chloride intrusion.

Deformations:
When calculating deformations, the cracking strength of the Hi-Con UHPFRC is taken as 5 MPa. This has been validated by model tests as well as full scale tests, where the measured deflections have been compared against the calculated deflections.

Annex B – Examples of Hi-Con balcony types

A wide range of balcony types are produced by Hi-Con and the common thread is that the same material composition is used for all of them – as well as the same calculation principles. A few examples of balconies are shown in figs. 1-3.

Figure 1: Cantilevered balcony elements ready for installation. The cantilevered flaps are cast monolithically as part of the element for attachment to the building façade.

Figure 2: Cantilevered balcony element placed on corbels in the bottom of the deck and with bolted connections transferring tensile forces into the façade from the top of the balcony upstands.

Fig. 3: a) Balcony elements partly supported by columns. b) The outer edge of the balcony element contains an integrated beam/rib.

While the balconies in fig. 3 are relatively straightforward regarding support conditions the typical connection details for figs. 1 and 2 have been shown in figs. 4 and 5. Either the type shown in fig. 5 can be with a concrete upstand, that transfers the tensile forces to the connection or a strut can be used. Alternatively, both types can be combined with a concrete upstand in one side and a strut in the other side as shown in fig. 6. It is possible to design this, so that the concrete upstand can support the full balcony in a fire situation, in which case the strut does not have to be protected against fire – it is merely in place to make sure that the deformations remain acceptable under service loads and that there are no problems with vibrations.

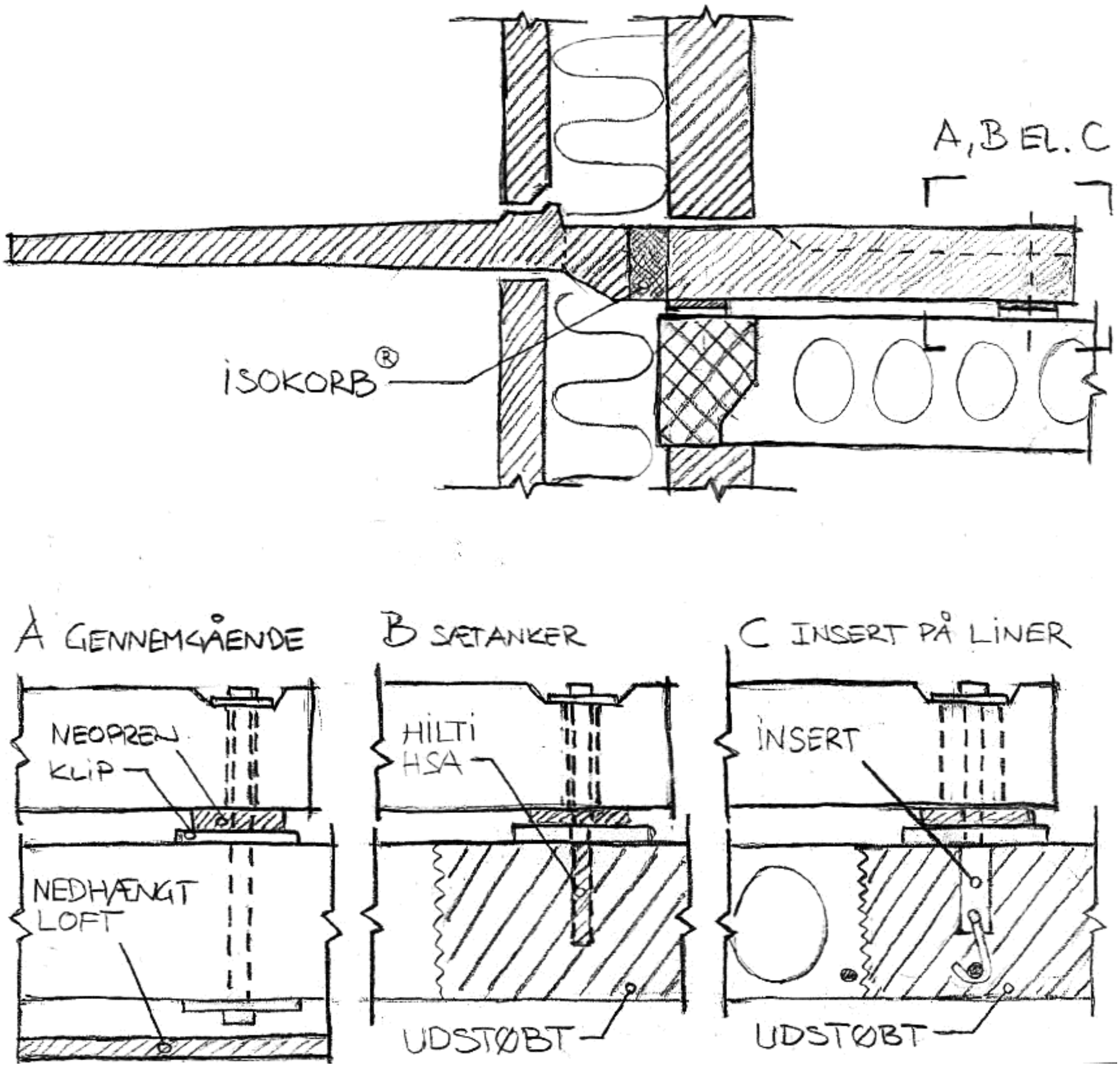


Fig. 4 Schematic showing installation of balcony with cold bridge-breaker such as shown in fig. 1.

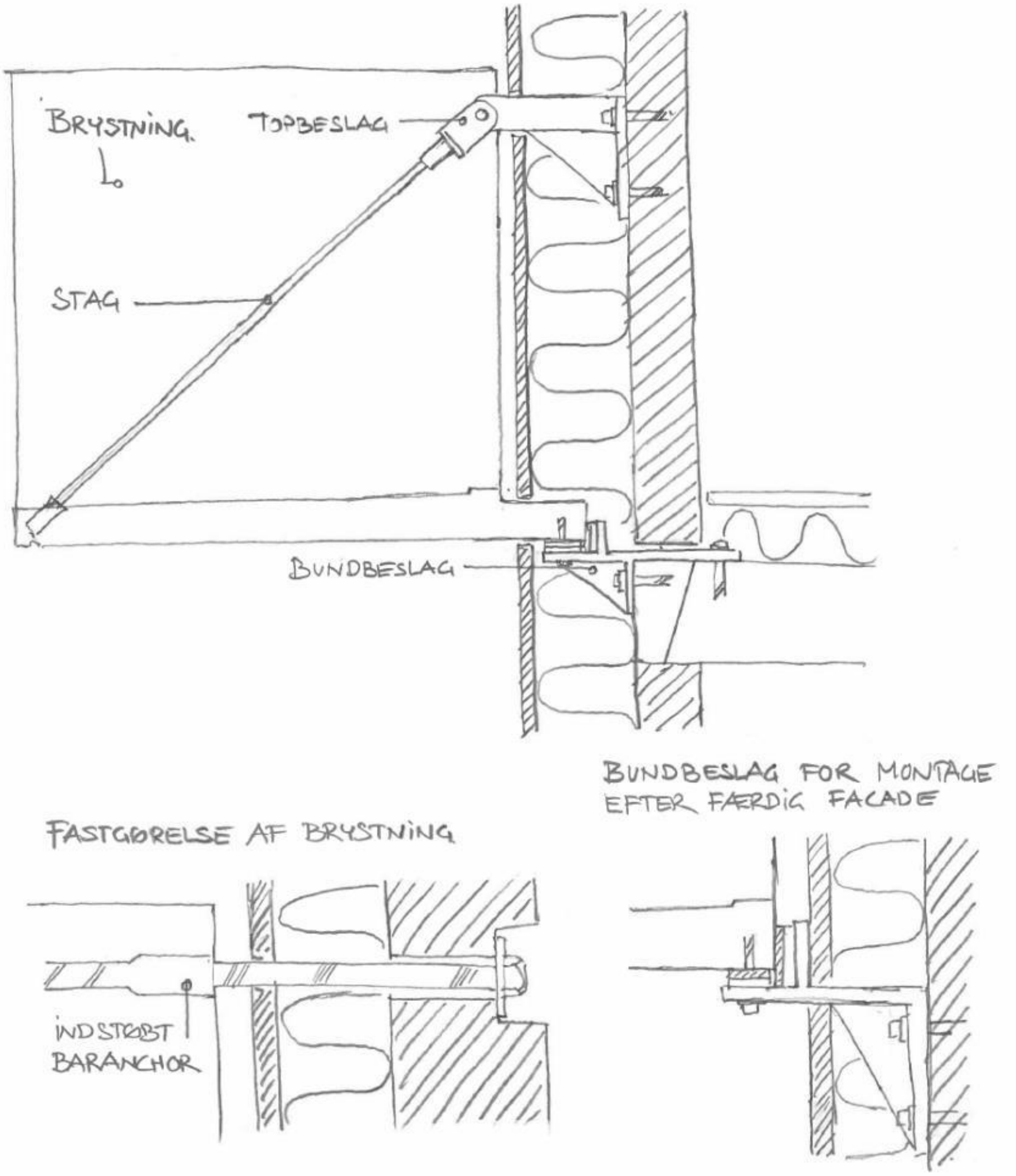


Fig. 5 Connection details of balcony with struts or concrete upstand such as shown in fig. 2.

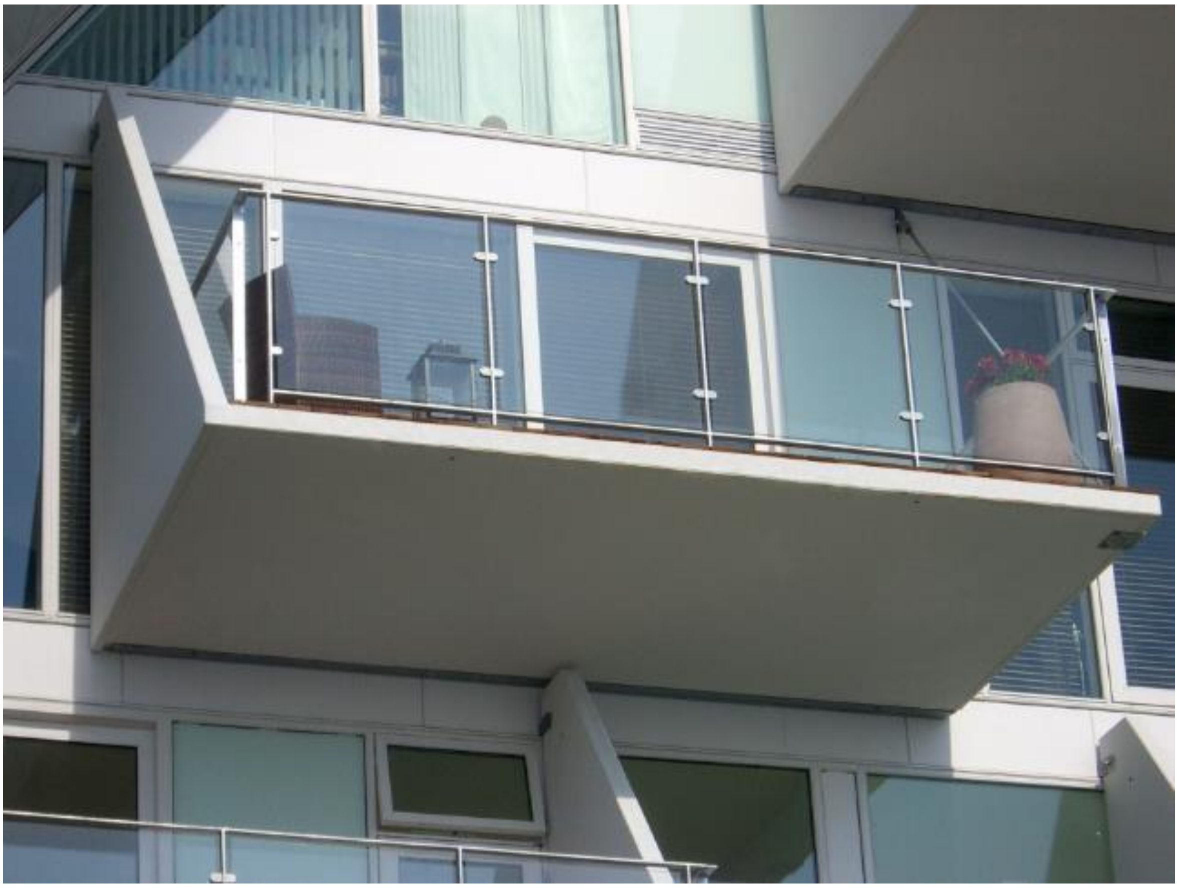


Fig. 6 Balcony combining concrete upstand and strut.

Annex C – formulas for rebar anchorage length

The empirical formulas are:

For fibre index 1.8:

$$\frac{\tau_u}{\sqrt{f_c}} = 0.5 + 17\phi_t + 0.7\frac{c}{d}\sqrt{\frac{d}{L}}$$

Where:
τ_u = shear strength (MPa)
f_c = compressive strength of CRC (MPa)
c = cover to reinforcing bar
d = diameter of reinforcing bar
L = embedment length of reinforcing bar
$\phi_t = nA_{st}/dL < 0.1$
A_{st} = cross section area of the reinforcing bar
n = number of transverse bars

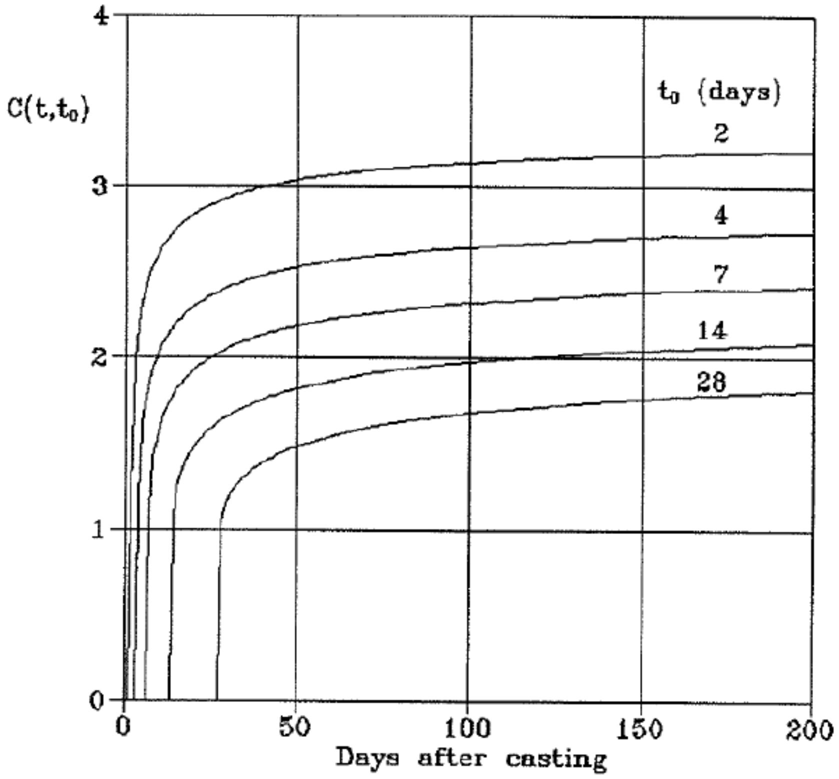
For fibre index 0.6:

$$\frac{\tau_u}{0.7\sqrt{f_c}} = 0.5 + 17\phi_t + 0.7\frac{c}{d}\sqrt{\frac{d}{L}}$$

If there is a significant deviation from the following parameters, additional testing should be carried out:
Rebars from Ø6 to Ø25
Ratio of transverse reinforcement from 0 to 0.17
Cover of reinforcement from 10 to 70 mm
Ratio of embedment length to rebar diameter from 1.25 to 5.7

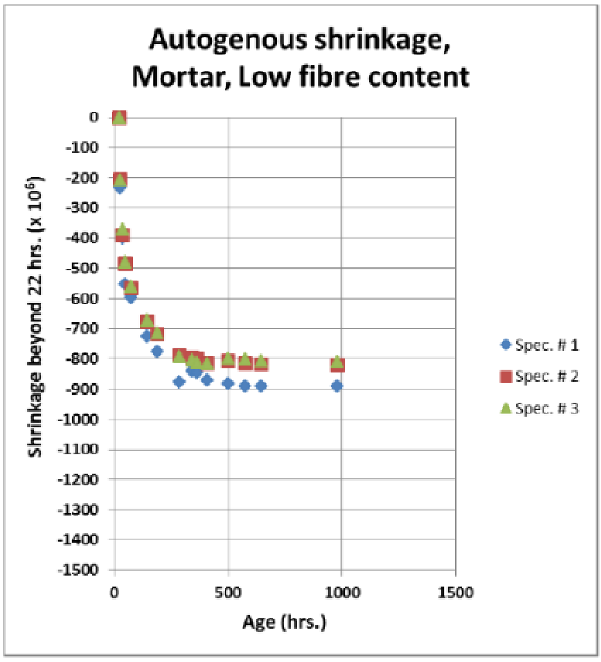
Annex D – Creep and shrinkage

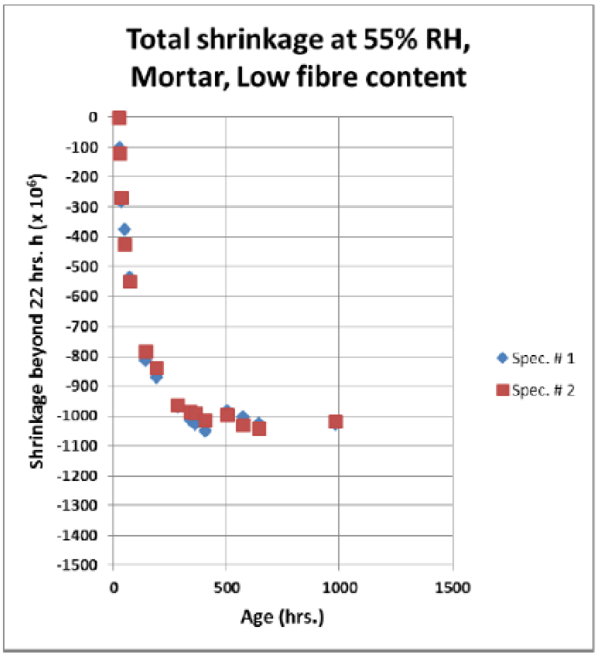
Creep, fibre index 1.8 (limited effect of fibre index)



Shrinkage, fibre index 0.2 (safe side)

Results for autogenous and drying shrinkage:





Annex E – Design values for resistance to fire classification of REI 120

Simply supported slab							
Concequence class	CC2						
qk =	2,5kN/m2	No railing					
Slab thickness	Span	Fire rating	Reinforcement	Cover	$M_{gk,\theta}$	$M_{qk,\theta}$	$s_{rd,\theta}$
[mm]	[mm]	[-]	[-]	[mm]	[kNm]	[kNm]	[MPa]
50	2460	RE120	20 no. Y8	15	1.02	1.89	7
60	2850	RE120	20 no. Y8	15	1.64	2.54	7
70	3220	RE120	15 no. Y10	15	2.45	3.24	7
80	3580	RE120	15 no. Y10	15	3.46	4.01	7
90	3910	RE120	15 no. Y10	15	4.64	4.78	7
100	4230	RE120	15 no. Y12	15	6.07	5.62	7
110	4540	RE120	15 no. Y12	15	7.65	6.44	7
120	4830	RE120	15 no. Y12	15	9.45	7.29	7
130	5120	RE120	15 no. Y12	15	11.50	8.19	7
140	5390	RE120	15 no. Y12	15	13.73	9.08	7
150	5660	RE120	20 no. Y12	15	16.22	10.01	7
160	5920	RE120	20 no. Y12	15	18.93	10.95	7
170	6160	RE120	20 no. Y12	15	21.77	11.86	7
180	6400	RE120	10 no. Y16	15	24.88	12.80	7
190	6640	RE120	10 no. Y16	15	28.27	13.78	7
200	6870	RE120	15 no. Y16	15	31.86	14.75	7

Table E.1

Simply supported element							
Consequence class	CC2						
Cat. A: Balconies	2,5	kN/m^2	Railing =	1,5	kN/m		
Eq. 6.10b	1,15	$G_{kj,sup}$	1,5	$Q_{k,1}$			
Cat. A: Residential	$Y_0 = 0,7$	$Y_1 = 0,5$	$Y_2 = 0,3$				
Thickness [mm]	Span [mm]	Fire Resistance [-]	Reinforcement [-]	Cover layer [mm]	$M_{gk,\theta}$ [kNm]	$M_{qk,\theta}$ [kNm]	$s_{rd,\theta}$ [Mpa]
50	1850	RE60	15 pcs Y6	15	2,2	1,1	6,6
60	2300	RE60	10 pcs Y8	15	3,1	1,7	6,6
70	2725	RE60	10 pcs Y8	15	4,2	2,3	6,6
80	3150	RE60	10 pcs Y8	15	5,6	3,1	6,7
90	3500	RE60	10 pcs Y8	15	6,9	3,8	6,5
100	3850	RE60	10 pcs Y8	15	8,5	4,6	6,5
110	4100	RE60	10 pcs Y8	15	9,8	5,3	6,2
120	4400	RE60	10 pcs Y8	15	11,6	6,1	6,1
130	4700	RE60	10 pcs Y8	15	13,7	6,9	6,1
140	4975	RE60	15 pcs Y8	15	15,8	7,7	6
150	5225	RE60	15 pcs Y8	15	18,1	8,5	6
160	5450	RE60	15 pcs Y8	15	20,4	9,3	5,9
170	5700	RE60	10 pcs Y16	15	23,1	10,2	5,9
180	6000	RE60	10 pcs Y16	15	26,6	11,3	6
190	6200	RE60	10 pcs Y16	15	29,4	12	5,9
200	6400	RE60	10 pcs Y16	15	32,4	12,8	5,8

Table E.2

The fire resistance for the simply supported slab is calculated in accordance with DS/EN 1992-1-2 DK NA2011 and SFS/EN 1992-1-2. The calculation according to the Danish standard is shown in table E.1 and has been based on a RE 120 requirement, while the calculation for the Finnish standard is shown in table E.2 and has been based on an RE 60 requirement. A standard fire in accordance with DS/EN 1992-1-2 DK NA2011, Annex A and method B2 in SFS-EN 1992-1-2 annex B, has been used for the temperature curve. For heat capacity Cp a value of 750 J/kgK is used and for thermal conductivity a value of 1,15 W/mK is used for CRC-i2. The simply supported slab is considered as being exposed to a fire from below, so the fire scenario is treated as one-sided.

Cantilevered slab							
Concequence class	CC2						
qk =	2,5kN/m2	No railing					
Slab thickness	Cantilever	Fire rating	Reinforcement	Cover	$M_{gk,\theta}$	$M_{qk,\theta}$	$s_{rd,\theta}$
[mm]	[mm]	[-]	[-]	[mm]	[kNm]	[kNm]	[MPa]
50	1230	RE120	15 no. Y6	15	1.02	1.89	7
60	1430	RE120	15 no. Y6	15	1.66	2.56	7
70	1610	RE120	10 no. Y8	15	2.45	3.24	7
80	1790	RE120	10 no. Y8	15	3.46	4.01	7
90	1960	RE120	10 no. Y8	15	4.67	4.80	7
100	2125	RE120	15 no. Y8	15	6.10	5.64	7
110	2275	RE120	15 no. Y8	15	7.69	6.47	7
120	2425	RE120	15 no. Y8	15	9.53	7.35	7
130	2570	RE120	10 no. Y10	15	11.59	8.26	7
140	2700	RE120	10 no. Y10	15	13.78	9.11	7
150	2825	RE120	10 no. Y10	15	16.16	9.98	7
160	2950	RE120	10 no. Y10	15	18.80	10.88	7
170	3075	RE120	10 no. Y10	15	21.70	11.82	7
180	3200	RE120	10 no. Y12	15	24.88	12.80	7
190	3325	RE120	10 no. Y12	15	28.36	13.82	7
200	3425	RE120	10 no. Y12	15	31.67	14.66	7

Table E.3

Cantilevered element							
Consequence class	CC2						
Cat. A: Balconies	2,5 kN/m2		Railing =	1,5 kN/m			
Eq. 6.10b	1,15 $G_{kj,sup}$		1,5 $Q_{k,1}$				
Cat. A: Residential	$Y_0 = 0,7$	$Y_1 = 0,5$	$Y_2 = 0,3$				
Thickness [mm]	Span [mm]	Fire Resistance [-]	Reinforcement [-]	Cover layer [mm]	$M_{gk,\theta}$ [kNm]	$M_{qk,\theta}$ [kNm]	$s_{rd,\theta}$ [Mpa]
50	925	RE60	15 pcs Y6	15	2	1,1	6
60	1125	RE60	10 pcs Y8	15	2,7	1,6	5,8
70	1325	RE60	10 pcs Y8	15	3,6	2,2	5,8
80	1525	RE60	10 pcs Y8	15	4,8	2,9	5,9
90	1700	RE60	10 pcs Y8	15	6,1	3,6	5,8
100	1900	RE60	10 pcs Y8	15	7,7	4,5	6
110	2075	RE60	10 pcs Y8	15	9,5	5,4	6
120	2250	RE60	10 pcs Y8	15	11,6	6,3	6,1
130	2400	RE60	10 pcs Y8	15	13,7	7,2	6,1
140	2550	RE60	15 pcs Y8	15	16,1	8,1	6,2
150	2700	RE60	15 pcs Y8	15	18,8	9,1	6,2
160	2850	RE60	15 pcs Y8	15	21,8	10,2	6,3
170	3000	RE60	15 pcs Y8	15	25,2	11,3	6,4
180	3150	RE60	15 pcs Y8	15	28,8	12,4	6,5
190	3300	RE60	20 pcs Y8	15	32,9	13,6	6,6
200	3425	RE60	20 pcs Y8	15	36,8	14,7	6,6

Table E.4

The fire resistance for the cantilevered slab is calculated in accordance with DS/EN 1992-1-2 DK NA2011 and SFS/EN 1992-1-2. The calculation according to the Danish standard is shown in table E.3 and has been based on a RE 120 requirement, while the calculation for the Finnish standard is shown in table E.4 and has been based on an RE 60 requirement. A standard fire in accordance with DS/EN 1992-1-2 DK NA2011, Annex A and method B2 in SFS-EN 1992-1-2 annex B has been used for the temperature curve. For heat capacity Cp a value of 750 J/kgK is used and for thermal conductivity a value of 1,15 W/mK is used for CRC-i2. The cantilevered slab is considered as being exposed to a fire from below, so the fire scenario is treated as one-sided.