Aalto University
School of Engineering

MEC-E6007 Mechanical Testing of Materials

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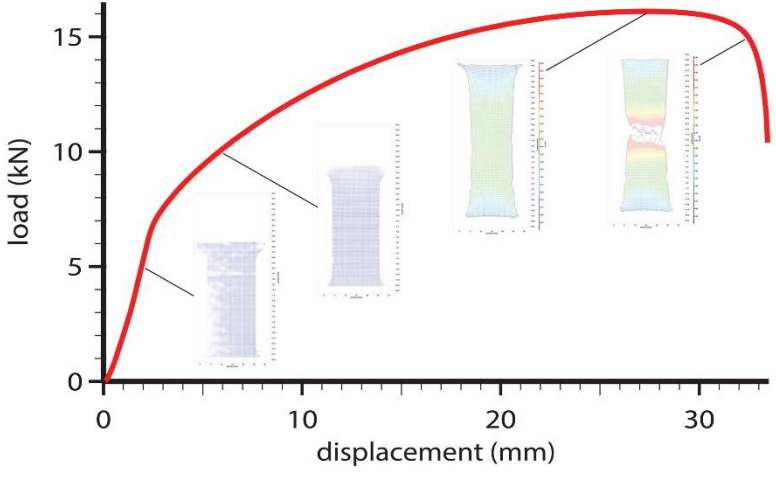
load frames, grips, and actuators

Course Content: *learning from breaking things*

- Load
  - *loadframes, actuators, and grips*
  - *quasi-static, dynamic, and cyclic loading*
- Measure
  - *measurement of force, displacement, and strain*
  - *digital image correlation and other full-field measurement techniques*
- Analyse
  - *selected special challenges in mechanical testing (ask for yours!)*
  - *introduction to inverse problem methodologies in experimental mechanics*



Load frames

rigid physical platform anchoring the grips and actuators for mechanical testing

- "universal testing machines"
- modular assemblies
- special purpose
  - *torsion, axial+torsion, cruciform biaxial, triaxial, hydrostatic pressure, …*
  - *sheet metal forming, bulge testing, …*
  - *environmental chambers, microscopes, tomographs, synchrotron or neutron beam lines, …*

load frame stiffness

- including grips, fixtures and connections
- determines dynamic response at fracture or serrated flow
  - *dynamic response of load cell matters too*

Tensile grips

apply boundary conditions

- slipping or stress concentrations may affect observed behaviour
- lateral gripping force needed to transfer axial force by friction
  - *wedge action increases lateral force when axial force increases*
  - *mechanical, pneumatic, or hydraulic action*
  - *in some cases this does not work*
    - end tabs glued to the specimen's grip area to transfer the force
    - a pin through a hole in the specimen to prevent complete slipping
- different grips for flat or round specimens
- special grips for textile or fibers
- hinges to avoid bending moments

Compression testing

easy to do, easy to do wrong

- stability against buckling
- care needed to avoid bending moments
  - *need to critically examine results to distinguish material behaviour from effects of uneven loading*
- carbide inserts to spread the load

special specimen shapes to achieve particular stress state

- e.g. “Brazilian disk”

Flexure testing

often adjustable to change base length

- 3-point or 4-point bending most common
- stoppers to keep specimen centered
- stress concentration at rollers

larger displacement and lower actuating force than axial testing

smaller area of maximum stress

- statistical correction for distribution of defects

Shear testing

difficult to maintain pure shear throughout deformation

- deformation tends to induce a tensile component to the load

complex grips, or specific specimen shape

- mixed mode loading

Actuators

screw-driven
- twin screws on either side to ensure even loading
- do not endure cyclic loading well

servo-hydraulic
- require hydraulic power unit
- suitable for high loads and cyclic loading

pneumatic
- better for load control than displacement control

electromagnetic
- same operating principle as loudspeaker
- ideal for cyclic loading

piezoelectric
- precise small displacements
- also magnetostrictive etc.

inertial
- mostly used for dynamic (impact) loading

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quasi-static, dynamic, and cyclic loading

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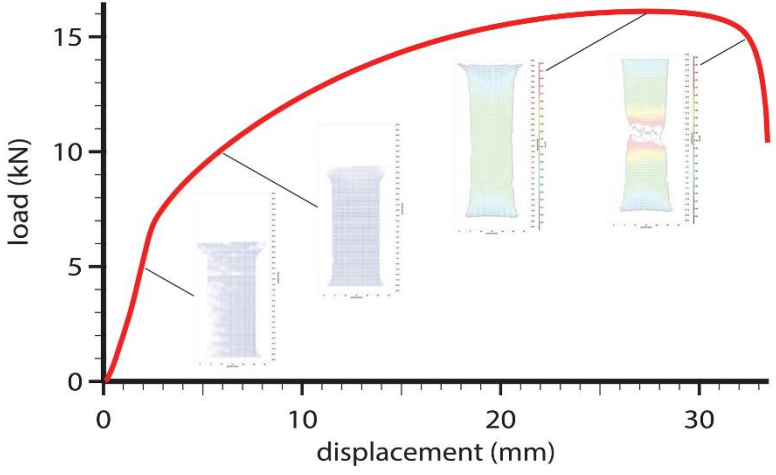

quasi-static loading

slowly applied load or displacement

- strain rates typically on the order of 10^{-3} s^{-1} or lower
  - *experiments take minutes or longer*
- feedback loop load control or strain control
- fracture or serrated flow may still be dynamic

dynamic loading

impact loading

- e.g. Charpy toughness test
  - *can have instrumented hammer to get load displacement curve*
- tests take on the order of 1 second

shock loading

- pressure pulse from shock propagating in fluid
  - *generated by explosives or diaphragm rupture*
  - *difficult to calibrate the variation of pressure in time and space*

high rate loading

- Kolsky bar / split Hopkinson bar
  - *elastically transmitted wave from impact on a long rod*
  - *load shaping requires a sacrificial insert that will deform with that load profile*
  - *load and deformation deduced from transmitted and reflected waves*

ballistic loading

- impact of a projectile with a larger target generates elastic shocks in target
- in hypervelocity impact the projectile is supersonic also in the target

cyclic loading / fatigue

necessary due to fatigue behaviour of metals

- may be problematic for the testing machine for the same reason
- rotating axle in bending does not cause fatigue in machine

programmable cyclic or spectrum loading

- simplest form is sinusoidal between minimum and maximum