Supporting presentation for lecturers of Architecture/Civil Engineering

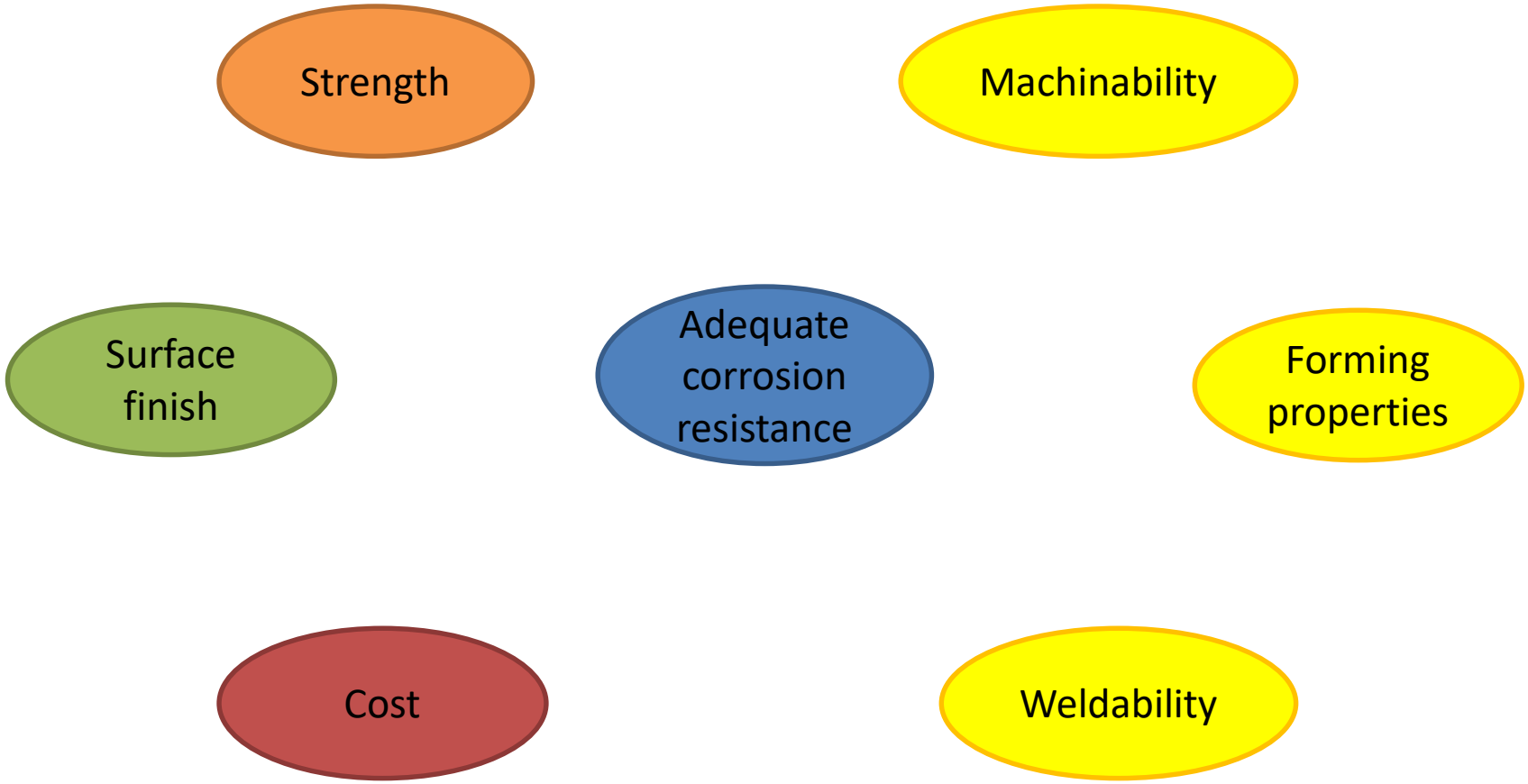
# Chapter 06

# 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

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

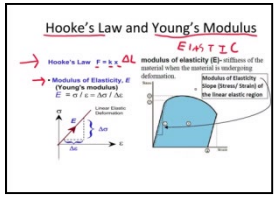
- Main standards
  - ISO
  - ASTM/AISI
  - EN
  - JS
  - Others

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

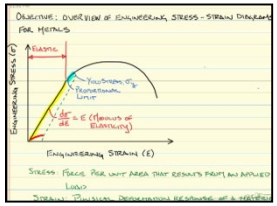
# Mechanical Properties: background information

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

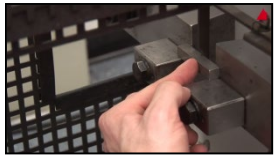
http://www.youtube.com/watch?v=67fSwIjYJ-E




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

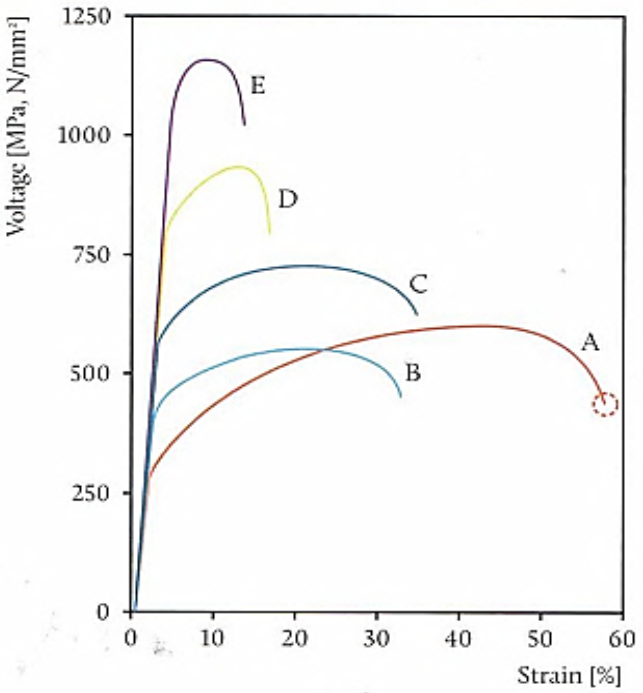
http://www.engineeringarchives.com/les_mom_stressstraindiagram.html

& 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**



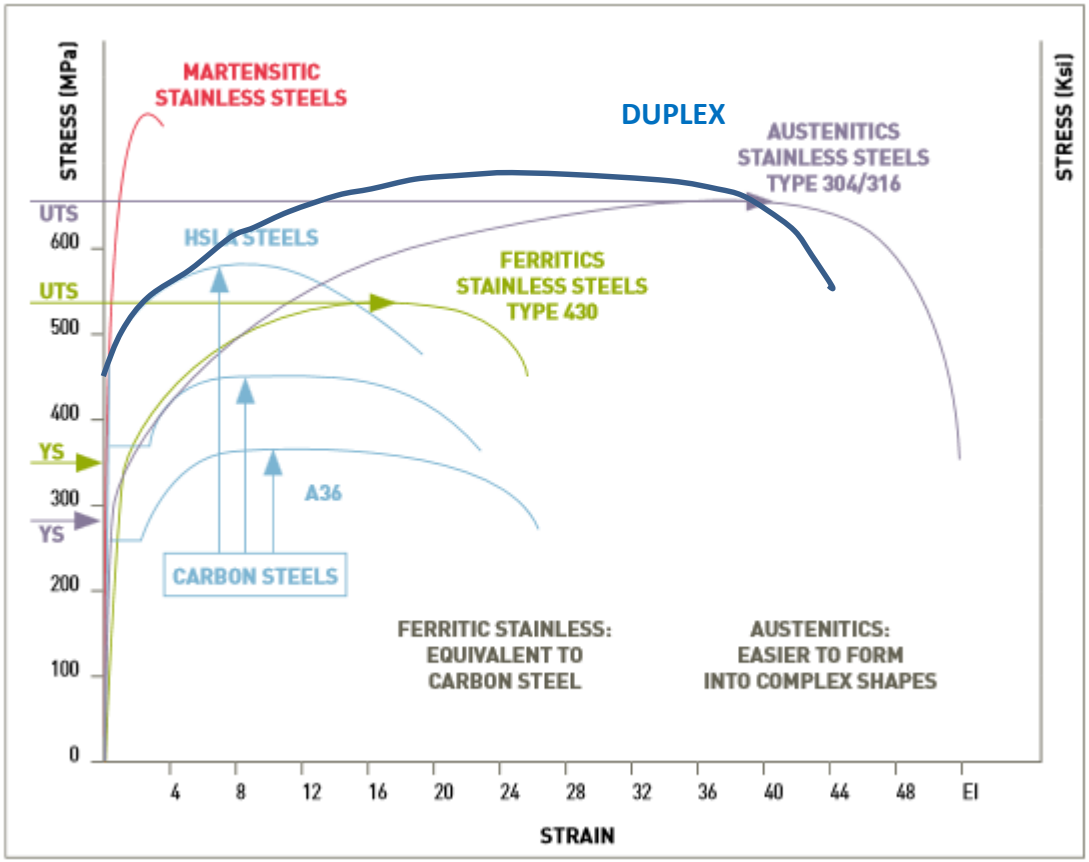

*Outline stress-strain test of different types of stainless steel:*
*A: Austenitic (e.g. 4301, 4307, 4404, etc.)*
*B: Ferritic (e.g. 4016, 4509, 4521)*
*C: Ferritic-austenitic (duplex, e.g. 4462)*
*D: Precipitation hardening (PH) steel (e.g. 4542)*
*E: Martensitic (e.g. 4057, 4109, 4034)*
*The dotted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

A wide range of properties is available

From

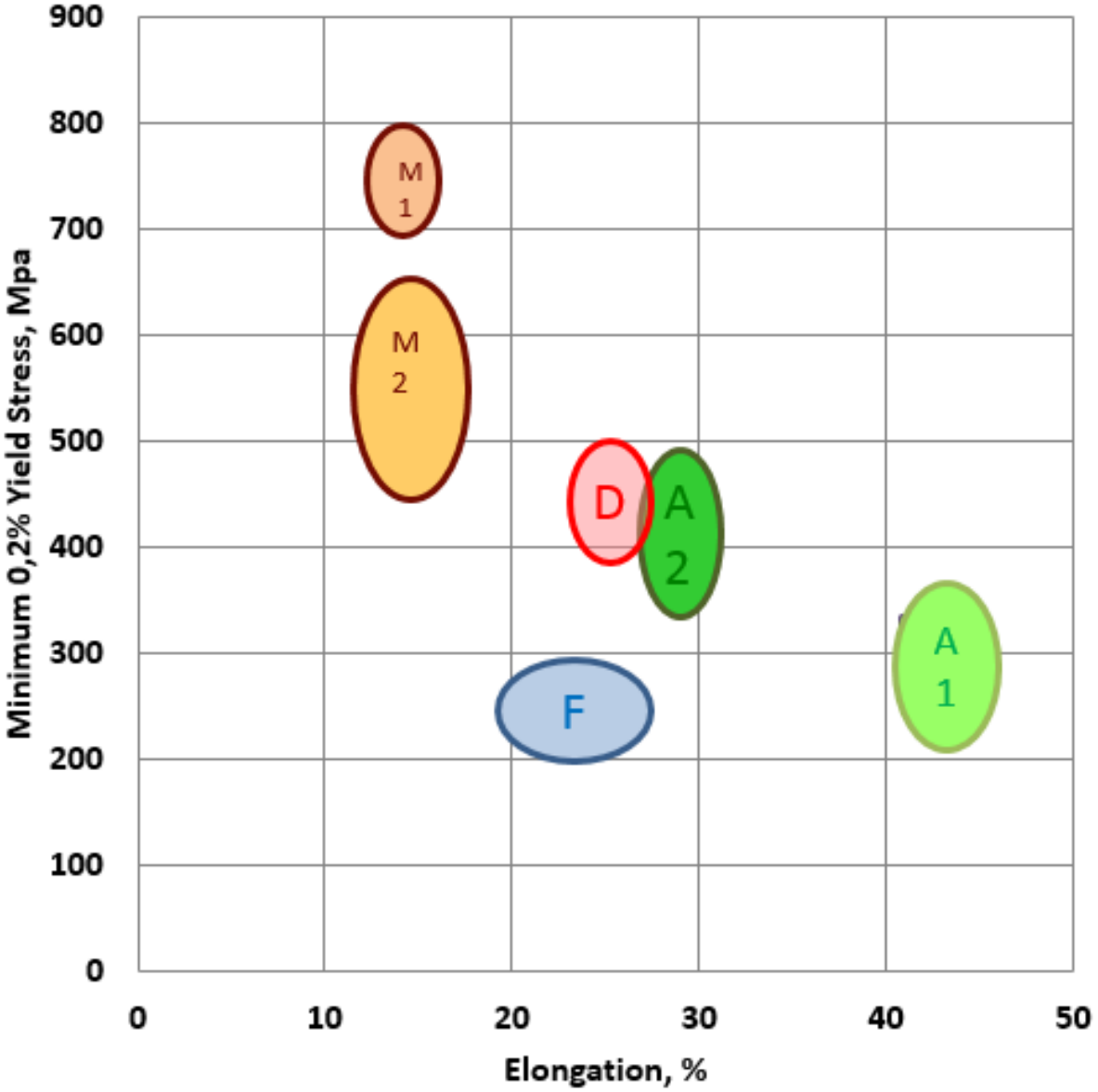
- High strength and low elongation to
- Lower strength and very high elongation

# 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**

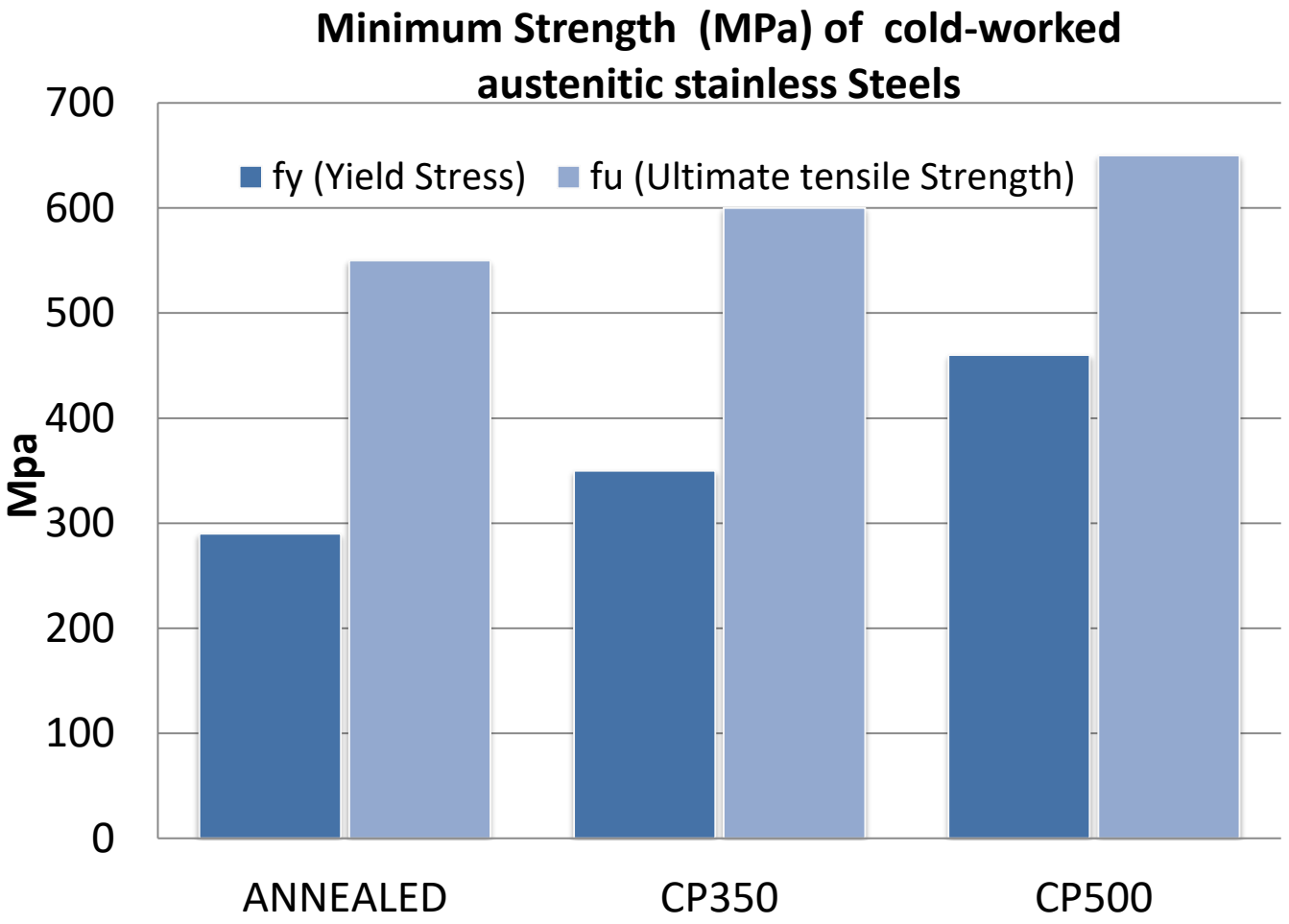
A1:Austenitics, annealed**

A2:Austenitics, cold-worked***

* EN 10088-3, (heat treated )

** EN 10088-2 (annealed)

*** EN 10088-2 (Cold Worked)

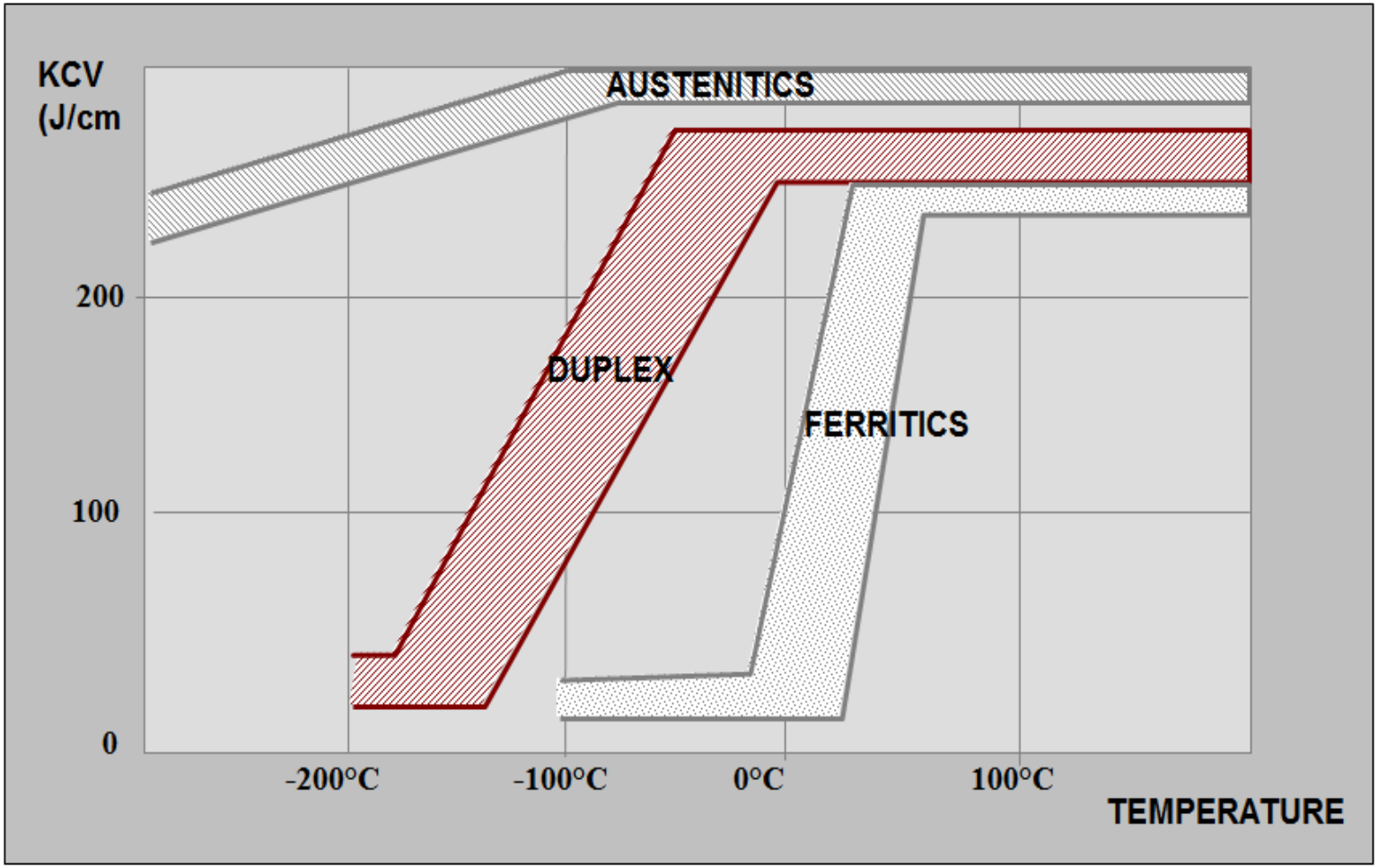



## Higher tensile strength by cold work[7]

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.



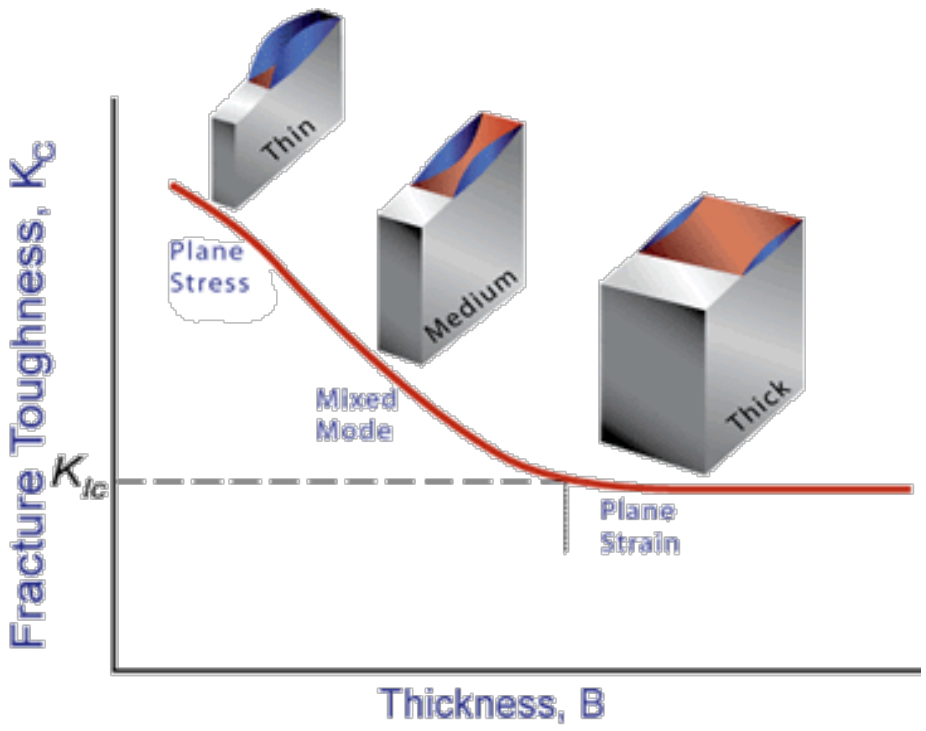

## Charpy Impact toughness of stainless steels (ref 8)

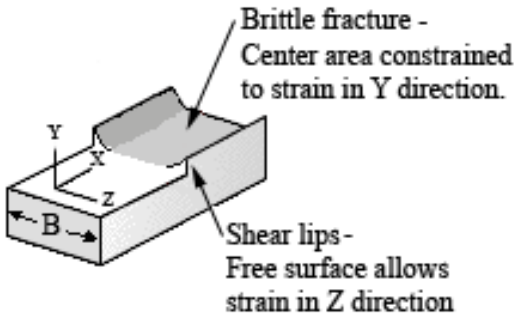
Note: These curves are for thick products (bars or plates)

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.

~

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]

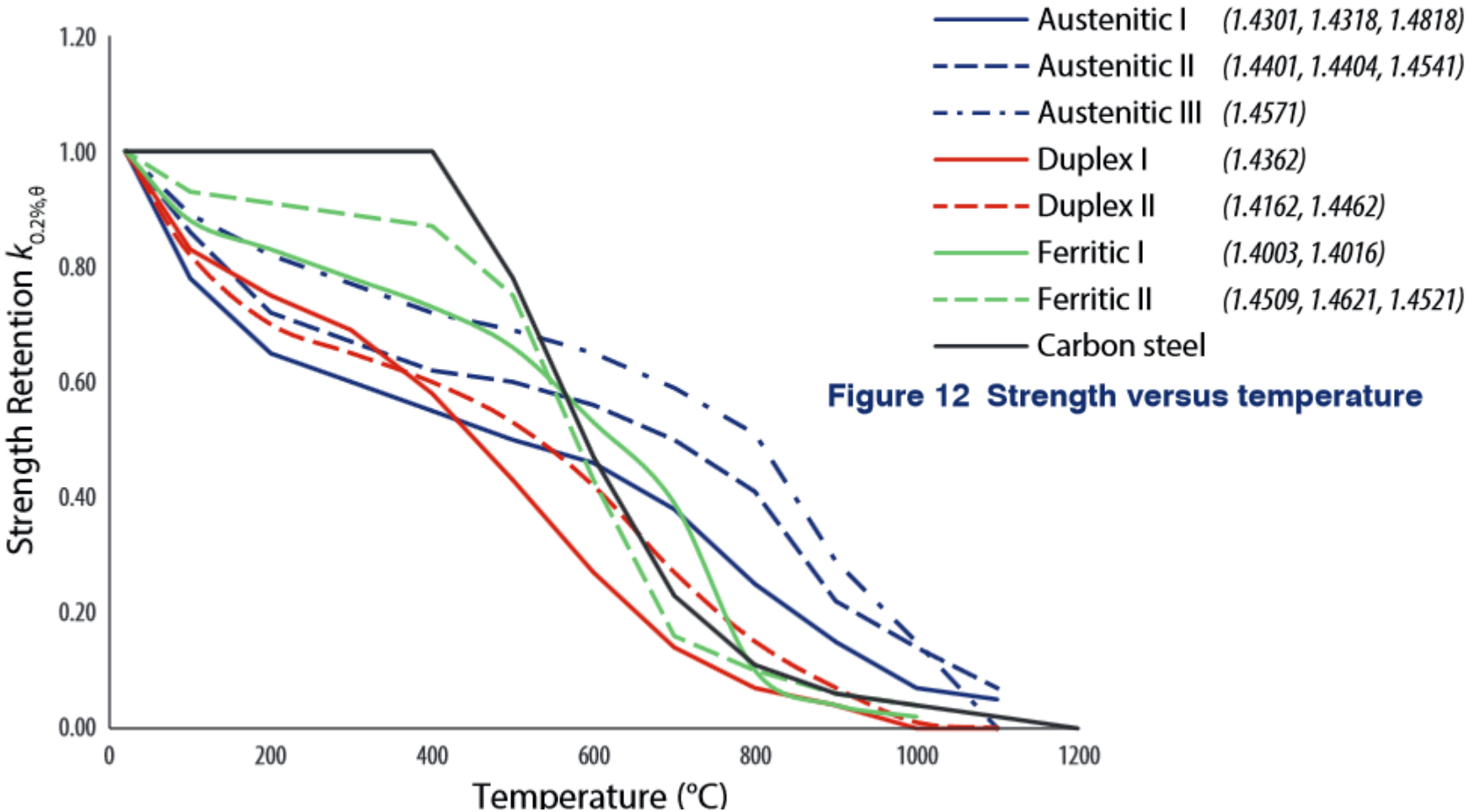



**Figure 12 Strength versus temperature**

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

# Fire resistance[9 -10]

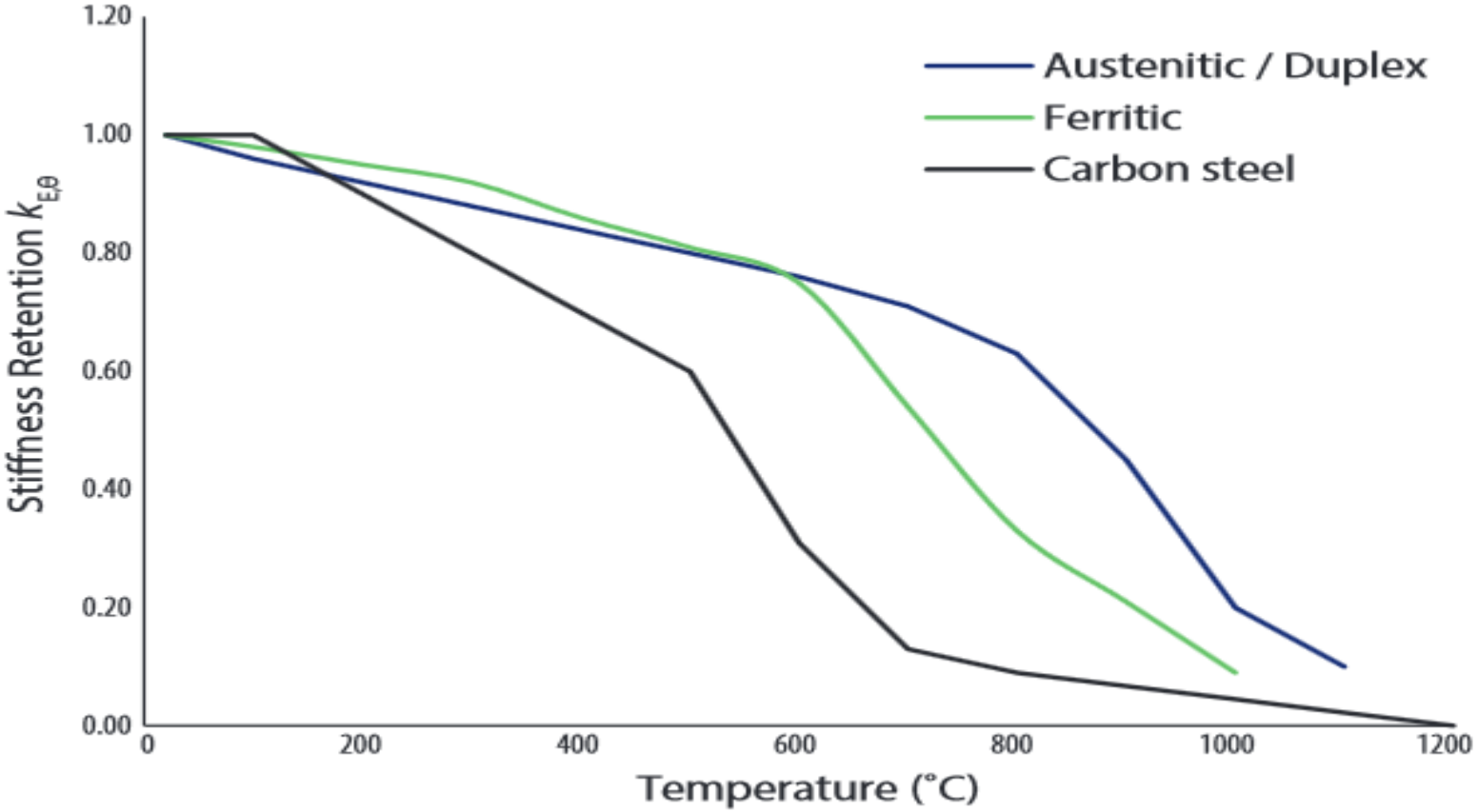
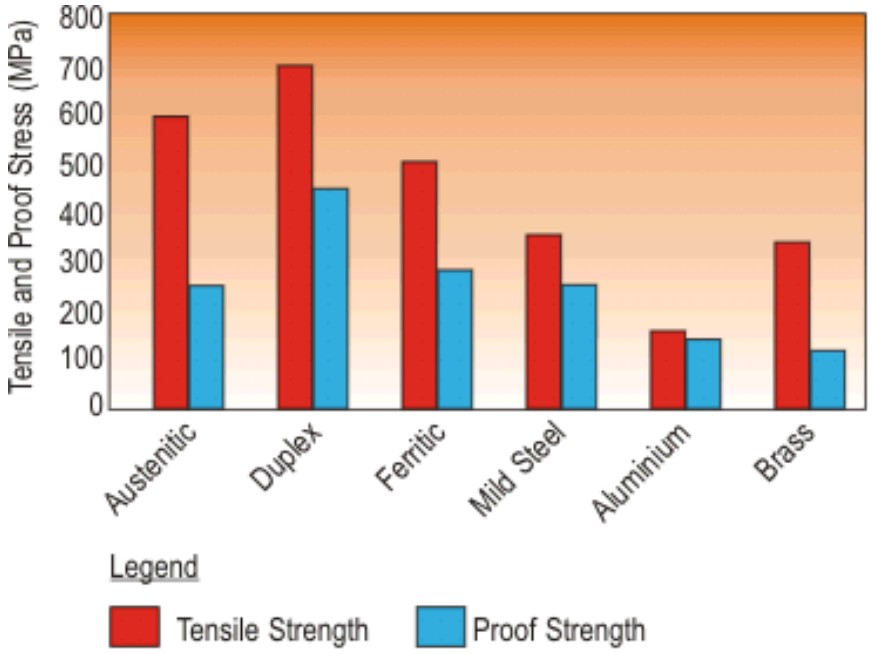
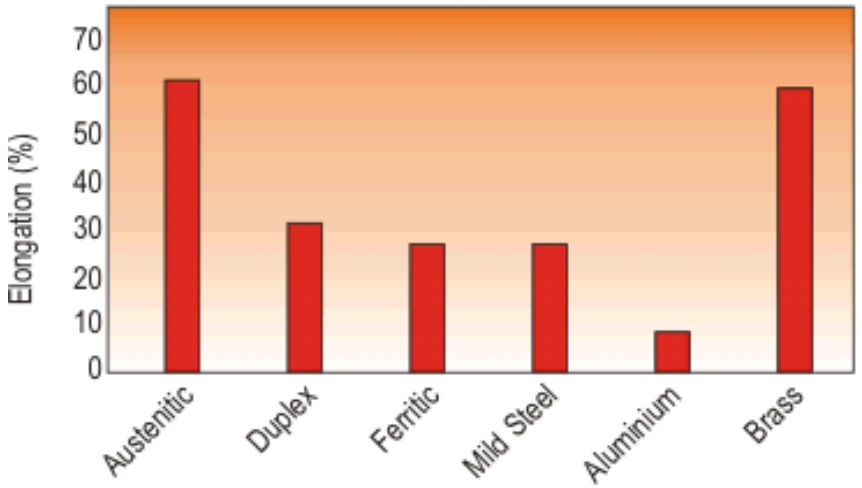



**Figure 13 Stiffness versus temperature**

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


1. http://www.engineeringtoolbox.com/young-modulus-d_417.html
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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