SafeSteel for Safety Barriers

1. Introduction: EN1317 in Europe
2. Material Conformity Evaluation (Experience on Steels)
   1) Reason and methodology of this study
   2) Results of N2 simulation
   3) Results of H4b simulation
   4) Conclusions

Yihui Wu
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Road safety: International context

– 1st cause of injury mortality in the world with 22.8%
– 1,185,000 persons dead/year

Source: WHO Global Burden of Disease project, 2002, Version 1
Road safety: European context

- 41,200 persons dead/year
- 1,225,500 persons injured/year
Road safety: European context

- Estimated social costs = 200 BLN €/year = 2 % EU GDP

→ EU asked to halve fatalities btw 2000 & 2010 (white book)
Introduction of EN1317

Some Criteria in EN1317:

**ASI**: Acceleration severity index

**WW**: Working Width

**VI**: Vehicle Intrusion
Acceleration Severity Index

\[
ASI = \max_k \left\{ \max_k \left\{ \left( \frac{k - a_x}{12} \right)^2 + \left( \frac{k - a_y}{9} \right)^2 + \left( \frac{k - a_z}{10} \right)^2 \right\} \right\}^{1/2}
\]
Working Width

<table>
<thead>
<tr>
<th>Working Width classes</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
<th>W7</th>
<th>W8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Intrusion</td>
<td>VI1</td>
<td>VI2</td>
<td>VI3</td>
<td>VI4</td>
<td>VI5</td>
<td>VI6</td>
<td>VI7</td>
<td>VI8</td>
</tr>
<tr>
<td>Lateral displacement</td>
<td>≤ 0,6 m</td>
<td>≤ 0,8 m</td>
<td>≤ 1,0 m</td>
<td>≤ 1,3 m</td>
<td>≤ 1,7 m</td>
<td>≤ 2,1 m</td>
<td>≤ 2,5 m</td>
<td>≤ 3,5 m</td>
</tr>
</tbody>
</table>
Vehicle Intrusion and Rolling Angle

Vehicle Intrusion
EN1317 contribution since 2000

Before 2000: A low-cost market & bad image for steel

Now: A market changing to performance with new steel solutions
Europe: Results achieved so far

- **NEW SAFER barriers** using more & more High Strength Steels:
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Reason for this study

Example: Definition of S235JR Steel

<table>
<thead>
<tr>
<th>Désignation</th>
<th>Limite d'élasticité minimale $R_{el}^{a}$</th>
<th>Résistance à la traction $R_{m}^{a}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MPa $^{b)}$</td>
<td>MPa $^{b)}$</td>
</tr>
<tr>
<td></td>
<td>Épaisseur nominale mm</td>
<td>Épaisseur nominale mm</td>
</tr>
<tr>
<td>Seion EN 10027-1 et CR 10260</td>
<td>≤ 16</td>
<td>&gt; 16</td>
</tr>
<tr>
<td>S235JR</td>
<td>1.0038</td>
<td>235</td>
</tr>
<tr>
<td>S235J0</td>
<td>1.0114</td>
<td>235</td>
</tr>
<tr>
<td>S235J2</td>
<td>1.0117</td>
<td>235</td>
</tr>
</tbody>
</table>

235MPa - ?
No maximum yield strength is defined.

360MPa – 510MPa
Too wide range of tensile strength is defined.
Reason for this study

S235JR Steels

- $\sigma$: Stress
- $\varepsilon$: Strain

- 235MPa
- 360MPa
- 510MPa
Reason for this study

**WW**
CONTAINMENT LEVEL

Need of STRENGTH

**ASI**
SEVERITY IMPACT

Need of SOFTNESS

- **MIN limits = strong enough**
- **MAX limits = soft enough**
## Softness and Strength

| Small Displacements D (W or VI <<) | Hard Shock ➔ F >>  
(ASI >>) | Soft Shock ➔ F <<  
(ASI <<) |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Small Displacements" /></td>
<td><img src="image2" alt="Hard Shock" /></td>
<td><img src="image3" alt="Soft Shock" /></td>
</tr>
<tr>
<td><img src="image4" alt="Low injury to the driver or passengers! Low damage to the vehicles!" /></td>
<td><img src="image5" alt="Worst Case!" /></td>
<td><img src="image6" alt="Worst Case!" /></td>
</tr>
</tbody>
</table>

Low injury to the driver or passengers! Low damage to the vehicles!
Methodology of this study

N2 Safety Barrier

H4b Safety Barrier

900 kg car

1500 kg car

38 tons truck
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N2 Model

N2 Safety Barrier

900 kg car

1500 kg car

S235JR Steels

SafeSteel 1

235MPa

360MPa

510MPa

235MPa

360MPa

320MPa

360MPa

450MPa
N2 Crash Test

Steel used:
S235JR
Post-galvanized
(No Material Analysis)

1. Real Crash Tests: (From Lier test house)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Containment level</td>
<td>N2</td>
<td>H1</td>
</tr>
<tr>
<td>ASI</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Working width [mm]</td>
<td>W6 (1.8m)</td>
<td>W5 (1.5m)</td>
</tr>
</tbody>
</table>
N2 Model Validation

2. Analysis of the crash test

3. Validate AM numerical models

- Beam to beam connections
  - Have to resist!

- Beam to post connections:
  - Must break under a controlled load!

4. Use AM tools to simulate and analysis

5. Evaluate the performance of changing steel S235JR to SafeSteel 1.
N2 Simulation Results

Safe Steel 1

S235JR According to the Norm

Delta = 0.1m (10%)

Delta = 0.25m (25%)

Steel class

W [m]

ASI [g]

Working Width

ASI
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## H4b Model

![H4b Safety Barrier](image)

<table>
<thead>
<tr>
<th>Steel</th>
<th>Yield stress</th>
<th>Ultimate strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>235 MPa</td>
<td>360 MPa</td>
</tr>
<tr>
<td>SafeSteel 1_max</td>
<td>320 MPa</td>
<td>450 MPa</td>
</tr>
<tr>
<td>S235JR_max</td>
<td>360 MPa</td>
<td>510 MPa</td>
</tr>
</tbody>
</table>

- 900 kg car
- 38 tons truck
TB11 Simulations

Minimum

SafeSteel 1_max

S235JR_max
TB11 Simulations

Minimum

SafeSteel 1_max

S235JR_max
TB11 Simulations

Minimum

SafeSteel 1_max

S235JR_max
Minimum

SafeSteel 1\_max

S235JR\_max
TB11 Simulations

Minimum

SafeSteel 1_max

S235JR_max
TB11 Simulations

Minimum

SafeSteel 1_max

S235JR_max
TB11 Simulations

Minimum

SafeSteel 1_max

S235JR_max
## Results

<table>
<thead>
<tr>
<th>Steel</th>
<th>Minimum</th>
<th>SafeSteel 1_max</th>
<th>S235JR_max</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASI (TB11)</td>
<td>1.66</td>
<td>1.86</td>
<td>2.12</td>
</tr>
</tbody>
</table>

Minimum & SafeSteel 1_max & S235JR_max
TB81 Simulations

Minimum

SafeSteel 1_max

S235JR_max
TB81 Simulations

Minimum

SafeSteel 1_max

S235JR_max
TB81 Simulations

Minimum

SafeSteel 1_max

S235JR_max
TB81 Simulations

Minimum

SafeSteel 1_max

S235JR_max
TB81 Simulations

Minimum

SafeSteel 1_max

S235JR_max
TB81 Simulations

Minimum

SafeSteel 1_max  

S235JR_max
TB81 Simulations

Minimum

SafeSteel 1_max

S235JR_max
## TB81 Results

<table>
<thead>
<tr>
<th>Steel</th>
<th>Minimum</th>
<th>SafeSteel 1_max</th>
<th>S235JR_max</th>
</tr>
</thead>
<tbody>
<tr>
<td>VI [m]</td>
<td>2.95</td>
<td>2.17</td>
<td>2.06</td>
</tr>
<tr>
<td>WW [m]</td>
<td>1.79</td>
<td>1.60</td>
<td>1.50</td>
</tr>
<tr>
<td>DD [m]</td>
<td>1.12</td>
<td>1.01</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Minimum | SafeSteel 1_max | S235JR_max
H4b Simulation Results

<table>
<thead>
<tr>
<th>ASI</th>
<th>S235JR</th>
<th>SAFE STEEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td></td>
<td></td>
</tr>
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Failed
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Conclusion

• Compared to other materials (wood, …), the variation of the steel mechanical characteristics is quite low

• The performance of the barriers can be more controlled if a controlled steel as SAFESTEEL is used

• Using High Strength SafeSteels will not only help to increase the control on the barrier`s performances but also to improve their competitiveness
Thank you for your attention!

Emails:

yihui.wu@arcelormittal.com
joseph.marra@arcelormittal.com