IPHA Technical Seminar 2015

October 21-22, Malmö - Sweden

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

Stef MAAS

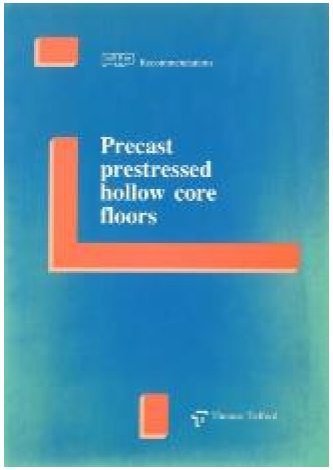
fib COM6 Prefabrication

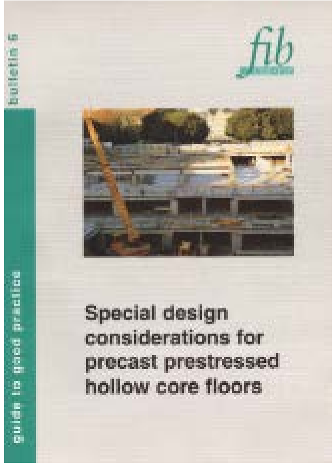
INTERNATIONAL PRESTRESSED HOLLOWCORE ASSOCIATION

in cooperation with StruSoft

History

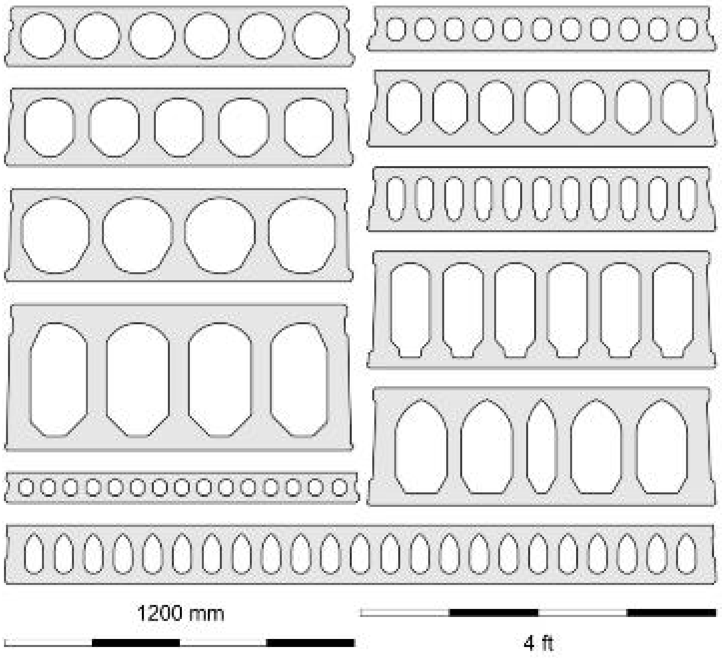
- ….
- **1988 - Precast prestressed hollowcore floors (Thomas Telfort),**
- **2000 - Special design recommendations for precast prestressed hollowcore floors**
- **2015 - New recommendations Main work item of TG 6.1**
  - Content accepted untill 12/2015
  - 2016 editing + approval





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



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2. **Description of hollow core units and floor systems**
3. **Design of the cross-section**
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9. **Design considerations regarding manufacture**

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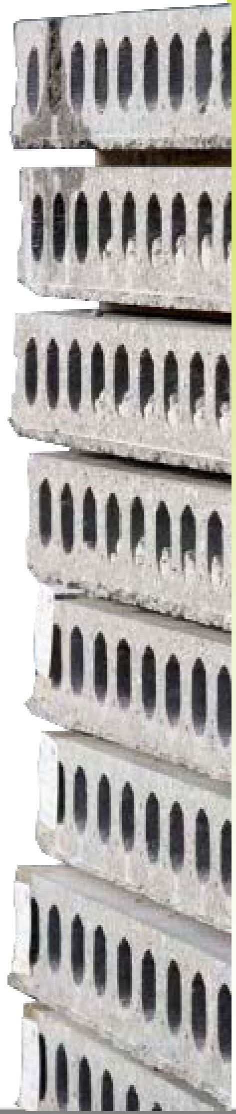


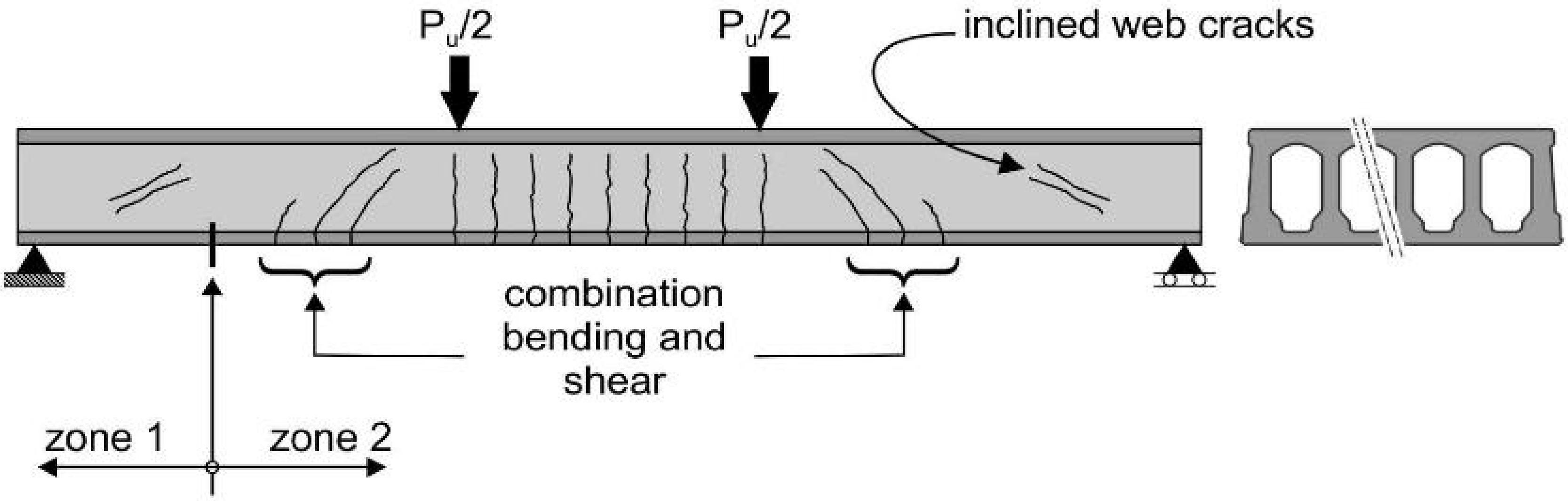
Chapter 3: Design of the CSS

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

Chapter 3: Design of the CSS

3.5 Shear capacity

- Regions cracked in bending
- Regions not cracked in bending



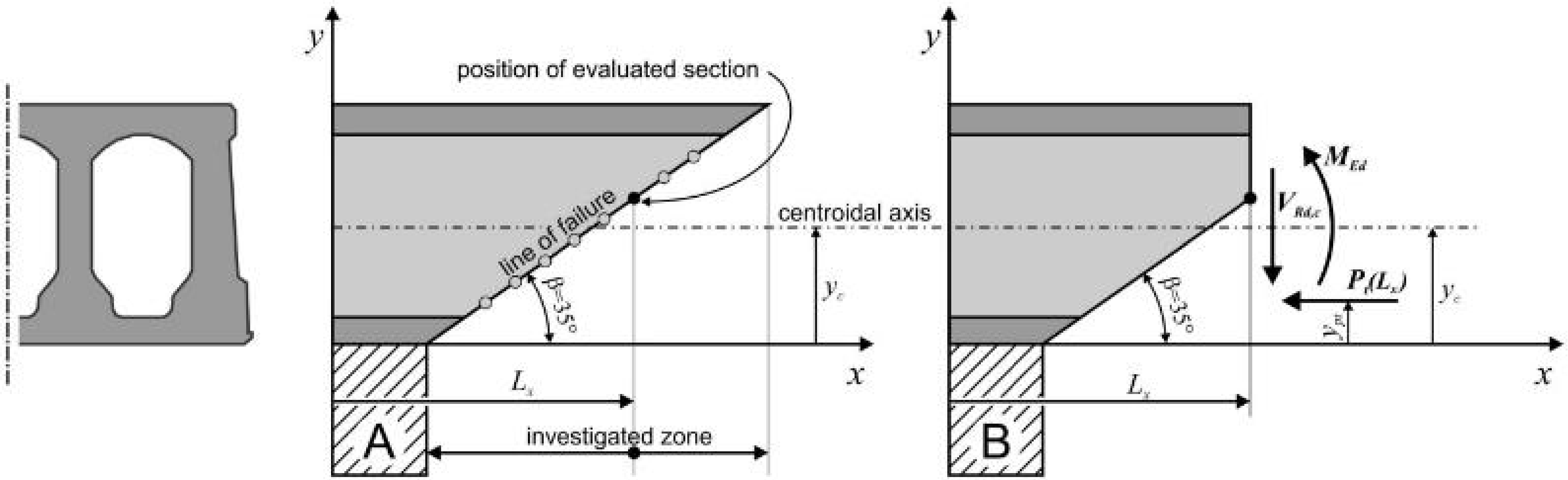
Chapter 3: Design of the CSS

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**

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



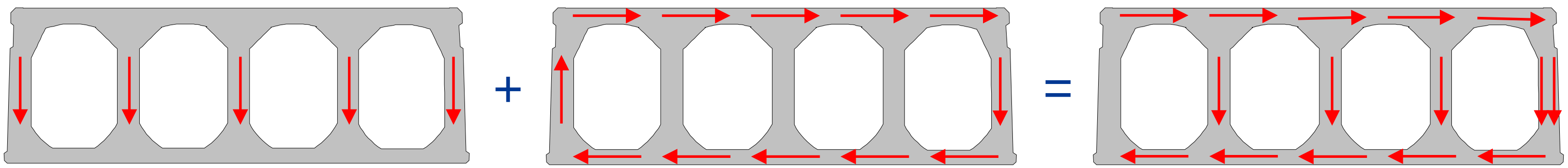
3.6 Shear and bending interaction

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

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

Chapter 3: Design of the CSS

3.8 Shear and torsion interaction



Shear + Torsion = Interaction

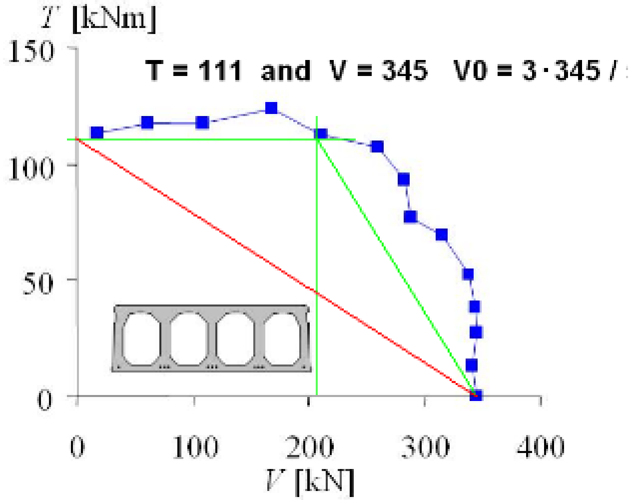
Extensive research programme funded by the European Commission under the “Competitive and Sustainable Growth” Programme

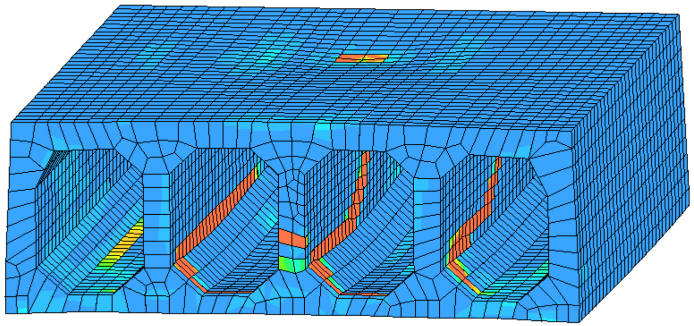
(1998 – 2002)

Chapter 3: Design of the CSS

3.8 Shear and torsion interaction

- **Sophisticated way (Holcotors)**



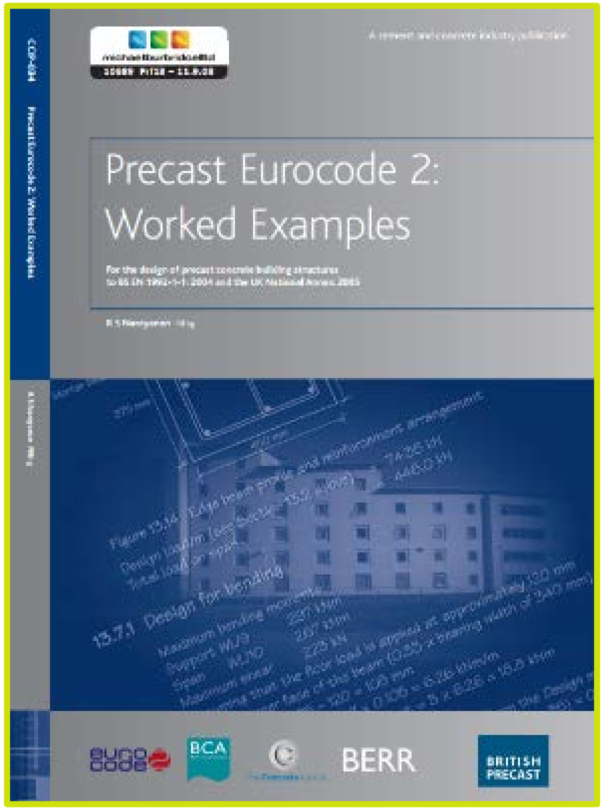


- **This bulletin: 5-step simplified method**

Chapter 3: Design of the CSS

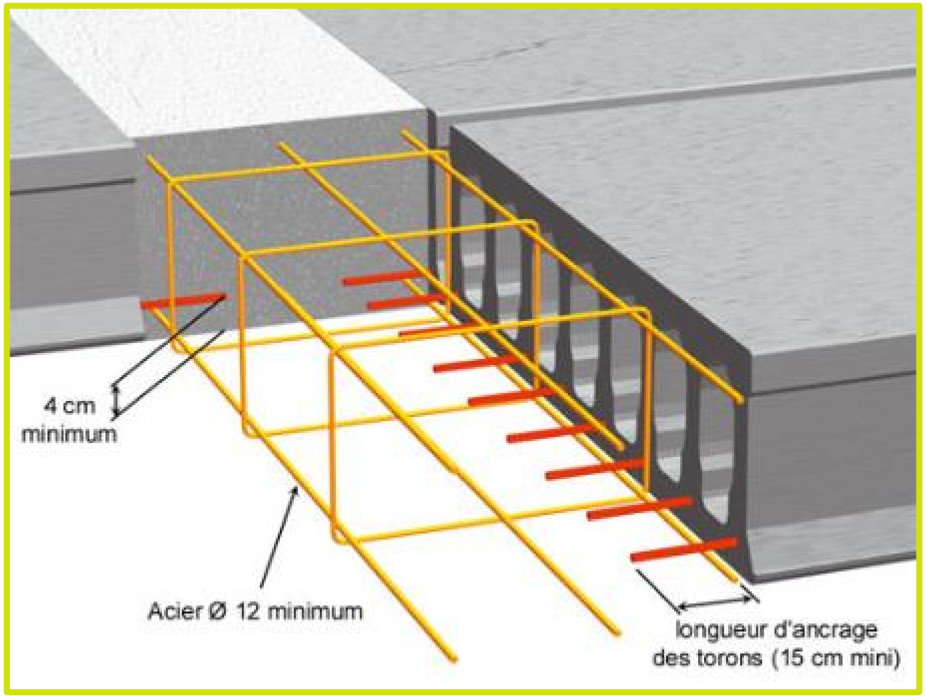
3.10 Camber design and deflection

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



Chapter 3: Design of the CSS

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

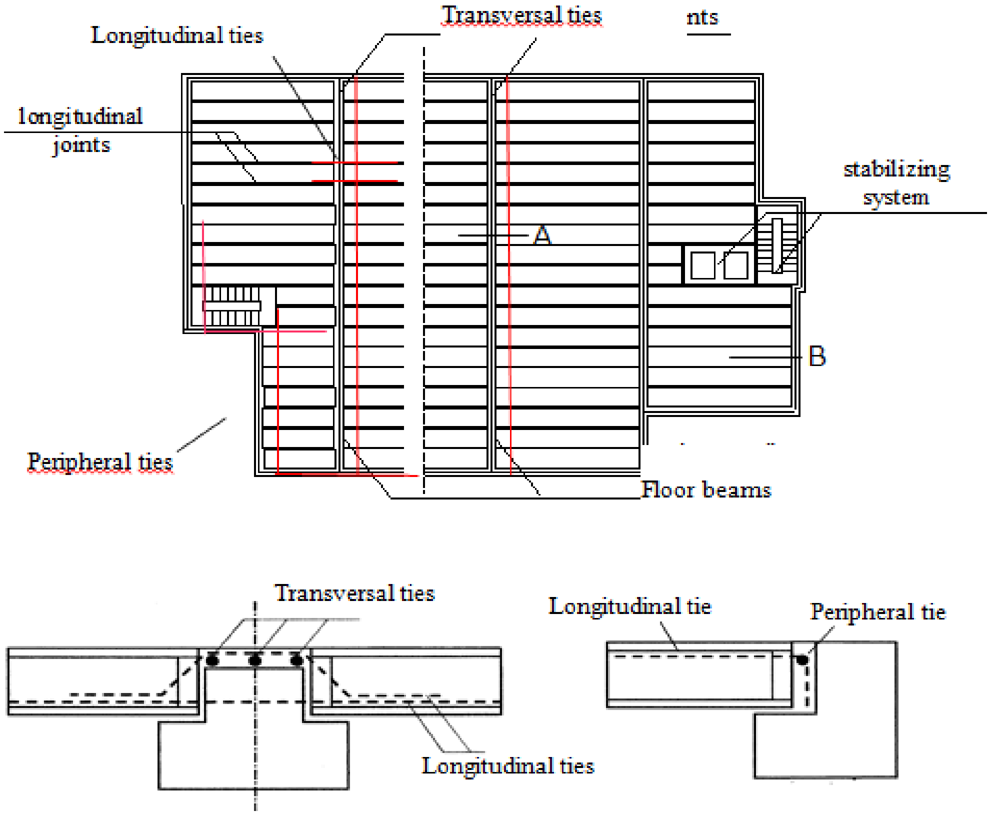
4.12 Connections

4.13 Light load fixings

4.14 Openings and block-outs

Chapter 4: design of the floor

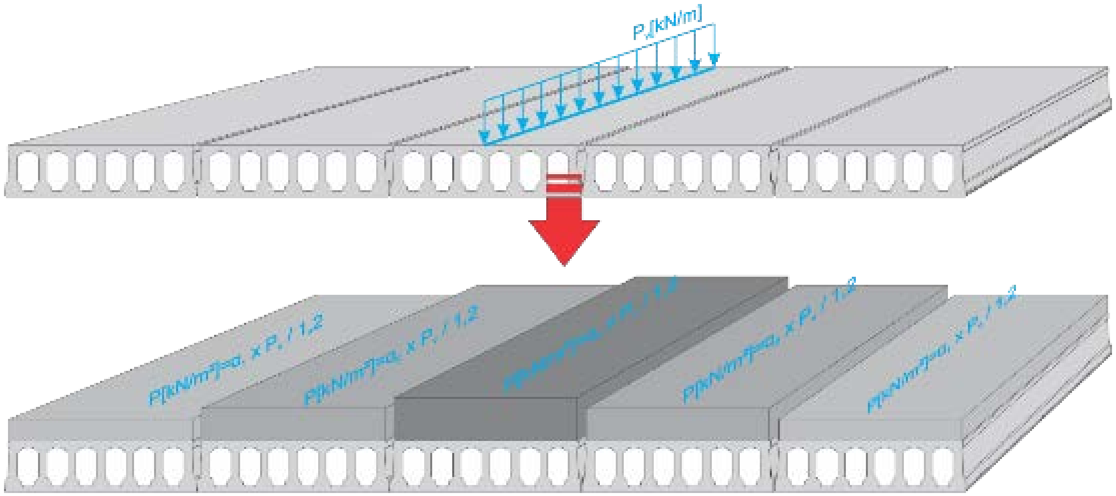
4.2.1 Tie systems

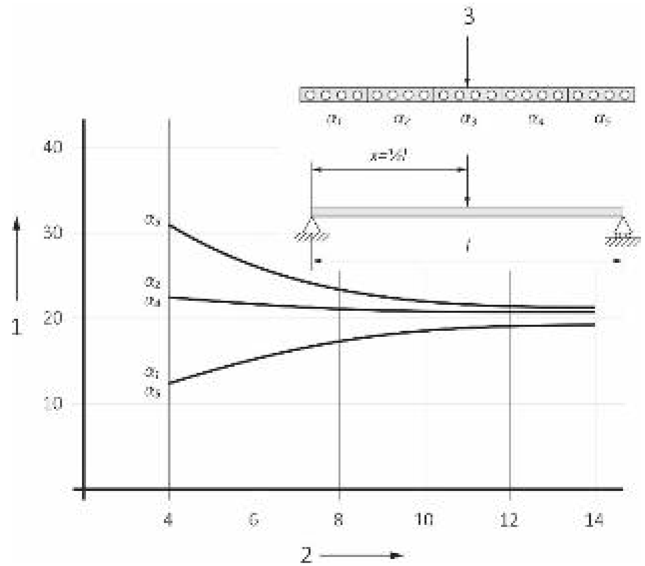


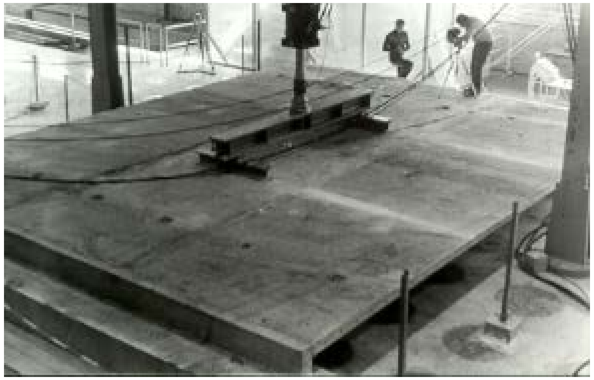
Chapter 4: design of the floor

Chapter 4: design of the floor

4.4 Transversal load distribution

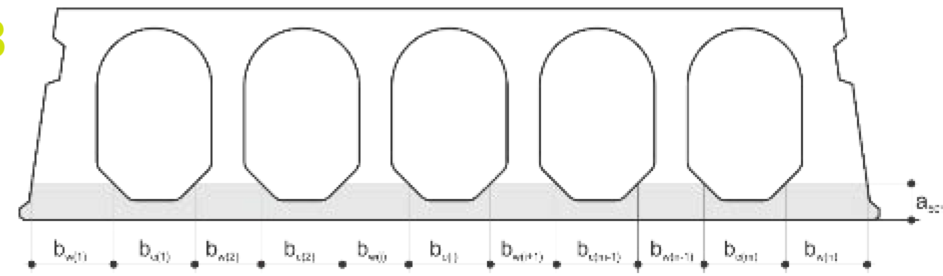


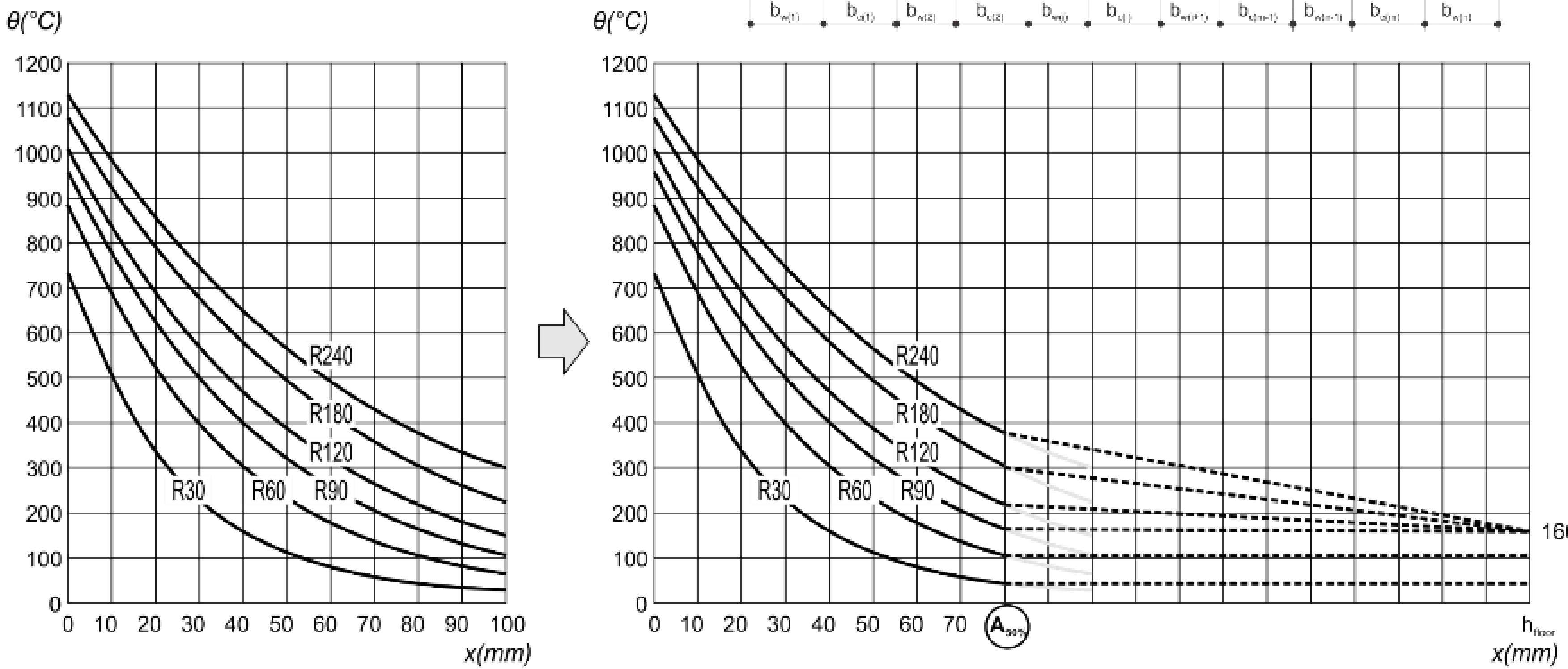




4.11 Fire resistance

- **Approach of EN 1168**





Chapter 4: design of the floor

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)

Chapter 4: design of the floor

Calculation shear capacity

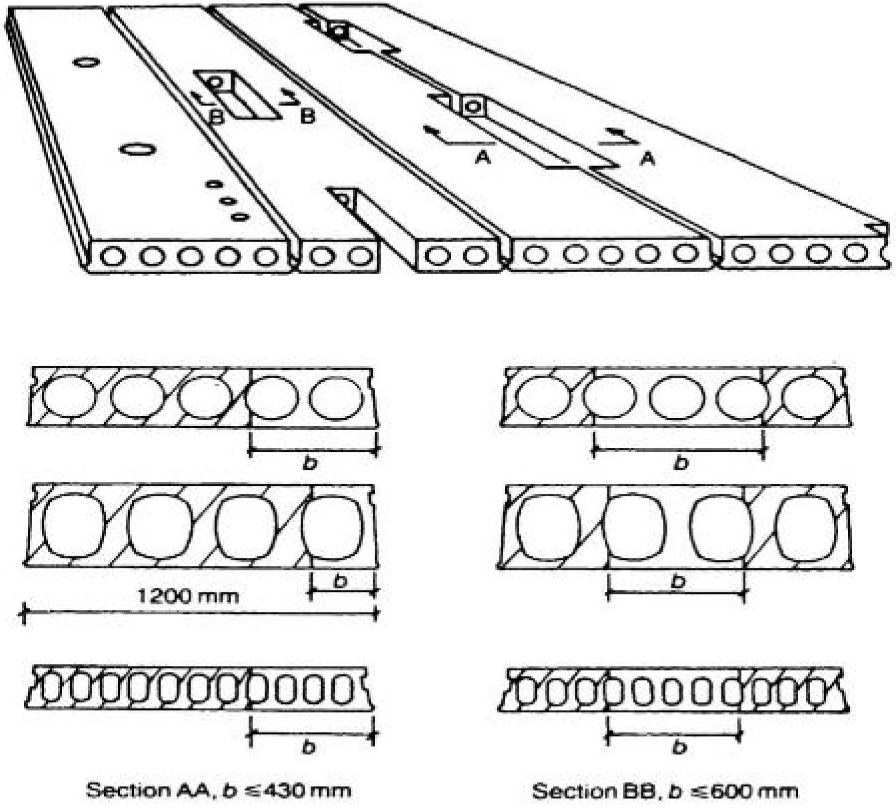
$V_{Rd,c,fi}/V_{rd,c,cold}$ (%)	Slab thickness [mm]				
Fire resistance	160	200	240-280	320	360-400
REI 60	70 %	65 %	60 %	60 %	55 %
REI 90	65 %	60 %	60 %	55 %	50 %
REI 120	60 %	60 %	55 %	50 %	50 %
REI 180	45 %	50 %	50 %	45 %	45 %

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

Chapter 4: design of the floor

4.14 Openings and block-outs (WIP)

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



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Chapter 5: Building physics

5.1 Thermal performances

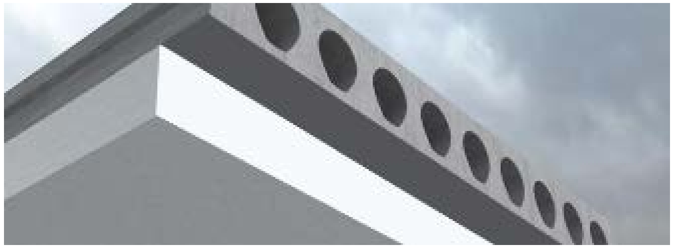
5.2 Acoustic insulation

5.3 (Moisture content)

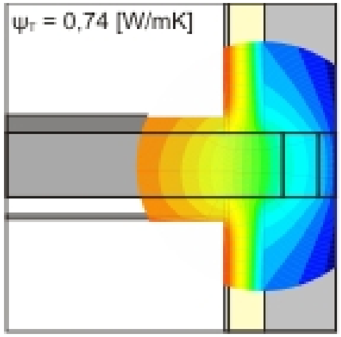
Office building with thermal activated floors – Hasselt - Belgium

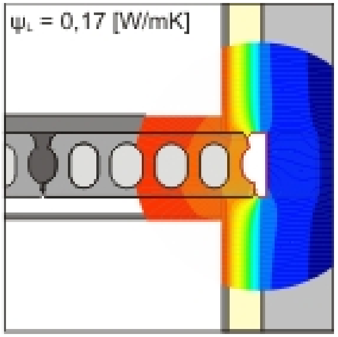
Chapter 5: Building physics

5.1.1 Thermal insulation



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

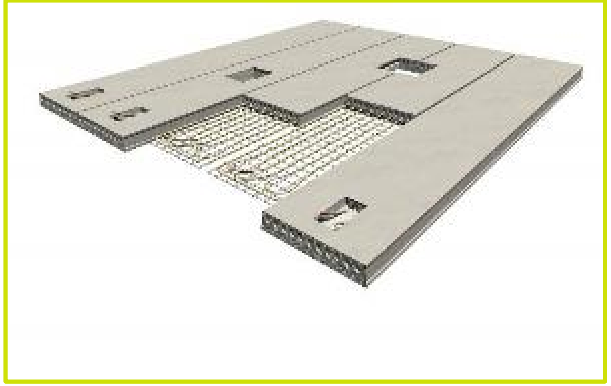


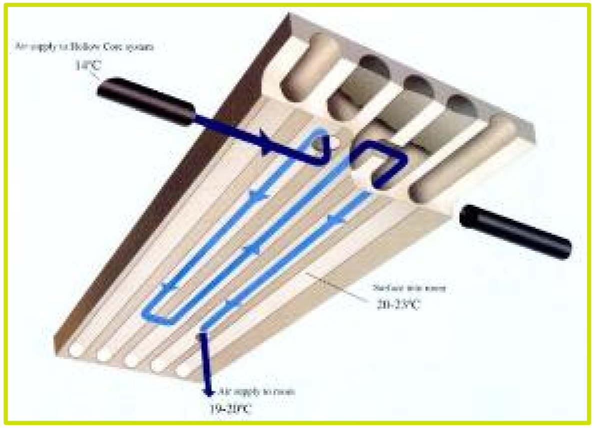


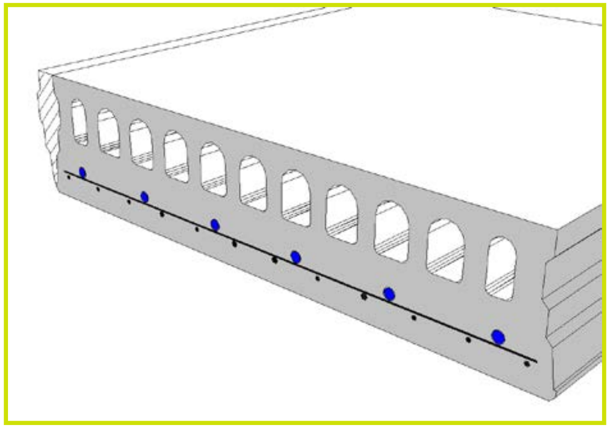
Chapter 5: Building physics

5.1.2 Thermal active floors

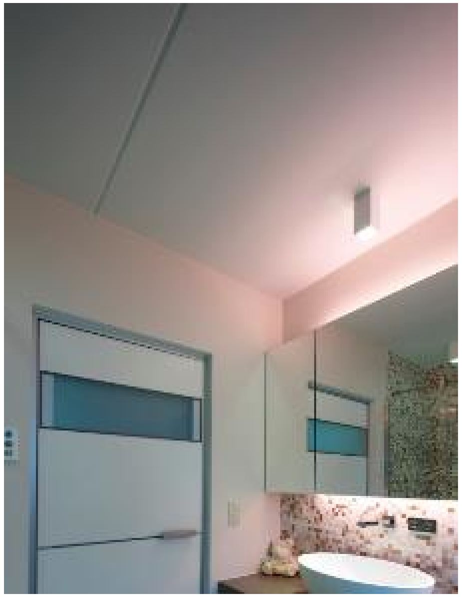
- **Cooling and heating is integrated in the HC-slab**
- **Many examples :**
  - Termodeck (SE)
  - ClimaDeck (BE)
  - Climate floor (NL)
  - Wingfloor (NL)
  - …







Chapter 5: Building physics



Chapter 5: Building physics

5.2 Acoustic insulation

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

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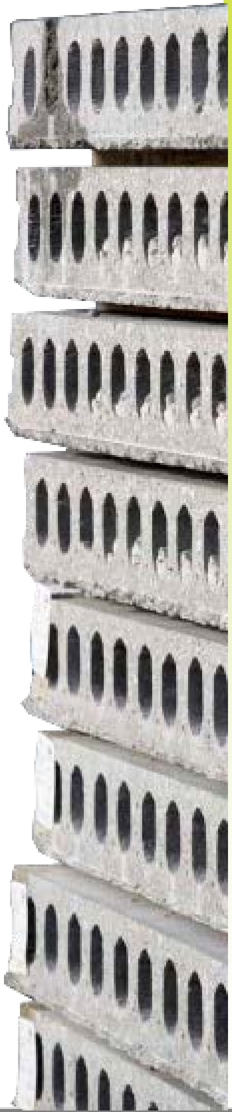

Chapter 6: Environmental issues

General information

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

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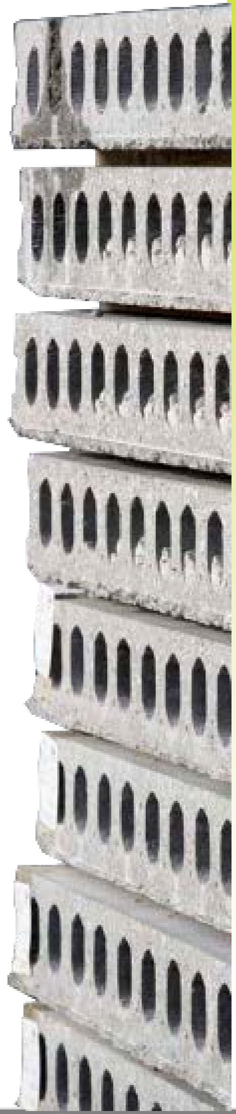
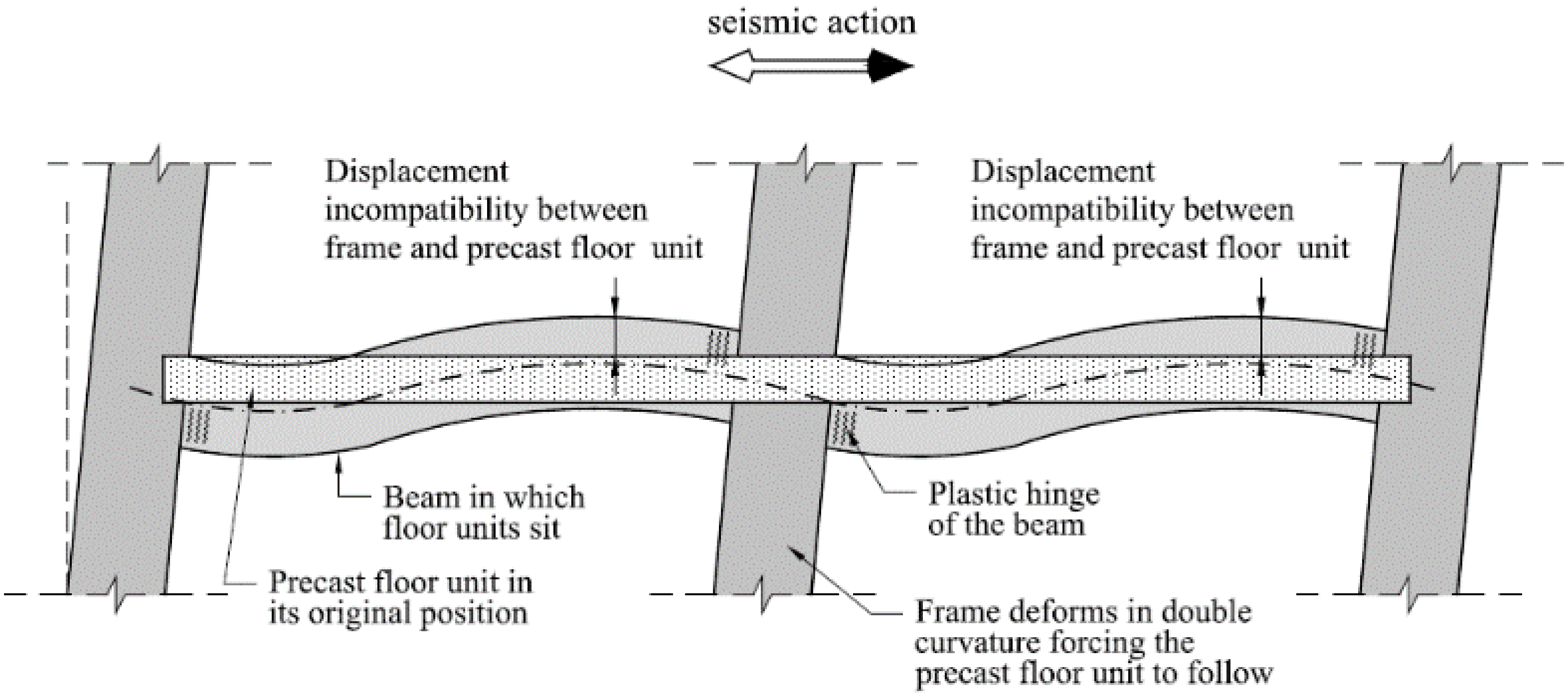
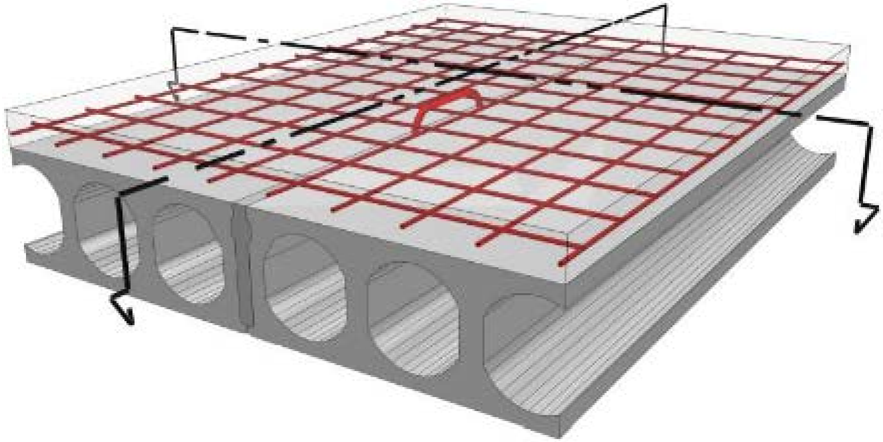


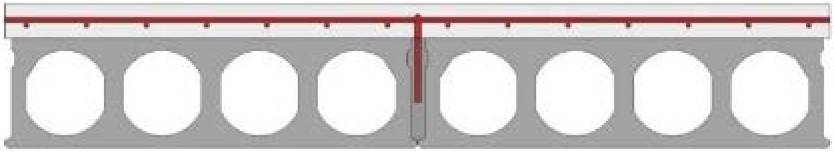
7.4 Potential failure modes

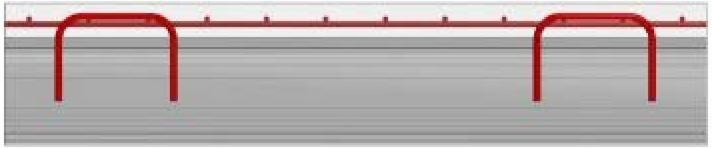


Chapter 7: Hollow core in seismic regions

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







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Chapter 8: Design considerations – Finished HC

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

Chapter 8: Design considerations - manufacture

8.6 Test methods



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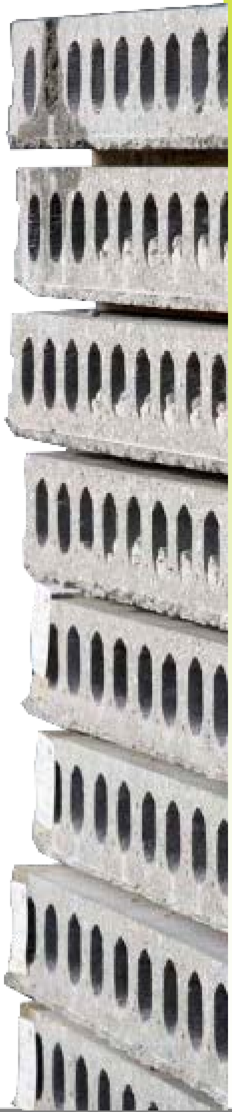


Chapter 9: Design considerations – Manufacture

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

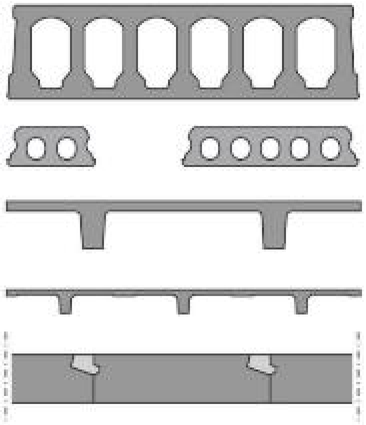
Input from IPHA

- **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,…)

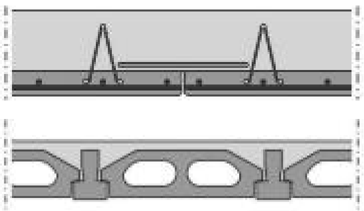
Future

- *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



THANK YOU

For your attention

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