Latest Developments in the Production and Use of High Strength Structural Steels

ArcelorMittal Commercial Sections S.A.

May 28th, 2008

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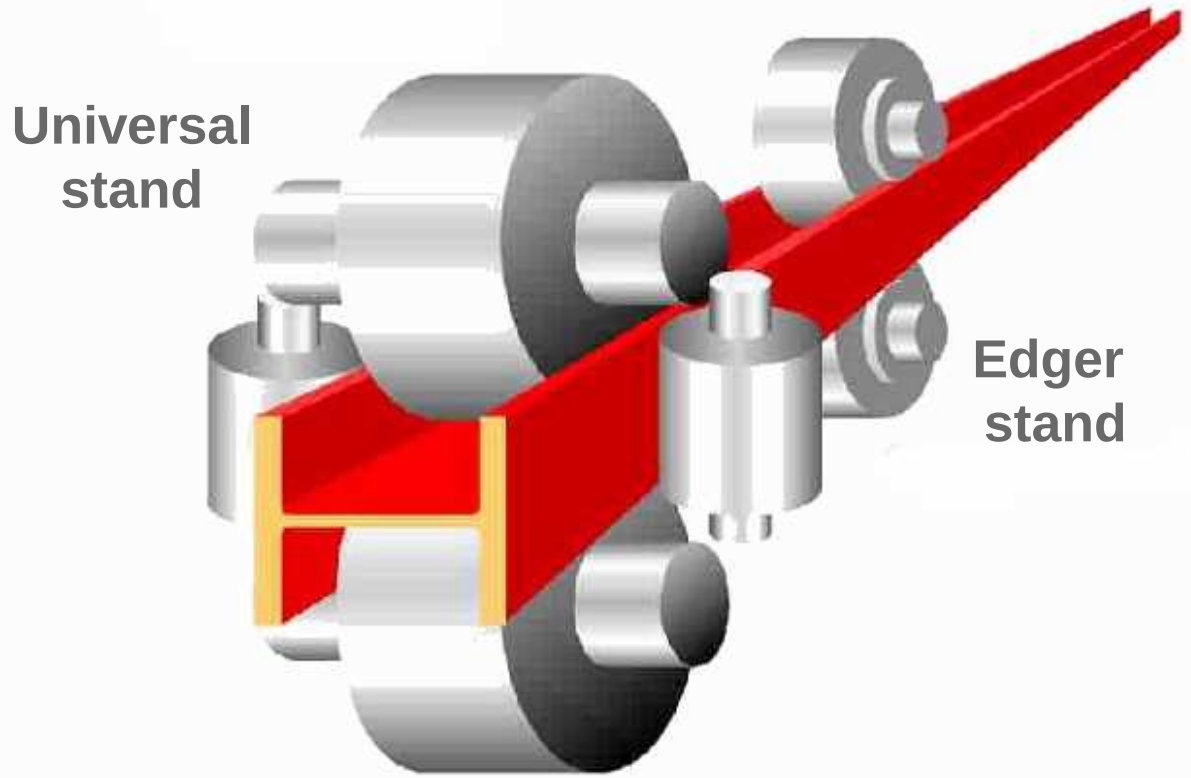
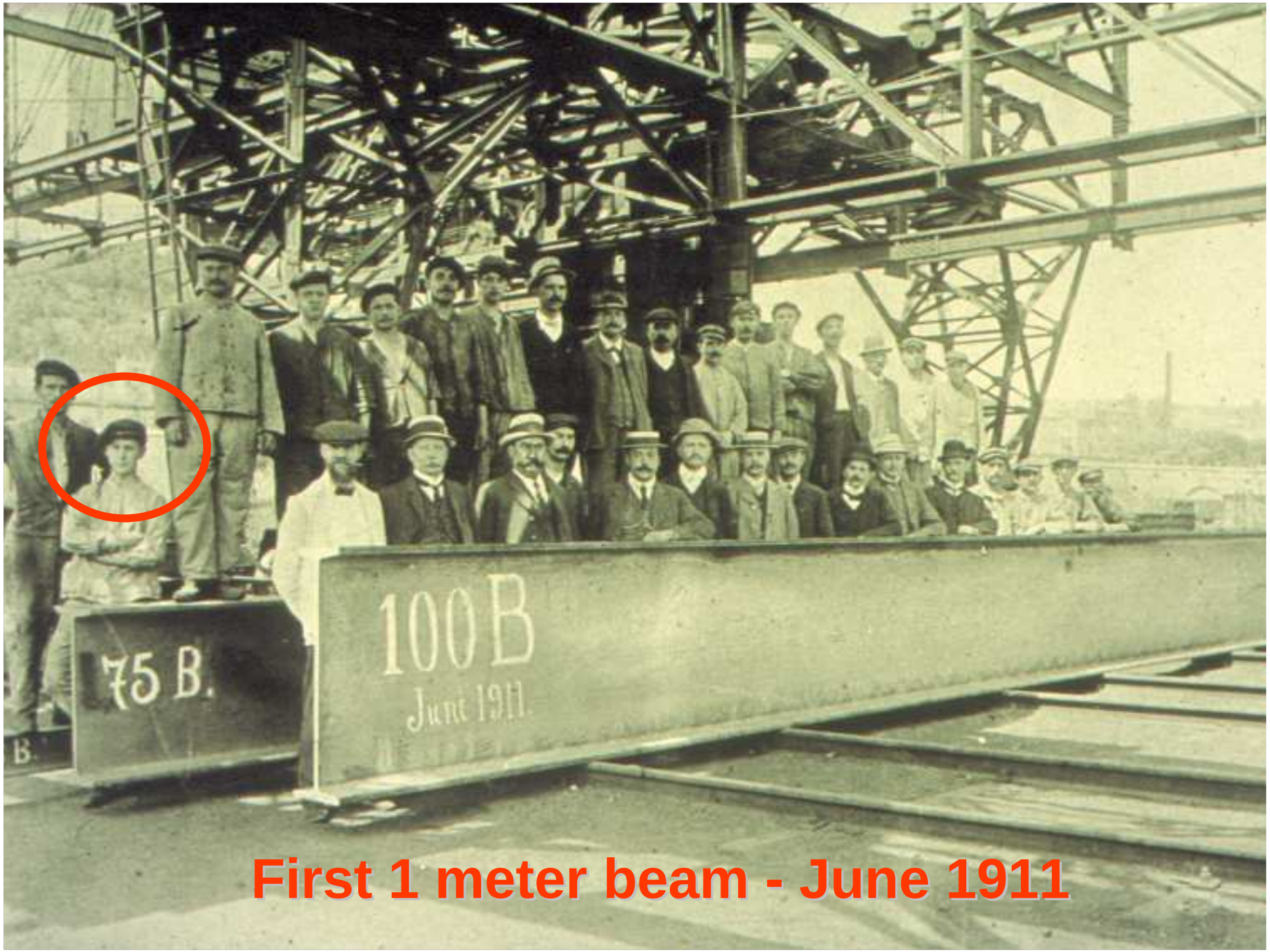
Summary

1. **Production of rolled sections**
2. **Tailor - Made Beams**
3. **HISTAR**
4. **Applications**

Universal rolling principle

Grey patent in 1902



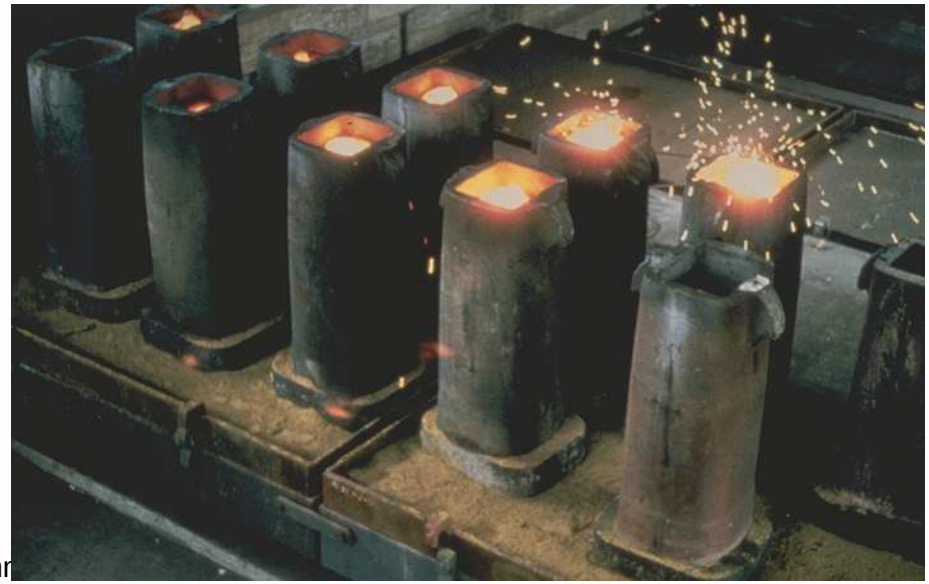


First 1 meter beam - June 1911

Ingot route

Before 1950, structural steel grades were characterised by

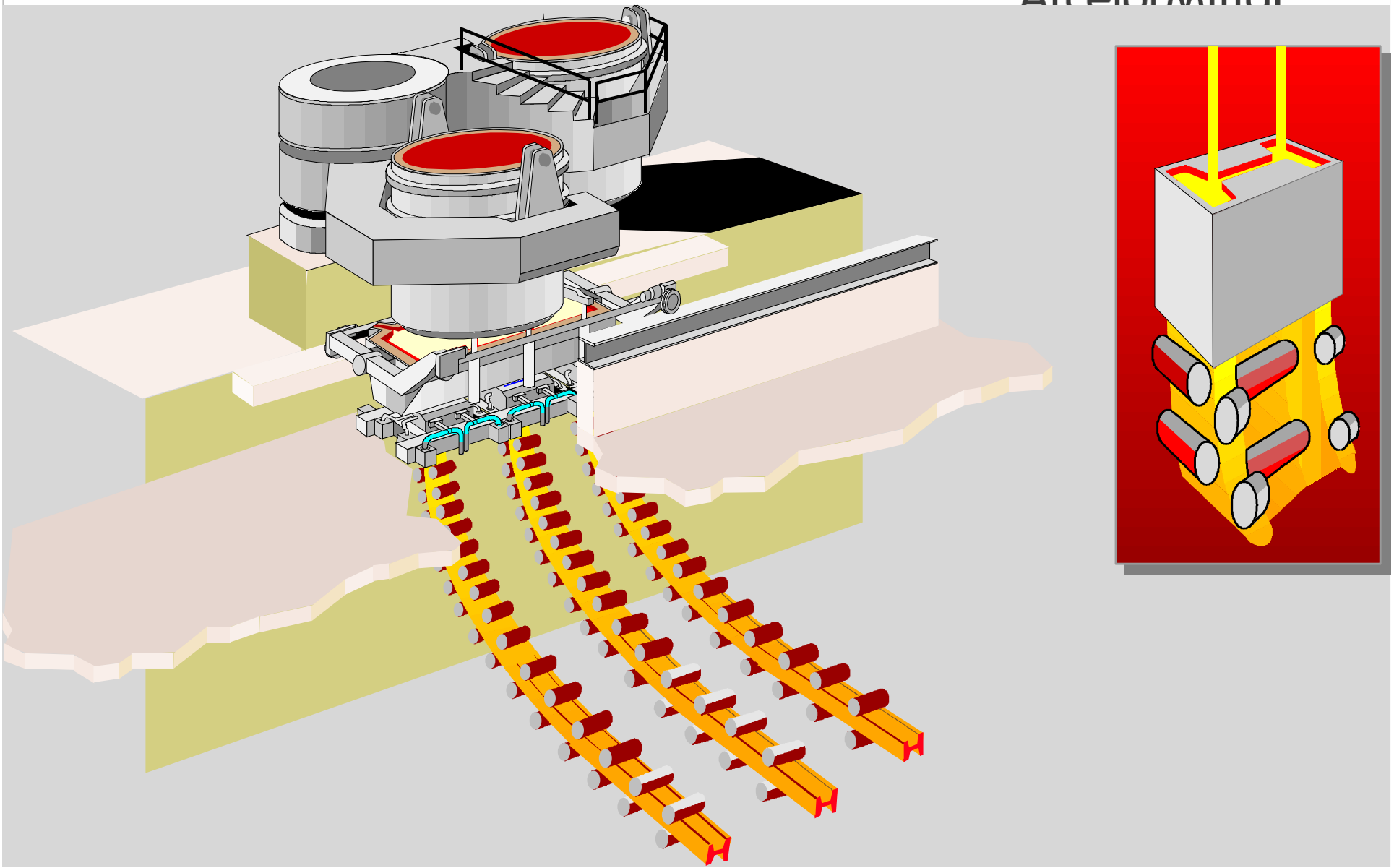
- **low mechanical characteristics (Re=210-320 MPa)**
- **low toughness and ductility**
- **poor weldability due to high CE values and nitrogen content**

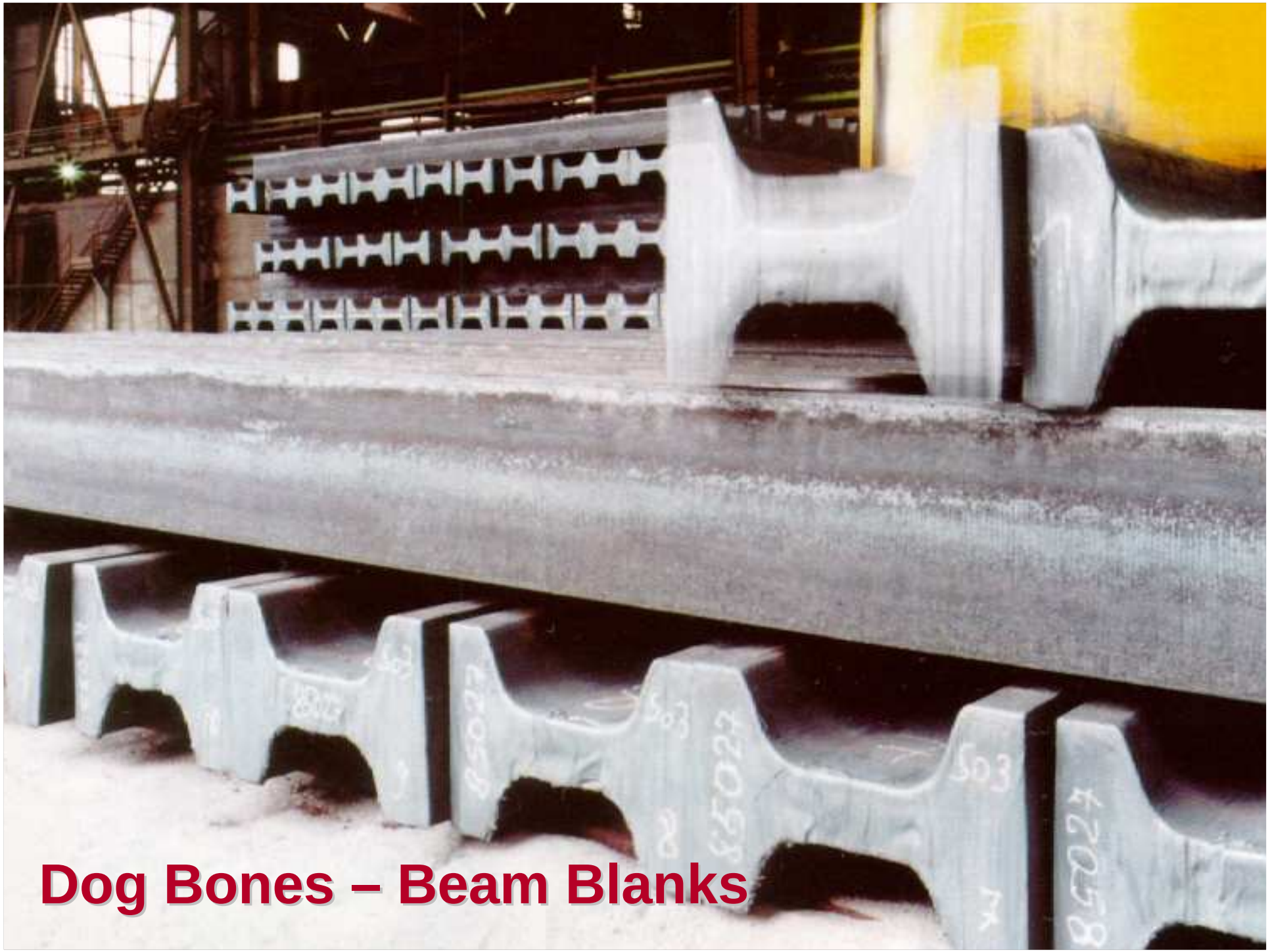



Today : no blast furnace anymore

Electric Arc Furnaces

and beam blanks casters





Dog Bones – Beam Blanks

Sustainability

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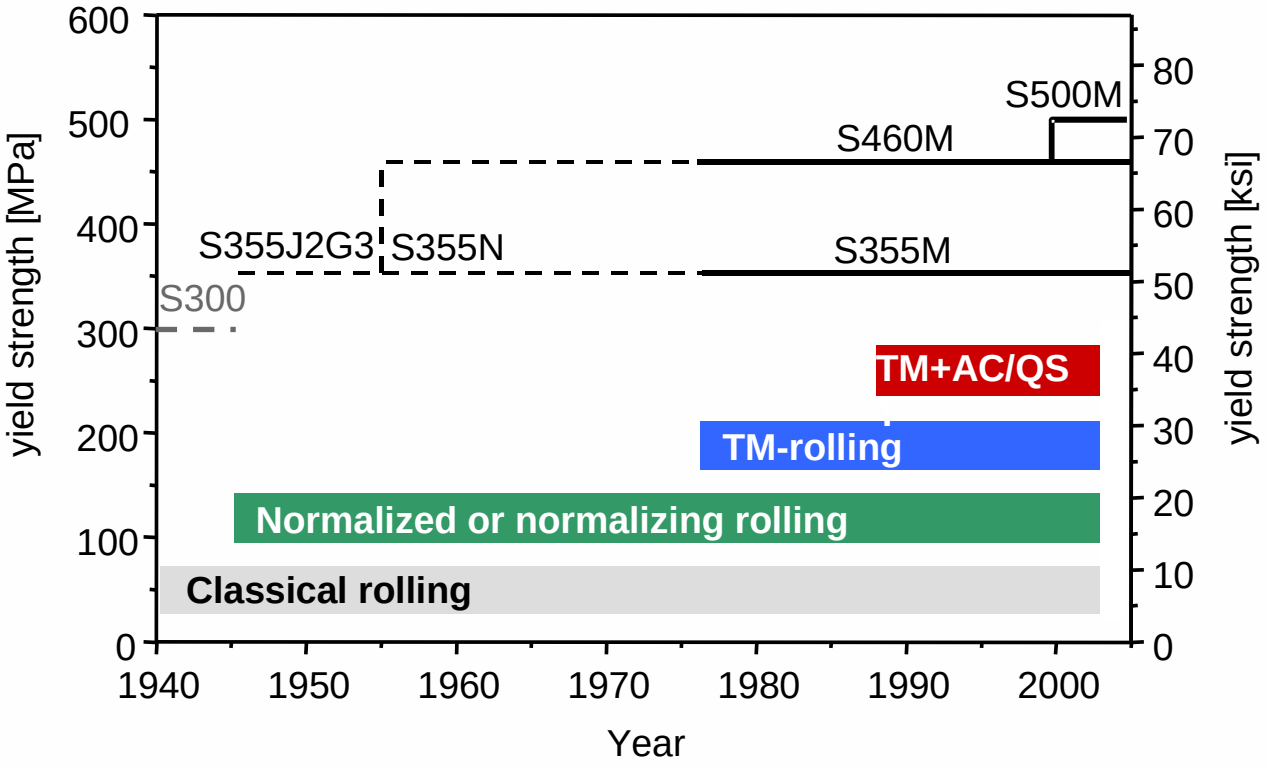
Advantages of the EAF route versus the conventional integrated production route (Luxembourg 1993/1998)

- **Noise:** Limitation of acoustic emissions to 45 dB
- **Particles:** reduction of 97%
- **Waste:** reduction of 95%
- **Water:** reduction of 50%
- **Energy:** reduction of 55%

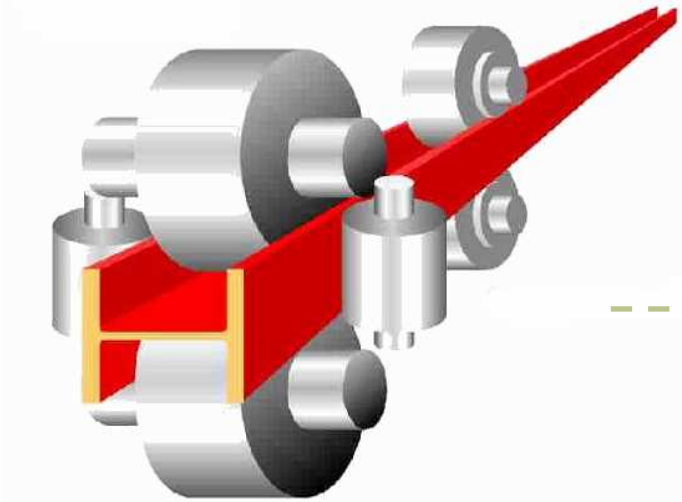
Historical Development

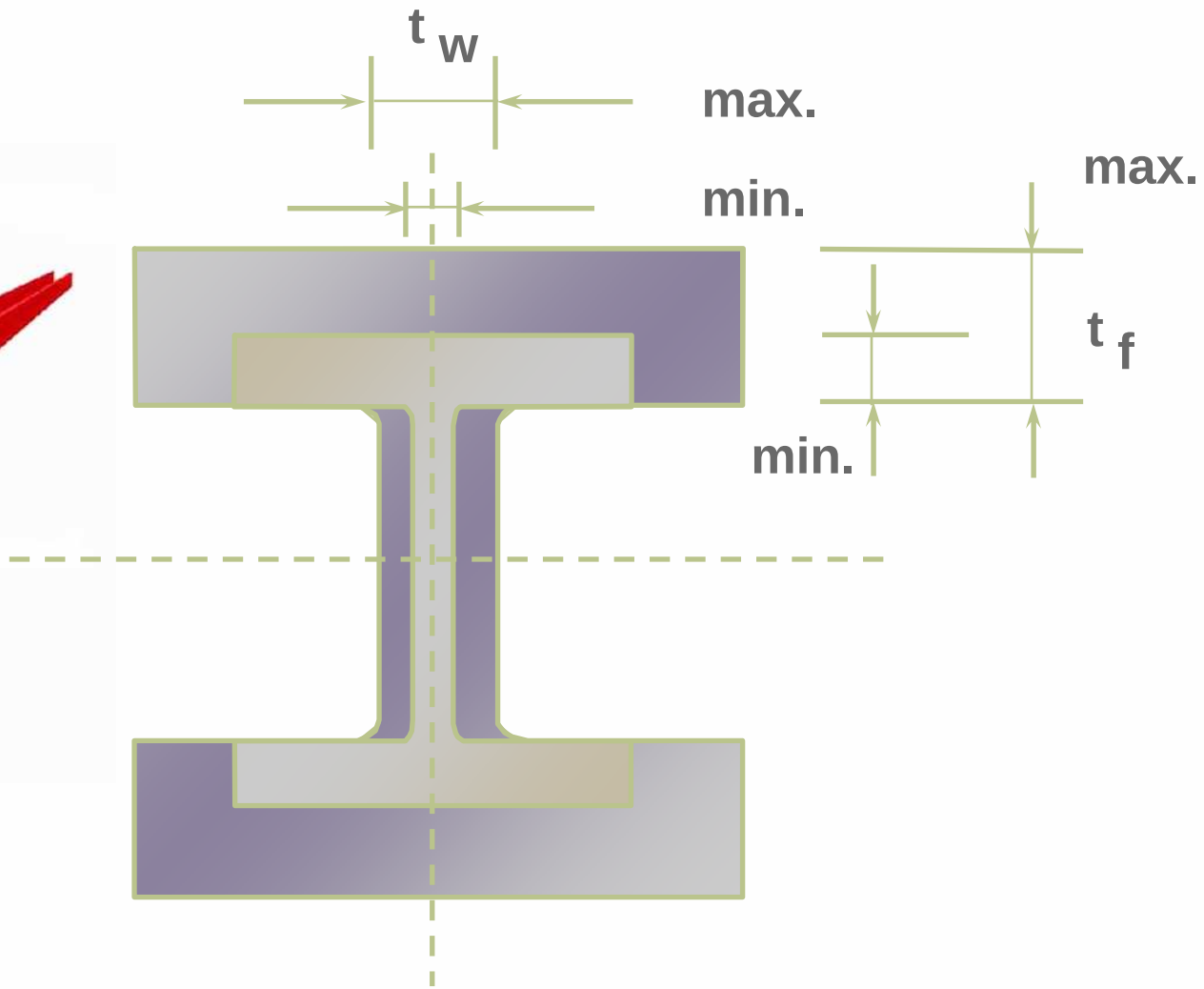


Production processes for hot-rolled steel products

1. Production of rolled sections
2. **Tailor - Made Beams**
3. HISTAR
4. Applications

Tailor Made Beams - 1979





heaviest JUMBO

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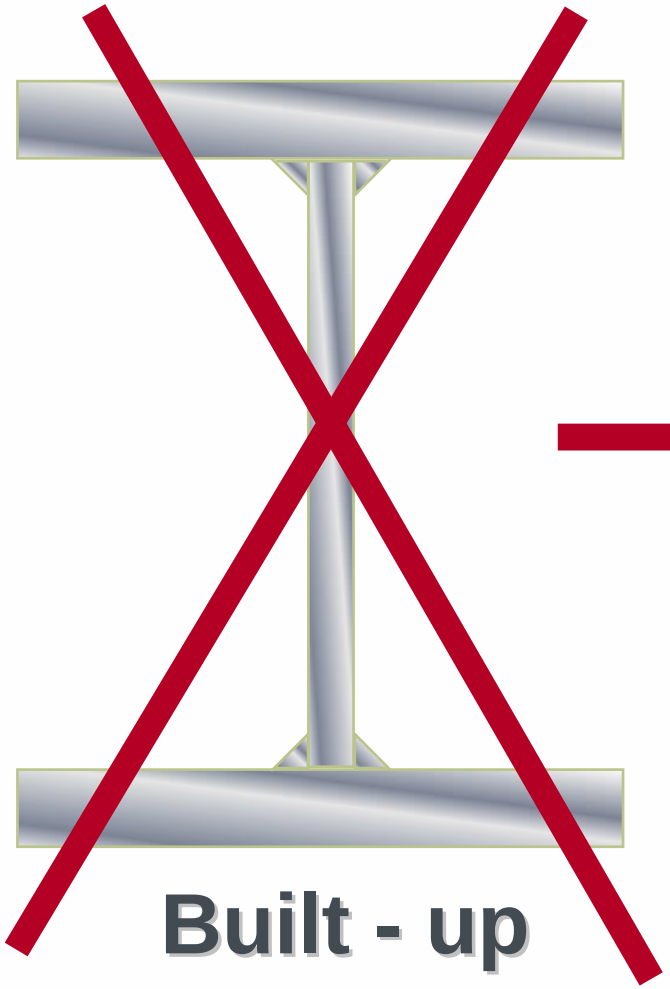
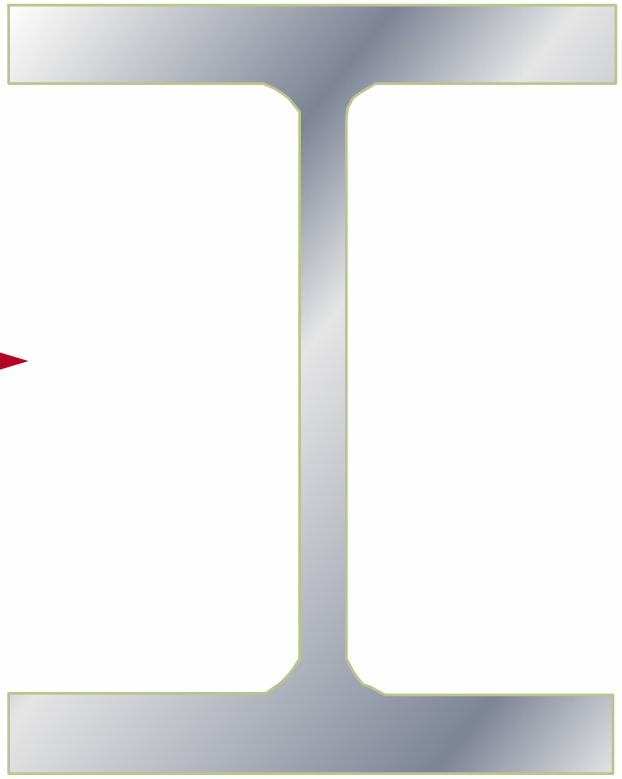
1100 mm (44”) for bridges

Tailor Made beams



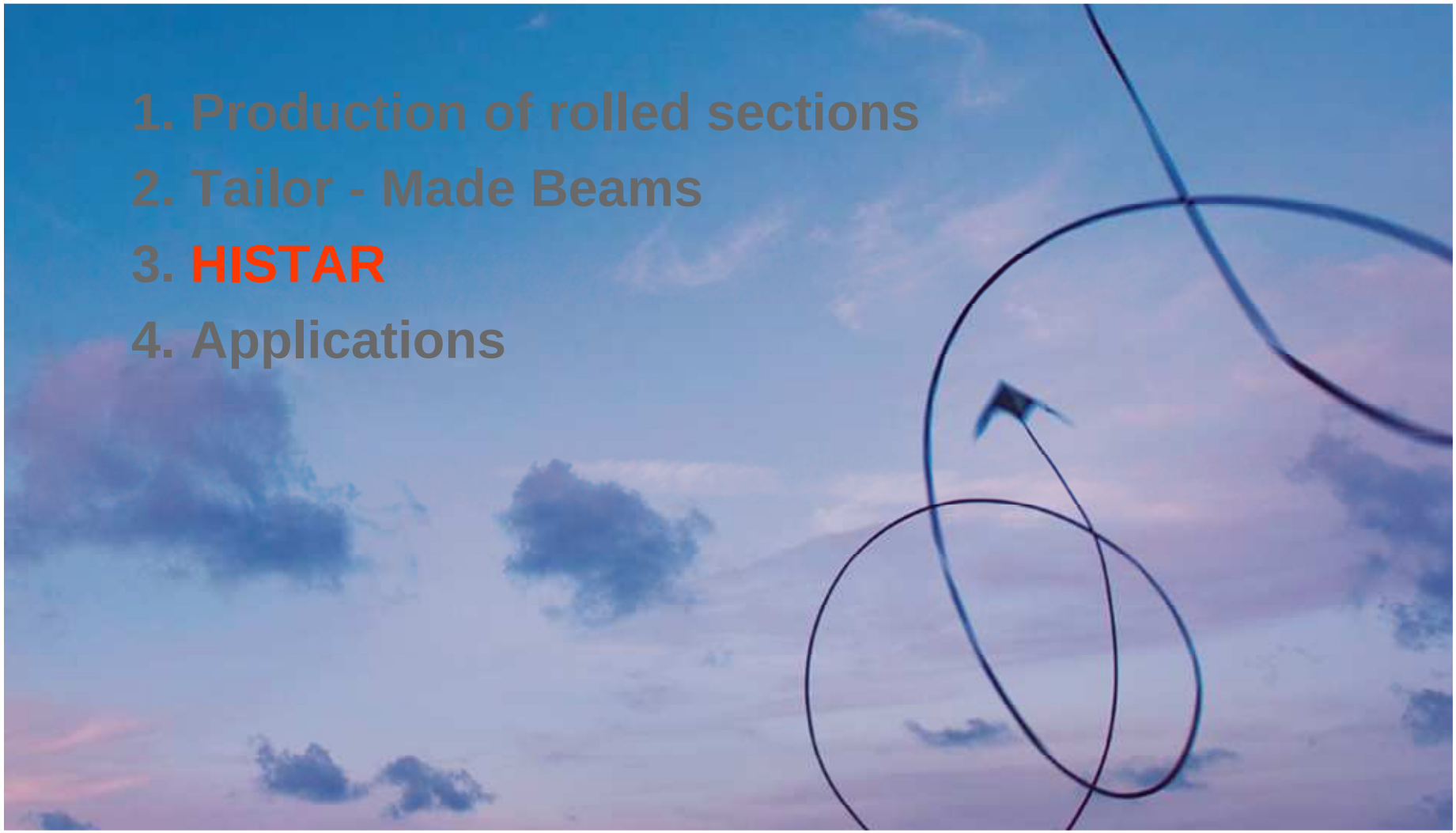
Built - up



Rolled Section

Tailor Made beams

- **> 900 high-rise buildings in the U.S.**
- **> 1500 high-rise buildings worldwide**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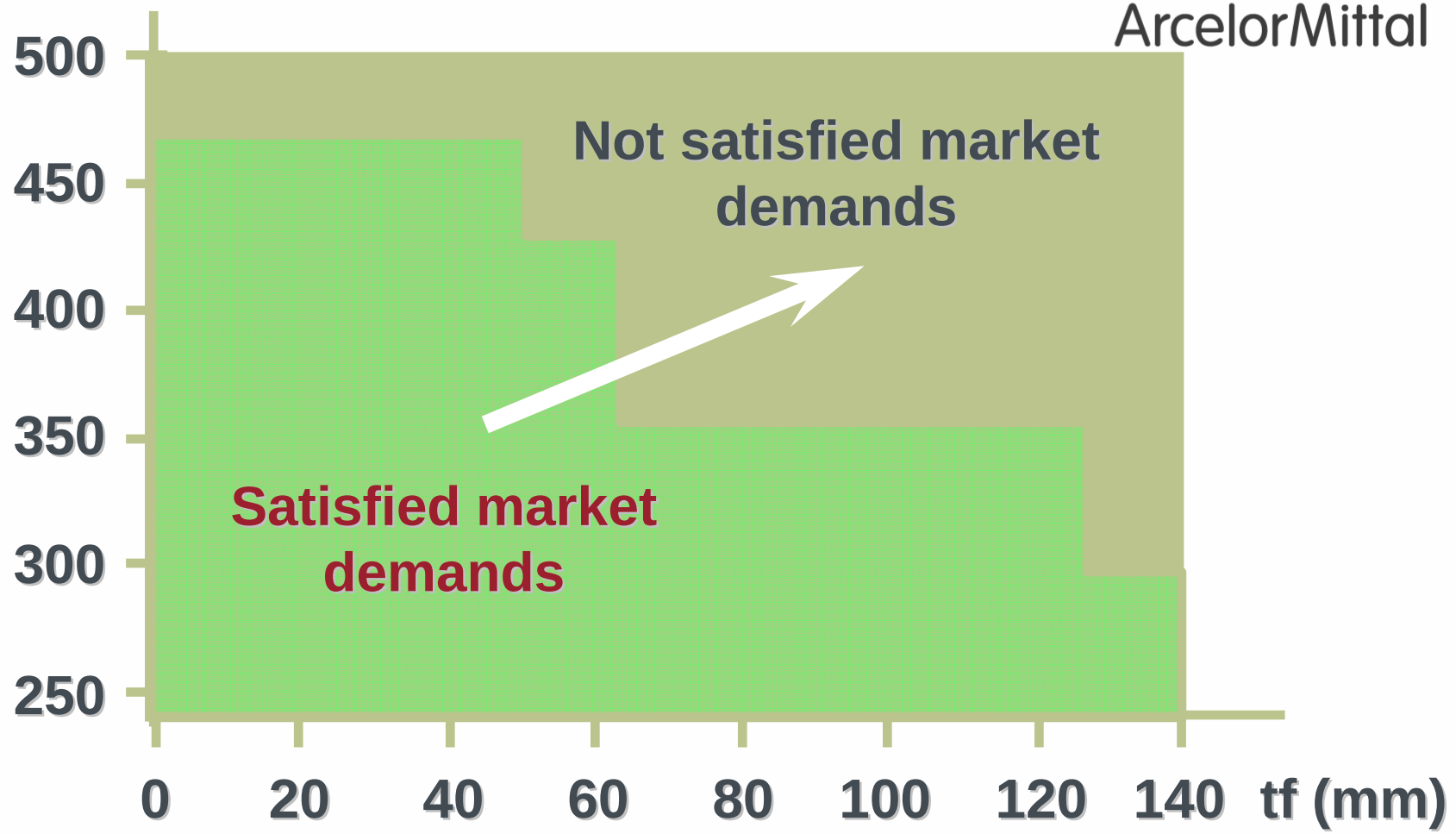
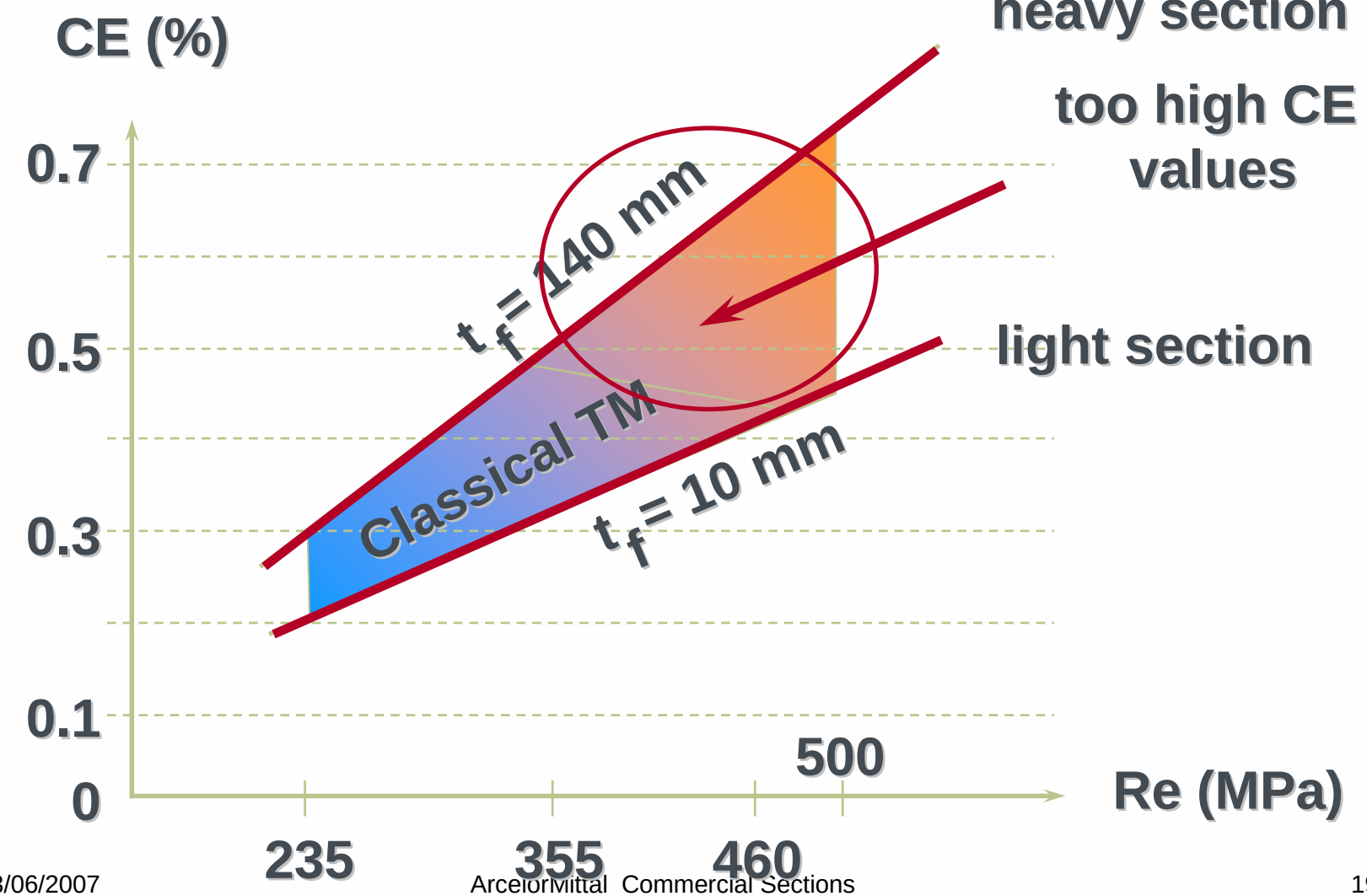
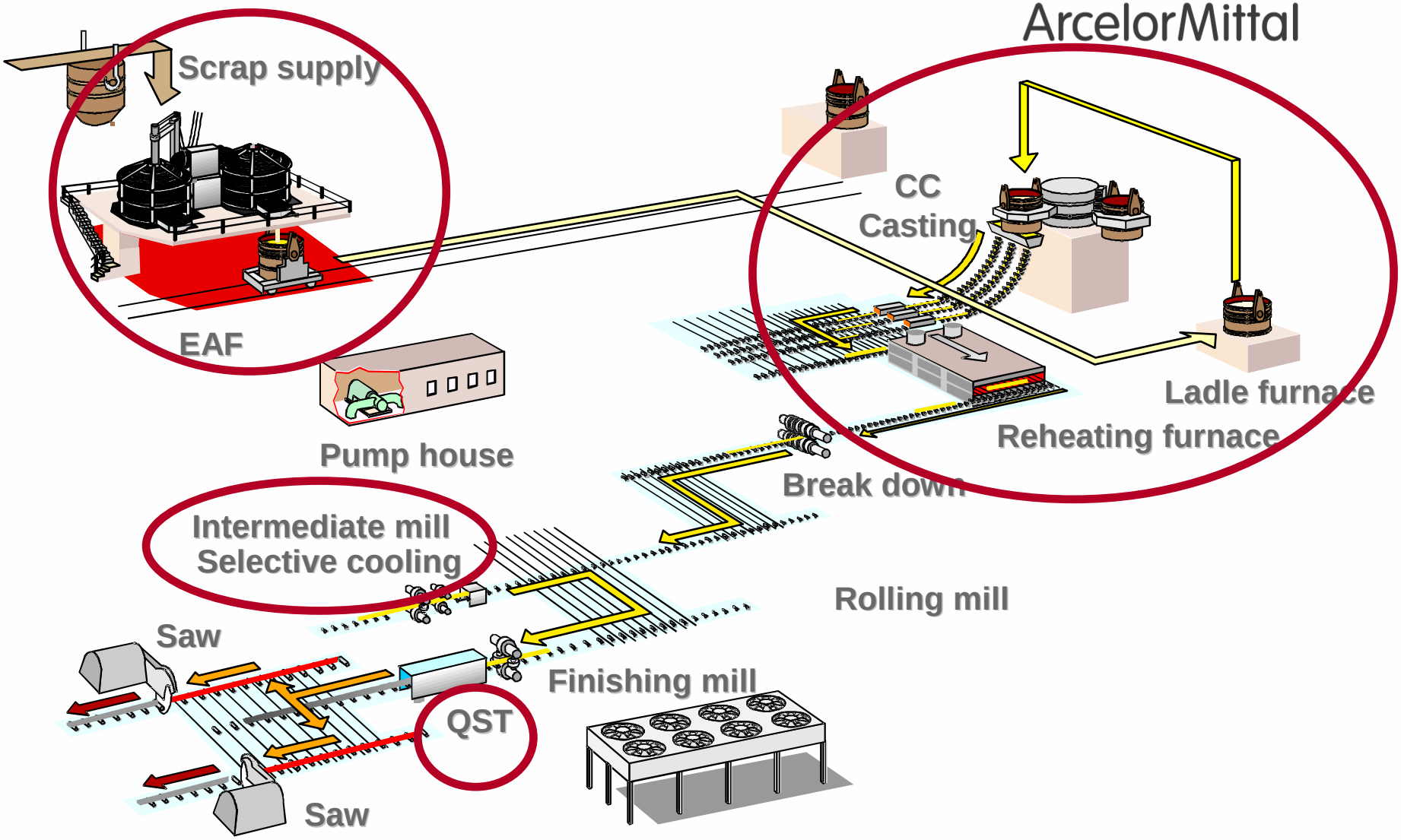
Market in 1980



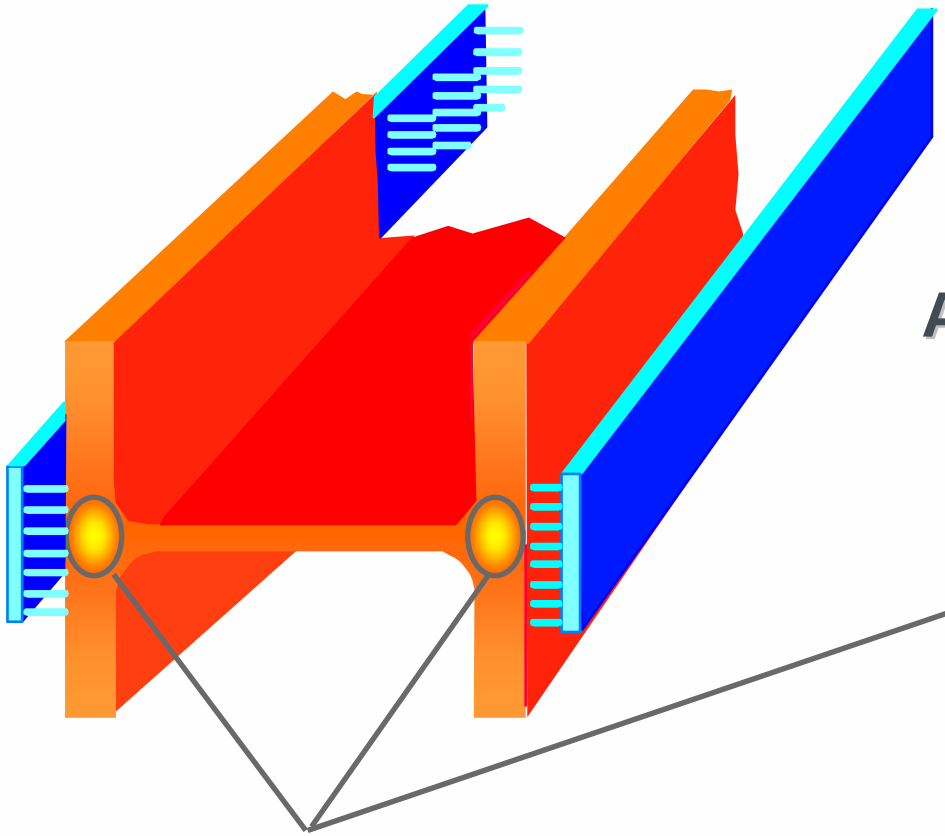
CE Values

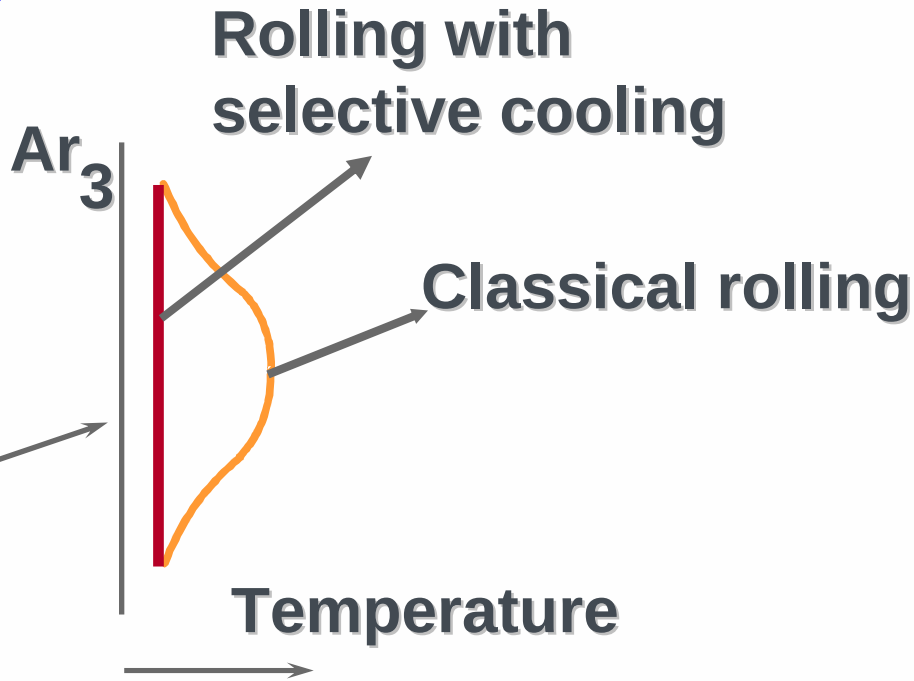

CE (%)
0.7
0.5
0.3
0.1
0
235
355
460
500
Re (MPa)
heavy section
too high CE values
light section
t_f = 140 mm
t_f = 10 mm
Classical TM

Layout of the GREY mill



Selective Cooling

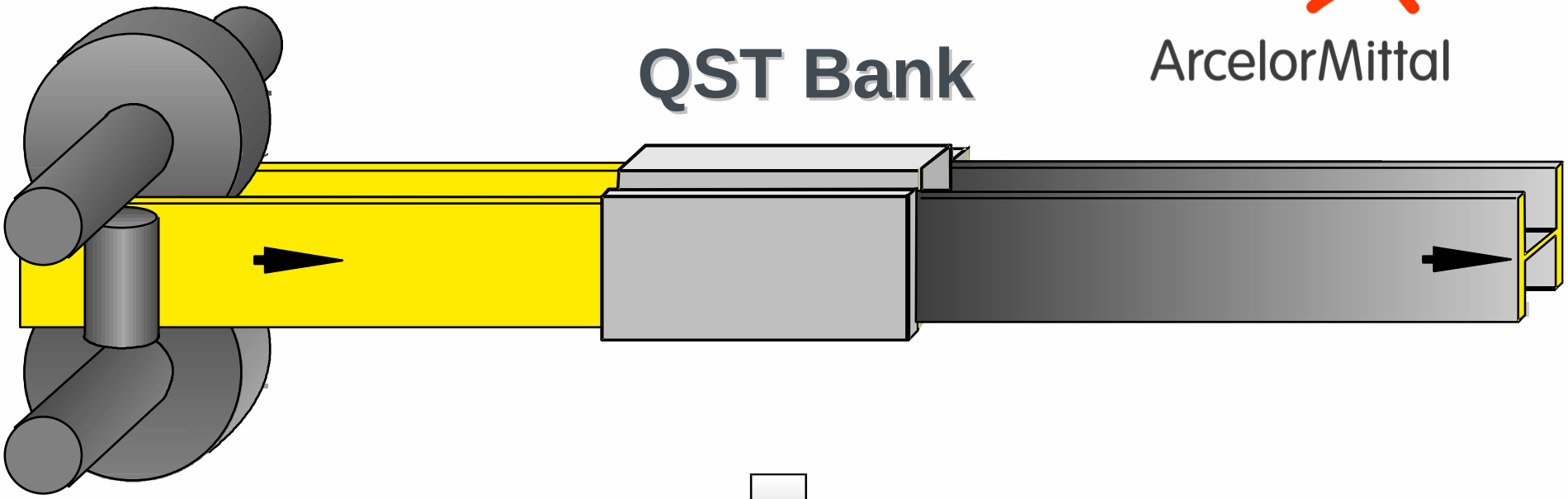




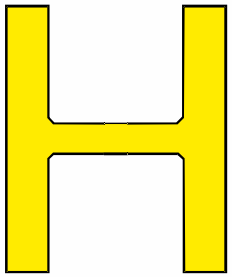

Selective Cooling

QST Process

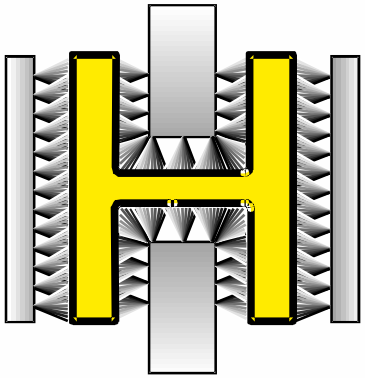
QST Bank



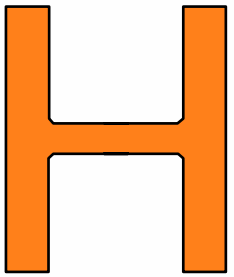
Finishing stand



QST Bank entry 850 °C

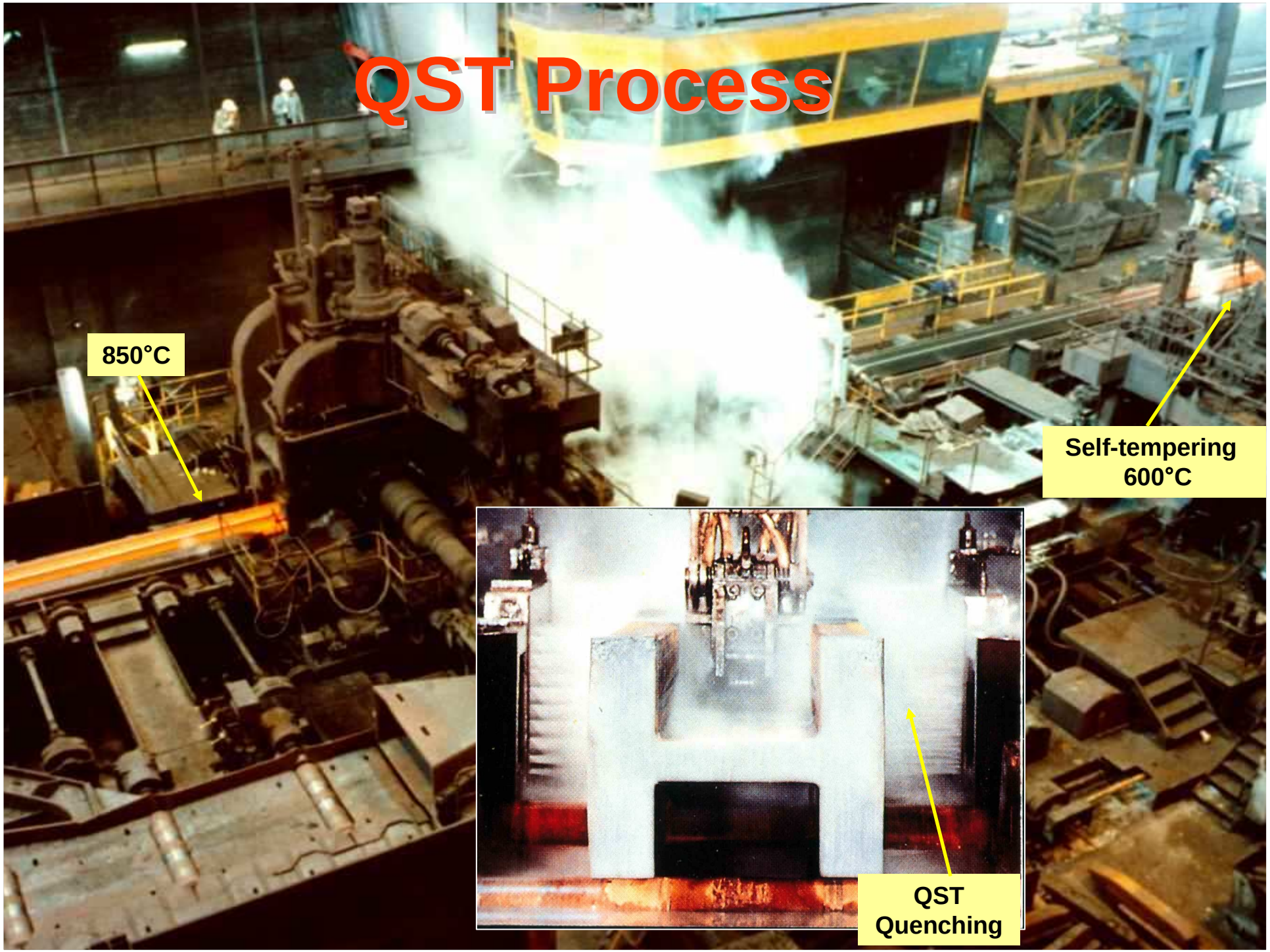


Quenching



Self Tempering 600 °C

QST Process



Rolled Sections - Grades

- 235 MPa = S235 JR, St 37-2, Fe 360, A36 (245 MPa), Q235
- 275 MPa = S275 JR, 43B, 43C
- 355 MPa = S355 JR, 50B, 50C, 50D, A572/50, A992/50, Q345
- **HISTAR** 355, A913 / 50 (345 MPa)
- **HISTAR** 460, A913 / 65 (450 MPa)
- **HISTAR** 355 TZK, OS (for offshore – low temp.)
- **HISTAR** 460 TZK, OS (for offshore – low temp.)

Properties of HISTAR Steels

Production of hot-rolled H-beams

Comparison of rolling processes

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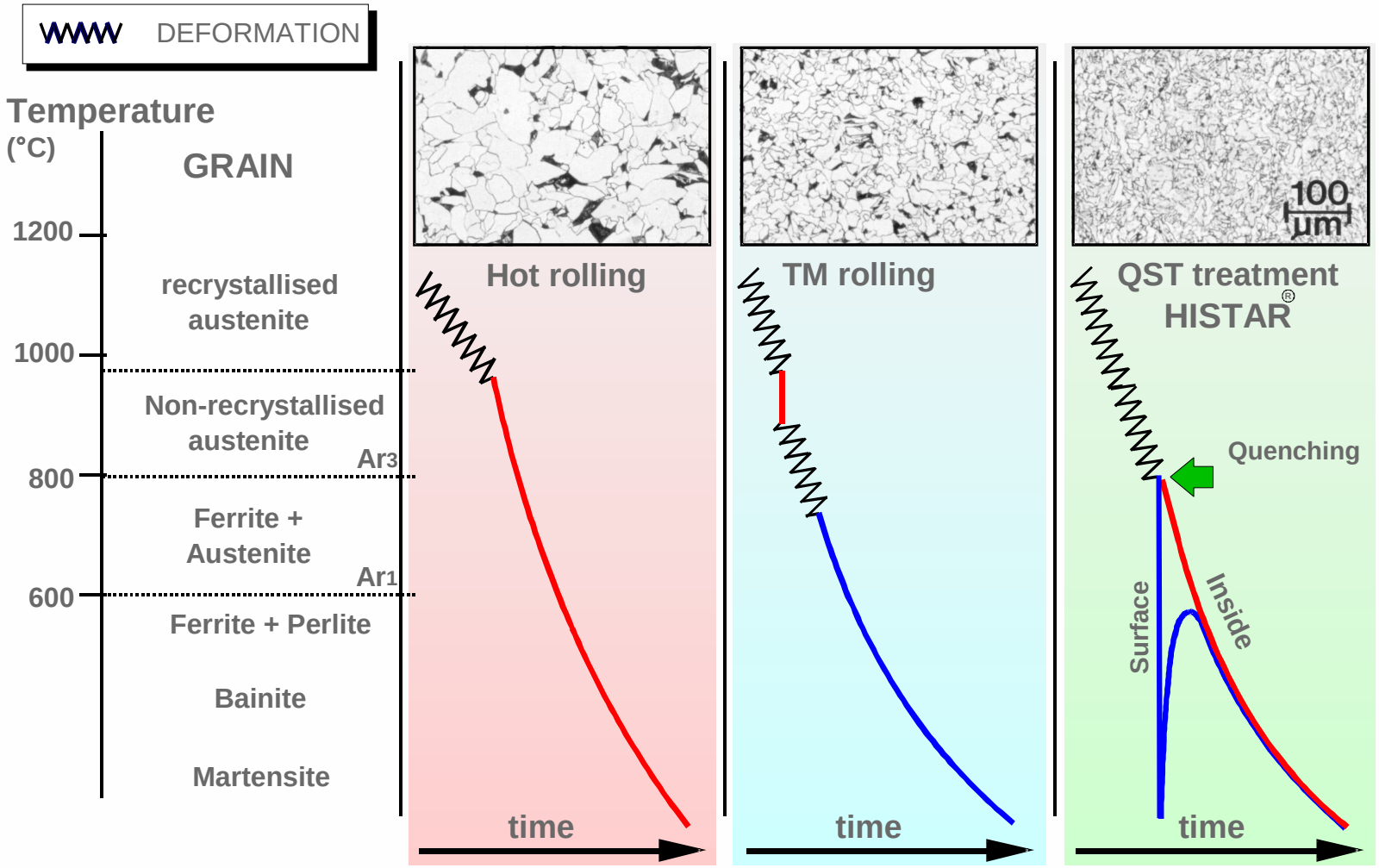
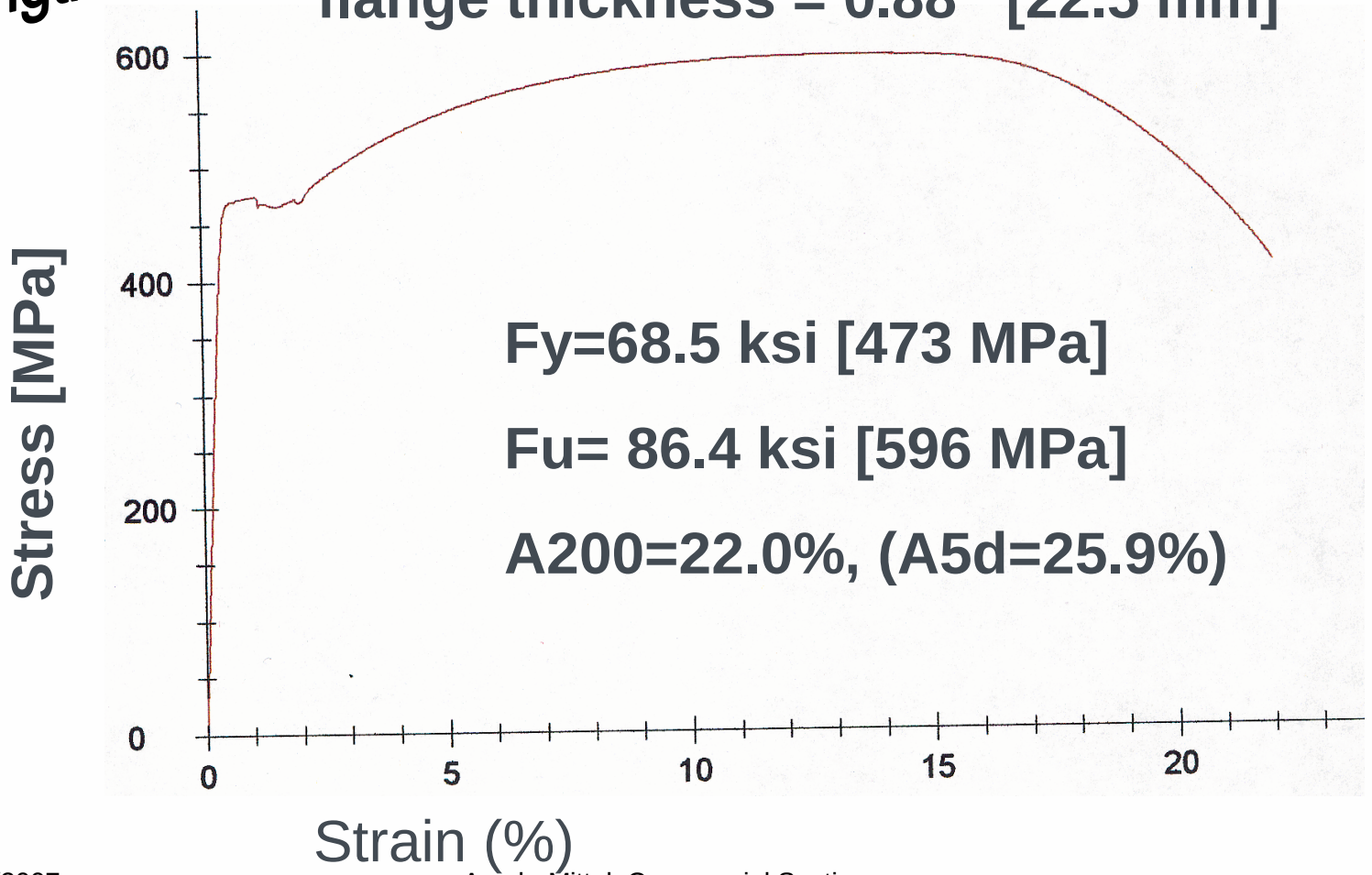


Stress – Srain curve

A913 Grade 450

Strength & Ductility

flange thickness = 0.88'' [22.5 mm]

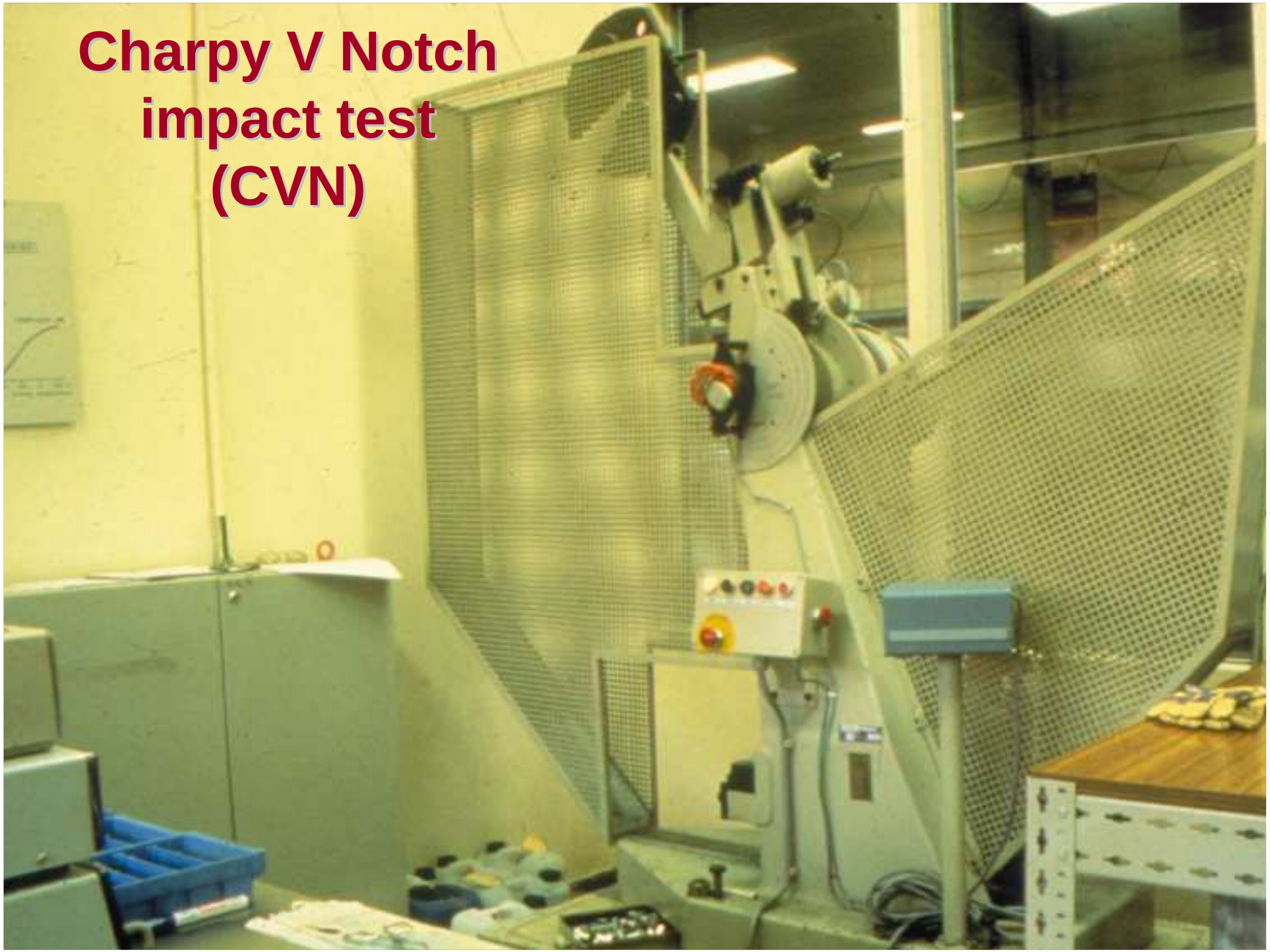


Fy=68.5 ksi [473 MPa]

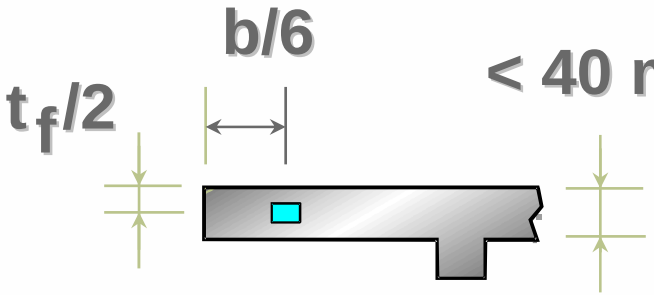
Fu= 86.4 ksi [596 MPa]

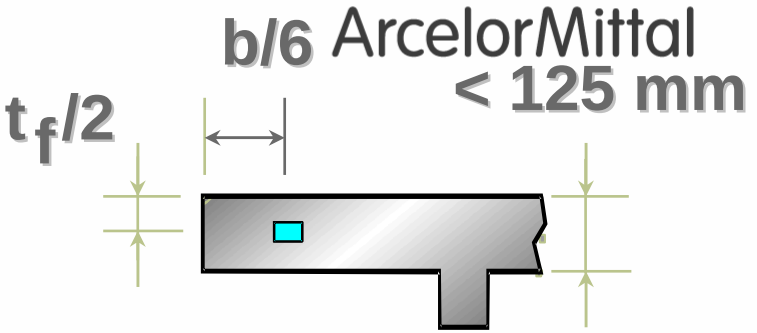
A200=22.0%, (A5d=25.9%)

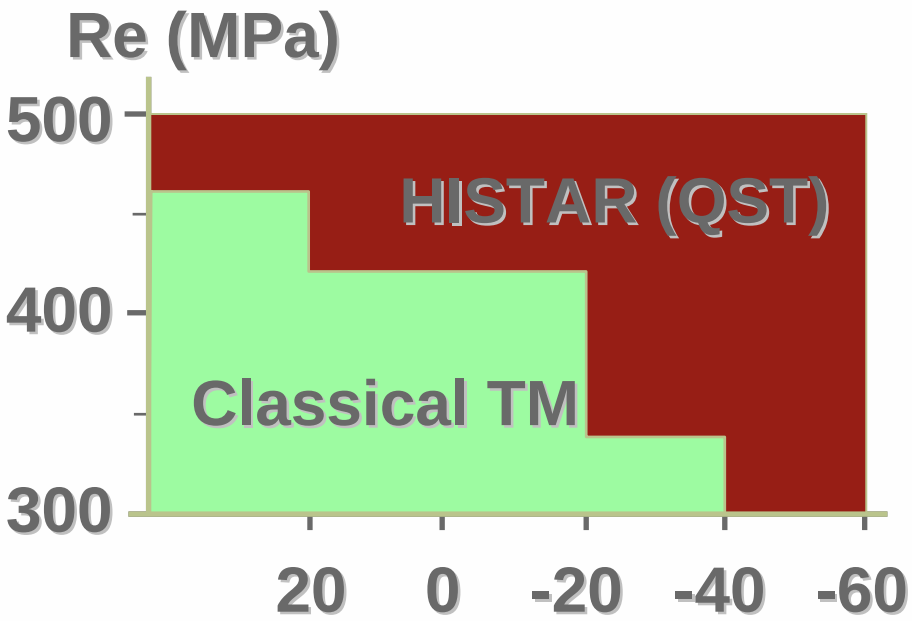
Charpy V Notch impact test (CVN)

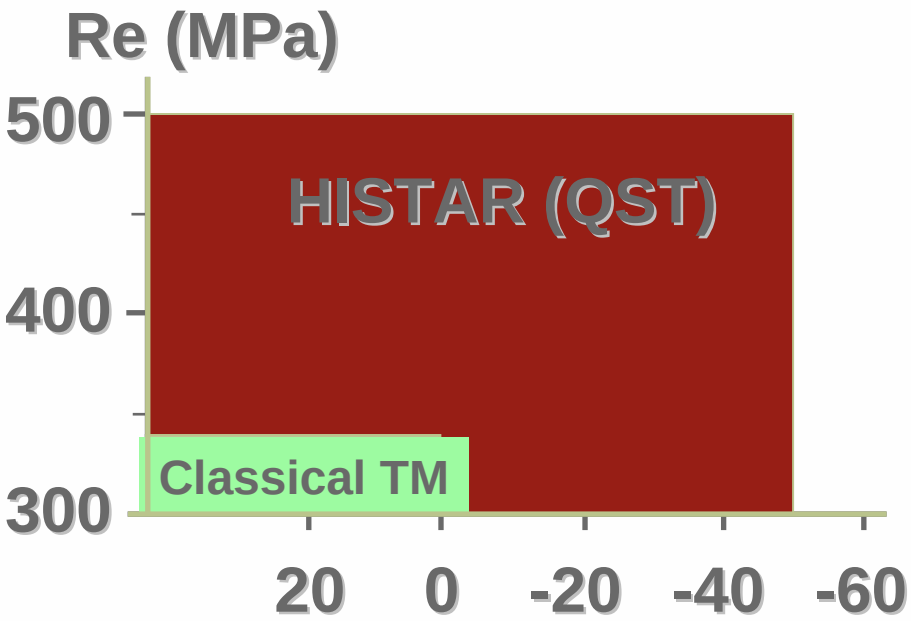


A913 - HISTAR: Toughness









Temperature for toughness Guarantee (°C)
= Transition temperature

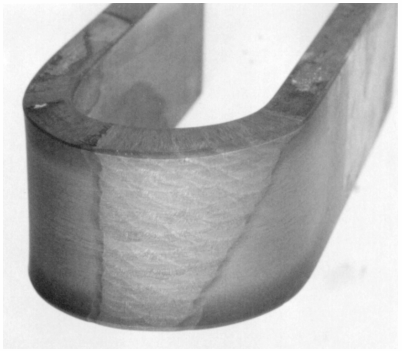
ASTM A913 : Ductility

Bent test at 180°
Radius = 0

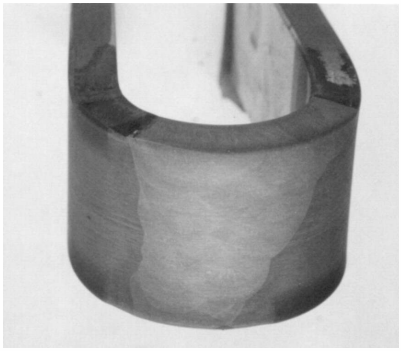
HISTAR : HD 400 x 1086 kg/m in A913/gr. 450

Bent test after welding : A913/gr. 450

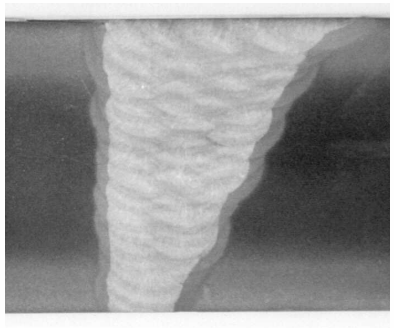
SMAW
E= 12kJ/cm



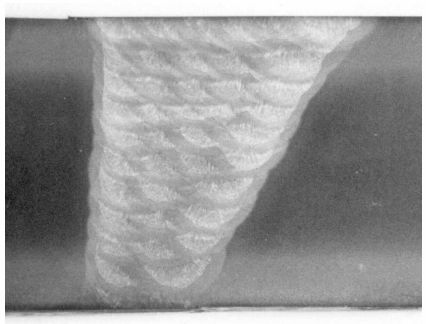
FCAW
E= 8 kJ/cm



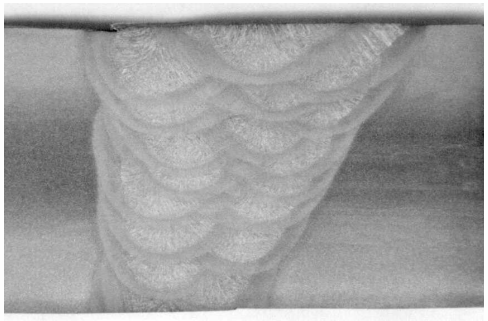
SAW
E= 35 kJ/cm



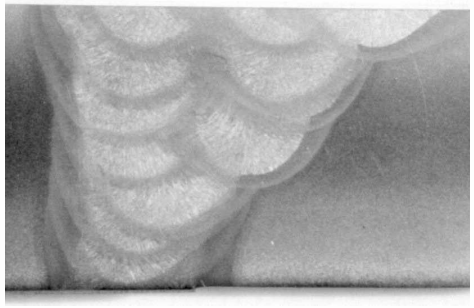
SMAW
E= 12kJ/cm



FCAW
E= 8 kJ/cm

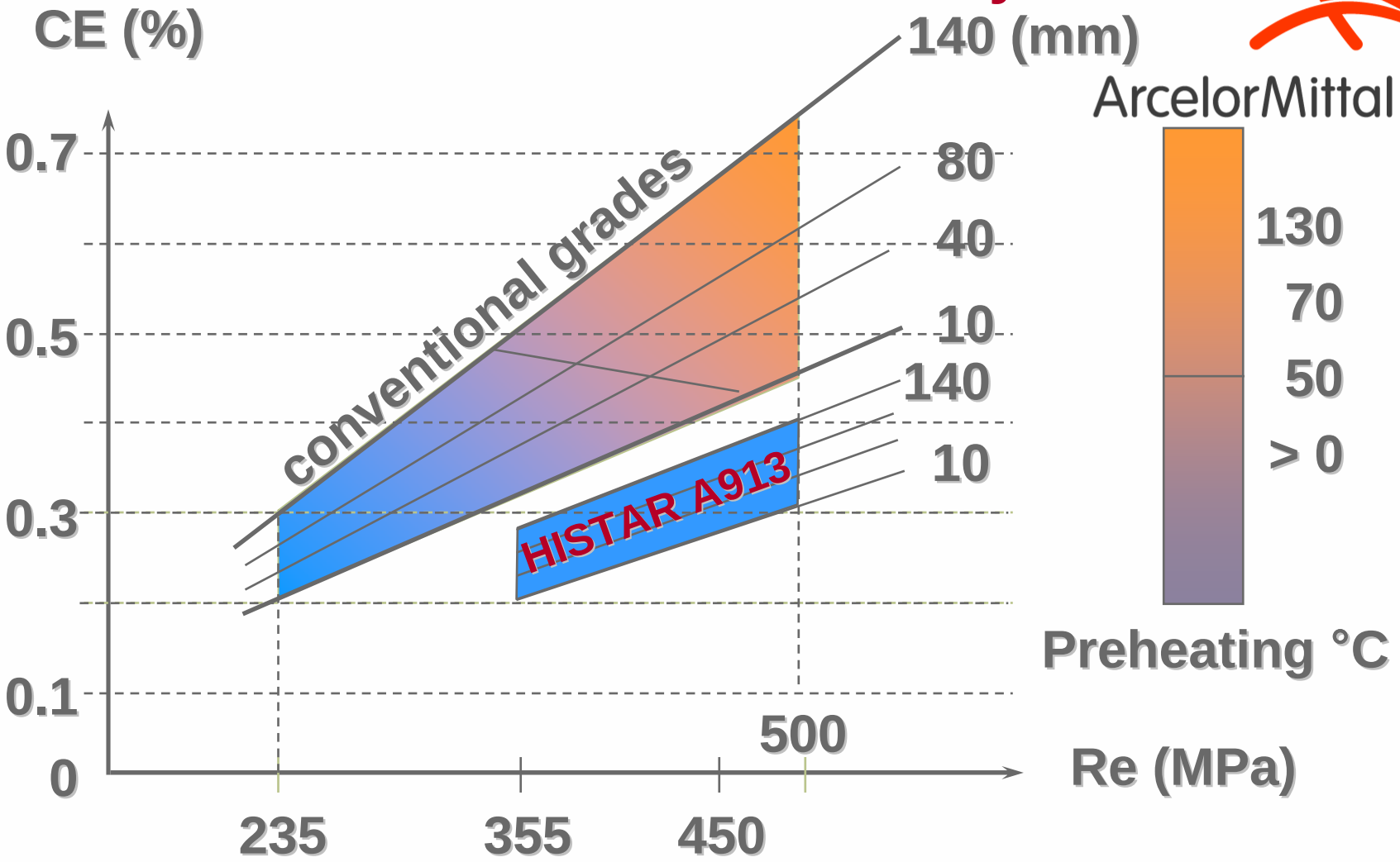


SAW
E= 35 kJ/cm



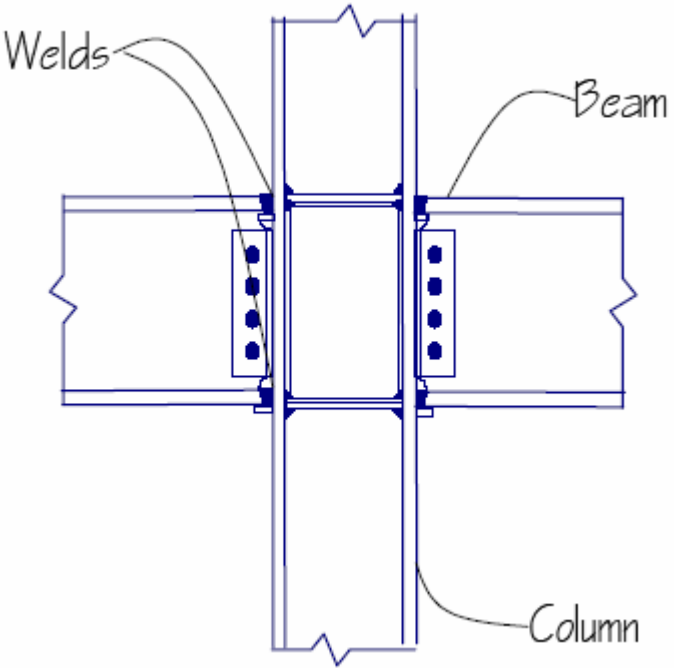
SAW
E= 50 kJ/cm

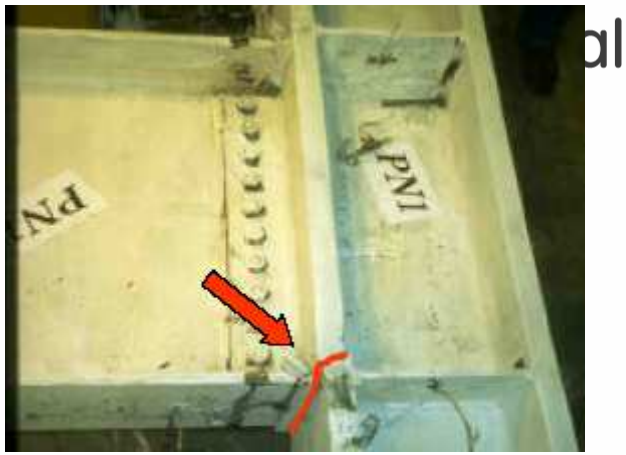
HISTAR / A913 : Weldability



$$CE\ (\%) = C\ (\%) + \frac{Mn\ (\%)}{6} + \frac{(Cr + Mo + V)\ (\%)}{5} + \frac{(Cu + Ni)\ (\%)}{15}$$

Seismic Design



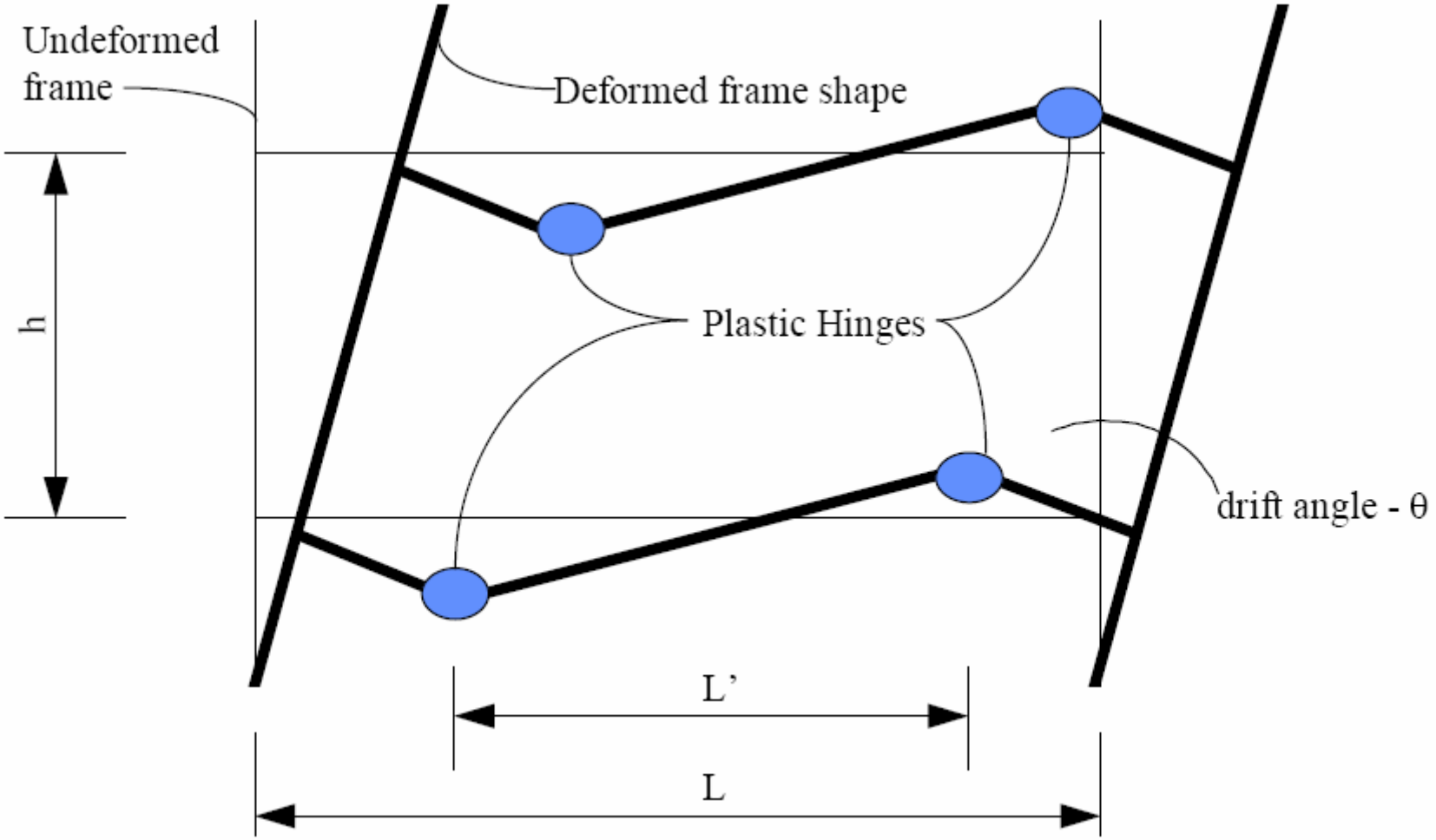


Fractures commonly initiate at the welded joint of the beam bottom flange to column.

The typical connection used prior to 1994.
Severe stress concentrations inherent in its configuration were not considered in the design.

Fractures Commonly initiate at the welded joint of the beam bottom flange to column.

Seismic Design

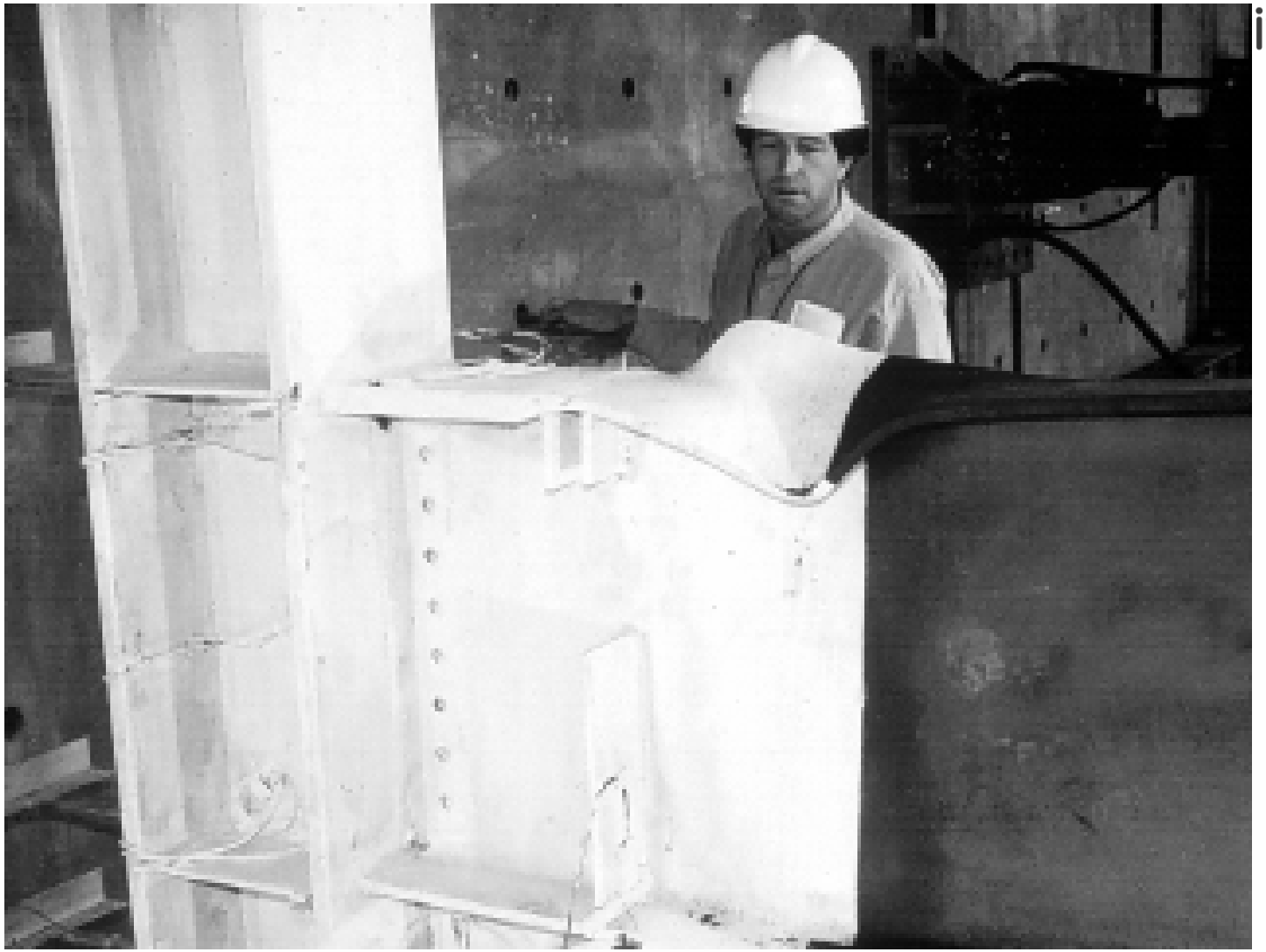


Desired plastic frame behavior

Seismic Design

Many steel moment-frame buildings were damaged in the 1995 Kobe earthquake.

Seismic Design



ASTM A913 : Through-thickness

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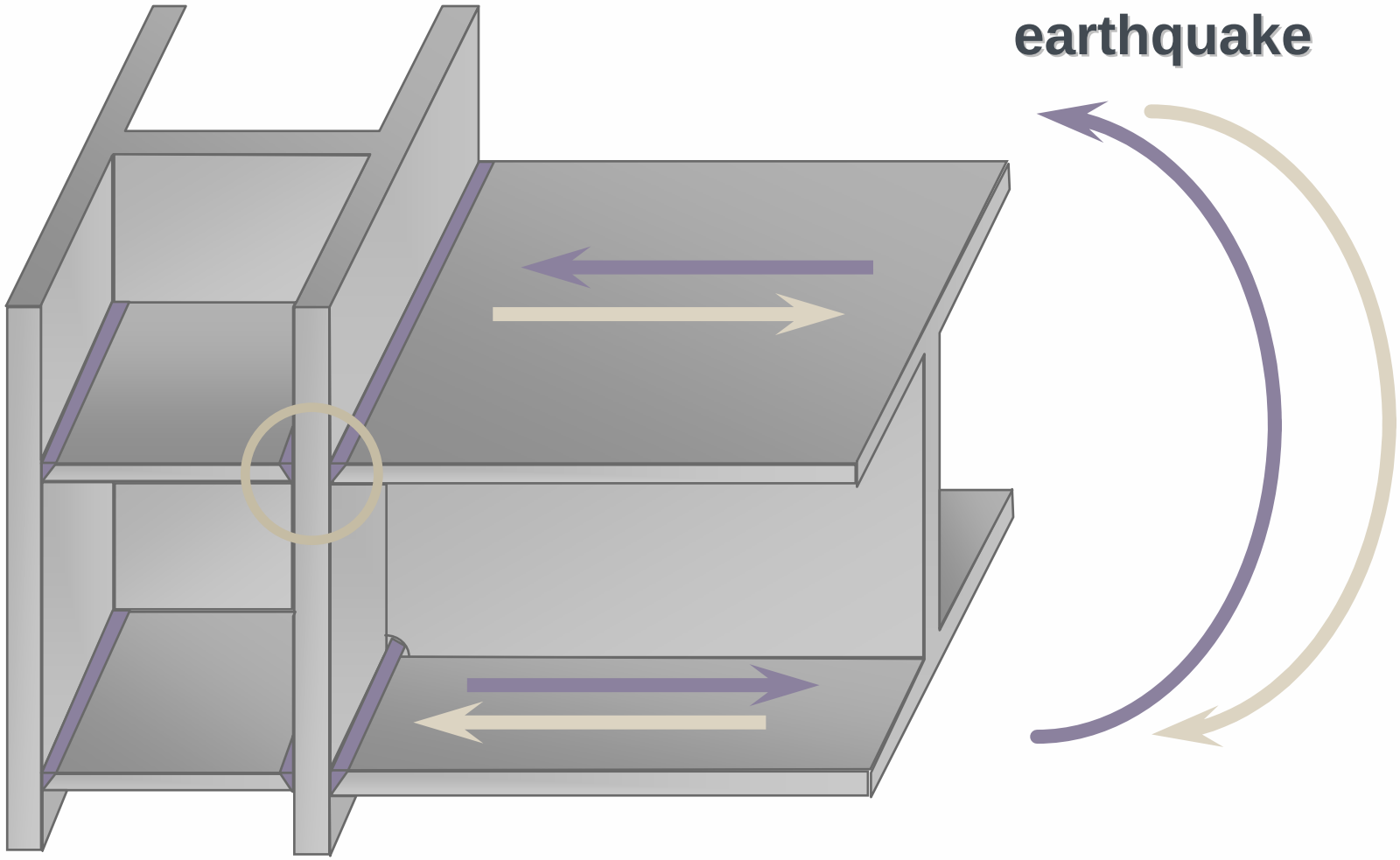
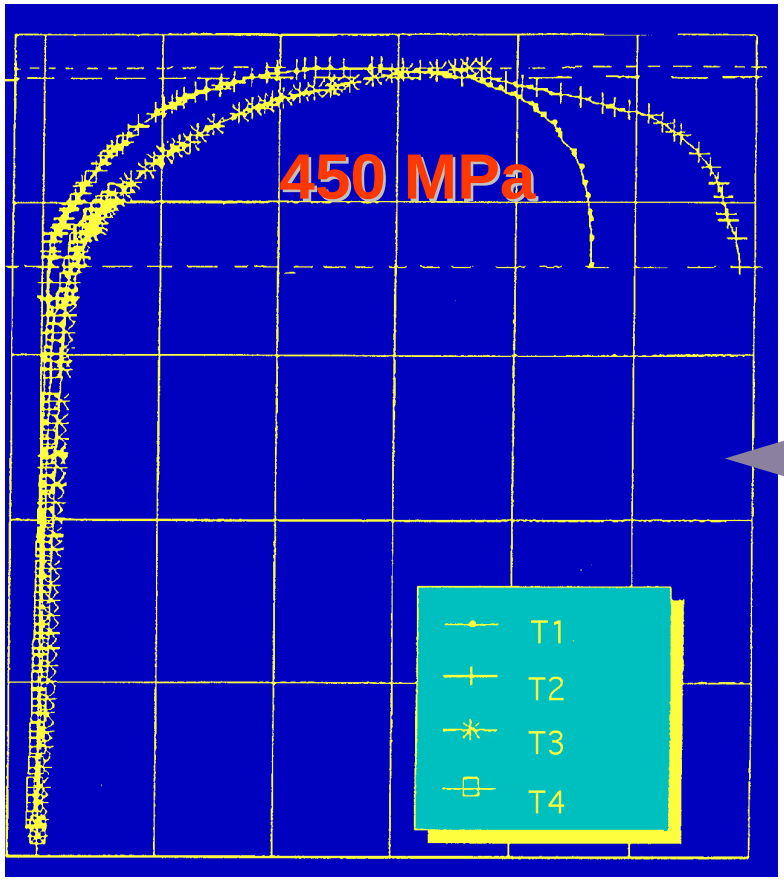
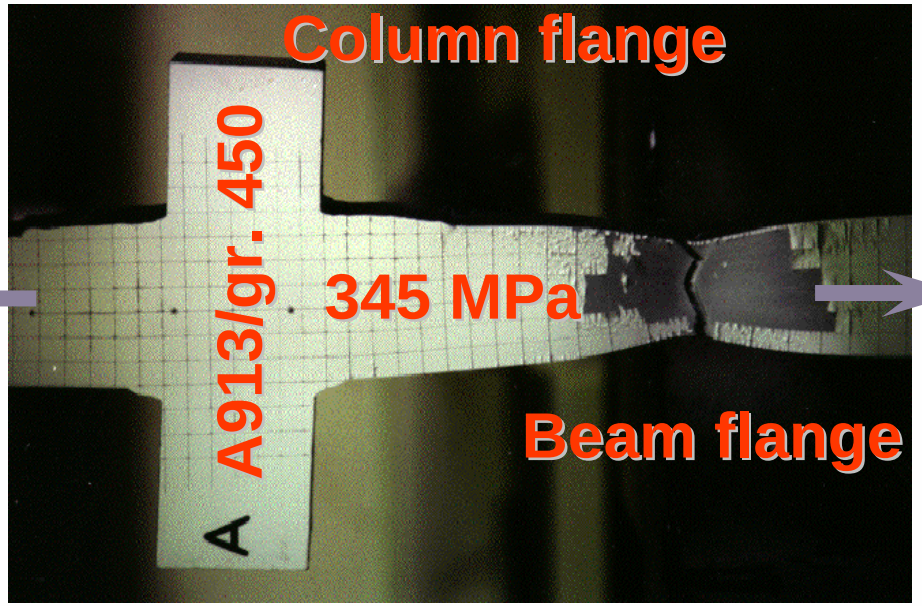
earthquake



ASTM A913 : Through-thickness





Strong Column - Weak Beam Concept enhanced by Reduced Beam Section (RBS)

Courtesy KMD architects

Column: A913 Grade 450

Beam: Grade 345

Courtesy EQE International

Comparison of Standards

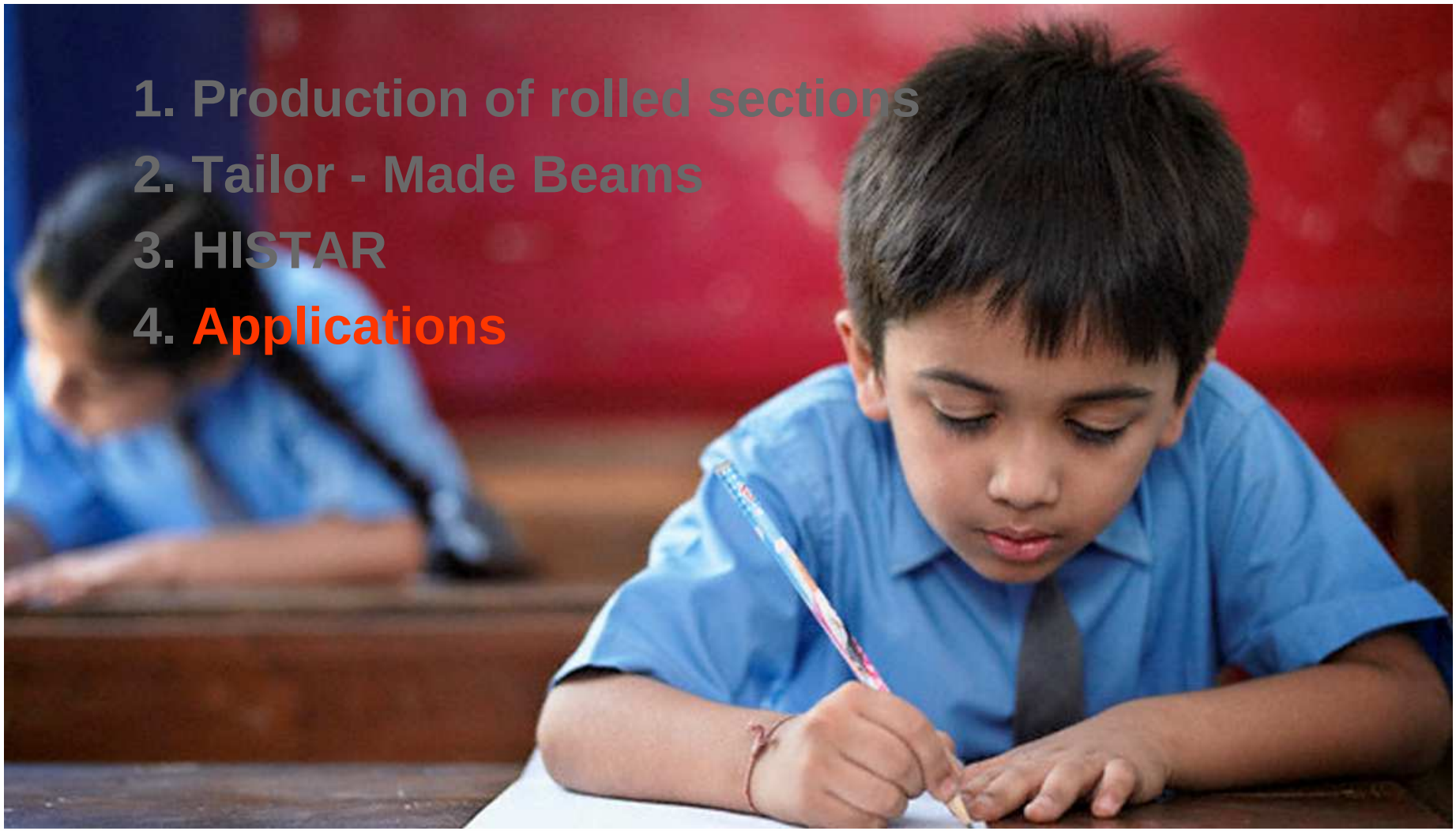
ASTM	A913/Gr. 450	A913/Gr.345	A572(A992)/Gr.345
Carbon Equiv. max.	0.43 %	0.38%	0.47 %(0.45 %)
Carbon max.	0.14 %	0.12%	0.23 %
Sulfur max.	0.030 %	0.030 %	0.045 %
Copper max.	0.35 %	0.45 %	0.60 %
CVN min.	54 J @ 21°C	54 J @ 21°C	No min.

30 % higher yield strength

All at the same cost

HISTAR and the Codes

• Tailor-Made beams ASTM A6	(1985)
• ASTM A913 - Euronorms	(1993)
• AISC - ASD and LRFD	(1996)
• AISC –Seismic provisions 2002	(1997)
• UBC 1997	(1997)
• IBC 2003	(2000)
• FEMA 350, FEMA 353	(2000)
• AWS D1.1 -- Welding Code	(1996)
• NYC - Building Code	(2001)
• Approved in China	(2004)


1. Production of rolled sections
2. Tailor - Made Beams
3. HISTAR
4. Applications

ArcelorMittal loves NY

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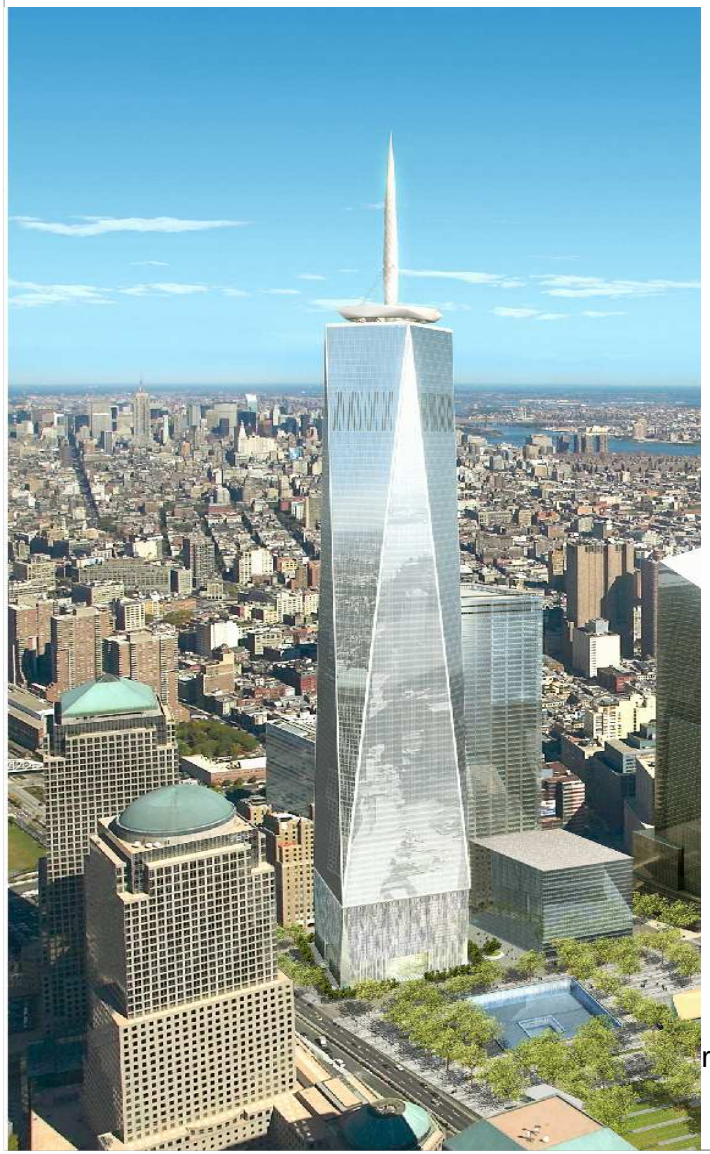
Sloan Kettering Hosp.
731 Lexington
Citicorp
Mt. Sinai Hosp.
Time Warner
"Lipstick"
Hearst
599 Lex.
Worldwide Plaza
1745 B'way (Random H.)
750 Seventh Ave
Swiss Bank - Saks
1585 Broadway
Morgan Stanley
450 Lexington
New York Times
Loews Theater, 42nd St.
Hilton, 42nd St.
Times Square 4 (Conde Nast)
300 Madison (CIBC)
Times Sq. 5 (Ernst & Young)
383 Madison (Bear S.)
420 Fifth Ave
NYU Palladium
Hutton Plaza
Shearson Lehman
St. Luke's Hospital
Baruch College
60 & 75 Wall Street
World Financial C.
WTC 7 Reconstr.

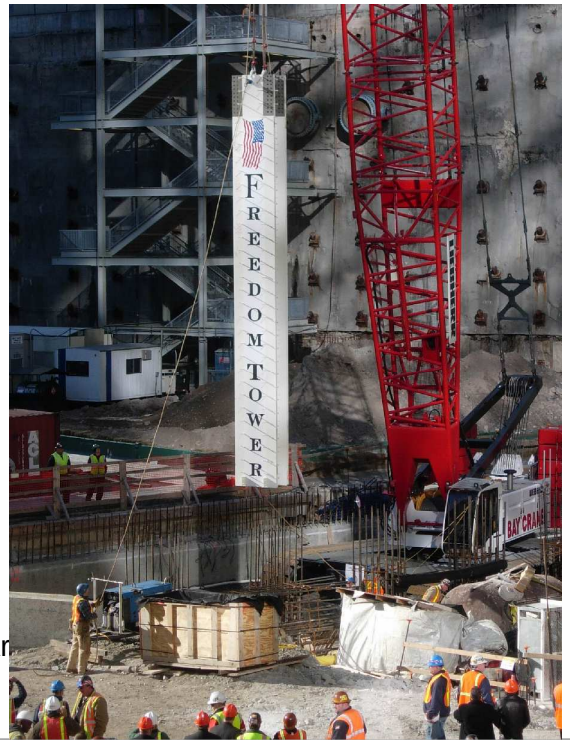
New York Skyline

Typical applications
Skyscrapers



Freedom Tower – New York

Architect: Skidmore, Owings&Merrill
Developer: Silverstein Properties
Total building height: 541m
~250 000m² office floor



First delivery of 850t of HISTAR jumbo sections for the structure of the basement (December 2006)

Typical applications
Skyscrapers

San Francisco skyline

Los Angeles
Bunker Hill Area

Emirate Towers - Dubai

13/06/2007

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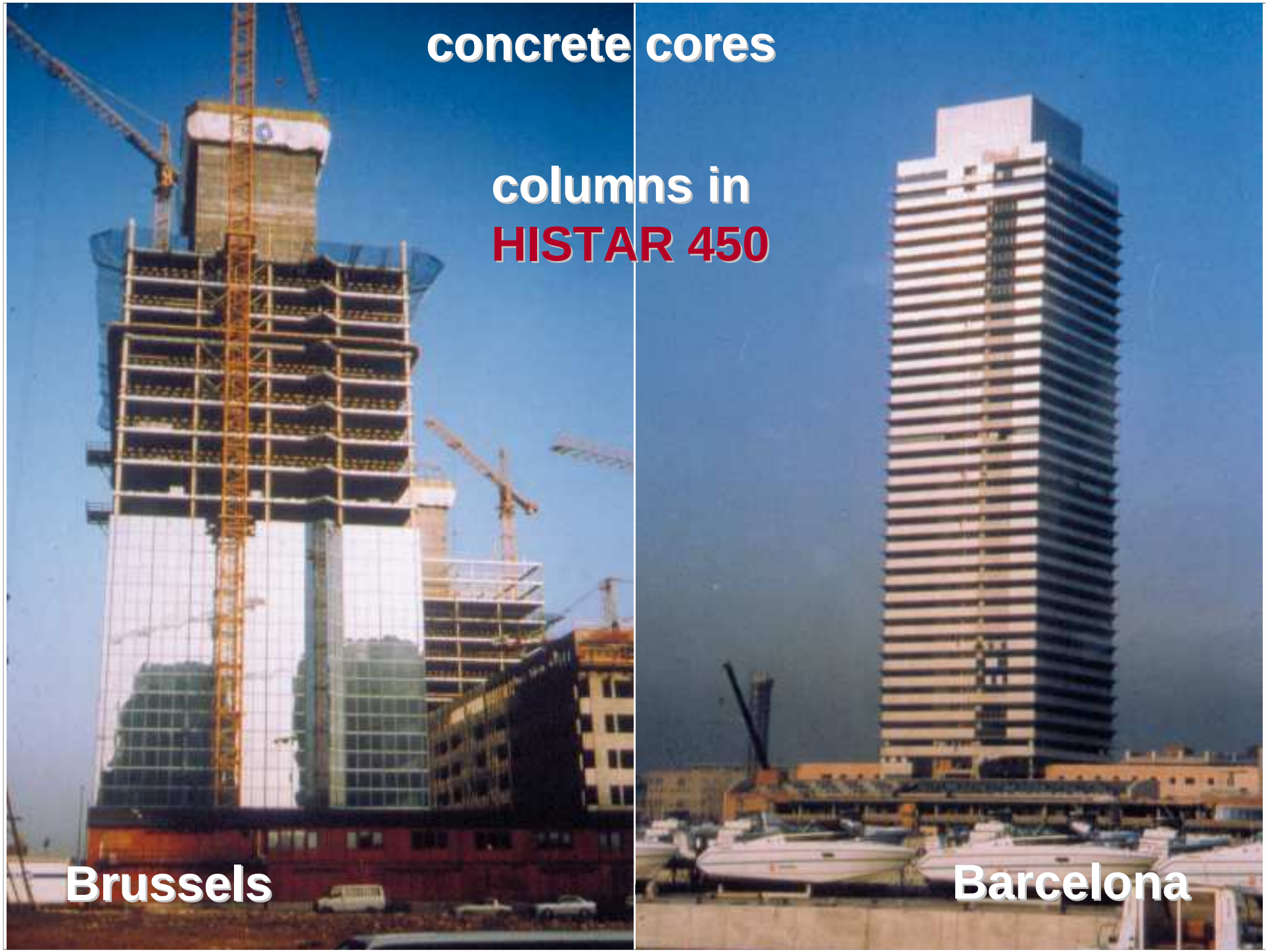
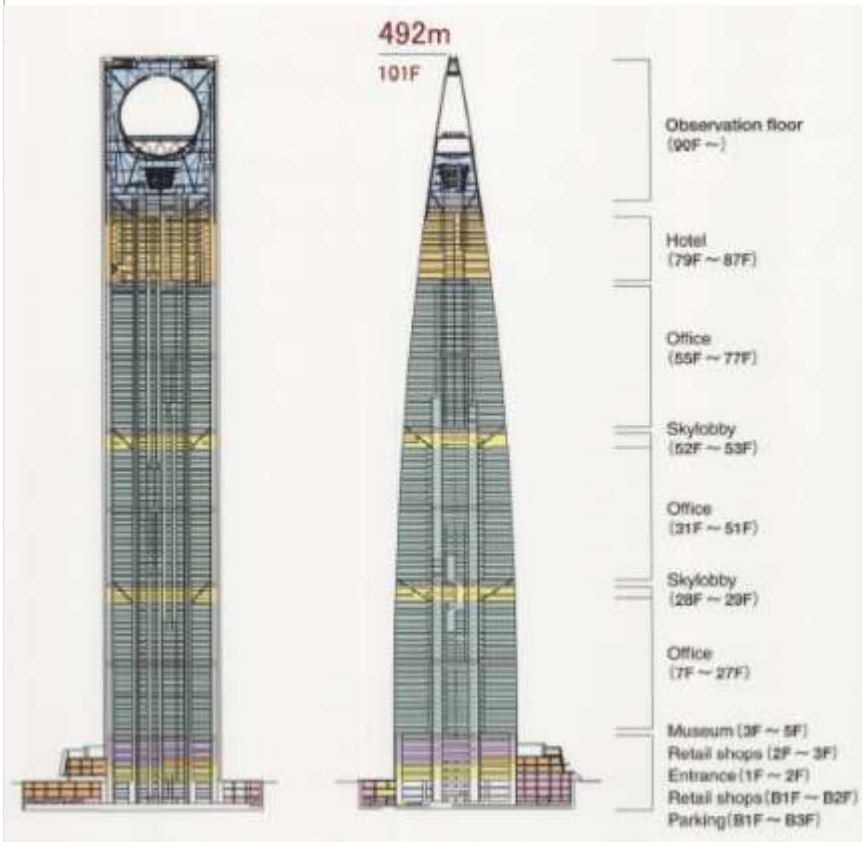
Gravity columns

Short buckling lengths

HISTAR 460


concrete cores
columns in
HISTAR 450
Brussels
Barcelona

Shanghai
World Financial Center
ASTM A913

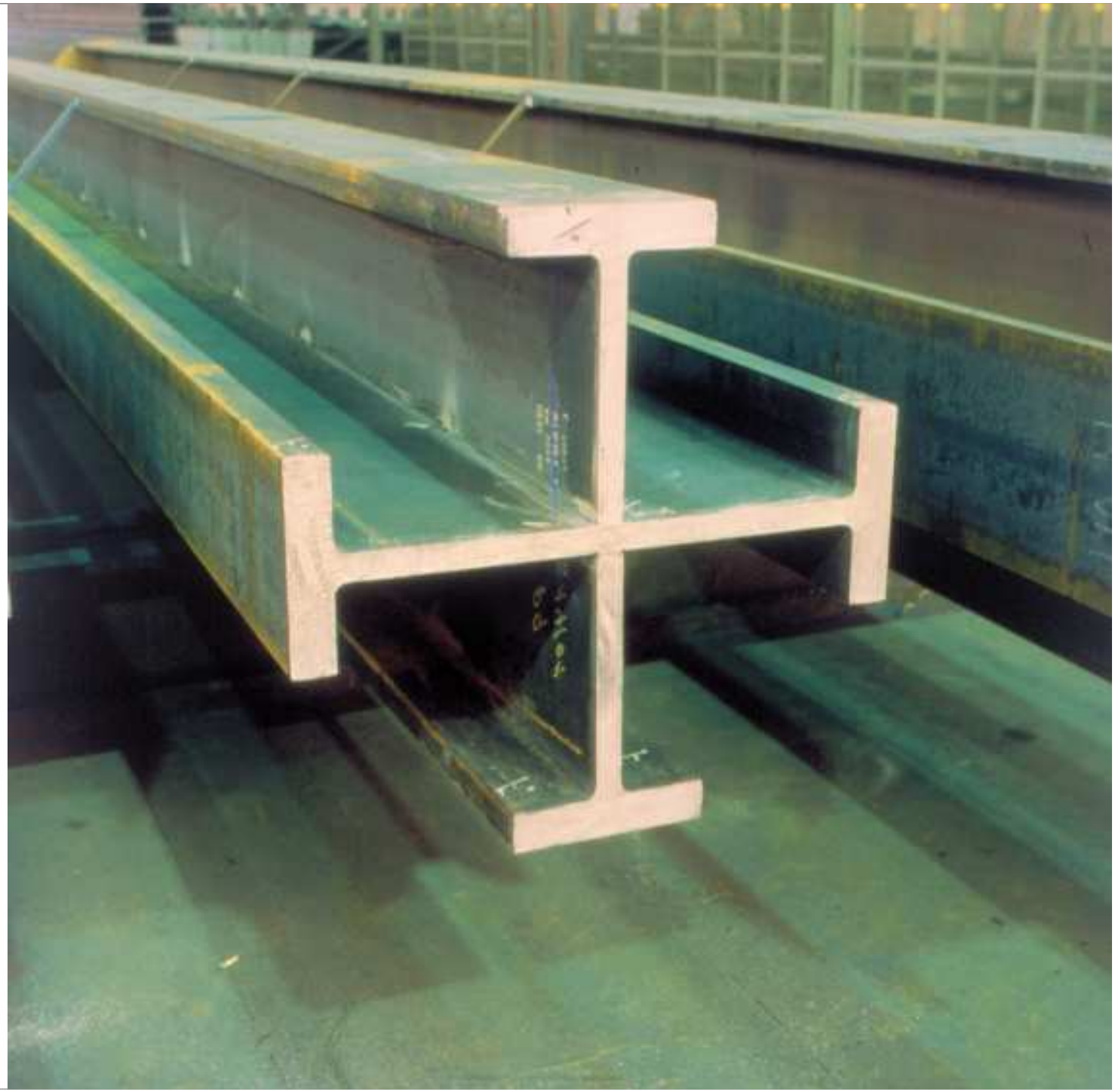



Plot 10
Federation Tower
2/2/2007

Applications

- Buildings
- **Offshore platforms**
- Plants
- Parking garages
- Bridges
- Trusses


STATFJORD B
BLOKK 33/12



13/06/2007

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Conversion from built-up sections to rolled sections

Lanxi Power Plant - China

Applications

- Buildings
- Offshore platforms
- Plants
- **Parking garages**
- Bridges
- Trusses


Long span : no internal columns

Applications

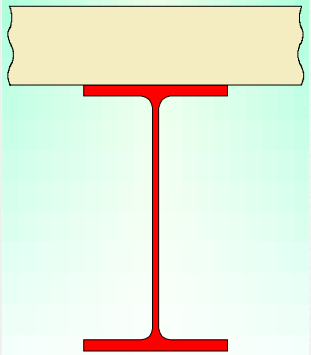
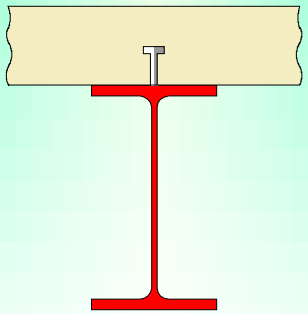
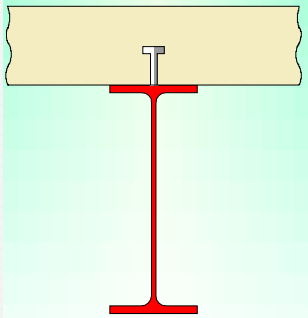
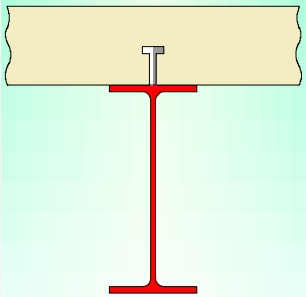
- Buildings
- Offshore platforms
- Plants
- Parking garages
- **Bridges**
- Trusses

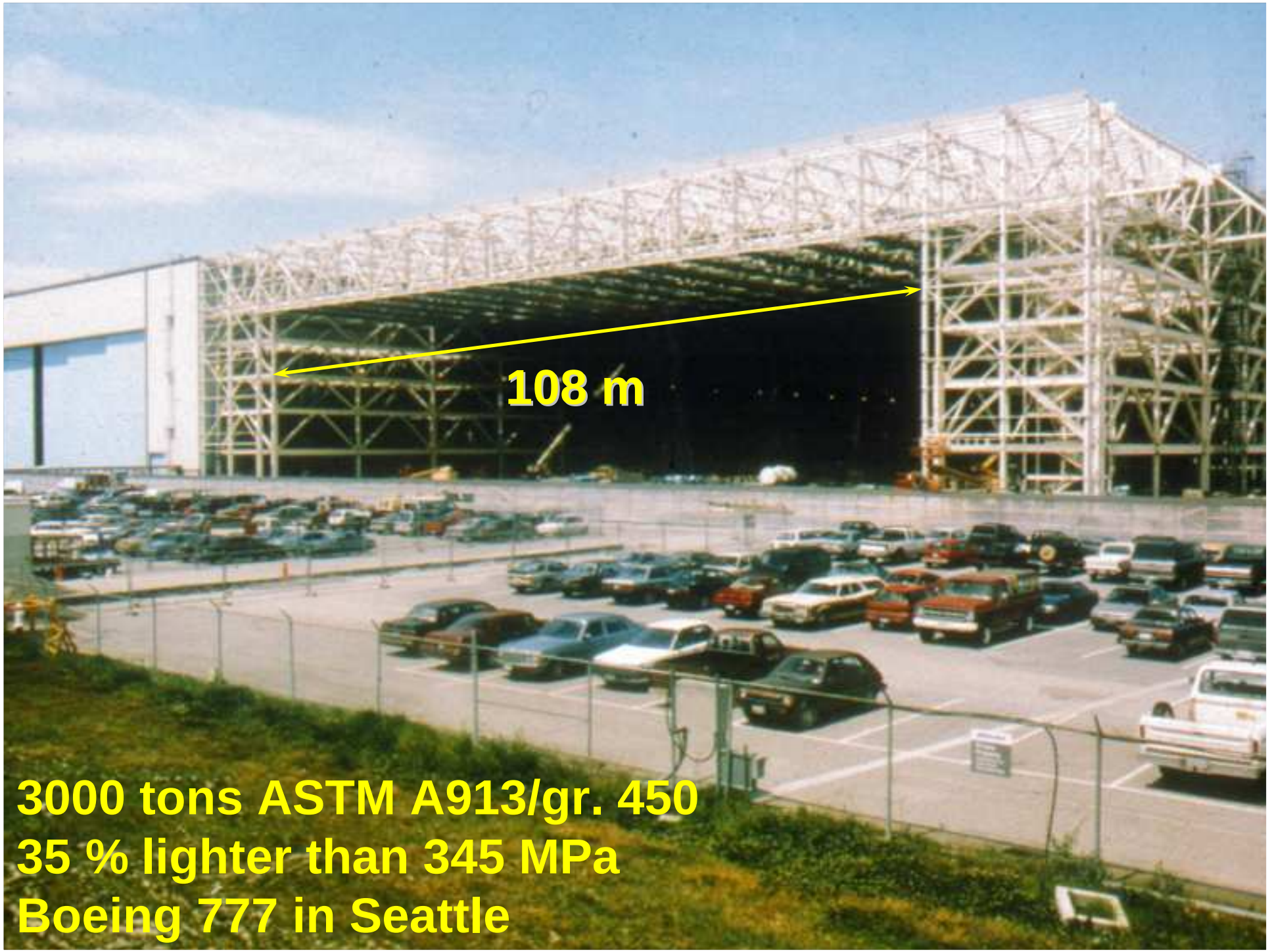

Istanbul

Economical aspects of steel structures

ArcelorMittal

Advantages of high strength steels in steel-concrete composite construction

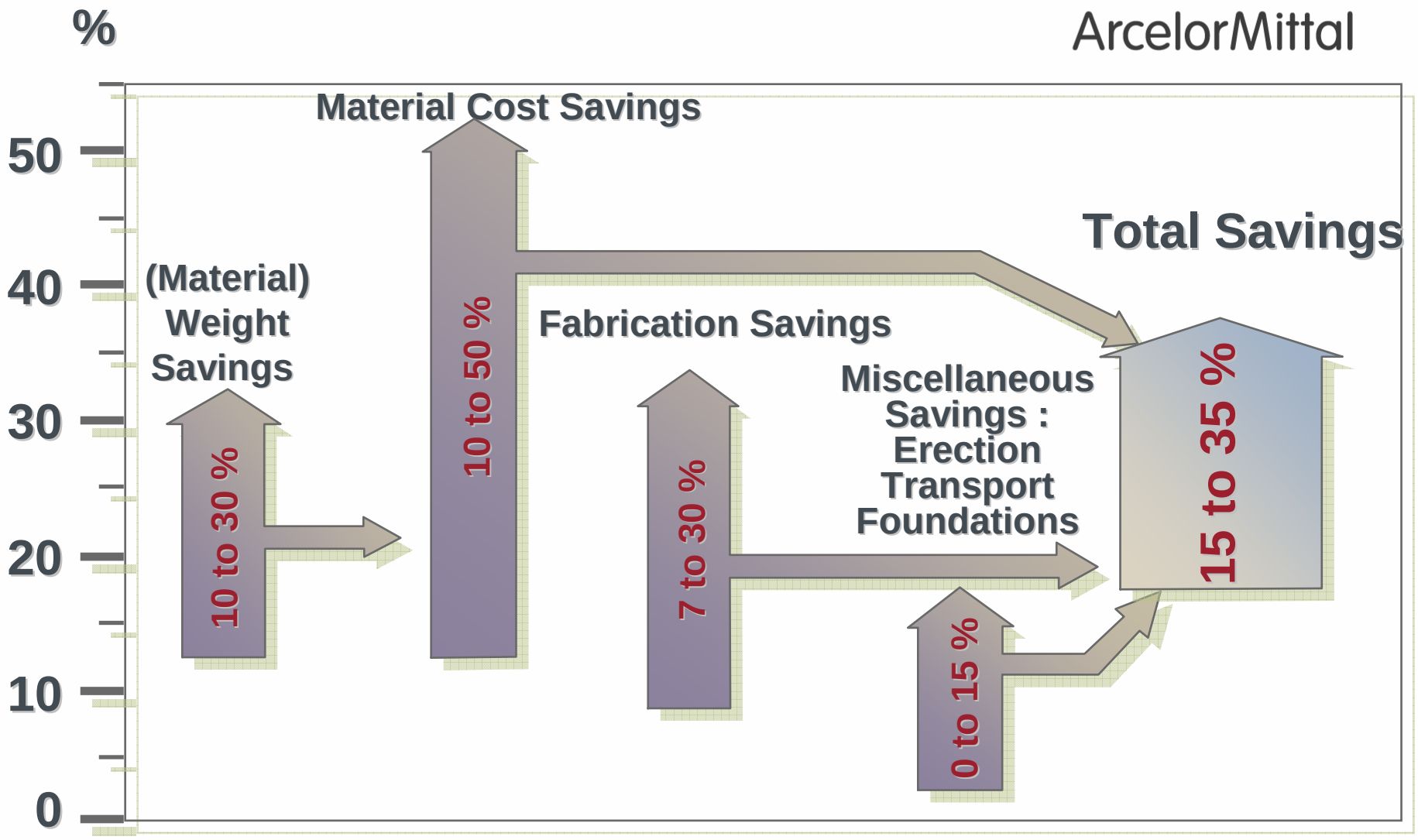
Type of construction	non-composite	composite	composite	composite
Steel grade	S 235	S 235	S 355	S 460
Section				
H beam	HE 650 A	HE 550 A	IPE 550	IPE 500
Reduction in weight of steel	-	**13 %**	**44 %**	**52 %**


108 m
3000 tons ASTM A913/gr. 450
35 % lighter than 345 MPa
Boeing 777 in Seattle

Typical applications
Trusses

Typical applications
Trusses

Potential savings A913/gr. 450 ⟷ gr. 245



Thank you for your attention!

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