Supporting presentation for lecturers of Architecture/Civil Engineering

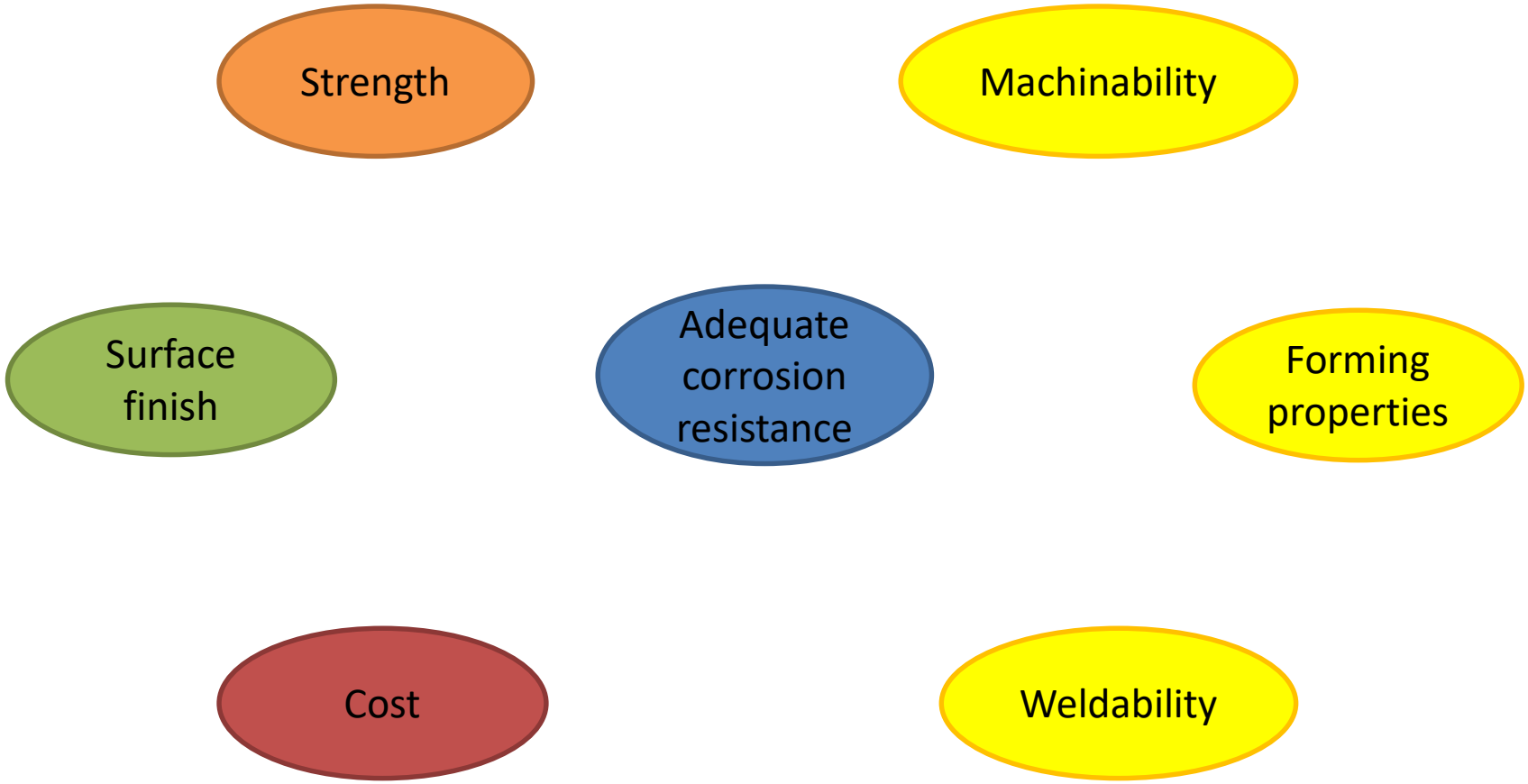
Chapter 06

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



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

NEW !

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

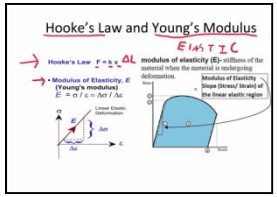
- Main standards
  - ISO
  - ASTM/AISI
  - EN
  - JS
  - Others

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

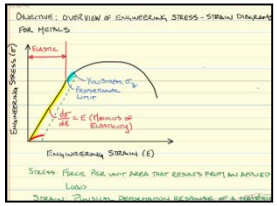
Mechanical Properties: background information

Tensile and impact tests:
Please have a look at the videos!

http://www.youtube.com/watch?v=67fSwIjYJ-E



http://www.youtube.com/watch?v=_b6UIsANNl0



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:

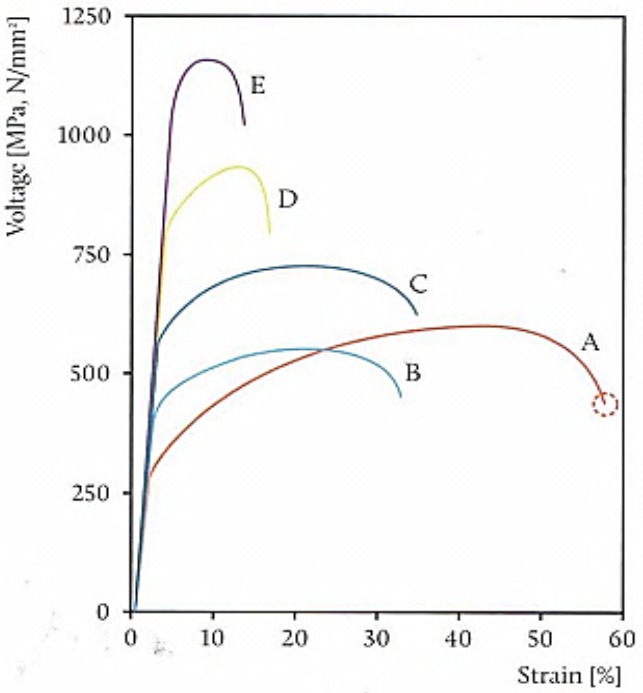
http://www.engineeringarchives.com/les_mom_truestresstruestrainengstressengstrain.html

& 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



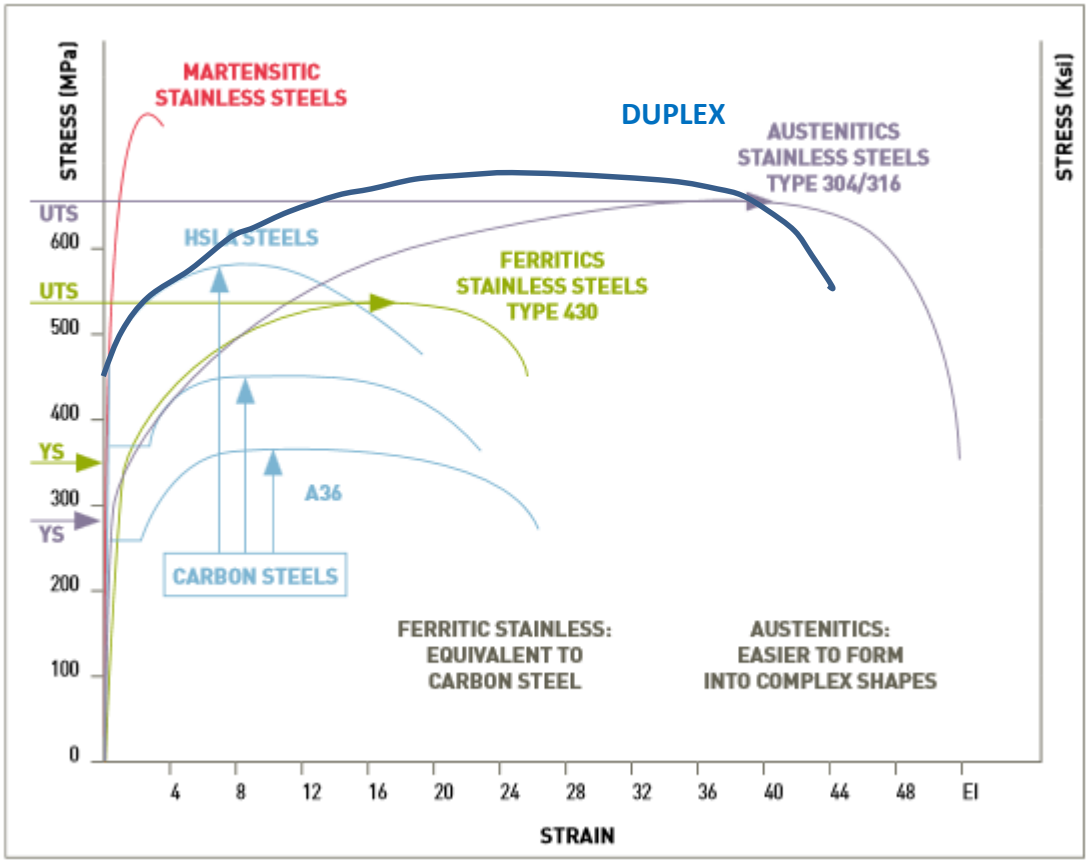
Outline stress-strain test of different types of stainless steel:
A: Austenitic (e.g. 4301, 4307, 4404, etc.)
B: Ferritic (e.g. 4016, 4509, 4521)
C: Ferritic-austenitic (duplex, e.g. 4462)
D: Precipitation hardening (PH) steel (e.g. 4542)
E: Martensitic (e.g. 4057, 4109, 4034)
The dotted circle shows the rupture for curve A.

A wide range of properties is available

From

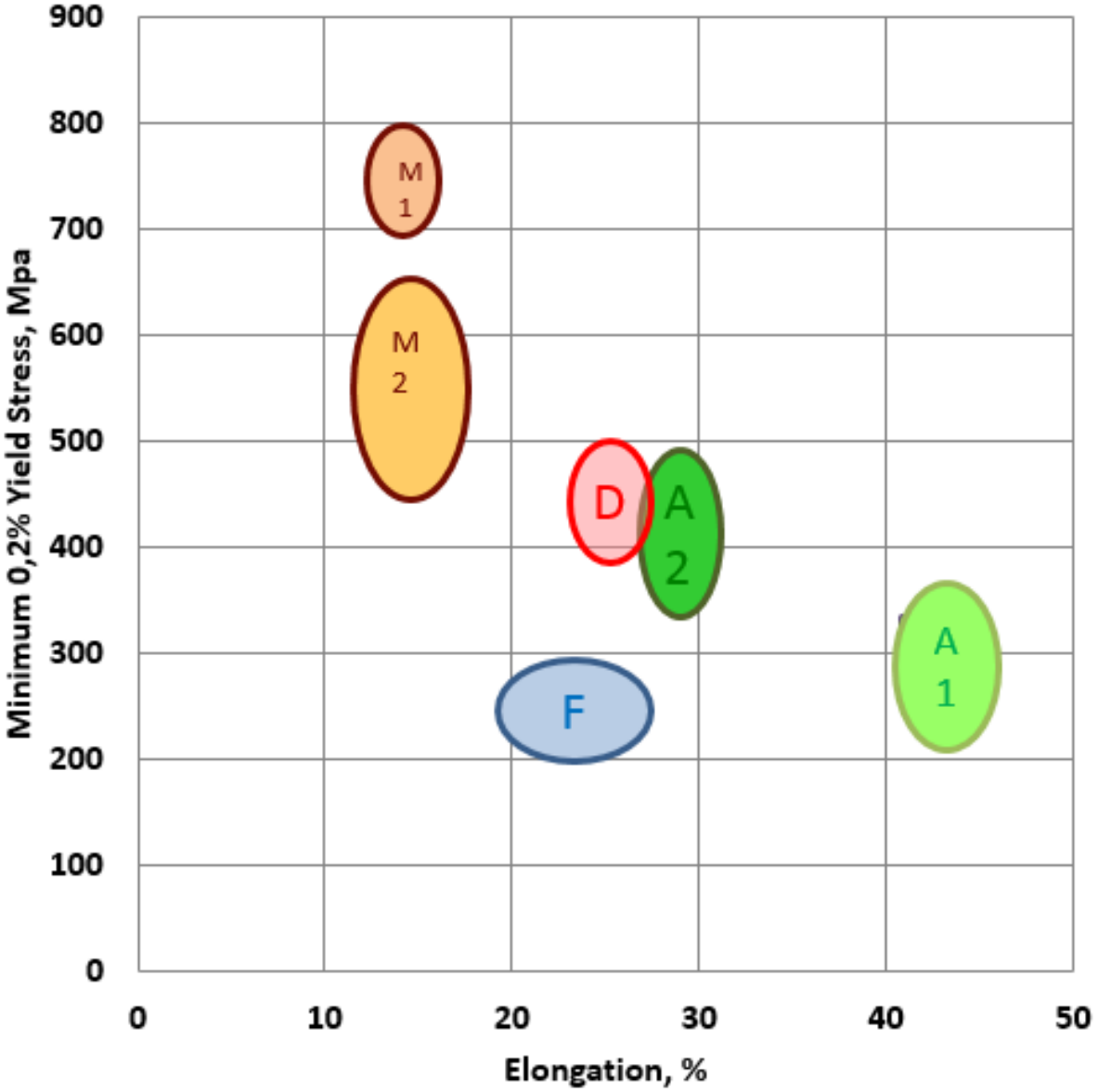
- High strength and low elongation to
- Lower strength and very high elongation

Comparison between carbon steels and stainless steels



Stainless steels do match carbon steel strength level

Mechanical Properties of stainless steels[3-7]



M: Martensitics*

M1 C-Cr-Ni grades

M2 C-Cr grades

D: Duplex**

F: Ferritics**

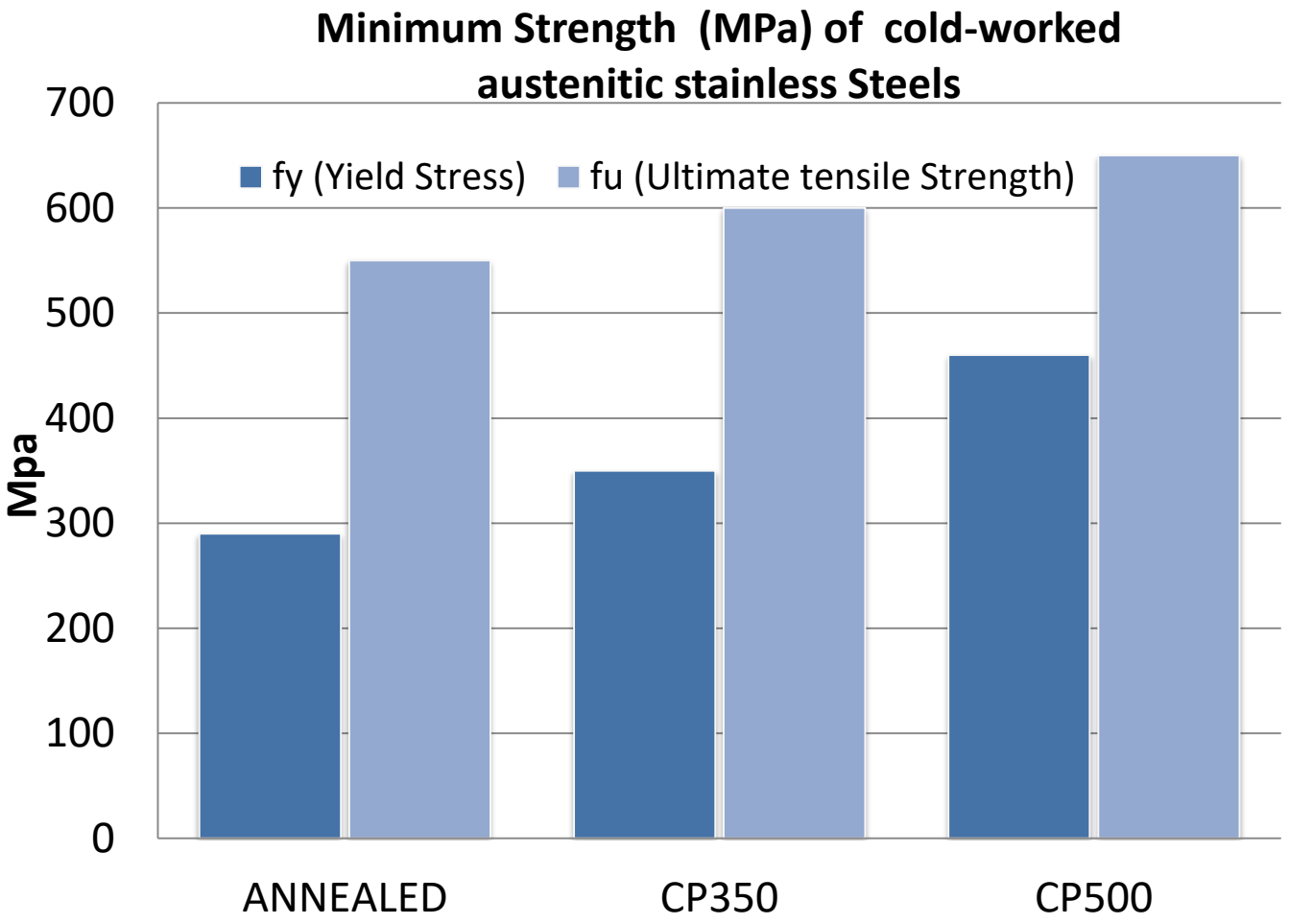
A1:Austenitics, annealed**

A2:Austenitics, cold-worked***

* EN 10088-3, (heat treated)

** EN 10088-2 (annealed)

*** EN 10088-2 (Cold Worked)

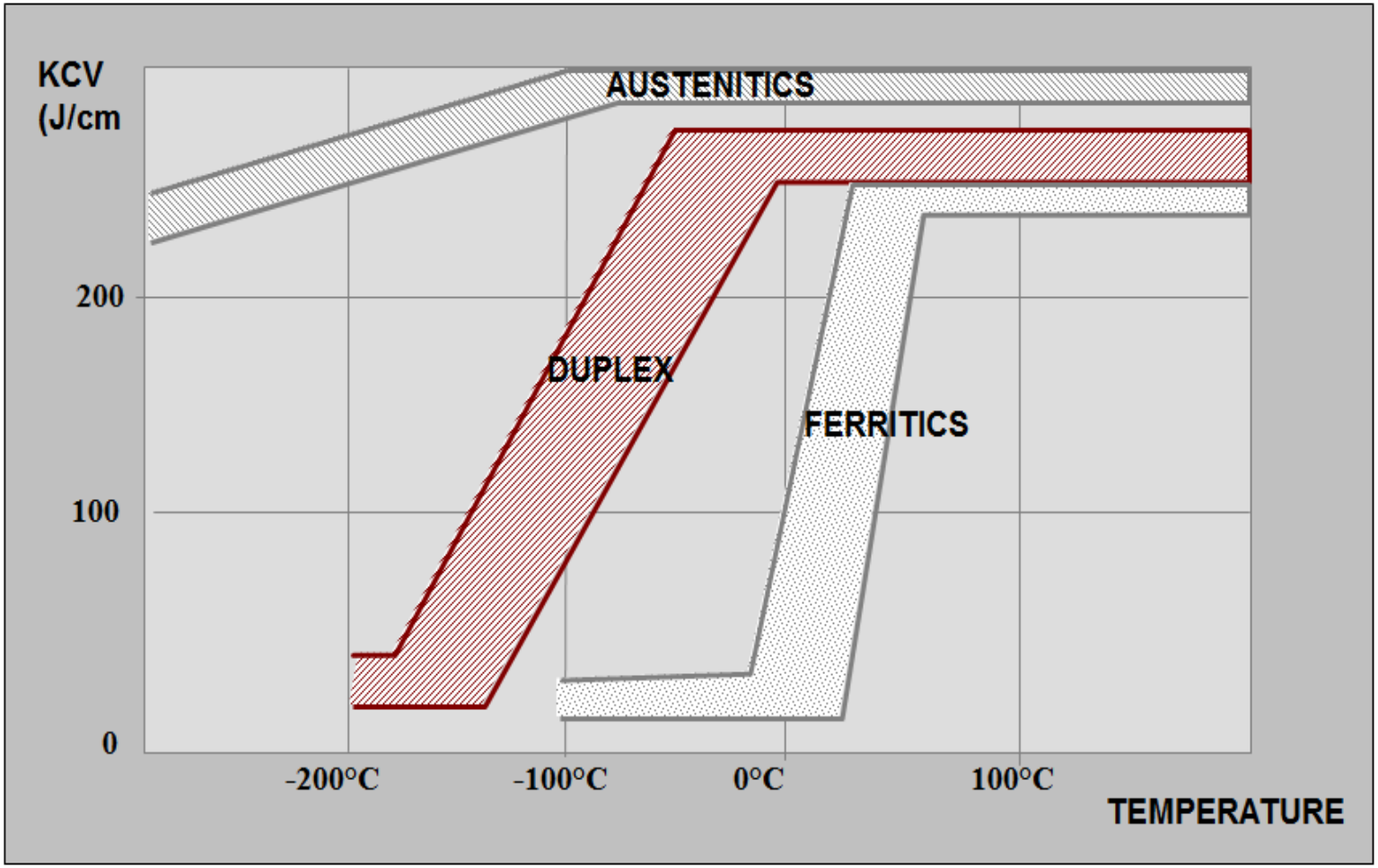


Higher tensile strength by cold work[7]

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.



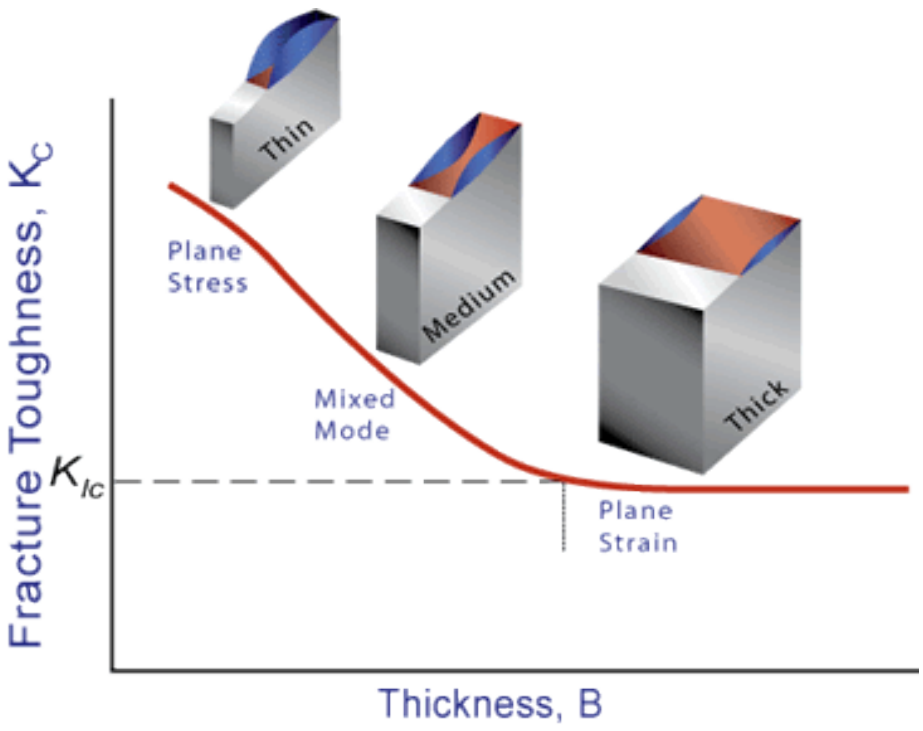
Charpy Impact toughness of stainless steels (ref 8)

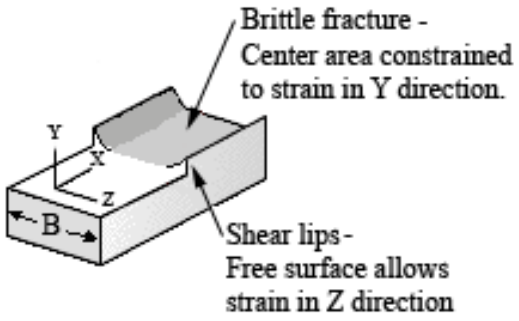
Note: These curves are for thick products (bars or plates)

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)





Thin Section

Predominately ductile fracture due to biaxial stress state.

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Shear lips occupy a large percentage of thickness.

Thick Section

Predominately brittle fracture due to triaxial stress state

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Shear lips occupy a small percentage of thickness

Fire resistance[9 -10]

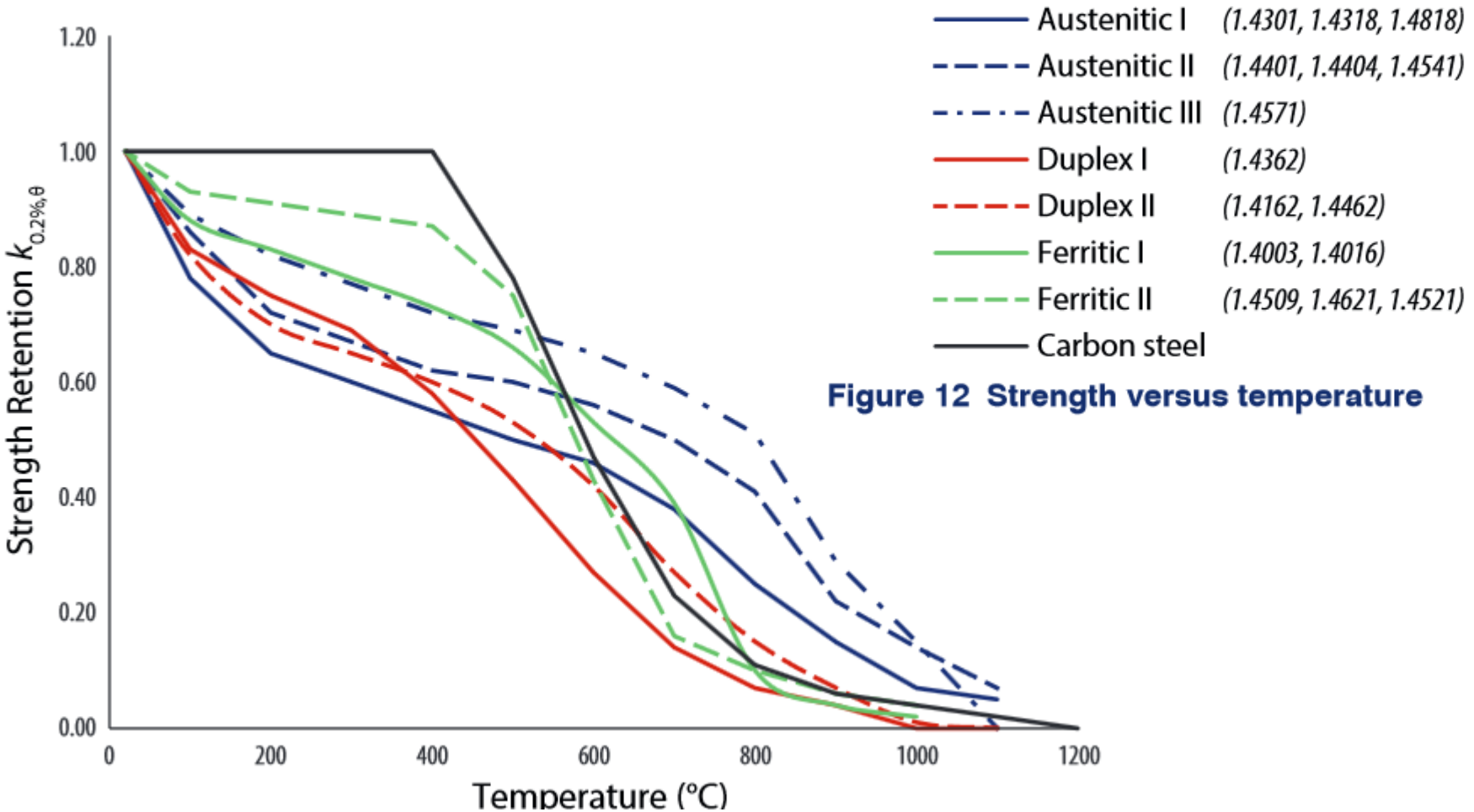


Figure 12 Strength versus temperature

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

Fire resistance[9 -10]

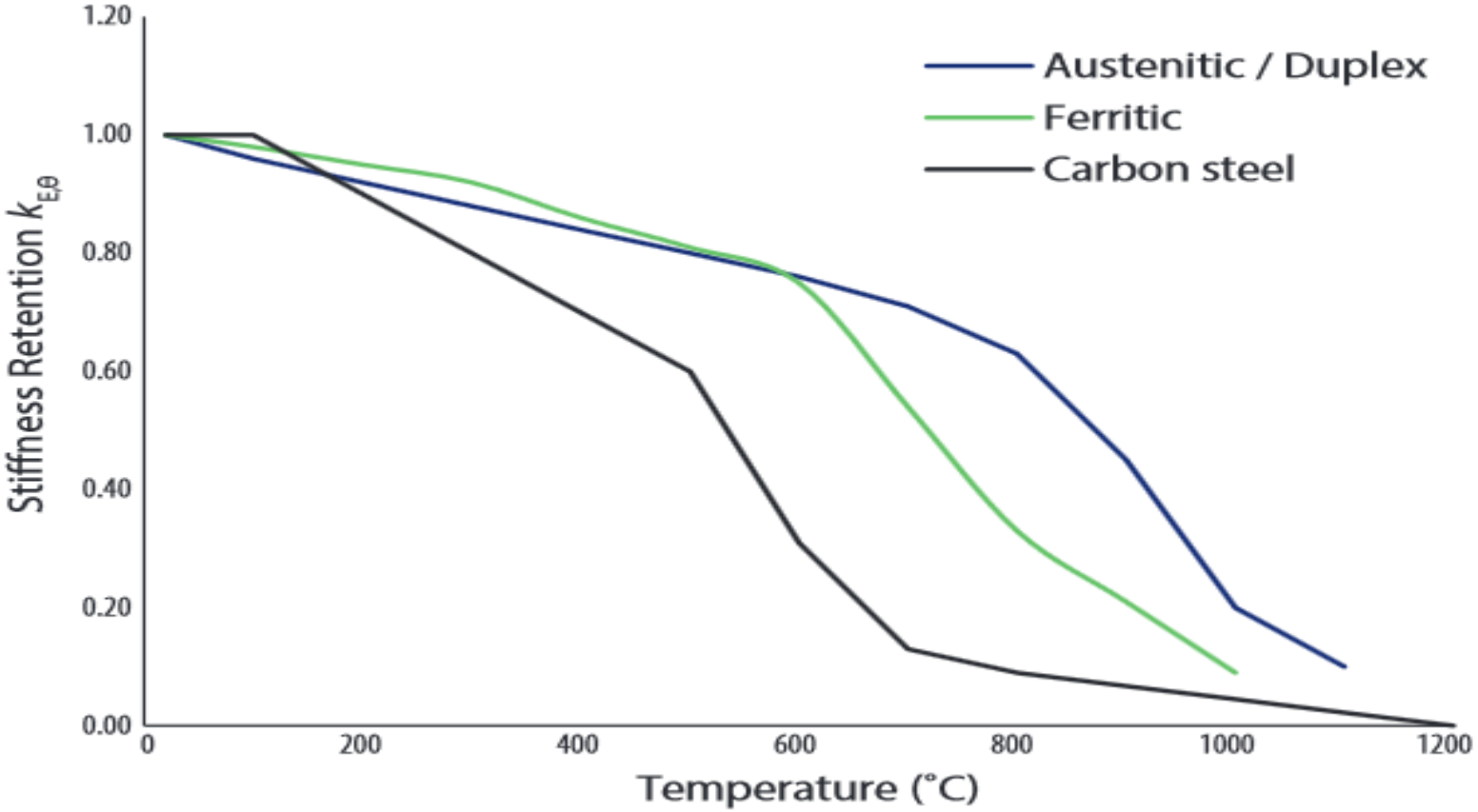
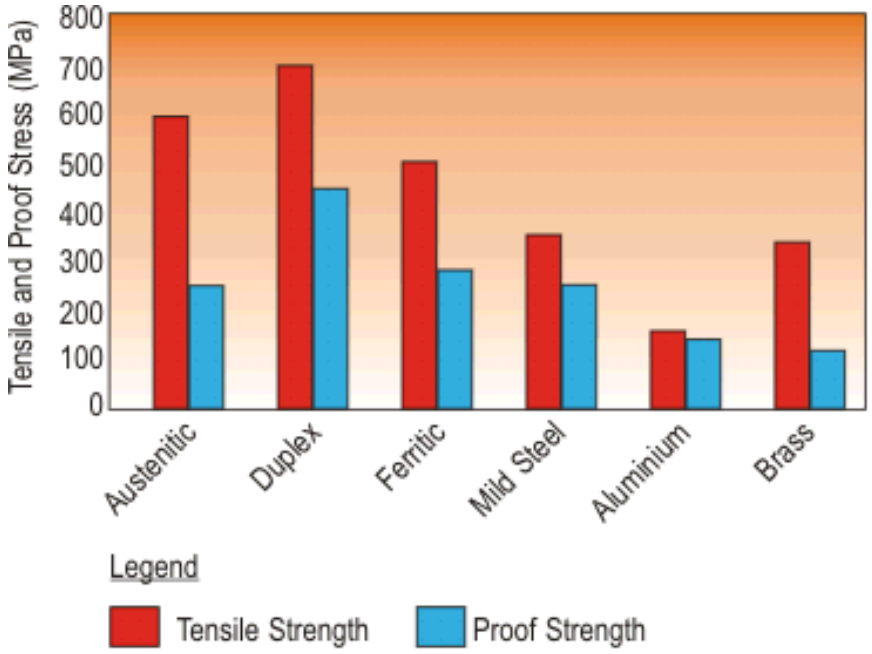
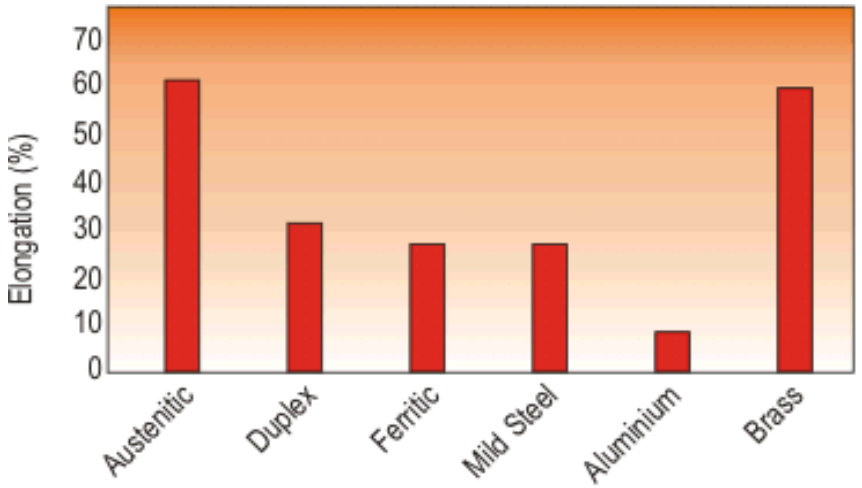


Figure 13 Stiffness versus temperature

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

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Thank you