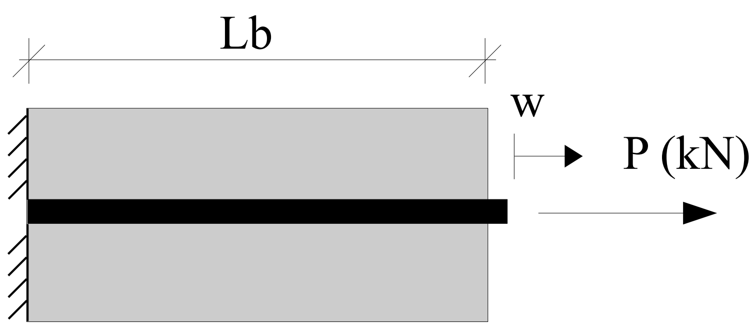
Anchorage length

The results of two pull-out tests of steel bar pulled out from concrete with varied bond length are presented in the following table. Assume the constant bond-slip behavior.



Test No.	bond length (mm)	P_{max} (kN)	Failure mode
1	50	45	pull-out
2	120	100	reinforcement yielding

a) Calculate the rebar area and diameter, assuming that reinforcement yielding stress leading to the failure in the second test was $fy = 500$ [MPa] .

b) Evaluate the bond strength of the bond-slip law.

c) Evaluate the minimum anchorage length utilizing the full yielding stress of the reinforcement avoiding pull-out failure. Explain your answer.

d) Assuming a rigid matrix, calculate the control slip w at the failure of the specimen 2. Consider the elastic modulus of the steel reinforcement is $Ef = 2 \times 10^5$ [MPa].

Anchorage length

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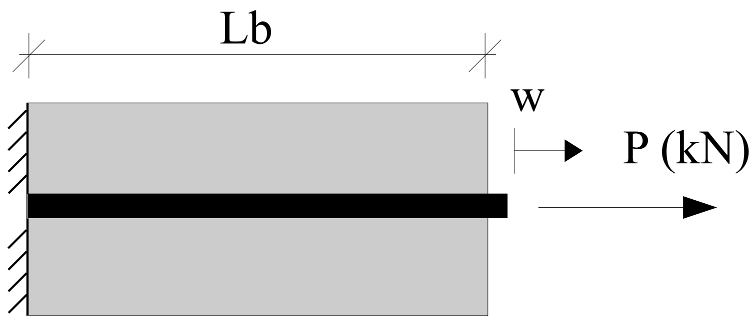

Test No.	bond length (mm)	P_{max} (kN)	Failure mode
1	50	45	pull-out
2	120	100	reinforcement yielding

a) Calculate the rebar area and diameter, assuming that reinforcement yielding stress leading to the failure in the second test was fy = 500 [MPa] .

Solution:

The force leads to the yielding of the bar P = 100 kN

$$A_f * f_y = P \longrightarrow \frac{\pi\, d^2}{4} * f_y = P$$

$$\longrightarrow d = \sqrt{\frac{4 \times P}{\pi \times f_y}} = \sqrt{\frac{4 \times 100 \times 1000}{\pi \times 500}} = 16[\mathrm{mm}]$$

Anchorage length

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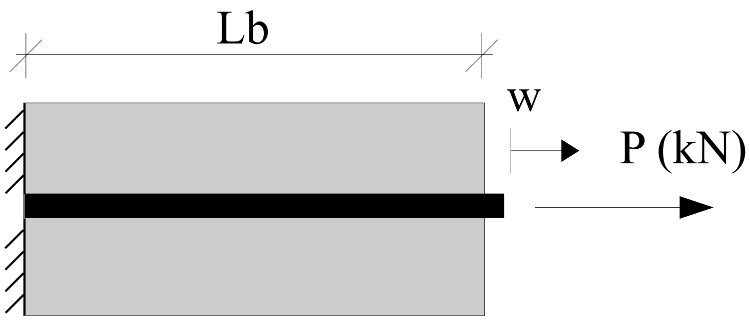


Test No.	bond length (mm)	P_{max} (kN)	Failure mode
1	50	45	pull-out
2	120	100	reinforcement yielding

b) Evaluate the bond strength of the bond-slip law.

Solution:

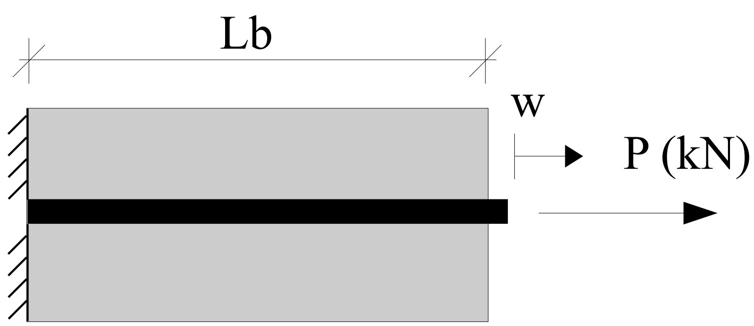
The bond strength of the constant bond-slip behavior can be determined from the first test where a pull-out failure occurs.

Pull-out force: $P_{\max} = \bar{\tau} \times p \times L$

$$\longrightarrow \bar{\tau} = \frac{P_{\max}}{p \times L} = \frac{45 \times 1000}{\pi \times 16 \times 50} = 17.9[\mathrm{MPa}]$$

Anchorage length

The results of two pull-out tests of steel bar pulled out from concrete with varied bond length are presented in the following table. Assume the constant bond-slip behavior.



Test No.	bond length (mm)	P_{max} (kN)	Failure mode
1	50	45	pull-out
2	120	100	reinforcement yielding

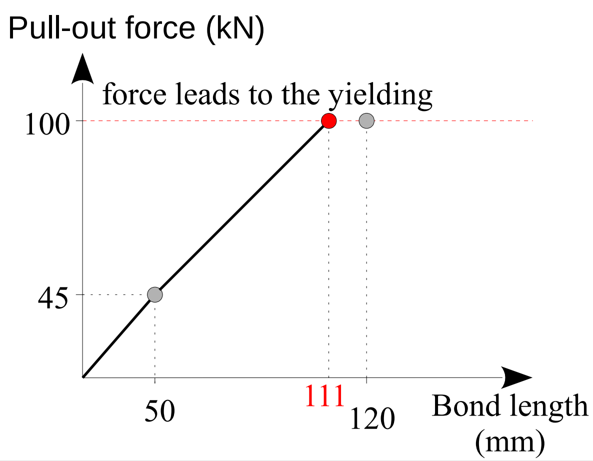
c) Evaluate the minimum anchorage length utilizing the full yielding stress of the reinforcement avoiding pull-out failure. Explain your answer.

Solution:

The anchorage length can be obtained from the equation: $P_{\max} = \bar{\tau} \times p \times L$

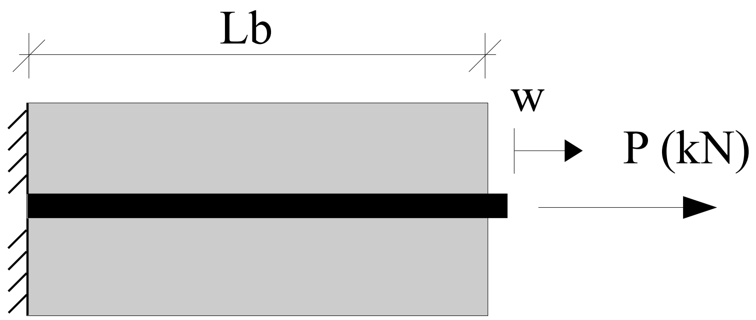
By setting the maximum pull-out force equal to the force leads to reinforcement yielding. $P_{\max} = 100 \text{ [kN]}$

The anchorage length: $\longrightarrow L = \dfrac{P_{\max}}{\bar{\tau} \times p} = \dfrac{100 \times 1000}{17.9 \times \pi \times 16} = 111.14\text{[mm]}$



Anchorage length

The results of two pull-out tests of steel bar pulled out from concrete with varied bond length are presented in the following table. Assume the constant bond-slip behavior.



Test No.	bond length (mm)	P_{max} (kN)	Failure mode
1	50	45	pull-out
2	120	100	reinforcement yielding

d) Assuming a rigid matrix, calculate the control slip w at the failure of the specimen 2. Consider the elastic modulus of the steel reinforcement is $E_f = 2 \times 10^5$ [MPa].

Solution:

The pullout curve can be obtained as: $P(w) = \sqrt{2p\,\bar{\tau}\,E_f\,A_f\,w}$

The slip w at the failure: $\longrightarrow \mathrm{w} = \dfrac{P(\mathrm{w})^2}{2p\,\bar{\tau}\,E_\mathrm{f}\,A_f} = \dfrac{(100 \times 1000)^2}{2\pi \times 16 \times 17.9 \times 200000 \times \pi \times (16)^2/4} = 0.138[\mathrm{mm}]$