BBG UHPC
Lier 11-06-2020

Structural Concrete
Belgium

Our Heritage … from small local beginnings…to a Global Leader today

2017

- #2 Worldwide (Enterprise value)
- €27bn Sales
- 31 Countries
- 3,800 Locations
- 87,000 Employees
- Fortune 500 Company
- FTSE 100 Index
- EuroStoxx 50 Index

Our Products

Europe Materials

- Aggregates
- Asphalt
- Cement
- Lime
- Readymixed Concrete
- Structural Concrete

Lightside & Products

- Architectural Products
- Construction Accessories
- Glass and Glazing Systems
- Network Access Products
- Perimeter Protection
- Shutters and Awnings

Building Materials Distribution

- DIY
- General Builders Merchants
- Sanitary, Heating and Plumbing

Europe Materials

€7bn
sales

€780m
EBITDA

25,000
people

1,300
locations

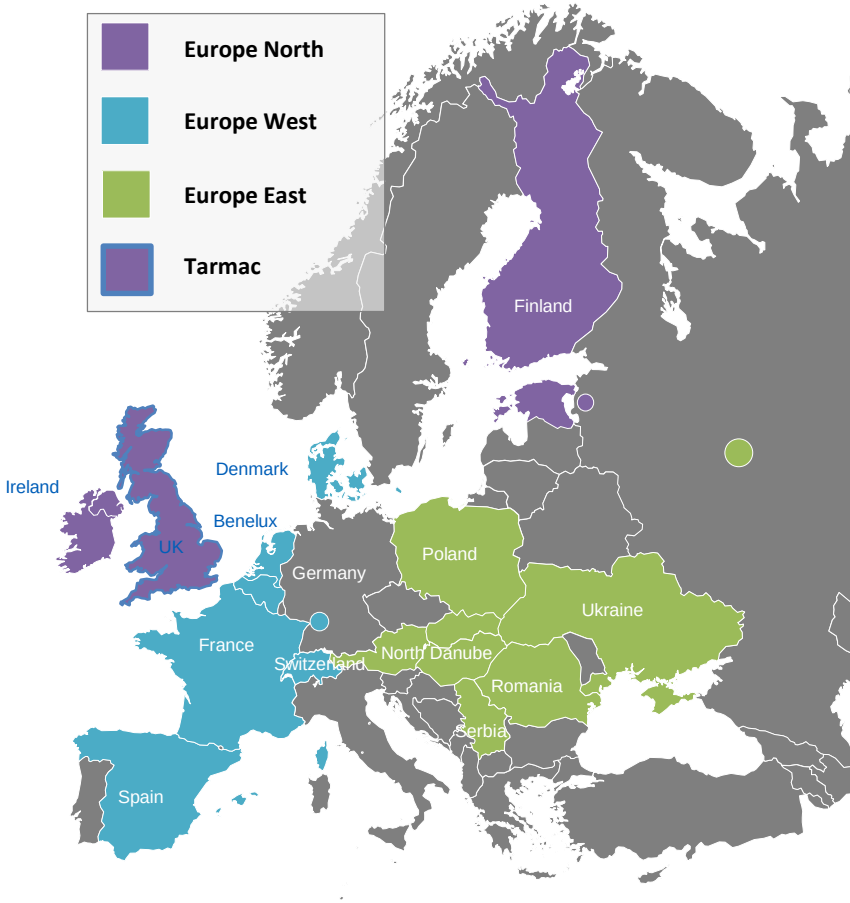
Cement
26mt

Aggregates
120mt

Asphalt
10mt

RMC
16m m^3

Concrete Products
6mt



CRH Belgium

Sanitary, Heating and Plumbing

- Sax sanitair
- Lambrechts
- Schrauwen

Builders Merchants

- Heumatop
- Halschoor
- Creyns
- Costermans
- Van den Broeck

Gamma

Halfen

Heras/Hela

Marlux

Plaka Group

Remacle beton

Stradus Infra

VVM cement

CRH Belgium

€700m
sales

1,850
employees

71
locations

Structural Concrete Belgium

1

Structural Concrete Belgium

Europe Materials

- Aggregates
- Asphalt
- Cement
- Lime
- Readymixed Concrete
- Structural Concrete

- A solid base where the Belgian building companies can rely on and trust.

Single point of contact for all your precast concrete needs

- The strength of our group manifests itself in many ways.
  We are the only one in Belgium who can offer a complete package of products and structures for each project.

Floors

- Douterloigne
- Echo
- Ergon
- Prefaco

Walls

- Prefaco
  Calduran
- Schelfhout

Housing

- Echo
- Douterloigne

Precast elements

- Ergon
- Prefaco

Structural Concrete Belgium

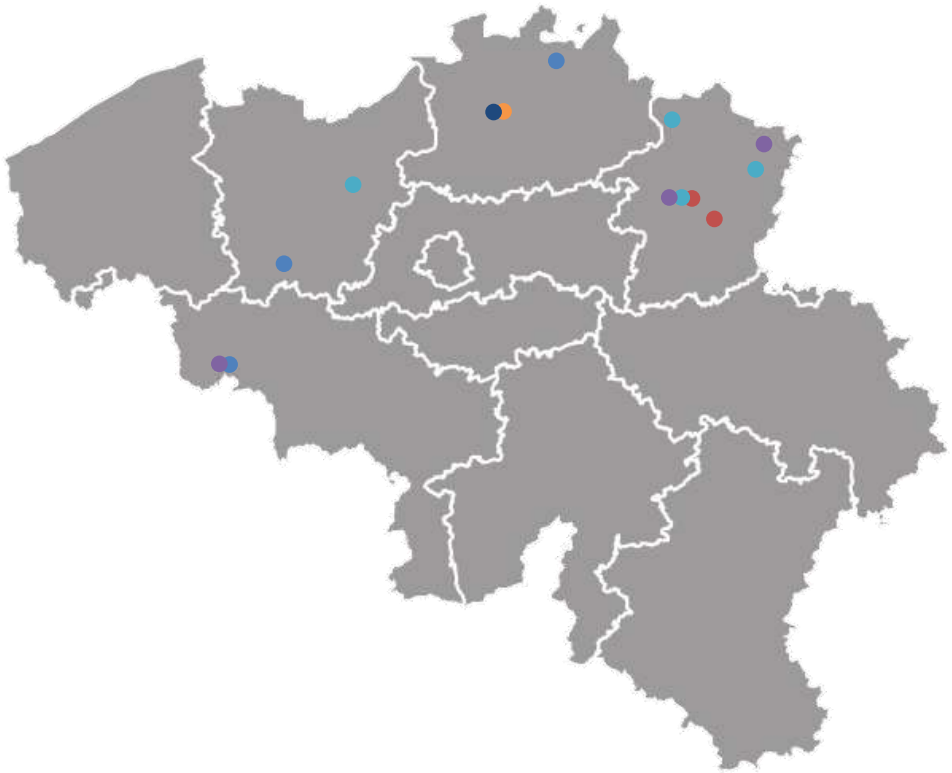
€220m
sales

1,265
employees

12
locations

HQ
Lier

- d-Concrete! : Lier
- Douterloigne : Anzegem, Tournai, Beerse
- Echo : Houthalen, Genk
- Ergon : Lier
- Prefaco : Wieze, Lommel, Houthalen, Neeroeteren
- Schelfhout : Kinrooi, Houthalen, Tournai



Ergon
A concrete reputation

2

A concrete reputation

- Production of prestressed concrete elements
- Established in 1963, part of CRH since 2004
- Main office in Lier
- Production location in Lier

€45m
sales

270
employees

1
location

Site Lier

Market segments

- Non residential
- Residential
- Infrastructure
- Logistic
- Utility

Products

- Hollowcore slabs
- TTP floor slabs
- TTD & TTT roof slabs
- Structural elements
- Bridge elements

Services

- Engineering
- Design
- Alternative suggestions
- Production
- Transport
- Erection

Facts & figures

- Production volume: 95 000 to 120 000 m³/y
- Longest element: 51 m
- Heaviest element: 245 Tons

48 x

Production site: 24 ha

10 x

Production halls: 49 000 m²

100 x

500 000m² floor elements

Introduction:

Pieter van der Zee
Working for Ergon since 1989 as project engineer
since 2007 head technical engineering
and since 2016 technical director CRH Structural Concrete Belgium

Member of:
Fib commission 6 precast
Board of IPHA
CEN-TC250-SC2-WG1
CEN-TC229-WG1-TG1
CEN-TC229-WG1-TG4

UHPC I-beam

Collaboration with WTCB

2012 Testprogram initiated by WTCB to test mixture of UHPC with local aggregates in collaboration with some precasters in Belgium

Ergon produced 4 beams I 600/240 L = 6000 mm

Publication in CPI 05-2013 and 06-2015

Table 1: Composition of the UHPC used:

Component - Type	M2 [kg/m³]
Cement - CEM I 42.5 R HSR LA	830
Quartz powder - dav = 7 µm	83
Quartz sand - 0/0.5	335
Porphyry - 2/4	776
Silica fume (solid fraction)	166
Water	178
Superplasticizer (Polycarboxylate 30 %)	24
Fibers (6 and 30 mm length)	78
w/c value [-]	0.23
w/b value [-]	0.20

Table 3: Modulus of elasticity at various age after casting

Specimen's dimensions	Test's date	Age	E_{cm}	$\sigma(E_{cm})$	$f_{cm.prism}$	$\sigma(f_{cm})$
		[d]	[GPa]	[-]	[N/mm²]	[-]
Prisms (100 mm x 100 mm x 400 mm)	19/4/2012	1	21.8	0.47	38.57	0.48
	8/6/2012	51	43.3	0.45	143.43	3.51

UHPC I-beam

WTCB Testing

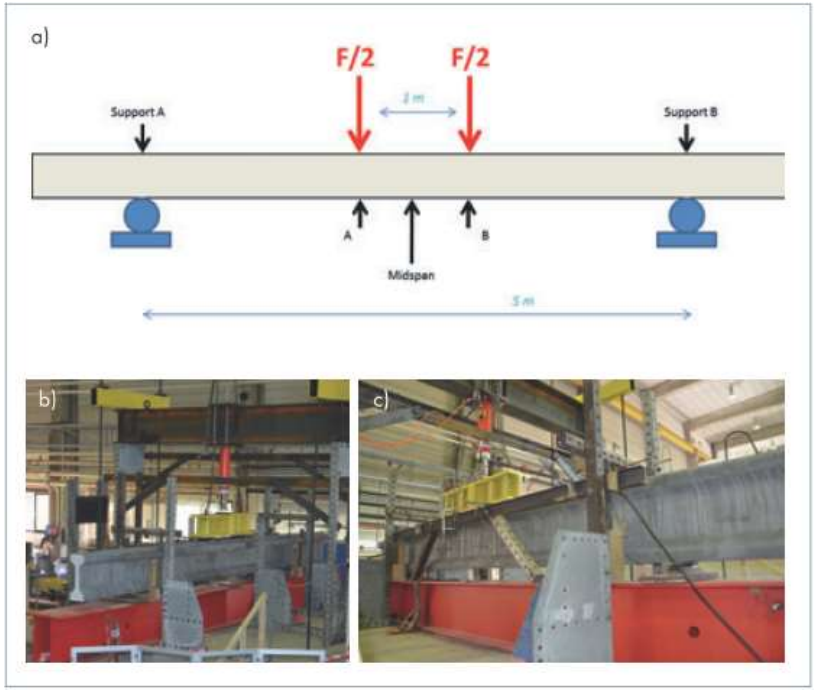


Fig. 2: Test configuration

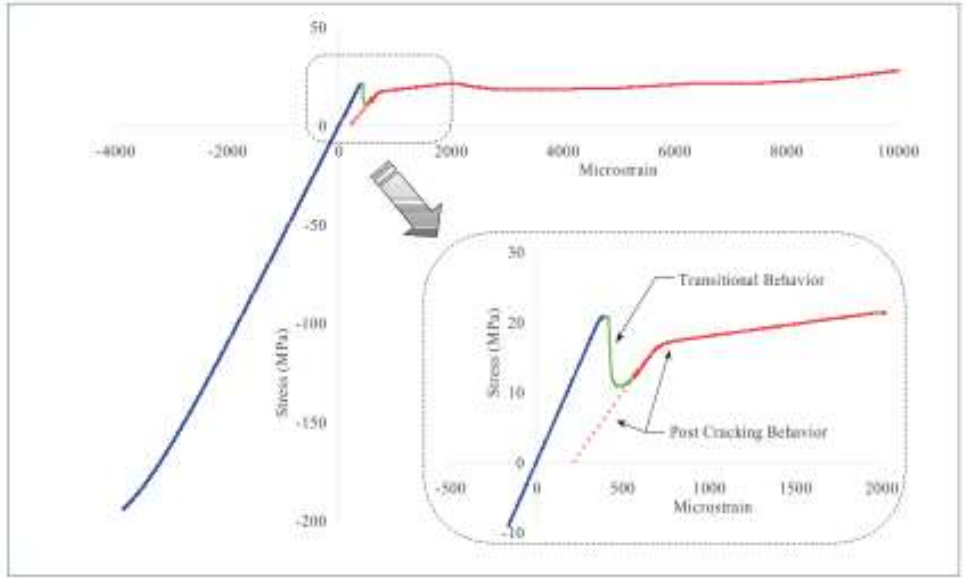
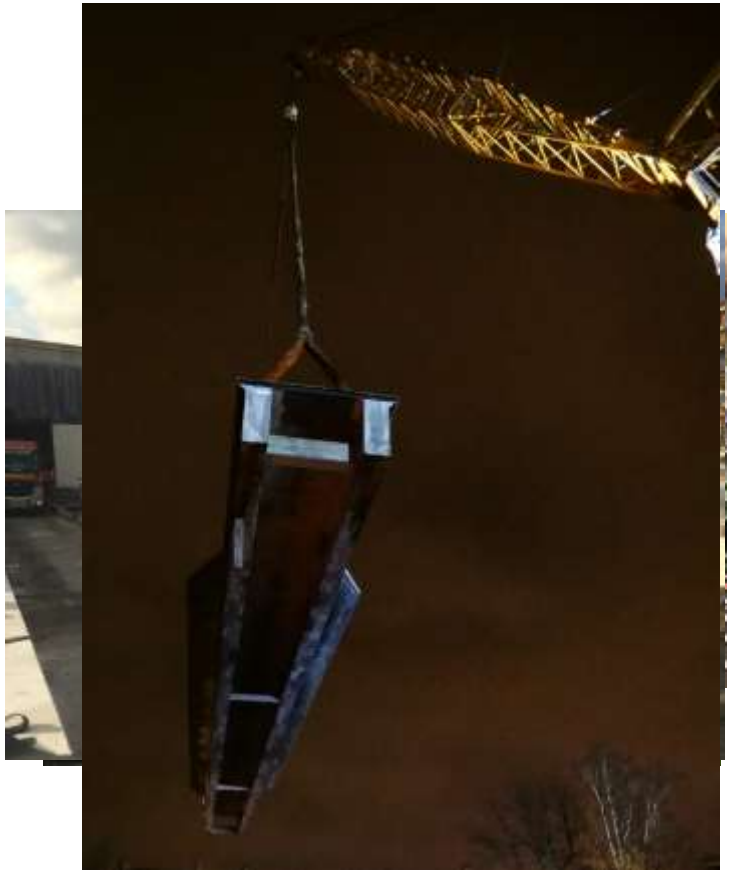


Fig. 8: Analytically derived uniaxial stress-strain behaviour of UHPC (Graybeal, 2007 [5]).

Table 6: Peak loads achieved by predictions and relative errors between this values and the mean obtained by tests.

	Type of failure	Total Charge [kN]	ε [%]
Test	Test 1 Test 2 Average	741 755 748	0,9 0,9 0*
Prediction 1: Eurocode, 150 MPa	Concrete failure Strands failure	670 665	11,0
Prediction 2: Eurocode + lab data	Concrete failure Strands failure	676 664	11,2
Prediction 3: Eurocode + lab data + tensile properties	Concrete failure Strands failure	704 709	5,9

UHPC bridge element



History

First contact with Infrabel Jan, 2013

First meeting with Infrabel Nov, 2013
replacement prestressed footbridge built 1956

First design Ergon Jan, 2014

Meeting with partners Nov 2014:
Infrabel → Seco
Ergon → WTCB

New design of infrabel “closed shape” may 2015

After feasibility study counter design “open shape” aug, 2016

Accord with infrabel to produce testelement with open shape sept, 2016

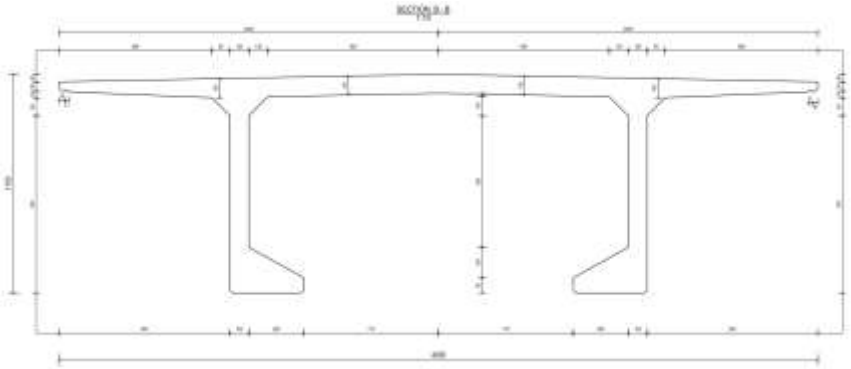
Production of testelement dec 2016 element 14 102 € testing WTCB 14 840 €

Contract with contractor to produce bridge element UHPC 36 m febr, 2018

First attempt of production aug 2018 Production will be okt 2018

Erection 6-12-2018

UHPC bridge element



Shape – Challenges in Production

- Slope 1 % is difficult with an almost self-compacting concrete, Slump-Flow 800 mm
- Time of production:
  - To make 1 m³ or 1 batch will take 15 minutes of mixing,
  - Element ± 24 m³ time between first and last mixture ± 6,0 h
  - How to make 1 element of this size ?
- How to produce a mould taking in account:
  - Connection of bottom flanges
  - Connection in support zone “End-block”
  - Early shrinkage and creep
- Calculating:
  - bending capacity of deck
  - Shearflow between several batches

UHPC Bridge element

Mixture WTCB

		kg/m³	kg
Cement	CEM I 42,5 R	830	19920
Quartz powder	7 µm	83	1992
Quartz sand	0/0,5	335	8040
Porphyry	2/4 R	723	17352
Silica fume	Solid fraction	166	3984
Water		12	288
Superplast	Polycarboxylate 30%	24	576
Fibers	6 mm + 30 mm	79	1872

w/c value 0,23 w/b value 0,20

Cost with profit of concrete ± 1800 €/m³

UHPC Bridge element

Why UHPC ?

- You can only make a business case when there is an economic value,
- Rought estimation:

First design		Weight	cost	
Type	m³	t	€/m³	€
C 120/150	20,5	51,25	1800	36.900
C 80/90	29,2	73	900	26.280
C 50/60	38,3	95,75	650	24.895

- In the final case C120/150
  The weight of the element is 67 t to erect there is a crane needed of 800t,
- Because of the cost of the crane this is a valid solution, only 2 nights no rail passing for demolishing old bridge to replacement new element
- Post-tensioned solution will take longer intervention

UHPC Bridge Element

Lessons learned

Stability mixture not stable, a lot of fine miss fraction between 1-2 mm

This mixture in tension is strength softening, → No cracks allowed

Which type of fibers are needed to get strength-hardening ?? → Long fibers
What amount is needed ?? → 2% , 4% fibers are very costly

Regulations in EU work against innovation,
Question for extra safety because of uncertainties in behavior and no codes available

Strength hardening vs softening

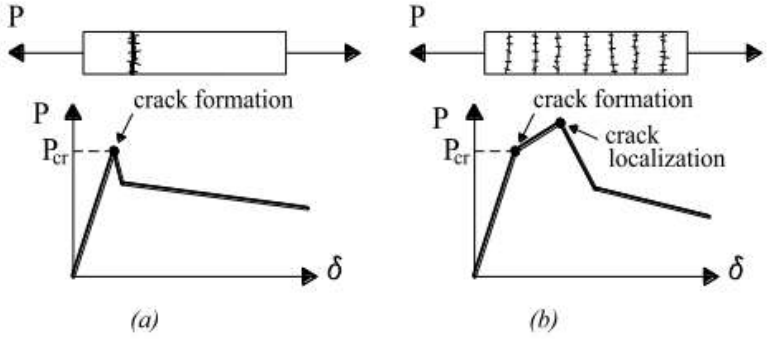
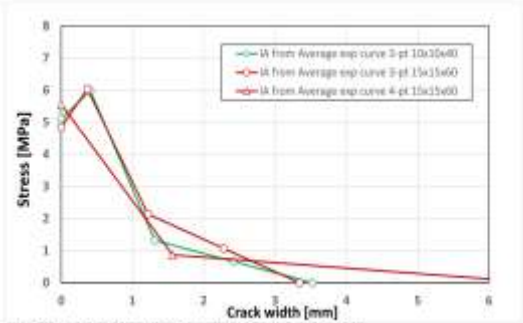


Figure 5.6-2 : Softening (a) and hardening (b) behaviour in axial tension

How to calculate plate

- From tests we know, Stress-Crackwidth diagram
- We can calculate stress-deformation diagram
- We can determine internal forces and capacity
- Demand M_{Ed} = 5,72 kNm/m < M_{Rd}
- ? What is M_{Rd}, Without safety, with average values
  M = 19,0 kNm
  From test k_local is 1,6, γ_c = 1,5
- M_{Rd} = 19,0 / (1,6 x 1,5) = 7,9 kNm
  So we have an extra safety of: 7,9 / 5,72 = 1,38

- This was enough to confince SECO



Figuur 15 : Overzicht van de bi- en tri-lineaire modellen na inverse analyse

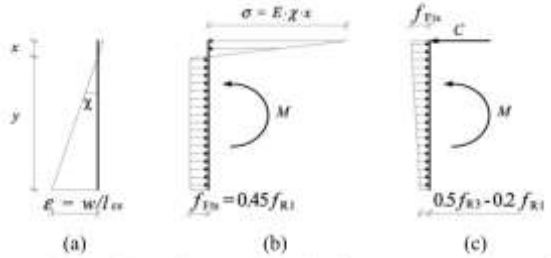
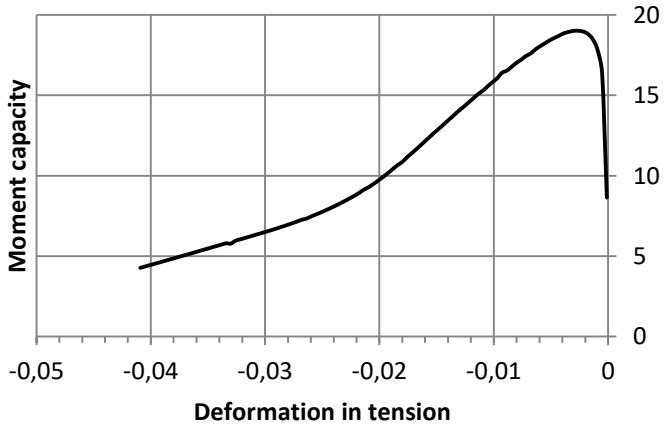


Figure 5.6-9: Stress diagrams for the determination of the residual tensile strength f_{Fts} (b) and f_{Fts} (c) for the linear model, respectively

Tabel 13 : Herhaling van de relevante resultaten (fL en fL_min uit de tabellenreeks Tabel 5 tem. Tabel 10) voor de berekening van de K-factoren

Oriëntatie/type	$f_{L,gemid}$ (per reeks) [N/mm²]	$f_{L,min}$ (per reeks) [N/mm²]	K_global	K_local
F3 (bekist) - gemiddeld	11.9	-		
F4 (uitkraging)	11.5	10.2	1.04	1.16
F5 (lijf - vert.)	10.0	7.4	1.19	**1.60**
F6 (lijf - hor.)	8.8	7.8	**1.35**	1.53
F7 (lijf - schuin)	10.9	9.6	1.10	1.24

M internal with α_{cc} = 0,85



UHPC Bridge element

Who worked on this project

<u>Internal CRH</u>	
Mr Bart Van De Velde, Mr Johan Vanwelde	Concrete technology
Mr Ruben Draulans,	Sales bridge elements
Mr Hans Mostmans	Innovation
Mr Steffen Grünewald	Knowlegde of admixtures
Mr Pieter van der Zee	Calculation, engineering
<u>External</u>	
Mr Niki Cauberg	WTCB Concrete technology
Mr Benoit Parmentier	Calculation codes UHSC
<u>Fib com 6</u>	
Dr Voo “Dura Beton Malasia”	Inspiration
others	

Load test 1

Design load 2690 kg (5 kN/m²)
Load placed 6260 kg
Deformation 2-3 mm

Load test 1

Here we have placed 12320 kg onto the plate, We heard some cracks but it stopped after a while,

We added 900 + 700 kg to a total of 13920 kg,

We heard a lot of noise the deformation did not reach a stable situation, After 5 to 10 minutes the slab suddenly broke,

Now we have a moment of 19,04 kNm/m

The element as produced

Concrete
24 h > 120 N/mm²
28 d > 160 N/mm²

Loading test 5 kN/m²
+ mesuring deformations

Thanks Questions ?