Overview of the Evolution of EN1992: Design of concrete structures

17 December 2021
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Structure of this slide deck

→ General overview of the evolution of EN 1992

→ Specific overview of the evolution of EN 1992 parts:
  - EN 1992-1-1 General rules – Rules for buildings, bridges and civil engineering structures (merged current parts -1-1, -2 and -3)
  - EN 1992-1-2 General rules – Structural fire design
General overview of the Evolution of EN1992: Design of concrete structures

17 December 2021
Agenda – Evolution of EN 1992

- Key changes to EN 1992
- New content included in the scope of EN 1992
- How ease of use has been enhanced

The following slides provide a general overview of the evolution of EN 1992. Complementary slides provide greater details for individual Eurocode Parts.
Key changes to EN 1992

- Design rules which are based on physical models avoiding member specific rules, sufficiently comprehensive for existing structures but simplified for new construction

- Commonly used design provisions are given in the main text, special design provisions which are used for less common structures or members are given in Annexes

- Simple fatigue verification for all types of structures is given in Clause 10; detailed fatigue verification is given in Annex E; bridge specific fatigue verification provisions are given in Annex K
Key changes to EN 1992

» Introducing new performance based provisions for concrete structures facilitating increased use of new types of cements and concretes (green concretes) and thus permitting improved sustainability of new concrete structures
New content included in scope of EN 1992

- Assessment of existing structures
- Strengthening with CFRP materials
- New materials and products: FRP reinforcement; steel fibre reinforced concrete structures; recycled aggregate concrete structures; stainless steel reinforcement
- New methods of anchoring reinforcement: Headed bars, U-loop bars, post-installed bars
How ease of use has been enhanced

- Provided extended list of terms and definitions and list of symbols
- Removed rules of little practical use and alternative application rules
- Start design provisions with a simple check whether verification is required at all before going into simplified and then comprehensive verification rules adapted to the specific task
- Unified design provisions for complete range of concrete strength avoiding duplicate rules for grades up to 50MPa and grades above 50MPa
Overview of the Evolution of EN1992-1-1: General rules, rules for buildings, bridges and civil engineering structures

17 December 2021
Agenda – Evolution of EN 1992-1-1: General rules, rules for buildings, bridges and civil engineering structures

- Key changes to EN 1992-1-1
- New content included in the scope of EN 1992-1-1
- How ease of use has been enhanced
Key changes to EN 1992-1-1

→ Provisions for improved sustainability of concrete structures:

- Permitting reference age for concrete strength to be chosen up to 91 days to benefit from slow strength development of “green concretes”

- Introducing Exposure Resistance Concept for durability assessment of concretes, suitable for common and new types of concrete such as “green concretes”

- Introducing provisions for recycled aggregates concrete

- Introducing provisions for assessment of existing structures

- Introducing provisions for adaptation of partial material factors for improved quality control and/or improved knowledge
Key changes to EN 1992-1-1

→ Design rules which are based on physical models avoiding member specific rules, sufficiently comprehensive for existing structures but simplified for new construction

→ Commonly used design provisions are given in the main text, special design provisions which are used for less common structures or members are given in Annexes

→ Simple fatigue verification for all types of structures is given in Clause 10; detailed fatigue verification is given in Annex E; bridge specific fatigue verification provisions are given in Annex K
Key changes to EN 1992-1-1


→ Integration of containment structures provisions from current EN 1992-3:2006 into future EN 1992-1-1, Annex D (cracking due to restraint) and Annex H (water tightness)

→ Re-defined effective concrete strength $f_{cd}$ such as to avoid different design provisions for grades up to 50MPa and for grades above 50MPa, and to simplify assumptions for strain and stress distributions in concrete compression zone

\[ \varepsilon_c = 0.002 \]
\[ \varepsilon_{cu} = 0.0035 \]
New content included in scope of EN 1992-1-1

→ Assessment of existing structures
→ Strengthening with CFRP materials
→ New materials and products: FRP reinforcement; steel fibre reinforced concrete structures; recycled aggregate concrete structures; stainless steel reinforcement
New content included in scope of EN 1992-1-1

- Requirements assumed in design provisions and for specification of materials in Annex C serve as interface to product standards
- Safety format for non-linear analysis procedures
- Design of membrane-, shell- and slab type members
- Durability design with performance-based approach for consideration of new types of cement and concrete (e.g. green concretes)
- Coverage of new methods of anchoring reinforcing steel (U-bar, headed bar, post-installed bar)
- Strength of confined concrete
How ease of use has been enhanced

- Collected all partial action and material factors in easy to read table form in Clause 4
- Kept only material properties needed for common design in Clause 5; properties for detailed design or less commonly used materials and requirements for products moved to Annex
- Removed 122 NDPs and added 51 new NDPs (new items)
- Reduced volume of text corresponding to current version of EN 1992-1-1, EN 1992-2 and EN 1992-3 by 35%
- Provided comprehensive background document on design provisions
How ease of use has been enhanced

Shear and punching shear strength: comprehensive design model and formulae for detailed verification of new members without and with shear reinforcement; amendments for existing structures not complying with detailing rules of new construction; simplification of comprehensive model for quick check whether shear or punching needs detailed verification at all

Anchorage and lap length: tabulated data for anchorage length of bars stressed to design yield strength as a function of concrete strength; detailed formula for verification of anchorage and lap length as a function of stress in reinforcement, concrete strength, cover, confinement, bends/hooks, etc.
How ease of use has been enhanced

- **Collected detailing rules for members in easy to read and compact table format**

<table>
<thead>
<tr>
<th>Description</th>
<th>Symbol</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Minimum longitudinal reinforcement, in those parts of the section where</td>
<td>$A_{\text{min}}$</td>
<td>12.2(2), see also 12.2(3), 12.2(6)</td>
</tr>
<tr>
<td>tension may occur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Minimum shear and transverse torsional reinforcement, when required.</td>
<td>$\rho_{\text{min}}$</td>
<td>12.2(4)</td>
</tr>
<tr>
<td>Minimum torsion reinforcement should be provided to the full perimeter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>including features not counted part of the thin walled section.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Minimum bottom reinforcement at inner supports taking account of</td>
<td>$0,25\ A_{\text{req}}\ \text{span}$</td>
<td></td>
</tr>
<tr>
<td>unforeseen effects at supports</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Maximum longitudinal spacing of shear assemblies/stirrups</td>
<td>$S_{\text{max}}$</td>
<td>$0,75d\ (1 + \cot\alpha)$</td>
</tr>
<tr>
<td>$^*$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Maximum longitudinal spacing of bent-up bars $^*$</td>
<td>$S_{\text{max,bu}}$</td>
<td>$0,6d\ (1 + \cot\alpha)$</td>
</tr>
<tr>
<td>6 Maximum transverse spacing of shear legs $^*$</td>
<td>$S_{\text{max,t}}$</td>
<td>$0,75d \leq 600\ \text{mm}$</td>
</tr>
<tr>
<td>7 Minimum ratio of shear reinforcement in the form of stirrups with</td>
<td>$\rho_{\text{stir}}$</td>
<td>$\geq 0,5\rho_{\text{req}}$</td>
</tr>
<tr>
<td>respect to the required reinforcement ratio (taking account of unforeseen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>effects e.g. compatibility torsion)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Minimum ratio of torsion reinforcement in the form of closed</td>
<td>$\rho_{\text{tor}}$</td>
<td>$\geq 0,2\rho_{\text{req}}$</td>
</tr>
<tr>
<td>stirrups with respect to the required reinforcement ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Maximum spacing for torsion assemblies/stirrups (is defined in 8.3.2(2)</td>
<td>$S_{\text{max,tor}}$</td>
<td>$u/8 \leq \min(b, h)$</td>
</tr>
<tr>
<td>)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Minimum area and spacing of longitudinal surface</td>
<td>$A_{\text{web}}$</td>
<td>$9.2.2(6)$</td>
</tr>
<tr>
<td>reinforcement in beams with downstand $\geq 600\ \text{mm}$ to avoid</td>
<td>$S_{\text{max,torf}}$</td>
<td>$300\ \text{mm}$</td>
</tr>
<tr>
<td>coarse cracks in SLS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Minimum transverse reinforcement in flanges (those part of flanges</td>
<td>$A_{\text{flm}}$</td>
<td>12.2(2) see 8.2.5, Figure 8.13</td>
</tr>
<tr>
<td>where tension in the transverse direction may occur</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^*$ These spacings are consistent with the shear model in 8.2.3. Where alternative models are used alternative spacings may be required.
Overview of the Evolution of EN1992-1-2: General – Structural fire design

17 December 2021
Agenda – Evolution of EN 1992-1-2: General – Structural fire design

→ Key changes to EN 1992-1-2
→ New content included in the scope of EN 1992-1-2
→ How ease of use has been enhanced
Key changes to EN 1992-1-2

- Harmonised structure / table of contents of EN 1992-1-2 with other fire parts
- Amended and improved simplified design methods
- Ensured consistency between tabulated design data, simplified and advanced design methods
New content included in scope of EN 1992-1-2

→ Properties of steel fibre reinforced concrete at high temperature
→ Properties of recycled aggregate concrete at high temperature
→ Specific rules for avoiding / controlling spalling
→ Simplified analytical formulae for determination of temperature profiles in members
How ease of use has been enhanced

- Reduced number of alternative application rules
- Clarified use and scope of tabulated data
- Included simplified analytical formulae for determination of temperature profiles in members
- Removed 14 NDPs and added 2 new NDP
- Reduced volume of text corresponding to current version of EN 1992-1-2 by about 30%
- Provided comprehensive background document on design provisions