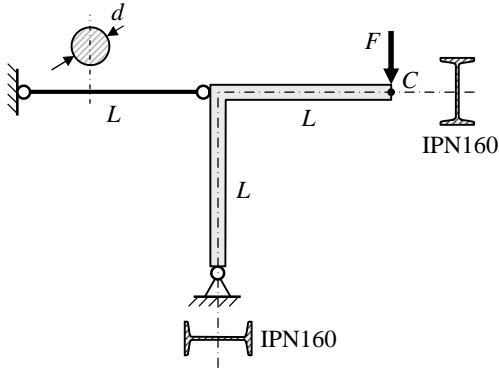


**3**



\_\_\_\_\_ :

IPN

\_\_\_\_\_ :

$F = 10 \text{ kN}; L = 1 \text{ m}; d = 0,006 \text{ m}; E = 2,1 \cdot 10^{11} \text{ Pa}.$

1. (v) \_\_\_\_\_, \_\_\_\_\_ (h) \_\_\_\_\_.
2. \_\_\_\_\_ (AD) \_\_\_\_\_, \_\_\_\_\_ N. \_\_\_\_\_ L. (CD) \_\_\_\_\_ (BD) \_\_\_\_\_, \_\_\_\_\_ N, Qz \_\_\_\_\_, \_\_\_\_\_

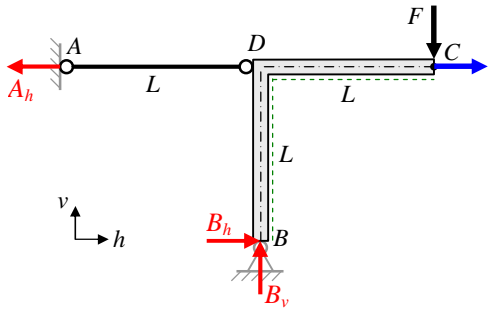
$$c_{,v} = \frac{\partial U}{\partial F} = \int_{L_1} \frac{N_1}{EA_1} \frac{\partial N_1}{\partial F} dx + \int_{L_2} \frac{M_{y2}}{EI_{y2}} \frac{\partial M_{y2}}{\partial F} dx + \int_{L_3} \frac{M_{y3}}{EI_{y3}} \frac{\partial M_{y3}}{\partial F} dx. \quad (1)$$

$$c_{,h} = \frac{\partial U}{\partial \Phi} = \int_{L_1} \frac{N_1}{EA_1} \frac{\partial N_1}{\partial \Phi} dx + \int_{L_2} \frac{M_{y2}}{EI_{y2}} \frac{\partial M_{y2}}{\partial \Phi} dx + \int_{L_3} \frac{M_{y3}}{EI_{y3}} \frac{\partial M_{y3}}{\partial \Phi} dx. \quad (2)$$

$$u_C = \sqrt{u_{C,v}^2 + u_{C,h}^2}. \quad (3)$$

$N, \quad 1, \quad 2 \quad F$

3.



$$\begin{aligned}
 M_i = 0: & \quad A_h L - FL - L = 0; & \quad A_h = F + \dots \\
 h_i = 0: & \quad B_h + -A_h = 0; & \quad B_h = F. \\
 v_i = 0: & \quad B_v - F = 0; & \quad B_v = F. \\
 M_{Ai} = 0: & \quad F \cdot 2L - B_h L - B_v L = 2FL - FL - FL = 0 \Rightarrow \dots
 \end{aligned}$$

4.

4.1. (AD),  $x \in [0; L]$

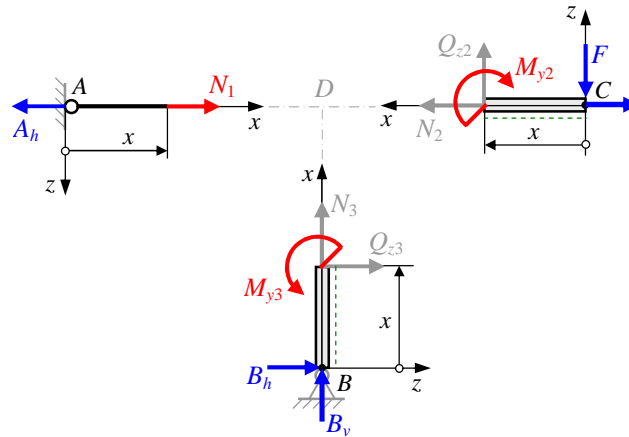
$$x_i = 0: \quad N_1 - A_h = 0; \quad N_1 = F + \dots; \quad N_1 / F = 1; \quad N_1 / = 1.$$

4.2. (CD),  $x \in [0; L]$

$$M_{yi} = 0: \quad M_{y2} + Fx = 0; \quad M_{y2} = -Fx; \quad M_{y2} / F = -x; \quad M_{y2} / = 0.$$

4.3. (BD),  $x \in [0; L]$

$$M_{yi} = 0: \quad M_{y3} + B_h \cdot x = 0; \quad M_{y3} = -Fx; \quad M_{y3} / F = -x; \quad M_{y3} / = 0.$$



5.

(1) (2)

$$u_{C,v} = \frac{1}{EA_1} \int_0^L N_1 \frac{\partial N_1}{\partial F} dx + \frac{1}{EI_{y2}} \int_0^L M_{y2} \frac{\partial M_{y2}}{\partial F} dx + \frac{1}{EI_{y3}} \int_0^L M_{y3} \frac{\partial M_{y3}}{\partial F} dx = \frac{1}{EA_1} \int_0^L F \cdot 1 \cdot dx + \frac{2}{EI_{y2}} \int_0^L (-Fx)(-x) dx;$$

$$u_{C,v} = \frac{FL}{EA_1} + \frac{2}{EI_{y2}} \int_0^L (-Fx^2) dx = \frac{FL}{EA_1} + \frac{2FL^3}{3EI_{y2}}.$$

$$u_{C,h} = \frac{1}{EA_1} \int_0^L N_1 \frac{\partial N_1}{\partial W} dx + \frac{1}{EI_{y2}} \int_0^L M_{y2} \frac{\partial M_{y2}}{\partial W} dx + \frac{1}{EI_{y3}} \int_0^L M_{y3} \frac{\partial M_{y3}}{\partial W} dx = \frac{1}{EA_1} \int_0^L F \cdot 1 \cdot dx + \frac{2}{EI_{y2}} \int_0^L (-Fx) \cdot 0 \cdot dx;$$

$$u_{C,h} = \frac{FL}{EA_1}.$$

6.

$$A_1 = \frac{fd^2}{4} = \frac{f \cdot 0,006^2}{4} = 0,2827 \cdot 10^{-4} \text{ m}^2;$$

$$I_{y2} = I_{y3} = I_y = 935 \text{ cm}^4 = 935 \cdot 10^{-8} \text{ m}^4 \text{ (IPN160);}$$

$$u_{C,v} = \frac{FL}{EA_1} + \frac{2FL^3}{3EI_{y2}} = \frac{10 \cdot 10^3 \cdot 1}{2,1 \cdot 10^{11} \cdot 0,2827 \cdot 10^{-4}} + \frac{2 \cdot 10 \cdot 10^3 \cdot 1^3}{3 \cdot 2,1 \cdot 10^{11} \cdot 935 \cdot 10^{-8}} = 0,001684 + 0,003395 = 0,005079 \text{ m};$$

$$u_{C,h} = \frac{FL}{EA_1} = \frac{10 \cdot 10^3 \cdot 1}{2,1 \cdot 10^{11} \cdot 0,2827 \cdot 10^{-4}} = 0,001684 \text{ m}.$$

7.

$$c = \sqrt{\frac{2}{c_{v}} + \frac{2}{c_{h}}} = \sqrt{0,005079^2 + 0,001684^2} = 0,005351 \text{ m} = 5,35 \text{ mm}.$$