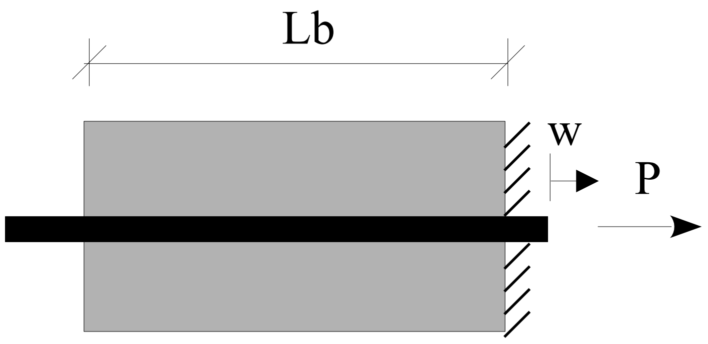
X0202: Pull-out with constant bond-slip law and elastic matrix (ELF-ELM)

For the displayed pull-out test assuming a constant bond-slip law, elastic long matrix and elastic long fiber with the given data:



Steel reinforcement bar:
$d_s = 16$ [mm] , $E_f = 210000$[MPa].
Reinforcement strength $f_y = 500$[MPa]

Concrete matrix:
$A_m = 10000$[mm^2], $E_m = 30000$[MPa].

Bond:
$\tau = 8$ [MPa]

a) Plot qualitatively the pull-out response at both the loaded and unloaded ends.

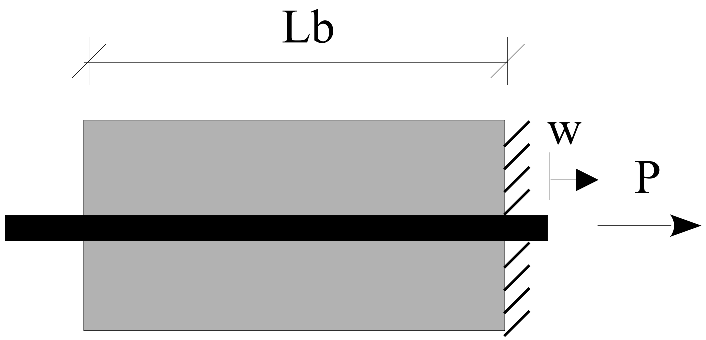
Assuming short matrix (Lb=10 ds):

b) Determine the maximum pull-out force that can be achieved.

c) How will the specimen fail? is it pull-out or steel rapture failure?

d) If the bond length set to Lb = 20 ds, how will the specimen fail then?

X0202: Pull-out with constant bond-slip law and elastic matrix (ELF-ELM)



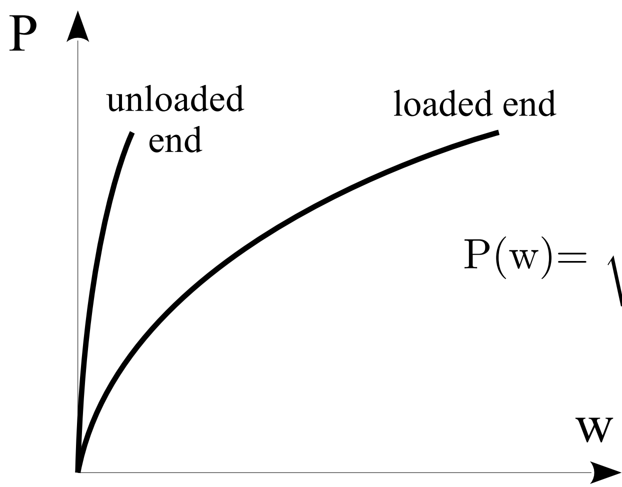
Steel reinforcement bar:
ds = 16 [mm] , E_f = 210000[MPa].
Reinforcement strength f_y = 500[MPa]

Concrete matrix:
A_m = 10000[mm^2], E_m = 30000[MPa].

Bond:
τ = 8 [MPa]

a) Plot qualitatively the pull-out response at both the loaded and unloaded ends.

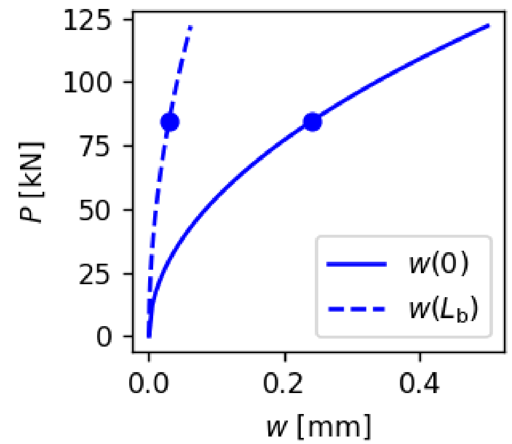
Solution:



$$P(w) = \sqrt{2p\,\bar{\tau}\,w\,\frac{E_f\,A_f\,E_m\,A_m}{E_f\,A_f + E_m\,A_m}}$$

→ Using the corresponding OpenWebApp:

2.2: PO-ELF-ELM



X0202: Pull-out with constant bond-slip law and elastic matrix (ELF-ELM)

Steel reinforcement bar:
$d_s = 16$ [mm] , $E_f = 210000$[MPa].
Reinforcement strength $f_y = 500$[MPa]

Concrete matrix:
$A_m = 10000$[mm^2], $E_m = 30000$[MPa].

Bond:
Lb = 10 ds, $\tau = 8$ [MPa]

b) Determine the maximum pull-out force that can be achieved.

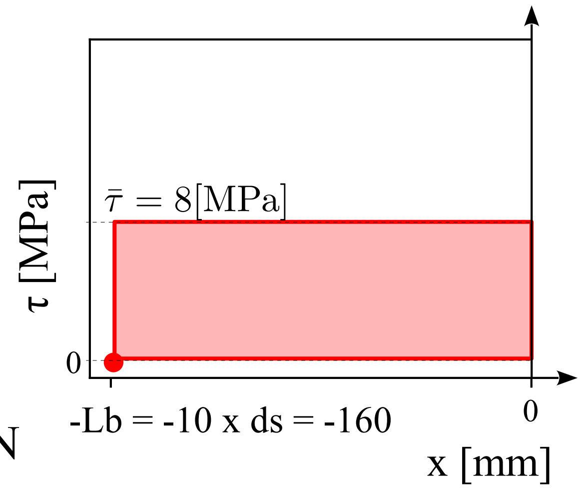
Solution:

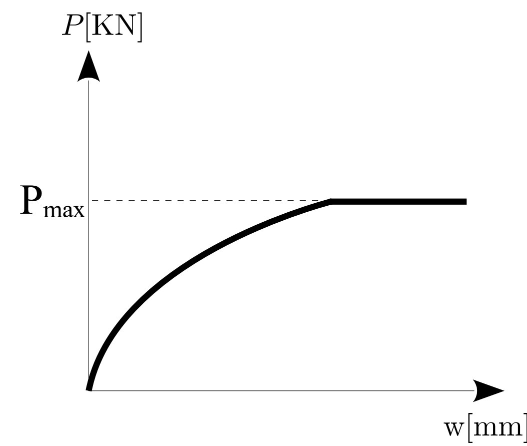
$$P = \int_0^L p\,\tau(x)\mathrm{d}x$$

$$P(w) = p \times a(w) \times \bar{\tau}$$

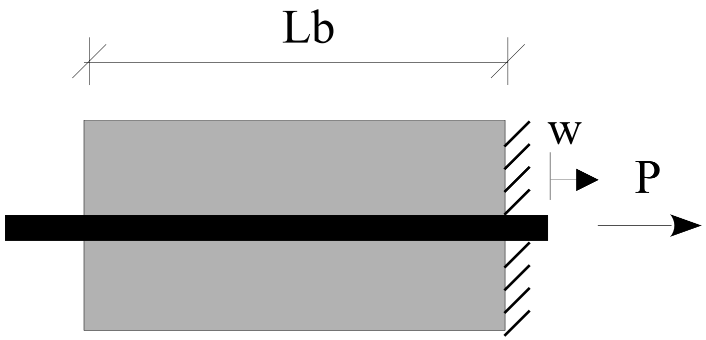
$$P_{max} = (\pi \times 16) \times a_{max} \times 8$$

$$= (\pi \times 16) \times (10 \times 16) \times 8 = 64.34 \text{ kN}$$





X0202: Pull-out with constant bond-slip law and elastic matrix (ELF-ELM)



Steel reinforcement bar:
ds = 16 [mm] , E_f = 210000[MPa].
Reinforcement strength f_y = 500[MPa]

Concrete matrix:
A_m = 10000[mm^2], E_m = 30000[MPa].

Bond:
Lb = 10 ds, τ = 8 [MPa]

c) How will the specimen fail? is it pull-out or steel rapture failure?

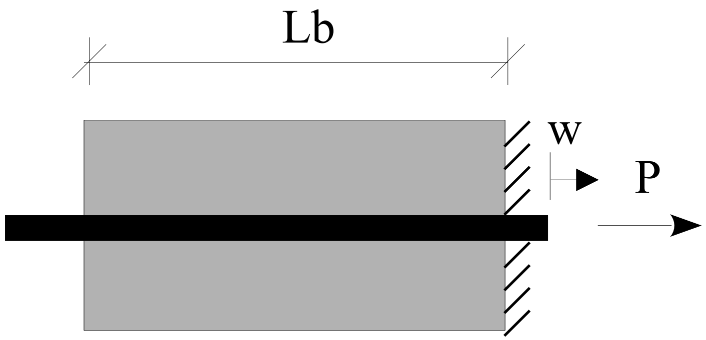
Solution:

Maximum pull-out force: from task (b) → P_{max}= 64.34 kN

Force needed for steel rapture: $F_{rapture} = A_f \text{ x } fy = (\pi \text{ x } d^2 /4) \text{ x } fy = (\pi \text{ x } 16^2 / 4) \text{ x } 500 = 100.5 \text{ kN} > P_{max}$

→ It is a pull-out failure.

X0202: Pull-out with constant bond-slip law and elastic matrix (ELF-ELM)



Steel reinforcement bar:
ds = 16 [mm] , E_f = 210000[MPa].
Reinforcement strength f_y = 500[MPa]

Concrete matrix:
A_m = 10000[mm^2], E_m = 30000[MPa].

Bond:
Lb = 10 ds, τ = 8 [MPa]

d) If the bond length set to Lb = 20 ds, how will the specimen fail then?

Solution:

Maximum pull-out force: $P_{max} = (\pi \times 16) \times a_{max} \times 8$

$= (\pi \times 16) \times (20 \times 16) \times 8 = 128.68\ \text{kN} > F_{rapture} = 100.5\ \text{kN}$

→ It is a steel rapture failure.