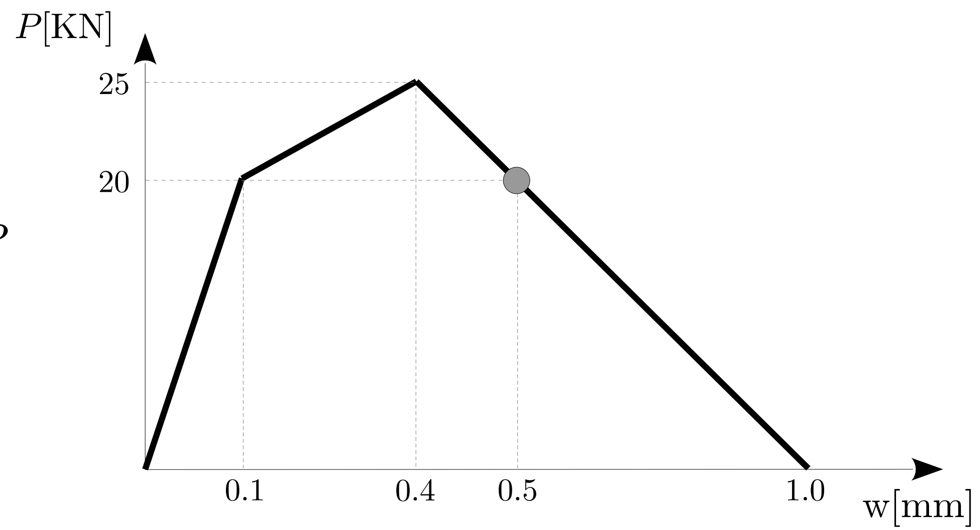
Energy supply and dissipated energy

The displayed pull-out test delivered the shown tri-linear pull-out curve. Considering the state marked with the filled circle, assuming a damage model governed the bod slip behavior.



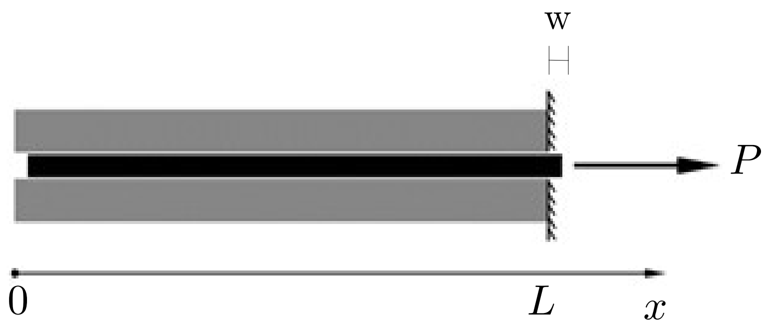
a) Evaluate and sketch the work supply, stored energy and released energy assuming that the bond-slip law is governed purely by damage.

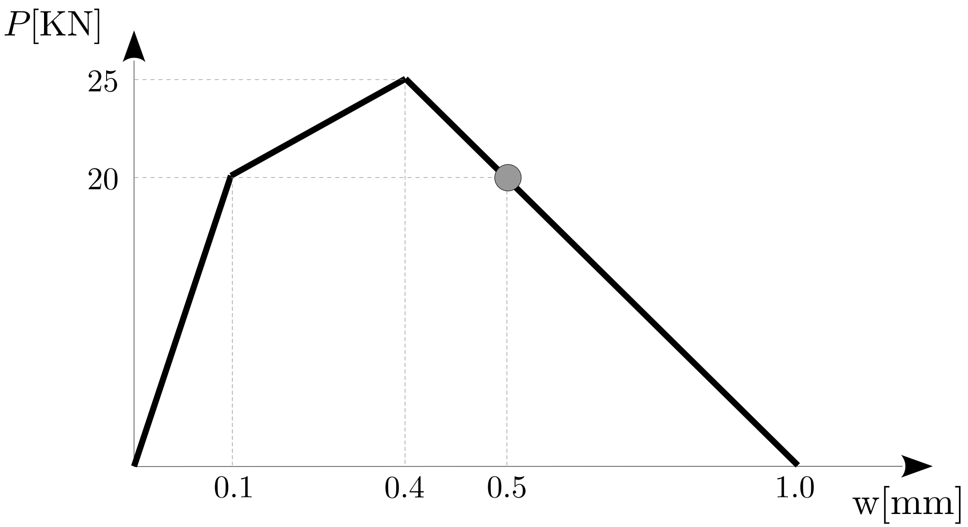
b) If we consider the embedded length Lb = 1 mm and the fiber perimeter p = 1 mm, calculate the fracture energy G_f needed to fully damage the unit area of the bond interface.

c) If the bond slip behavior is governed by plasticity, calculate the stored energy (Considering the state marked with the filled circle).

d) How to calculate the energy release rate between two points at the loading history.

Energy supply and dissipated energy



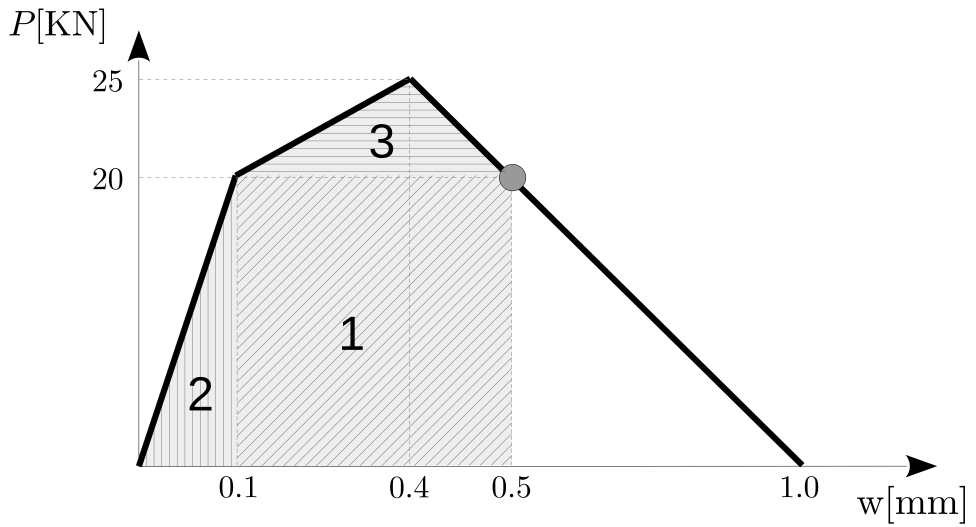


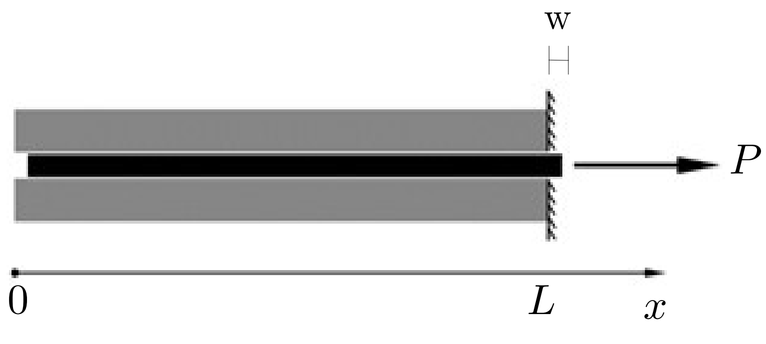
a) Evaluate and sketch the work supply, stored energy and released energy assuming that the bond-slip law is governed purely by damage.

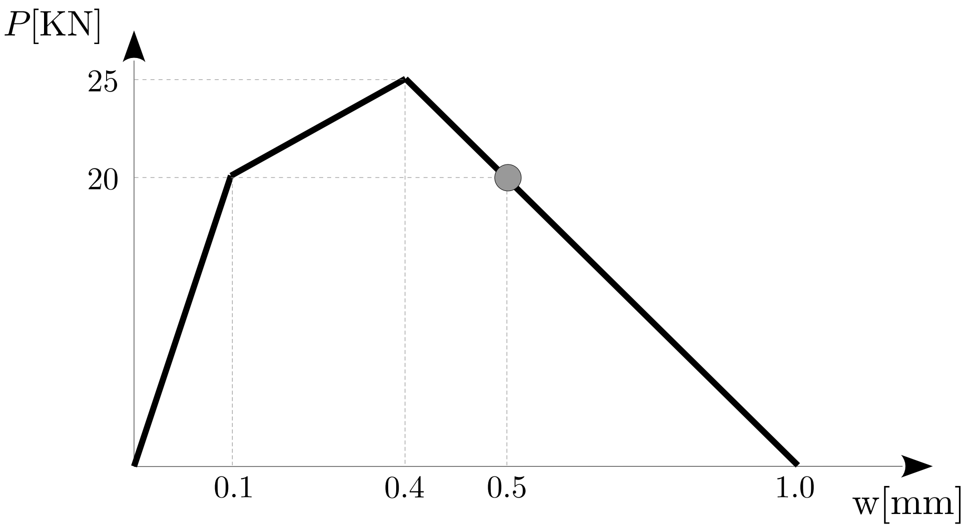
Solution:

- work supply

$$\mathcal{W} = 20 \times 0.4 + 0.5 \times 20 \times 0.1 + 0.5 \times 5 \times 0.4$$
$$= 10\ [\mathrm{kN\ mm}]$$





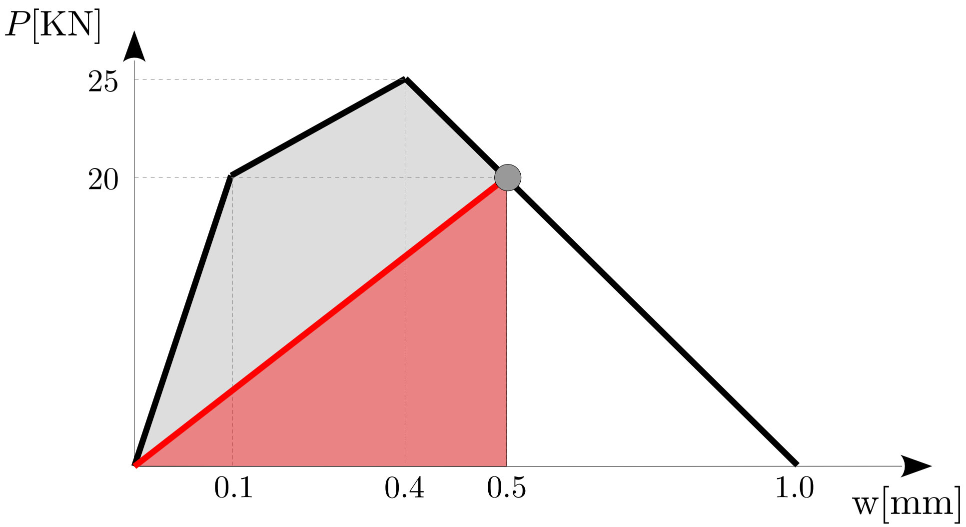


a) Evaluate and sketch the work supply , stored energy and released energy assuming that the bond-slip law is governed purely by damage.

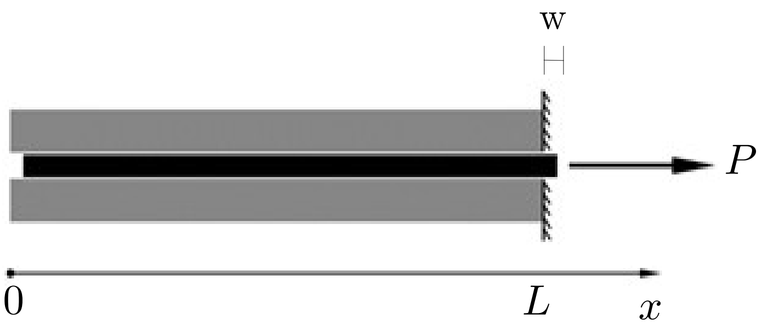
Solution:

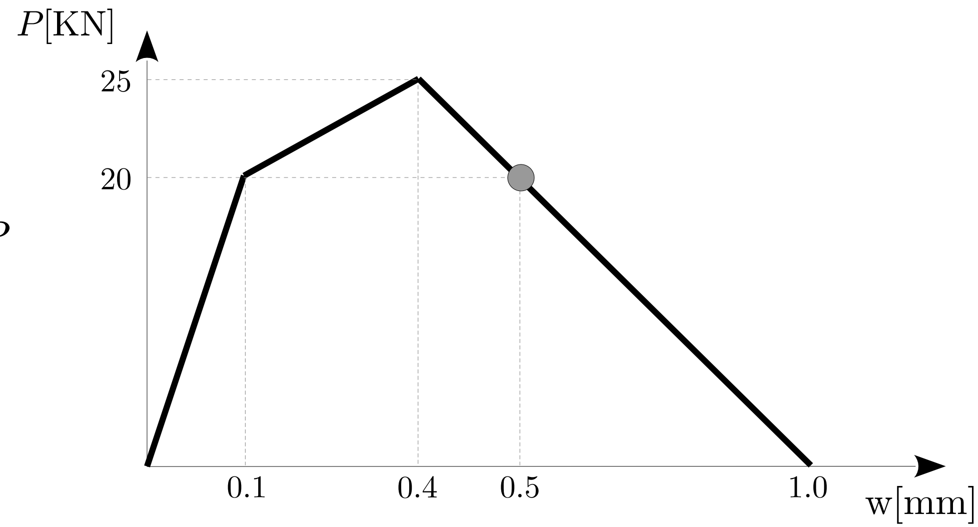
- stored energy

$$\mathcal{U} = 0.5 \times 20 \times 0.5 = 5 \text{ [kN mm]}$$



Energy supply and dissipated energy



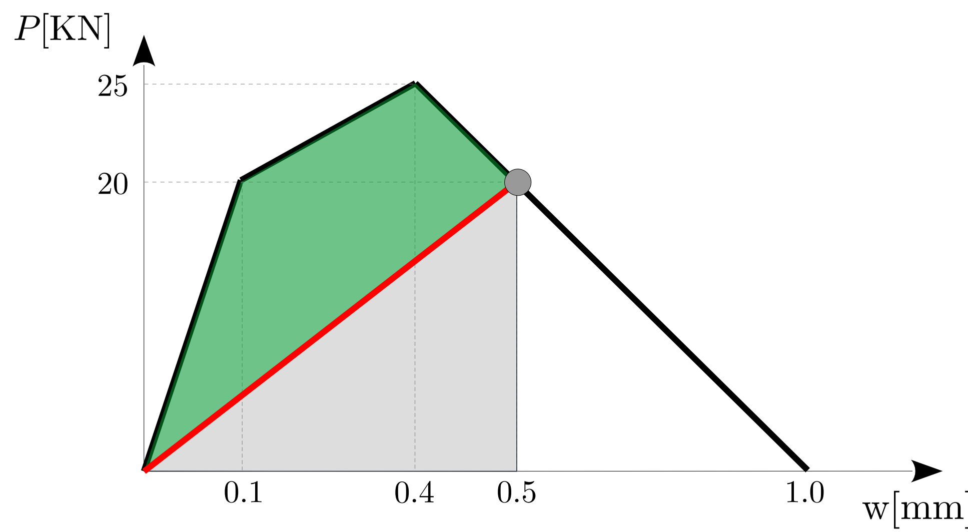


a) Evaluate and sketch the work supply , stored energy and released energy assuming that the bond-slip law is governed purely by damage.

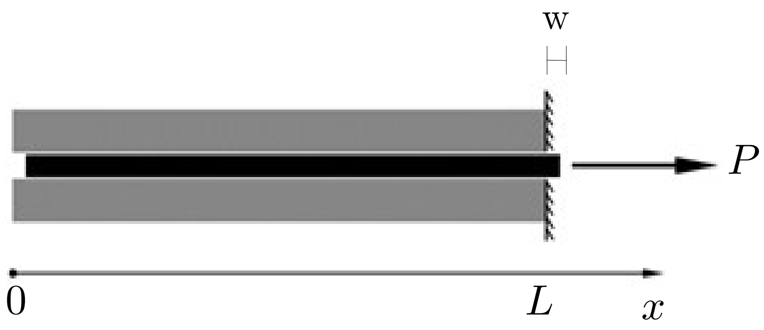
Solution:

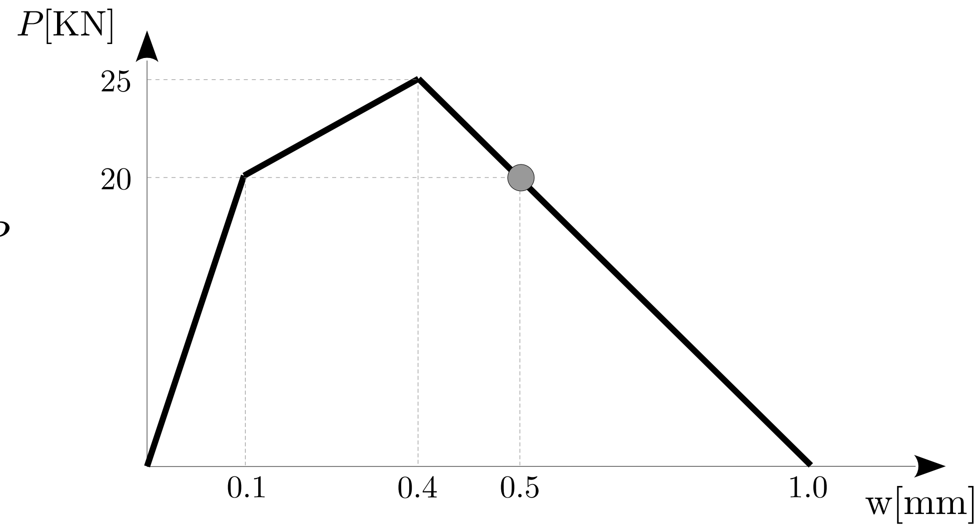
- released energy

$$\mathcal{G} = \mathcal{W} - \mathcal{U} = 5 \; [\mathrm{kN\ mm}]$$



Energy supply and dissipated energy





b) If we consider the embedded length Lb = 1 mm and the fiber perimeter p = 1 mm, calculate the fracture energy G_f needed to fully damage the unit area of the bond interface.

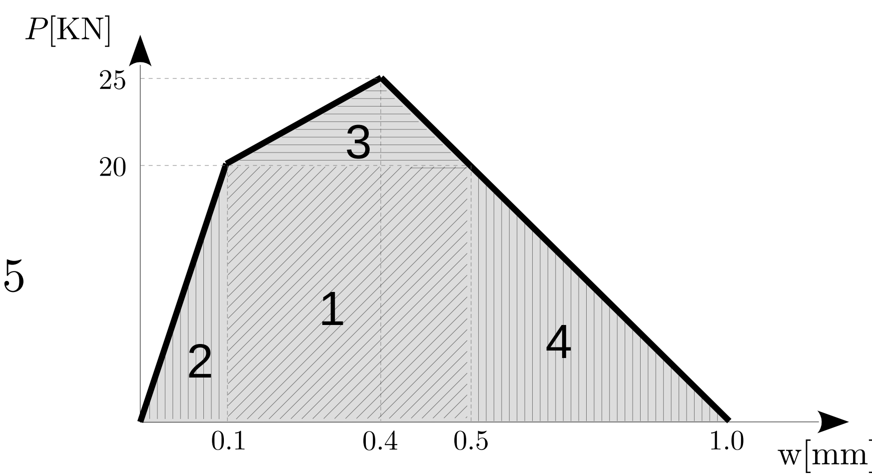
Solution:

The fracture energy: $G_F = \mathcal{W}/A$

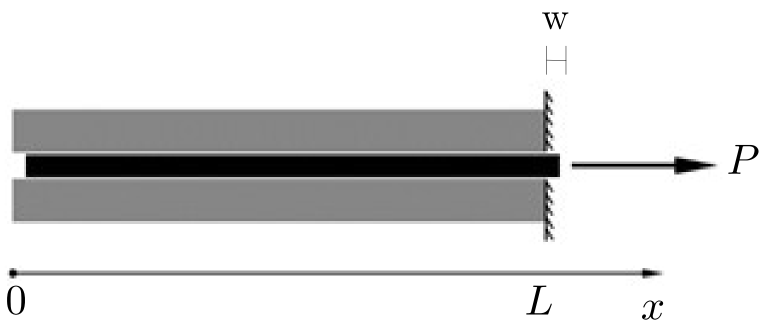
$\mathcal{W}$: the work supply needed to fully damage the unit area A

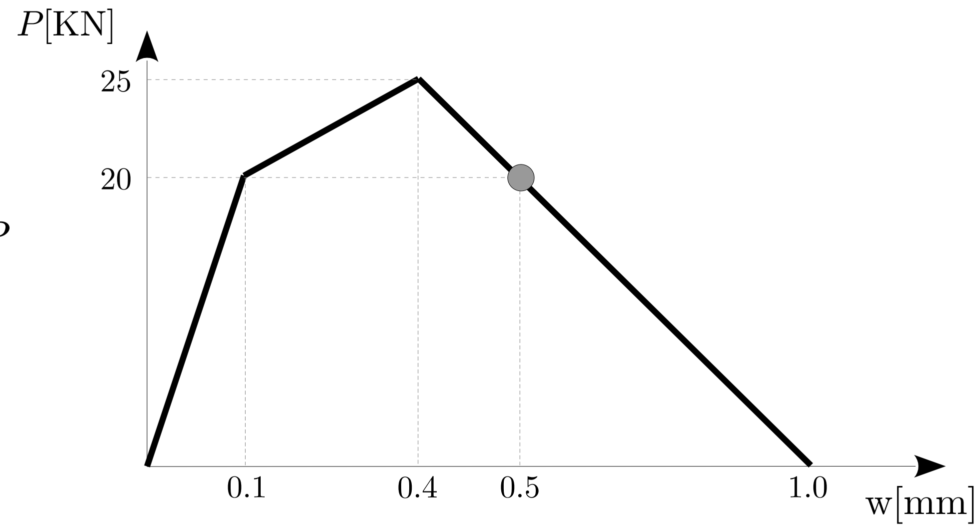
$$\mathcal{W} = 20 \times 0.4 + 0.5 \times 20 \times 0.1 + 0.5 \times 5 \times 0.4 + 0.5 \times 20 \times 0.5$$
$$= 15 \text{ [kN mm]}$$

$$G_F = \mathcal{W}/A = 15/1 = 15[\text{kN}/\text{mm}]$$



Energy supply and dissipated energy



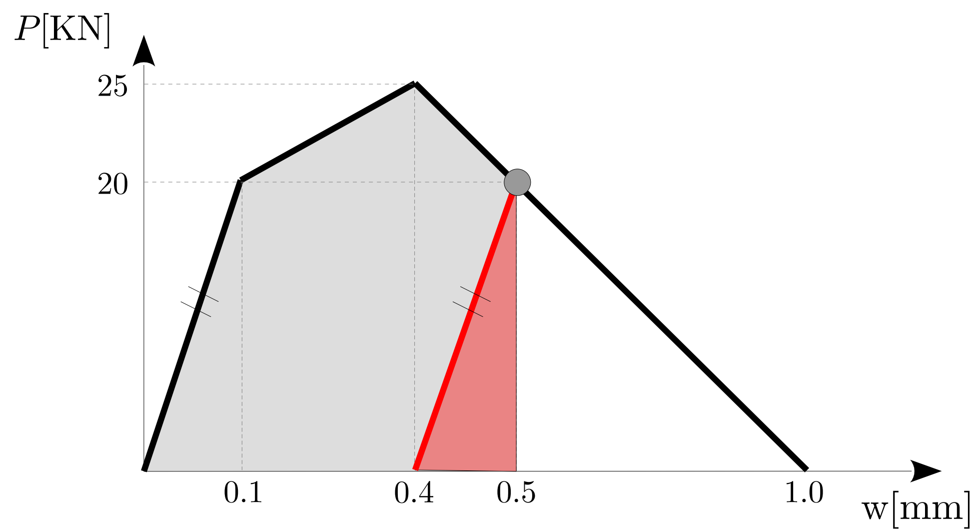


c) If the bond slip behavior is governed by plasticity, calculate the stored energy (Considering the state marked with the filled circle).

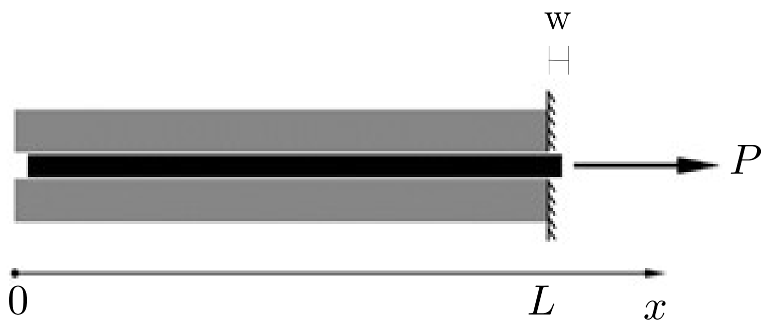
Solution:

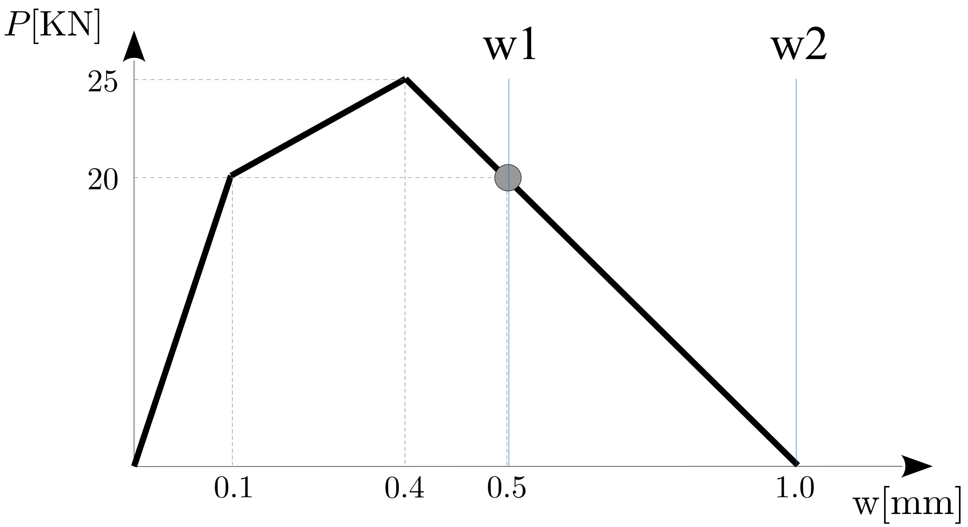
- stored energy

$$\mathcal{U} = 0.5 \times 20 \times 0.1 = 1 \text{ [kN mm]}$$



Energy supply and dissipated energy





d) How to calculate the energy release rate between two points at the loading history.

Solution:

The energy release rate can be calculated between the states w2 and w1 as follows:

$$d\mathcal{G}/dt = [\mathcal{G}(\mathrm{w} = \mathrm{w2}) - \mathcal{G}(\mathrm{w} = \mathrm{w1})]/(\mathrm{w2} - \mathrm{w1})$$