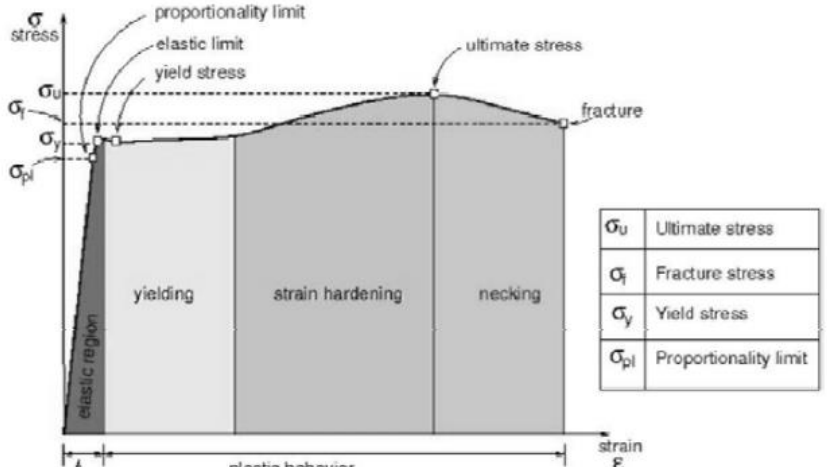
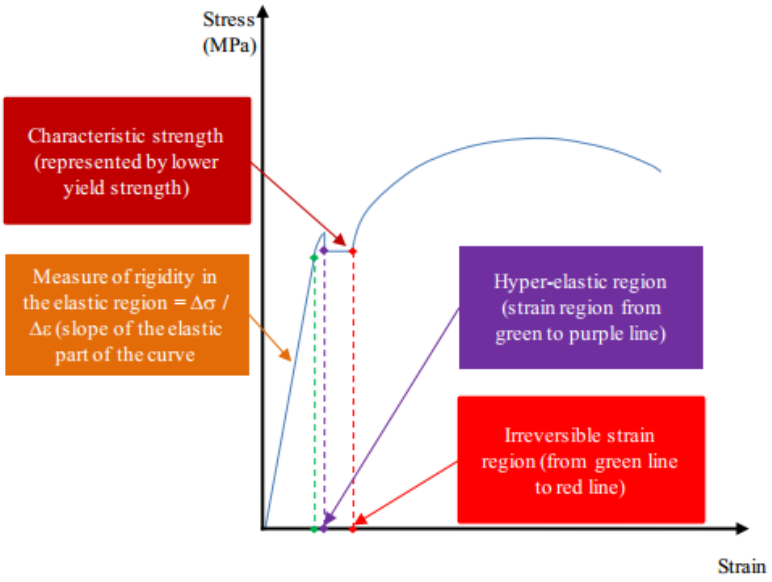
Mechanical Properties

- **Properties**
  - Strength-tensile, compressive and flexural
  - Stiffness-modulus of elasticity
  - Ductility-toughness and failure pattern
  - Resilience-elastic and hyper-elastic
- **Stress=Load/Area** (associated with load)
- **Strain=Change in length/original length** (associated with extension)
- From stress/strain plot we can determine yield strength, tensile strength, modulus of elasticity and toughness
- Brittle metals have **sudden failure**, no necking, eg cast iron (high carbon, 4%) and high tensile steel
- Ductile metals have **slow progressive failure**, visible **necking**, cup and cone model, eg mild steel (0.2% carbon), aluminium and copper
- Region 1 is **elastic**, region 2 is **yielding** (termed plastic or **hyper-elastic**), region 3 is **strain-hardening** or elasto-plastic and the final stage is necking and **fracture**.
- **Yield point**-first unit of stress at which deformation continues without an increase in load (constant)
- **Elastic resilience**-energy stored per unit of volume at elastic limit
- **Hyper-elastic** resilience-energy recovered when stress applied to metal passes yield point
- For **Hypo-elastic** use the elastic limit, for hyper-elastic use proportional limit
- Engineering strain incorporates factor of safety, also FOS = allowable yield stress/actual yield stress
- Increase in **carbon** = -magnetism, - corrosion, + brittle and + compression strength





- Wrought (low carbon steel) iron has lowest C content, steel has medium (good for engineering) and cast iron has highest, good for tools
- Low carbon steel is 0.15-0.3%, medium is 0.3-0.8%, and high is 0.8-1.5%

Cement

- **Concrete** made up of cement (binder, Portland cement and supplementary cementitious materials), aggregates, water and admixtures
- **C3S**-hardens and hydrates rapidly, moderate amount of head (causes cracking and shrinkage), initial set (loses workability) and early age strength < 28 days
- **C2S**- hardens and hydrates slowly, low amount of heat, increase in later age strength < 28 days, highest eventual strength tho
- **C3A**- reacts and hardens quicker than C3S, high heat, setting and early strength gain, poor sulphate resistance, could flash set
- **C4AF**- reduces clinkering temp, moderate heat, no contribution to strength
- Types;
    - **GP**-General purpose
    - **GL**-general purpose limestone (less CO2)
    - **GB**-General purpose blended (fly ash), used for marine and thick sections
    - **SP**-Special purpose
        - **HE**-high early strength-early stripping, cold weather, repair work
        - **LH**-low heat-thick sections (decrease thermal stress), hot weather
        - **SR**-Sulphate resistance-soil and water
        - **SL**_Shrinkage limited-decreases 28 day shrinkage strain
    - Class C is both pozzolanic and cementitious, class f is pozolanic and is more reactive and less pores, class c is cementitious.
    - **Flyash**- both Poz and Cem, 20% replacement, decrease emissions, improves workability, decreases rise in temp therefore reducing thermal cracking, increases ultimate strength, improves durability
    - **GGBFS**- both Poz and Cem, 70% replacement, improves workability, delays set time, decrease in temp rise, reduces permeability and increase durability
    - **Silica Fume**- pozzolanic, increases water demand (needs water reducer), decreases bleeding and permeability, increase early age strength (>85 MPa)

Aggregates

- **Coarse** (>4.75mm, includes gravel, basalt, granite and limestone)
- **Fine** (<4.75mm, uncludes sand, crushed stone)
- Normal weight = 2.4, includes basalt, limestone, granite and sandstone
- Light weight = 1.17, expanded clay, foamed slag, sintered fly ash and polystyrene
- **Categorized** as rounded (river gravel), irregular (rounded ended), angular (crushed rock), flaky (small thickness), elongated (long), flaky and elongated (particle interaction).
- Higher **surface to volume ratios** require more PC, decreases lubrication, decreases workability. Irregular particles increase interaction and decrease workability.
- Flaky and elongated increase SA/V ratio, increase interaction, increase segregation, decrease bonding
- **Ovendry** (no water), **air dry** (less than potential absorbtion), **SSD** (equal to potential) and **damp/wet** (greater than absorbtion).
- **Absorption capacity**=[(SSD wt – overndry wt) / oven dry wt] X 100
- **Moisture content**=[(aggregate wt – ovendry wt)/ovendry wt] X 100
- **Effective absorption**=AC – MC
- **Surface Moisture** = MC – AC
- **Silt**- increases water demand, PC content, makes uneconomical mix, increases drying shrinkage
- **Continuous (well-graded) grading-** minimum void content (parabolic shape), blended fine and coarse aggregate