Prestressed Hollowcore Floors
New fib - recommendations
- update -

Stef MAAS
fib COM6 Prefabrication
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 until 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
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
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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

- More accurate method

\[
V_{Rd,c} = \frac{I \cdot b_w(y)}{S_c(y)} \left( \sqrt{f_{ctd}^2 + \sigma_{cp}(y) \cdot f_{ctd} - \tau_{cp}(y)} \right)
\]
Chapter 3: Design of the CSS

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 (Holcators)

- 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 restraint
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
Chapter 4: design of the floor

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)
      - Tabulated data
  - E and I
    - Minimum dimensions (tabulated data)

\[ V_{Rd,fi} = [(C_{\theta_1} + \alpha_k \cdot C_{\theta_2}) \cdot b_w \cdot d] \]
Chapter 4: design of the floor

Calculation shear capacity

<table>
<thead>
<tr>
<th>$\frac{V_{Rd,c,fi}}{V_{rd,c,cold}}$ (%)</th>
<th>Slab thickness [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fire resistance</strong></td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>200</td>
</tr>
<tr>
<td><strong>REI 60</strong></td>
<td>70 %</td>
</tr>
<tr>
<td><strong>REI 90</strong></td>
<td>65 %</td>
</tr>
<tr>
<td><strong>REI 120</strong></td>
<td>60 %</td>
</tr>
<tr>
<td><strong>REI 180</strong></td>
<td>45 %</td>
</tr>
</tbody>
</table>

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
  - ...

Technical Seminar 2015, October 21-22, Malmö - Sweden
Content

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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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Chapter 7: Hollow core in seismic regions

7.4 Potential failure modes

Displacement incompatibility between frame and precast floor unit

Beam in which floor units sit

Precast floor unit in its original position

Displacement incompatibility between frame and precast floor unit

Plastic hinge of the beam

Frame deforms in double curvature forcing the precast floor unit to follow
Chapter 7: Hollow core in seismic regions

7.3 Diaphragm action of precast hollow-core floors in seismic actions
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8. **Design considerations regarding finished elements**  
9. Design considerations regarding manufacture
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
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,…)

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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