

Supporting presentation for
lecturers of Architecture/Civil
Engineering

Chapter 06
Mechanical Properties

Please note:

This chapter is about non-structural applications
(for structural applications please go to chapter 7)

Non-structural applications usually do not demand high strength.
Material selection optimizes a set of properties

Strength

Machinability

Surface
finish

Adequate
corrosion
resistance

Forming
properties

Cost

Weldability

Mechanical properties:

1. Yield Strength (MPa)
2. Ultimate Tensile Strength (MPa)
3. Elongation (%)
4. Young's Modulus (MPa)
5. Impact resistance
6. Fire Resistance
7. Creep resistance
8. Fatigue resistance
9. Properties at cryogenic temperatures
10. Properties at elevated temperatures

Properties 1-6 are the most relevant to architecture & engineering

Standards

The mechanical properties of stainless steels are well known and minimum values guaranteed international standards.

- Main standards
 - ISO
 - ASTM/AISI
 - EN
 - JS
 - Others

- Applicable to all grades & products:
 - Sheets
 - Plates
 - Bars
 - Tubes
 - Forgings
 - Castings
 - Fasteners
 - Wires
 - Welding products
 - ...etc

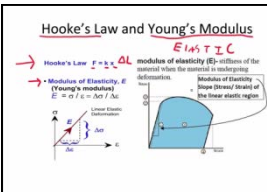
Mechanical Properties: background information

Tensile and impact tests:

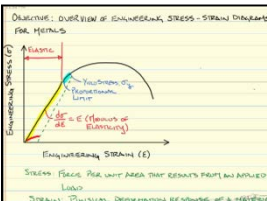
Please have a look at the videos!



<http://www.youtube.com/watch?v=67fSwljYJ-E>



<http://www.youtube.com/watch?v=b6UIsANNIO>



<http://www.youtube.com/watch?v=t9eB0PKYAt8>



<http://www.youtube.com/watch?v=tpGhqQvftAo>

For more details on Mechanical Properties and on the derivation of stress strain curves go to:

http://www.engineeringarchives.com/es_mom_truестresstruestrainengstress_engstrain.html

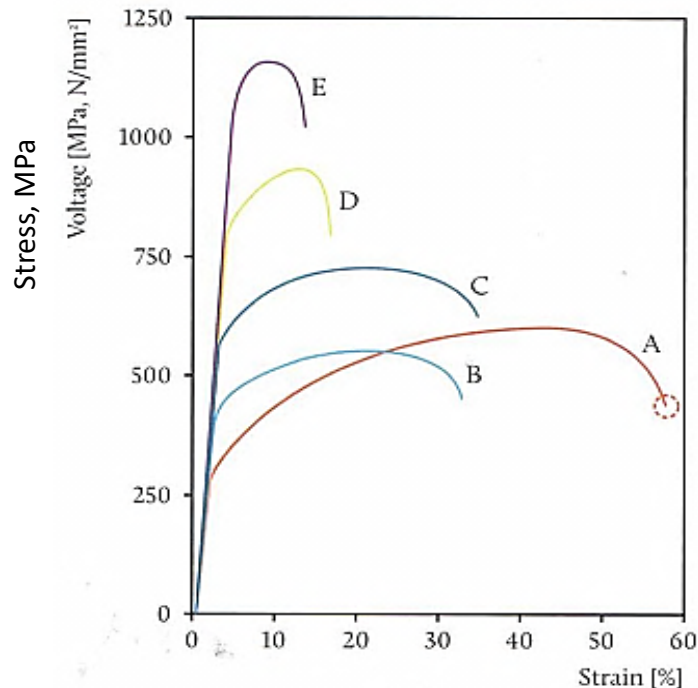
http://www.engineeringarchives.com/es_mom_stressstraindiagram.html

& previous & following pages on the website

& refs 1-2

Typical tensile curves of stainless steels

Typical stress-strain curves of different types of stainless steels



Outline stress-strain test of different types of stainless steel:

A: Austenitic (e.g. 430I, 4307, 4404, etc.)

B: Ferritic (e.g. 4016, 4509, 4521)

C: Ferritic-austenitic (duplex, e.g. 4462)

D: Precipitation hardening (PH) steel (e.g. 4542)

E: Martensitic (e.g. 4057, 4109, 4034)

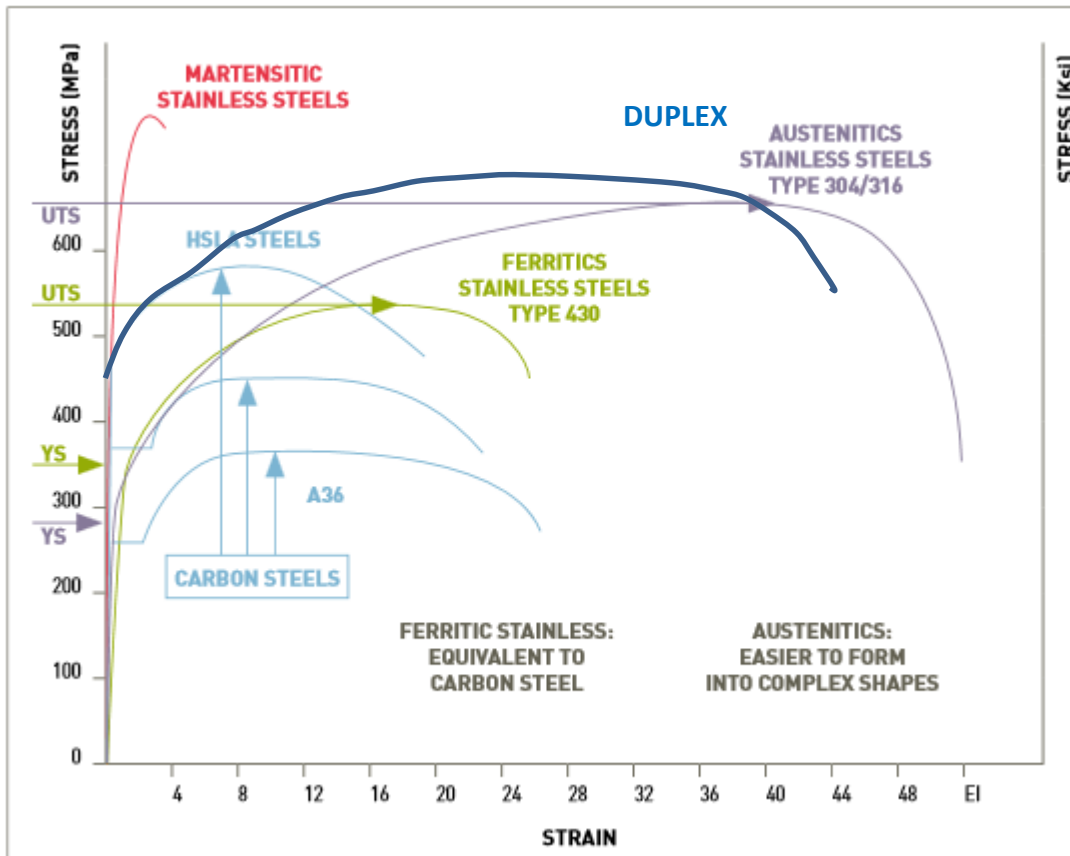
The dotted circle shows the rupture for curve A.

A wide range of properties is available

From

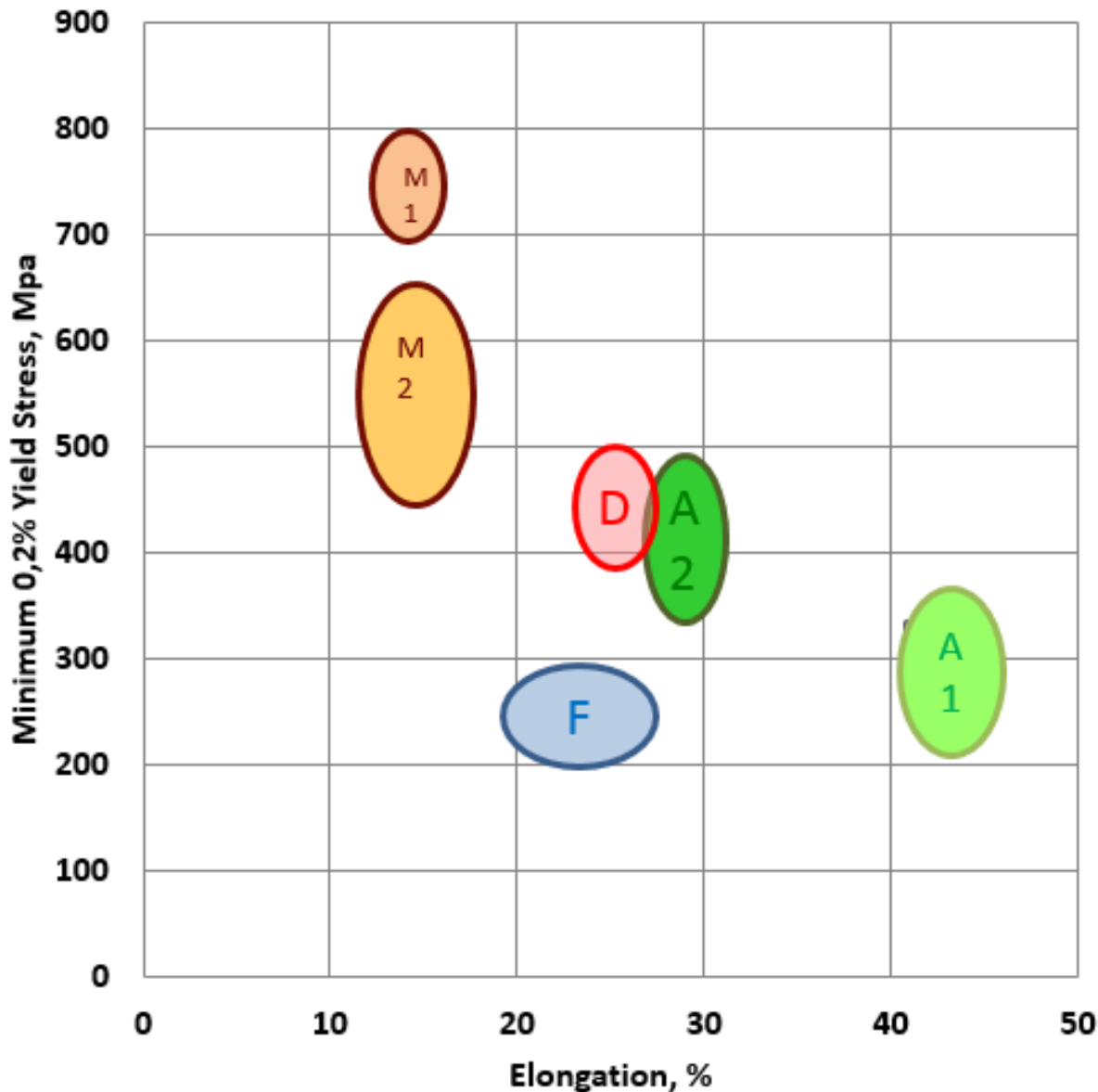
- High strength and low elongation to
- Lower strength and very high elongation

Comparison between carbon steels and stainless steels



Stainless steels do match carbon steel strength level

Mechanical Properties of stainless steels³⁻⁷



M: Martensitics*

M1 C-Cr-Ni grades

M2 C-Cr grades

D: Duplex**

F: Ferritics**

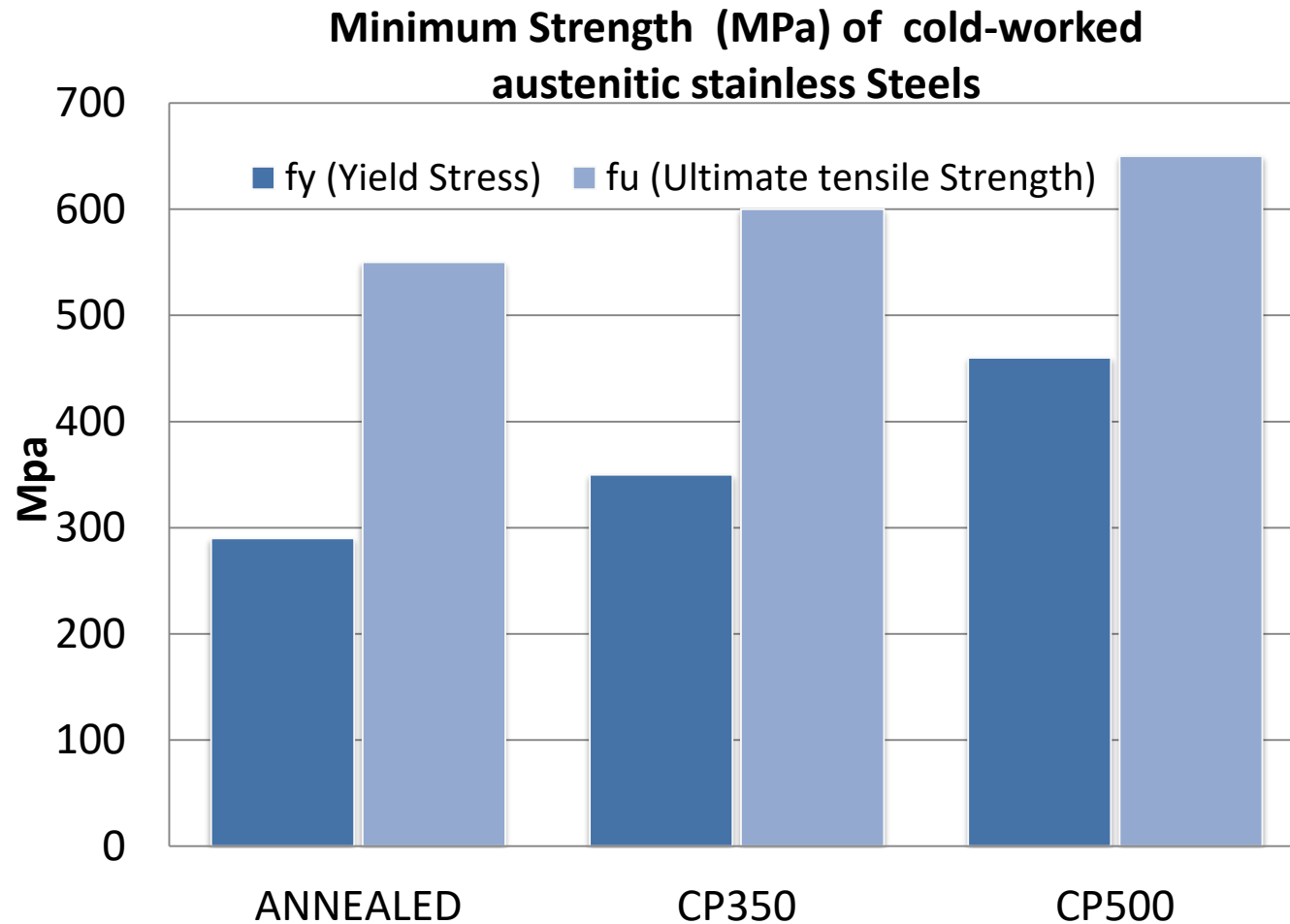
A1: Austenitics,
annealed**

A2: Austenitics, cold-
worked***

* EN 10088-3, (heat treated)

** EN 10088-2 (annealed)

*** EN 10088-2 (Cold Worked)

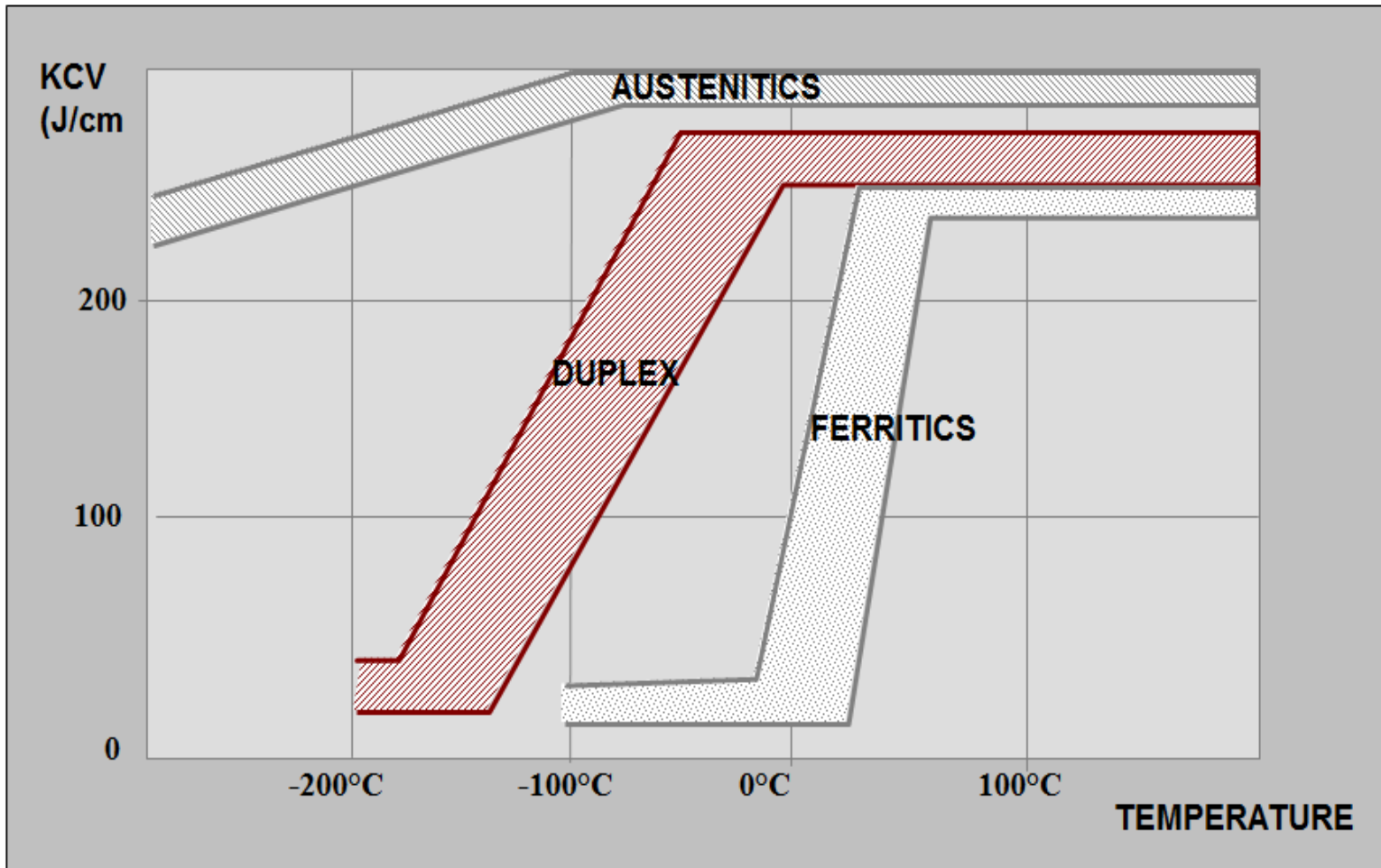


Higher tensile strength by cold work⁷

High strength cold-worked stainless grades offer a big potential for future developments.

For structural applications, please go chapter 7

A lot of experimental data is available in reference 8 below.



Charpy Impact toughness of stainless steels (ref 8)

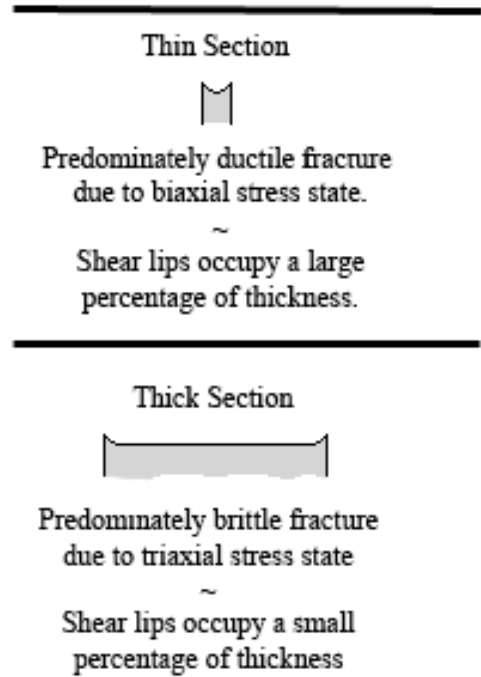
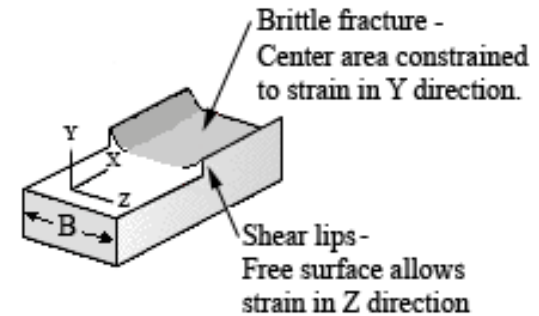
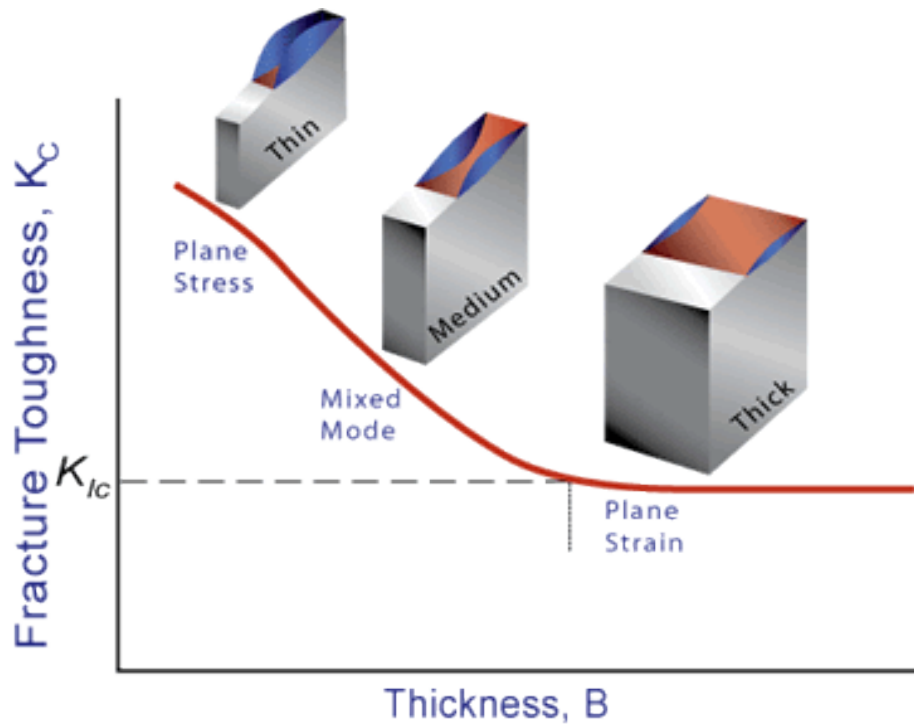
Note: These curves are for thick products (bars or plates)

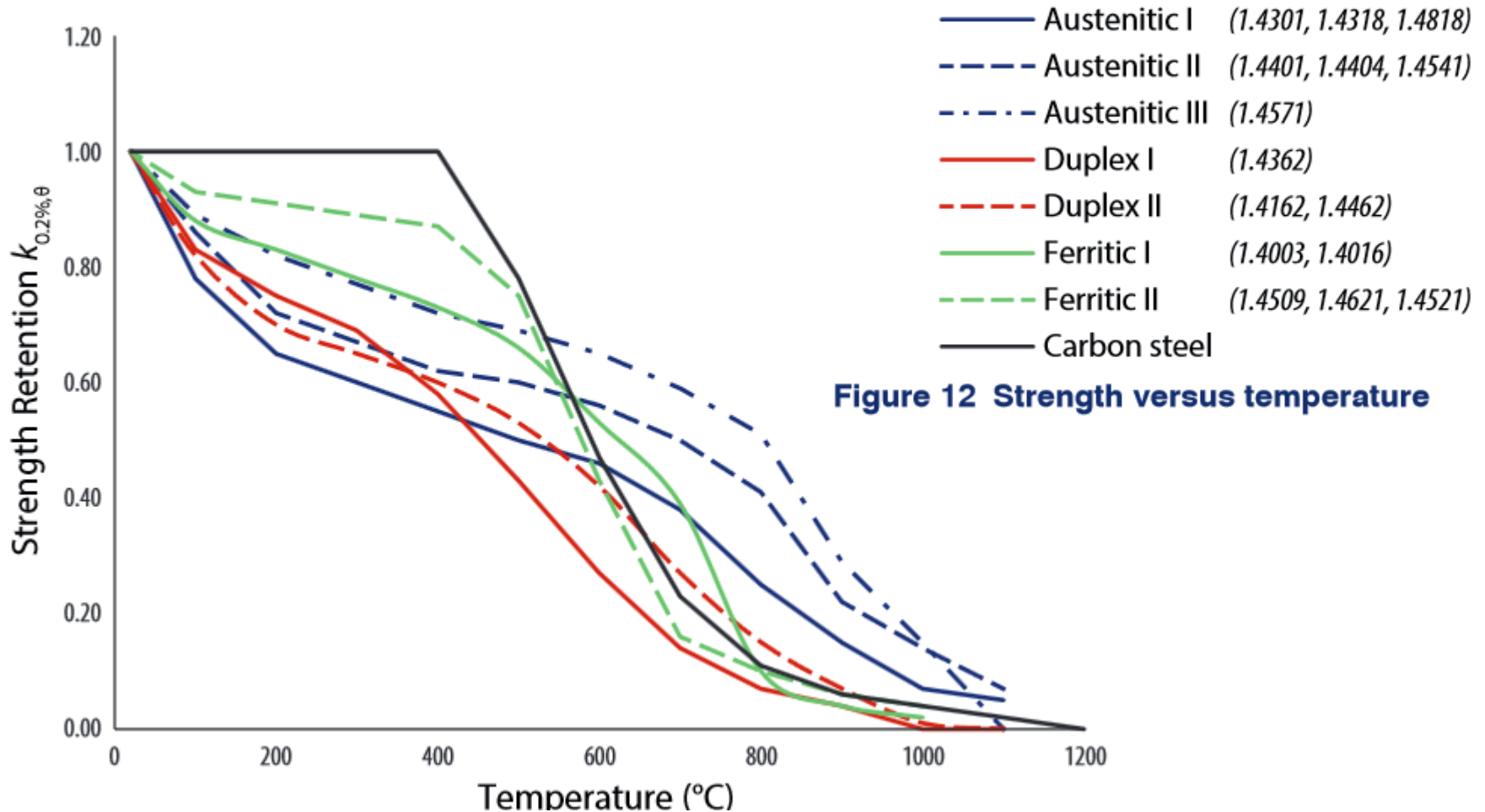
Thin products exhibit a larger fracture toughness.

Hence ferritic grades can be used for construction purposes in sheet form but not in plates or bars

Fracture mechanics

Effect of thickness on fracture toughness (see also ref 9, Figure 5)



Fire resistance⁹⁻¹⁰

Austenitic Stainless Steels offer a much better strength retention factor than Carbon Steel above 500°C

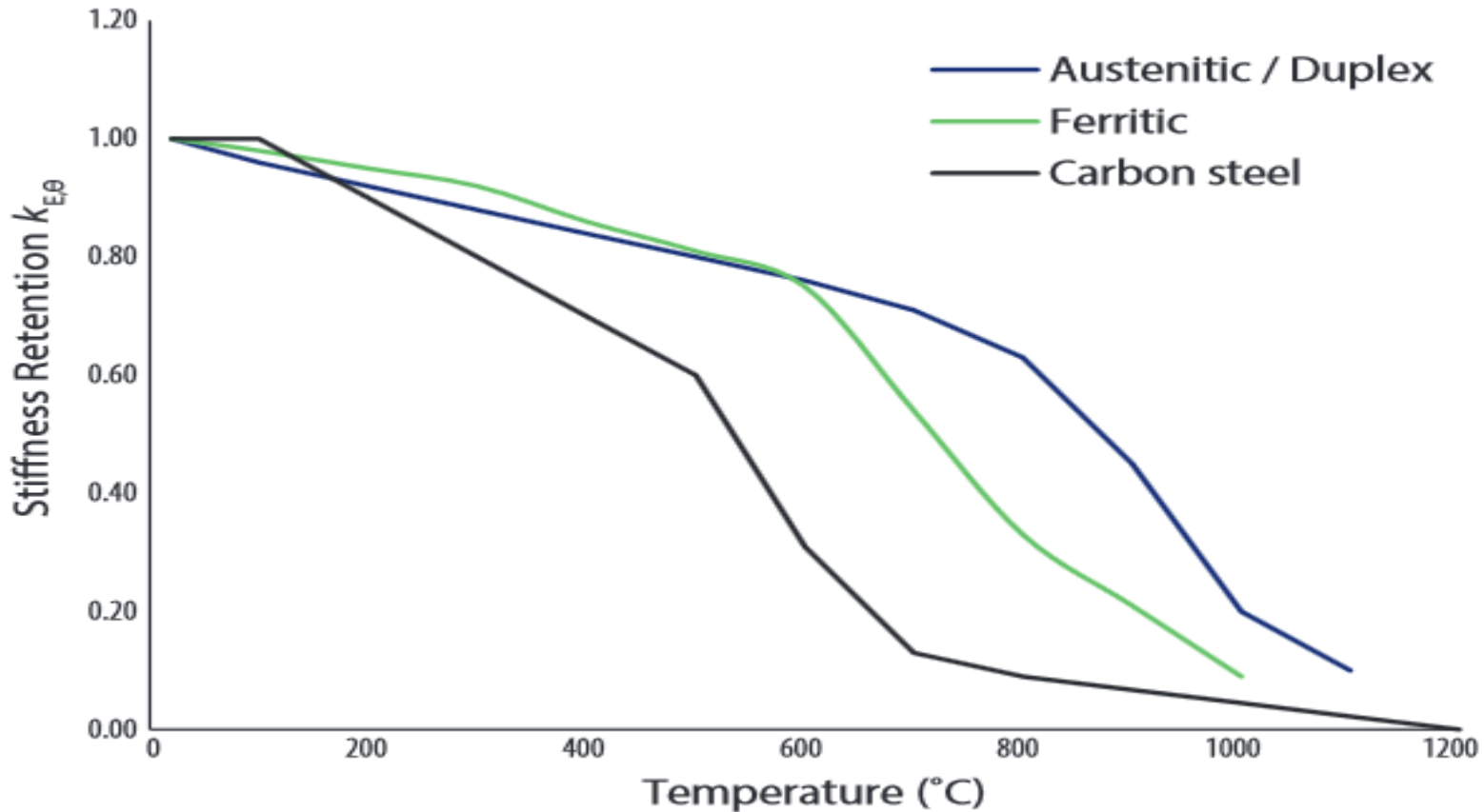
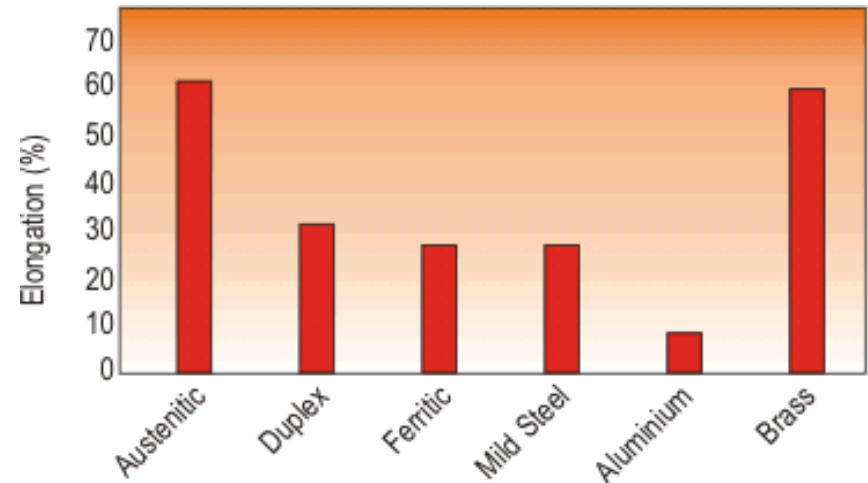
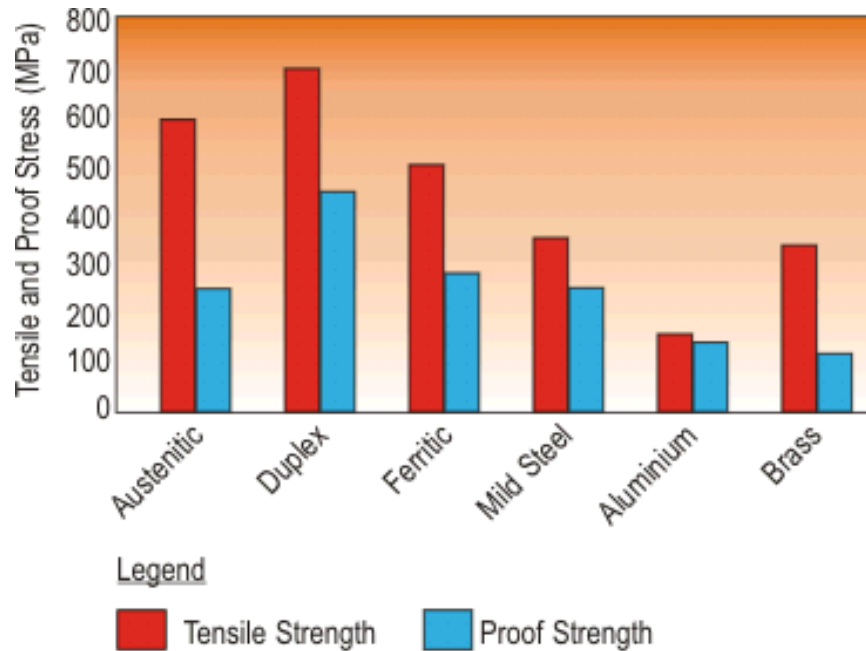
Fire resistance⁹⁻¹⁰

Figure 13 Stiffness versus temperature

Stainless Steels offer a much better stiffness retention factor than Carbon Steel above 300°C

Comparison of Tensile properties of various alloys



Stainless steels show higher tensile properties than Mild steel, Aluminium and Brass. Duplex grades offer an excellent strength/ductility ratio

References and sources

1. http://www.engineeringtoolbox.com/young-modulus-d_417.html
2. <http://www.worldstainless.org/news/show/2125>
3. <http://www.worldstainless.org/news/show/34>
4. [http://www.imoa.info/download_files/stainless-steel/Duplex Stainless Steel 3rd Edition.pdf](http://www.imoa.info/download_files/stainless-steel/Duplex%20Stainless%20Steel%203rd%20Edition.pdf)
5. [http://www.worldstainless.org/Files/issf/non-image-files/PDF/Euro Inox/Tables TechnicalProperties EN.pdf](http://www.worldstainless.org/Files/issf/non-image-files/PDF/Euro%20Inox/Tables%20TechnicalProperties%20EN.pdf)
6. <http://www.worldstainless.org/news/show/1867>
7. <http://bookshop.europa.eu/en/structural-design-of-cold-worked-austenitic-stainless-steel-pbKINA21975/?CatalogCategoryID=w2wKABst3XAAAAEjfJEY4e5L>
8. Source of the graph: Ugitech (<http://www.ugitech.com/>)
9. <http://www.steel-stainless.org/media/1187/safss-01-04.pdf>
10. Source: « Stainless steels in Fire » European Union report EUR 23745 EN, 2009 (<http://bookshop.europa.eu/en/stainless-steel-in-fire-pbKINA23745/?CatalogCategoryID=w2wKABst3XAAAAEjfJEY4e5L>)
11. <https://www.imoa.info/molybdenum-uses/molybdenum-grade-stainless-steels/duplex-stainless-steel.php>
12. <http://www.bssa.org.uk/topics.php?article=111>

Thank you

Test your knowledge of stainless steel here:

<https://www.surveymonkey.com/r/3BVK2X6>