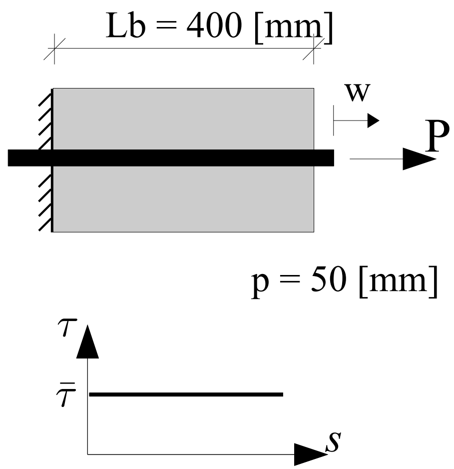
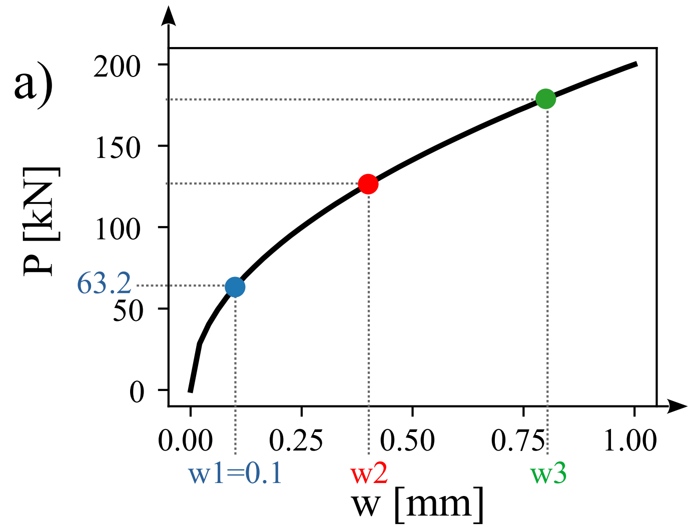
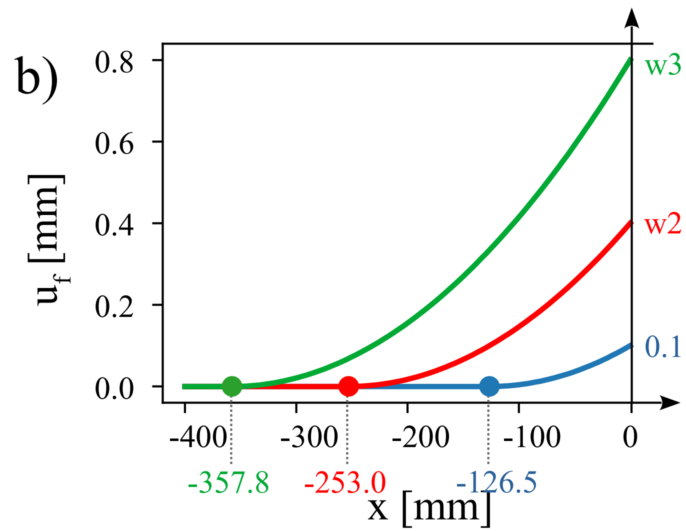
X0201: Pull-out with constant bond-slip law

For the displayed pull-out test, the pull-out curve and the displacement profiles of the rebar at three loading stages are given. The pull-out response is governed by a <u>constant bod-slip law</u>, and a <u>rigid matrix</u> is assumed.



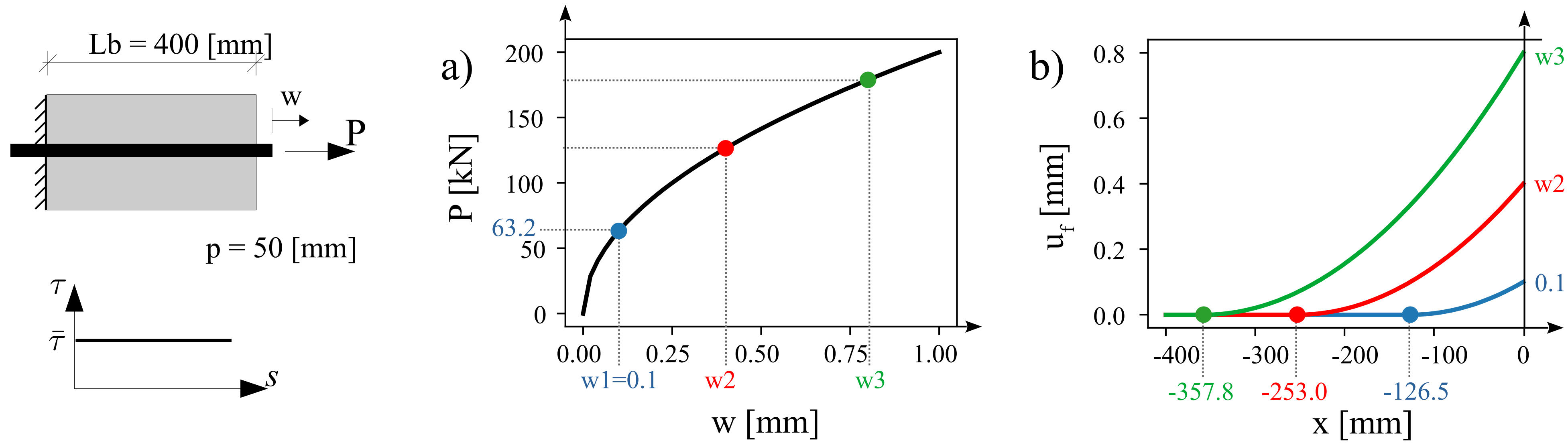




The steel rebar area and stiffness are given as: $A_f = 200[\mathrm{mm}^2]$, $E_f = 200000[\mathrm{MPa}]$.

a) Determine the bond stress ($\bar{\tau}$) governing the constant bond-slip law.
b) Plot the shear flow profiles at the loading stages w1, w2 and w3.
c) Calculate the pull-out force at the loading stages w2 and w3.
d) Calculate the displacements w2 and w3.
e) Plot strain profiles of the steel rebar at the loading stages w1, w2 and w3.
f) Plot the stress profiles of the steel rebar at the loading stages w1, w2 and w3.

X0201: Pull-out with constant bond-slip law



a) Determine the bond stress ($\bar{\tau}$) governing the constant bond-slip law

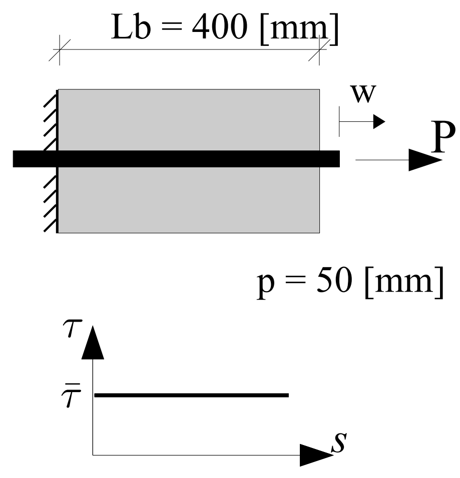
Solution:

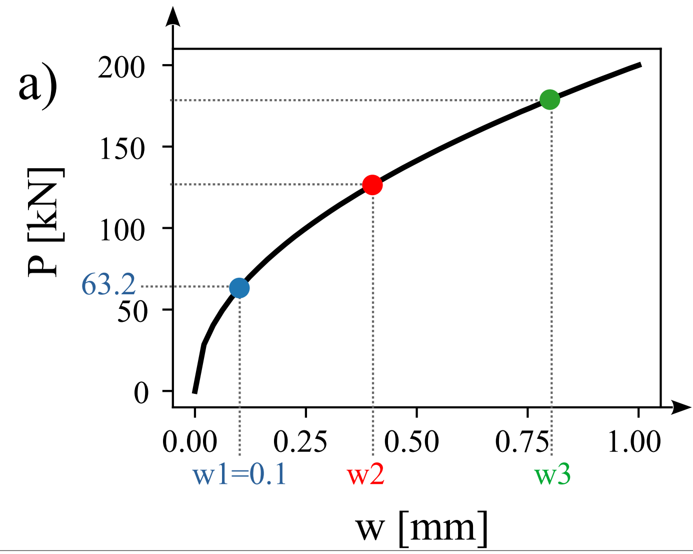
$$P(\mathrm{w}) = \sqrt{2\; p\; \bar{\tau}\; E_f\; A_f\; \mathrm{w}}$$

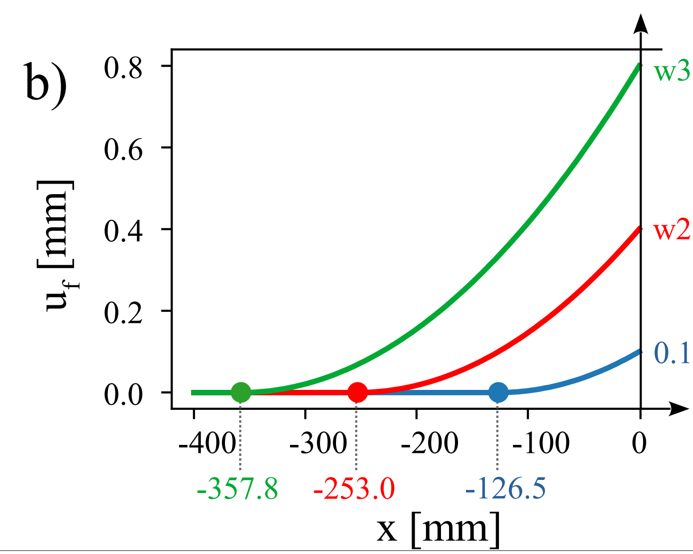
$$\bar{\tau} = \frac{[P(\mathrm{w})]^2}{2\; p\; E_f\; A_f\; \mathrm{w}}$$

at w1: $$\bar{\tau} = \frac{[63.2 \times 1000]^2}{2 \times 50 \times 200000 \times 200 \times 0.1} = 10\ [\mathrm{MPa}]$$

X0201: Pull-out with constant bond-slip law





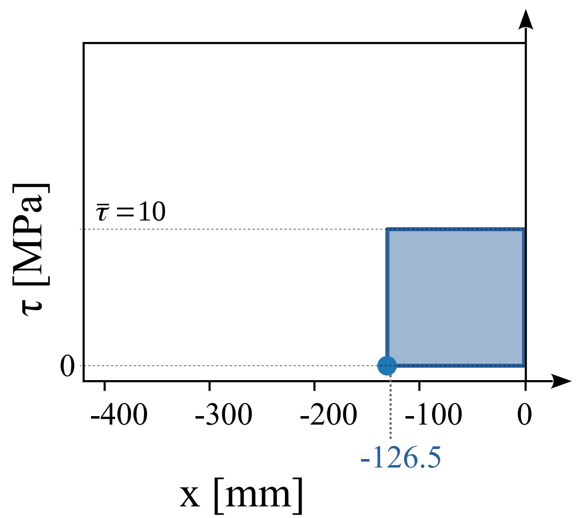


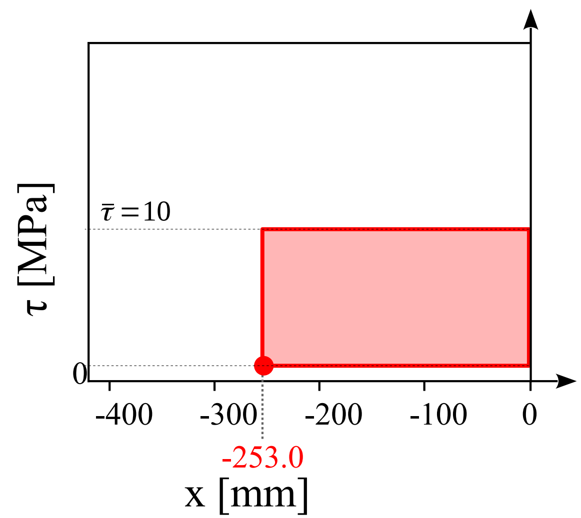
b) Plot the shear flow profiles at the loading stages w1, w2 and w3.

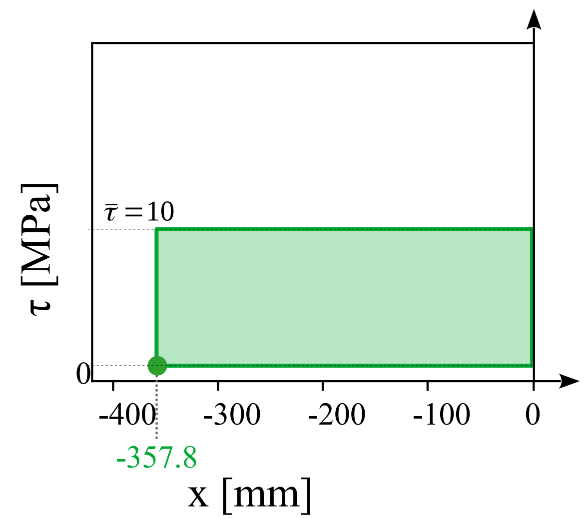
Solution:

Rigid matrix:

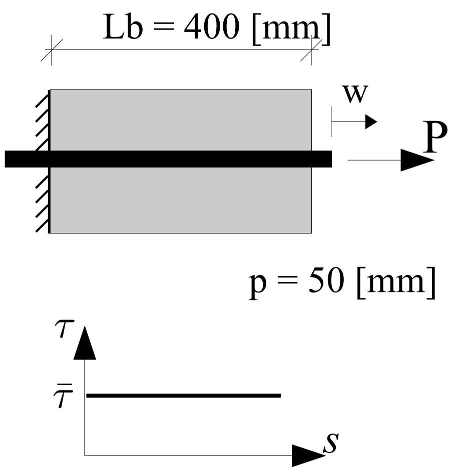
$$u_f = s$$

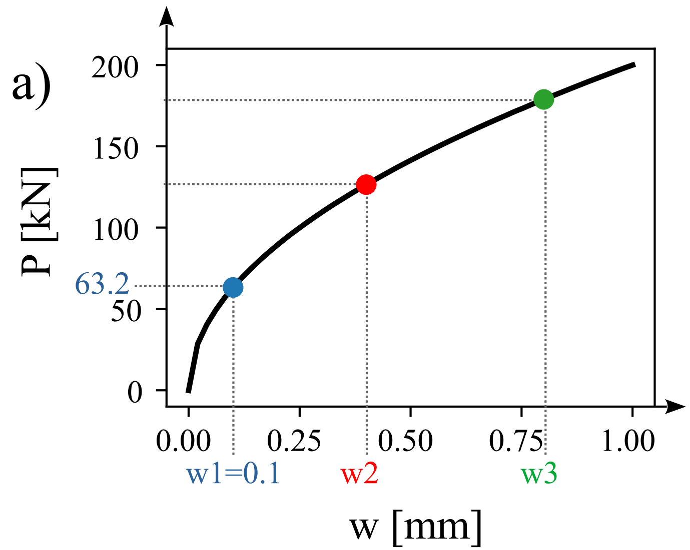


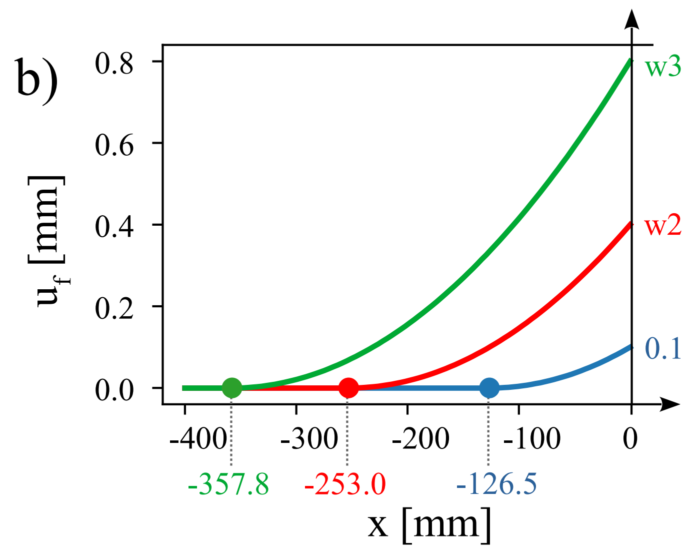




X0201: Pull-out with constant bond-slip law







c) Calculate the pull-out force at the loading stages w2 and w3.

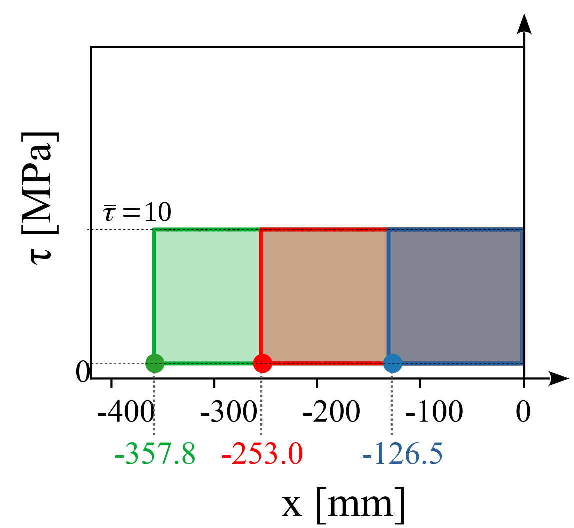
Solution:

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

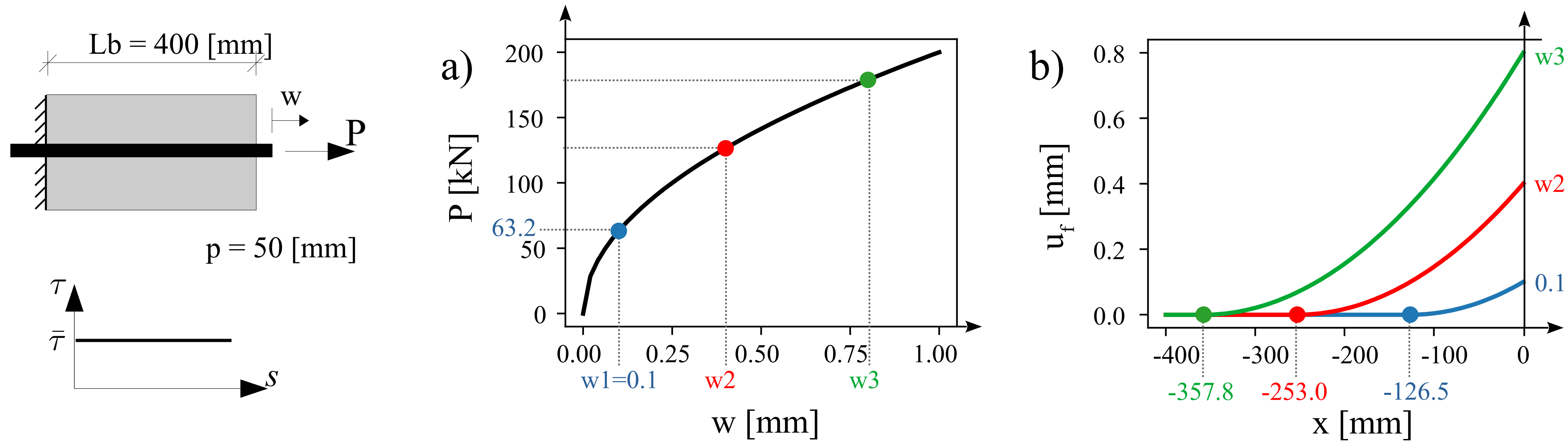
$$\mathrm{P(w)} = \mathrm{p} \times a(\mathrm{w}) \times \bar{\tau}$$

at w2: P(w2) = 50 x 253 x 10 = 126.5 kN

at w3: P(w3) = 50 x 357.8 x 10 = 178.9 kN



X0201: Pull-out with constant bond-slip law



d)Calculate the displacements w2 and w3.

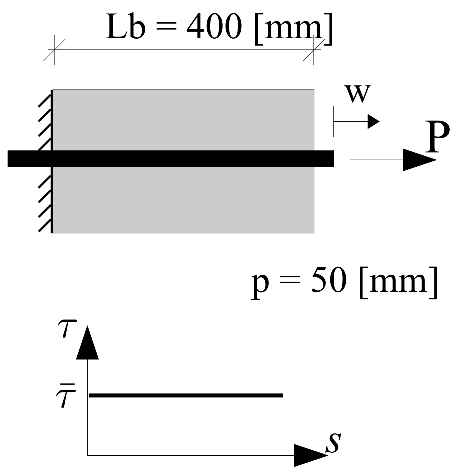
Solution:

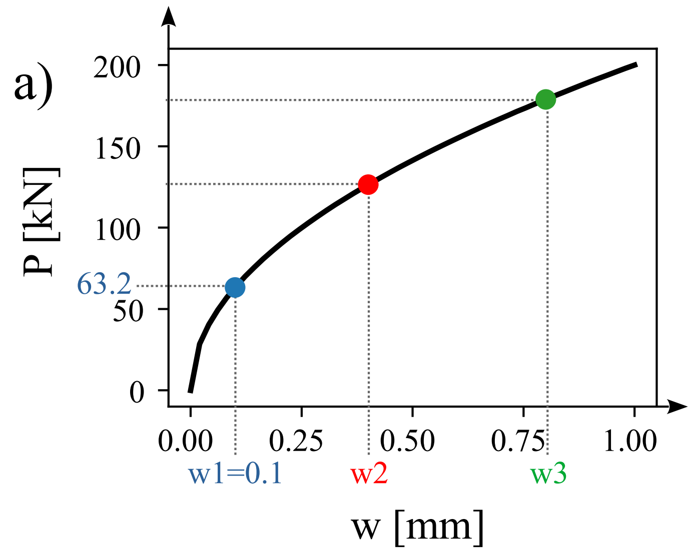
$$P(\mathrm{w}) = \sqrt{2\, p\, \bar{\tau}\, E_f\, A_f\, \mathrm{w}} \longrightarrow \mathrm{w} = \frac{[P(\mathrm{w})]^2}{2\, p\, \bar{\tau}\, E_f\, A_f}$$

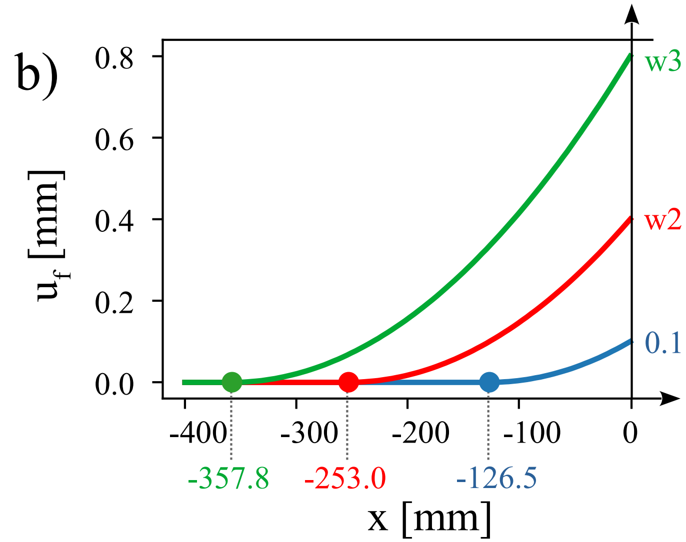
$$\mathrm{w2} = \frac{[126.5 \times 1000]^2}{2 \times 50 \times 10 \times 200000 \times 200} = 0.4\ [\mathrm{mm}]$$

$$\mathrm{w3} = \frac{[178.9 \times 1000]^2}{2 \times 50 \times 10 \times 200000 \times 200} = 0.8\ [\mathrm{mm}]$$

X0201: Pull-out with constant bond-slip law







f) Plot strain profiles of the steel rebar at the loading stages w1, w2 and w3.

Solution:

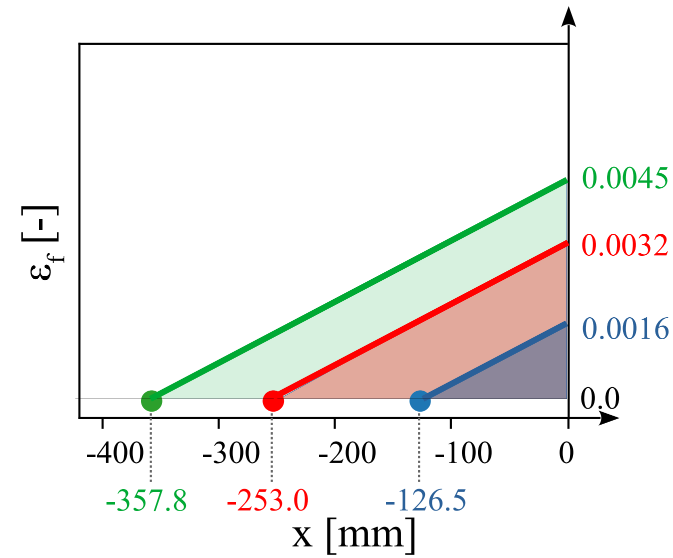
$$u_{f,0} = \int_0^L \varepsilon_f \, dx$$

$$w = \frac{1}{2} \times \varepsilon_f(x=0) \times a(w)$$

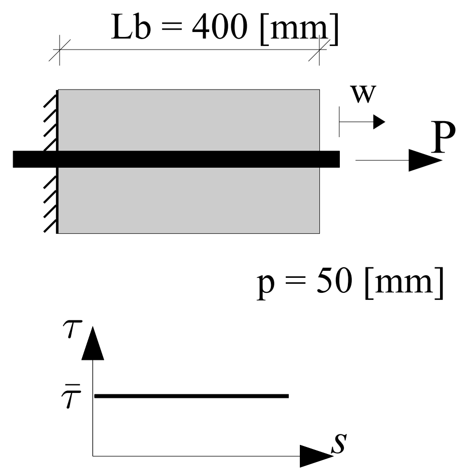
at w1: ε_f (x=0) = 2 x 0.1 / 126.5 = 0.0016

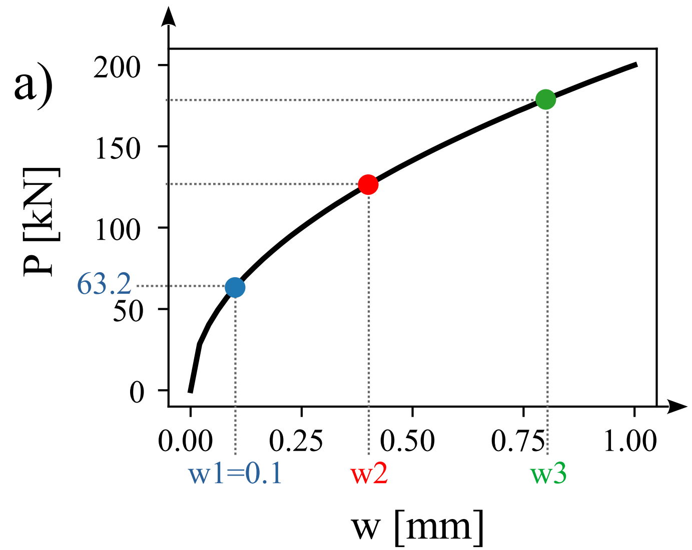
at w2: ε_f (x=0) = 2 x 0.4 / 253.0 = 0.0032

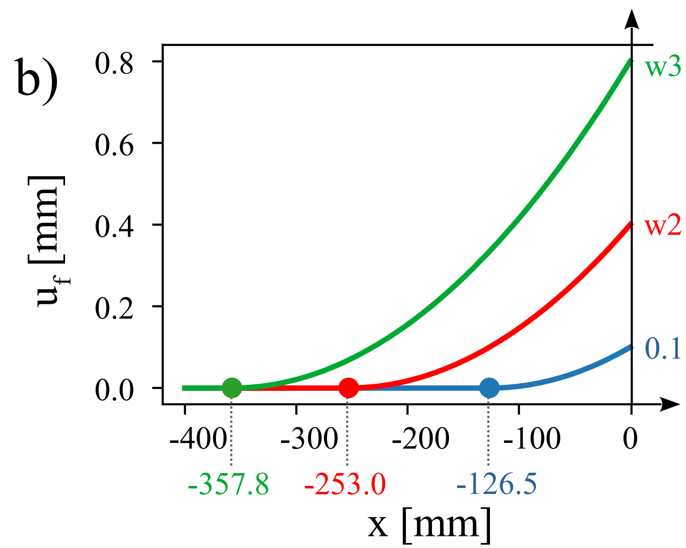
at w3: ε_f (x=0) = 2 x 0.8 / 357.8 = 0.0045



X0201: Pull-out with constant bond-slip law







f) Plot the stress profiles of the steel rebar at the loading stages w1, w2 and w3.

Solution:

$$\sigma_f = \varepsilon_f \times E_f$$

at w1: $\sigma_f\,(x=0) = 0.0016 \times 200000 = 320$ [MPa]

at w2: $\sigma_f\,(x=0) = 0.0032 \times 200000 = 640$ [MPa]

at w3: $\sigma_f\,(x=0) = 0.0045 \times 200000 = 900$ [MPa]