Structural applications of ferritic stainless steels
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About the project

- 60% funded by EC RFCS
- 40% funded by stainless steel industry
- 3 year project (July 2010 – July 2013)
- 8 European partners
  - Co-ordinated by SCI
Overview: today’s discussion

- Background and objectives of the project
- Key findings to date
  - Material response
  - Member response
  - Connections
  - Corrosion
- What next?

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A little about ferritics…

*Compared to carbon steel*
  - Good corrosion-resistance

*Compared to typical stainless steel*
  - Low-cost
  - Price-stable (no nickel!)

*As well as….*
  - Durable, strong, good impact-resistance
Objective of the project

- Generate & provide technical information so ferritics can be specified in buildings
  - Structural performance
  - Fire resistance
  - Atmospheric corrosion resistance
  - Guidance on connections
- Investigate and highlight the advantages of this steel (economic, environmental…)

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WP1: End user requirements (Arup)

- Unknown in the construction industry
- Provide data on:
  - Corrosion and durability
  - Mechanical properties
  - Welding procedures and joining
  - Toughness
  - Grade selection
WP1: Material properties

![Stress vs Strain Graph](image)

- **Stress (N/mm²)**
- **Strain (%)**

Lines indicate:
- 1.4003
- 1.4016
- 1.4509
- 1.4521

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WP1: Material properties

<table>
<thead>
<tr>
<th></th>
<th>Typical cold-rolled ferritic</th>
<th>Typical austenitic</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f_y$ (N/mm²)</td>
<td>350</td>
<td>280</td>
</tr>
<tr>
<td>$f_u$ (N/mm²)</td>
<td>500</td>
<td>650</td>
</tr>
<tr>
<td>$\varepsilon_u$ (A80)</td>
<td>27%</td>
<td>55%</td>
</tr>
</tbody>
</table>

![Stress vs. Strain Graph]

- **Austenitic**
- **Duplex**
- **Ferritic**
WP1: Material properties

- Relatively low $f_u/f_y$ ratio (by SS standards)
- $n$ value = under review
  - Look to be relatively high (like CS)
  - Annealed/cold formed
- $E_s$ = under discussion
  - Around 200 N/mm$^2$
WP1: Toughness properties

1. Charpy tests
   • -40 to +20°C
   • Results: OK toughness for stabilised.
   • Need to do fracture toughness tests

2. Fracture toughness tests
   • Happening early 2013
WP2: Member performance

- **Aim**: to develop efficient design methods for ferritic thin-walled members
  - *Numerical analysis*: Based on GMNIA and use ABAQUS
  - *Experimental validation*: Thin walled top-hat and hollow sections
- Design expressions developed
- Recommendations for the use of DSM
Key findings (to date):

- Existing stainless steel buckling curve can be used in all cases
  - except cold-rolled hollow sections which should use carbon steel curves
- Higher “n” factor of ferritic steels can be taken into account for open sections
WP3: Composite performance

- Ferritic stainless steel decking
  - Decking tests (construction stage)
  - Composite slab tests
  - Stud welding trials
  - Push-out tests
  - Thermal performance
  - Fire performance
WP3: Thermal Modelling

- Utilisation of inherent thermal mass in comp. slab for efficient low-carbon solution
- Detailed FE analysis used to understand, quantify and compare behaviour
Temperature distribution (night)
Thermal flux for various profiles

![Graph showing thermal flux for various profiles over time. Each profile is represented by a different line and marker style, indicating different conditions or materials.]
WP4 Fire tests: Columns
WP4 Fire tests: Columns
WP4: Column analysis

**80x80x3-3000**

Axial displacement (mm) vs. Furnace temperature (°C)

**80x80x3-2500**

Axial displacement (mm) vs. Furnace temperature (°C)

**120x80x3-2500**

Axial displacement (mm) vs. Furnace temperature (°C)
WP4 Fire tests: Beams
WP5: Welded joints

- Mechanical tests and metallographic examination of welds
- Design guidance
WP5: Key findings

- Cold-rolled materials have adequate toughness down to temperatures around 0°C.
- HAZ toughness is reasonable
- Susceptible to grain growth at temperatures above 950 °C - decreased toughness
- Welding heat input should be kept low
- Use austenitic welding consumables
- Stabilised ferritics are readily weldable
WP5: Design rules welded joints

- The strength rules in EN 1993-1-8 can be applied to stainless steels in conjunction with the rules in EN1993-1-3
- No experiments have been carried out on ferritic stainless steel tubular joints to date
- The level of design guidance that can be offered is limited

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WP6: Bolted connections
WP7: Corrosion

- Develop a comprehensive understanding of the durability of the ferritic grades
- Base material + welded + bolted
- Exposure field tests, Accelerated tests, Electrochemical tests
- Design guidance
- Comparative study of the service life of building components
In conclusion

- Very successful consortium
- Results & findings are starting to emerge
- Toughness & durability are the key issues
- What next for ferritics?
  - Watch this space…

- Questions?
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