TATA STEEL

TATA

Specification of Structural Hollow Sections & Welded Joints In Tubular Steel

Steve Whitfield Beng (Hons) CEng MIStructE

Customer Technical Services - Manager

Tata Group

One of the world's fastest-growing and most reputable corporations

Tata Group is highly diversified

- Steel , Consultancy , Automotive , Power , Communications , Hotels . beverages
- Operations in more than 100 countries and 580,000 employees
- Total revenues $100 billion (67% from outside India)
- Ranked world's 11th most reputable and 17th most innovative company
- Tata Sons 66% owned by philanthropic trusts
- £170 million invested in community projects last year

Tata Steel Group

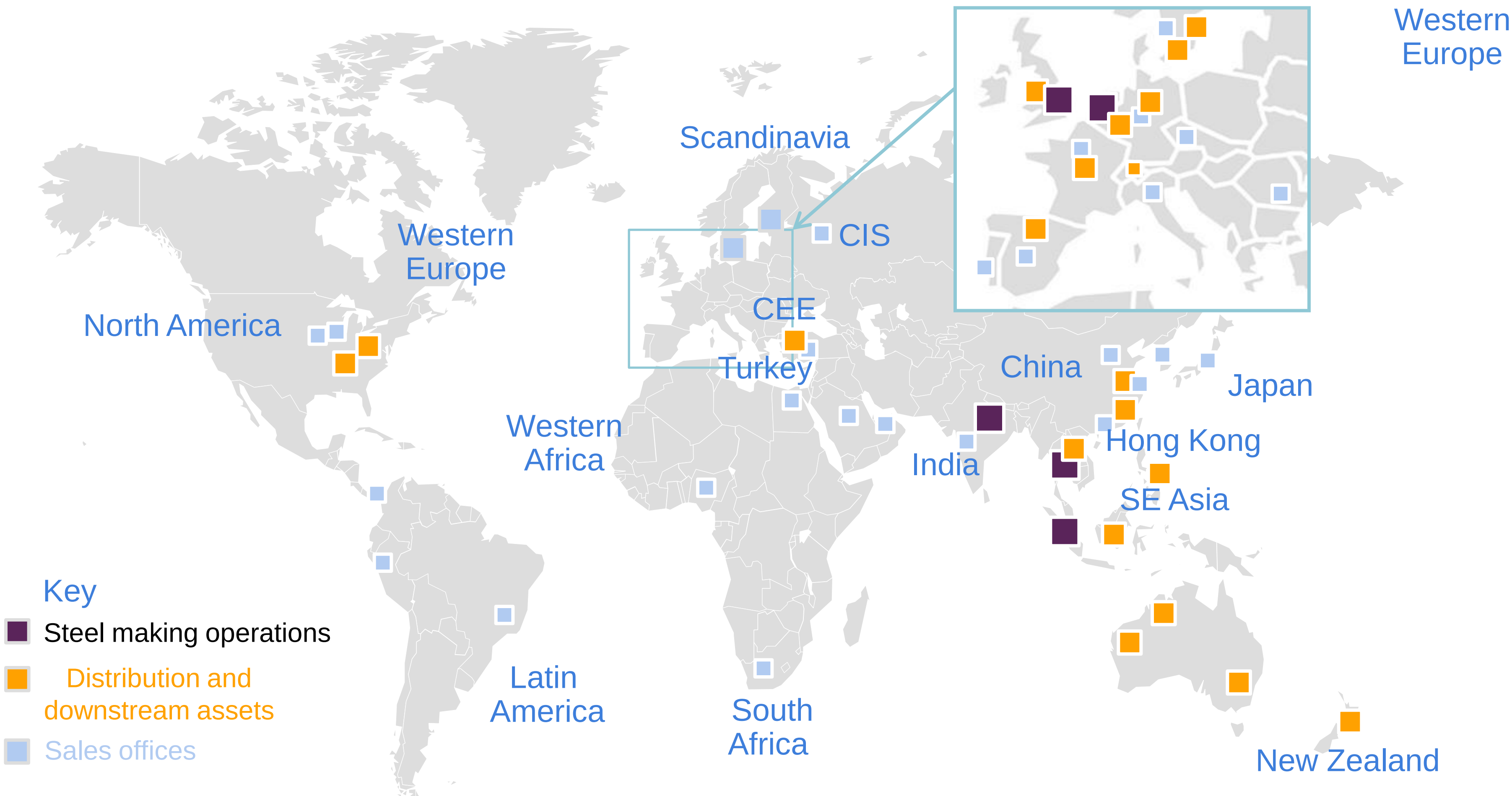
One of the world's most geographically-diversified steel producers

Tata Steel Group

- Top 12 global steel producer
- Annual crude steel capacity of more than 29 million tonnes
- Around 80,000 employees
- Manufacturing operations in 26 countries across 4 continents
- Present in both mature and emerging markets
- Turnover in 2013-14: $ 24.8 billion (€18.0 billion)
- Fortune 500 company

Tata Steel Group

A global network serving demanding markets worldwide



Our key markets

Serving the most demanding markets worldwide

Aerospace

Automotive

Construction

Consumer products

Defence & security

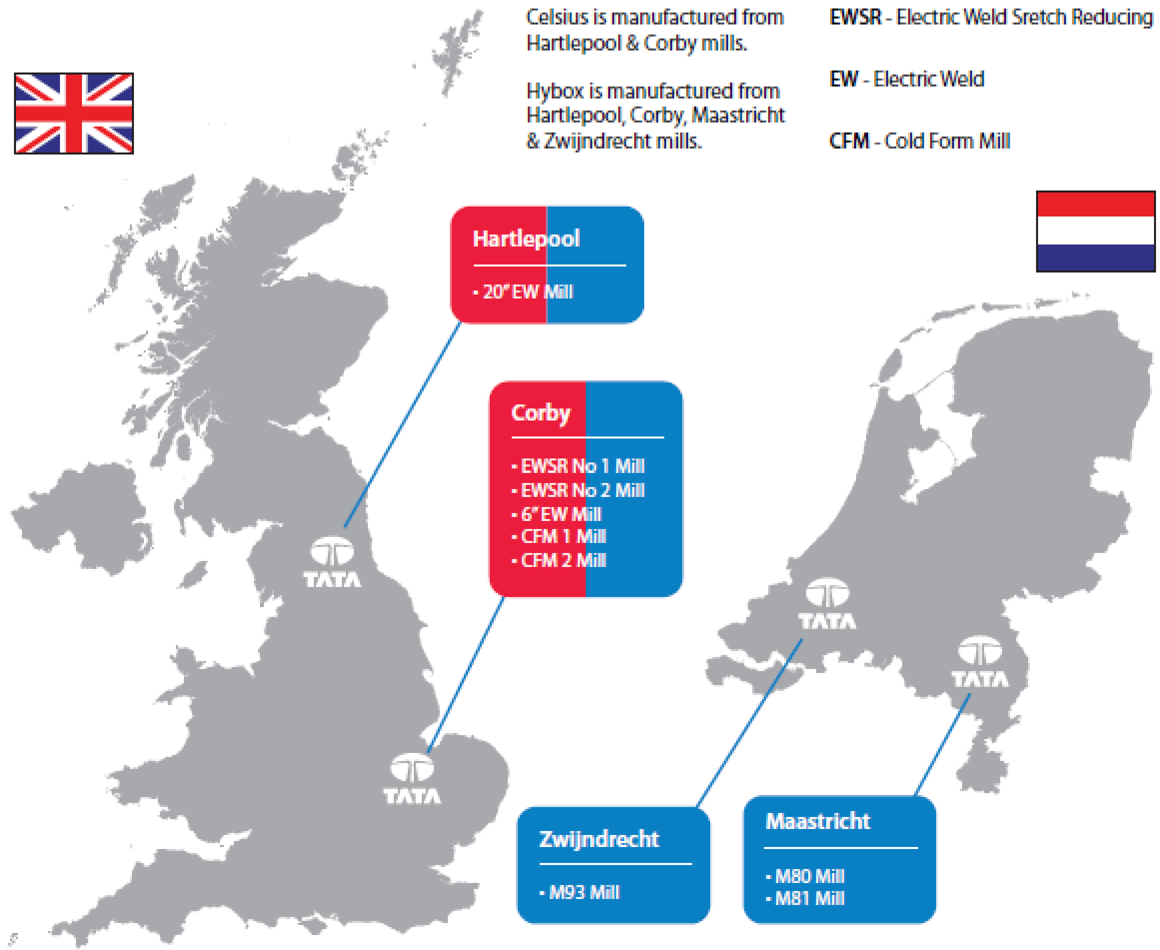
Energy & power

Lifting & excavating

Packaging

Rail

Tata Steel – Tube manufacturing



Tata Steel Europe, Tubes

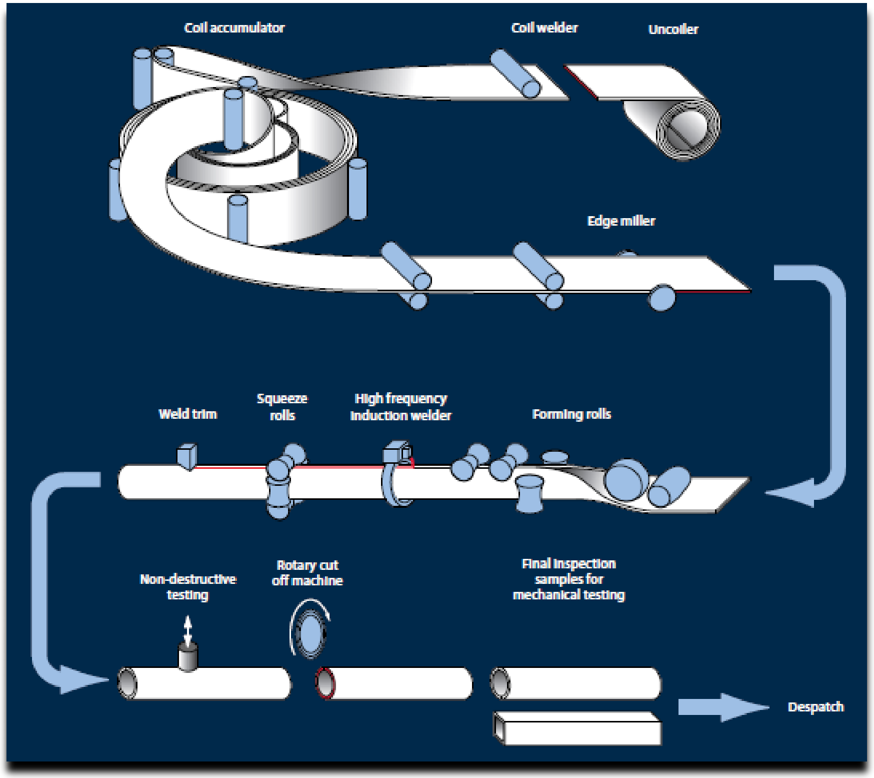
Celsius – EN10210 Hot finished Structural Hollow Sections

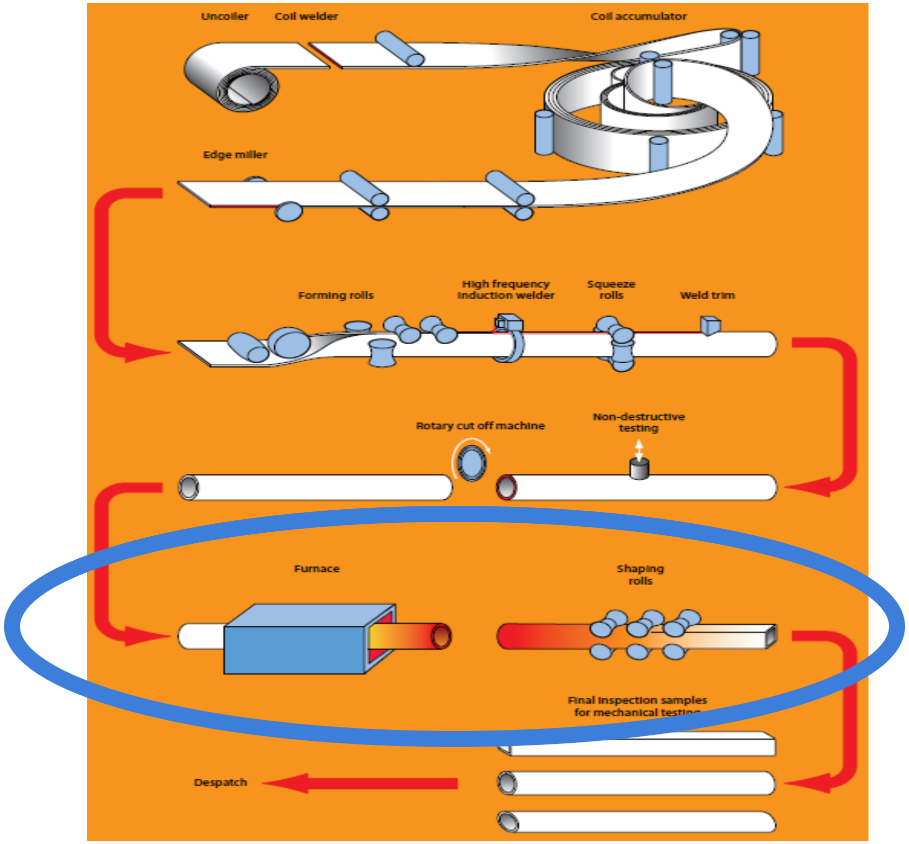
Steve Whitfield Beng (Hons) CEng MIStructE

Customer Technical Services - Manager

Tata Steel Europe, Tubes

Manufacture of Hollow Sections





EN10219 – Cold Formed Structural Hollow Sections

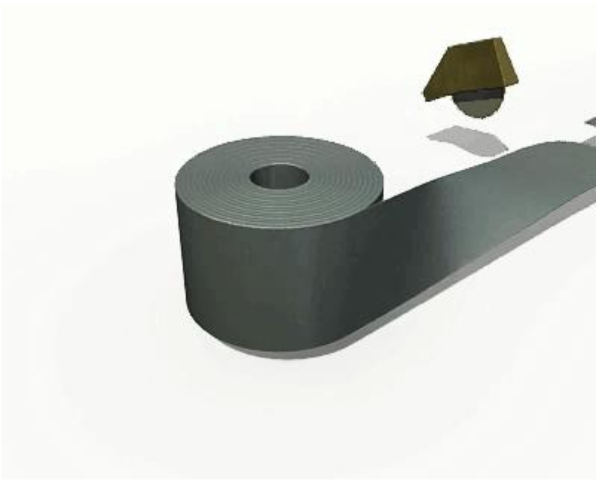
Hybox

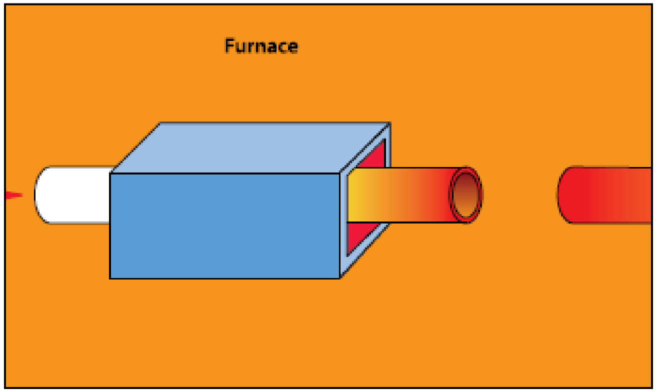
EN10210 – Hot Finished Structural Hollow Sections

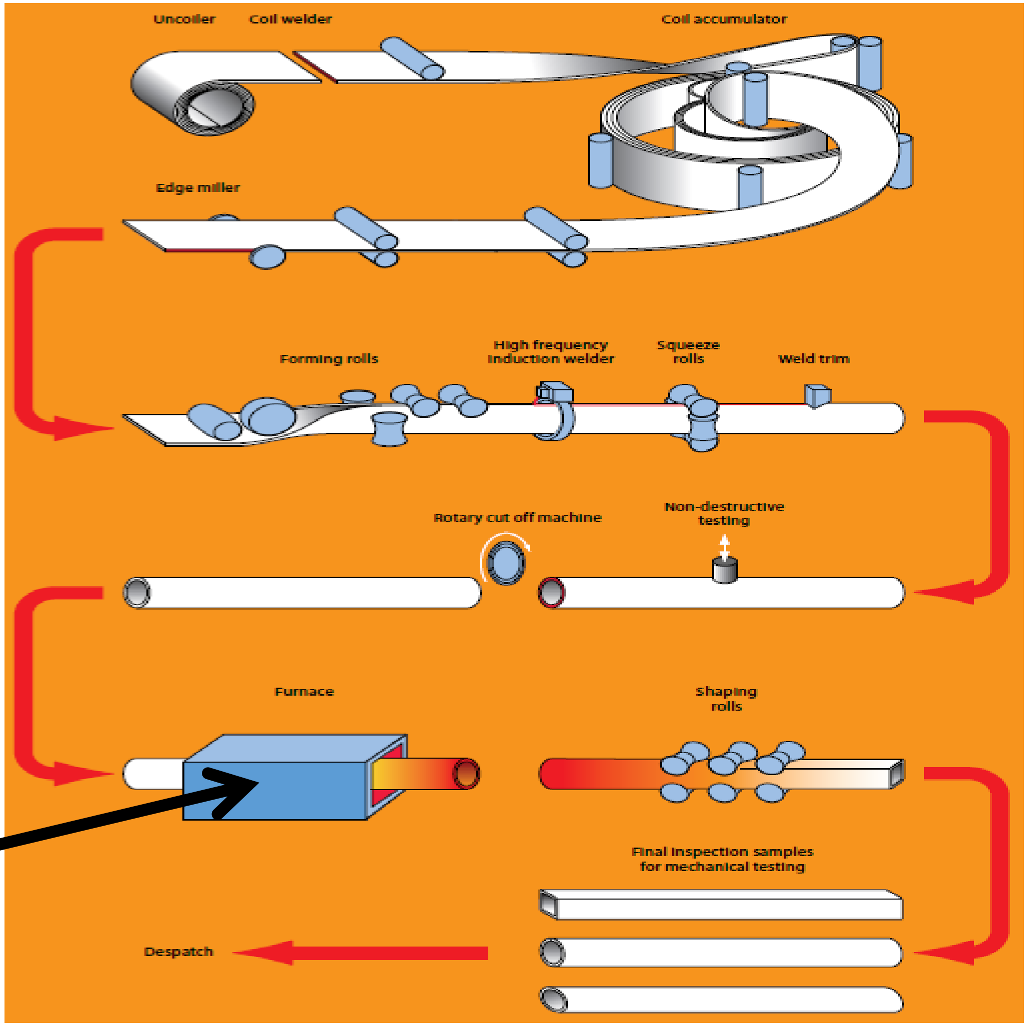
Celsius

Technical Information

Celsius 420 – Full Body Normalised







Furnace

The right product for the rights application

Hot Finished Structural Hollow Sections

- EN10210:S355 NH, EN10210:S355J2H
- EN10210:S420 NH

Cold Formed Structural Hollow Sections

- EN10219:S355J2H
- EN10219:S355JRH

It is important to ensure you have the correct specification

Technical Information

Hot Finished Structural Hollow Section of Non alloy and Fine Grain Steels

CELSIUS 355 - EN10210:S355 NH

Tensile Strength
470N/mm^2 – 630 N/mm^2

Minimum yield strength
<= 16mm :- 355 N/mm^2

Minimum Impact -20^{o}c @ 40 J

Elongation - 19 %

Carbon Equivalent (CEV) – 0.43

Silicon Content Si - 0.60

Silicon Content (Si) Celsius 420 NH – 0.15 to 0.25

Product Specification

Technical Information

Hot Finished Structural Hollow Section of Non alloy and Fine Grain Steels

CELSIUS 420 - EN10210:S420 NH

Tensile Strength
520N/mm^2 – 680 N/mm^2

Minimum yield strength
<= 16mm :- 420 N/mm^2

Minimum Impact -20^{o}c @ 40 J

Elongation - 19 %

Carbon Equivalent (CEV) – 0.50

Silicon Content Si - 0.60

Carbon Equivalent (CEV)
Celsius 420 NH – 0.45

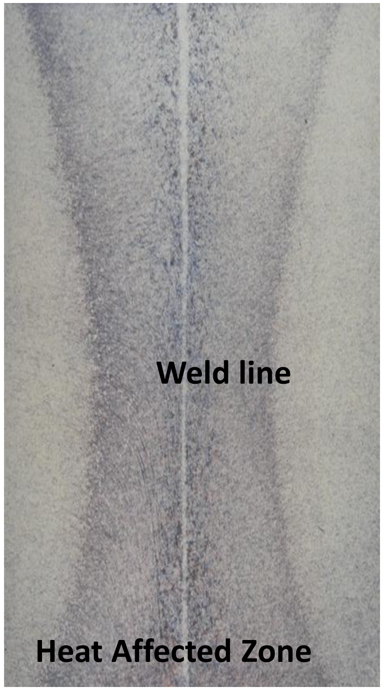
Silicon Content (Si)
Celsius 420 NH – 0.15 to 0.25

Product Specification

Technical Information

Due to the manufacture the Celsius has many advantages on a size for size basis compared to EN10219:

- Tighter corner profiles on hot. – Better area less weight.
- Weld line - Due to the full body normalising the weld line becomes the same as the tube. Better consistency for product
- Consistent hardness values around the whole perimeter. – During heating or manipulating/ bending no loss of yield, tensile, Charpy impacts. Can weld in corner of hot but issues with cold.
- No built in stress – Design standards recognise the difference and have higher compression and tension for same size same thickness.



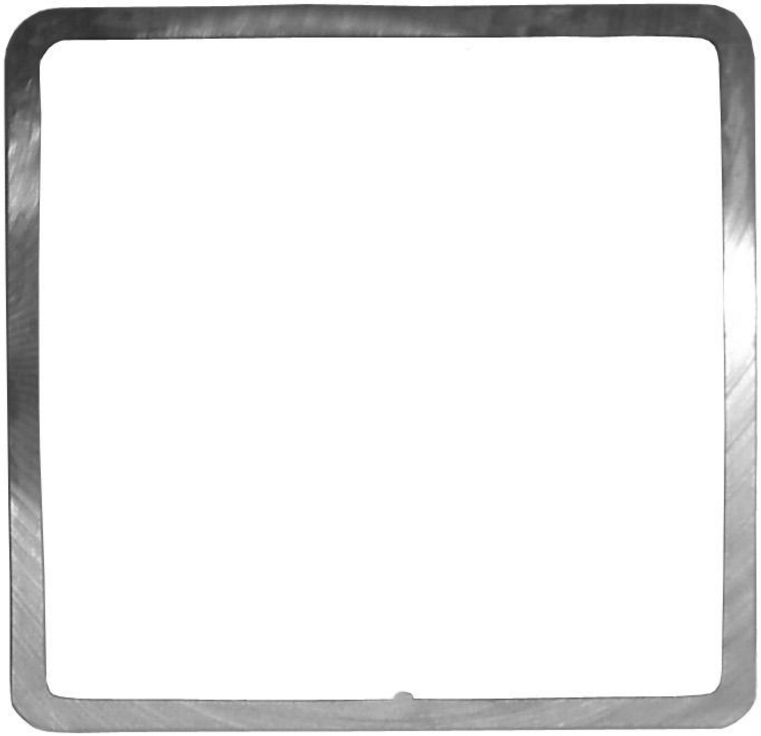
Cold Formed

Celsius 420

Advantages of Celsius Compared to Cold Formed

Technical Information

EN10219 Cold Formed products	EN10210 Hot Finished products
Hybox	Celsius



Advantages of Celsius Compared to Cold Formed

Technical Information

Comparison Hot and Cold for design - Sectional properties

EN10210 Hot finished EN 10219 Cold formed	**Area(A)** **cm^2**	**Moment of Inertia(I)** **cm^4**	**Elastic modulus(Z)** **cm^3**
120 x 120 x 8 RHS Hot Finished	**35.2**	**726**	**121**
120 x 120 x 8 RHS Cold Formed	33.6	677	113

Advantages of Celsius Compared to Cold Formed

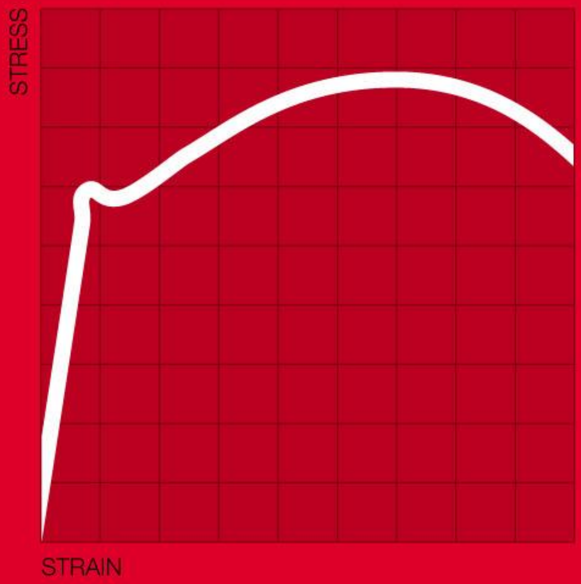
Mechanical properties

Hot finished

• Test results follow normal load extension characteristics with clear indication of yield strength.

• Gives the recommended ratio of yield to ultimate strength-0.84 maximum.

• High ductility-adequate warning of dangerous overload condition indicated by excessive deformation.

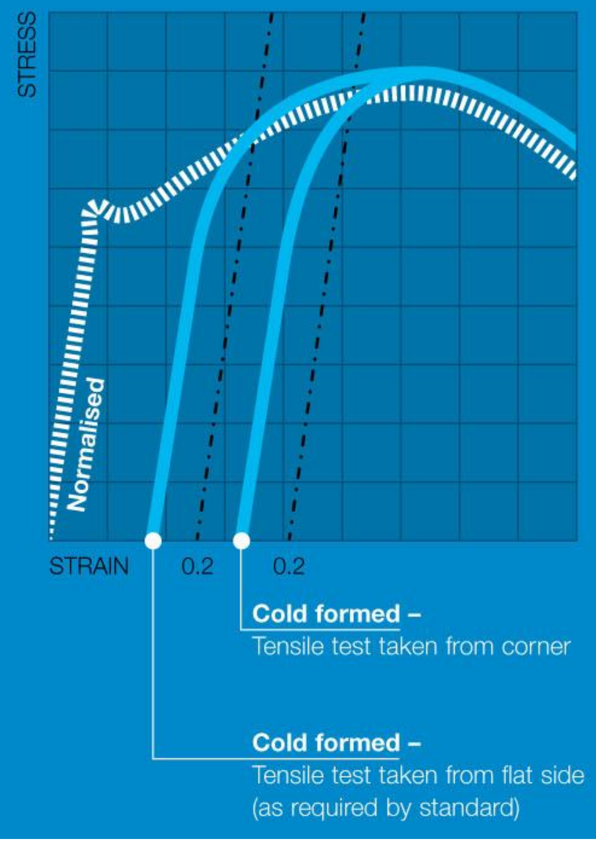


Normalised. Tensile test taken from flat side – Hot finished sections uniform across the section

Mechanical properties

Cold formed

- Test results differ in samples taken from corners and flat sides.
- There is no clear yield point-0.2% proof stress is normally quoted for yield strength.
- Increase in ratio of yield to ultimate strength-may be above that recommended by design standards.
- Lower ductility-less visible warning of dangerous overload condition-possibility of brittle fracture.



Effect of Cold working
(Taken from typical tensile tests)

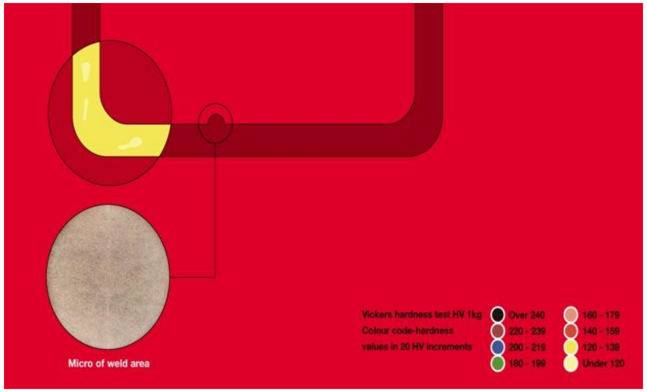
Advantages of Celsius Compared to Cold Formed

Comparison of strut capacity (kN) EC3

	λ bar	Hot finished S355J2H	Cold formed S355J2H	CF/HF Difference
120x120x5	0.8	641	526	0.82
120x120x10	0.8	1212	954	0.78
300x300x12.5	0.8	4011	3103	0.75
406.4 x 16	0.8	5536	4607	0.83

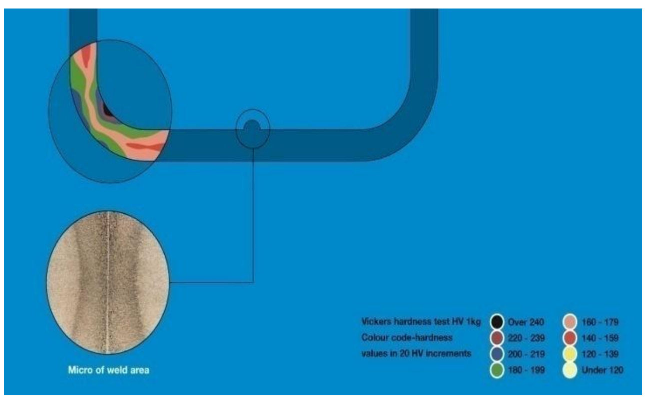
Advantages of Celsius Compared to Cold Formed

Structure & Hardness



Hot Finished products

- Uniform grain structure and hardness values
- Mechanical properties are stable and uniform across the whole section



Cold Formed products

- Varying grain structure and hardness values, particularly in the corners and seam weld area
- Mechanical properties vary across the section

Advantages of Celsius Compared to Cold Formed

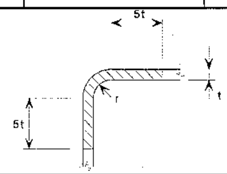
4.14 Welding in cold-formed zones

(1) Welding may be carried out within a length 5t either side of a cold-formed zone, see Table 4.2, provided that one of the following conditions is fulfilled:

- the cold-formed zones are normalized after cold-forming but before welding;
- the *r/t*-ratio satisfy the relevant value obtained from Table 4.2.

Table 4.2: Conditions for welding cold-formed zones and adjacent material

r/t	Strain due to cold forming (%)	Maximum thickness (mm)		
		Generally		Fully killed Aluminium-killed steel (Al ≥ 0,02 %)
		Predominantly static loading	Where fatigue predominates	
≥ 25	≤ 2	any	any	any
≥ 10	≤ 5	any	16	any
≥ 3,0	≤ 14	24	12	24
≥ 2,0	≤ 20	12	10	12
≥ 1,5	≤ 25	8	8	10
≥ 1,0	≤ 33	4	4	6



AC2 NOTE Cold formed hollow sections according to EN 10.219 which do not satisfy the limits given in Table 4.2 can be assumed to satisfy these limits if these sections have a thickness not exceeding 12,5 mm and are Al-killed with a quality J2H, K2H, MH, MLH, NH or NLH and further satisfy C ≤ 0,18%, P ≤ 0,020% and S ≤ 0,012%.

In other cases welding is only permitted within a distance of 5t from the corners if it can be shown by tests that welding is permitted for that particular application. AC2

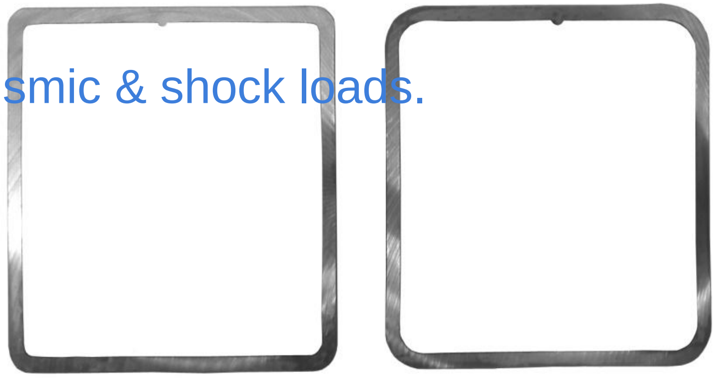
Eurocode

EC3-1-8 table 4.2 (including corrigenda feb 2010)

Advantages of Celsius Compared to Cold Formed

Comparison between Hot & Cold

- Hot Finished Celsius - has no residual stresses from manufacturing.
- Hot Finished Celsius - has uniform grain structure and hardness
- Hot Finished Celsius - has tighter corner profile (2T max – Celsius).
- Hot Finished Celsius - has higher geometric properties.
- Hot Finished Celsius - has higher load capacity.
- Hot Finished Celsius - is fully weldable at corners
- Hot Finished Celsius - has superior ductility for seismic & shock loads.
- Hot Finished Celsius - has greater fire resistance.



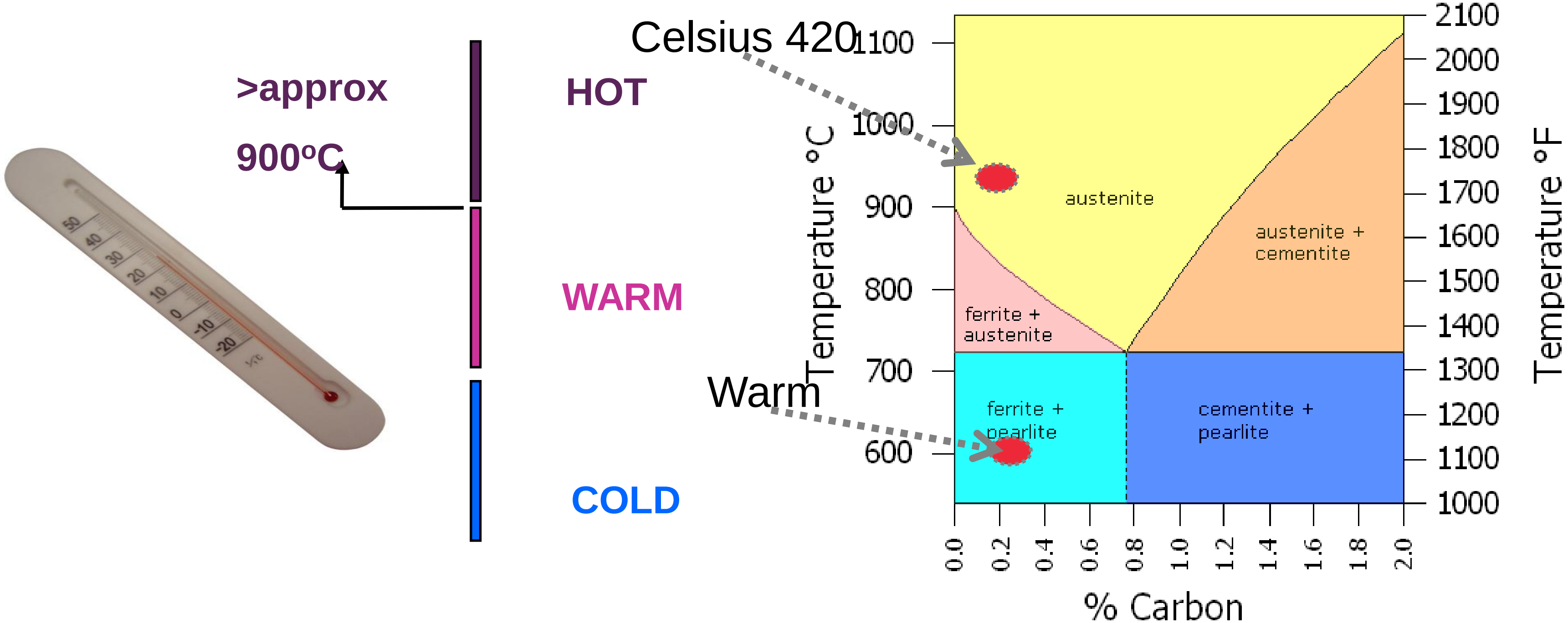
Advantages of Celsius Compared to Cold Formed

Technical Information

The Celsius 420 is full body normalised and final shaped at a high temperature ensuring that the product is fully stress relieved.

The product Standard EN10210 does allow for warm/ stress relieved which will not give the same consistent values as Celsius.

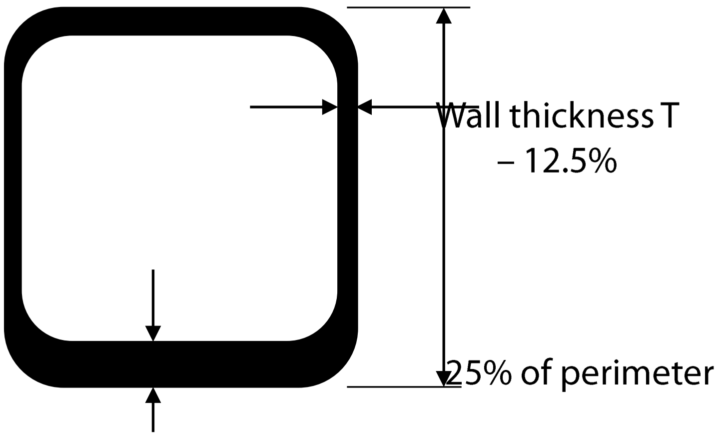
The warm product is manufactured cold then shaped giving similar disadvantages for manufacture as the cold product



Advantages of Celsius Compared to Warm/ Stress relieved products

Technical Information

The Celsius 420 is a true full body normalised hot finished structural hollow section. It should be compared more with the seamless tube than warm and cold. When we compare the Celsius 420 against the seamless product due to the consistent manufacture it has better tolerances. The product standard EN10210 recognises this and the Celsius has better tolerances.



- **Celsius 420®** has better control on wall thickness (seamless can be up to -12,5% over 25% of perimeter)
- **Celsius 420®** has a uniform wall thickness and thus a concentric “Bore”. Seamless sections may be more difficult in fabrication
- **Celsius 420®** sections have a finish similar to original strip condition whereas seamless finish is typical of a hot rolling process
- **Celsius 420®** has tighter tolerance on supplied length (0/+150mm) versus seamless (+/-500mm)
- **Celsius 420®** has full chemical composition stated on inspection certificate

Advantages of Celsius Compared to Seamless

TATA STEEL

TATA

Paul Watson MEng CEng MIStructE

Welded Joints In Tubular Steel

Steve Whitfield Beng (Hons) CEng MIStructE

Customer Technical Services - Manager

Overview

Introduction

Emirates Stadium

Long span trusses

Gloucester Quays

Speed and simplicity of construction

M8 Footbridge Harthill

Speed and simplicity of construction

M8 Footbridge Harthill

Quality control

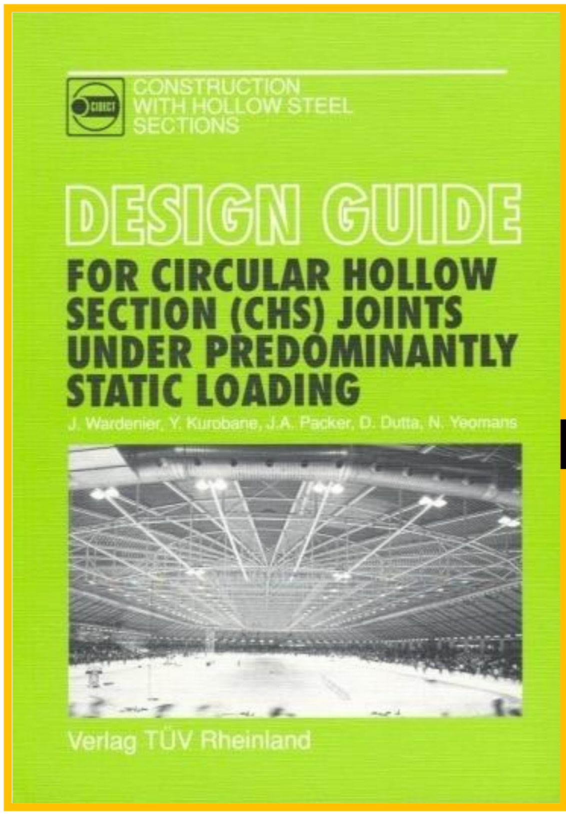
M8 Footbridge Harthill

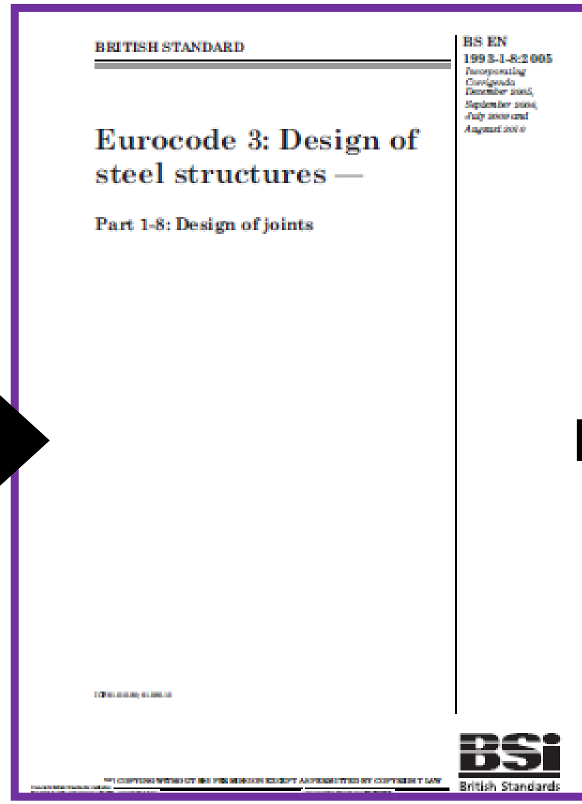
Lifting

Eurocode 3 Part 1-8

Design Guidance

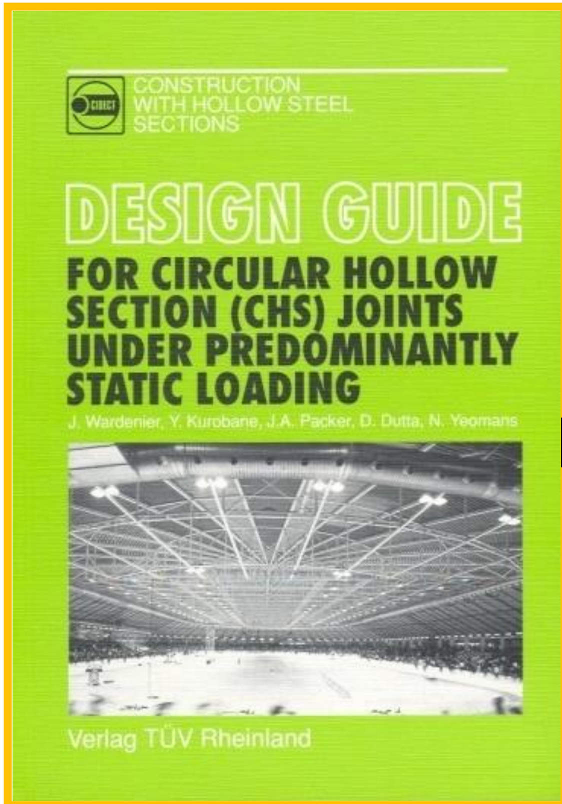
Evolution

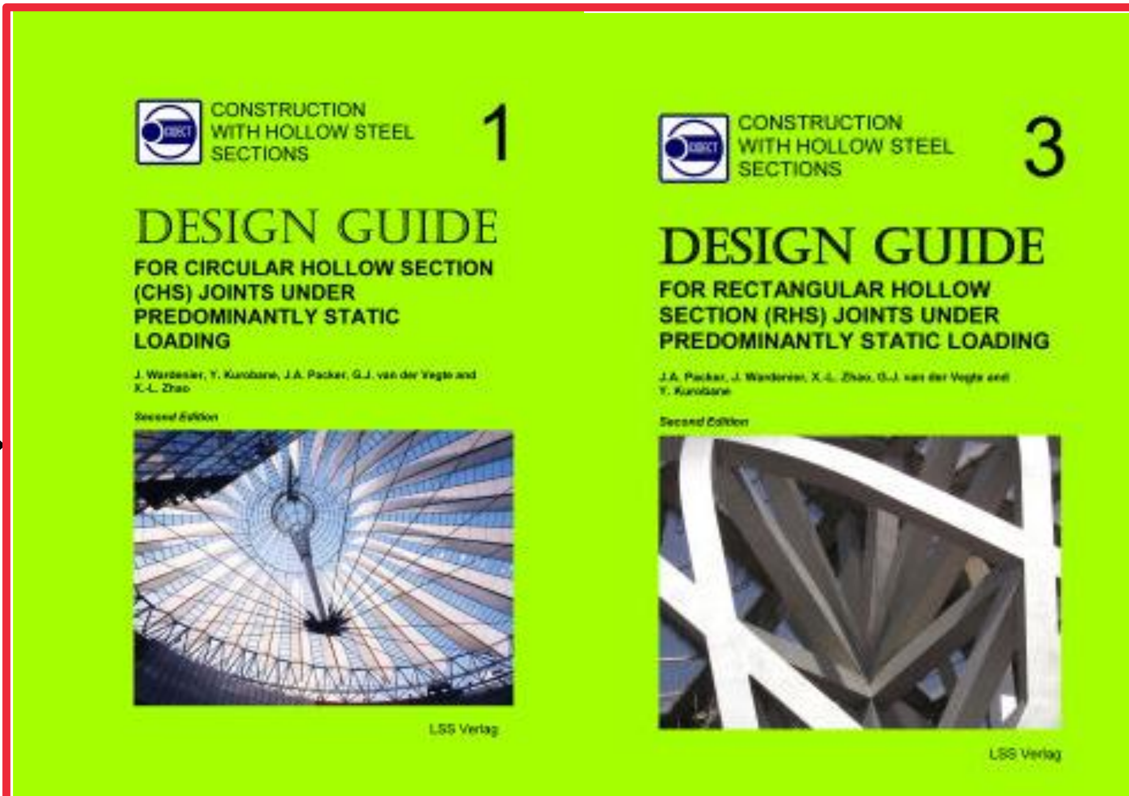




Design Guidance

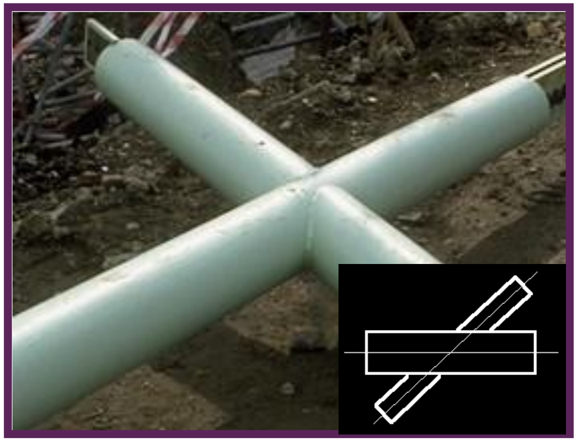
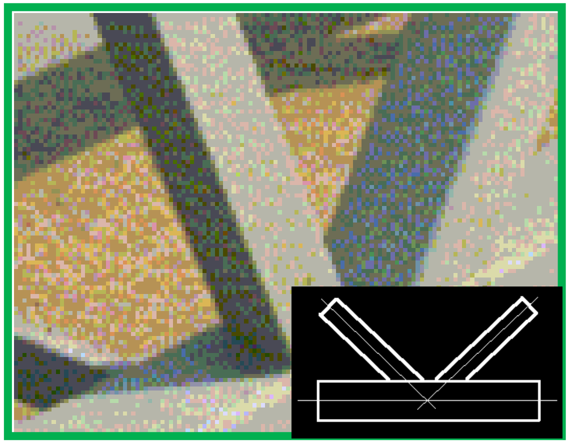
Second Edition Cidect Design Guides





Typical Joints

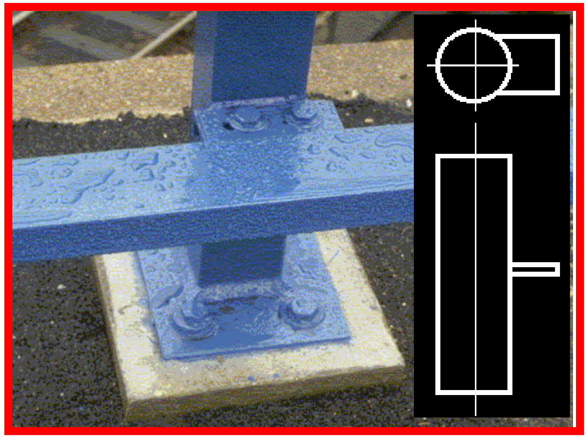
Lattice Girders

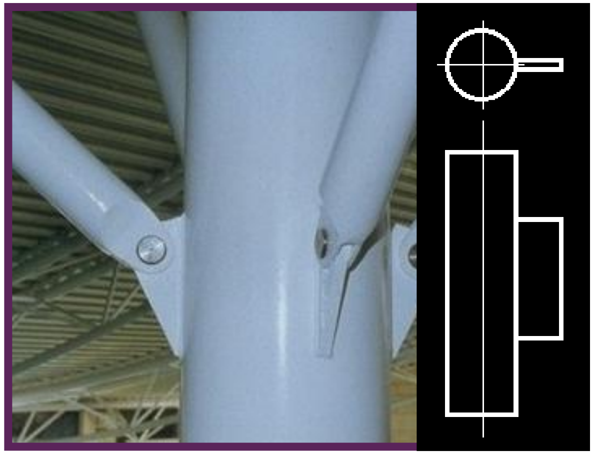




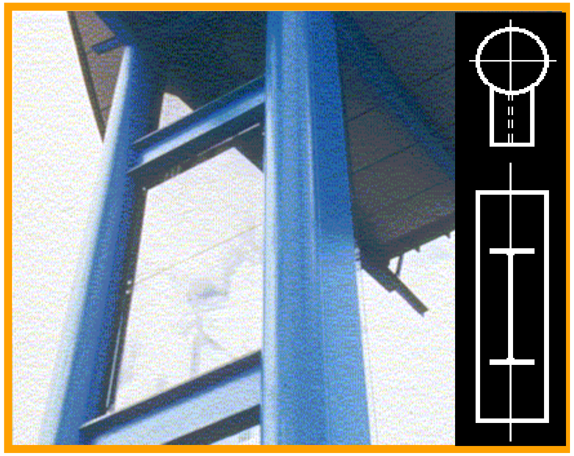
T or Y-Joint ➡ X-Joint ➡ Gap K-Joint

Typical Joints

Miscellaneous







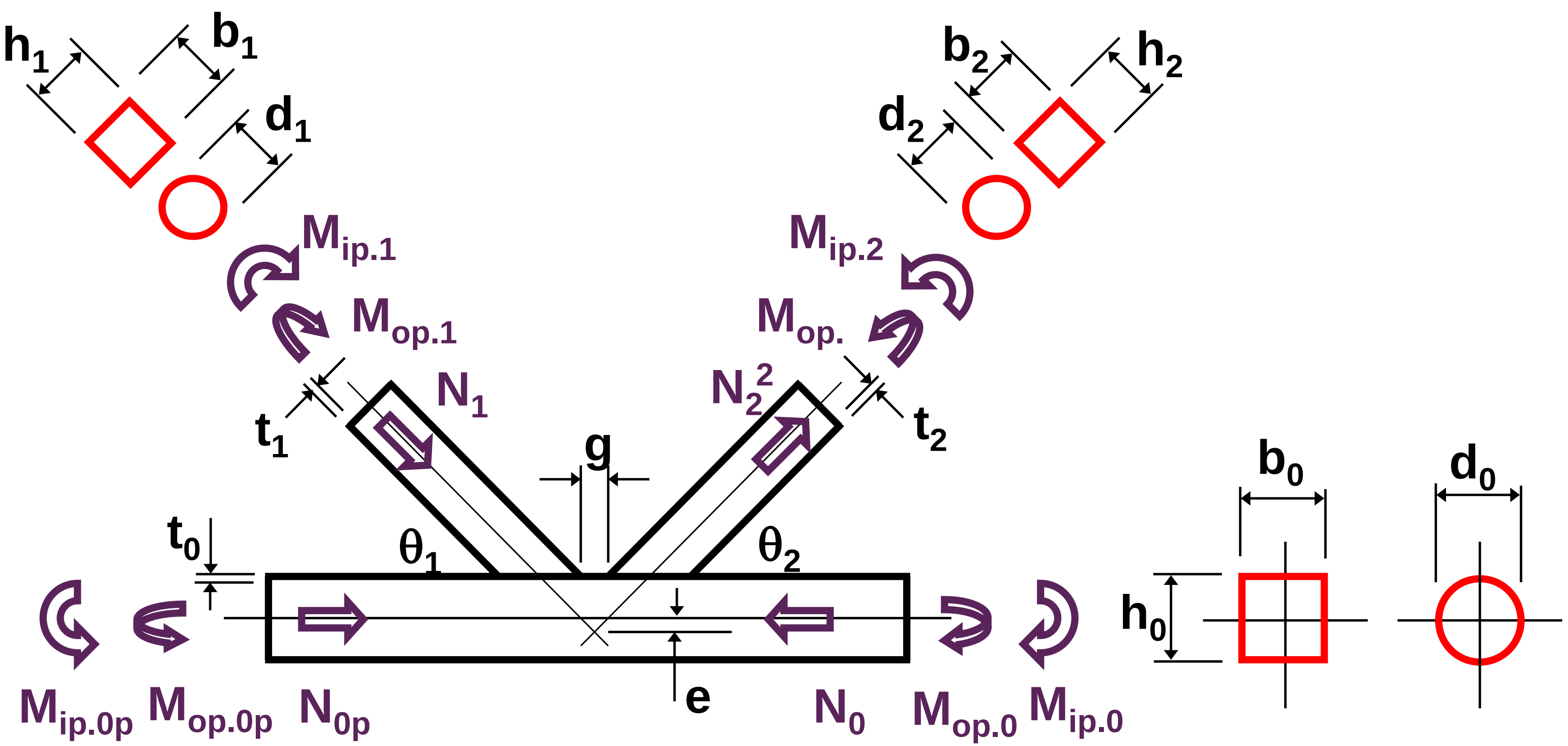
Transverse Gusset Plate

Longitudinal Gusset Plate

I or H Bracing

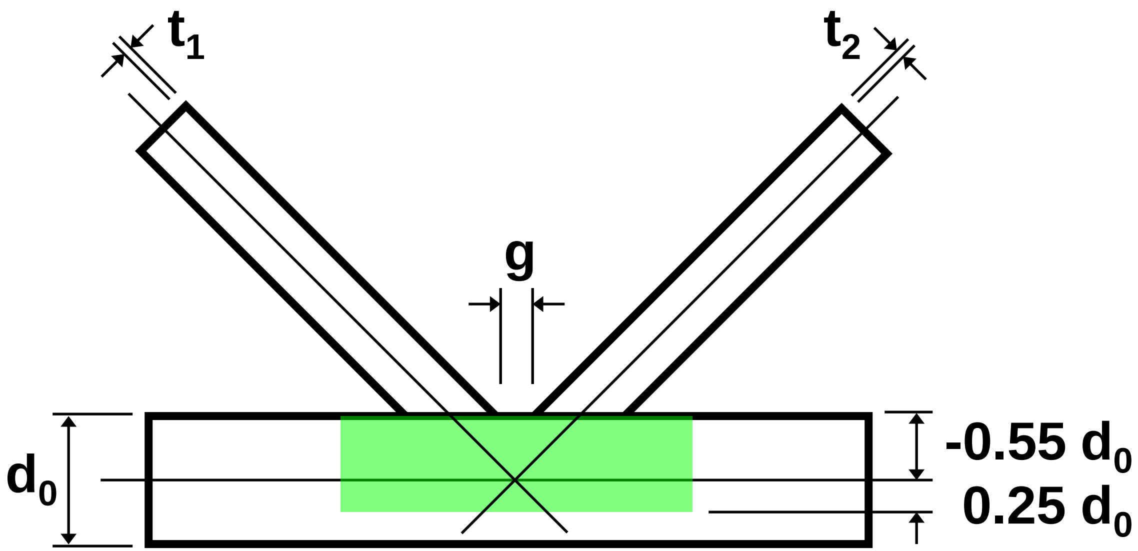
Joint Symbols

Brace 1 usually compression brace



Eccentricity & Effects On Geometry

Parameters

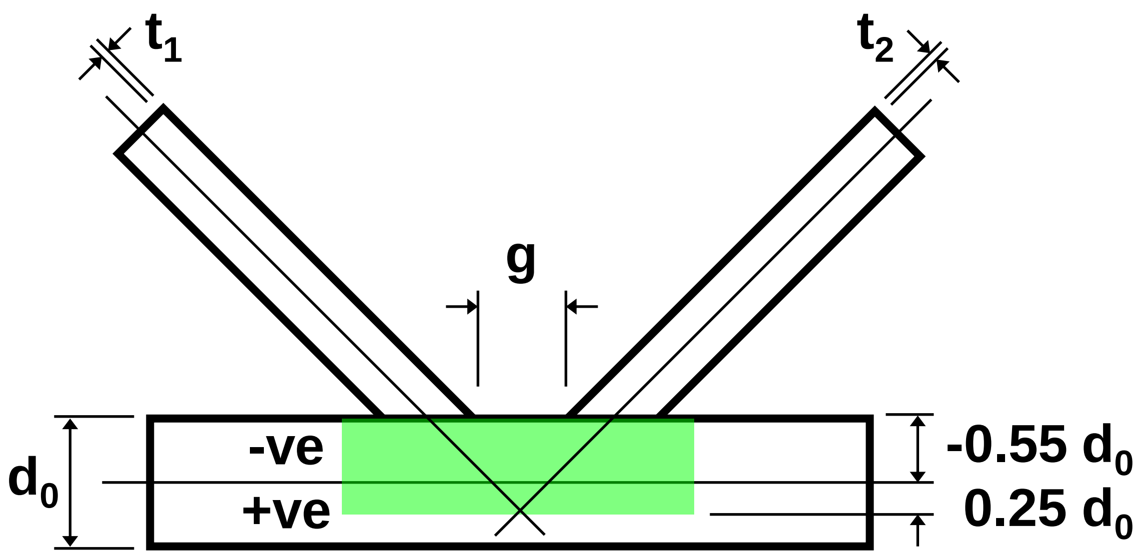


Joint with e = 0

Eccentricity limit:	$-0.55 \leq e/d_0 \leq 0.25$ (shaded)
Gap limits:	$g \geq t_1 + t_2$
	$0.5(1-\beta) \leq g/b_0 \leq 1.5(1-\beta)$
Overlap limit:	$25\% \leq Ov \leq 100\%$

Eccentricity & Effects On Geometry

Positive eccentricity – gap joint



Increase gap

Eccentricity limit: $-0.55 \le e/d_0 \le 0.25$

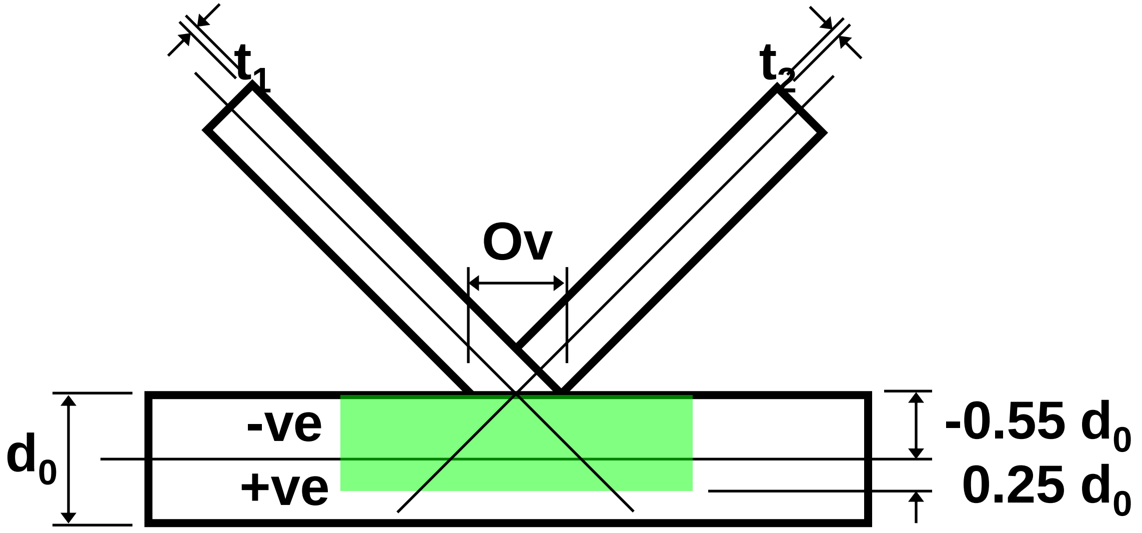
Gap limits: $g \ge t_1 + t_2$

$0.5(1-\beta) \le g/b_0 \le 1.5(1-\beta)$

Overlap limit: $25\% \le Ov \le 100\%$

Joint Symbols

Negative eccentricity – overlap joint



Overlap (100%)

Eccentricity limit: $-0.55 \leq e/d_0 \leq 0.25$

Gap limits: $g \geq t_1 + t_2$

$0.5(1-\beta) \leq g/b_0 \leq 1.5(1-\beta)$

Overlap limit: $25\% \leq Ov \leq 100\%$

Fabrication Costs

Bracing Handling, Cutting and Welding

Fabrication Cost	Type of Joint
	RHS chord - gap joints
	RHS chord – 100% overlap joints
	CHS chord – gap joints
	RHS chord – partial overlap joints
	CHS chord – 100% overlap joints
	CHS chord – partial overlap joints

Laser Cutting

Repeatability

High Volume Manufacturing

Versatility - Ease of assembly

Speed

Reduced Weld preparation

Can cut bent tube

Fabrication Costs

Bracing Handling, Cutting and Welding

Fabrication Cost	Type of Joint
	RHS chord - gap joints
	RHS chord – 100% overlap joints
	CHS chord – gap joints
	RHS chord – partial overlap joints
	CHS chord – 100% overlap joints
	CHS chord – partial overlap joints

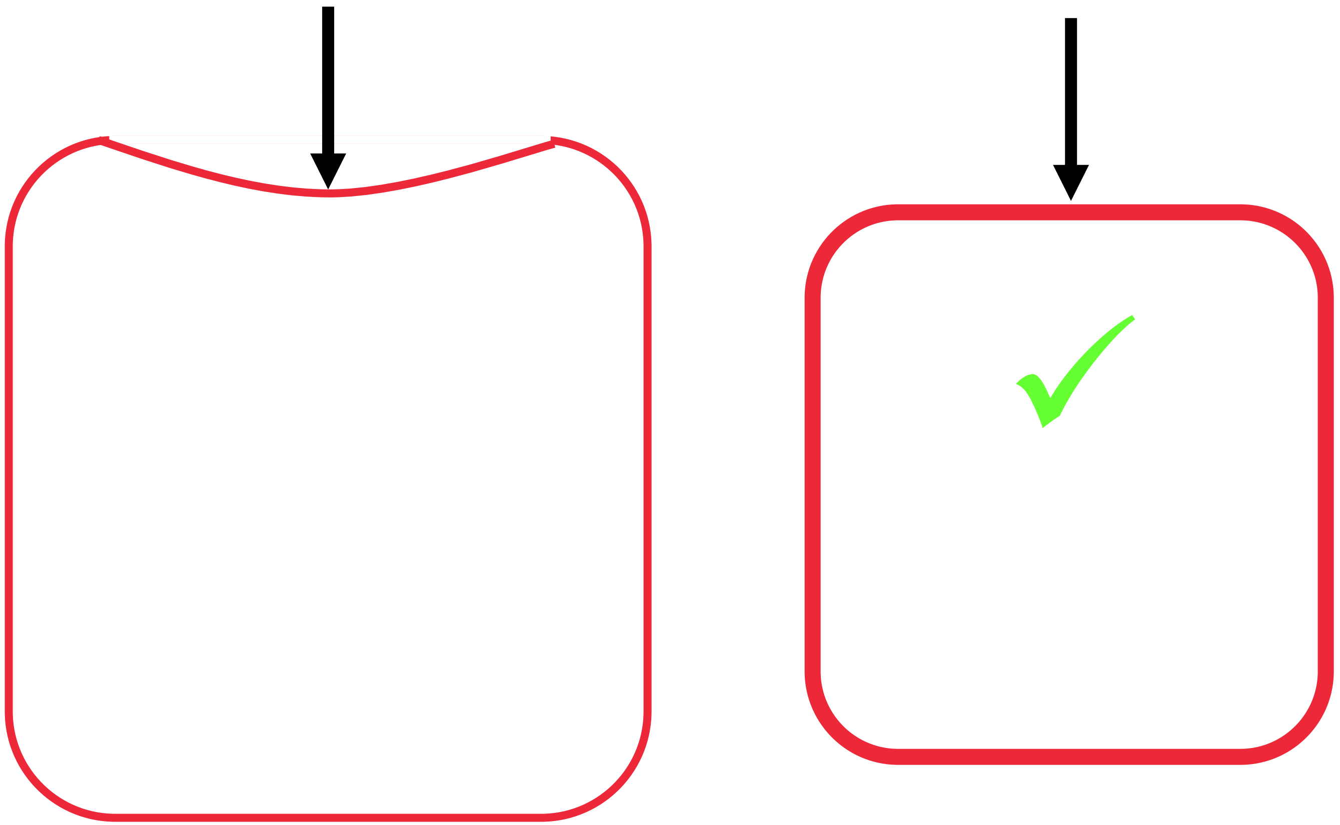
Parameter Effects

Gap Joints

Parameter	Direction	Effect
Chord width to thickness ratio	Down	Capacity up
Bracing to chord width ratio	Up	Capacity up
Bracing angle	Down	Capacity up
Chord factored to yield stress ratio	Less compressive	Capacity up

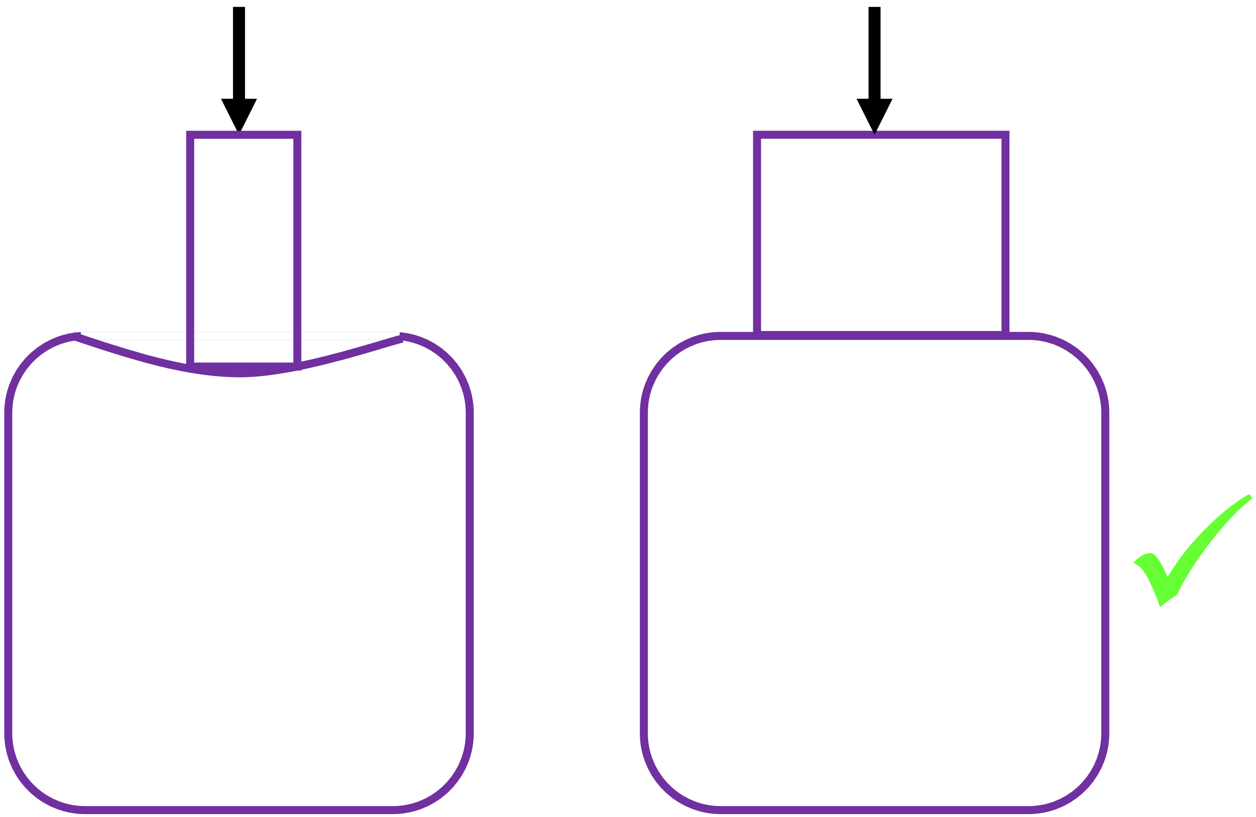
Parameter Effects – Gap Joints

Chord width to thickness ratio



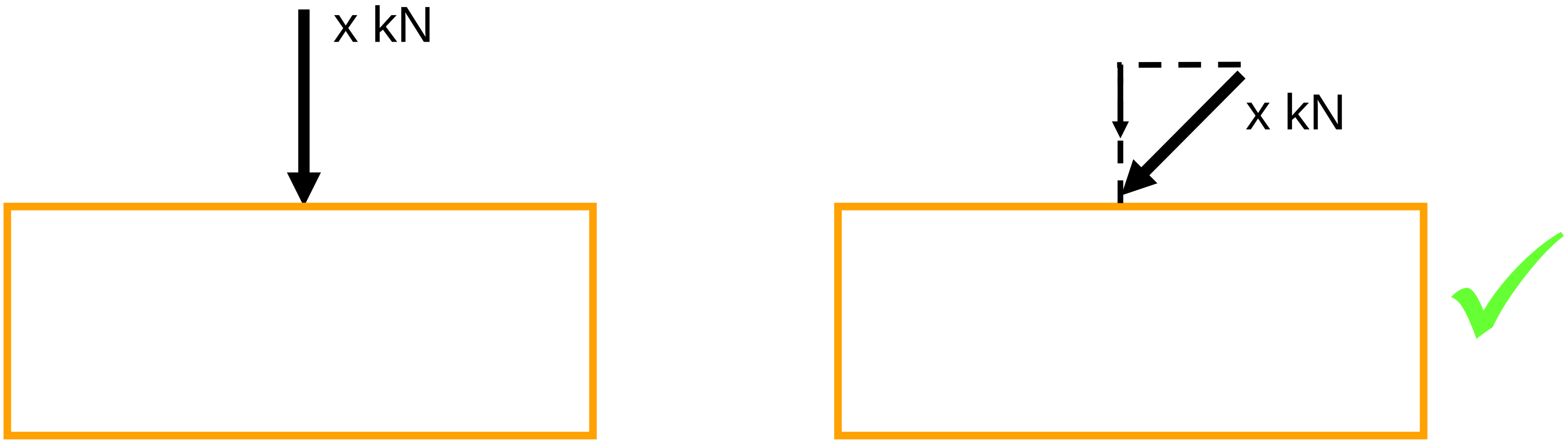
Parameter Effects – Gap Joints

Bracing to chord width ratio



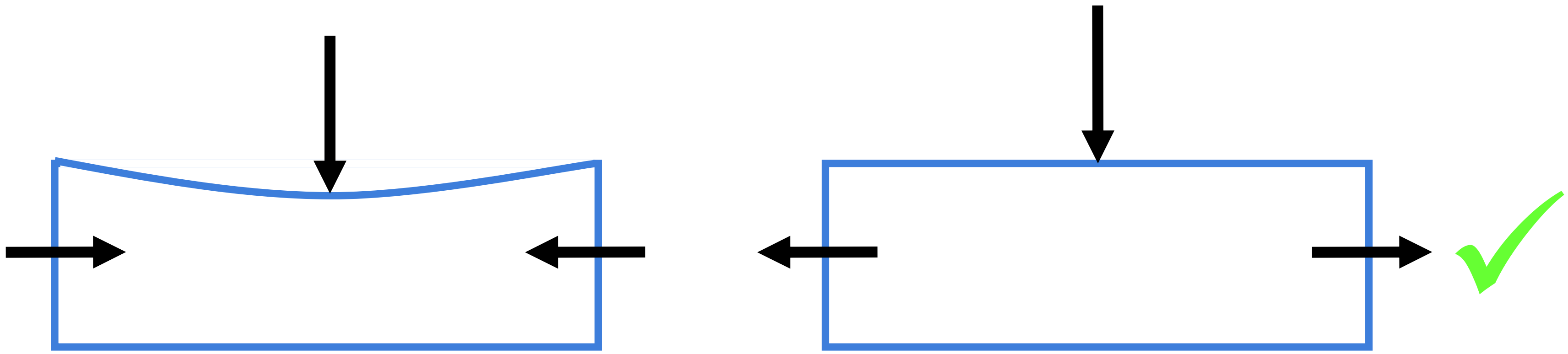
Parameter Effects – Gap Joints

Bracing angle



Parameter Effects – Gap Joints

Chord factored to yield stress ratio



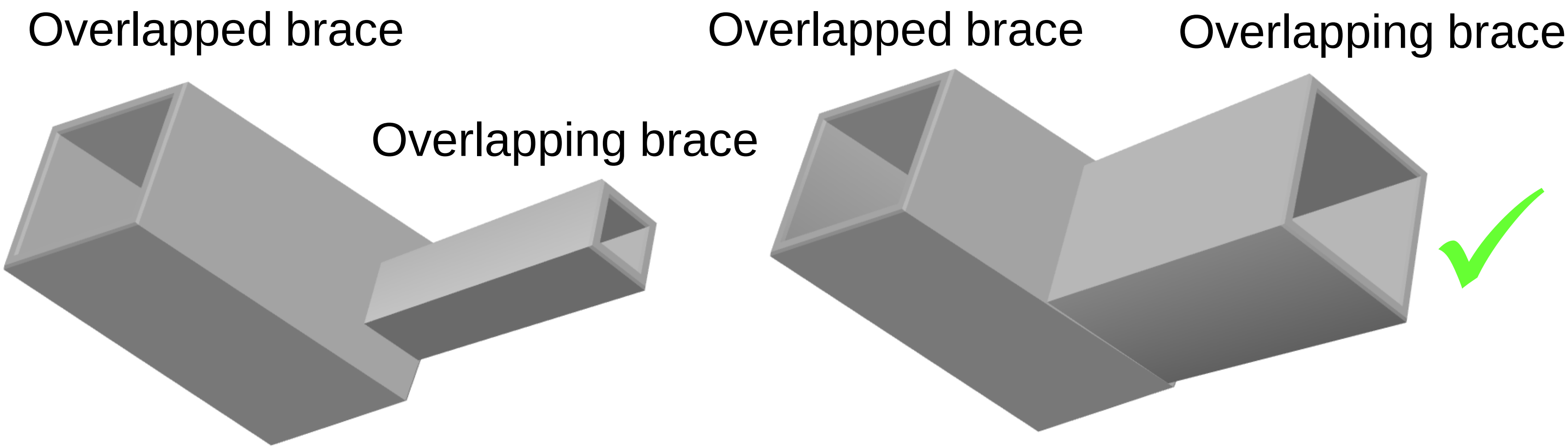
Parameter Effects

Overlap Joints

Parameter	Direction	Effect
Chord width to thickness ratio	Down	Capacity up
Bracing width ratios	Down	Capacity up
Overlap	Up	Capacity up
Chord factored to yield stress ratio	Less compressive	Capacity up (CHS only)
Bracing angle	Down	Capacity up (CHS only)

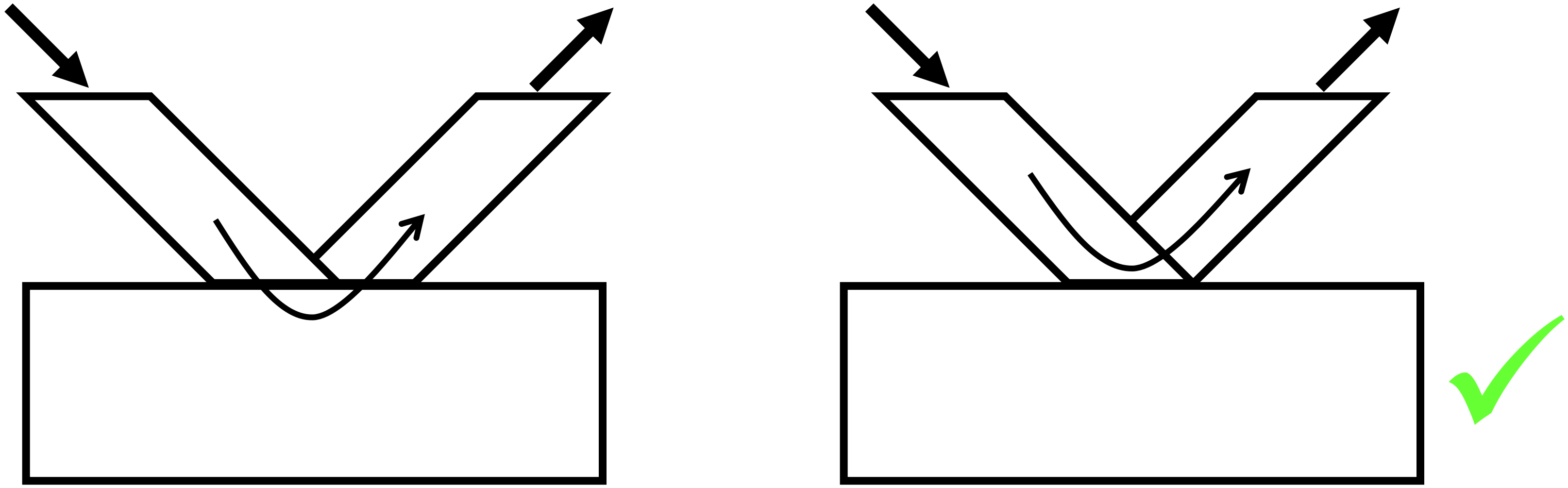
Parameter Effects – Overlap Joints

Bracing width ratios

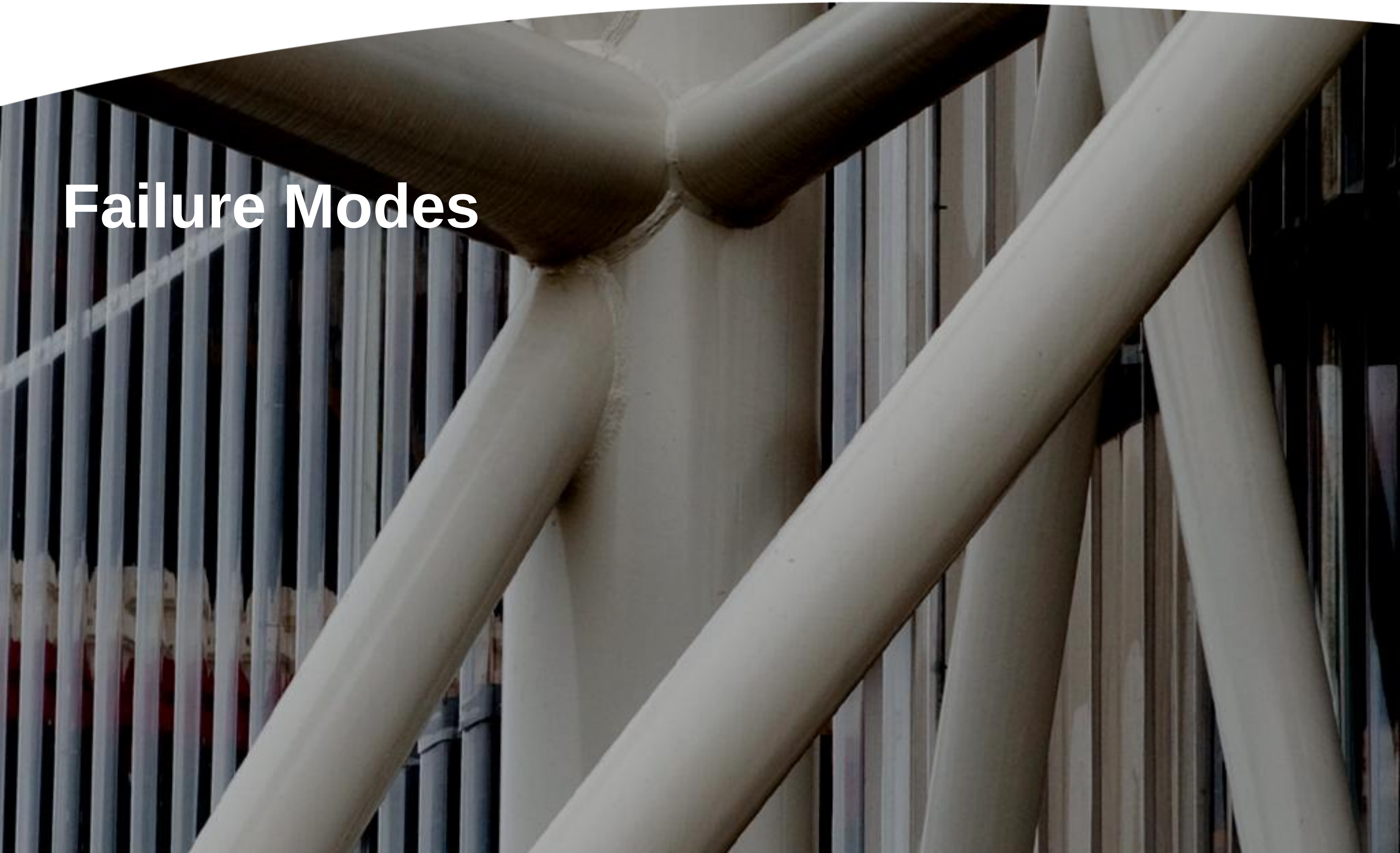


Parameter Effects – Overlap Joints

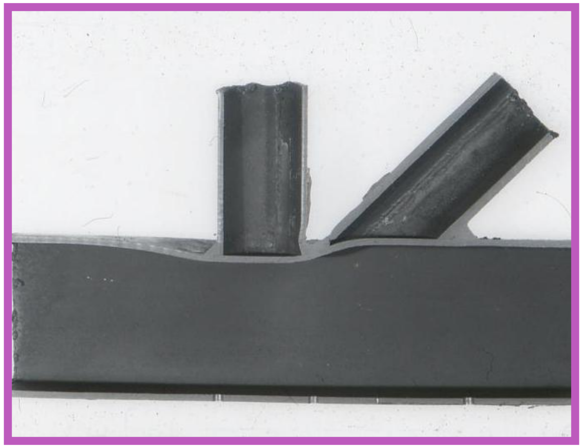
Overlap percentage



Failure Modes

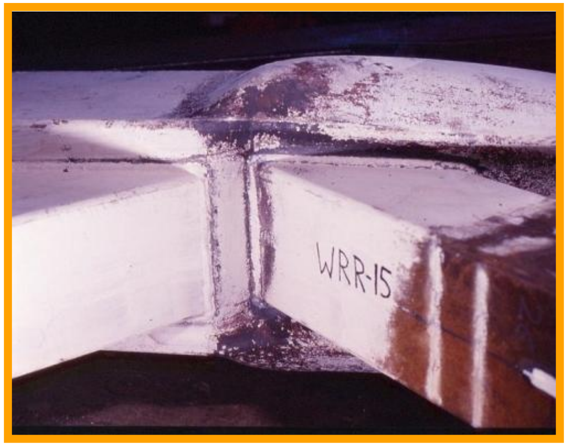


Failure modes



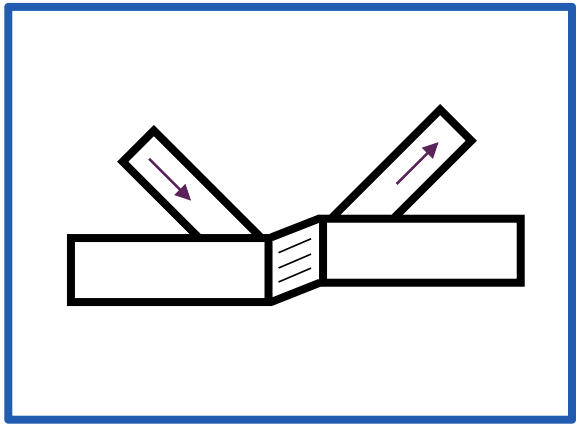
Chord Face Deformation

Chord Punching Shear



Chord Side Wall Buckling

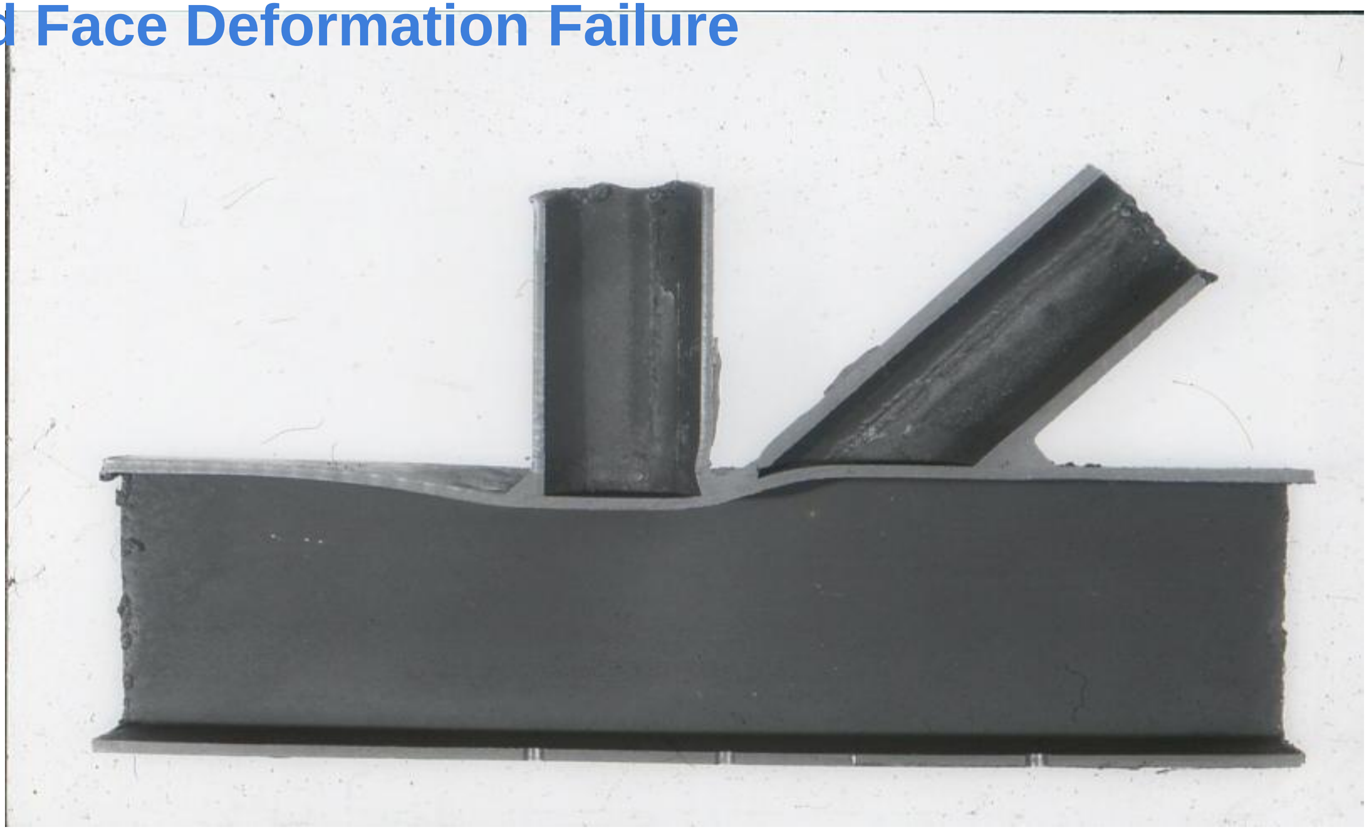
Chord or brace localised buckling



Chord Shear

Bracing Effective Width

Chord Face Deformation Failure



Also known as chord face yielding. This is the chord face deflecting under the bracing load. The formula limits the chord face deflection to 3% of the chord width as the deformation can be substantial without failing but it would not be practical to allow such deformation. Common for T, Y-joints and gap K, N-joints with the bracing to chord width ratio less than 0.85.

Chord Punching Shear

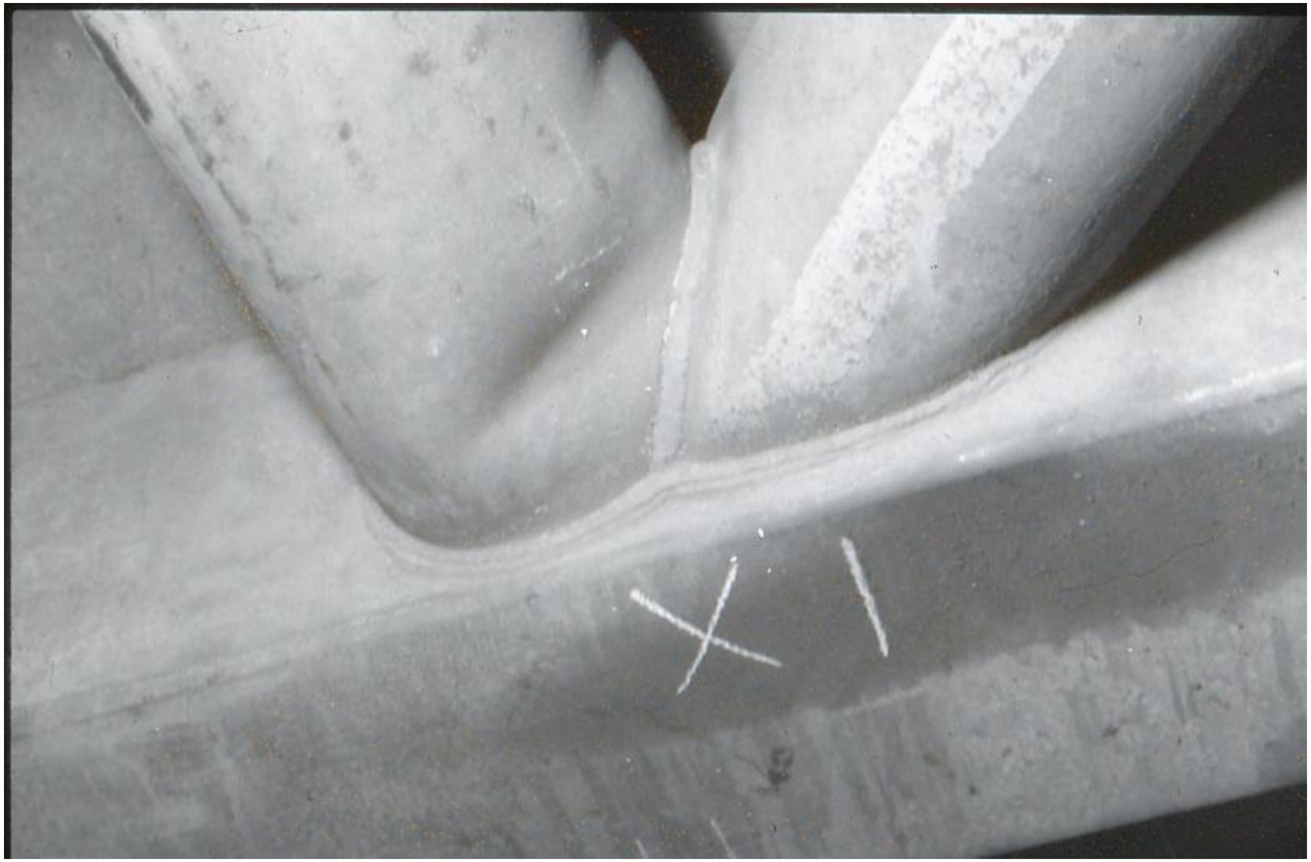
The chord has sheared not the weld.

Where the bracing punches through the chord face. This occurrs on the tension brace, important to realise it applies to compression and tension bracings. Shear can occur when the brace is pulling just the same as when the brace is pushing. Not usually critical but can occur when the chord width to thickness ratio is small.

Chord Side Wall Buckling

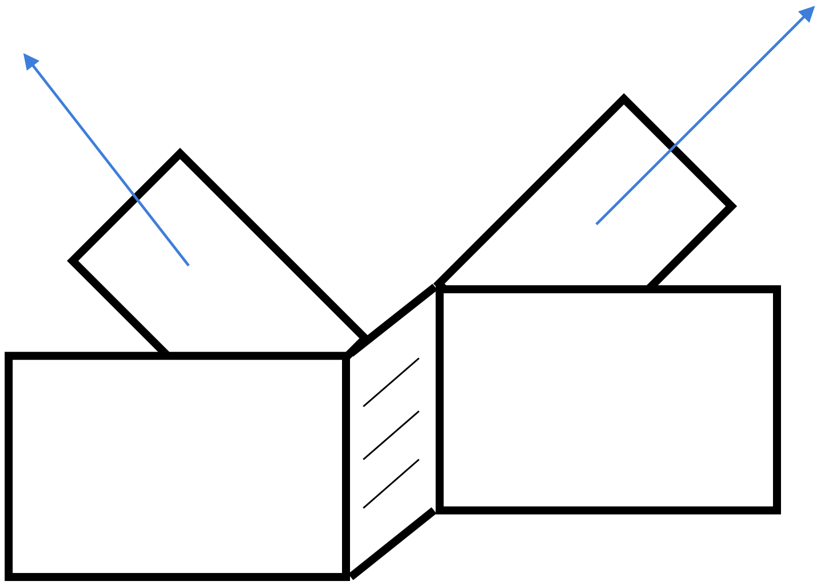
Typically a gap joint or single brace with beta ratio (brace width to chord width ratio) >0.85 as in this example. The chord side wall under the compression brace acts as a strut and if the chord side wall is too thin and tall it will buckle under the compressive load.

Chord or Bracing Localised Buckling



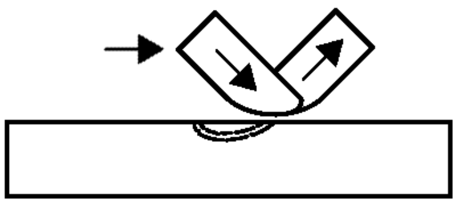
Due to a non-uniform stress distribution at the joint but does not occur providing the joint parameters are met.

Chord Shear



Not often critical unless RHS chords with width greater than depth are used. Does not occur for CHS joints if within parameters.

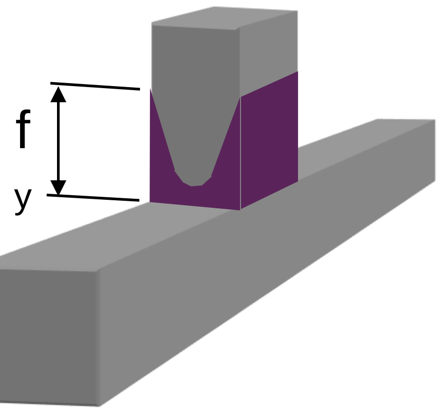
Horizontal Shear

Mode	Description
Shear of overlapping bracings	

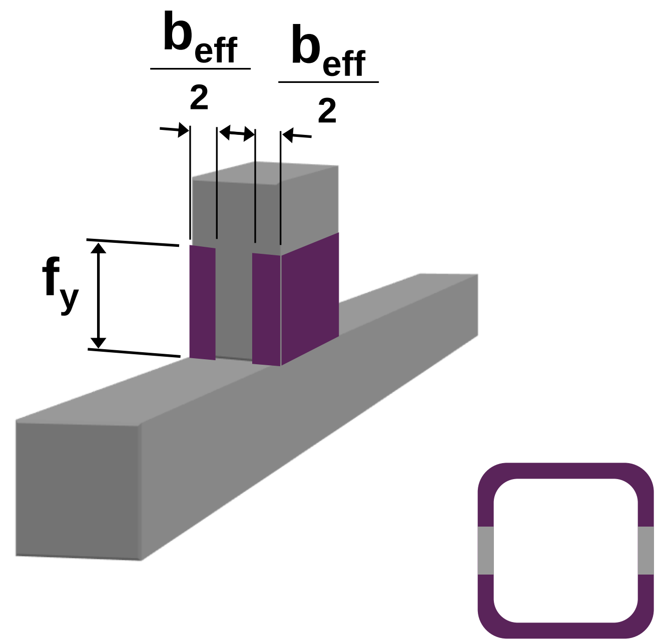
- **Local shear of overlapping bracings**, figure 17, is due to the horizontal component from the bracing forces shearing. This failure mode becomes critical for large overlaps, over 80% or 60% depending if the hidden toe of the overlapped bracing is welded to the chord

Failure modes

Bracing effective width RHS/SHS Chord



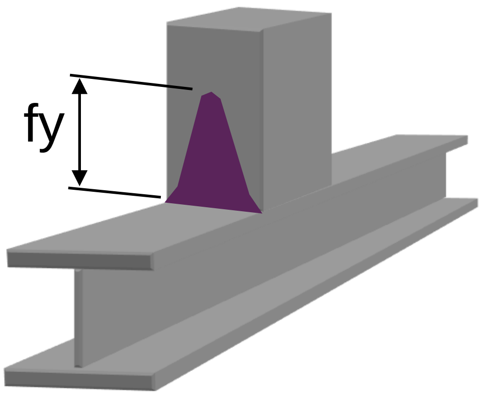
Axial stress distribution



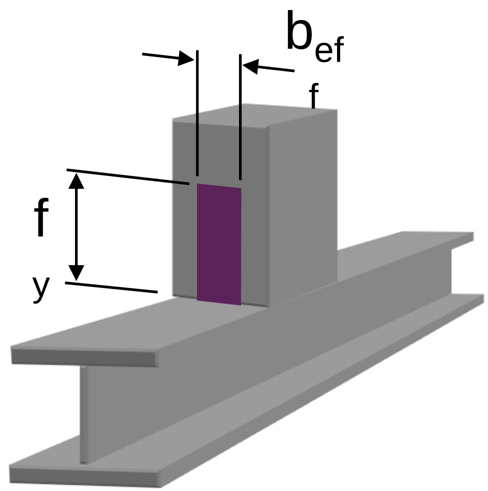
Hypothetical
axial stress distribution

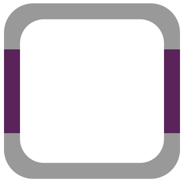
Failure modes

Bracing effective width UB/UC Chord



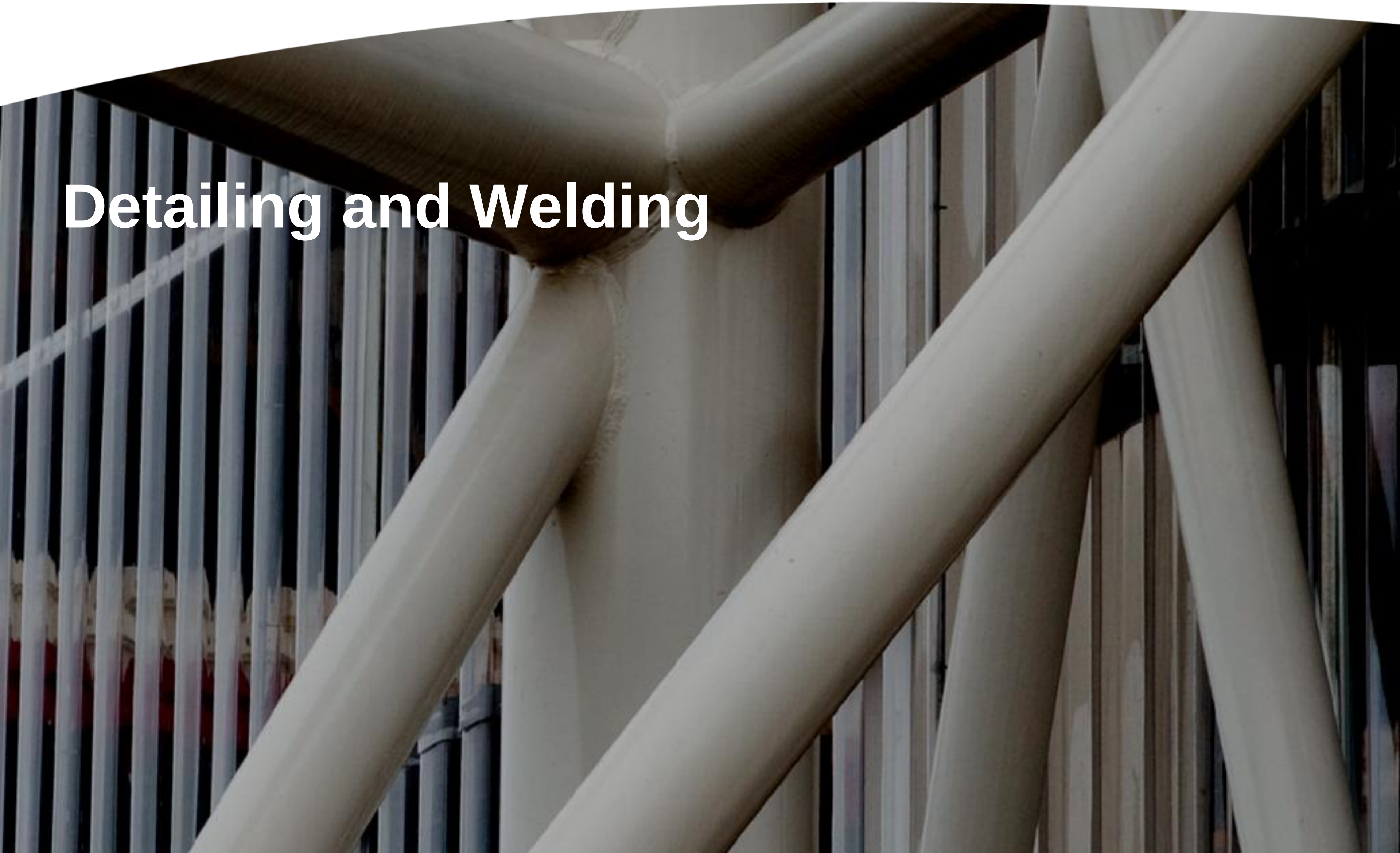
Axial stress distribution





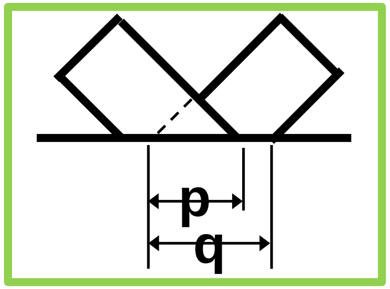
Hyperthetical
axial stress distribution

Detailing and Welding



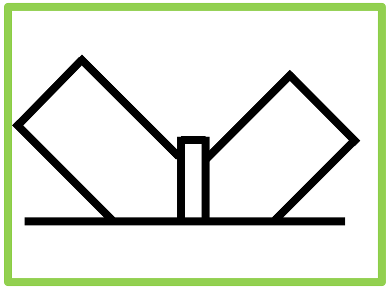
Detailing

Overlaps



- Overlap = p
- Overlap % = p/q x 100

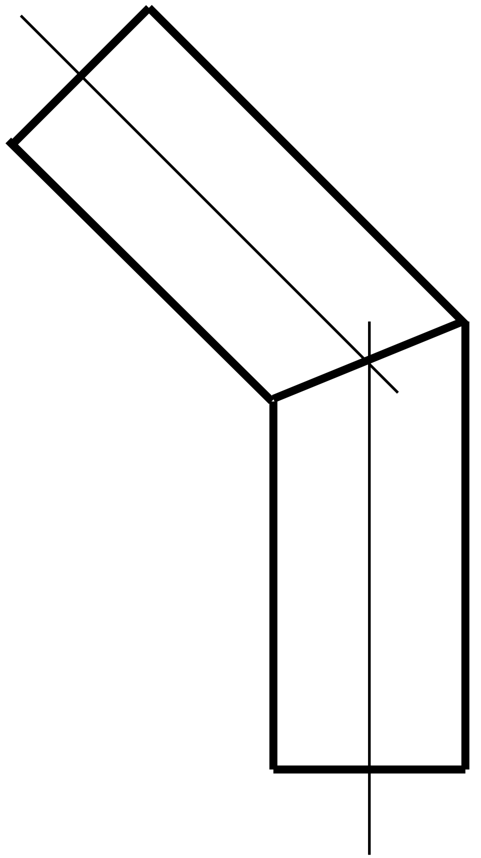
- Overlap bracings should NEVER be made like this
- Difficult to fabricate
- Up to 20% weaker



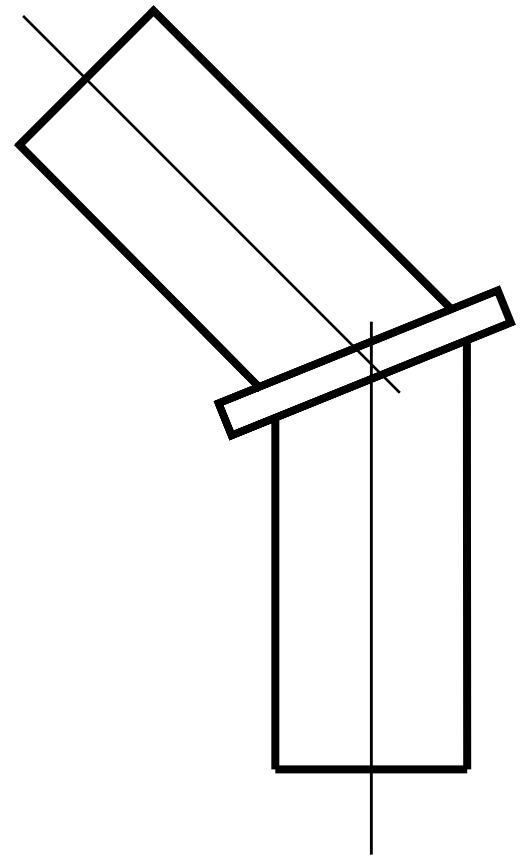
- Use division plate as alternative
- Helps to reinforce joint

Detailing

Knee Joints



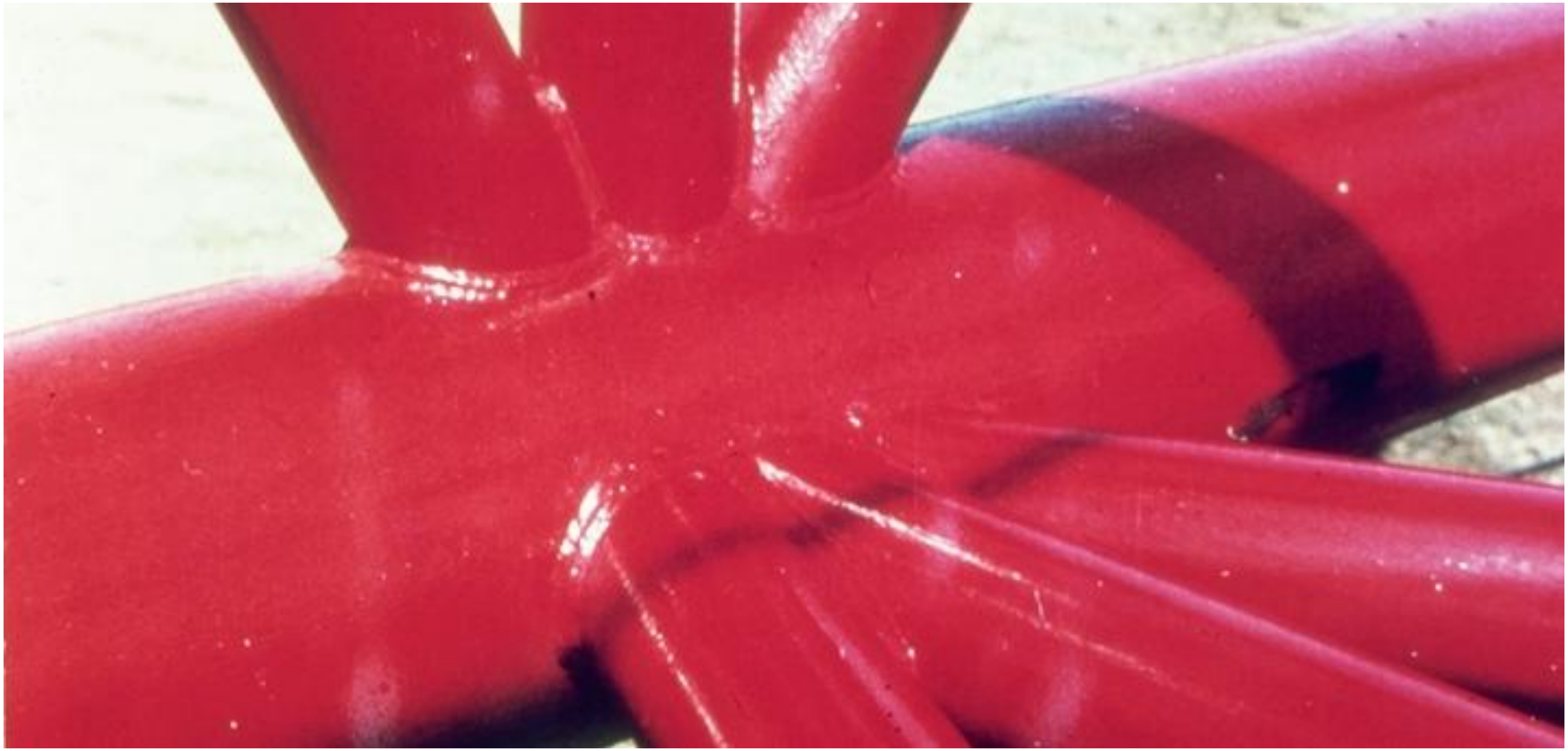
Un-reinforced Knee



Reinforced Knee

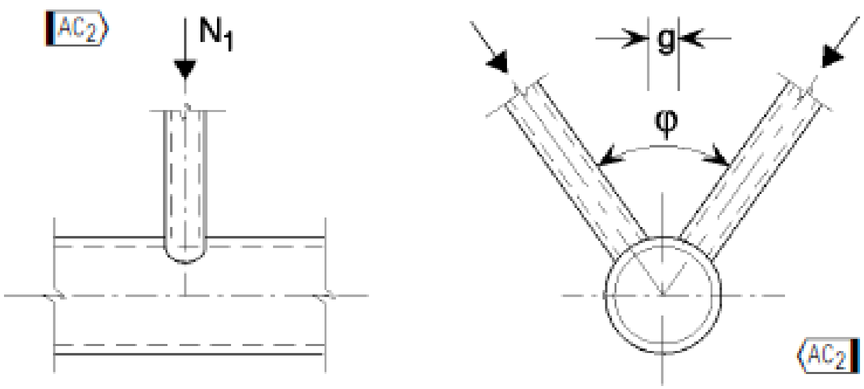
Detailing

Multiplanar joints



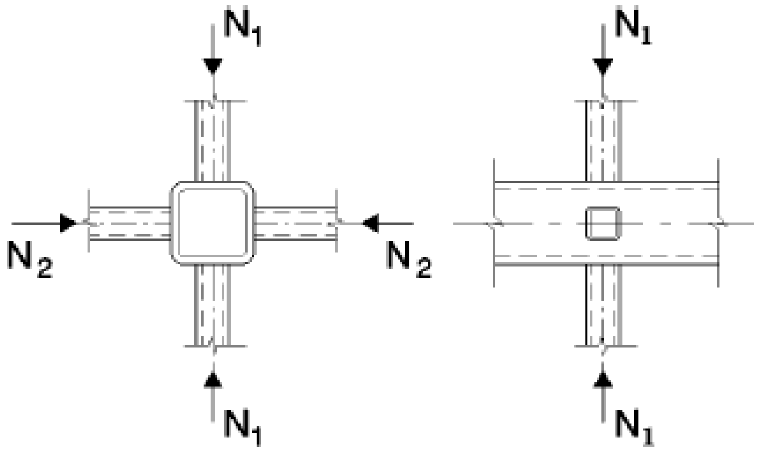
Multiplanar Joints

TT Joint

TT joint	$60° \leq \varphi \leq 90°$
Member 1 may be either tension or compression. 	$\mu = 1,0$

Multiplanar Joints

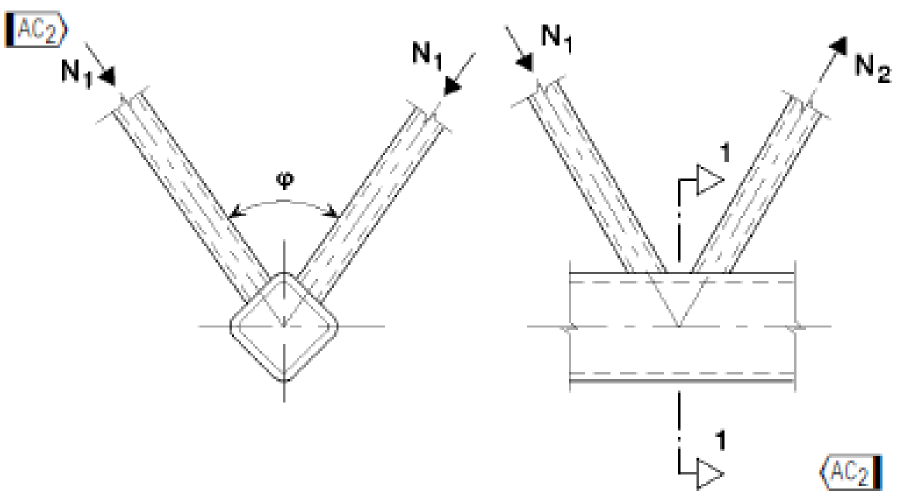
XX Joint

XX joint	
Members 1 and 2 can be either in compression or tension. $N_{2,\mathrm{Ed}}/N_{1,\mathrm{Ed}}$ is negative if one member is in tension and one in compression. AC2  AC2	$$\mu = 0{,}9\left(1 + 0{,}33 N_{2,Ed} / N_{1,Ed}\right)$$ taking account of the sign of $N_{1,\mathrm{Ed}}$ and $N_{2,\mathrm{Ed}}$ where $\lvert N_{2,\mathrm{Ed}} \rvert \leq \lvert N_{1,\mathrm{Ed}} \rvert$

Multiplanar Joints

KK Joint

KK joint $60° \leq \varphi \leq 90°$



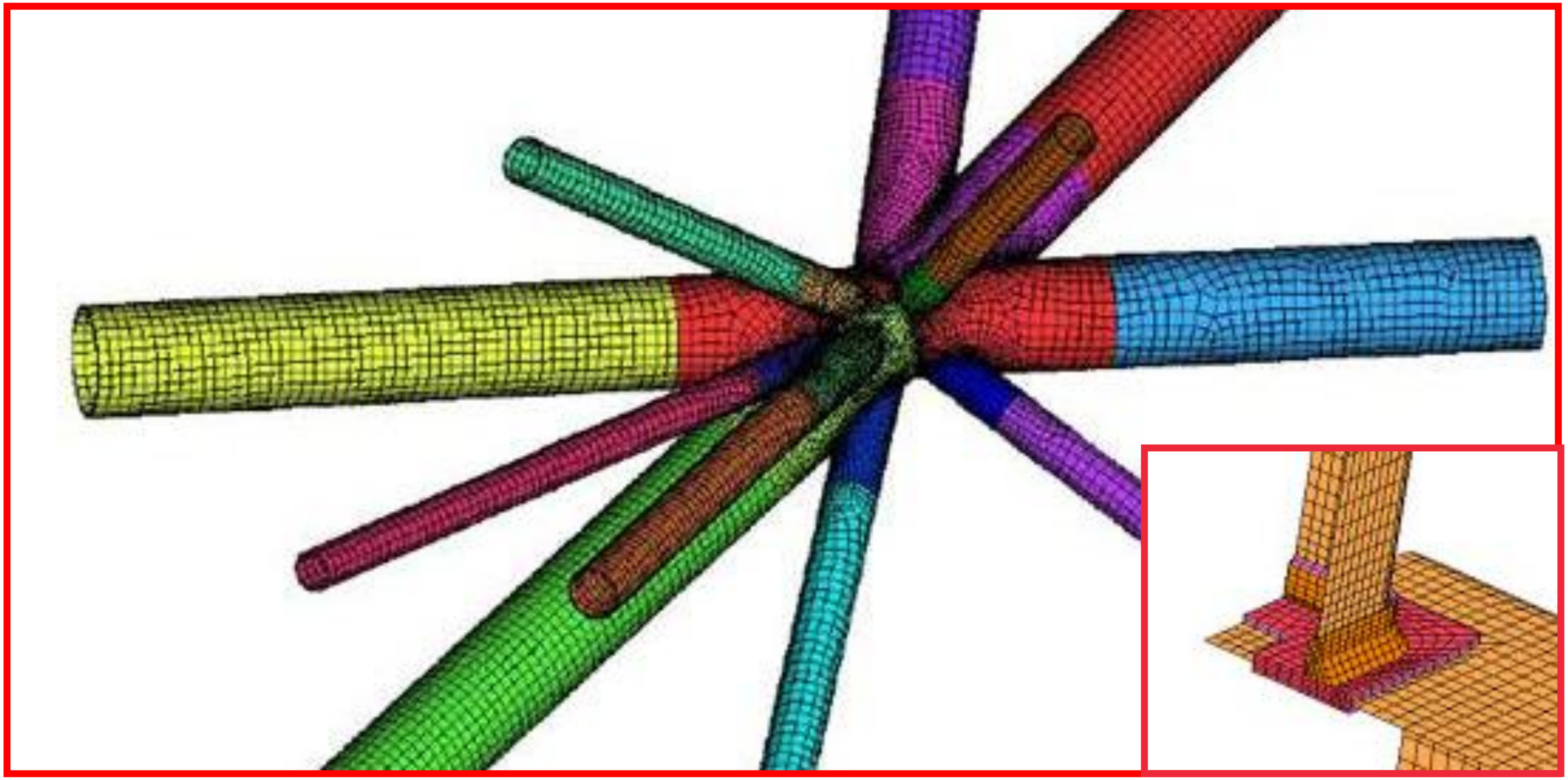
$\mu = 0{,}9$

provided that, in a gap-type joint, at section 1-1 the chord satisfies:

$$\left[\frac{N_{0,Ed}}{N_{pl,0,Rd}}\right]^2 + \left[\frac{V_{0,Ed}}{V_{pl,0,Rd}}\right]^2 \leq 1{,}0$$

Multiplanar Joints

Finite element modelling



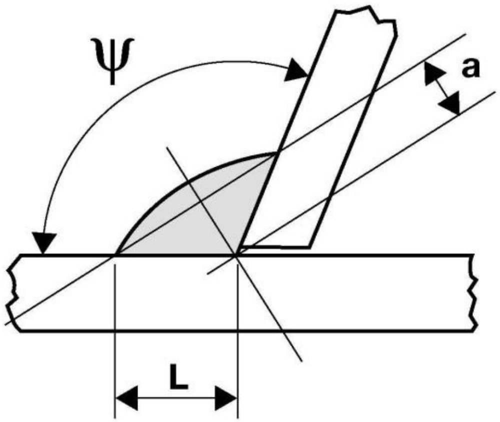
Welding

Throat thickness

STEEL GRADE (EN10210 S355J2H)	Minimum throat size a (mm) CIDECT DESIGN GUIDE 1 & 3
CELSIUS 355	1.1 t

Welding

Throat thickness



Leg length (l) mm	Throat thickness (a) mm
6	4.2
8	5.6
10	7.0

Elements at 90 º

Welding

Cold forming

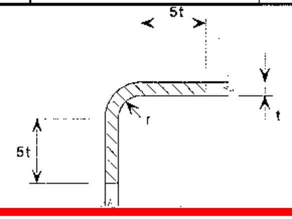
4.14 Welding in cold-formed zones

(1) Welding may be carried out within a length 5t either side of a cold-formed zone, see Table 4.2, provided that one of the following conditions is fulfilled:

- the cold-formed zones are normalized after cold-forming but before welding;
- the *r*/*t*-ratio satisfy the relevant value obtained from Table 4.2.

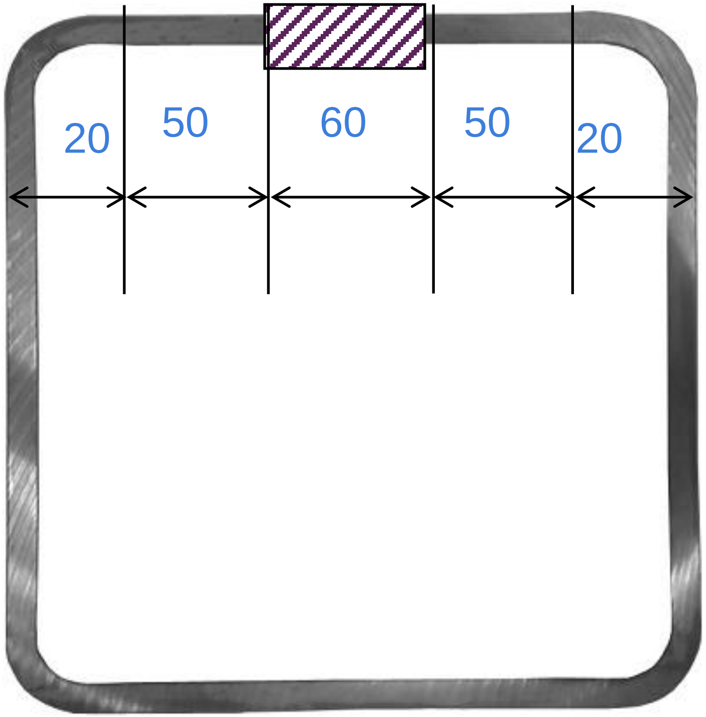
Table 4.2: Conditions for welding cold-formed zones and adjacent material

r/t	Strain due to cold forming (%)	Maximum thickness (mm)		
		Generally		Fully killed Aluminium-killed steel (Al ≥ 0,02 %)
		Predominantly static loading	Where fatigue predominates	
≥ 25	≤ 2	any	any	any
≥ 10	≤ 5	any	16	any
≥ 3,0	≤ 14	24	12	24
≥ 2,0	≤ 20	12	10	12
≥ 1,5	≤ 25	8	8	10
≥ 1,0	≤ 33	4	4	6



Welding

Cold forming



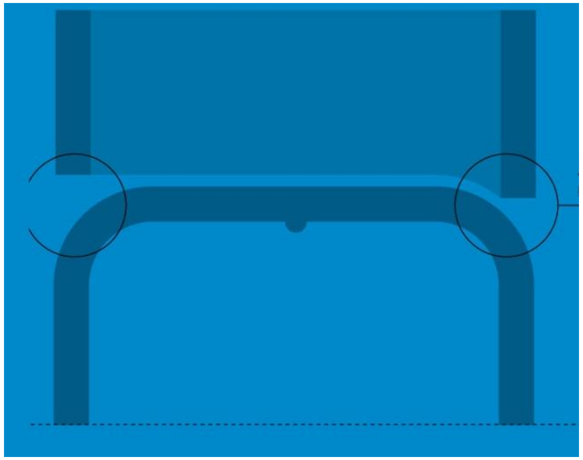
200 x 200 x 10 CF RHS

Welding

Cold forming

Material Standard EN10219 has the following corner radius range :-

- T<`6 mm 1.6T to 2.4T
- 6mm<T<10 2.0T to 3.0T
- 10<T 2.4T to 3.6T



Joint Design Considerations

- The joint strength is determined by the selected chord and bracing member sizes, grades and geometry
- These are decided by the

DESIGNER

Summary

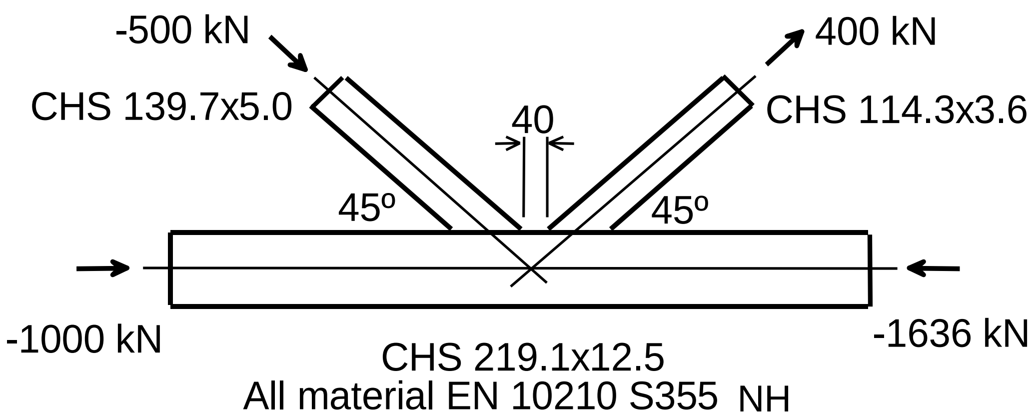
- From a compression member strength consideration , large thin wall sections are preferred (reduced l/r ratio).
- From a joint strength consideration , small thick wall chords are preferred to large thin wall chords.
- A large bracing width to chord width ratio generally increases the joint strength . This favours the use of a small thick wall chord to large thin bracing.

Conclusion

- Joint Capacity is dependant on:
  - Brace Angle
  - Bracing Width to Chord Width Ratio
  - Chord Width to Thickness Ratio
  - Gap or Overlap Bracings
  - Chord Compressive Stress
  - Chord Yield Strength

Joint Design Examples

Example 1 – CHS Gap K-joint

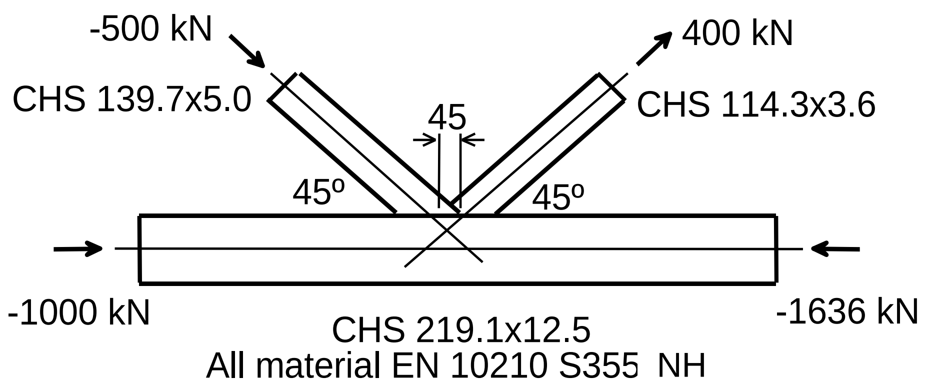


DESIGN CHECKS :-

- Parameter Limits (5.1.1)
- Chord Face Deformation (5.1.3), *Chord End Load Function (5.1.2)*
  Gap/Lap Function (5.1.2)
- Chord Punching Shear (5.1.3)

Joint Design Examples

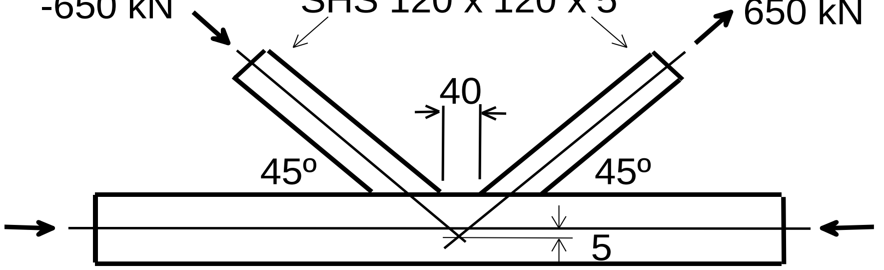
Example 2 – CHS Overlap K-joint



DESIGN CHECKS :-

- Parameter Limits (5.1.1)
- Chord Face Deformation (5.1.3), Chord End Load Function (5.1.2)
  Gap/Lap Function (5.1.2)
- Localised shear check (if greater than 60 %)
- Chord Punching Shear (5.1.3)

Joint Design Examples



Example 3 – RHS Gap K-joint

DESIGN CHECKS :-

- Parameter Limits (5.2.1)
- Chord Face Deformation (5.2.3), *Chord End Load Function (5.2.2)*
- Chord Shear Between Bracings (5.2.3), *Chord Shear Area (5.2.2)*
- 4. Bracing Effective Width (5.2.3), *Normal Effective Width (5.2.2)*
- 5. Chord Punching Shear (5.2.3), *Normal Effective Width (5.2.2)*
  Punching Shear Effec. Width (5.2.2)
- 6. Chord Axial Load Resistance At Gap (5.2.3),
  Factored Applied Shear Load In Gap (7.1)
  Chord Shear Capacity (7.1)

TATA STEEL

TATA

New Developments

New Developments

Tubular Joint Design Program

- Updated to include latest amendments to Eurocode 3 Part 1-8

Concrete Filled Hollow Section

- FireSoft design software available and Design Guide for Concrete Filled Structural Hollow Section which constitutes NCCI to Eurocode 4 Part 1-2

Fine Grained Steel

- Celsius S420 now available as EN10210 S420 NH

Celsius 420 - Specification

Hot Finished Structural Hollow Section of Non alloy and Fine Grain Steels

EN10210:S420 NH

Tensile Strength
520N/mm^2 – 680 N/mm^2

Minimum yield strength
<= 16mm:- 420 N/mm^2

Minimum Impact -20ºc @ 40 J

Elongation - 19 %

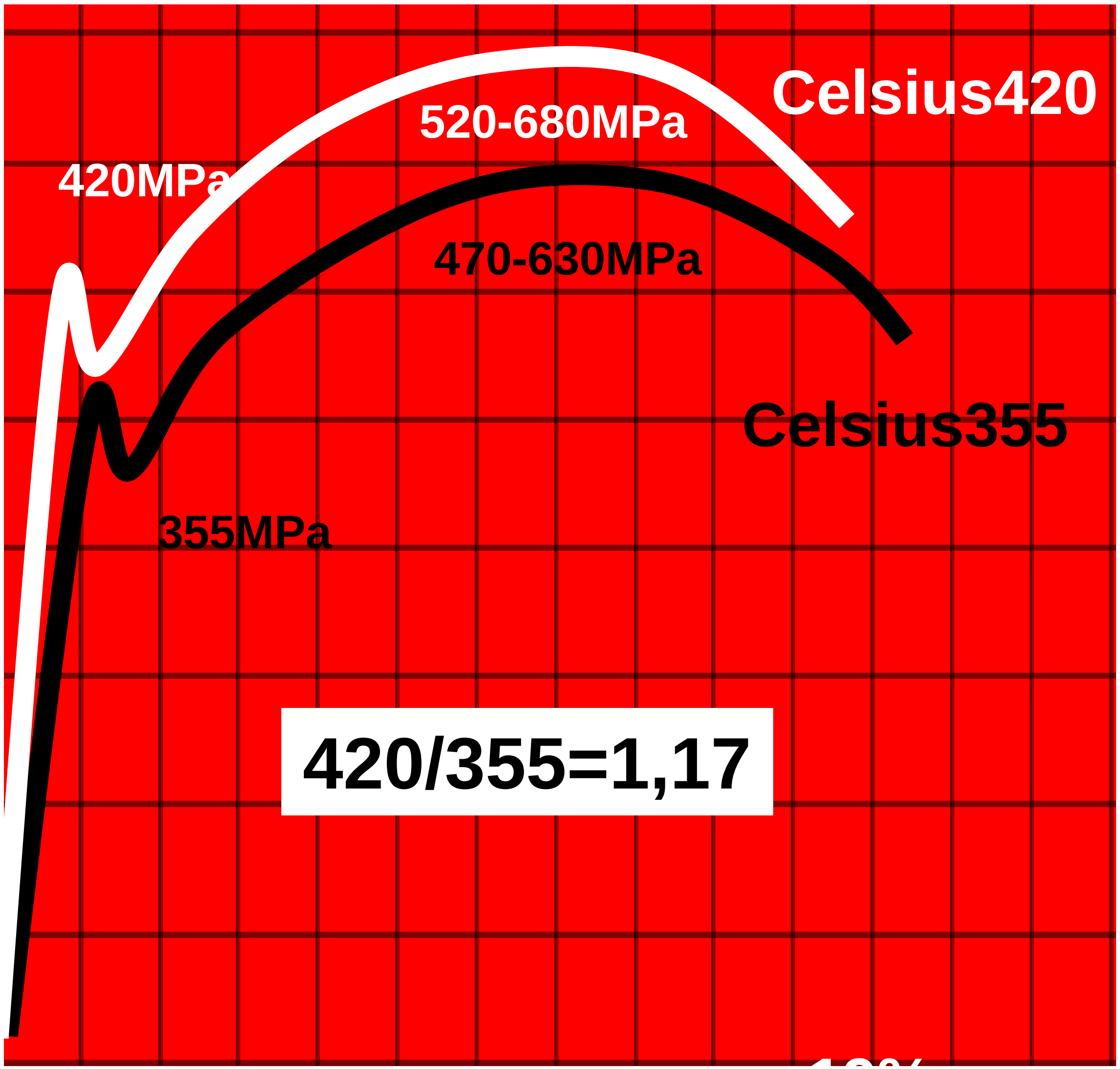
Carbon Equivalent (CEV)
– 0.50

Silicon Content Si
- 0.60

Carbon Equivalent (CEV)
Celsius 420 NH – 0.45

Silicon Content (Si)
Celsius 420 NH – 0.15 to 0.25

Celsius 420 - Technical Information



Yield / Ultimate

- Celsius420 starts to deform plastically (irreversible) at a higher Yield
- Celsius420 reaches a higher ultimate strength before sample fractures

Celsius 420 - Technical Information

Celsius S355

- 200x100x10

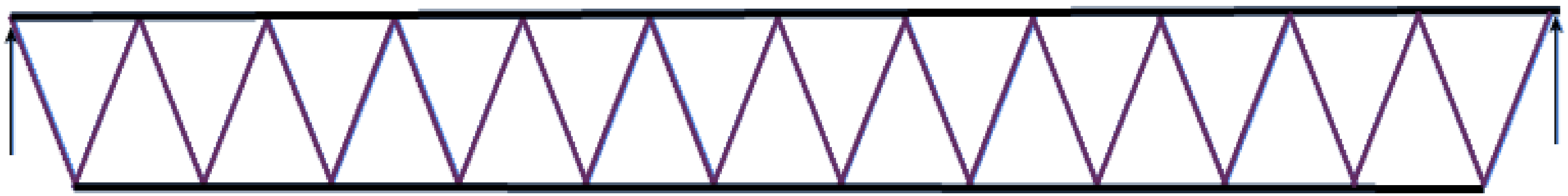
Celsius S420

- Can make thinner/lighter
- e.g. 200x100x6.3

Celsius S420

- Or smaller
- e.g. 200x100x6.3

Celsius 420 - Technical Information



50 m span plain roof truss
4m deep
Purlins at 4m centres, Trusses @ 15 m centres

EN10210 S355 J2H Design
Chord – 273 x 10 CHS
Brace – 219.1x6.3 CHS
Truss weight = 9.5 tonnes

Celsius EN10210 S420 NH Design
Chord – 244.5 x 10 CHS
Brace – 193.7x6.3 CHS
Truss weight = 8.4 tonnes

Weight Saving - Example

Celsius® 420 – Size range and offering

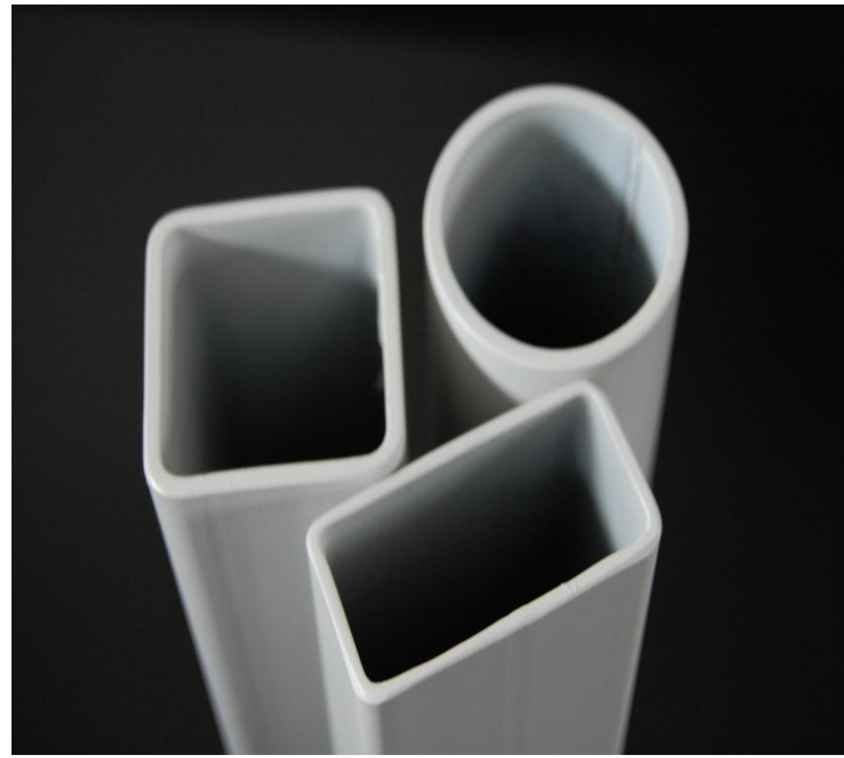
Celsius® 420 - Circular Hollow Sections

Size (mm)	2.6	2.9	3.2	3.6	4.0	4.5	5.0	6.3	8.0	10.0
21.3	■	■	■							
26.9	■	■	■	■						
33.7	■	■	■	■	■	■				
42.4	■	■	■	■	■	■	■			
48.3	■	■	■	■	■	■	■	■		
60.3	■	■	■	■	■	■	■	■		
76.1		■	■	■	■	■	■	■	■	
88.9			■	■	■	■	■	■	■	
101.6				■	■	■	■	■	■	
114.3				■	■	■	■	■	■	
139.7					■	■	■	■	■	■
168.3							■	■	■	■
193.7							■	■	■	■
219.1							■	■		
244.5							■	■		
273.0							■	■		
323.9							■	■	■	
355.6							■	■	■	

Celsius® 420 – Size range and offering

Celsius® 420 - Square Hollow Sections

Size (mm)	3.0	3.2	3.6	4.0	5.0	6.3	8.0	10.0	12.5
40 x 40	■	■	■	■	■				
50 x 50	■	■	■	■	■	■	■		
60 x 60	■	■	■	■	■	■	■		
70 x 70	■	■	■	■	■	■	■		
80 x 80	■	■	■	■	■	■	■		
90 x 90			■	■	■	■	■		
100 x 100			■	■	■	■	■	■	
120 x 120				■	■	■	■	■	
140 x 140					■	■	■	■	
150 x 150					■	■	■	■	
160 x 160					■	■	■	■	
180 x 180					■ r	■	■	■	■
200 x 200					■	■	■	■	
220 x 220							■	■	■
250 x 250					■	■	■	■	■
260 x 260						■ r	■	■	■
300 x 300						■	■	■	■
350 x 350							■	■	■
400 x 400							■	■	



Celsius® 420 – Size range and offering

Celsius® 420 - Rectangular Hollow Sections

Size (mm)	3.0	3.2	3.6	4.0	5.0	6.3	8.0	10.0	12.5
50 x 30	■	■	■	■	■				
60 x 40	■	■	■	■	■	■			
80 x 40	■	■	■	■	■	■	■		
90 x 50	■	■	■	■	■	■	■		
100 x 50	■	■	■	■	■	■	■		
100 x 60	■	■	■	■	■	■	■		
120 x 60			■	■	■	■	■		
120 x 80			■	■	■	■	■	■	
150 x 100				■	■	■	■	■	
160 x 80				■	■	■	■	■	
180 x 60				■	■	■	■	■	
180 x 100				■	■	■	■	■	
200 x 100				■	■	■	■	■	
200 x 120					■	■	■	■	
200 x 150					■	■	■	■	■
220 x 120					■ r	■ r	■	■	
250 x 100					■	■	■	■	■
250 x 150					■	■	■	■	
250 x 200								■ r	■ r
260 x 140					■	■	■	■	
260 x 180							■	■	■
300 x 100					■	■	■	■	
300 x 150							■ r	■ r	■ r
300 x 200					■	■	■	■	■
300 x 250					■	■	■	■	■
350 x 150					■	■	■	■	■
350 x 250						■	■	■	■
400 x 120						■ r	■ r	■ r	■ r
400 x 150					■	■	■	■	■
400 x 200						■	■	■	■
400 x 300							■	■	■
450 x 250							■	■	■
500 x 200							■	■	■
500 x 300							■	■	

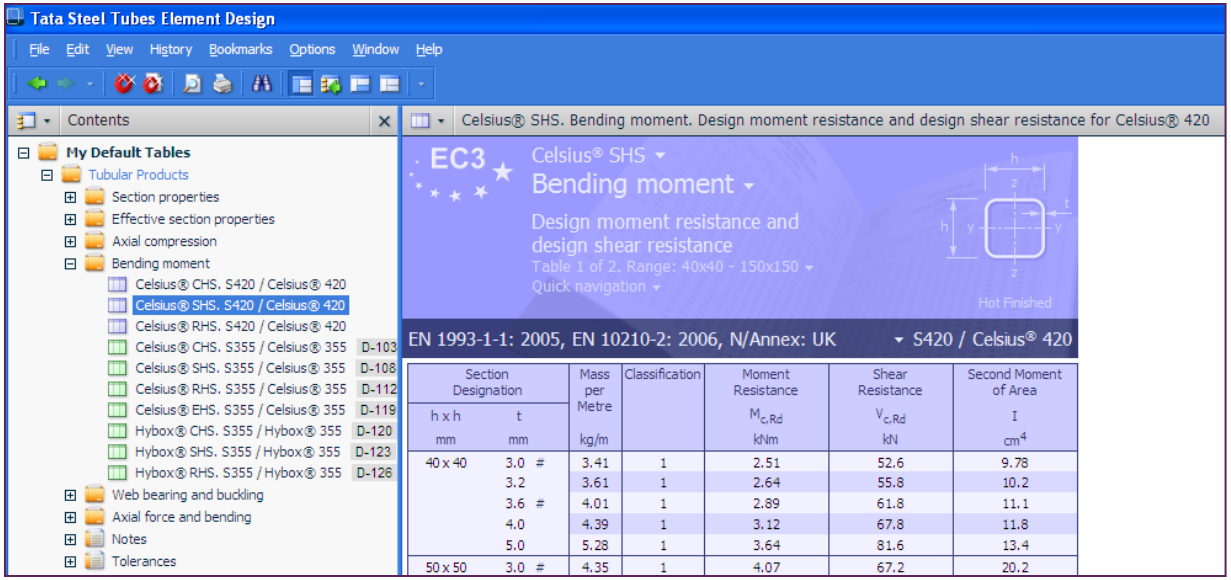
r = External corner radius >2T but <3T

Celsius® 420 - Elliptical Hollow Sections

Size (mm)	4.0	5.0	6.3	8.0	10.0
150 x 75	■	■	■		
200 x 100		■	■	■	■
250 x 125			■	■	■
300 x 150				■	■
400 x 200				■	■
500 x 250					■

Celsius® – Additional Tools

Tube Element Design Package



To assist Engineers in the design using Celsius®.
For software download from –
http://www.tatasteeleurope.com/en/products-and-services/long/tubes/technical-response-documents

Commercial enquiries – commercialcelsius420@tatasteel.com

Technical enquiries – technicalcelsius420@tatasteel.com

TATA STEEL

TATA

Tata Steel Europe, Tubes

Steve Whitfield Beng (Hons) CEng MIStructE

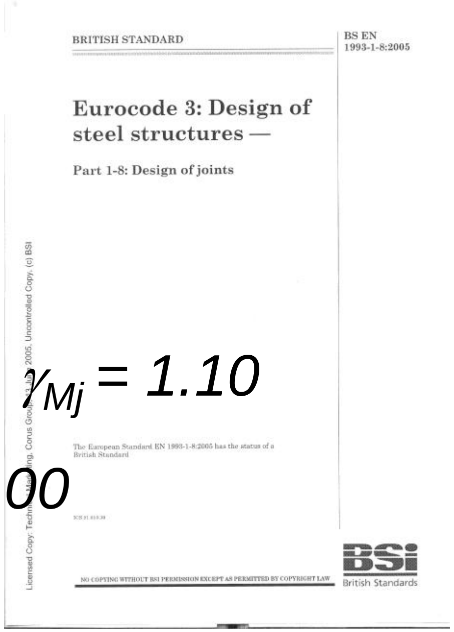
Customer Technical Services - Manager

Concrete Filled Hollow Sections

Wellcome Trust - London

SHS Joint Design References

- EUROCODE No. 3: EN 1993-1-8:2005 – with national annex
  - Corrigenda 2 was issued September 2006
    - Final CEN corrigenda added February 2010
  - Similar rules to Annex K (1992) except symbols changed but the major equations remain the same.
    - Eg: End load function f_n now k_p
    - Joint partial safety factor with UK NA
      - *Annex K :- Formula x 1.10/γ_{Mj} where γ_{Mj} = 1.10*
      - *EC3-1-8 :- Formula /γ_{M5} where γ_{M5}= 1.00*


BRITISH STANDARD

BS EN 1993-1-8:2005

Eurocode 3: Design of steel structures —

Part 1-8: Design of joints

The European Standard EN 1993-1-8:2005 has the status of a British Standard

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

British Standards