High Strength Steel in Long Span and High Rise structures

Recent European Research

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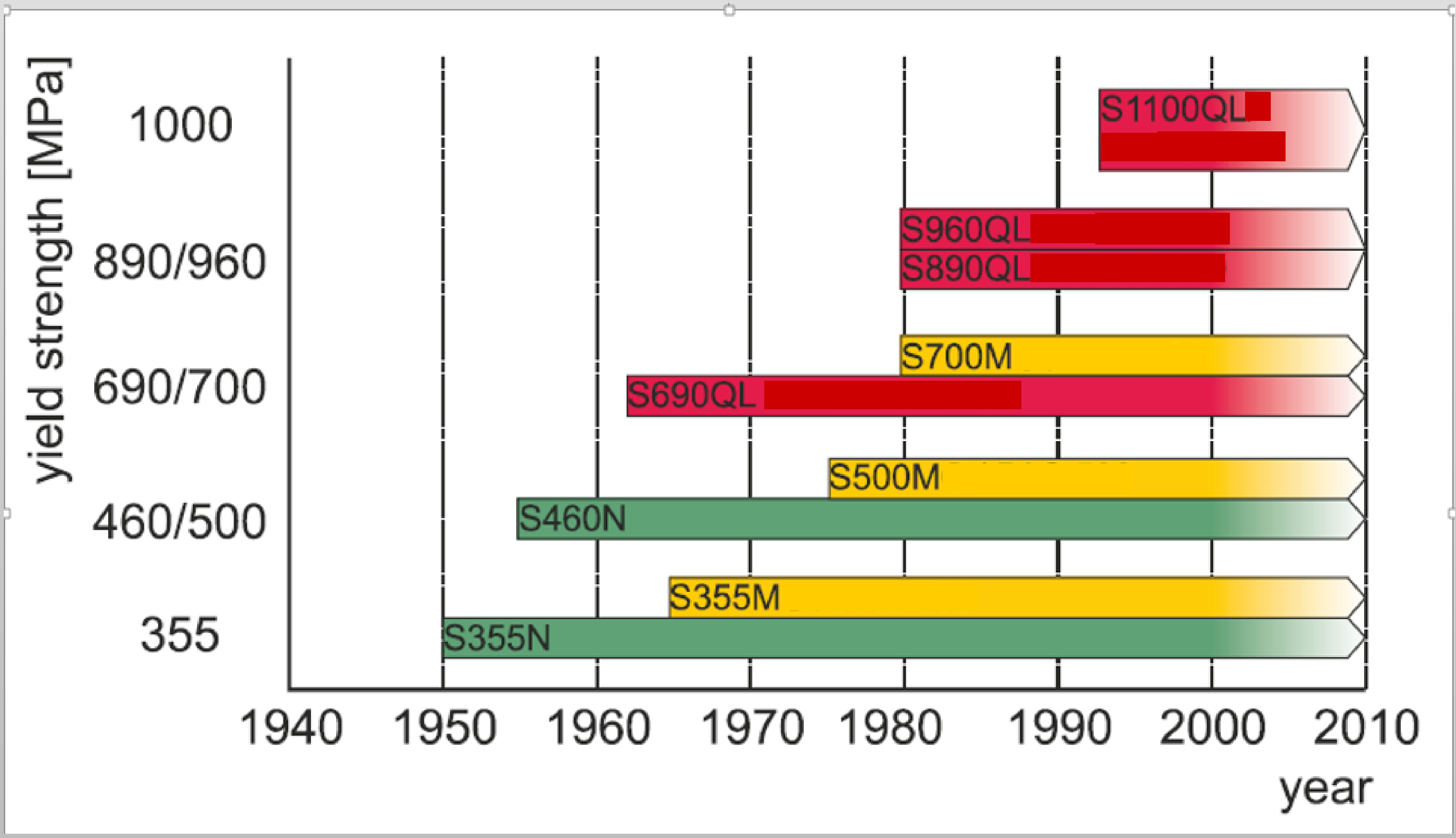
24 September 2015

Developments in HSS



Wegmann, H., & Gerster, P. (2003). *Schweißtechnische Verarbeitung und Anwendung hochfester Baustähle im Nutzfahrzeugbau*

The case for higher strength steel……

- Material (& carbon) savings
- Weight reduction → lighter supporting structure
- Reduced welding effort
- Easier transportation & handling
- More clearance, design freedom & less congestion

Typical uses of HSS in construction

EN 1993 Design Rules

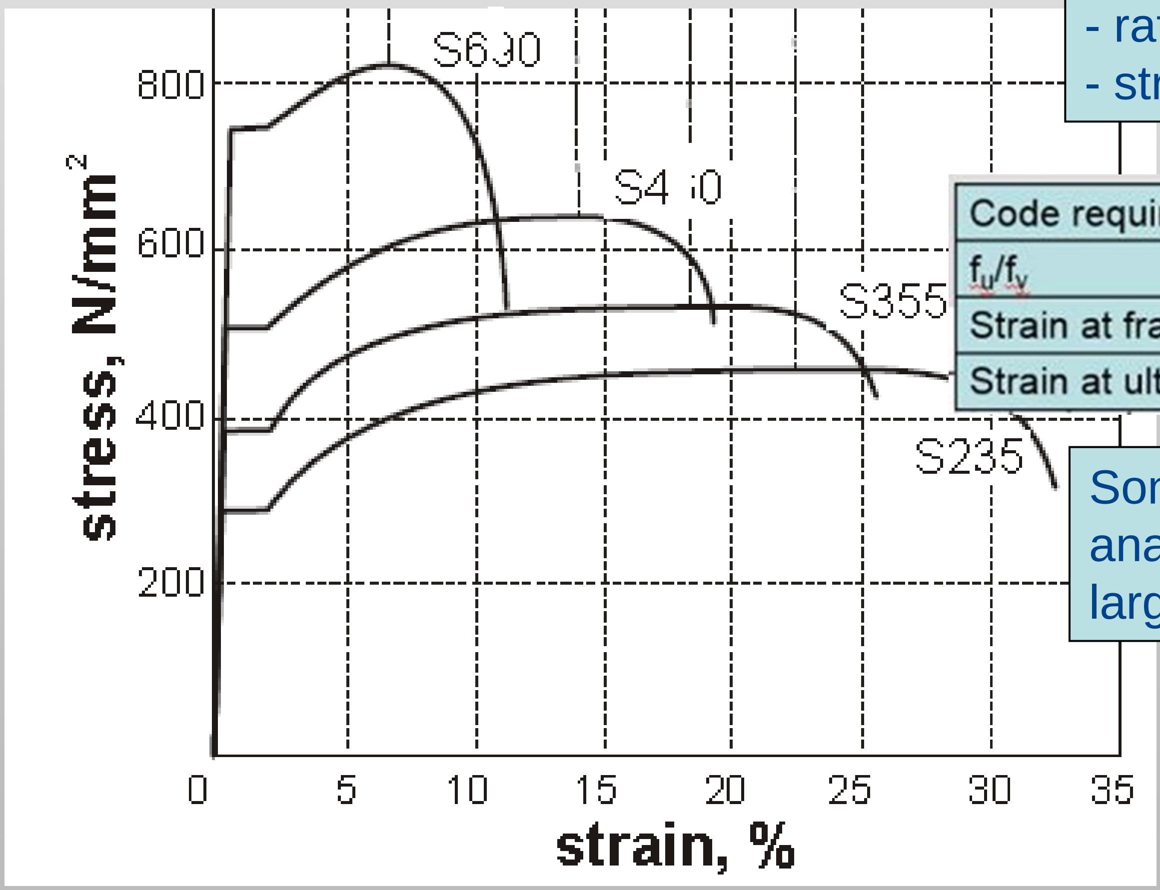
Now:

- EN 1993-1-1 S235 to S460
- EN 1993-1-12 S500 to S700

Looking ahead…

- EN 1993-1-1 S235 to S700
- EN 1993-1-12 S700 to S960

EN 1993 Design Rules



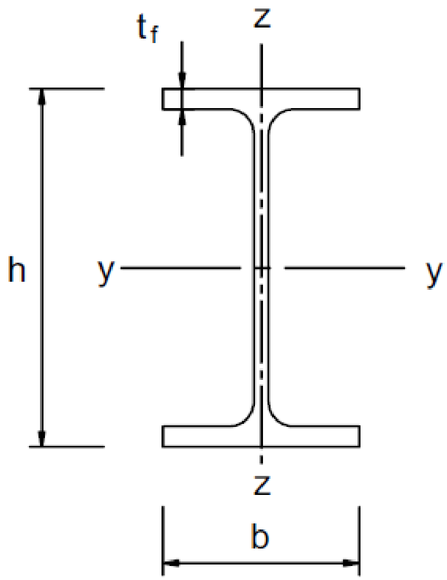
As strength increases:
- ratio of ultimate to yield reduces
- strain capacity reduces

Code requirements	EN 1993-1-1	EN 1993-1-12
f_u/f_y	1.10	1.05
Strain at fracture ε_f	15%	10%
Strain at ult. stress ε_u	$15\varepsilon_y$	$15\varepsilon_y$

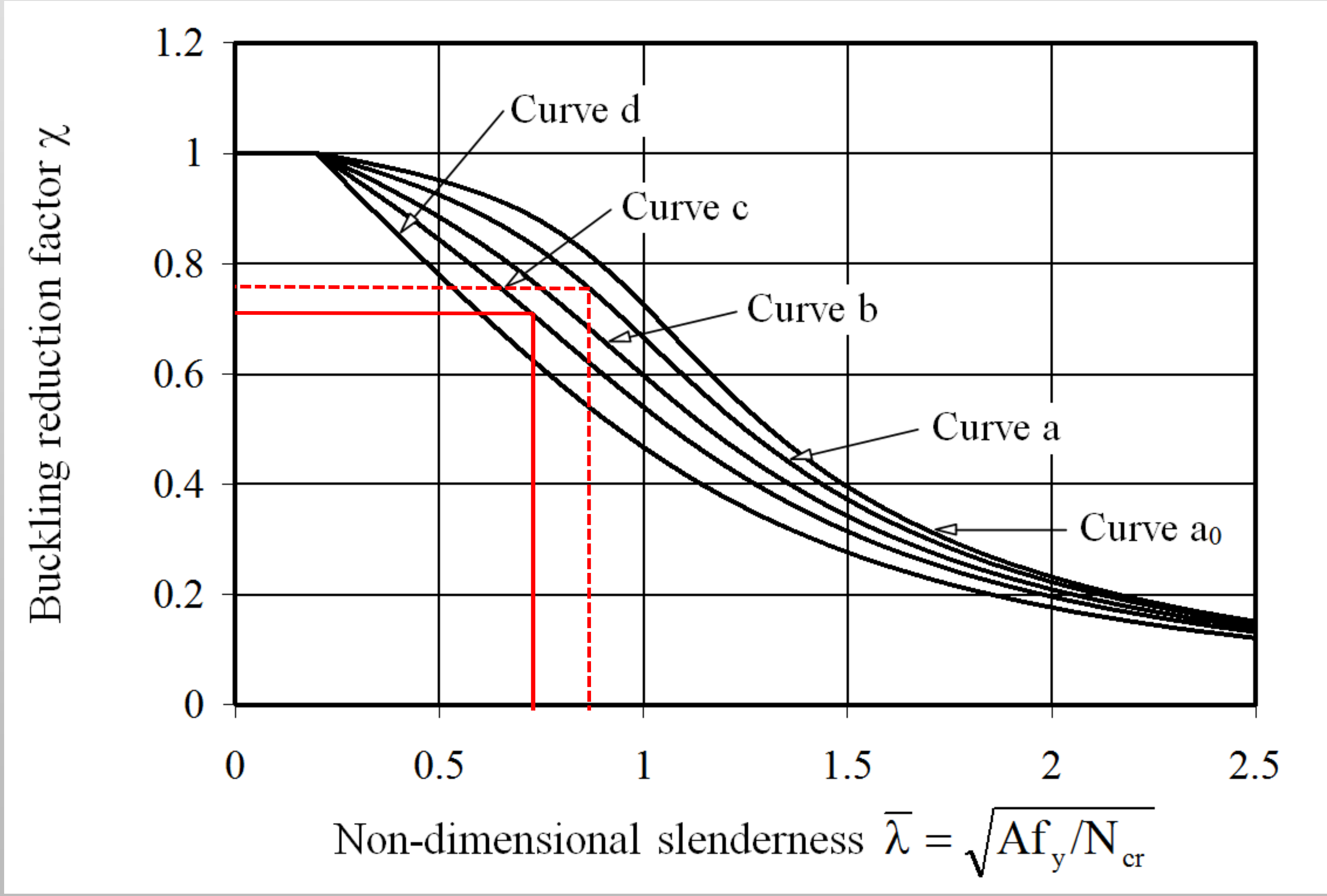
Some restrictions on use of plastic analysis and connections that utilise large plastic deformations

EN 1993 Design Rules
Flexural buckling

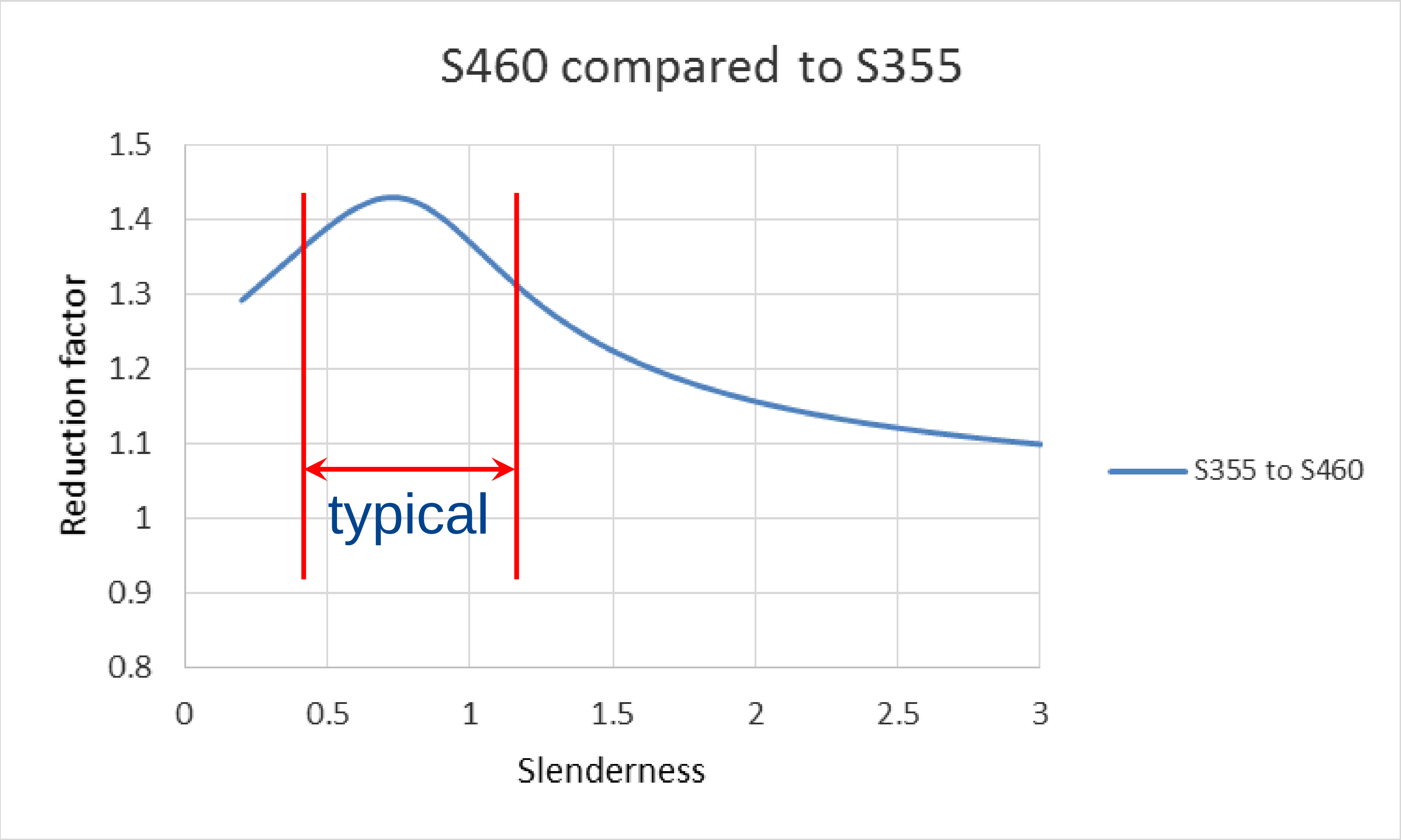
Table 6.2: Selection of buckling curve for a cross-section

Cross section		Limits		Buckling about axis	Buckling curve S 235 S 275 S 355 S 420	Buckling curve S 460
Rolled sections	 	$h/b > 1{,}2$	$t_f \leq 40$ mm	y – y z – z	a b	a_0 a_0
			40 mm < $t_f \leq 100$	y – y z – z	b c	a a
		$h/b \leq 1{,}2$	$t_f \leq 100$ mm	y – y z – z	b c	a a
			$t_f > 100$ mm	y – y z – z	d d	c c

EN 1993 Design Rules
Flexural Buckling



EN 1993 Design Rules
Flexural Buckling



EN 1993 Design Rules

Flexural Buckling

- Pure compression
- 6 m, 5000 kN

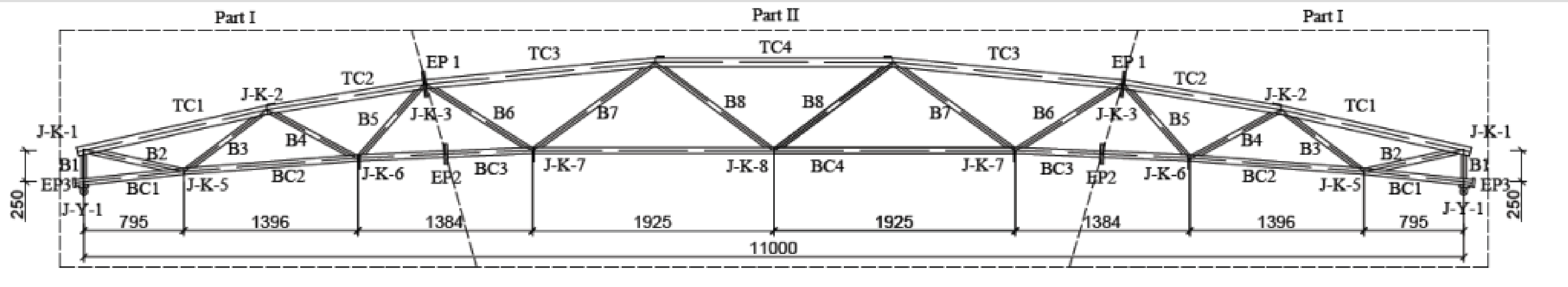
- S460
- 356 UC 129; 0.97
- 305 UC 158; 0.95

- S355
- 356 UC 177; 0.98
- 305 UC 240; 0.83

Technical Challenges

- Instability (buckling)
- Greater deflections
- More critical fatigue conditions

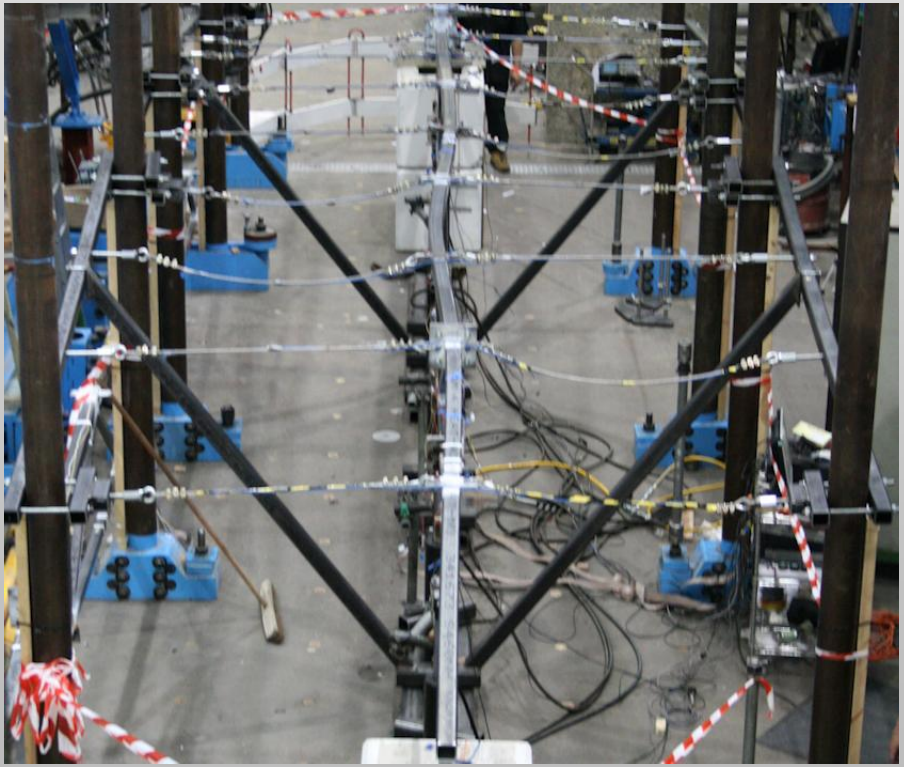
Reducing Deflections



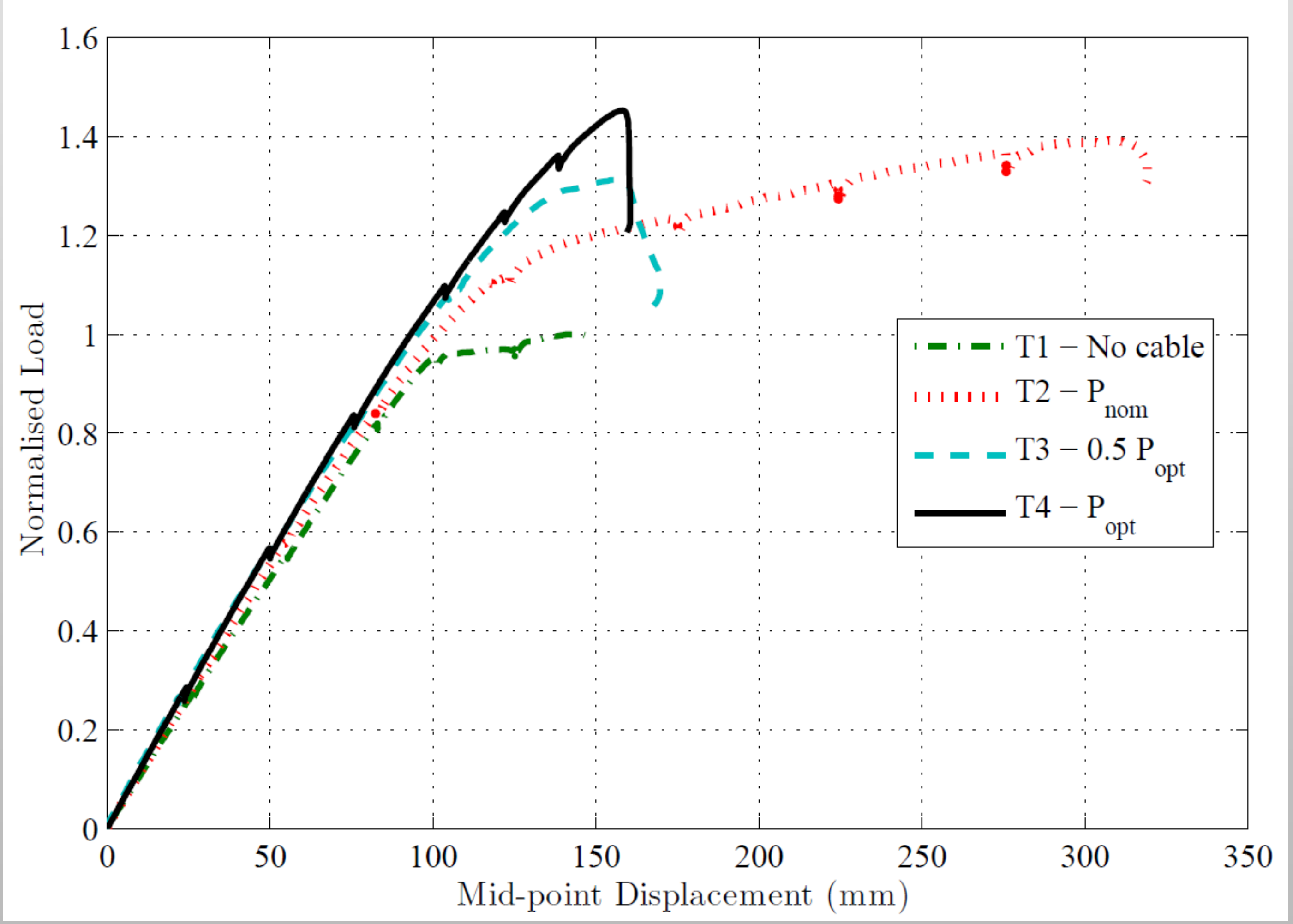
4 trusses (S460) tested:

- Truss 1: No cable
- Truss 2: Cable with nominal pre-stress level (5 kN)
- Truss 3: Cable with pre-stress = ½ Popt
- Truss 4: Cable with pre-stress = Popt

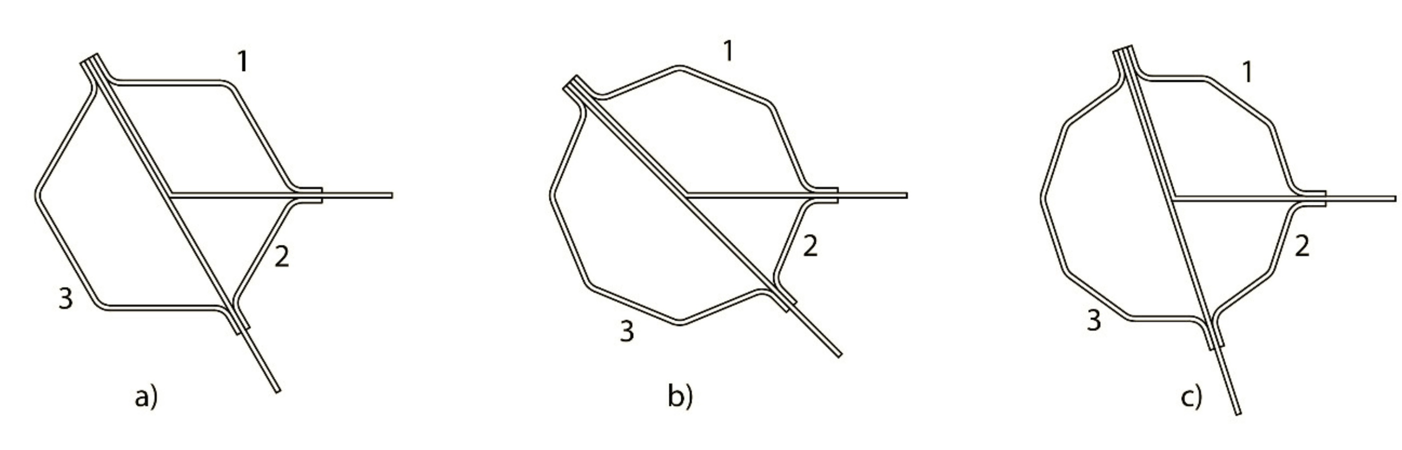
Reducing Deflections

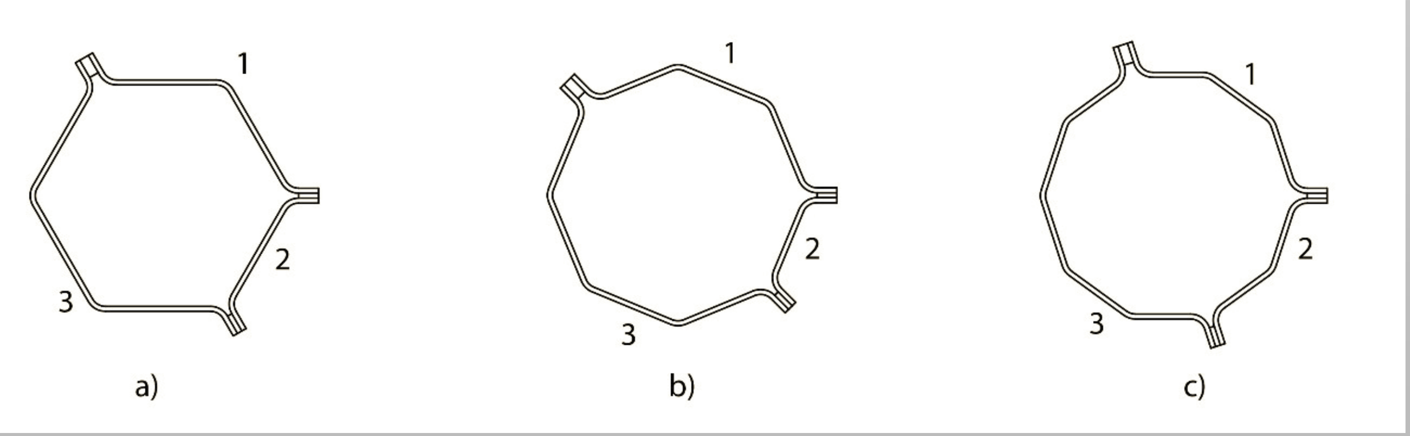


Reducing Deflections

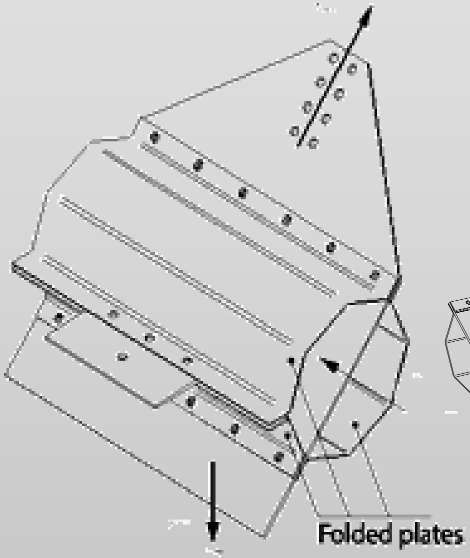


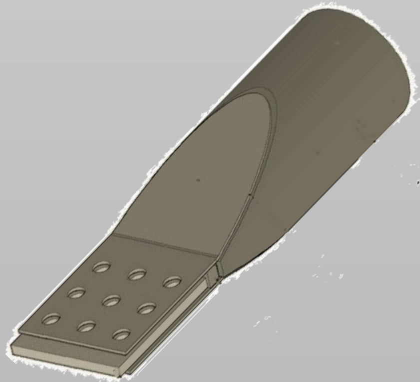
Improving Buckling Resistance

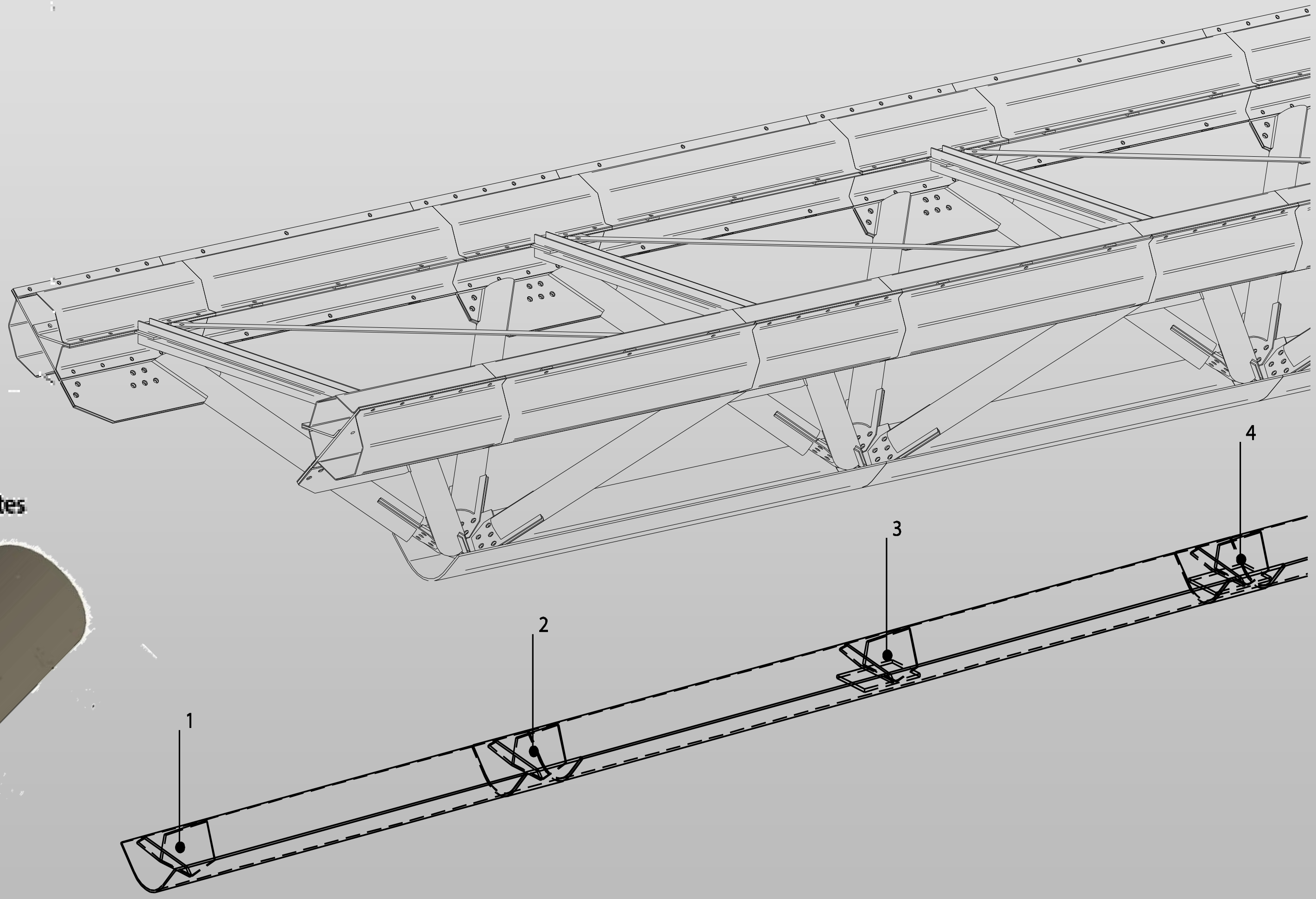




Improving Buckling Resistance







Necessity - the mother of all inventions …

“Fast Bridge 48” developed by KTH in 1990-ies for the Swedish army. Truss girders in 5 mm thick S1100. Span 48 m, designed for 65 t tank, deflection 0,65 m.

S1100 has the same weight/strength ratio as advanced Al-alloys

Summary

- HSS are not new and their use is increasing!
- Properties continue to improve
- Specification, design and execution of HSS are covered by European Standards
- Novel forms of construction can maximise the benefits of higher strength