# IPHA AGM 2016

May 28, 2016, Budapest, Hungary

## Report from the Technical Committee

IPHA 2016

21st Annual Conference
May 26 - 29, 2016
BUDAPEST - Hungary

Wim Jansze

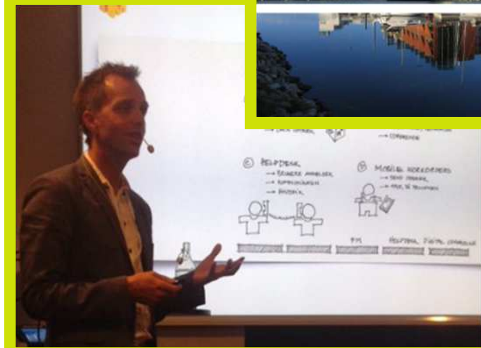
*IPHA*

IPHA
INTERNATIONAL PRESTRESSED HOLLOWCORE ASSOCIATION

in cooperation with
FERROBETON

# Technical Seminar Oct 2015 „BIM“ & „Design“ Malmo with 86 participants from IPHA!

| | | | |
|---|---|---|---|
| 13:15 | Architect’s view on BIM | Thomas Graabæk | BIM Equity |
| 14:00 | Contractor’s view on BIM: MalmoLive | Carl Jonsson | Skanska |
| 15:00 | Coffee Break | | |
| 15:30 | Developers view in white paper session | Wim Jansze | IPHA |
| 15:35 | - i-Theses’ view on BIM | Wouter Veelaert | i-Theses |
| 16:00 | - Nemetschek Engineering’s view on BIM | Susanne Schachinger | Nemetschek Engineering |
| 16:25 | - StruSoft’s view on BIM | Peter Karlsson | StruSoft |
| 16:50 | - Tekla’s view on BIM | Tero Kautto | Tekla |
| 17:15 | Closing discussion „BIM“ | Paul Rehn | StruSoft |
| 17:30 | MalmoLive building visit (optional) | Carl Jonsson | Skanska |


| | | | |
|---|---|---|---|
| 08:30 | Slim floor construction with hollowcore | Fredrik Lagerström | StruSoft |
| 09:15 | Skew-cut hollowcore slabs | Jesper Frøbert Jensen | Alectia |
| 10:00 | CE-marking | Stef Maas | FEBE |
| 10:30 | Coffee Break | | |
| 11:00 | Shear of hollowcore slabs with topping | Ronald Klein-Holte | VBI |
| 11:45 | Seismic performance of hollowcore | Gabriel Tarţa | CES Romania |
| 12:30 | Lunch | | |
| 13:30 | Project Holcofire update | Wim Jansze | On behalf of BIBM |
| 14:00 | *fib* recommendations update | Stef Maas | On behalf of *fib* C6 |
| 14:30 | EN 1168 new revision update | Ronald Klein-Holte | On behalf of CEN TC229 |
| 15:00 | Closing discus | | |

IPHA @IPHA_hollowcore · 22 okt. 2015
#IPHA2015 TS was very successful We'd like to thank all attendees, presenters and especially the host @StruSoft.
2 1

# Plans for Technical Seminar 2017

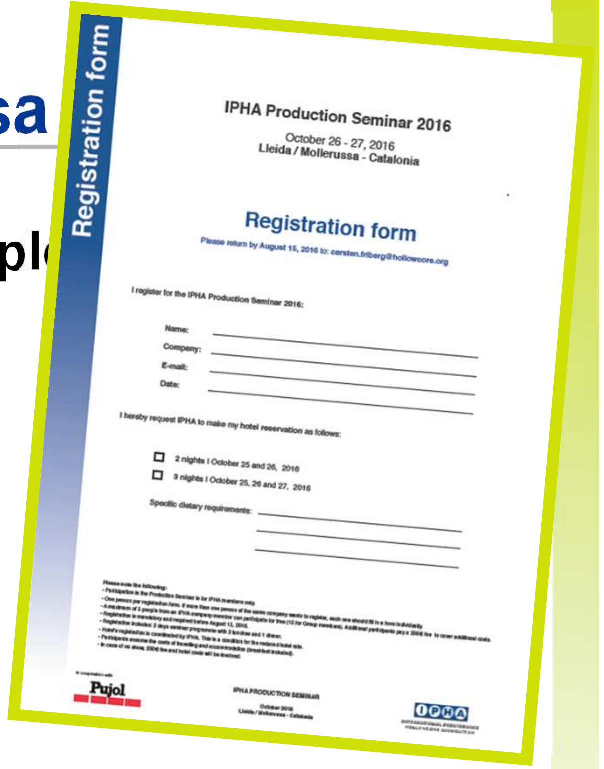
## IPHA TECHNICAL SEMINAR 2017

### "Course on Hollowcore Design"

October 25-26 2017, Tallinn, Estonia

- **The Technical Seminar in 2017 is a course and focuses on educating the young structural engineer**
- **Higher objective is to expand use of hollowcore**
- **2017 newly released *fib* publication "hollowcore design recommendation" will be used as reader for the course**
- **IPHA in cooperation with:**
  - *fib* commission COM6 (taskgroup T6.1)
  - Estonian Association of Civil Engineers
- **Target audience triple-digits, with members from *fib* and EEL**

# Production Seminar
# 26-27 October 2016, Lleida/Mollerussa


Registration form

IPHA Production Seminar 2016

October 26 - 27, 2016
Lleida / Mollerussa - Catalonia

Registration form

Please return by August 15, 2016 to: carsten.friberg@hollowcore.org

I register for the IPHA Production Seminar 2016:

Name:
Company:
E-mail:
Date:

I hereby request IPHA to make my hotel reservation as follows:

- ☐ 2 nights I October 25 and 26, 2016
- ☐ 3 nights I October 25, 26 and 27, 2016

Specific dietary requirements:

Pujol

IPHA PRODUCTION SEMINAR

**Fill in your registration form today for your people**

- **Production directors**
- **Factory Managers**
- **Other senior personnel around production**


# Present fire situation two years after Holcofire

bibm

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Wim Jansze

Project manager Holcofire

IPHA
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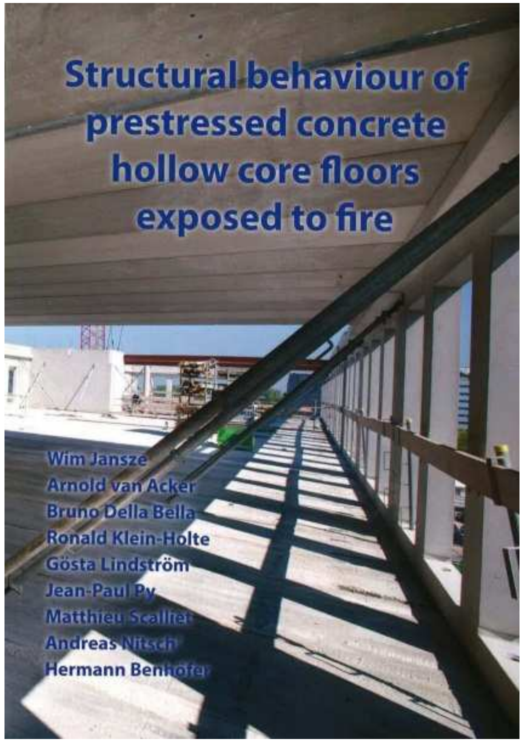
# Holcofire Lessons learned

- **The product meets regulations and requirements**
- **The product performs well when exposed to fire**
- **In specific cases  fires in car parks are more severe than standard fires**




→ **Recommendations are used by engineers**
→ **Standards are implemented**
→ **No mayor international accidents have happened these last years**

# Update The Netherlands

- **The commission concluded that** *"... in viewpoint of Dutch regulations ..... the total of all test results, real fires, model calculations, and track record show that on the basis of the recommendations with a sufficient degree of reliability, the probability of disproportional damage is sufficiently small.* **"**

- **The (to be published) recommendations contain an additional rule regarding the limitation of structural topping for new construction**

  **t ≤ 0.25 x depth hollowcore**

- **In case the thickness of structural topping is larger, then:**
  - Risk analysis
  - Alternative load path
  - Sprinkler installation
  - Fire protection

# Update France and UK

- **No issues, but regulatory institutions in France and UK are looking very much to The Netherlands what will be decided and published by the Dutch commission for recommendations (t ≤ 0.25 x depth hollowcore)**

# HOLCOFIRE update Denmark

- **Fire issue was "smouldering" for 2 years but is out now**
- **Abeo A/S (and Prof. Hertz) raised "questions" on the fire resistance of hollow core slabs**
  - 2 letters written to Ministry of Climate, Energy and Building
    - EN1168 can't be used to document R120 for slabs without transversal reinforcement.
    - EN1168 is not used correctly by the Danish producers as due to spalling 500 °C rule should be used
  - Danish Standard S-EN1992 commented through its well-known chairman with help of Jesper Frobert Jensen
  - As Abeo is bankrupt, we expect that the situation normalizes
  - … but Abeo is for sale: will new owner, if any, continue this strategy?

# HOLCOFIRE update Germany

- **No critical situation anymore, as the "Zulassung" (approval) has been extended by DIBt for 5 years.**
- **The German system with "Zulassung" is under discussion on a European level**
- **But DIBt had requested a fire test in Berlin at BAM research institut, and the way how to execute the test is under discussion.. Hollow core industry is involved and is asking now the difficult questions .... But fire tests have been carried out**
- **June 2016 a technical day will be organized in Germany with universitiy professors to bring formally the state-of-the-art in the industry on a higher level**

Deutsches Institut für Bautechnik DIBt

# New PCI Manual [2015]

Precast/Prestressed Concrete Institute

- **PCI Manual for the Design of Hollow Core Slabs and Walls**
- **3rd Edition, 2015, ePub + Hardcopy**

- This manual presents in detail design of hollow core slabs for gravity and lateral loads. A complete revision of the diaphragm chapter includes the latest design information.
- 
- The Third Edition of the Manual has added Hollow Core Wall Panels and is updated to ACI 318-11, PCI 7th Edition Design Handbook and 2012 IBC.

- 2015, 232 pages  
  3 edition  
  Product Format: ePub/Print  
  Item #: MNL-126-15e+P

# Revision of EN 1168/A3

Ronald Klein-Holte

Convenor of CEN TC229/WG1/TG1

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# Taskgroup 1 Hollow Core Slabs

- **Members:**
  - Jørn INJAR NO
  - Bruno DELLA BELLA IT
  - Robin WHITTLE UK
  - Matthieu SCALLIET F
  - Pieter VAN DER ZEE BE
  - Naceur KERKENI / Thomas ROGGENDORF D
  - Stefan SEYFFERT D
  - Ronald KLEIN-HOLTE NL
  - Vaclav VIMMR (corresponding) CZ

# Product Standard EN 1168

- **EU Product Standard for Hollow Core Slabs**
- **Not: a standard or code for design of Hollow Core Floors!**
- **Informative Annexes for design of HC Floors**
- **Harmonized standard with an Annex ZA for CE-marking**

# Revision EN1168

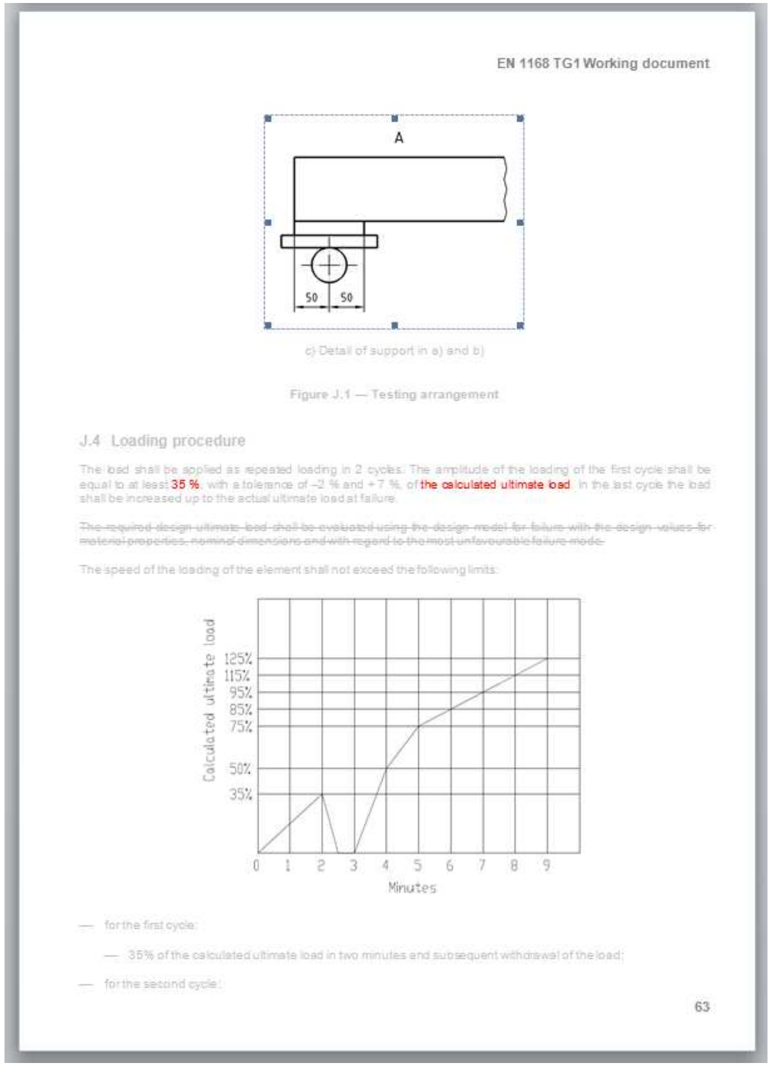
- **Status**
  - Feasibilty study
  - No TC229 Work Item (WI) yet

# EN 1168 Revision topics

- **Punching shear (Finnish proposal)**
- **Minor changes in body tekst: skew slab ends, min. amount of strands, drainage hole aspects, sag of top flange.**
- **Max. concentrated loads with regard to load distribution from body text to informative Annex C**
- **Move chapter “Three supported edges” to Annex C**
- **Annex E “unintended fixing moments” in line with EC2: NDP with recommended value 15%**
- **Holcofire update to Annex G: flexible support, drainage holes and limitation thickness topping.**

# EN 1168 Revision topics

- **Annex J Full Scale Test**


EN 1168 TG1 Working document



c) Detail of support in a) and b)

Figure J.1 — Testing arrangement

J.4 Loading procedure

The load shall be applied as repeated loading in 2 cycles. The amplitude of the loading of the first cycle shall be equal to at least 35 %, with a tolerance of −2 % and + 7 %, of the calculated ultimate load. In the last cycle the load shall be increased up to the actual ultimate load at failure.

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

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



— for the first cycle:

— 35% of the calculated ultimate load in two minutes and subsequent withdrawal of the load;

— for the second cycle:

63

# EN 1168 Revision topics

- **Informative Annex Flexible Supported HC**

EN 1168 TG1 Working document

**Annex L**
(informative)

**Flexible Supports**

*stresses in the web*

As shown in Figure 3.5, in the web act the following stresses:

$\sigma_1$, due to the effective prestressing force,
$\tau_1$, due to the vertical shear force and
$\tau_2$, due to the shear flow in transversal direction, caused by imposed load.

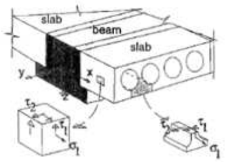



Fig. 3.5 Stress components in the web

*failure criterion*

Failure will take place when the maximum principle tensile stress $\sigma_{ps}$ becomes equal to the characteristic tensile strength $f_{ctk}$ of the concrete. So the design criterion will be:

$\sigma_{ps} \le f_{ctd}$, the design tensile strength of the concrete (1)

To simplify the calculations, a modified principle stress $\sigma_{ps}$ is used:

$$\sigma_{ps} = \frac{\sigma_1}{2} + \sqrt{\left(\frac{\sigma_1}{2}\right)^2 + \tau_1^2 + \tau_2^2} \quad (2)$$

The magnitude of the additional shear stress $\tau_2$ is depending on:

- type of beam
- type of slab
- continuous or free supported beam
- span of both beam and slab
- curvature profile of beam
- tie steel arrangement
- penetration of in situ infill concrete into the hollow cores
- presence of a composite reinforced concrete topping

70

Based on *fib* Bulletin 6

Agreement on HC without topping

Cooperation with fibCOM6 TG 6.1

# EN 1168 Revision topics

## Informative Annex Lifting Clamps



**ANNEX XX**
**(informative)**
**Testing to determine suitability between lifting clamp and hollow core slabs**

**XX.1. General**
The aim of this test is to determine suitability of the combination between lifting clamps and hollow core slabs regarding to the following criteria:
- Lifting clamps and the way of using them
- Dimensional checks
- Lifting and suitability test

**XX.2. Lifting clamps**
Lifting clamps are the responsibility of being provided by the precaster. Hollow core slabs can be lifted with a spreader beam and with two clamps or with a single device, unless a maximum length of the cantilevered part is respected (as shown in figure XX.1)

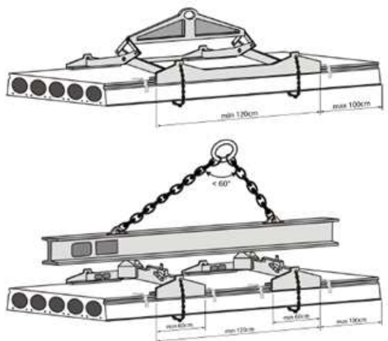



Figure XX.1 – Lifting for slab

# EN 1168 Revision topics

- **Informative Annex with design clauses**



**Annex ??**
(informative)

**Index of design clauses**

This annex contains an list of design clauses in this standard which are in addition to or different from those given in Eurocode 2 and related European Standards. It should be noted that further design rules can also be found in EN 13369 Common Rules.

**Clauses were reference is made to EN 13369:**

| | |
|---|---|
| 4.1 | Material requirements |
| 4.2 | Production requirements |
| 4.3 | Finished product requirements |
| 4.3.2 | Surface characteristics |
| 4.3.3 | Mechanical resistance |
| 4.3.4 | Resistance and reaction to fire |
| 4.3.5 | Acoustic properties |
| 4.3.6 | Thermal properties |
| 4.3.7 | Durability |

| Clauses in addition to EN 1992 (Eurocode 2): | | Clauses in EN 1992: |
|---|---|---|
| 4.2.1.1.1 | Longitudinal bars | EN 1992-1-1 8.2 |
| 4.2.1.1.2 | Transverse reinforcement | EN 1992-1-1 8.7.4.1 |
| 4.2.1.2.1 | Distribution of pre-stressing tendons | EN 1992-1-1 8.10.1 |
| 4.3.1.1.3 | Tolerances for concrete cover | EN 1992-1-1 4.4.1.1 |
| 4.3.1.2.1 | Thickness of webs and flanges | EN 1992-1-1 5.3.1 |
| 4.3.1.2.2 | Minimum concrete cover of pre-stressing steel | EN 1992-1-1 4.4.1 |
| 4.3.1.2.4 | Longitudinal joint shape | EN 1992-1-1 6.2.5 |
| 4.3.1.2.5 | Vertical grooves shape | EN 1992-1-1 ??? |
| 4.3.3.2.1 | Resistance to spalling | EN 1992-1-1 6.2 |
| 4.3.3.2.2 | Shear resistance | EN 1992-1-1 6.2.2 and 6.3.2 |
| 4.3.3.2.2.4 | Shear with torsion | EN 1992-1-1 6.3.2 |
| 4.3.3.2.3 | Shear capacity of longitudinal joints | EN 1992-1-1 6.2.5 |
| 4.3.3.2.4 | Punching shear capacity | EN 1992-1-1 6.4 |
| 4.3.4.1 | Resistance to fire | EN 1992-1-2 4.4 and Annex D |
| Annex G | Resistance to fire (informative) | EN 1992-1-2 4.4 and Annex D |
| Annex C | Transverse load distribution (informative) | EN 1992-1-1 10.9.3 (5) |
| Annex D | Diaphragm action (informative) | EN 1992-1-1 10.9.3 (12) |
| Annex E | Unintended restraining effects and negative moments (informative) | EN 1992-1-1 9.2.1.2 |
| Annex F | Mechanical resistance in case of verification by calculation: shear capacity of composite members (informative) | EN 1992-1-1 6.2 |
| Annex H | Design of connections (informative) | EN 1992-1-1 9.10 and 10.9 |

**Clauses in addition to EN 10138:**
4.1.1.1 Maximum diameter of pre-stressing steel

# EN 1168 Revision topics

- **Shear capacity**

Wish for only one formula for the shear tension capacity, and not loose for advantages of the simplified formula.

$$V_R(y,V) := \frac{b(y)\cdot I_{i2}}{S_{c2p}(y)}\cdot\left[\sqrt{f_{ct}^{\,2} - f_{ct}\cdot\sigma_c(y,V) - \left(\beta_f\,\tau_2(y,V)\right)^2} - \tau_1(y) - \tau_{pt}(y)\right]$$

Extended: compute the governing position y with the functions of the normal and shear stresses described in the functions.

Simplified: with assumptions or tabulated values:

Y = lowest point of the web with smallest thickness

Tabulated values…e:

| Span of the beam | Transverse Shearstress |
|---|---|
| 0 | 0 MPa |
| 1 | 0 |
| 2 | 0.5 |
| 4 | 1 |
| 8 | 3 |

Note: the span is the distance between the “momentzero” points.

Transmission shearstresses: = 1,0 MPa

Suggested values to be calibrated/validated.
This approach is in line with the basis formula of Eurocode 2 and is only more detailed referring to the remark of the Eurocode 2 formula.

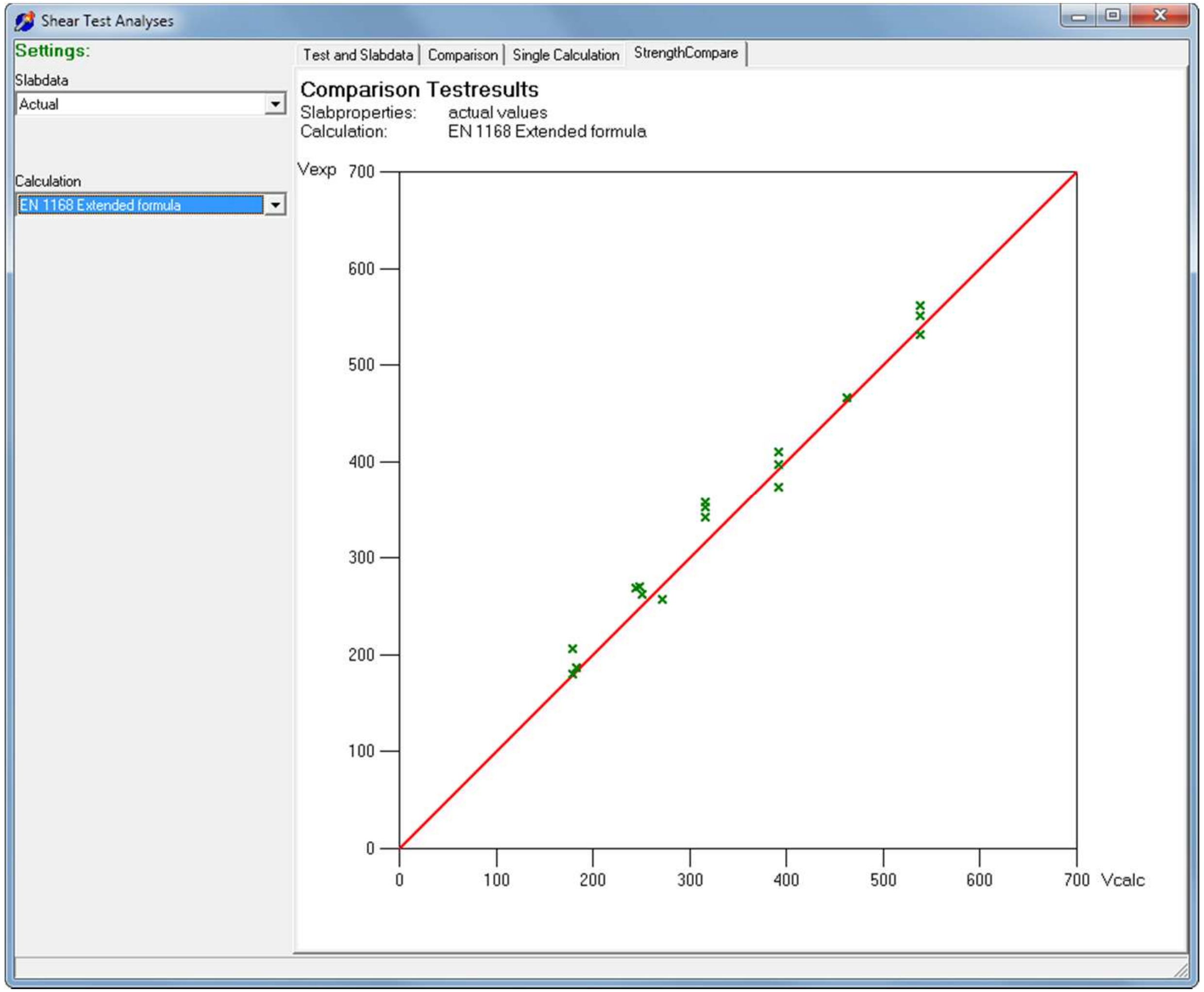
# EN 1168 Revision topics

- **Shear capacity**

  Increasing the background information on shear force…

  Collecting shear tests.

  Test reports are welcome….



# Prestressed Hollowcore Floors
# New *fib* - recommendations
# - update -

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Stef MAAS

*fib* COM6 Prefabrication

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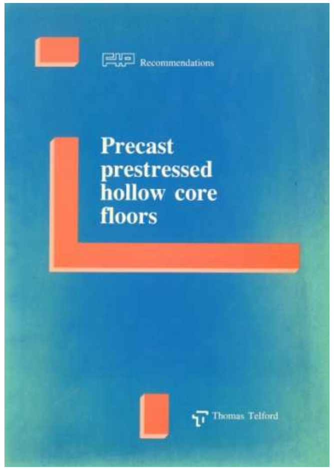
# History

- ….
- **1988 - Precast prestressed hollowcore floors (Thomas Telfort),**
- **2000 - Special design recommendations for precast prestressed hollowcore floors**
- **2015 - New recommendations Main work item of TG 6.1**
  - Content accepted untill 12/2015
  - 2016 editing + approval

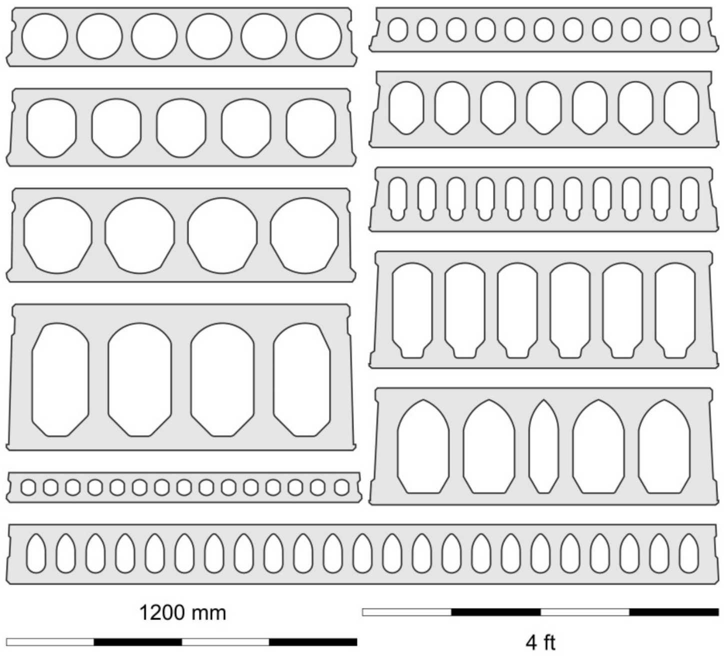




Have a look at http://www.fibcom6.org

# New recommendations: Why?

- **Why this update?**
  - 25 000 000 m²/y annual production
  - 40-60 % precast flooring
  - Evolutions over last decades
  - Partially covered in bulletin 6
  - Actual state of the art in this document
  - Experiences and gathered knowledge of last decade
  - Need for good calculation examples
- **Scope**
  - Prestressed elements
  - Depth ≤ 500 mm
  - Width ≤ 1200 mm



# Content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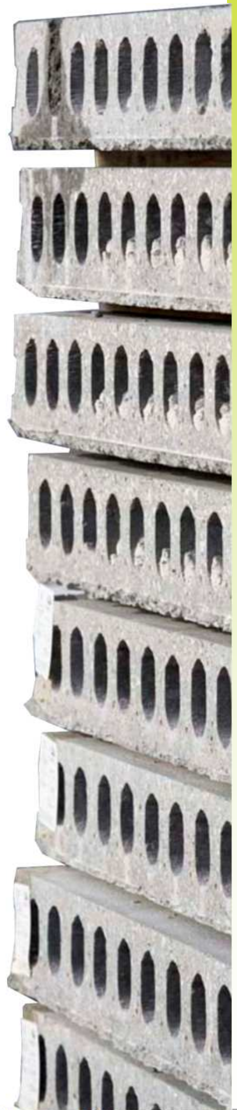
2. Description of hollow core units and floor systems
3. Design of the cross-section
4. Design of hollow core floors
5. Building physics
6. Environmental issues
7. HC in seismic regions
8. Design considerations regarding finished elements
9. Design considerations regarding manufacture

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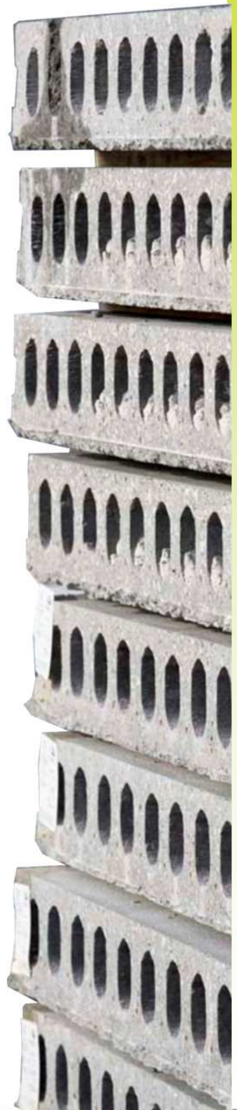


# Chapter 3: Design of the CSS


**3.1 General design principles**

**3.2 Basic design principles**

**3.3 Stresses in the transmission zone**

**3.4 Flexural capacity**

**3.5 Shear capacity**

**3.6 Shear and bending interaction**

**3.7 Shear capacity of elements subjected to torsion**

**3.8 Shear and torsion interaction**

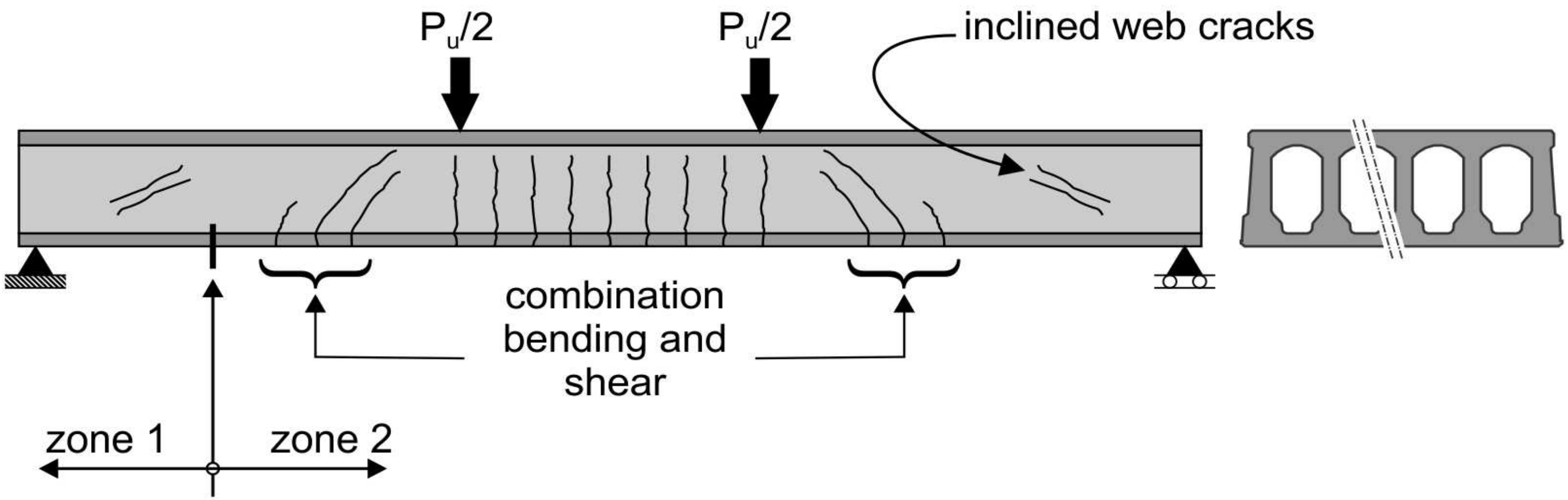
**3.9 Punching**

**3.10 Camber design and deflection**

**3.11 Protruding strands**

## 3.5 Shear capacity

- Regions cracked in bending
- Regions not cracked in bending

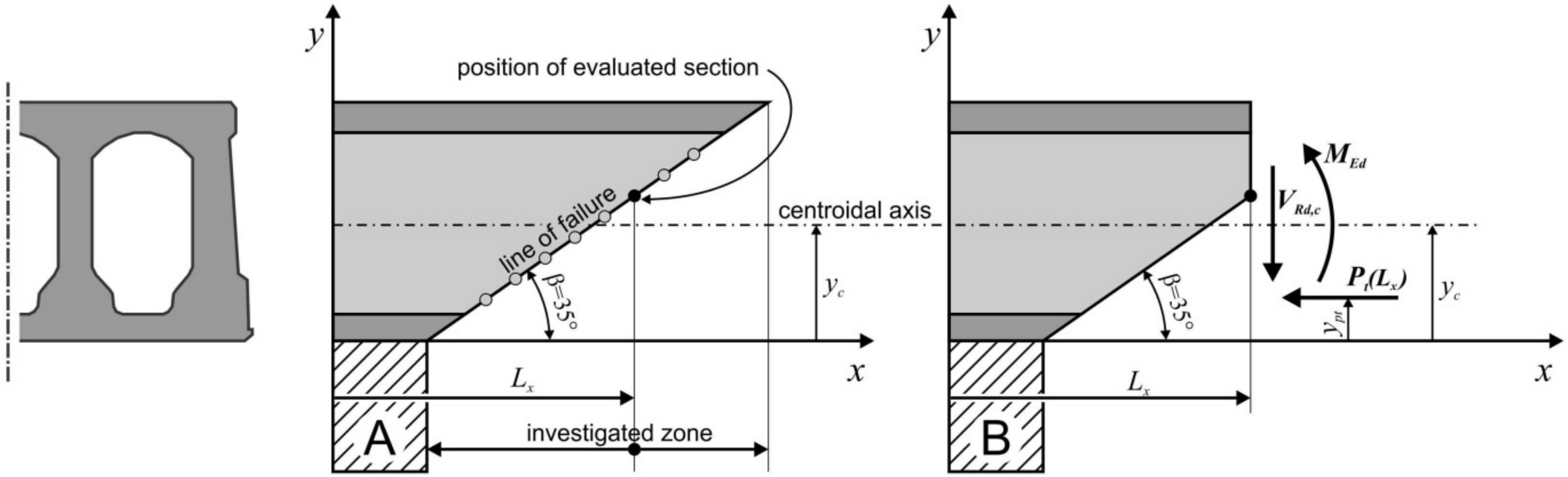


## Regions not cracked in bending

$$V_{Rd,c} = \frac{I \cdot b_w}{S}\sqrt{f_{ctd}^2 + \alpha \sigma_{cp} f_{ctd}}$$

- **More accurate method**

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

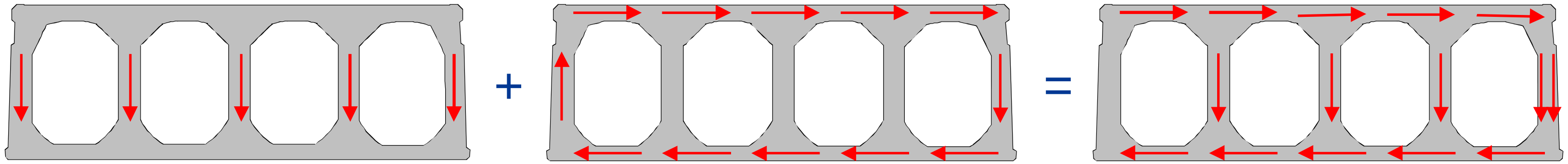


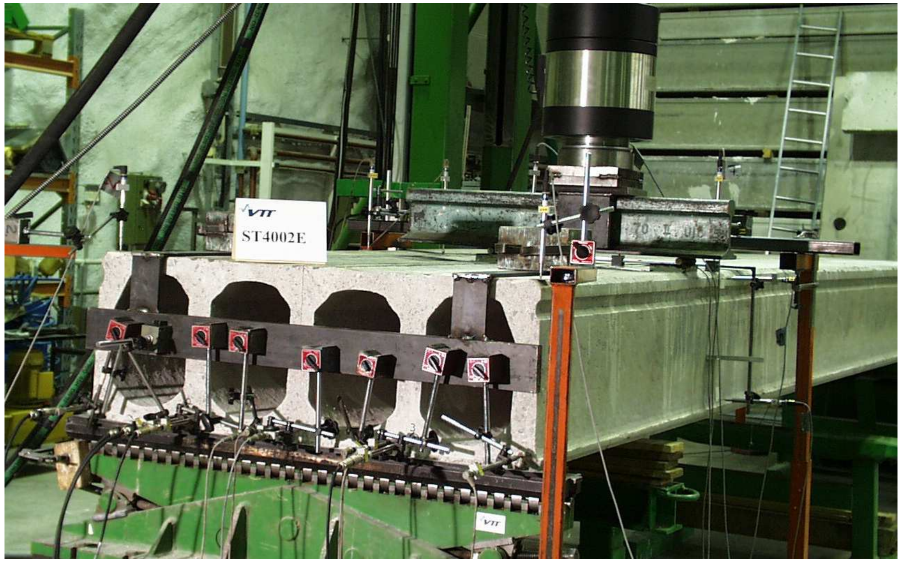
## 3.6 Shear and bending interaction

**When both shear and bending is present both cannot be independently fully utilized in the same position and it is suggested that the combined action needs to fulfil the following interaction formula for each position in the region cracked in bending**

$$U_{d,MV,Combined} = \left[ \left( \frac{M_{Ed}}{M_{Rd}} \right)^4 + \left( \frac{V_{Ed}}{V_{Rd,c}} \right)^4 \right]^{\frac{1}{4}} \leq 1$$

## 3.8 Shear and torsion interaction



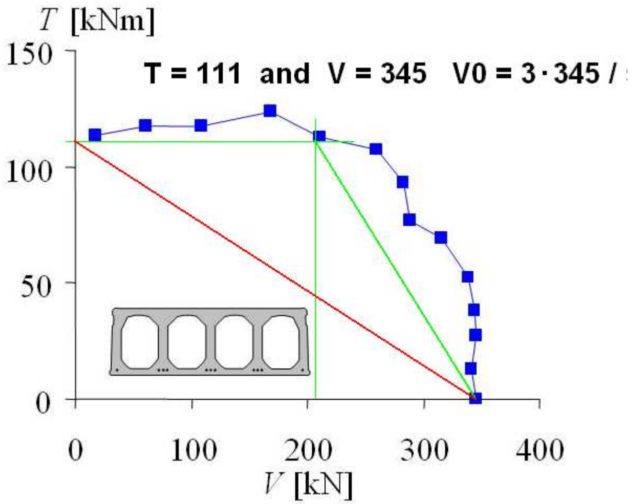



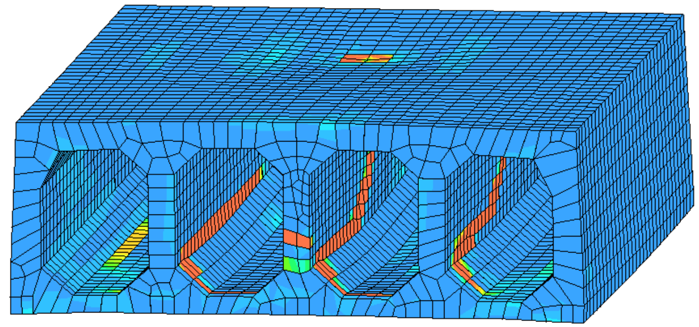

**Extensive research programme funded by the European Commission under the "Competitive and Sustainable Growth" Programme**

**(1998 – 2002)**

## 3.8 Shear and torsion interaction

- **Sophisticated way (Holcotors)**

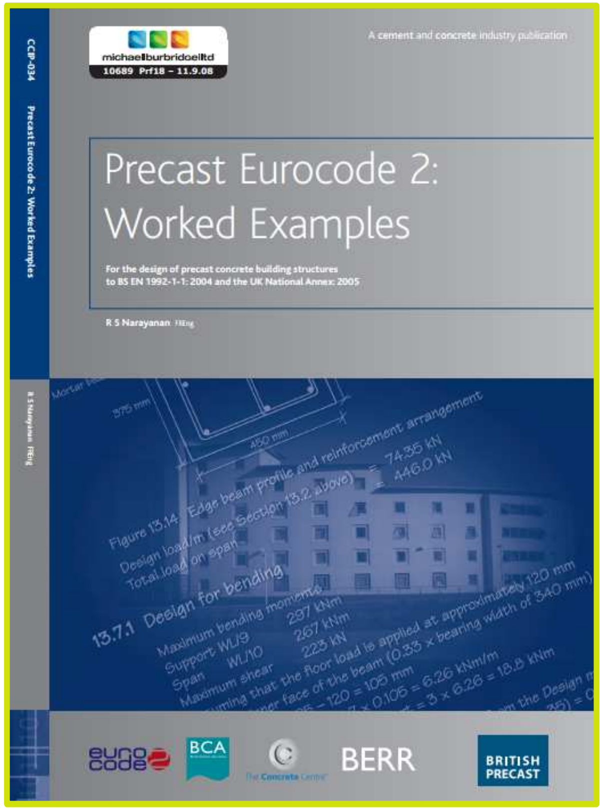


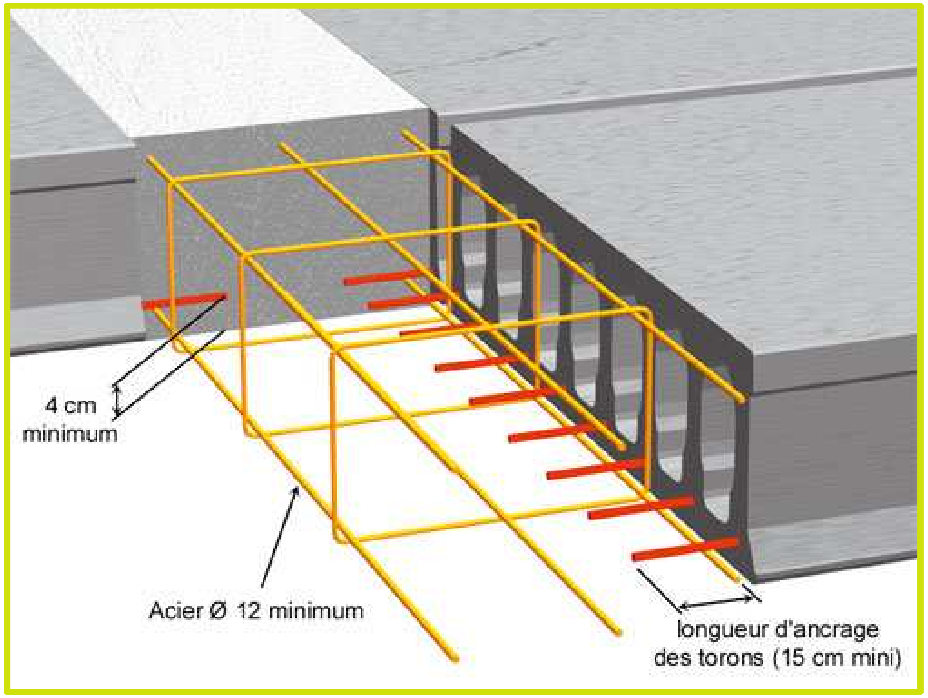
- **This bulletin: 5-step simplified method**

## 3.10 Camber design and deflection

- Simplified method ASSAP
  - Camber
  - Deflections
- **Expected differences**



## 3.11 Protruding strands

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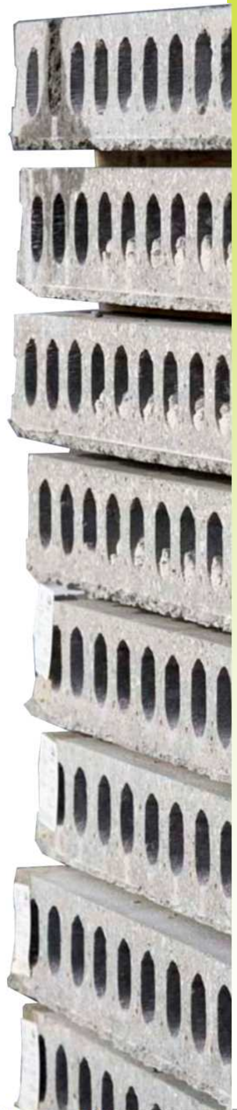
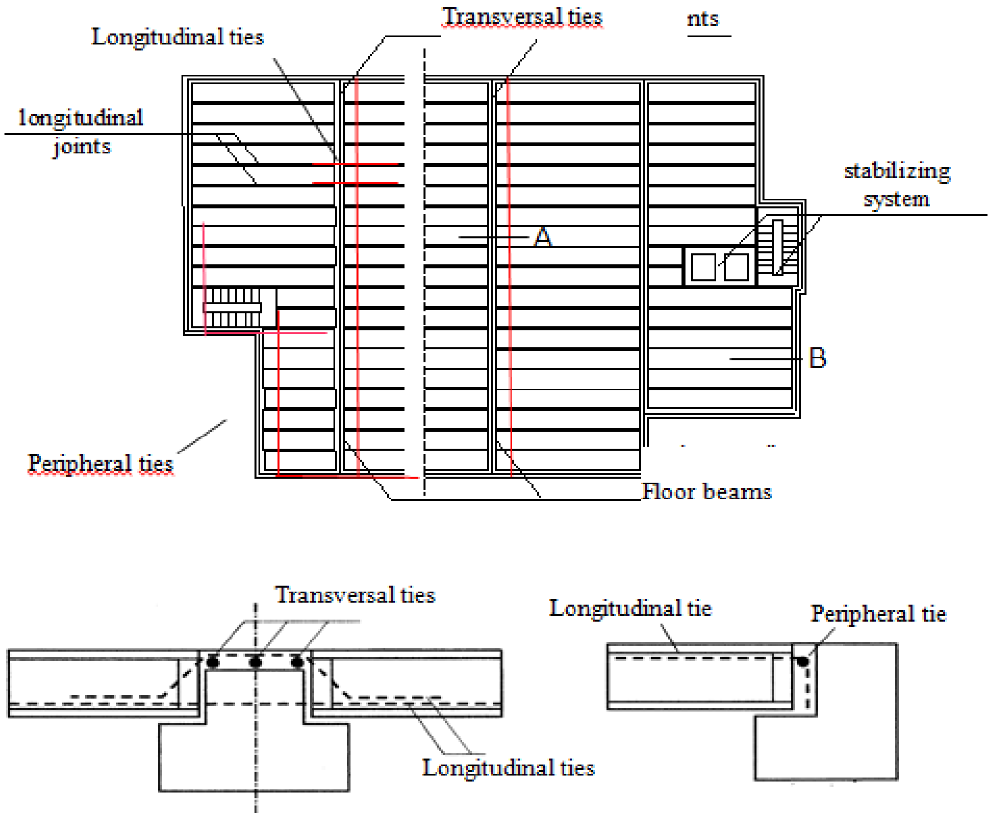


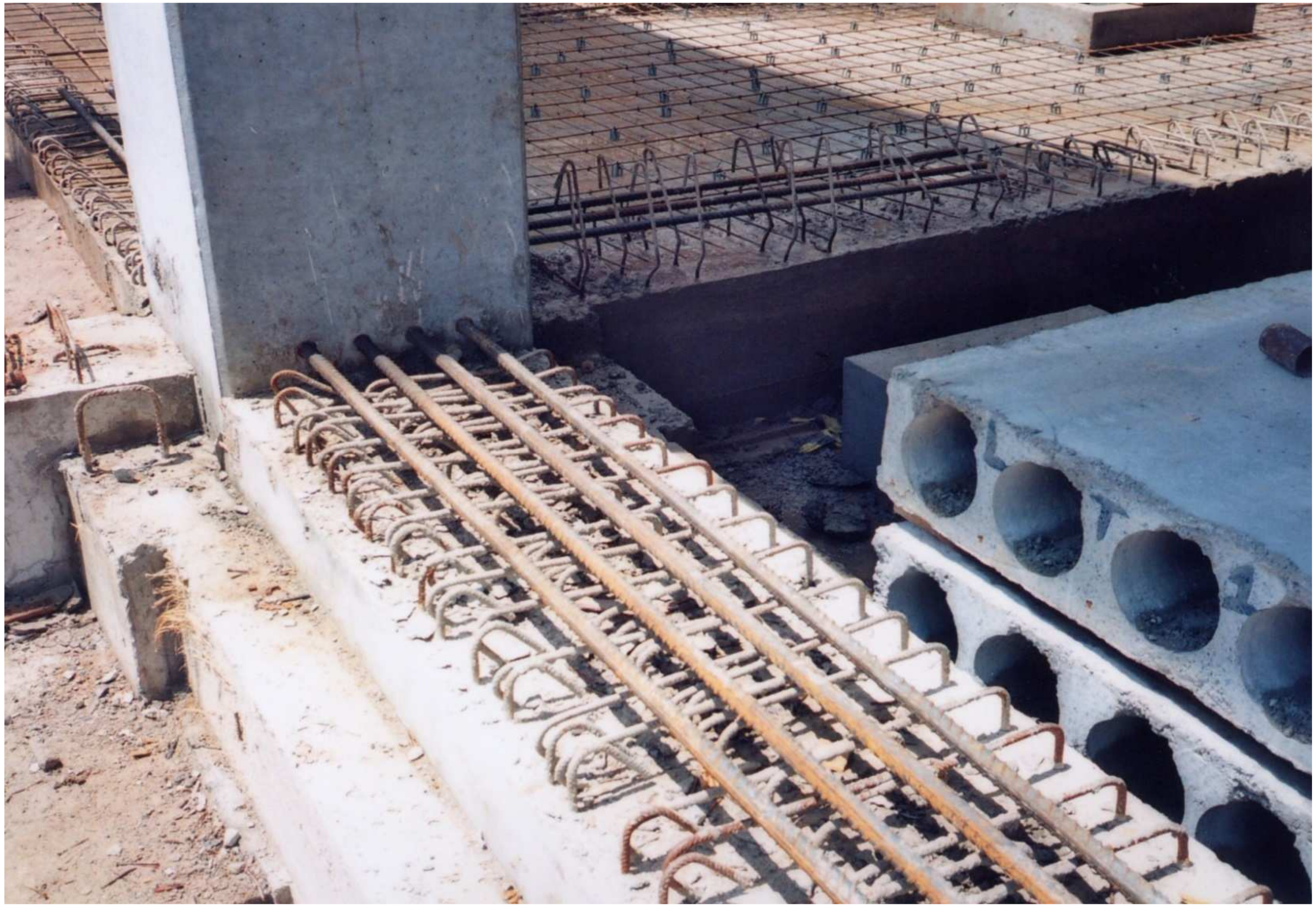
# Chapter 4: design of the floor


4.1 General
4.2 Structural integrity
4.3 In plane actions
4.4 Transversal load distribution
4.5 Structural topping and composite action
4.6 Non-rigid supports
4.7 Design of cantilevering slabs
4.8 Unintended support restrainment
4.9 HC floors subjected to horizontal actions
4.10 Dynamic actions end vibrations
4.11 Fire resistance
4.12 Connections
4.13 Light load fixings
4.14 Openings and block-outs

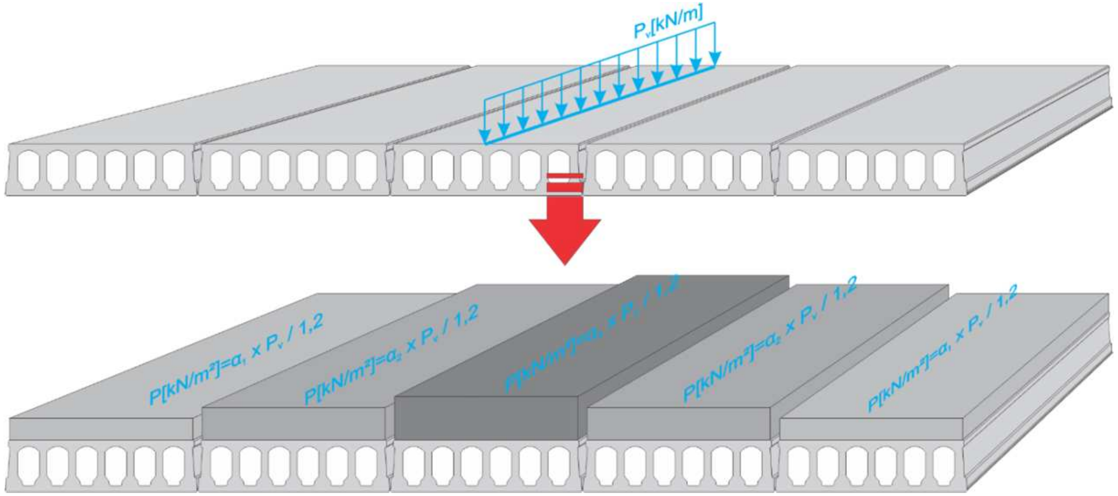
## 4.2.1 Tie systems

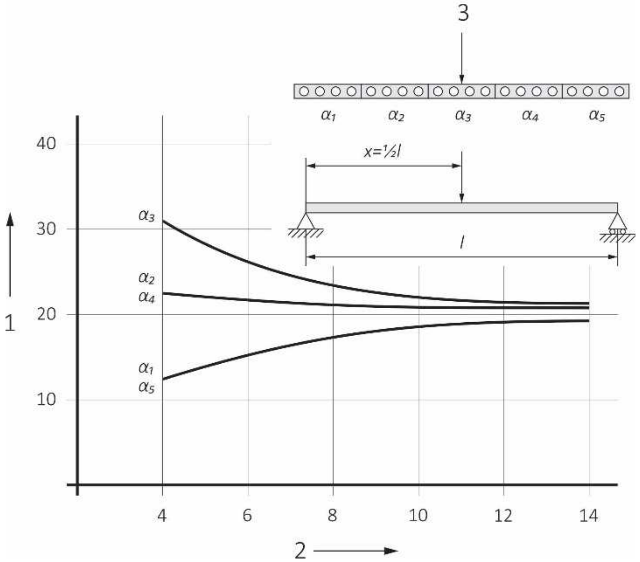


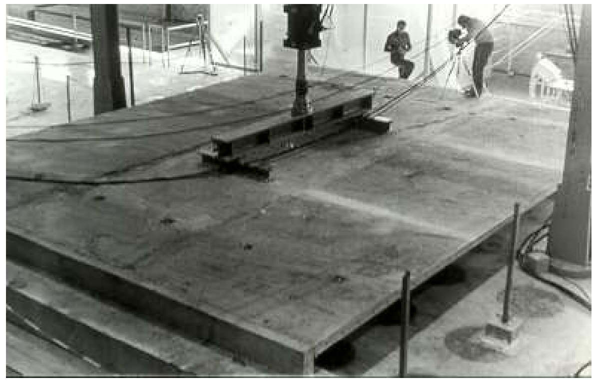
# Chapter 4: design of the floor



## 4.4 Transversal load distribution

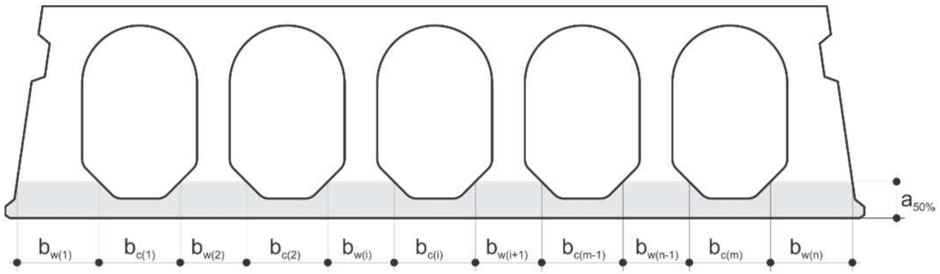


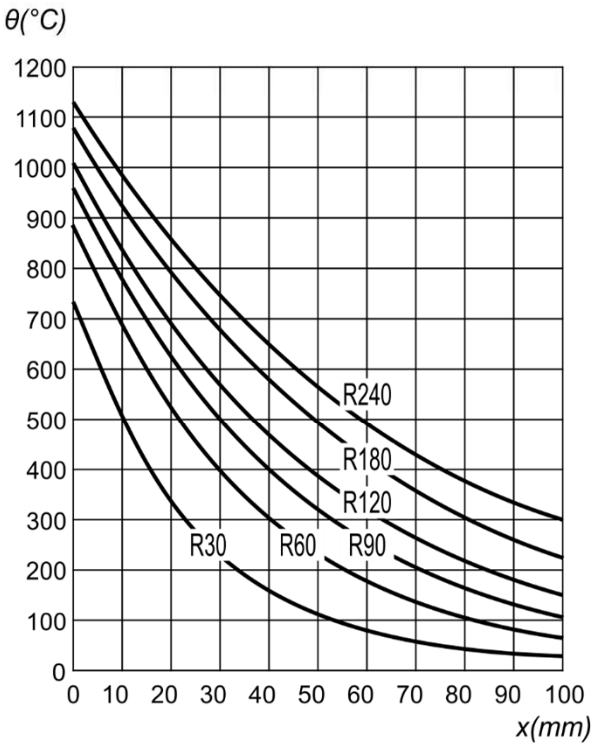



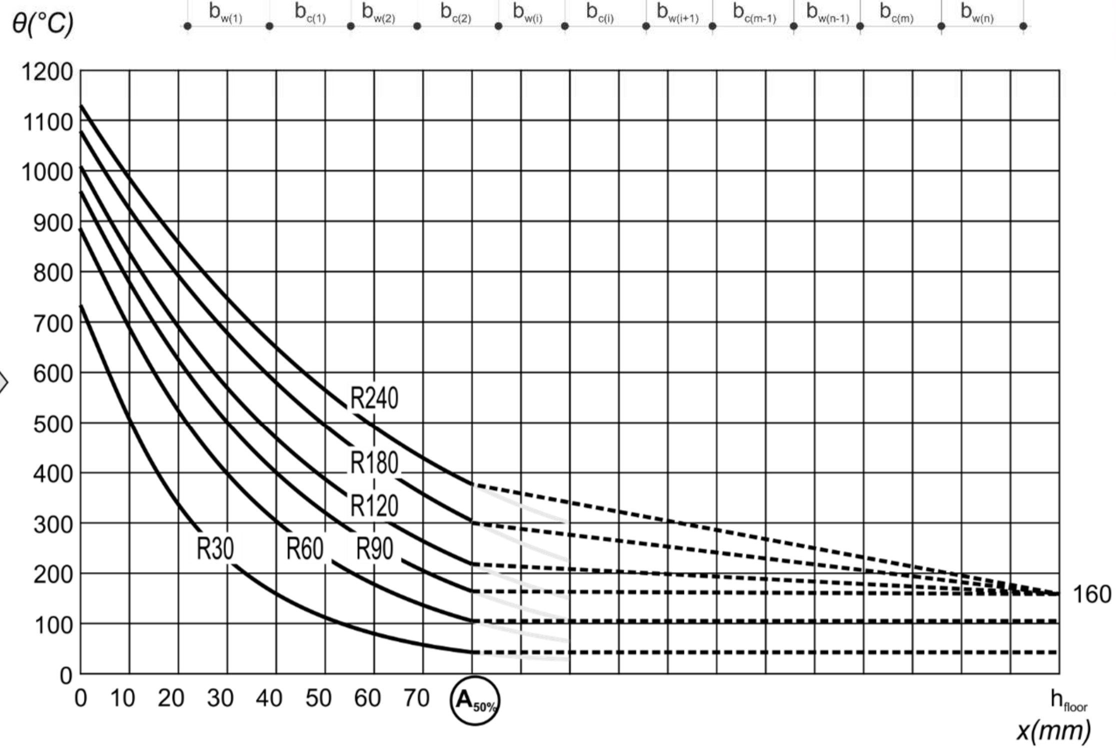



## 4.11 Fire resistance

- **Approach of EN 1168**



## 4.11 Fire resistance

- **Approach of EN 1168**
  - R criterion
    - Bending capacity
    - Shear capacity
      - Calculation method (calibrated empirical formula) $V_{Rdc,fi} = \left[C_{\theta 1} + \alpha_k \cdot C_{\theta 2}\right] \cdot b_w \cdot d$
      - Tabulated data
- **E and I**
  - Minimum dimensions (tabulated data)

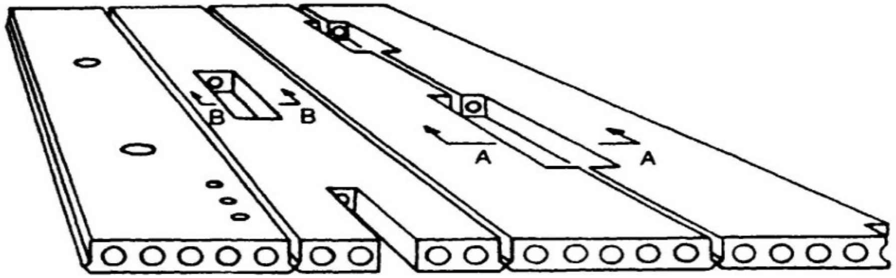
## Calculation shear capacity

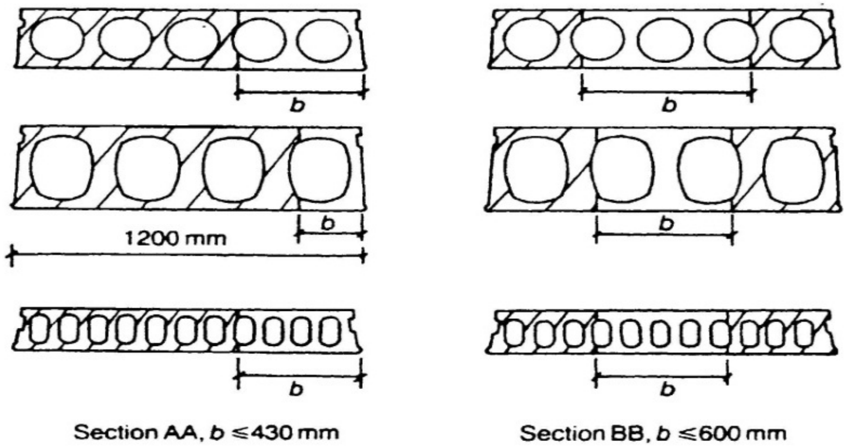
| $V_{Rd,c,fi}/V_{rd,c,cold}$ (%) | Slab thickness [mm] | | | | |
|---|---|---|---|---|---|
| **Fire resistance** | 160 | 200 | 240-280 | 320 | 360-400 |
| **REI 60** | 70 % | 65 % | 60 % | 60 % | 55 % |
| **REI 90** | 65 % | 60 % | 60 % | 55 % | 50 % |
| **REI 120** | 60 % | 60 % | 55 % | 50 % | 50 % |
| **REI 180** | 45 % | 50 % | 50 % | 45 % | 45 % |

Example of the shear capacity under fire conditions ($V_{Rd,c,fi}$) as a percentage of the shear capacity in ambient (cold) conditions ($V_{Rd,c,cold}$ )

## 4.14 Openings and block-outs (WIP)

- **Small openings**
- **Large openings**
  - Design charts
- **Considerations in case FEM is used**



# Content


1. Introduction
2. Description of hollow core units and floor systems
3. Design of the cross-section
4. Design of hollow core floors
5. **Building physics**
6. Environmental issues
7. HC in seismic regions
8. Design considerations regarding finished elements
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# Chapter 5: Building physics

**5.1 Thermal performances**

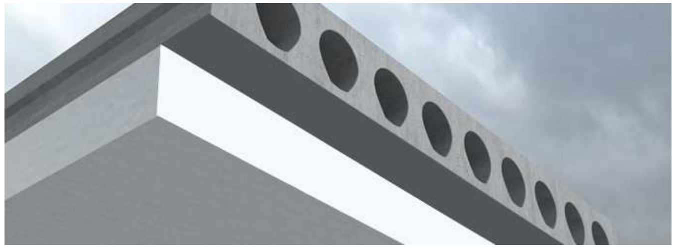
**5.2 Acoustic insulation**

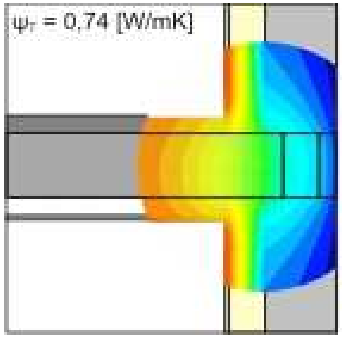
**5.3 (Moisture content)**

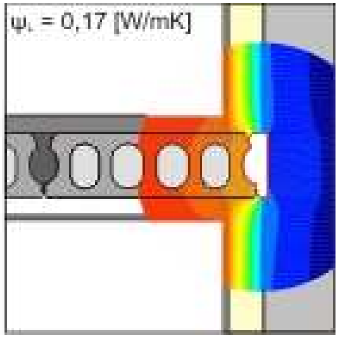
Office building with thermal activated floors – Hasselt - Belgium

## 5.1.1 Thermal insulation

- **Insulated slabs;**
  - Mono
  - Duo
- **Reduction of thermal bridges;**
  - Lateral
  - Longitudinal

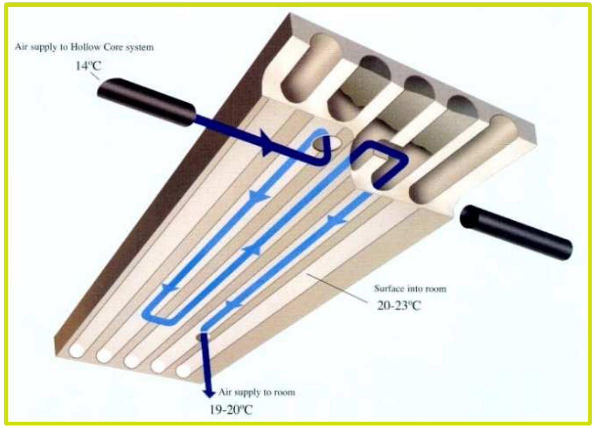


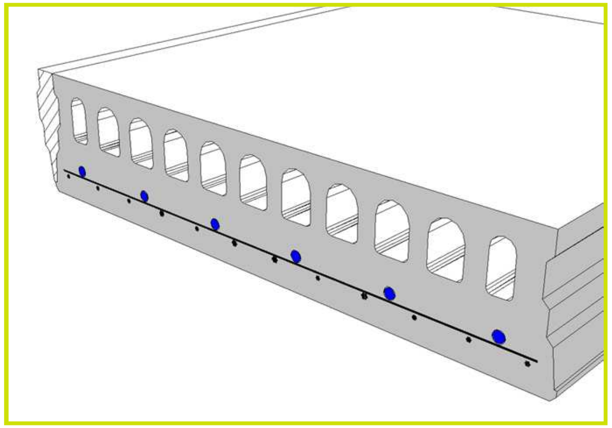


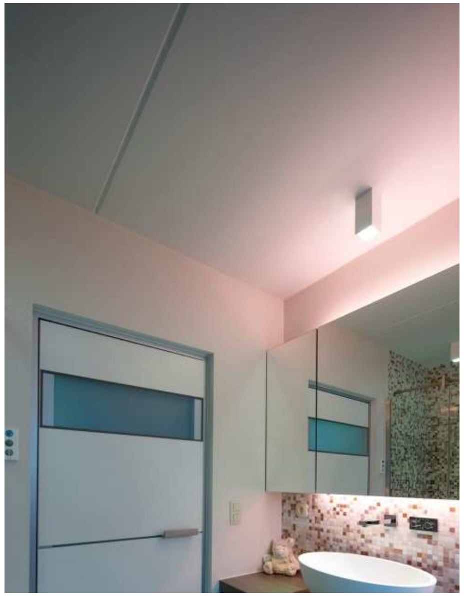



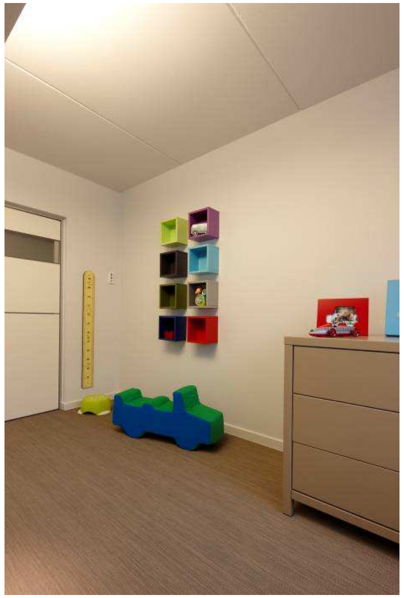

### 5.1.2 Thermal active floors

- **Cooling and heating is integrated in the HC-slab**
- **Many examples :**
  - Termodeck (SE)
  - ClimaDeck (BE)
  - Climate floor (NL)
  - Wingfloor (NL)
  - …



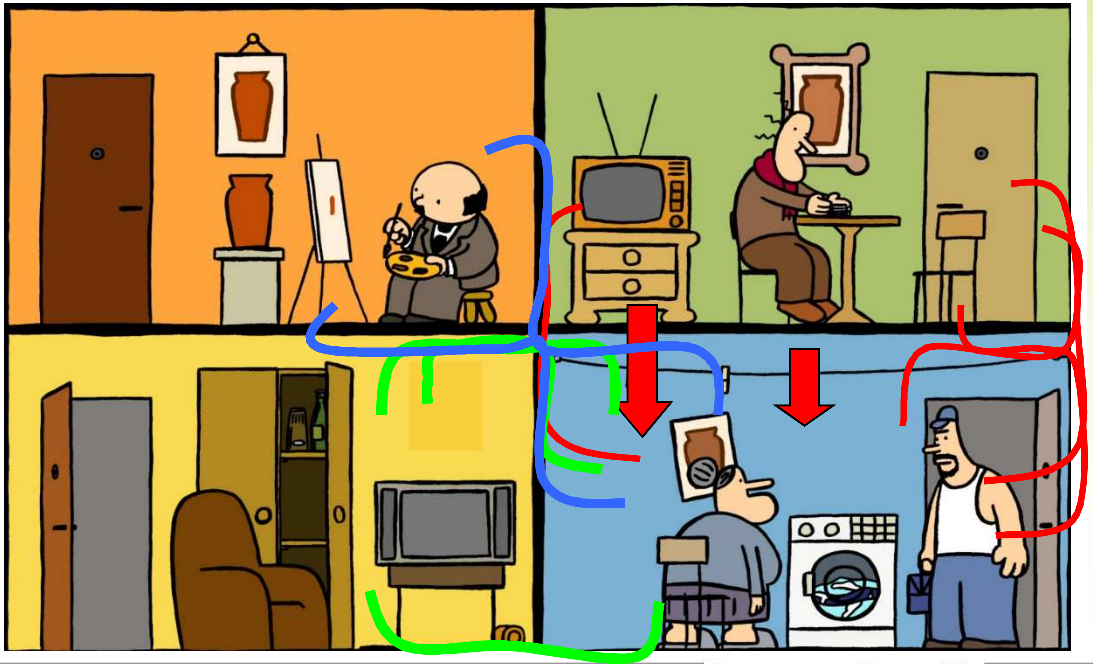







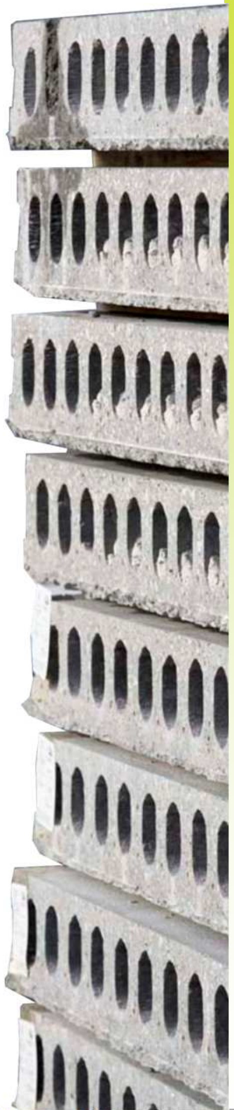
## 5.2 Acoustic insulation

- **Airborne sound**
- **Impact sound**
- **Solutions with hollowcore**
  - Results from tests
  - Different configurations
  - …



# Content

1. Introduction
2. Description of hollow core units and floor systems
3. Design of the cross-section
4. Design of hollow core floors
5. Building physics
6. **Environmental issues**
7. HC in seismic regions
8. Design considerations regarding finished elements
9. Design considerations regarding manufacture

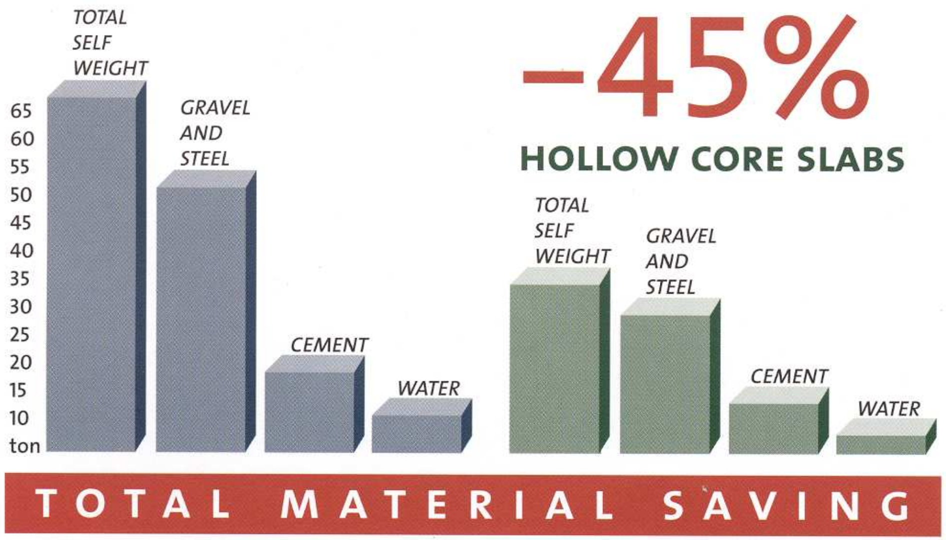


# Chapter 6: Environmental issues

**General information**

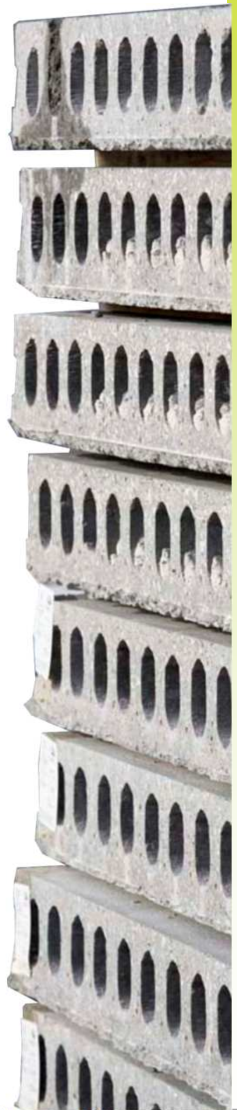
- “closed loop” factories
- 28% less primary energy consumption
- 40 to 50% less raw material
- 37,8% less generation of waste

...

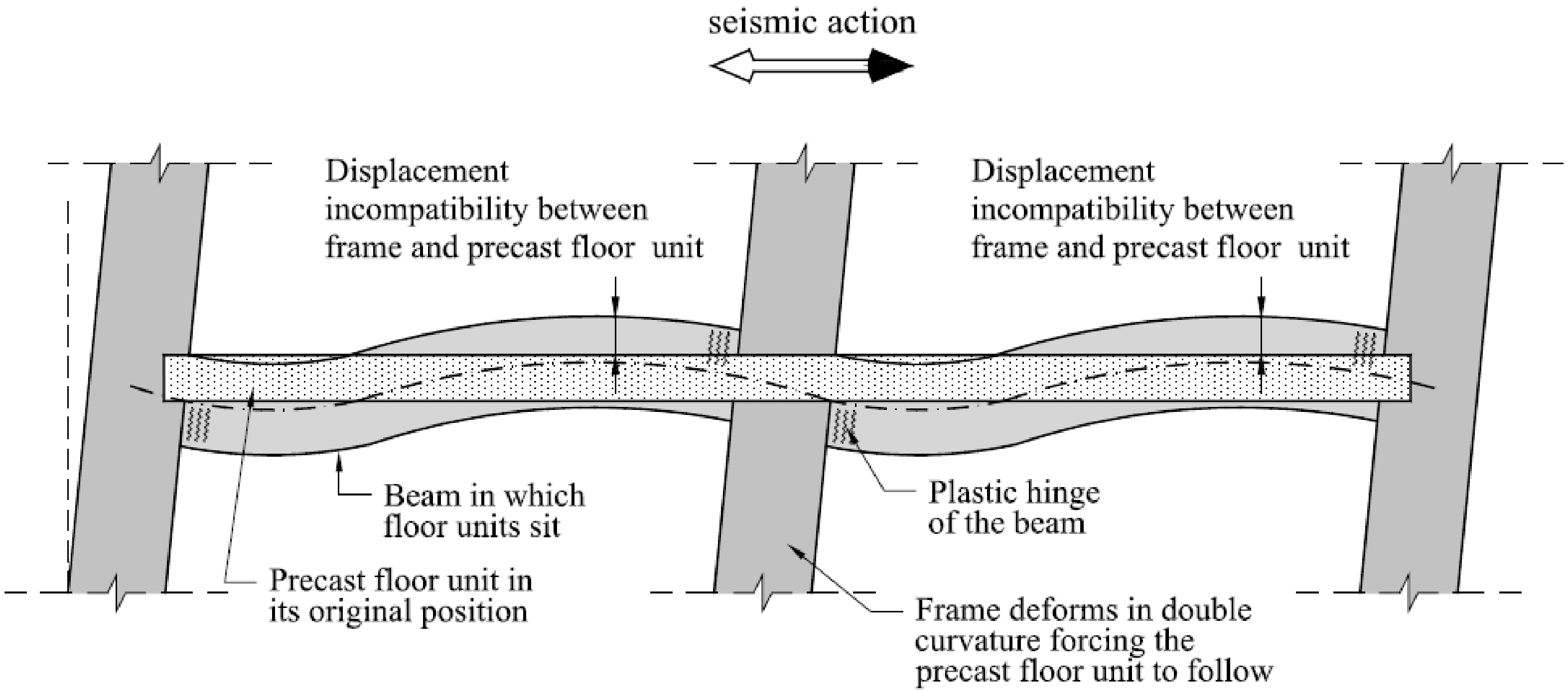


# Content

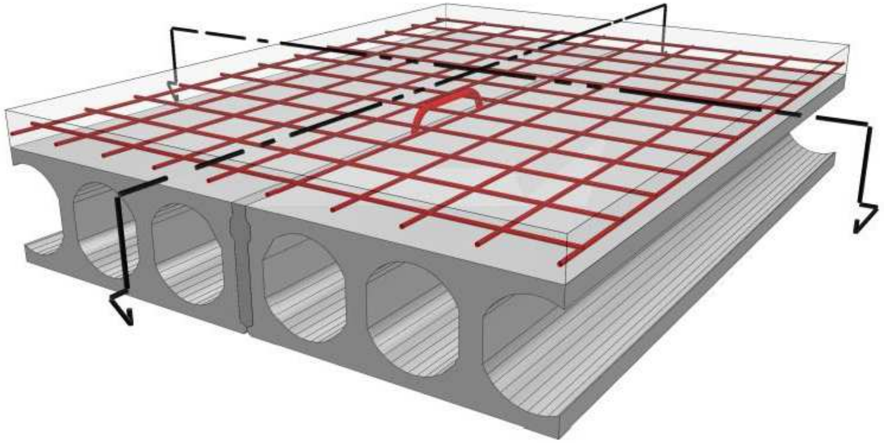
1. Introduction
2. Description of hollow core units and floor systems
3. Design of the cross-section
4. Design of hollow core floors
5. Building physics
6. Environmental issues
7. HC in seismic regions
8. Design considerations regarding finished elements
9. Design considerations regarding manufacture

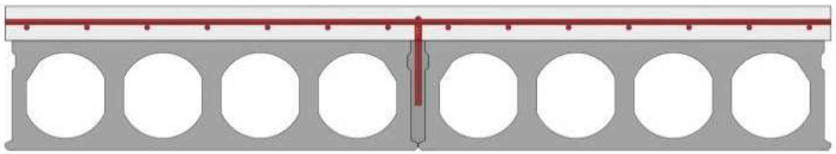


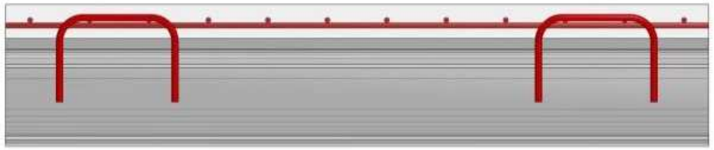
## 7.4 Potential failure modes



## 7.3 Diaphragm action of precast hollow-core floors in seismic actions







# Content

1. Introduction
2. Description of hollow core units and floor systems
3. Design of the cross-section
4. Design of hollow core floors
5. Building physics
6. Environmental issues
7. HC in seismic regions
8. Design considerations regarding finished elements
9. Design considerations regarding manufacture

**8.1 Dimensional tolerances**

**8.2 Slippage of prestressing tendons**

**8.3 Imperfections**

**8.4 Drainage holes**

**8.5 (Repair and retrofitting)**

**8.6 Test methods: shear and material tests**

## 8.6 Test methods

# Content


1. Introduction
2. Description of hollow core units and floor systems
3. Design of the cross-section
4. Design of hollow core floors
5. Building physics
6. Environmental issues
7. HC in seismic regions
8. Design considerations regarding finished elements
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9.1 During casting

9.2 Immediately after casting

9.3 Sawing of slabs

9.4 Lifting of slabs

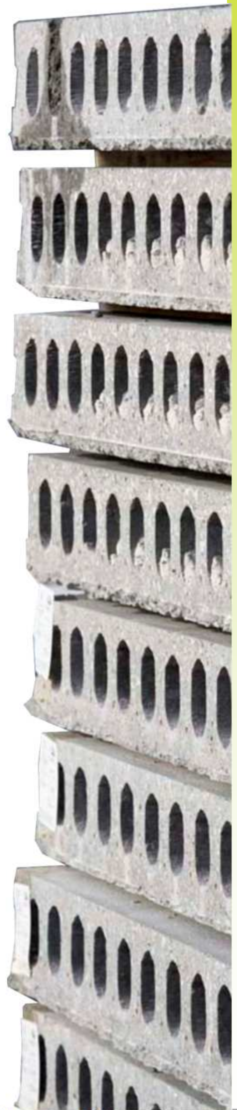
9.5 Storage


Source: Echo


Source: Bison Manufacturing

# Input from IPHA

- **Input from IPHA is highly appreciated**
  - Best practices
    - Acoustic insulation
    - Fixings in HC
  - Results
    - Punching
  - Terminology
    - Chapter in new recommendations
    - *fib* terminology tool under development
  - High resolution pictures
    - Pictures owned by your company
    - Educational
    - References (project, architect,…)



# Future

- *fib* **COM6 TG6.1 Prestressed Hollowcore Floors**

- *fib* **COM6 TG6.1 Floors**
  - Precast
    - Hollowcore floors
    - prestressed
    - reinforced
    - Prestressed ribbed floors
    - Light ribbed roof elements
    - Solid slab floors
  - Semi-Precast
    - Composite floor-plate floors
    - Beam and block floors