Uniaxial Loading

ENGINEERING MATERIAL PROPERTIES

NORMAL STRESS

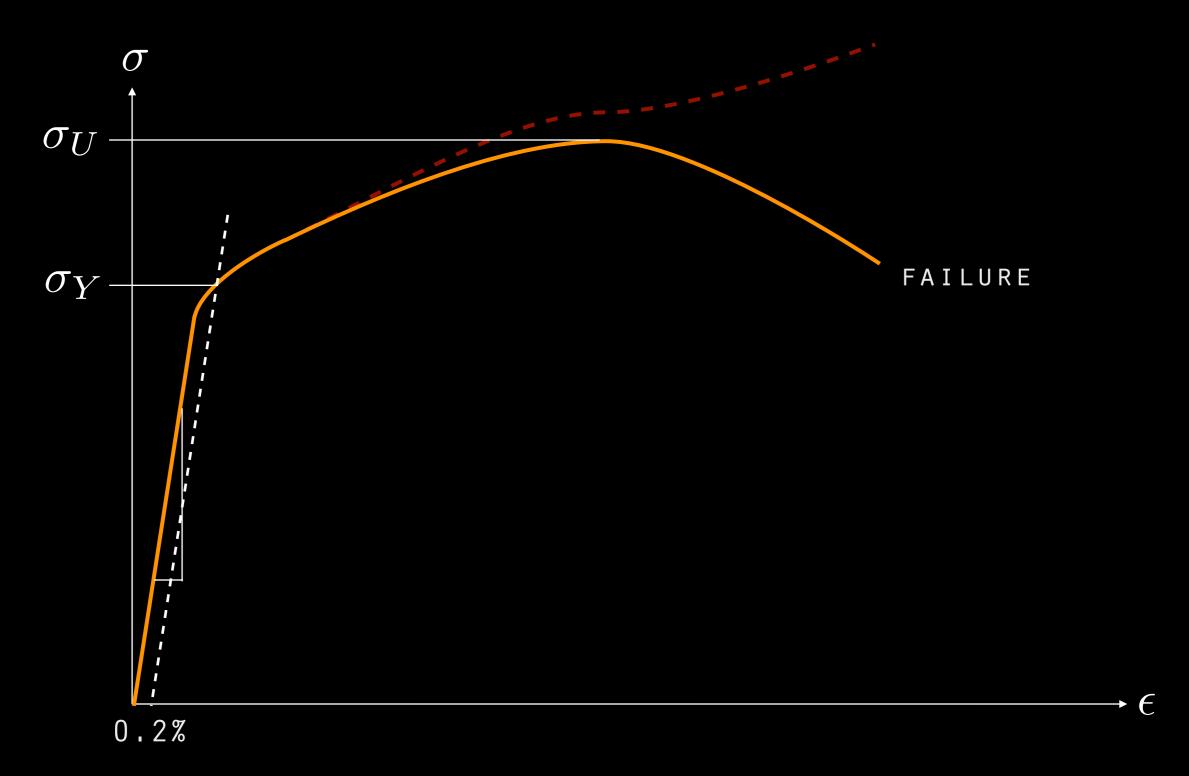$$\sigma = \frac{P}{A}$$

NORMAL STRAIN

$$\epsilon = \frac{\delta}{L}$$

"*ut tensio, sic vis*"

-Robert Hooke, 1678

HOOKE'S LAW

$$\sigma = E\epsilon$$

CONSTITUTIVE RELATION

DERIVED FROM STRESS-STRAIN PLOT

YOUNG'S MODULUS

$$E = \frac{\sigma}{\epsilon}$$

material	Young's modulus (10^9 N/m^2)
structural steel	200
aluminum	70
glass	65
high-strength concrete	30
Douglas Fir	13
Polystyrene	3

Quenched, tempered alloy steel (A709)

High-strength, low-alloy steel (A992)

Carbon steel (A36)

Pure iron

ϵ

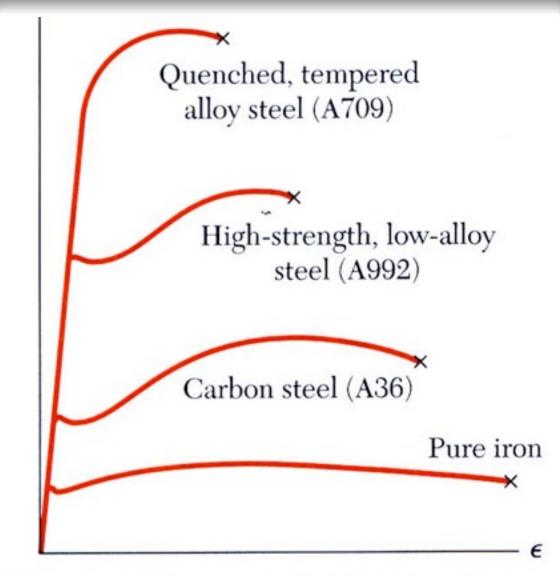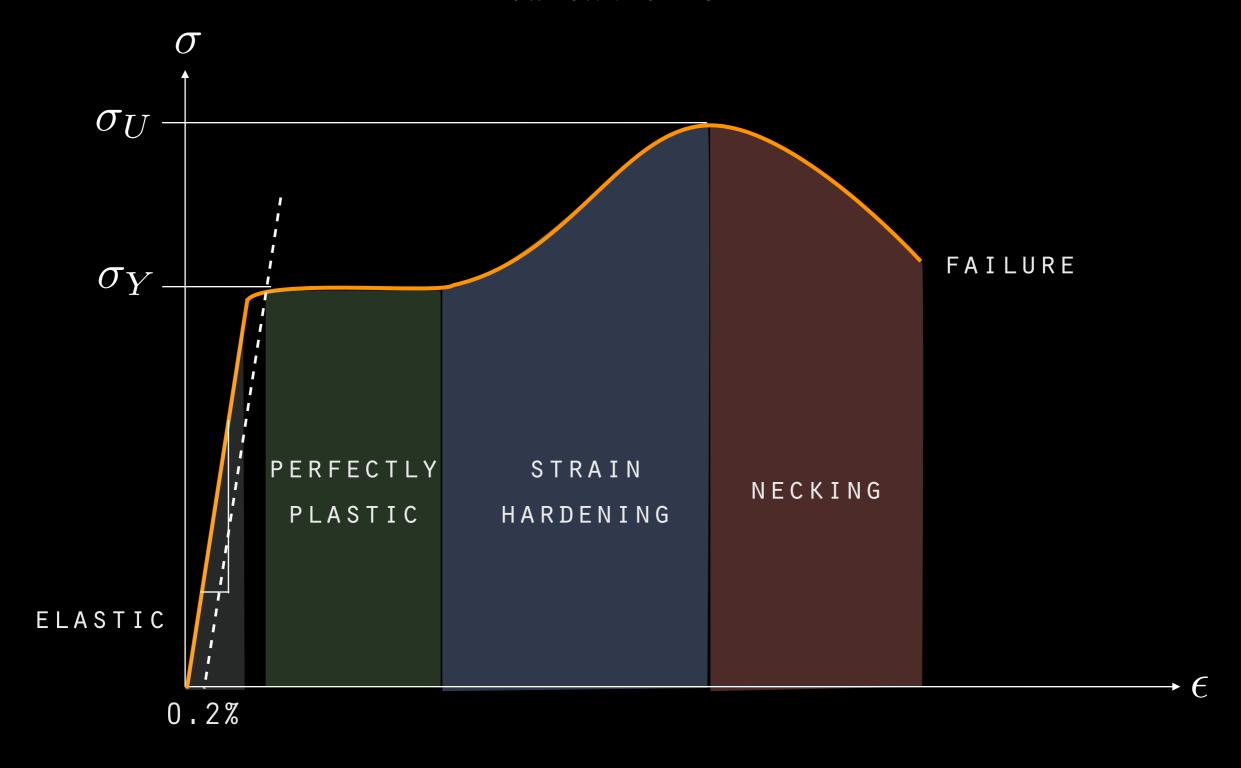**Fig. 2.16** Stress-strain diagrams for iron and different grades of steel.
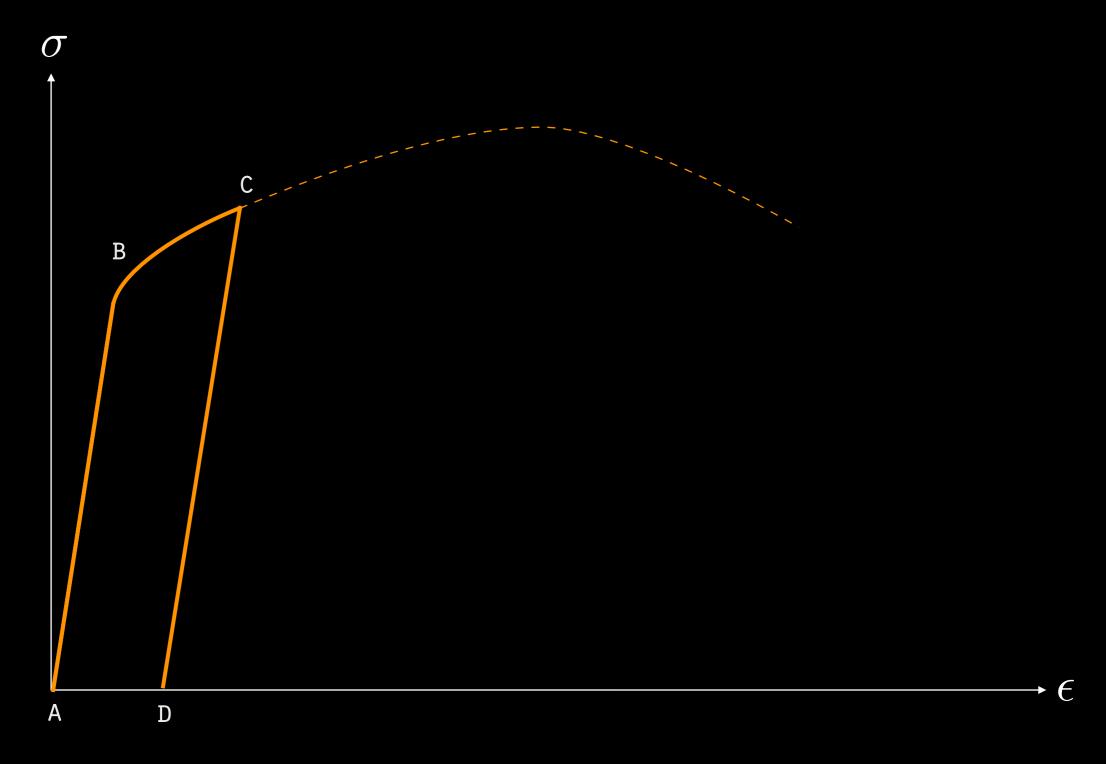
STRESS VS. STRAIN

LOW-CARBON STEEL

σ

σ_U

σ_Y

ELASTIC

PERFECTLY PLASTIC

STRAIN HARDENING

NECKING

FAILURE

0.2%

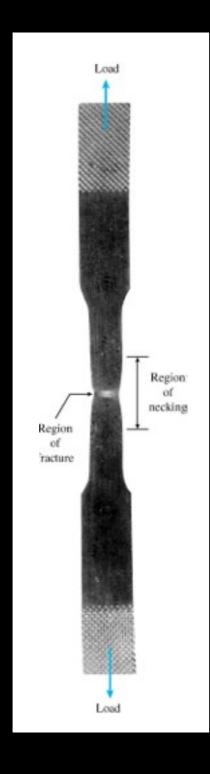ϵ

NOTE: NOT TO SCALE

PLASTIC DEFORMATION
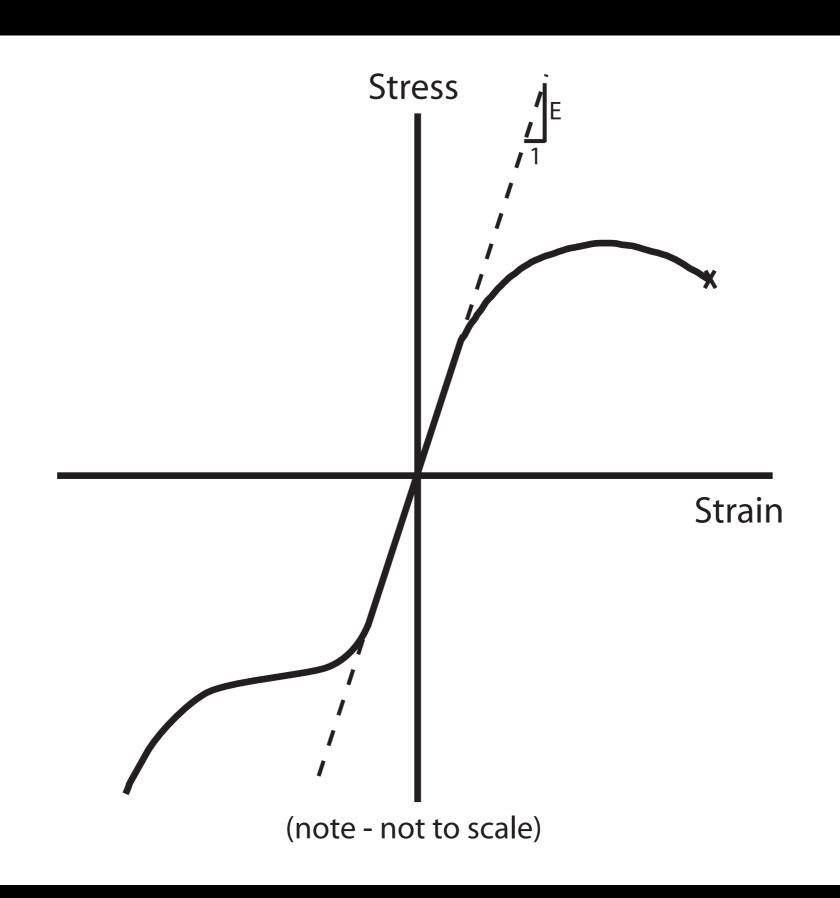
NOTE: NOT TO SCALE

DUCTILITY

$$\text{ductility} = \frac{A_o - A_f}{A_o}$$

Stress

E

1

Strain

(note - not to scale)
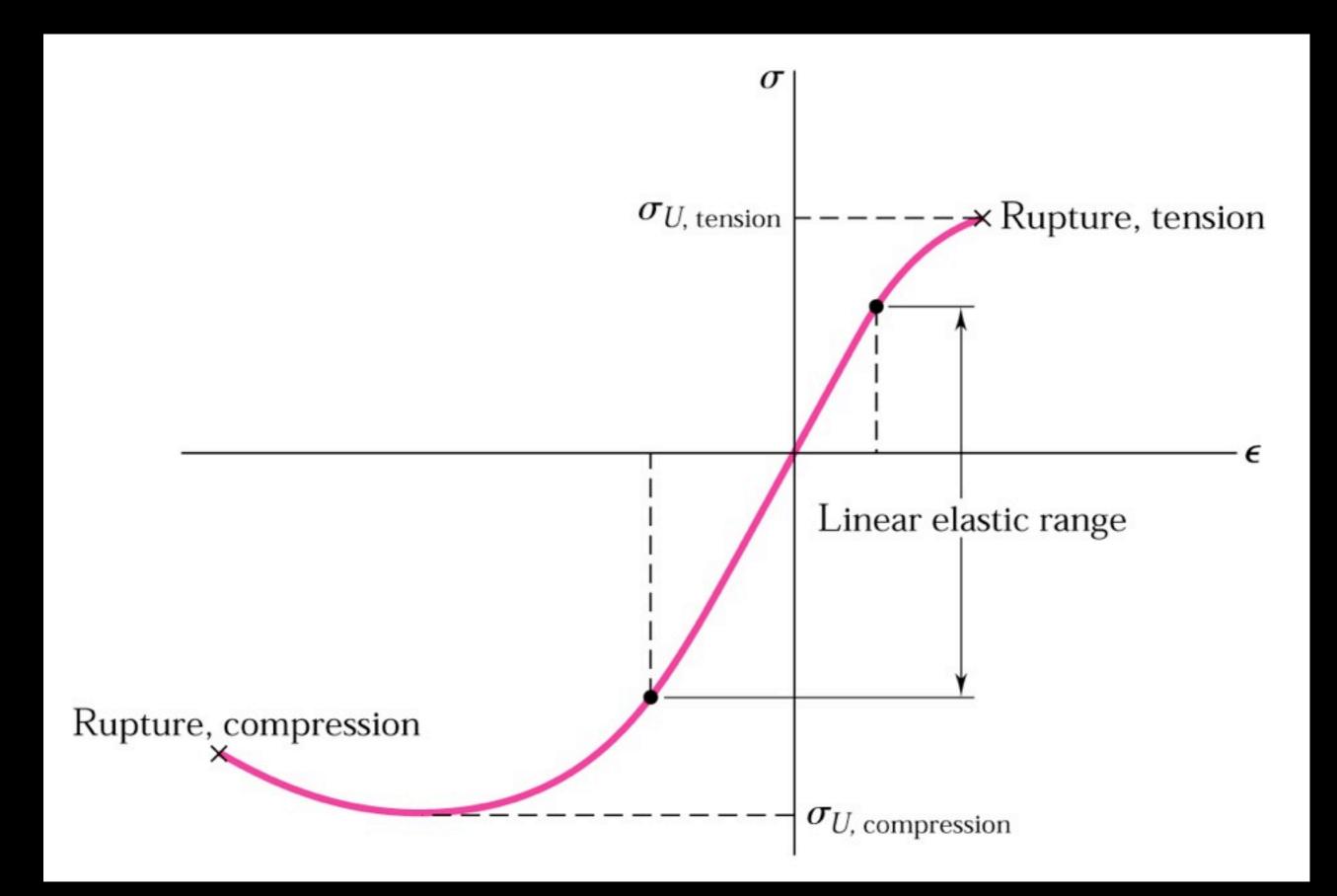
ULTIMATE TENSILE STRENGTHS
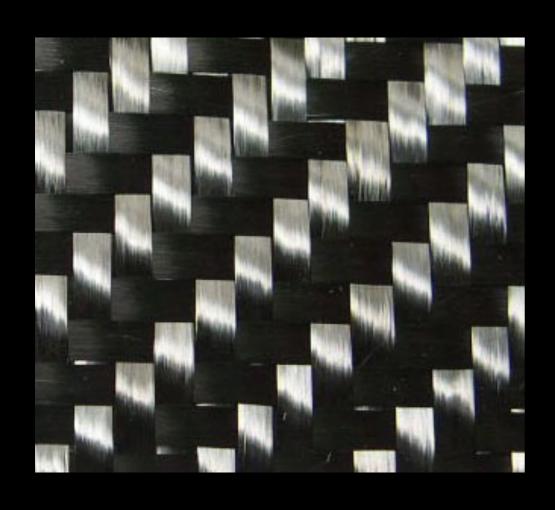
Material	Tension (MPa)	Compression (MPa)
Structural Steel ASTM-A36	400	~400
4.5%C Cast Iron ASTM-A48	170	655
Douglas Fir	100	50
Concrete	small, variable	40
Marble	20	240

STEEL-REINFORCED CONCRETE
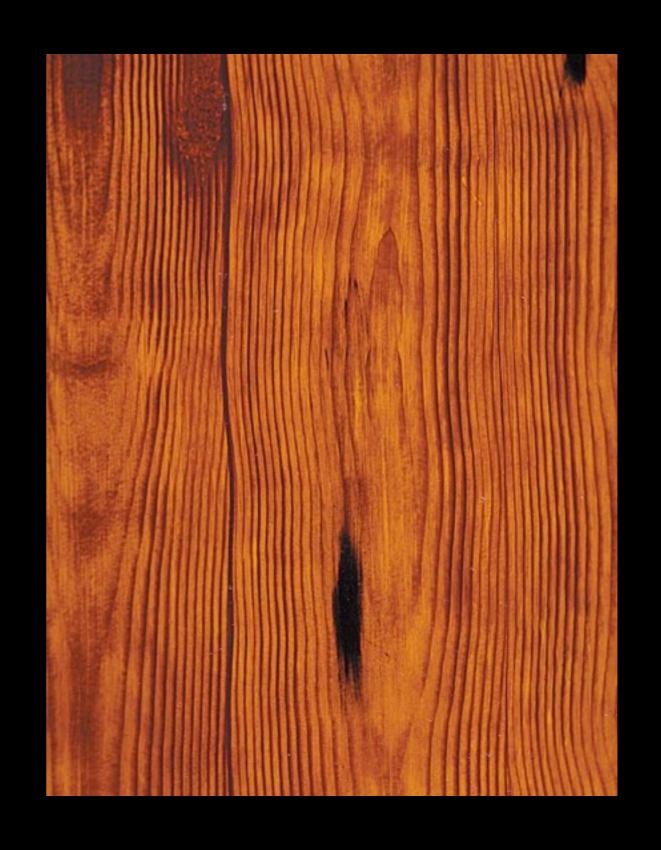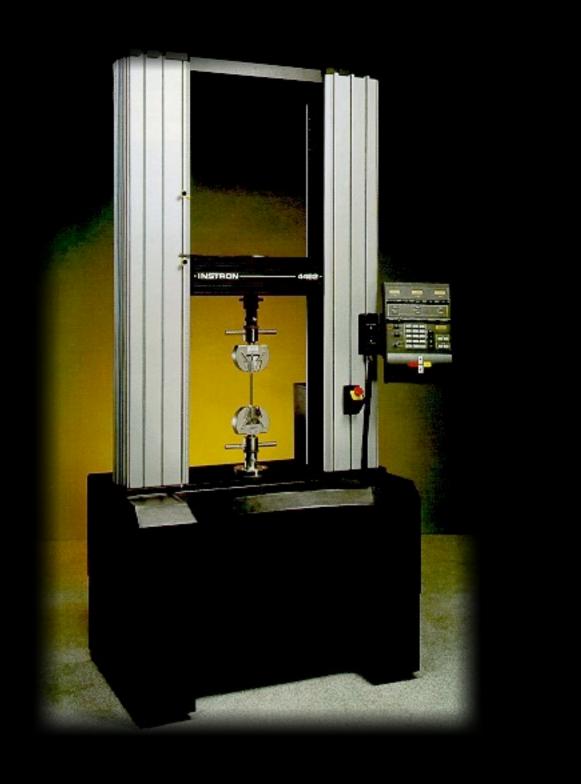
ANISOTROPIC MATERIALS
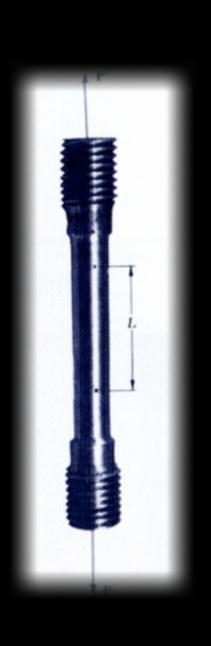
EXPERIMENTAL SETUP

TENSION TESTING
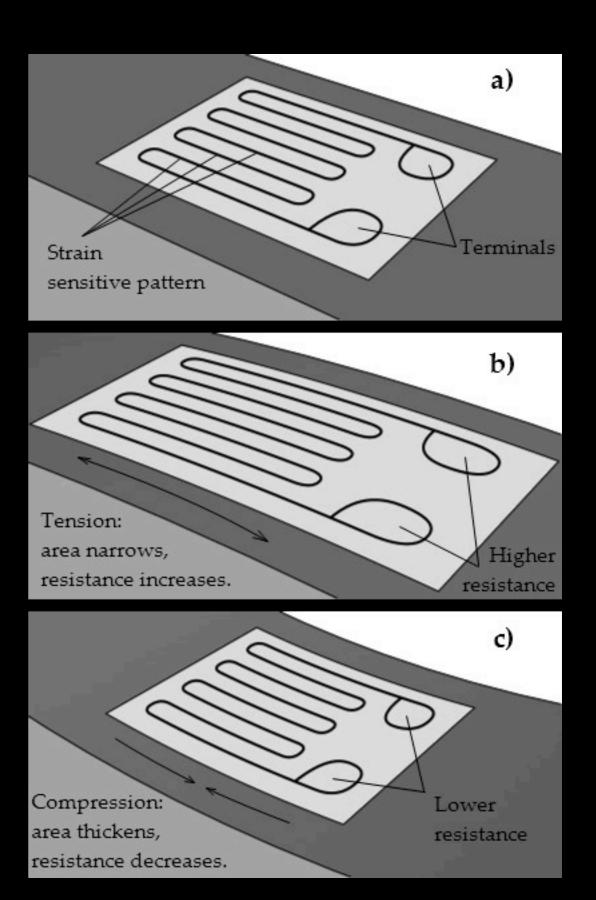
INSIDE A LOAD CELL

STRAIN GAUGES

a)

Strain sensitive pattern

Terminals

b)

Tension: area narrows, resistance increases.

Higher resistance

c)

Compression: area thickens, resistance decreases.

Lower resistance
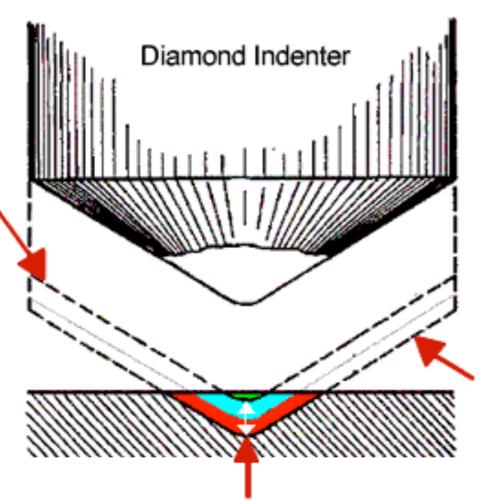
HARDNESS TESTING

RESISTANCE TO DEFORMATION

ROCKWELL HARDNESS TESTING

Diamond Indenter

Depth to which indenter is forced by minor load

Depth to which indenter is forced by major load

Increment in depth due to increment in load is the linear measurement that forms the basis of Rockwell hardness tester readings

INDENTERS

COMMON ROCKWELL SCALES

SCALE	MATERIALS	INDENTER	MAJOR LOAD
B	SOFT METALS	HARDENED STEEL BALL	100 KGF
C	HARD METALS	BRALE	150 KGF