Using Eurocodes to Design Stainless Steel Bridges

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Stainless Steel in Structures:
Fourth International Experts Seminar

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Stainless Steel Bridge Study

• Client: Outokumpu
• Steel composite highway bridge
• Eurocodes
• Construction costs
• Life-cycle costs
• Optimisation

Nynäshamn bridge, Sweden
Study - Reference Design

Elevation

Cross section

SCI Publication 357 – Composite Highway Bridge Design: Worked Example
Optimisation

• Remove material inefficiency
• Fully effective elements ($\chi = 1$)
• Class 2 (Compact) sections
• Member buckling restraint
• Extra fabrication to remove excess material
Stainless Steel Structure

- 1993-1-1 basic design rules for steel structures
- 1993-1-5 requirements of stiffened and unstiffened plates
- 1993-1-4 supplementary provisions that extend and modify 3-1-1 and 3-1-5 to stainless steels.
Steel Bridge

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- 1993-1-5 requirements of stiffened and unstiffened plates
- 1993-1-4 supplementary provisions that extend and modify 3-1-1 and 3-1-5 to stainless steels.
- 1993-2 general basis for the structural design of steel bridges.

It gives provisions that supplement, modify or supersede the equivalent provisions given in the various parts of EN 1993-1.
Stainless Steel Bridge?

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- 1993-1-5  requirements of stiffened and unstiffened plates
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## Eurocodes

<table>
<thead>
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<th>General Rules</th>
<th>Stainless Steel</th>
<th>Bridges</th>
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<tr>
<td></td>
<td>1993-1-1</td>
<td>1993-1-4</td>
<td>1993-2</td>
</tr>
<tr>
<td>Shear area factor, $\eta$</td>
<td>1.2</td>
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<tr>
<td>Partial factor for X-sections, $\gamma_{M0}$</td>
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<tr>
<td>Partial factor for members, $\gamma_{M1}$</td>
<td>1.0</td>
<td>1.1</td>
<td>1.1</td>
</tr>
</tbody>
</table>
Shape Limits – web in compression

$c/t$ limit for class 2 web

- **S450 (Part 1-1)**
- **Duplex (Part 1-4)**
- **Duplex (amended)**

**Class 3**

**Class 2**
Shape Limits – web in compression

$c/t$ limit for class 2 web

- EN1993-1-5
- EN1993-1-4

Class 3

Class 2

Web slenderness vs. Stress Ratio $\alpha$ for:
- S450 (Part 1-1)
- Duplex (Part 1-4)
- Duplex (amended)
Shape Limits – web in compression

c/t limit for class 3 web
Shape Limits – web in compression

$c/t$ limit for class 3 web

- S450 (Part 1-1)
- S450 (Part 1-5)
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Web Slenderness

Class 4

Class 3
Shape Limits – web in compression

c/t limit for class 3 web

Web Slenderness

Stress Ratio $\psi$

c/t limit for class 3 web

- $S_{450}$ (Part 1-1)
- $S_{450}$ (Part 1-5)
- Duplex (Part 1-4)

Class 4

Class 3

ARUP
Shape Limits – web in compression

\[
c/t \text{ limit for class 3 web}
\]

- **Class 3**
- **Class 4**

- S450 (Part 1-1)
- S450 (Part 1-5)
- Duplex (Part 1-4)

**Web Slenderness** vs **Stress Ratio \( \psi \)**

**C**

**T**

**EN1993-1-4**

**EN1993-1-5**

**EN1993-1-1**
Slip Resistant Connections

- Widely used in steel bridge construction
- Bolt relaxation
- Slip factor
- Thread galling

Image from SCI Publication 185
Summary

- Optimise design for stainless steel
- Eurocodes provides all the tools
- Stainless Steel Structure or Steel Bridge?
- Partial safety factors
- Web in compression shape limits
- Slip resistant connections

Thank you