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SHR

TU/e

COST E55, working group 2

- moisture induced stresses
- ductility

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- ductility

Ductility fact sheets

- General notes on ductility
    - why do we need ductility
        - warning before failure (large displacements)
        - redistribution of loads
        - redistribution of stresses
        - energy dissipation for earthquake design
        - robustness

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Ductility fact sheets

- General notes on ductility
    - why do we need ductility
    - member ductility
        - hard to achieve (only in compression)

COST E55, working group 2

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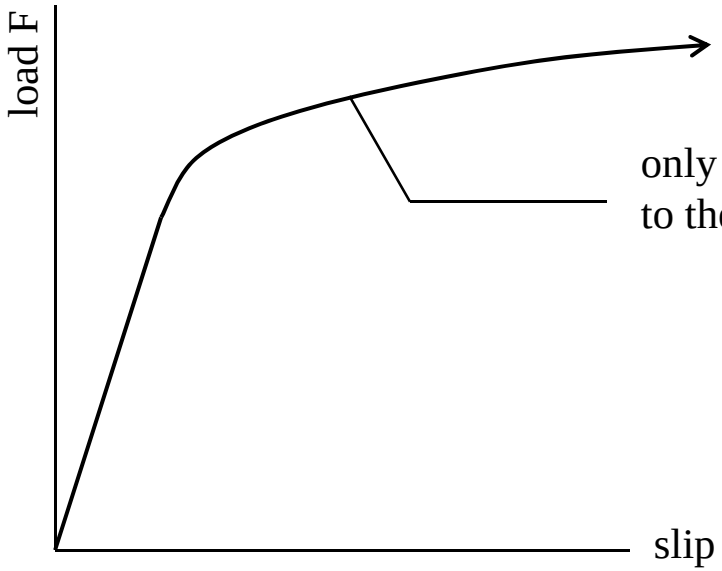
Ductility fact sheets

- General notes on ductility
  - why do we need ductility
  - member ductility: only in compression
  - connections
    - EYM: yield model ⇒ ductile
    -

} connections governing



only obtained when no or limited tension perpendicular to the grain is developed:

- single dowel type fastener connections
- multiple nail or staple connections
- toothed plate connections
- bearing
- reinforced

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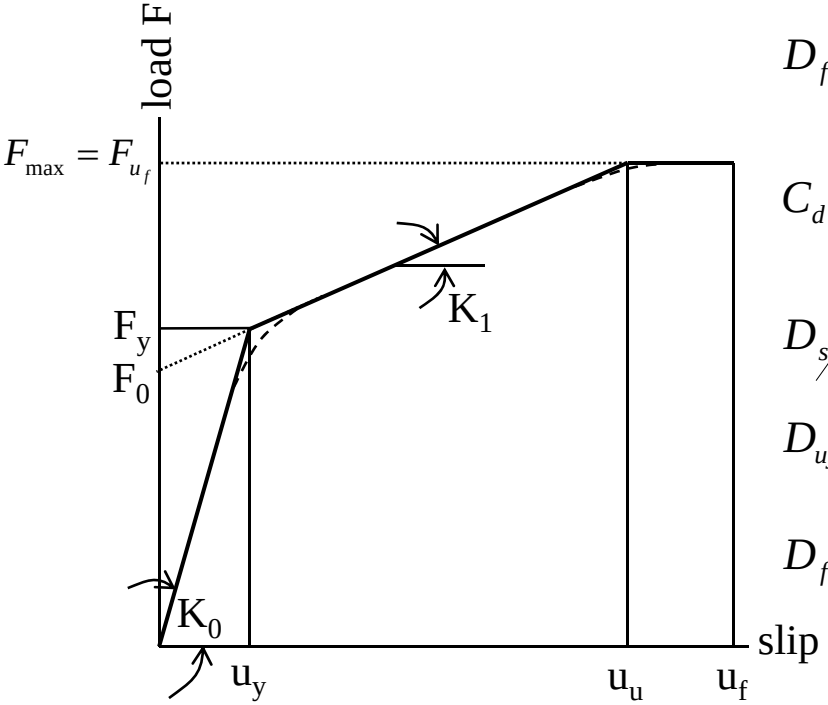
Ductility fact sheets

- General notes on ductility
  - why do we need ductility
  - member ductility: compression
  - connections
- static ductility
  - definitions (10 different are identified)
  - load-slip analyses (example discussed tomorrow)

static ductility

- definitions (10 different are identified)
- load-slip analyses (example discussed tomorrow)



$$D_f = \frac{u_f}{u_y} \quad (1) \qquad D_u = \frac{u_u}{u_y} \quad (2)$$

$$C_d = \frac{u_f - u_y}{u_f} \quad (3) \qquad D_{f/u} = \frac{u_f}{u_u} \quad (4)$$

$$D_{s/u} = \frac{K_1}{F_1} u_u \quad (5) \qquad D_{s/f} = \frac{K_1}{F_1} u_f \quad (6)$$

$$D_{uy} = u_u - u_y \quad (7) \qquad D_{fy} = u_f - u_y \quad (8)$$

$$D_{fu} = u_f - u_u \quad (9) \qquad E_d = \int_{u=0}^{u=u_f} f(F,u)du \quad (10)$$

$$F = \left(F_0 + K_1 u\right)\left(1 - e^{-\frac{K_1}{F_0}u}\right) \le F_{max}$$

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  - connections
- static ductility
  - definitions (12 different are identified)
  - load-slip analyses
- dynamic ductility
  - earthquake design
    - definitions (2 different are identified)
    - hysteresis analyses
  - bridges

dynamic ductility

- earthquake design
  - definitions (2 different are identified): energy dissipation
  - hysteresis analyses

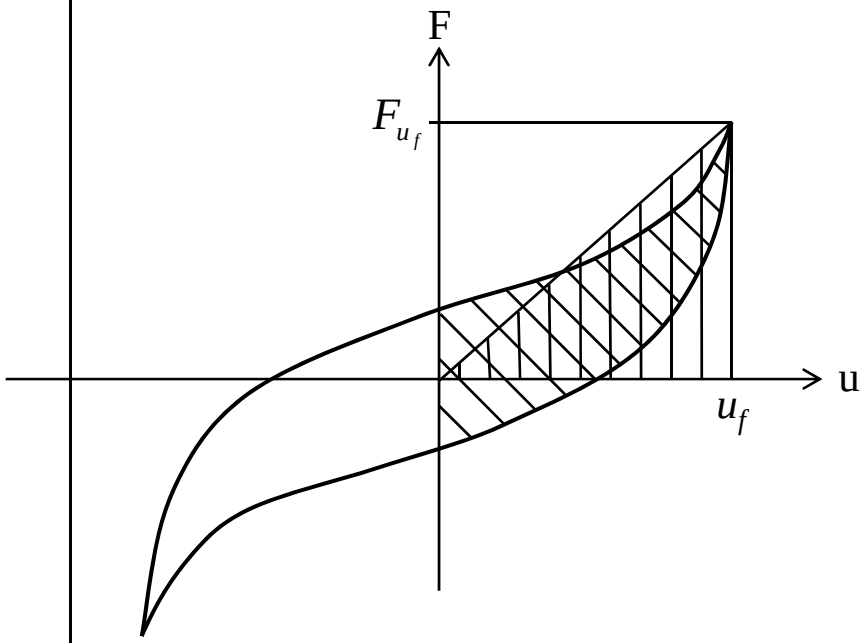
$$\upsilon_{eq} = \frac{E_d}{4\pi E_p} \qquad (1)$$

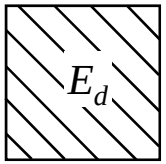
$$D_E = \frac{E_d}{E_{py}} \qquad (2)$$

E_d = *energy dissipated in a half hysteresis cycle*

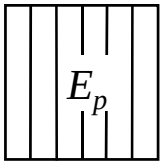
$E_p = \frac{1}{2} F_{u_f} u_f$ = *potential energy to failure*

$E_{py} = \frac{1}{2} F_y u_y$ = *elastic potential energy*





Energy dissipated per half cycle: E_d



Available potential energy: E_p

dynamic ductility

- earthquake design
  - definitions (2 different are identified): energy dissipation
  - hysteresis analyses

$$\upsilon_{eq} = \frac{E_d}{4\pi E_p} \qquad (1)$$

$$D_E = \frac{E_d}{E_{py}} \qquad (2)$$

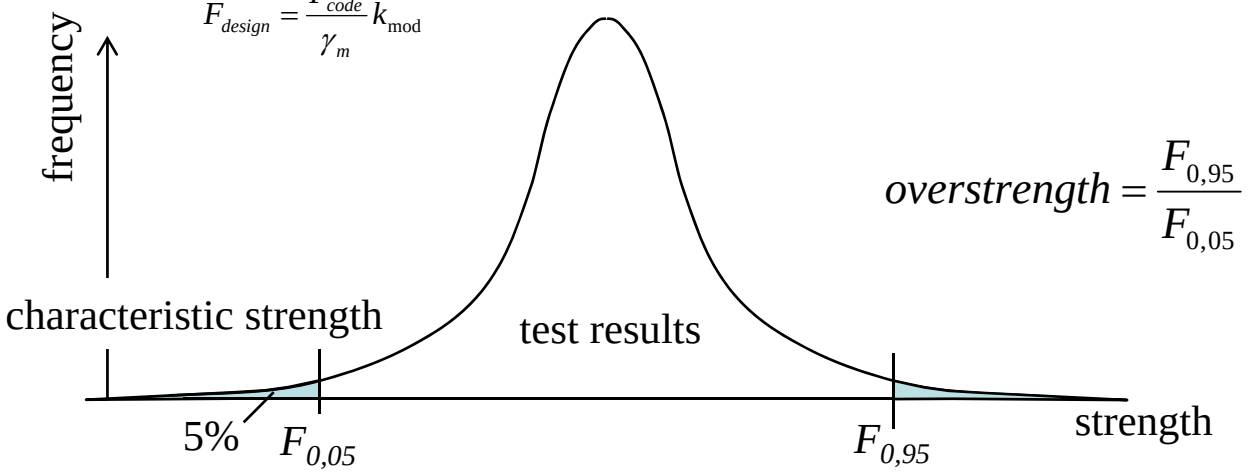
E_d = *energy dissipated in a half hysteresis cycle*

$E_p = \frac{1}{2} F_{u_f} u_f$ = *potential energy to failure*

$E_{py} = \frac{1}{2} F_y u_y$ = *elastic potential energy*

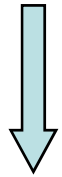
$$overstrength = \frac{F_{0,95}}{F_{0,05}} * \frac{F_{0,05}}{F_{code}} * \frac{F_{code}}{F_{design}} = \frac{F_{0,95}}{F_{design}}$$

$$F_{design} = \frac{F_{code}}{\gamma_m} k_{\mathrm{mod}}$$



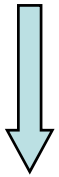
dynamic ductility

- earthquake design
  - definitions (2 different are identified)
  - hysteresis analyses
- bridges



reverse loading

- fatigue
- pinching



only elastic design allowed

Heimbach

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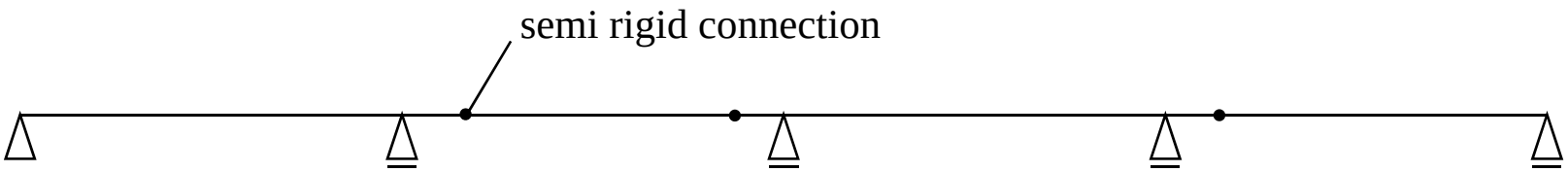
    - hysteresis analyses
  - bridges
- benchmark examples

benchmark examples



(1) redistribution of load possible
(2) no full mechanism: no large displacements
(3) plastic connection deformation: possible overload (warning)
(4) energy dissipation possible (earthquake design)

Thank you for your attention