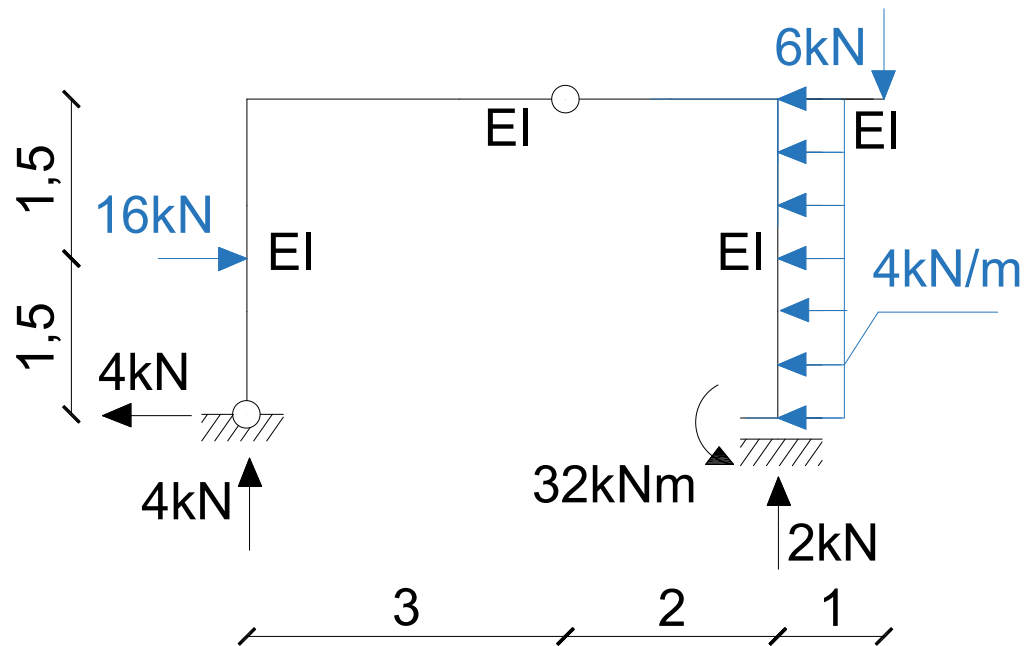
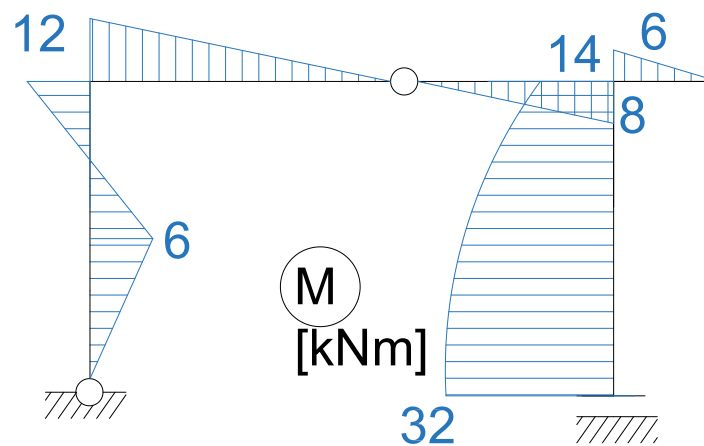
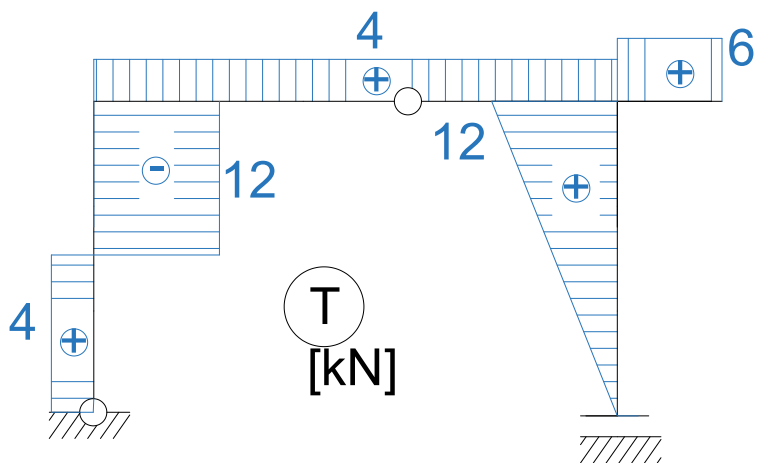
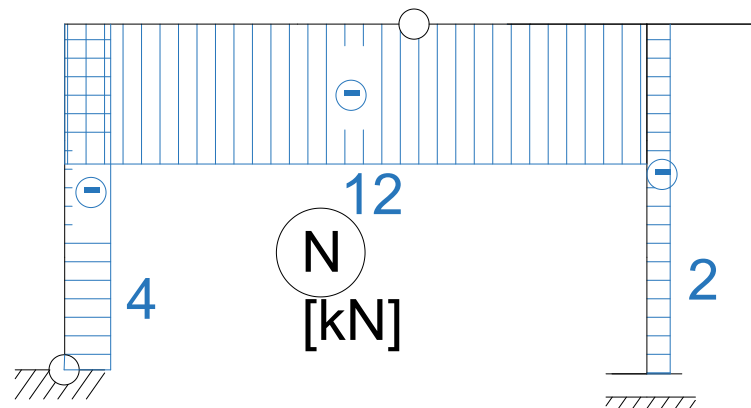
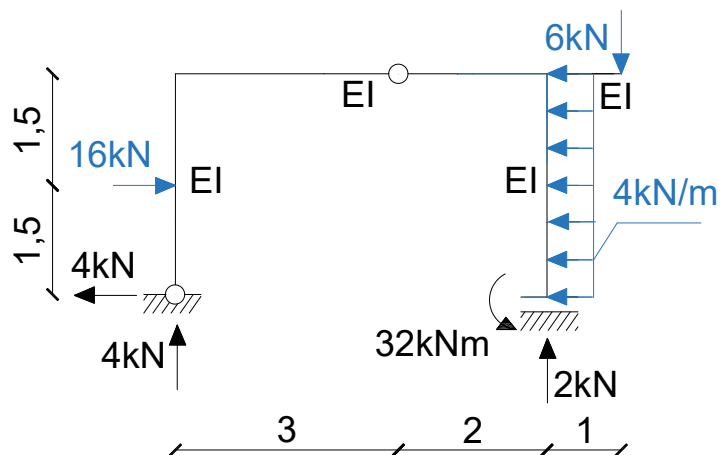


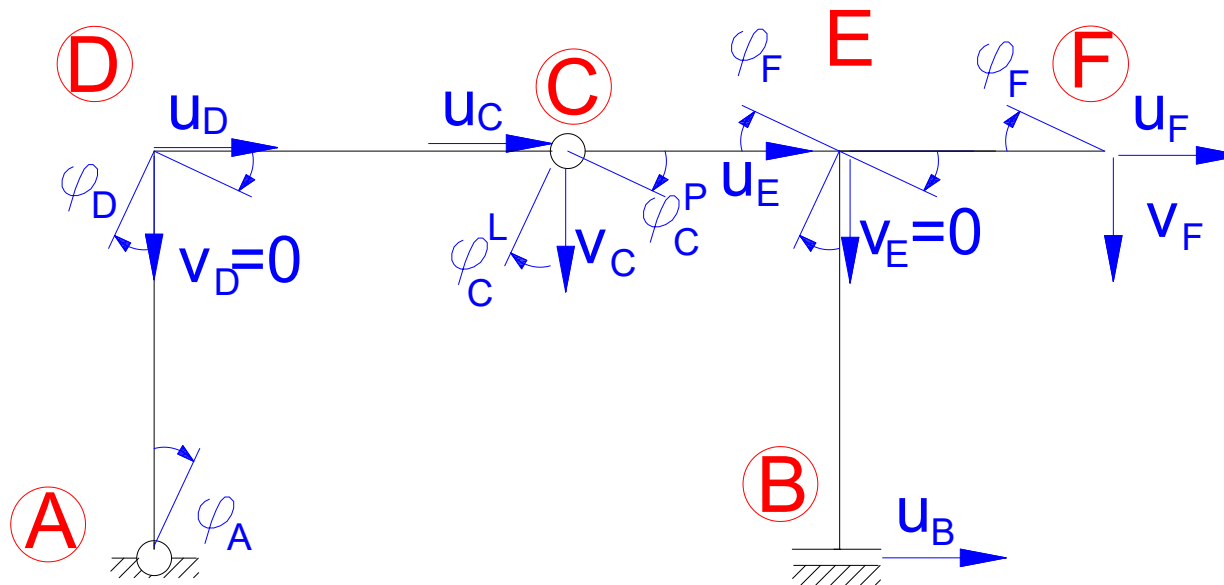
Obliczenia przemieszczeń z zasady prac wirtualnych:



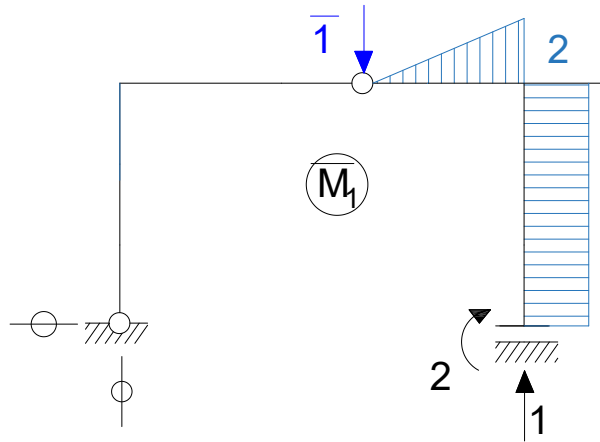
Wykresy sił wewnętrznych:



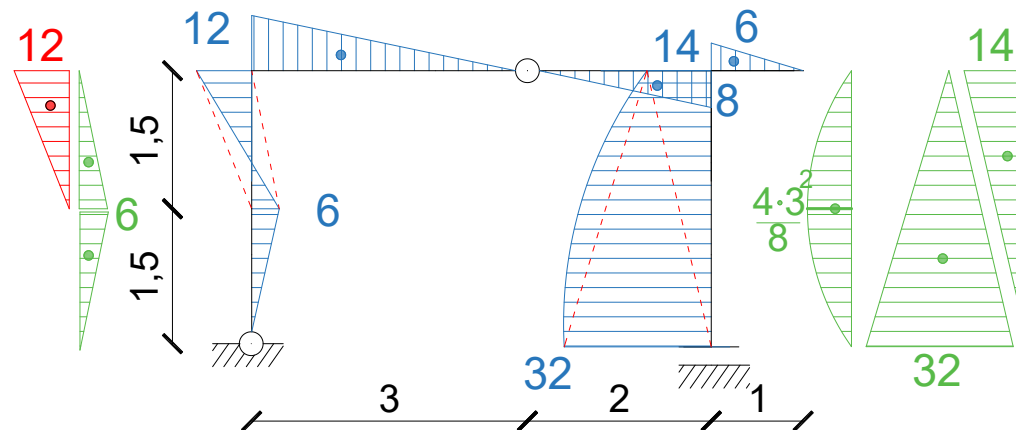
Odkształcona postać ramy:



Wyznaczenie przemieszczeń z zasady prac wirtualnych:

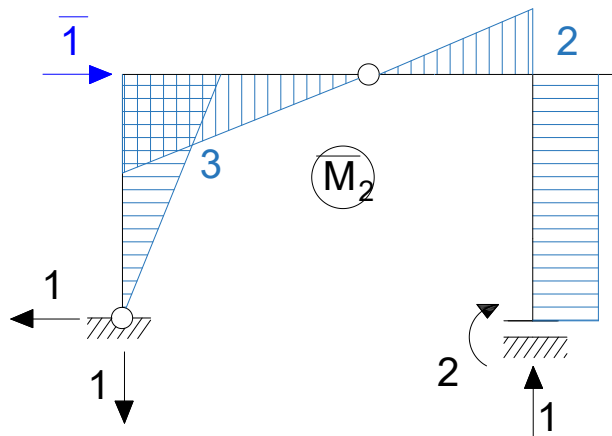


$$v_C = -\frac{500}{3EI}$$

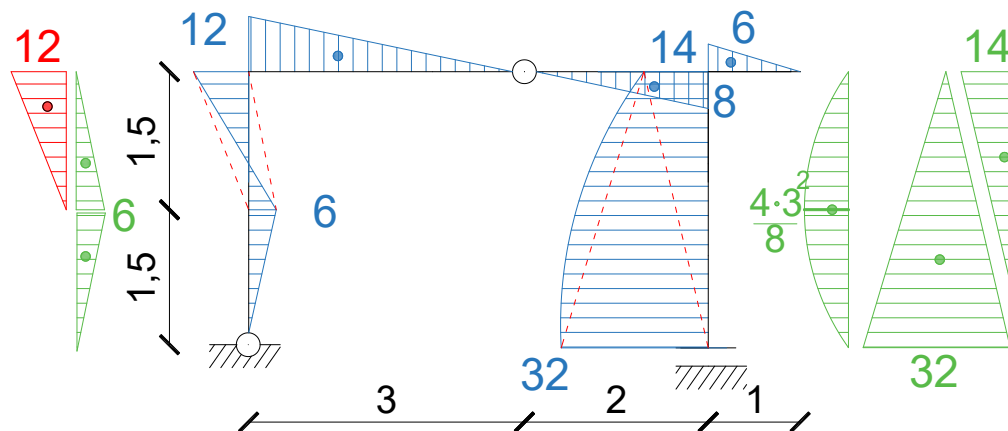


dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:

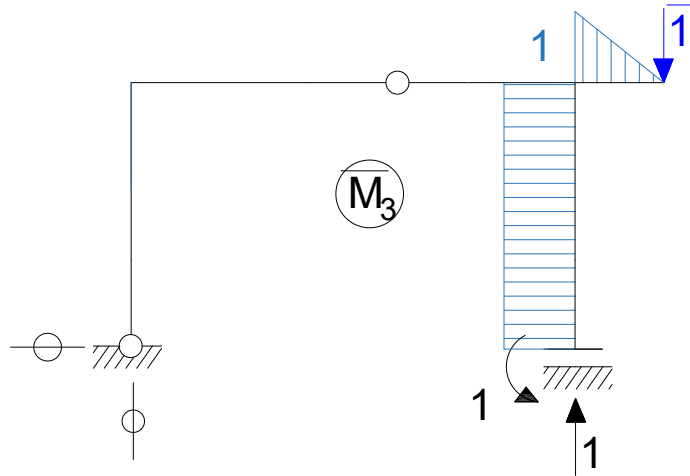


$$u_C = u_D = u_E = u_F = -\frac{635}{3EI}$$

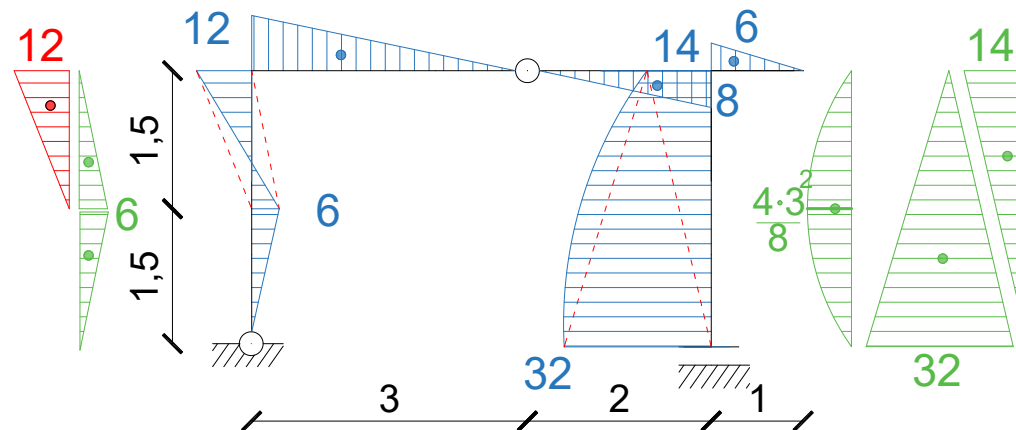


dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:

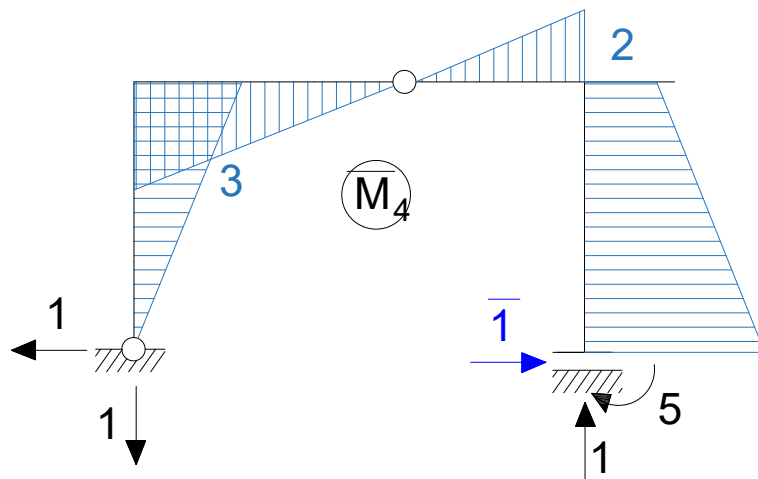


$$v_F = \frac{80}{EI}$$

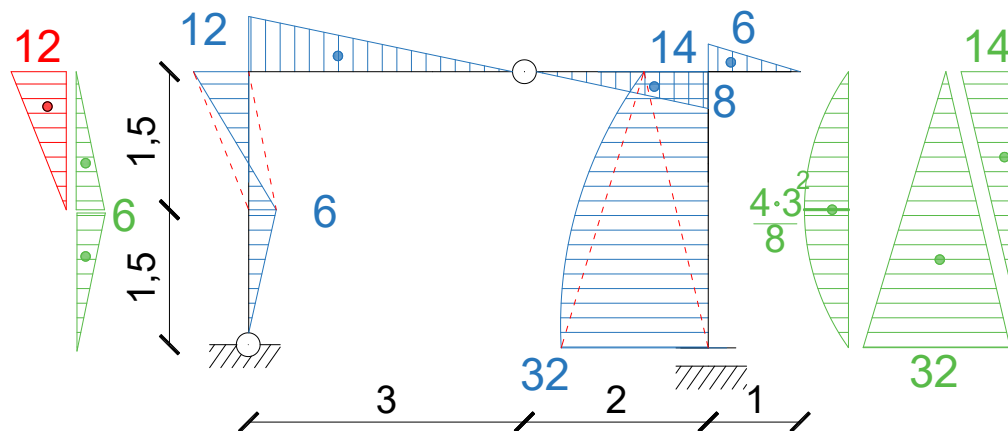


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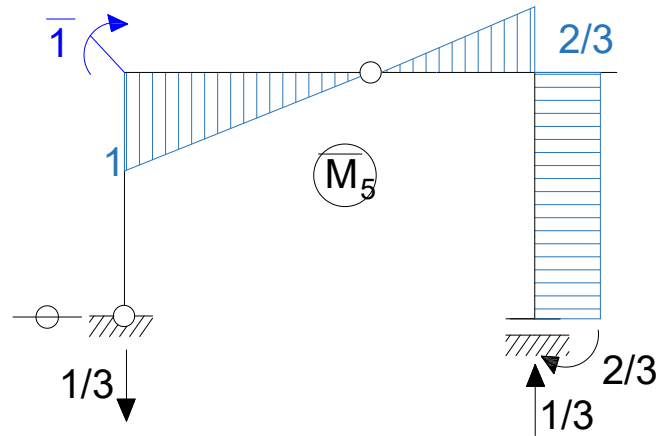
Wyznaczenie przemieszczeń z zasady prac wirtualnych:



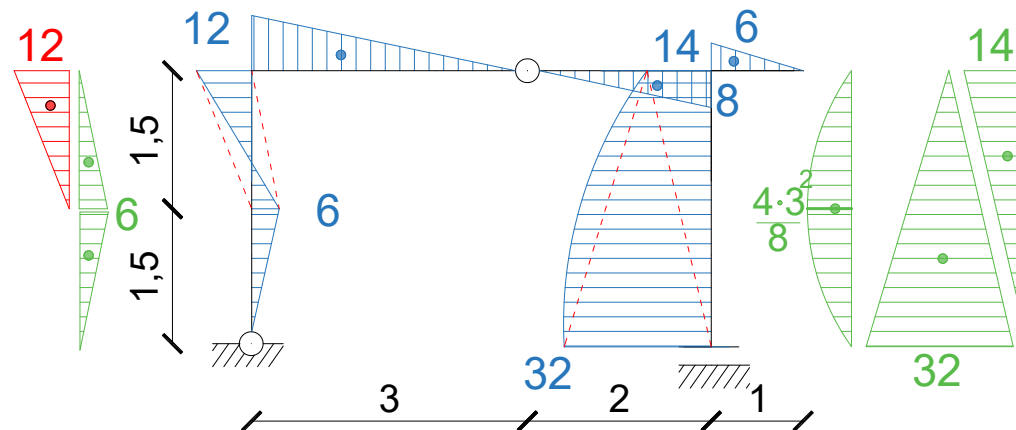
$$u_B = -\frac{2053}{6EI}$$



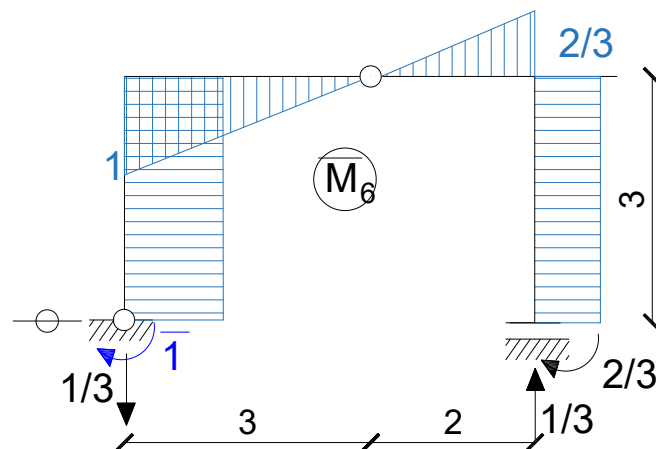
Wyznaczenie przemieszczeń z zasady prac wirtualnych:



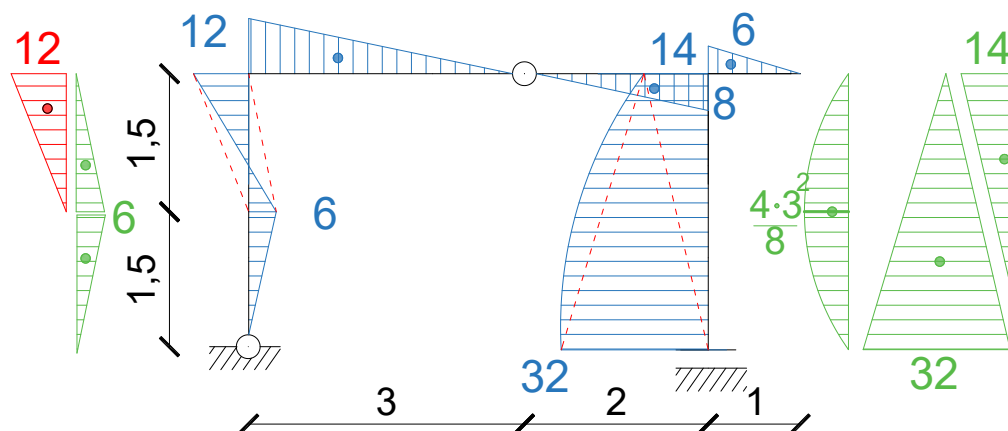
$$\varphi_D = \frac{1}{EI} \left(-\frac{1}{2} \cdot 12 \cdot 3 \cdot \frac{2}{3} \cdot 1 - \frac{1}{2} \cdot 8 \cdot 2 \cdot \frac{2}{3} \cdot \frac{2}{3} - \frac{1}{2} \cdot 14 \cdot 3 \cdot \frac{2}{3} - \frac{1}{2} \cdot 32 \cdot 3 \cdot \frac{2}{3} - \frac{2}{3} \cdot \frac{4 \cdot 3^2}{8} \cdot 3 \cdot \frac{2}{3} \right) = -\frac{608}{9EI}$$



Wyznaczenie przemieszczeń z zasady prac wirtualnych:

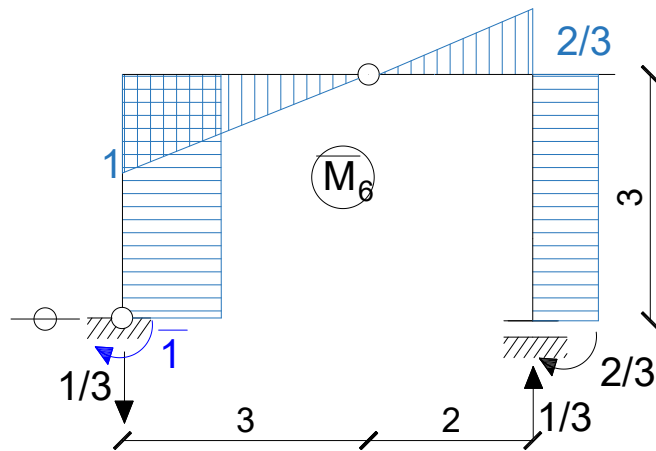


$$\varphi_D =$$

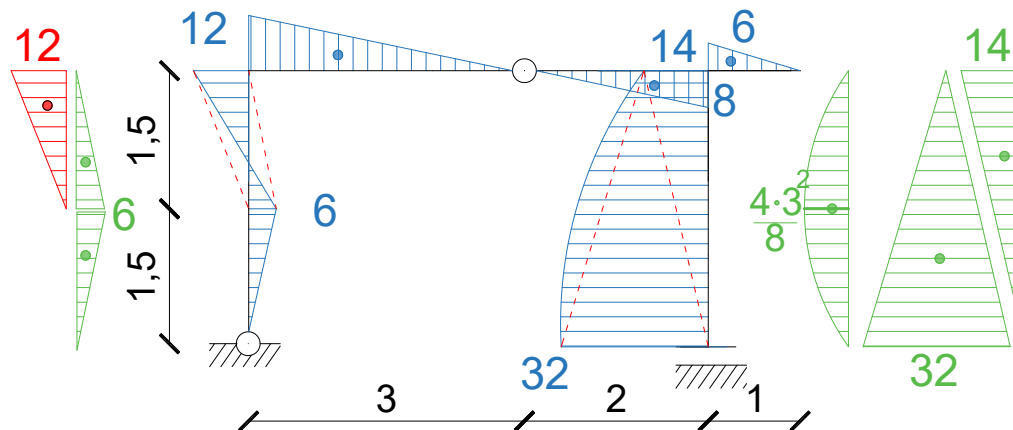


dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:

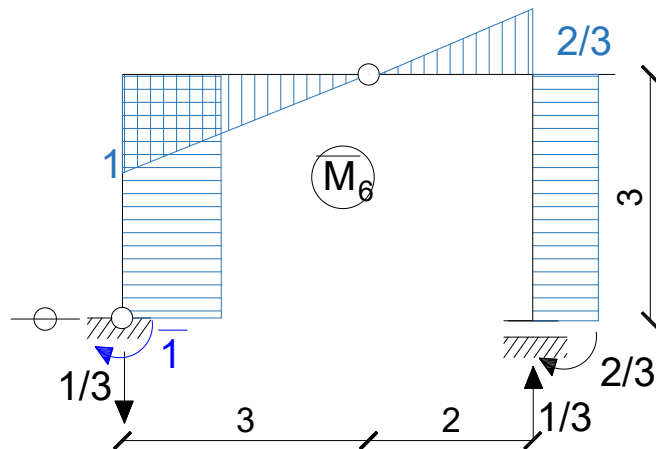


$$\varphi_D = -\frac{608}{9EI} +$$

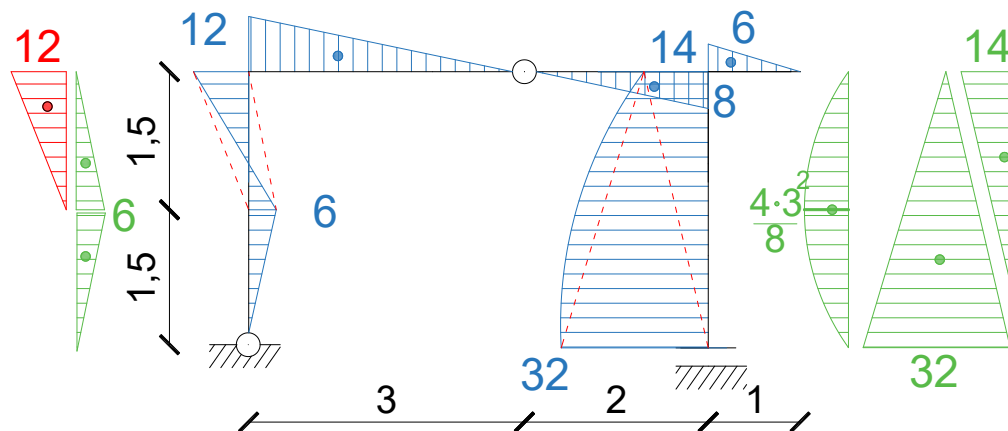


dr inż. Hanna Weber

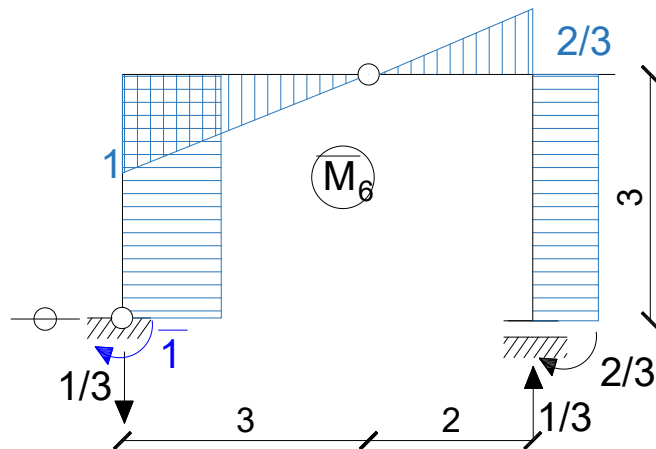
Wyznaczenie przemieszczeń z zasady prac wirtualnych:



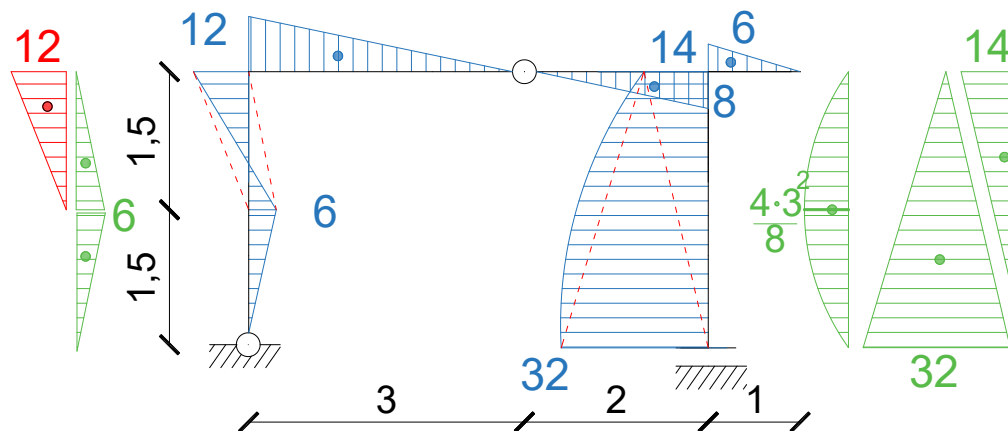
$$\varphi_D = -\frac{608}{9EI} + \frac{1}{EI} \left(-\frac{1}{2} \cdot 12 \cdot 1,5 \cdot 1 + \right)$$



Wyznaczenie przemieszczeń z zasady prac wirtualnych:

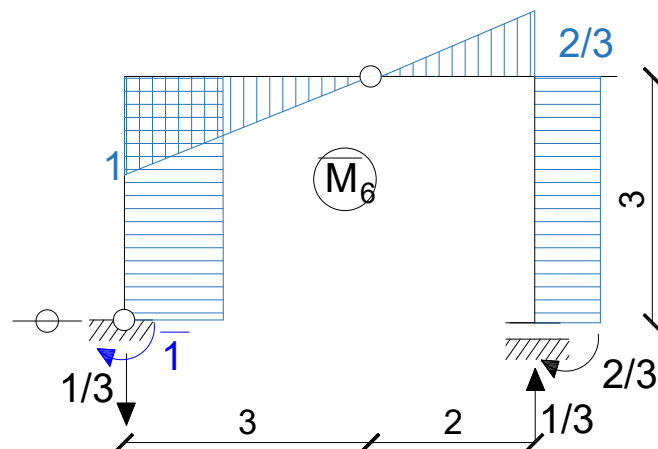


$$\varphi_D = -\frac{608}{9EI} + \frac{1}{EI} \left(-\frac{1}{2} \cdot 12 \cdot 1,5 \cdot 1 + \frac{1}{2} \cdot 6 \cdot 1,5 \cdot 1 + \right)$$

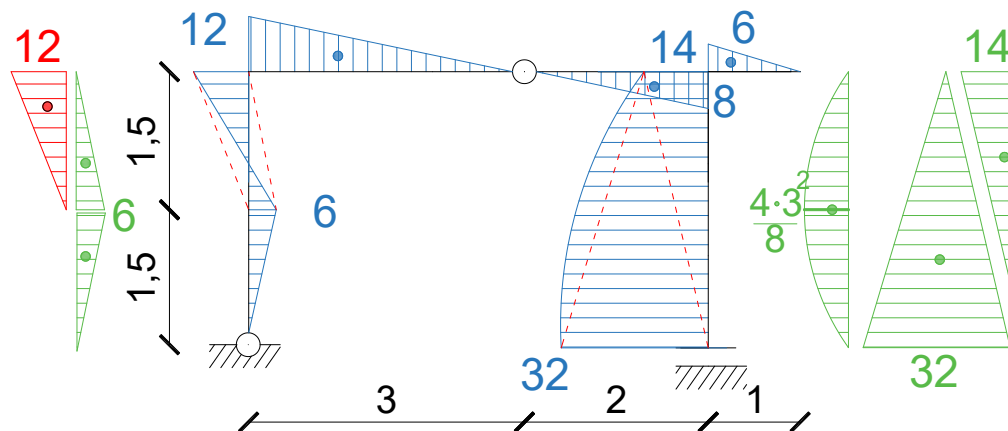


dr inż. Hanna Weber

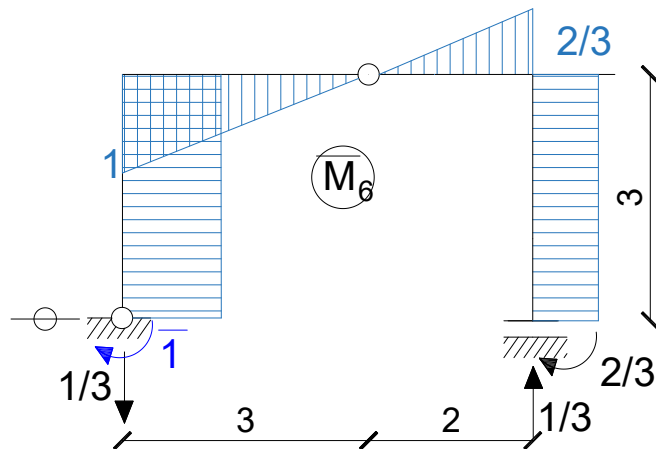
Wyznaczenie przemieszczeń z zasady prac wirtualnych:



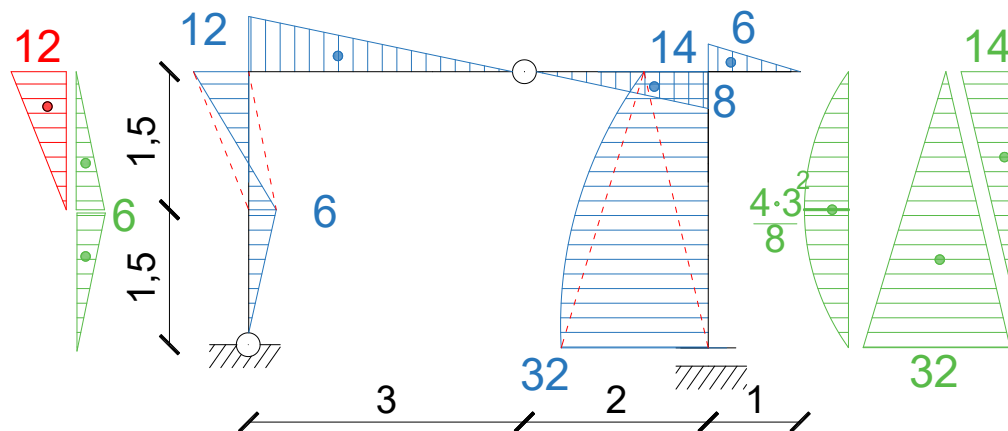
$$\varphi_D = -\frac{608}{9EI} + \frac{1}{EI} \left(-\frac{1}{2} \cdot 12 \cdot 1,5 \cdot 1 + \frac{1}{2} \cdot 6 \cdot 1,5 \cdot 1 + \frac{1}{2} \cdot 6 \cdot 1,5 \cdot 1 \right)$$



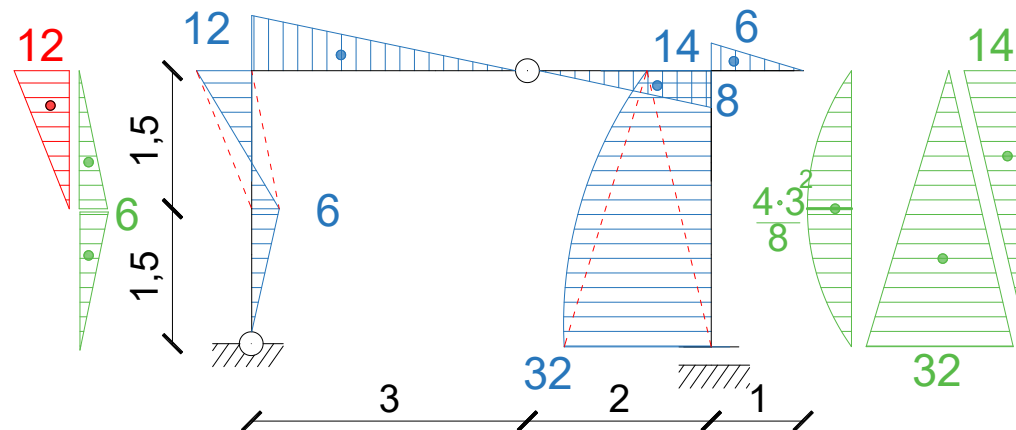
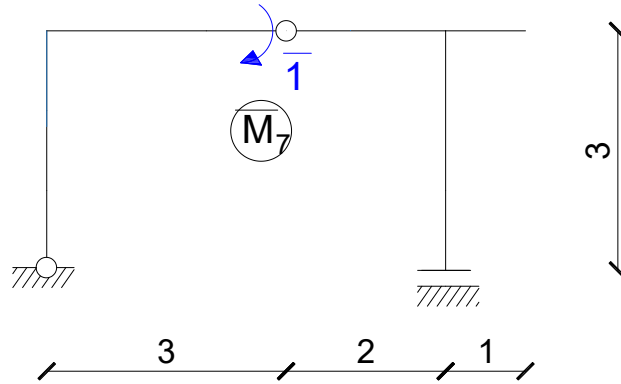
Wyznaczenie przemieszczeń z zasady prac wirtualnych:



$$\varphi_D = -\frac{608}{9EI} + \frac{1}{EI} \left(-\frac{1}{2} \cdot 12 \cdot 1,5 \cdot 1 + \frac{1}{2} \cdot 6 \cdot 1,5 \cdot 1 + \frac{1}{2} \cdot 6 \cdot 1,5 \cdot 1 \right) = -\frac{608}{9EI}$$

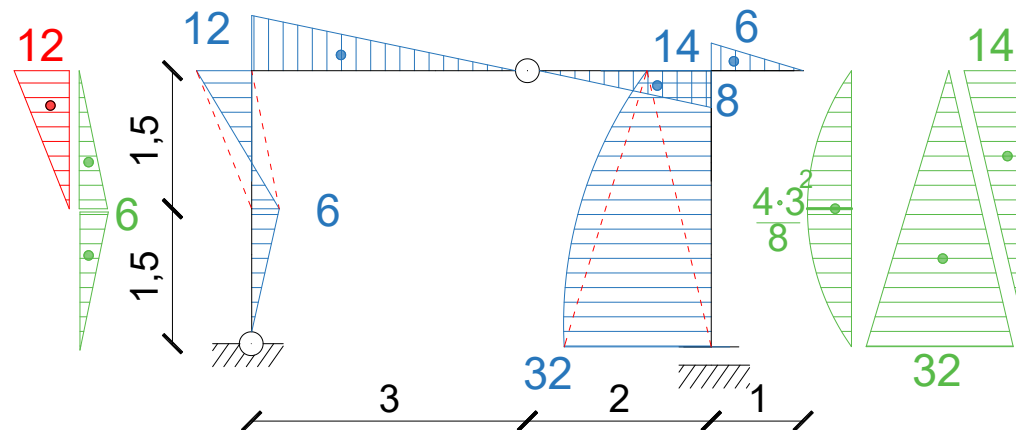
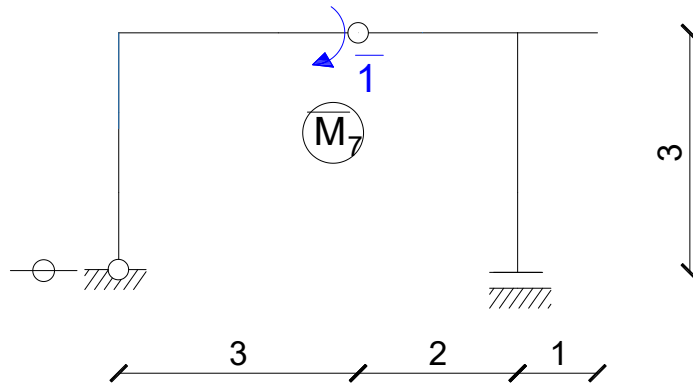


Wyznaczenie przemieszczeń z zasady prac wirtualnych:



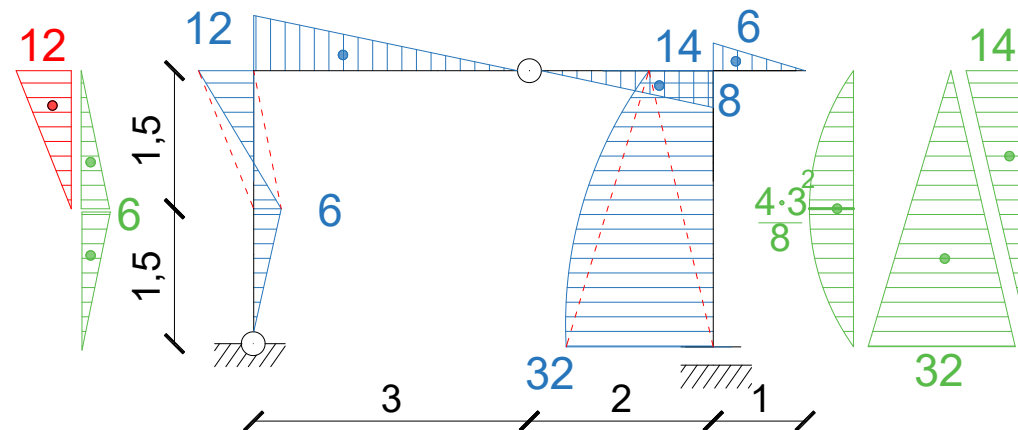
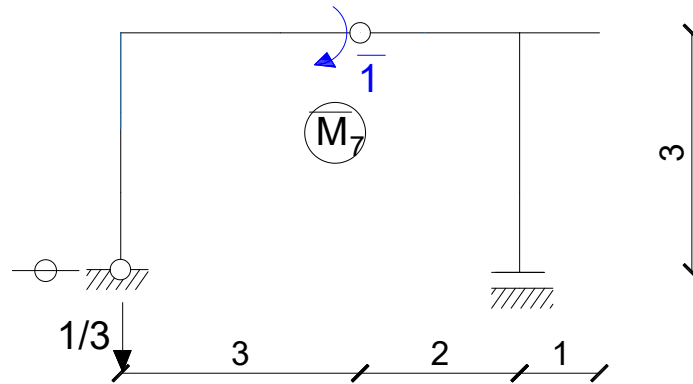
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Wyznaczenie przemieszczeń z zasady prac wirtualnych:



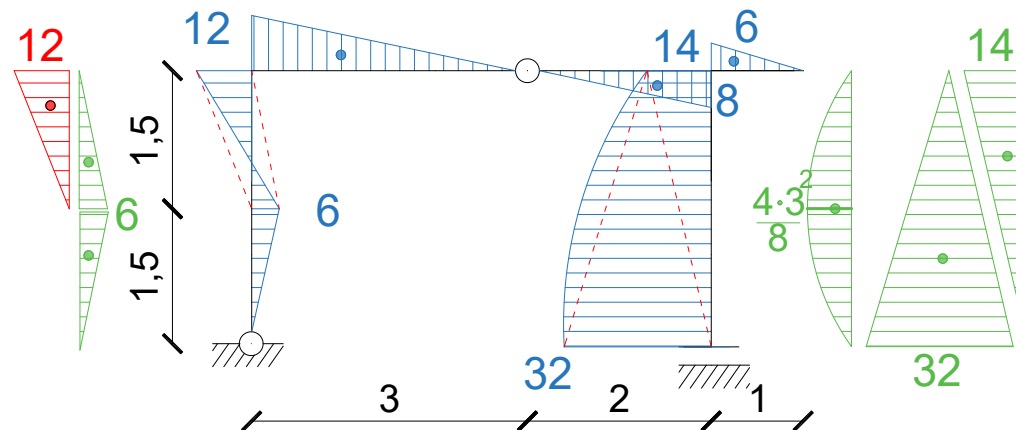
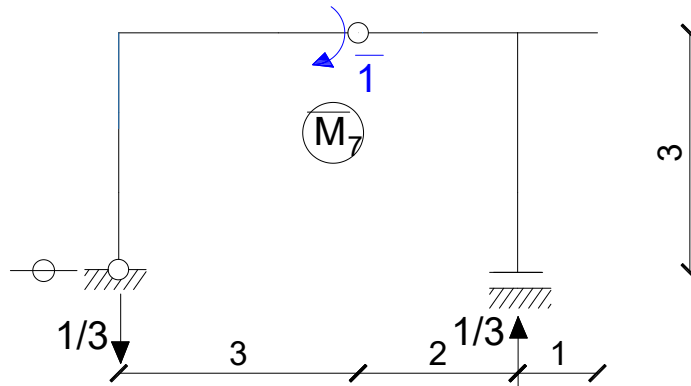
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



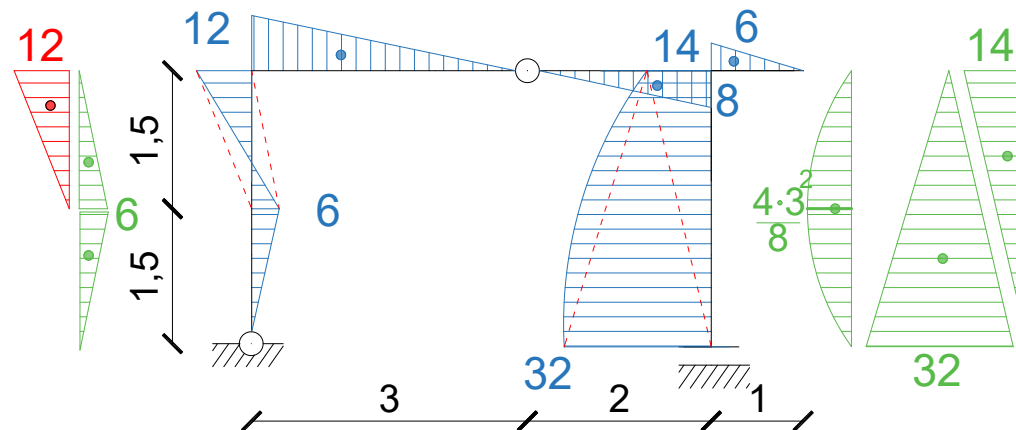
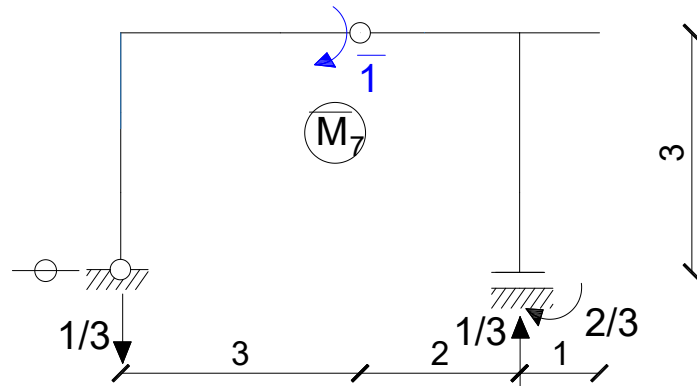
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



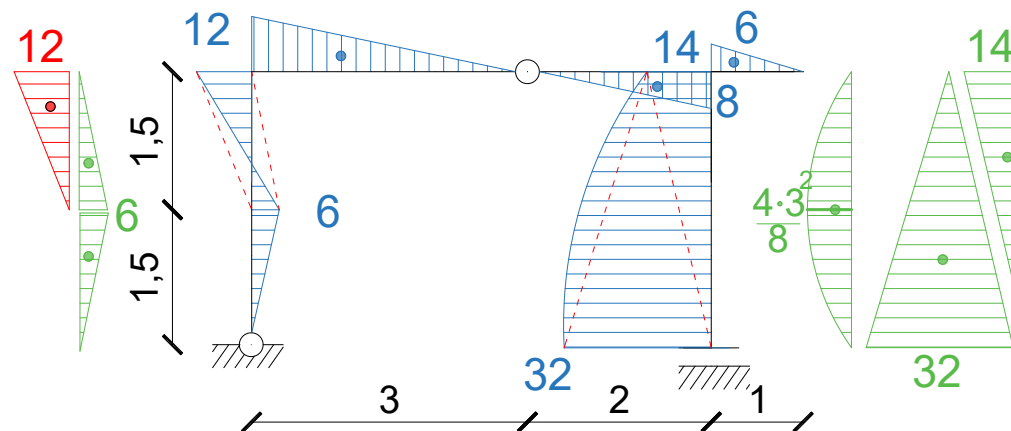
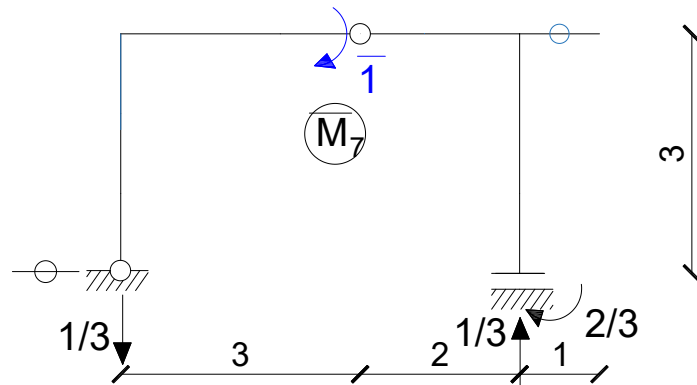
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



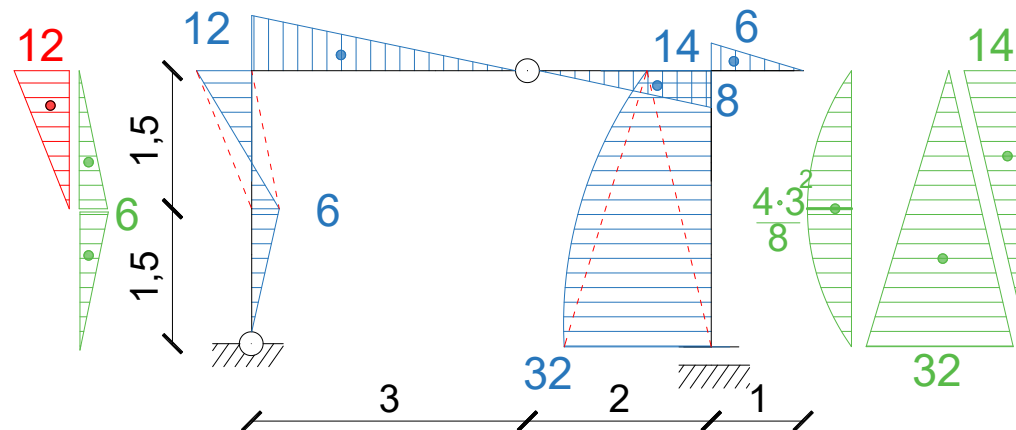
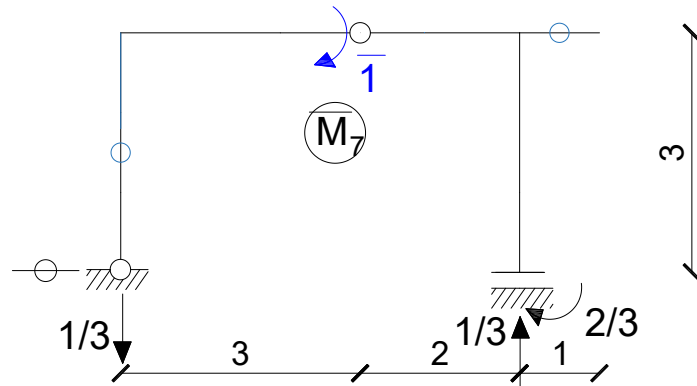
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



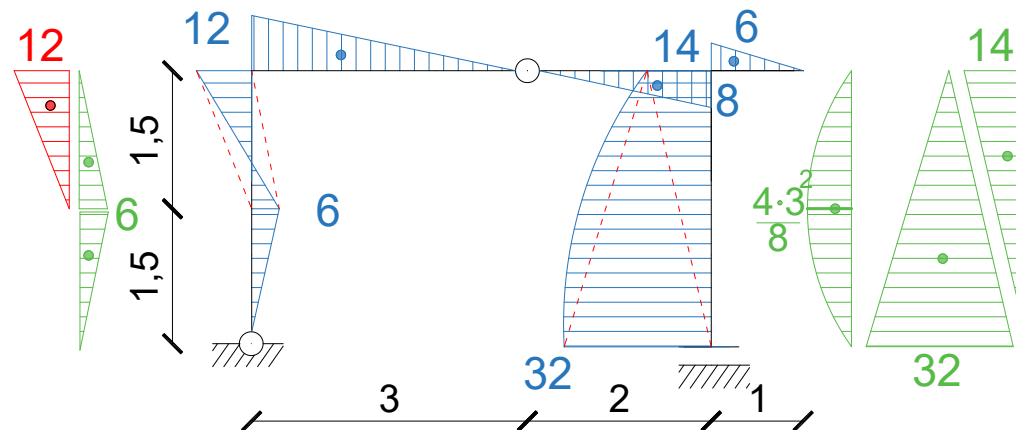
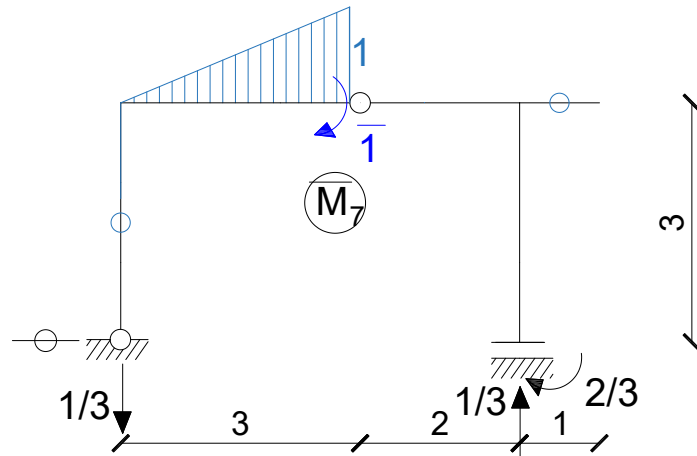
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



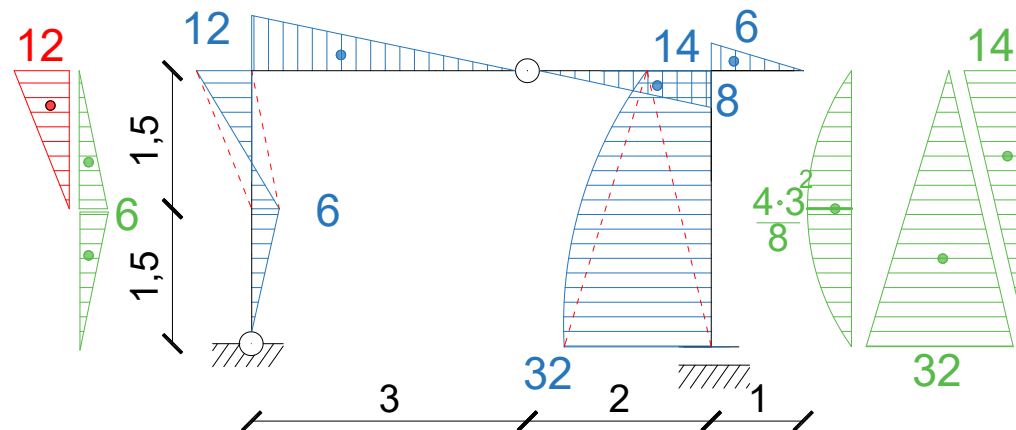
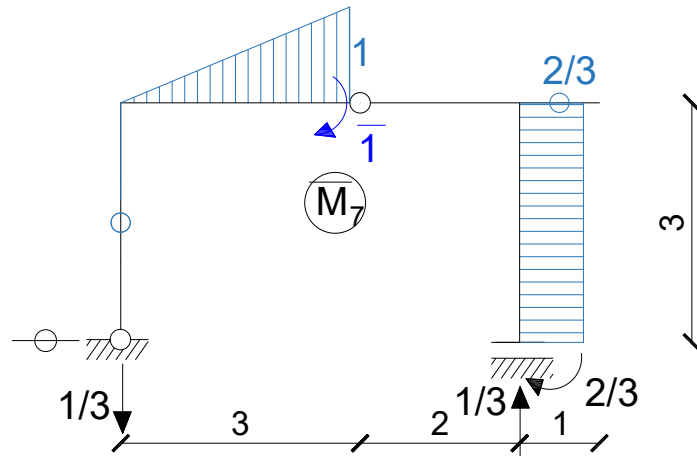
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



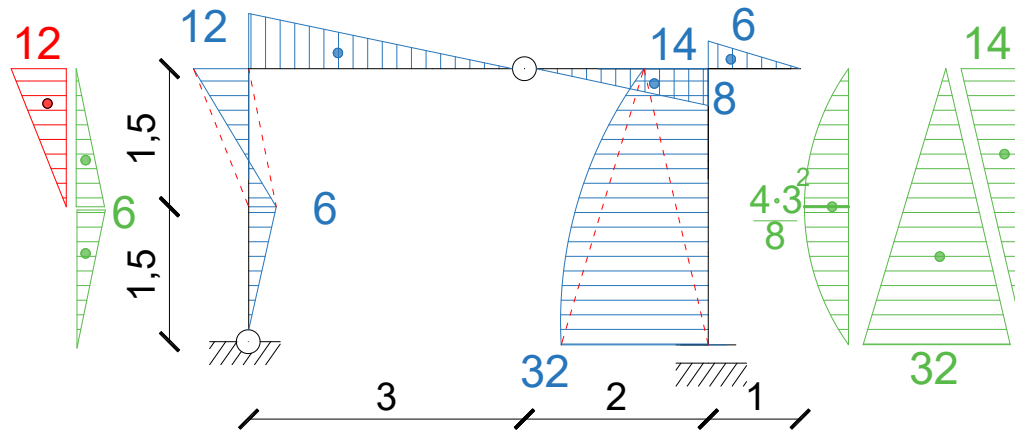
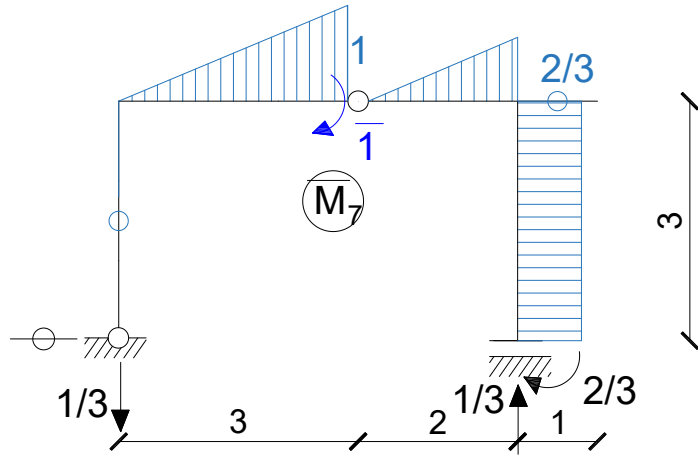
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



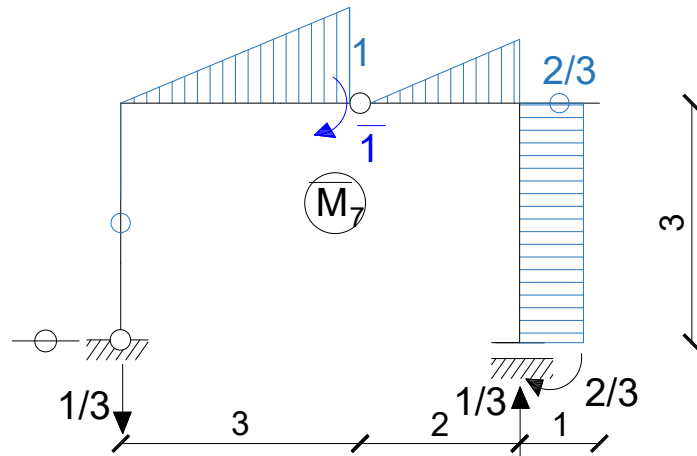
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:

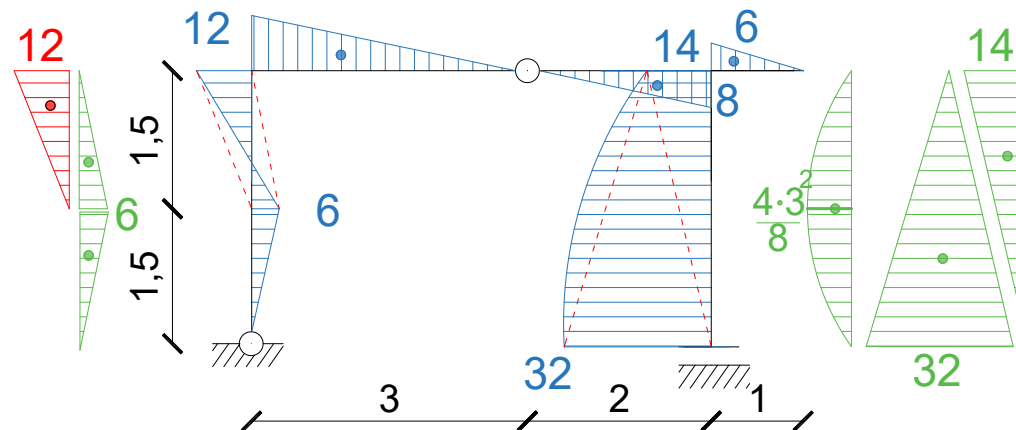


dr inż. Hanna Weber

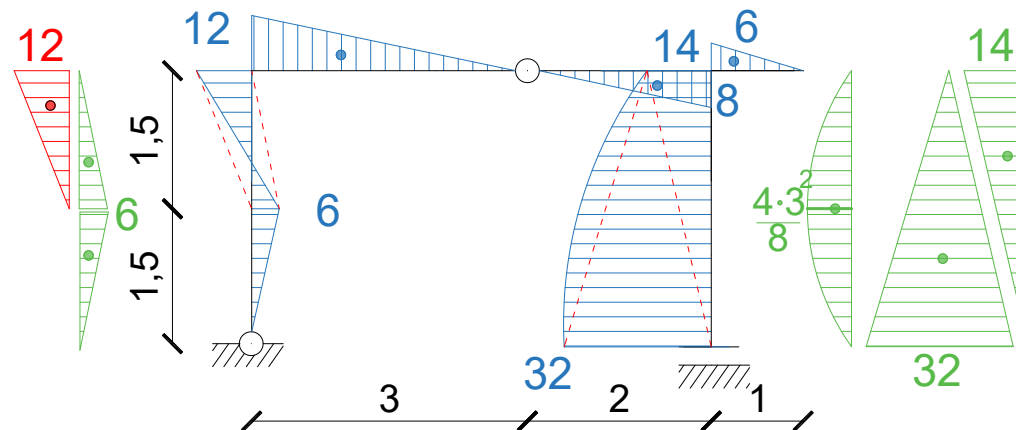
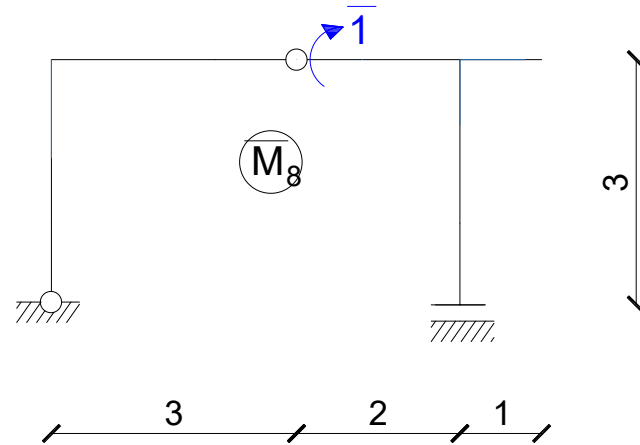
Wyznaczenie przemieszczeń z zasady prac wirtualnych:



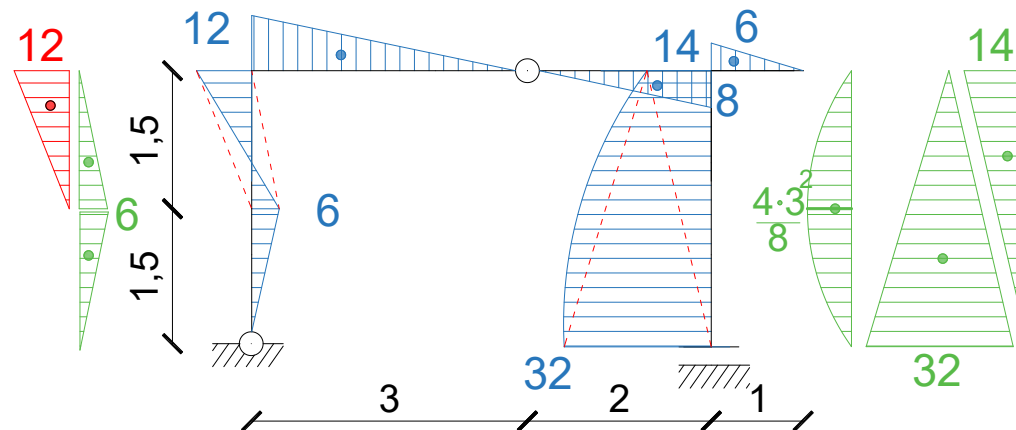
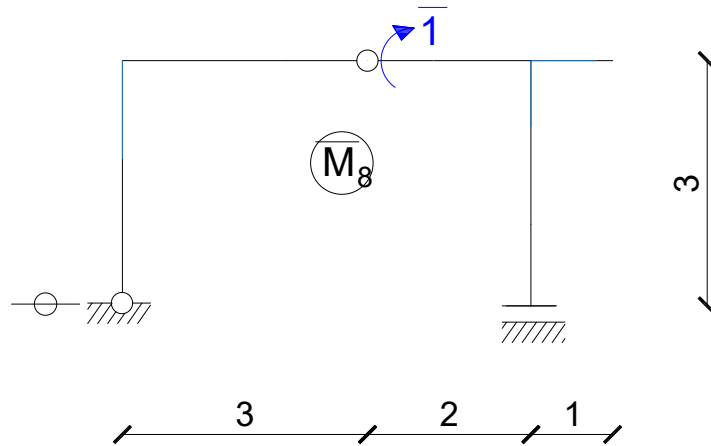
$$\varphi_C^L = \frac{1}{EI} \left(\frac{1}{2} \cdot 12 \cdot 3 \cdot \frac{1}{3} \cdot 1 - \frac{1}{2} \cdot 8 \cdot 2 \cdot \frac{2}{3} \cdot \frac{2}{3} - \frac{1}{2} \cdot 14 \cdot 3 \cdot \frac{2}{3} - \frac{1}{2} \cdot 32 \cdot 3 \cdot \frac{2}{3} - \frac{2}{3} \cdot \frac{4 \cdot 3^2}{8} \cdot 3 \cdot \frac{2}{3} \right) = -\frac{446}{9EI}$$



Wyznaczenie przemieszczeń z zasady prac wirtualnych:

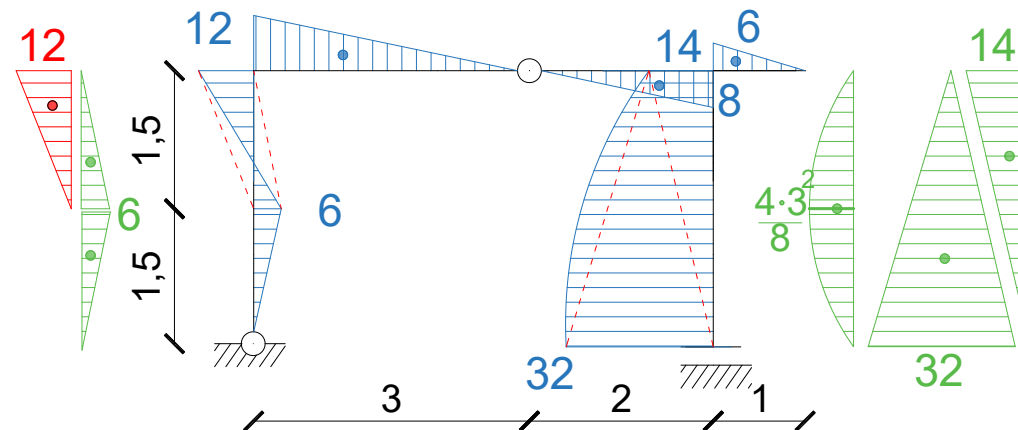
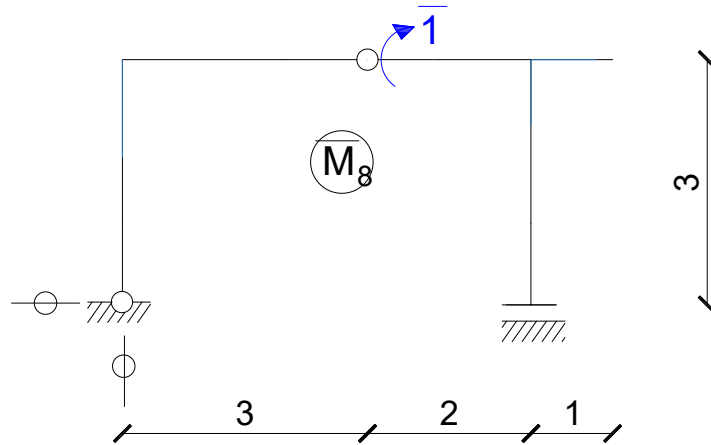


Wyznaczenie przemieszczeń z zasady prac wirtualnych:



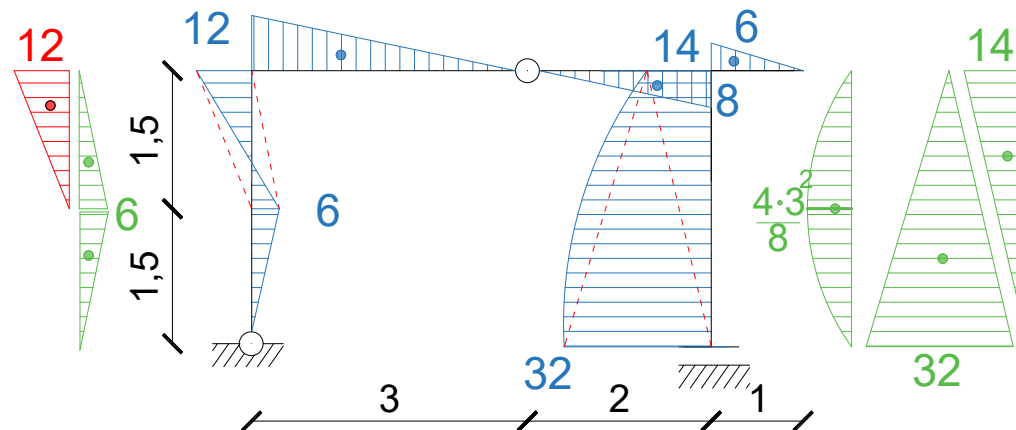
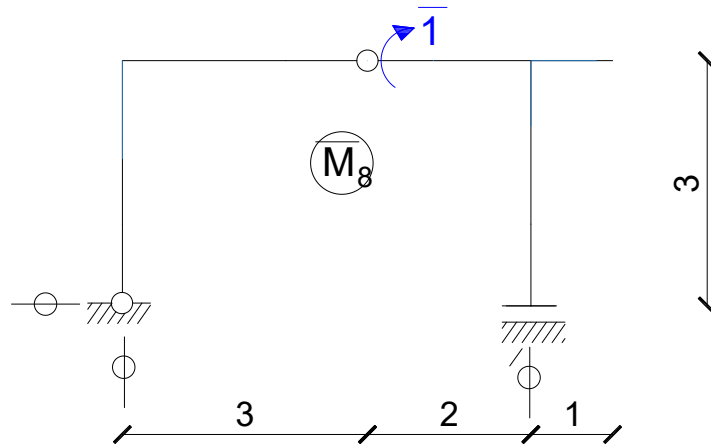
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



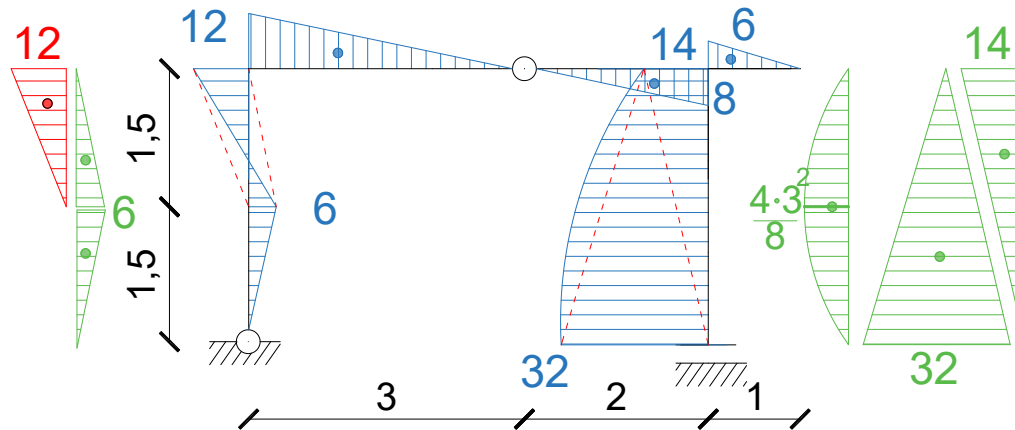
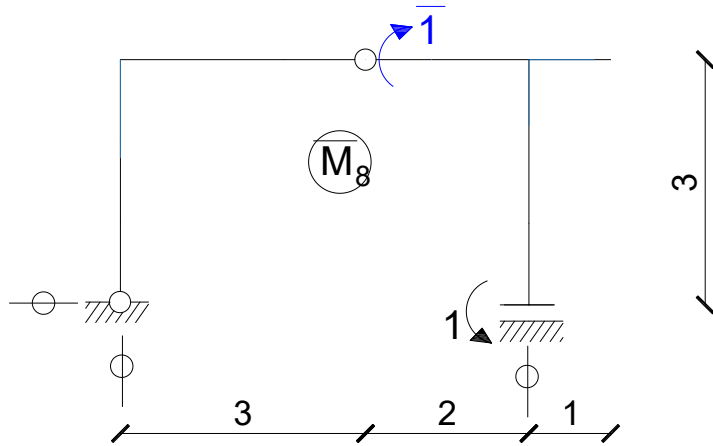
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



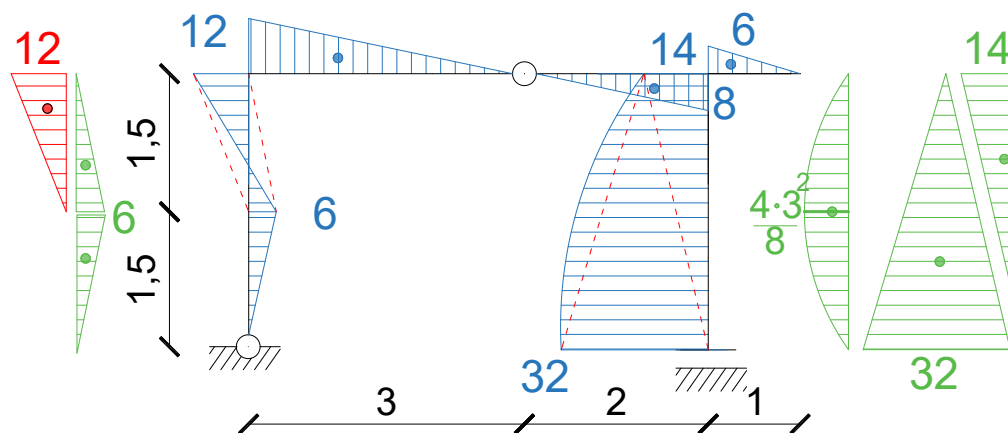
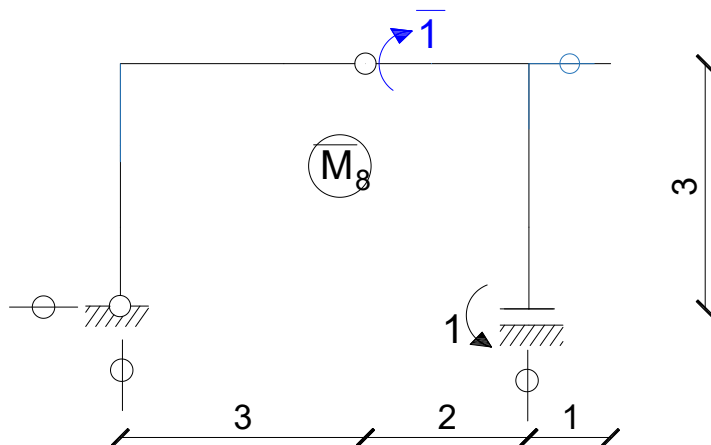
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



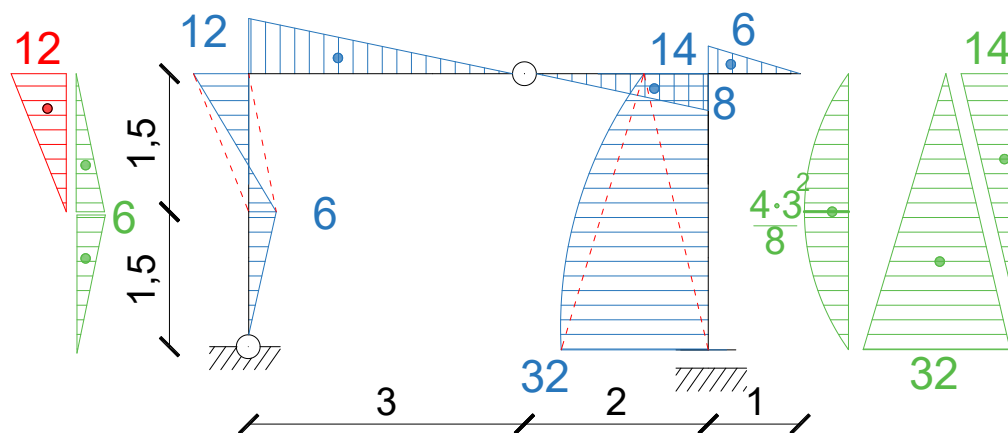
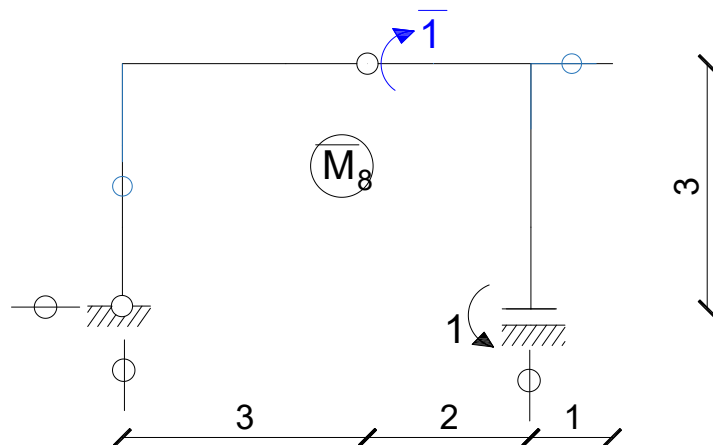
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



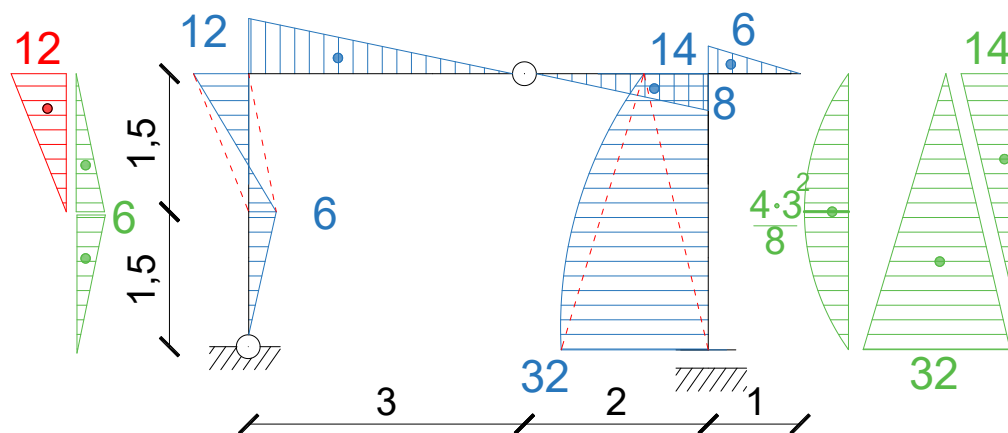
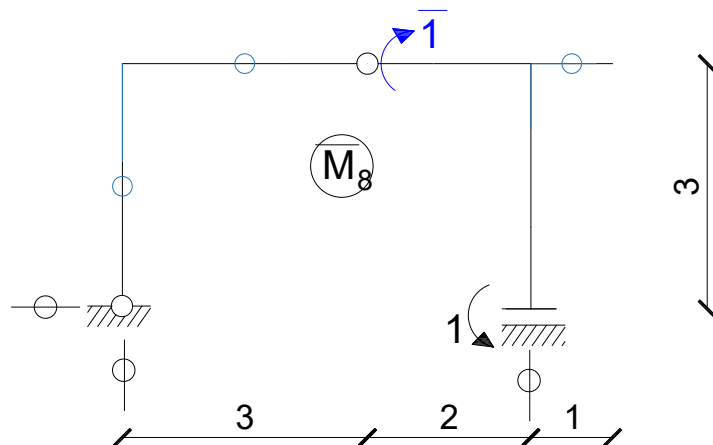
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



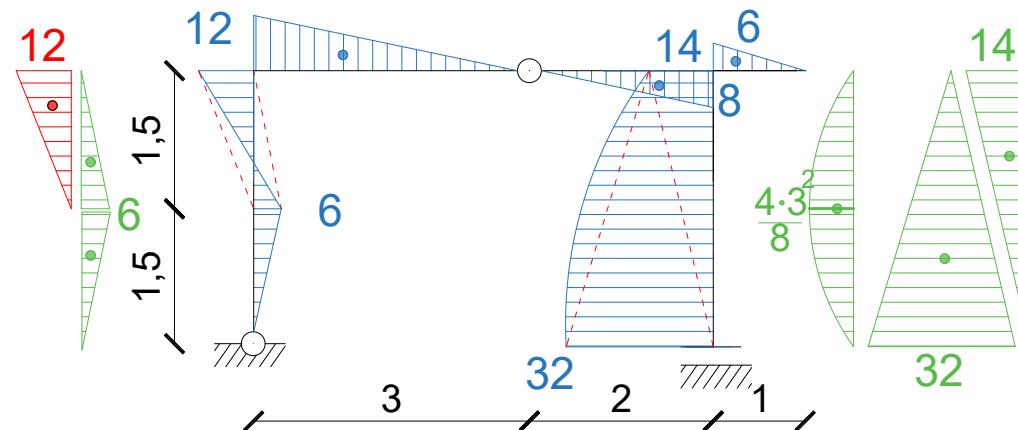
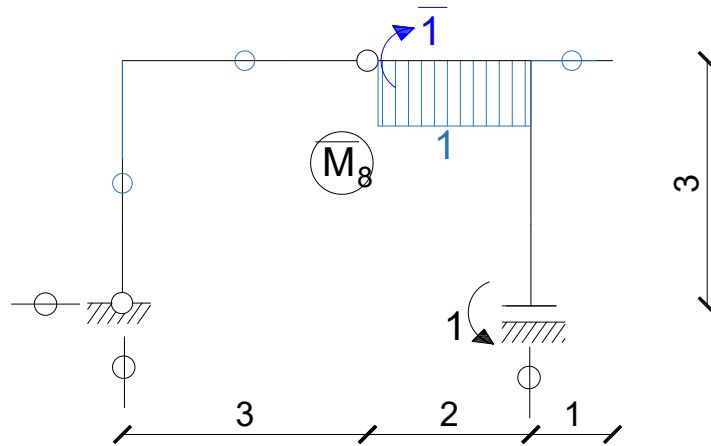
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



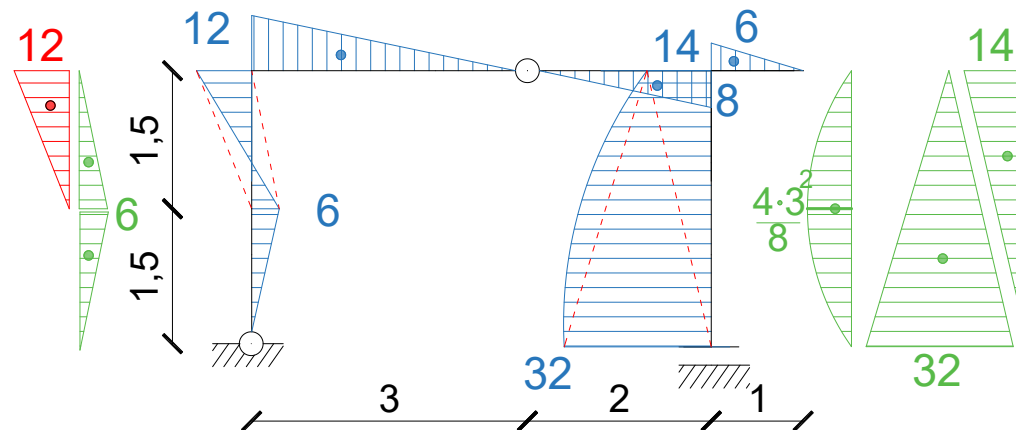
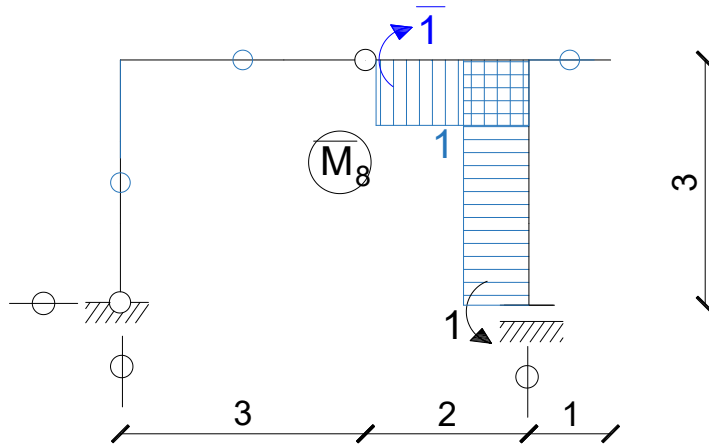
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



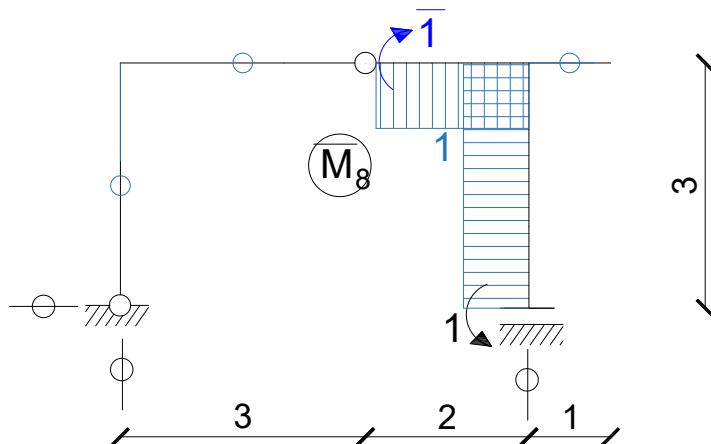
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:

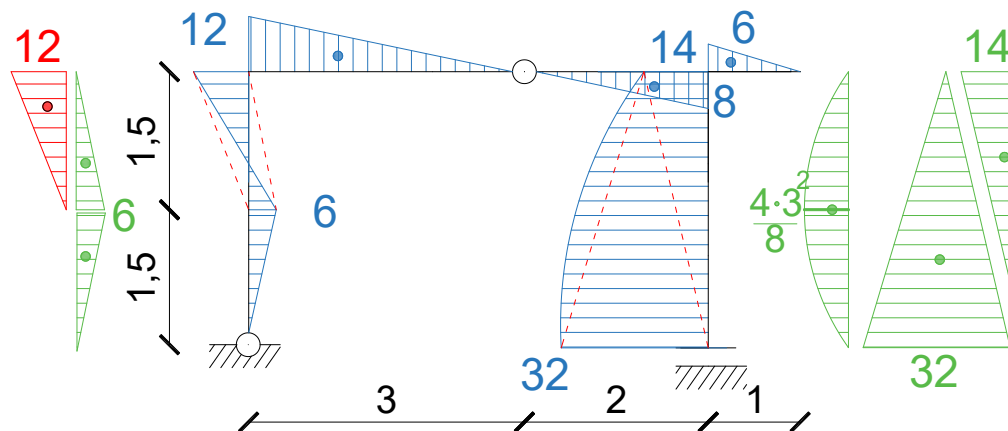


dr inż. Hanna Weber

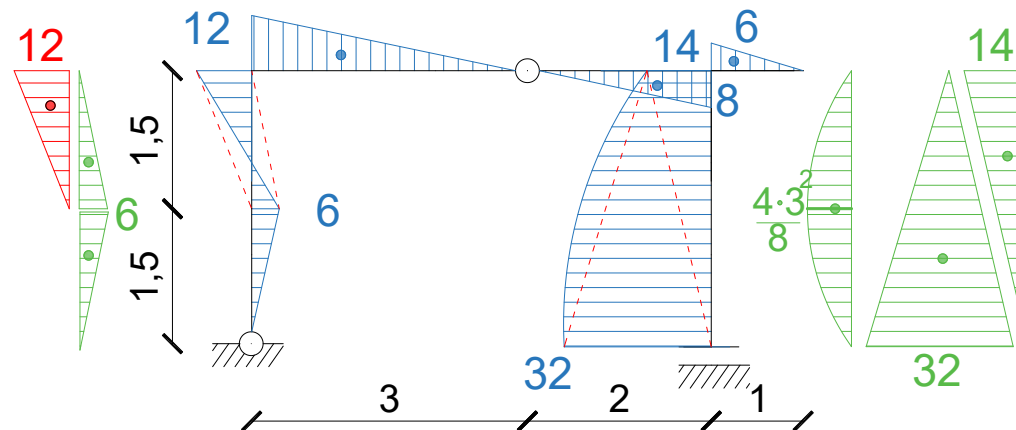
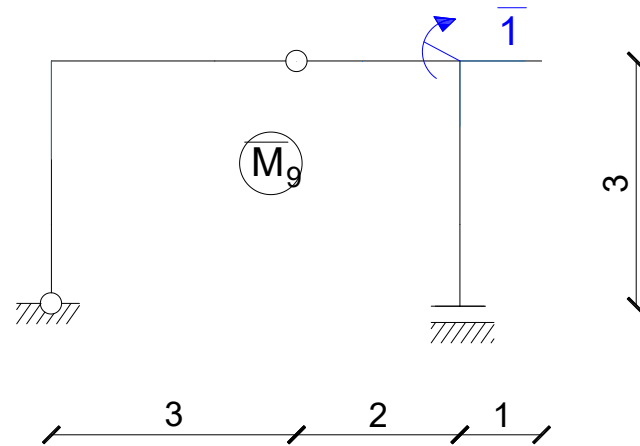
Wyznaczenie przemieszczeń z zasady prac wirtualnych:



$$\varphi_C^P = \frac{1}{EI} \left(\frac{1}{2} \cdot 8 \cdot 2 \cdot 1 + \frac{1}{2} \cdot 14 \cdot 3 \cdot 1 + \frac{1}{2} \cdot 32 \cdot 3 \cdot 1 + \frac{2}{3} \cdot \frac{4 \cdot 3^2}{8} \cdot 3 \cdot 1 \right) = \frac{86}{EI}$$

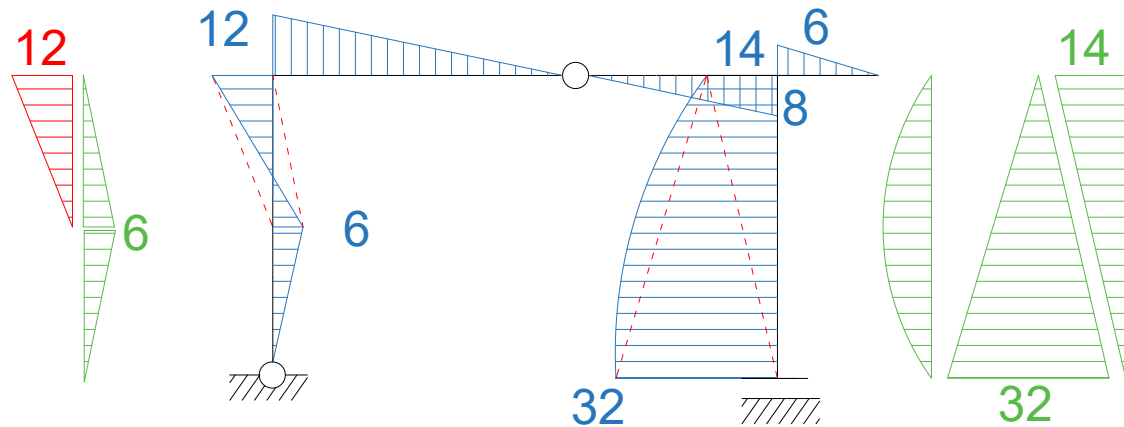
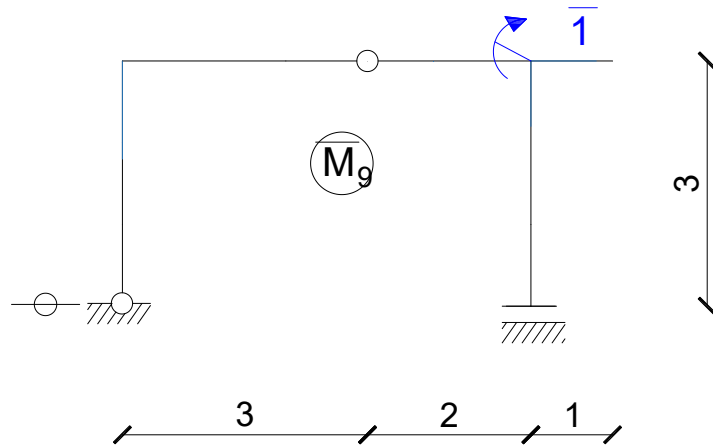


Wyznaczenie przemieszczeń z zasady prac wirtualnych:



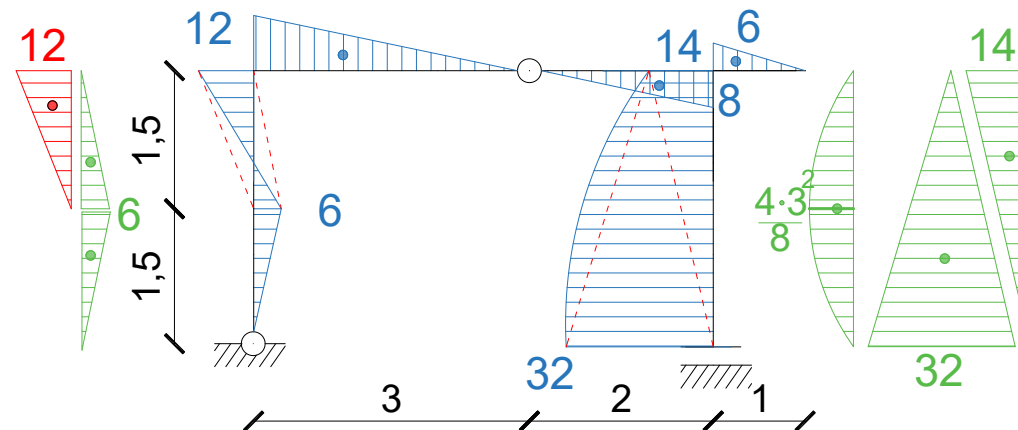
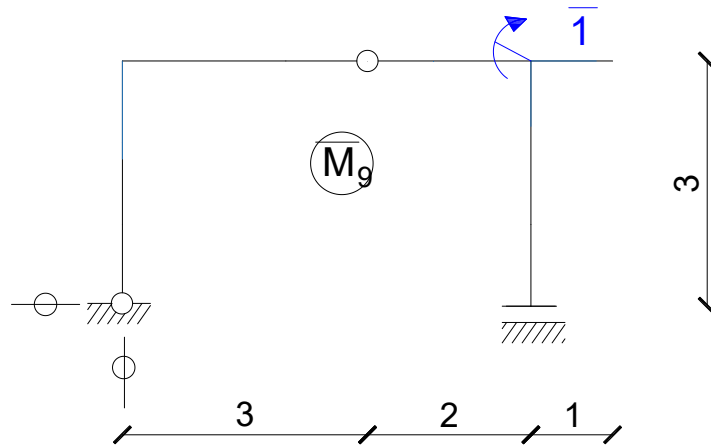
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



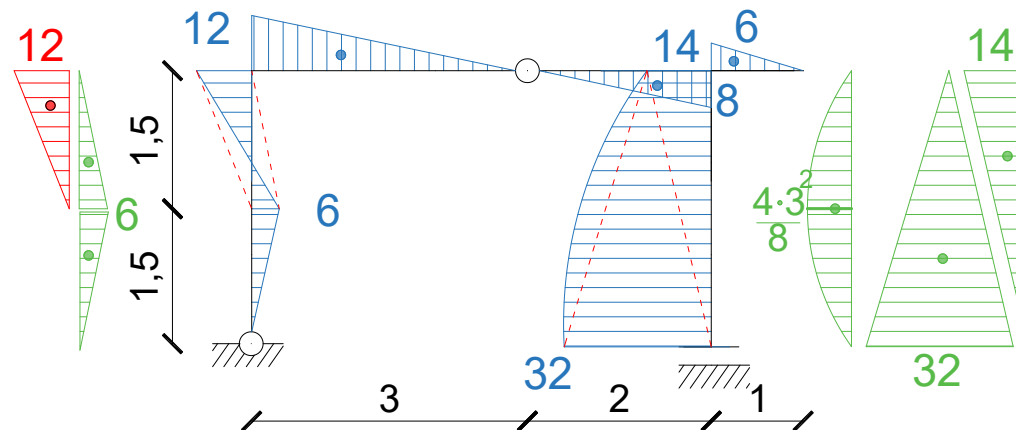
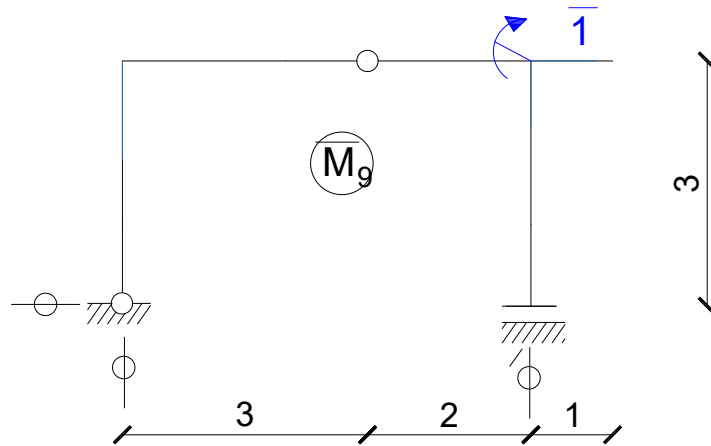
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



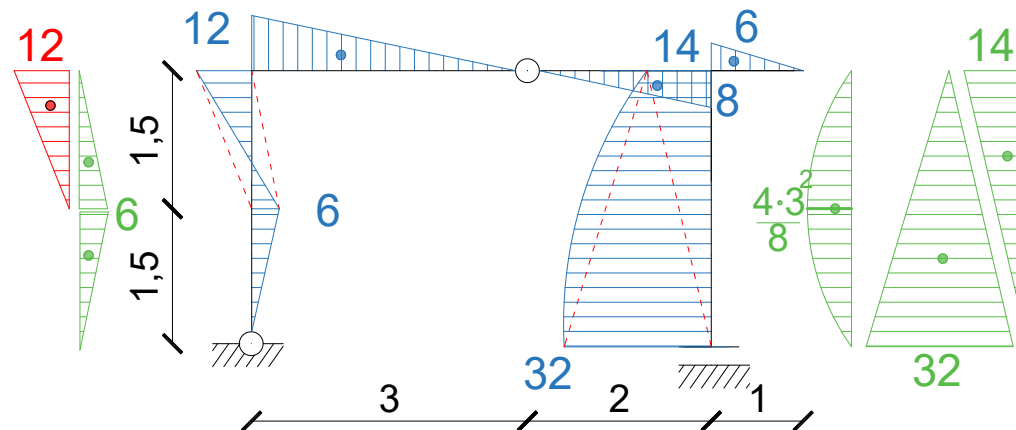
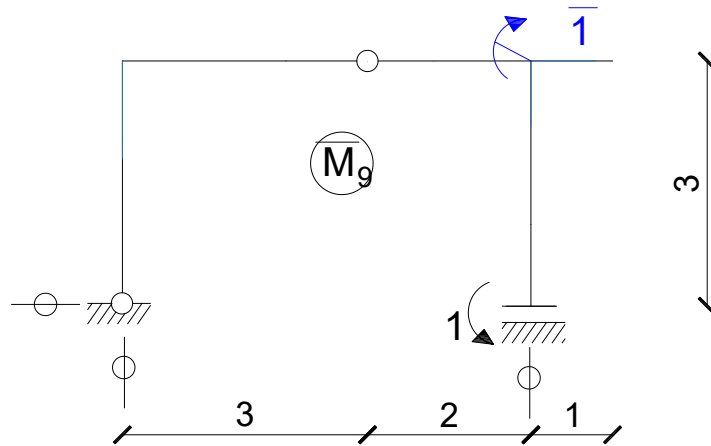
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



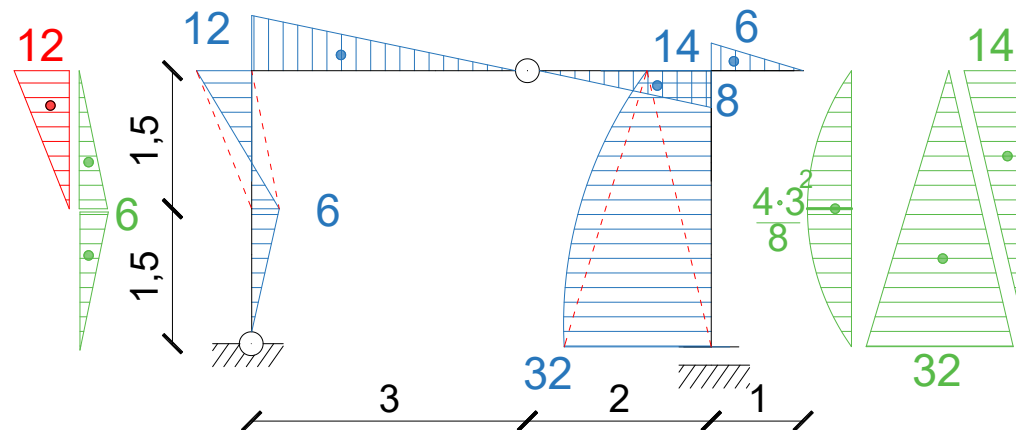
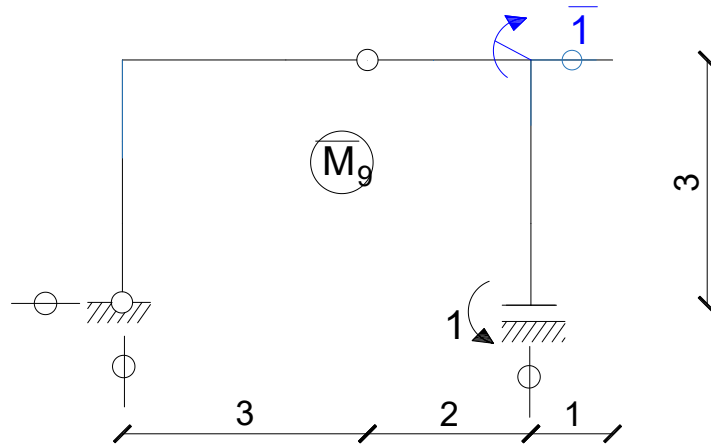
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



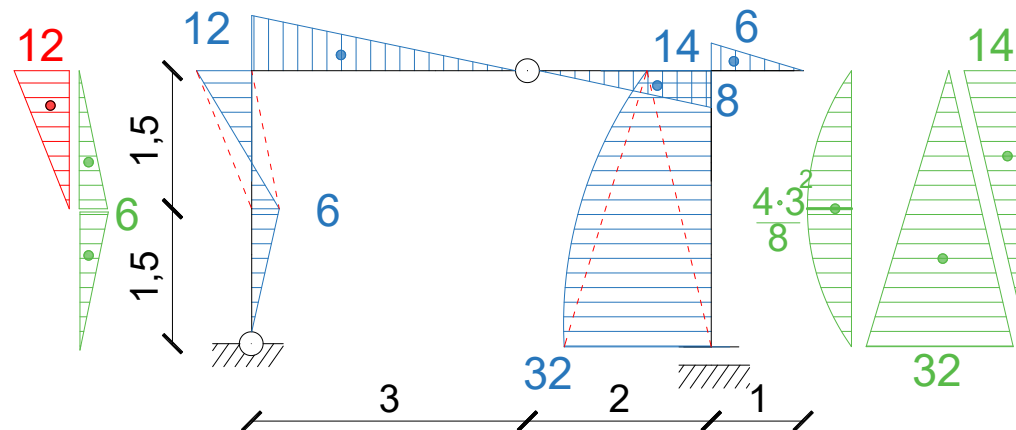
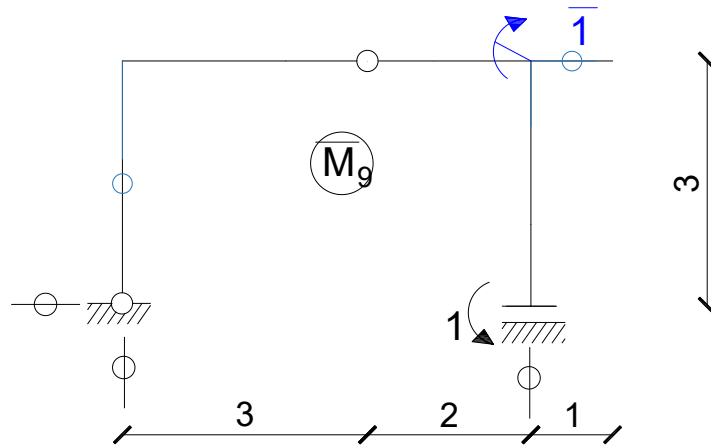
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



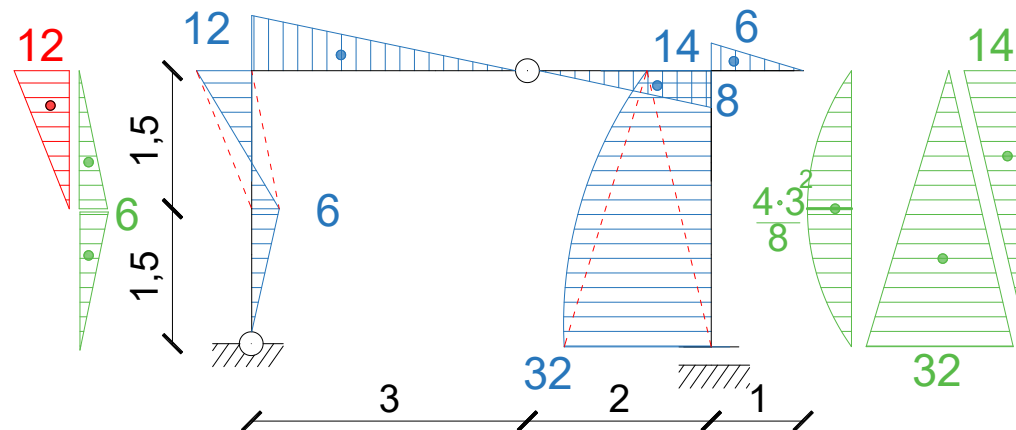
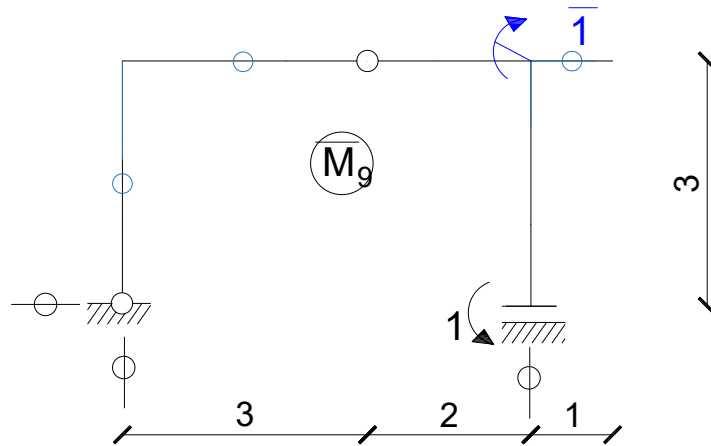
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



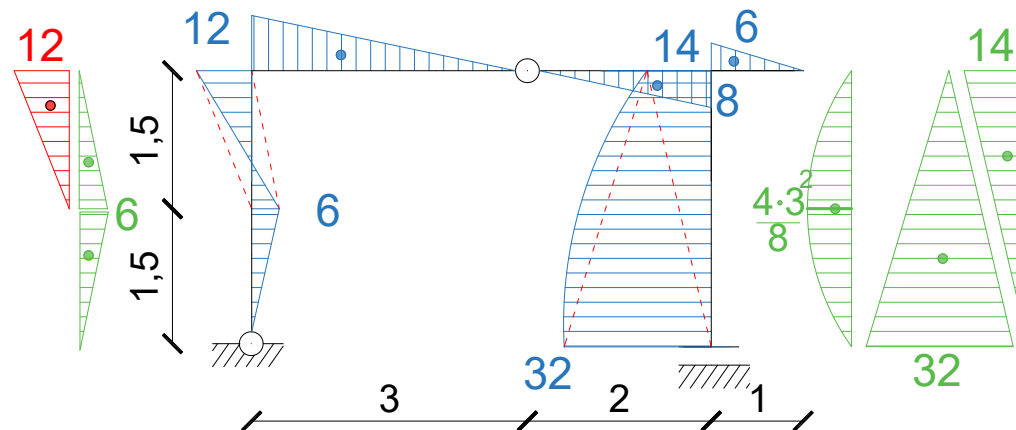
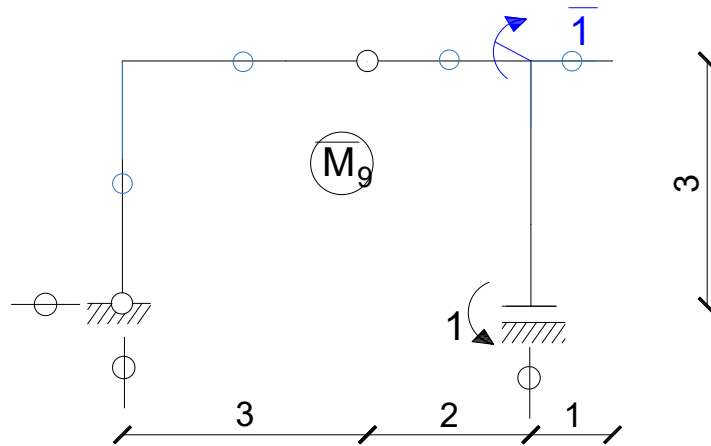
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



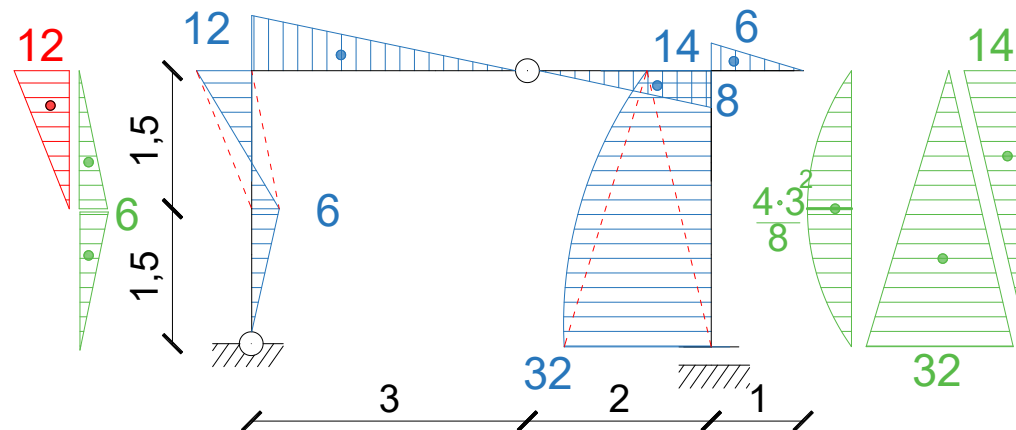
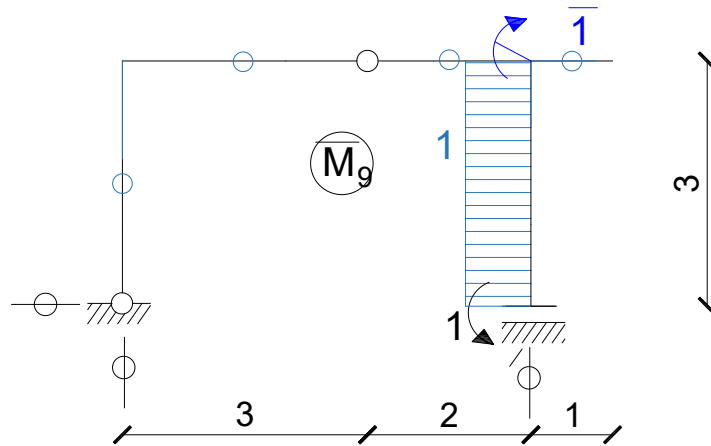
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



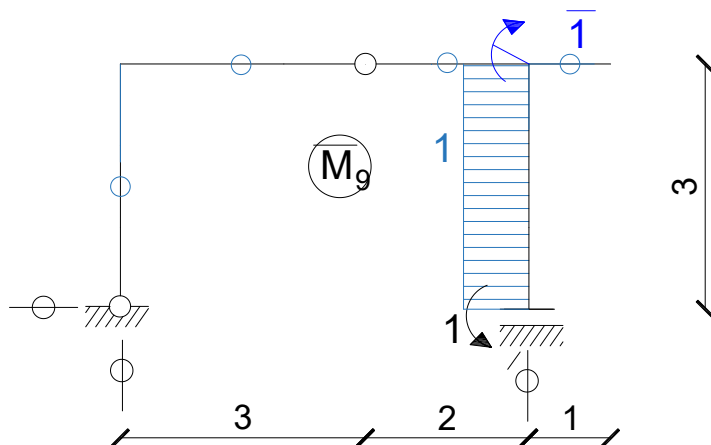
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:

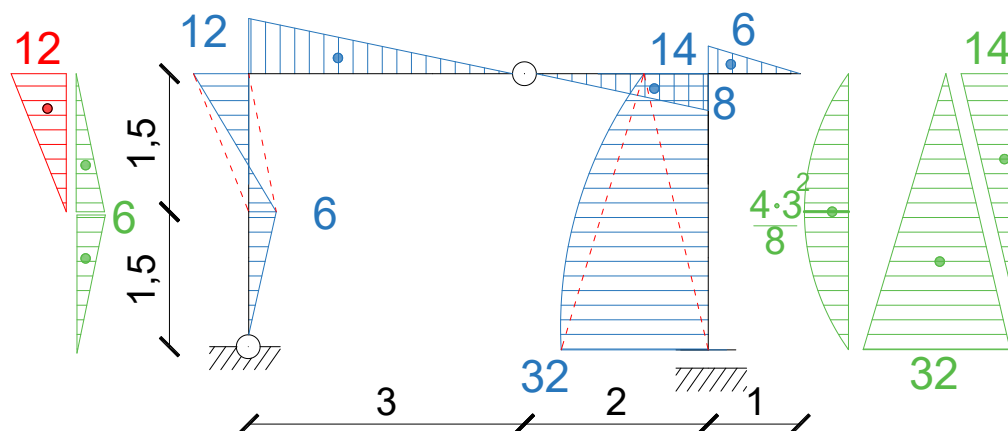


dr inż. Hanna Weber

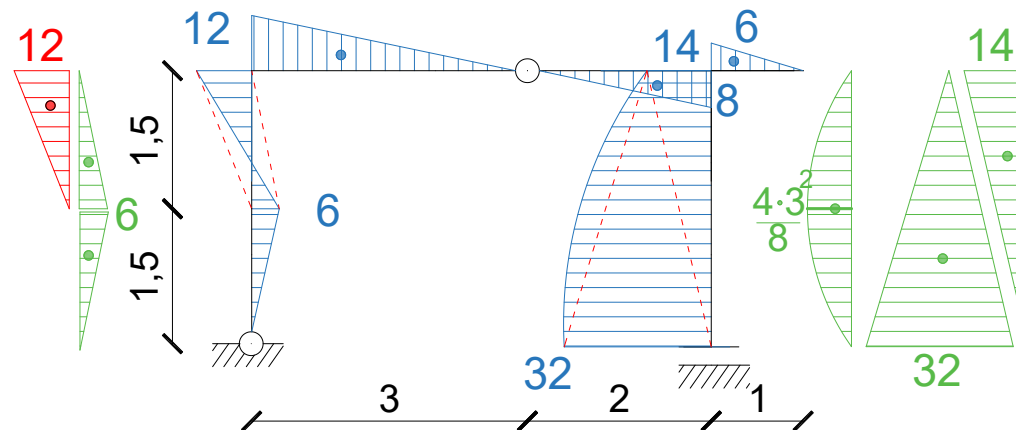
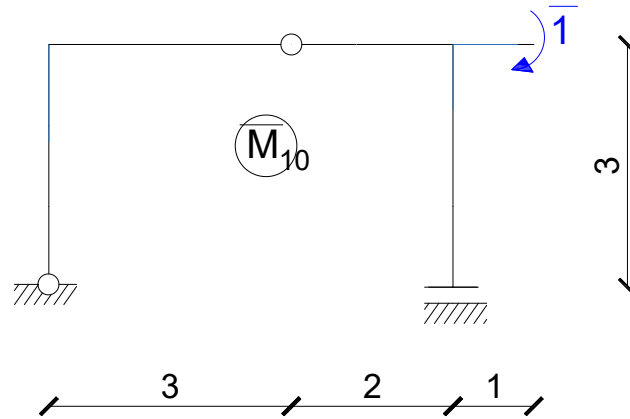
Wyznaczenie przemieszczeń z zasady prac wirtualnych:



$$\varphi_E = \frac{1}{EI} \left(\frac{1}{2} \cdot 14 \cdot 3 \cdot 1 + \frac{1}{2} \cdot 32 \cdot 3 \cdot 1 + \frac{2}{3} \cdot \frac{4 \cdot 3^2}{8} \cdot 3 \cdot 1 \right) = \frac{78}{EI}$$

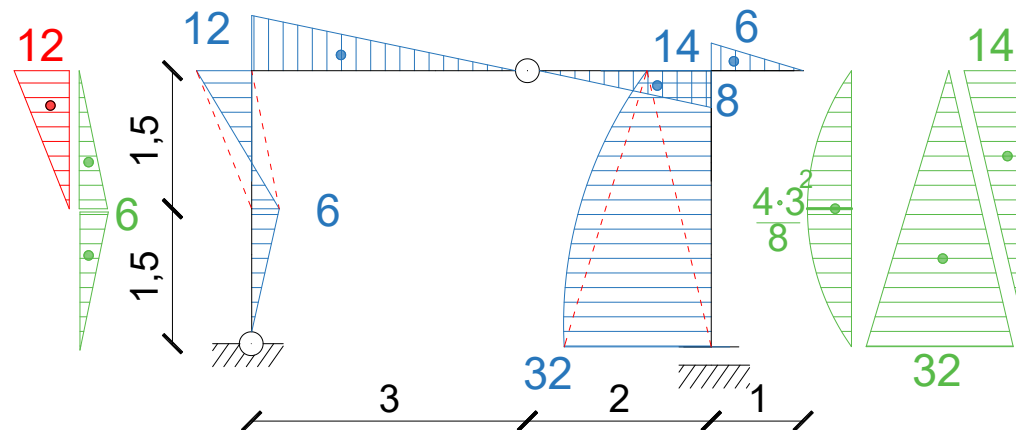
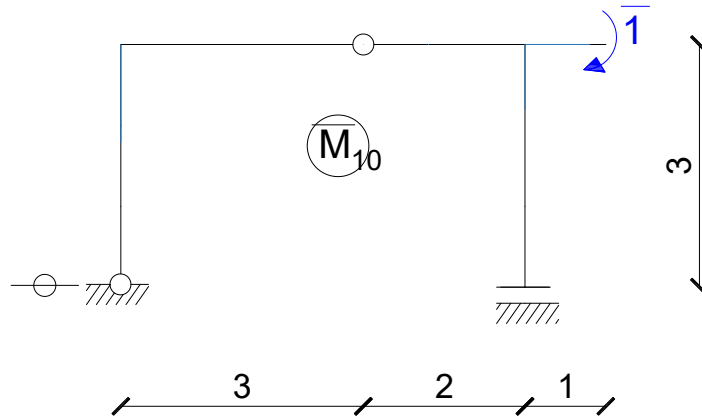


Wyznaczenie przemieszczeń z zasady prac wirtualnych:



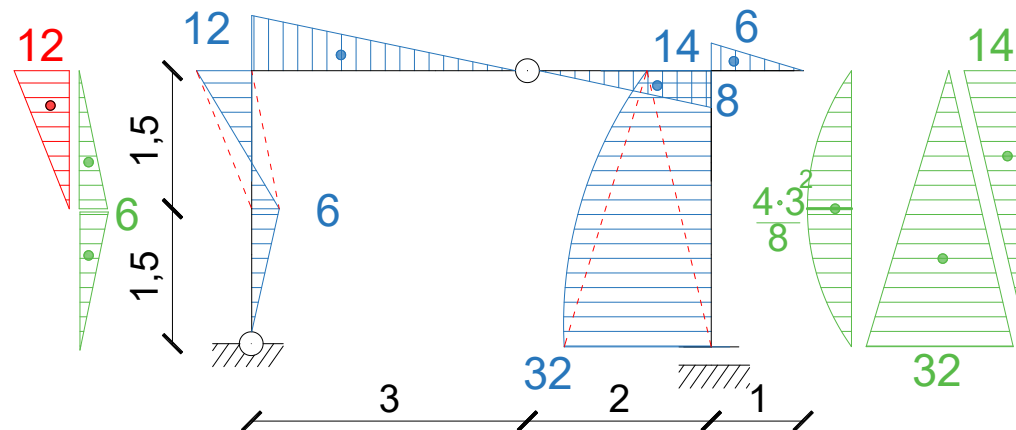
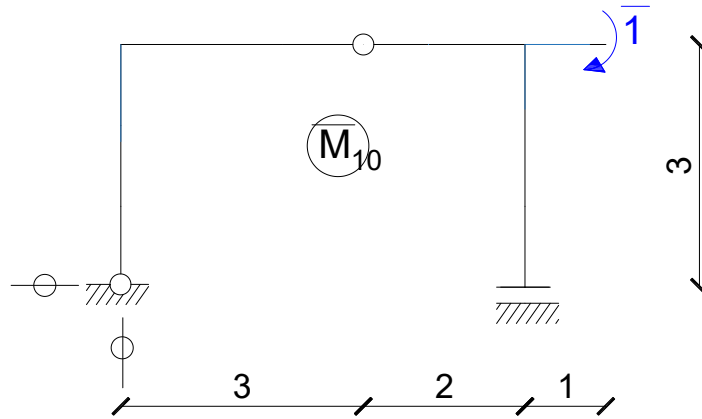
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



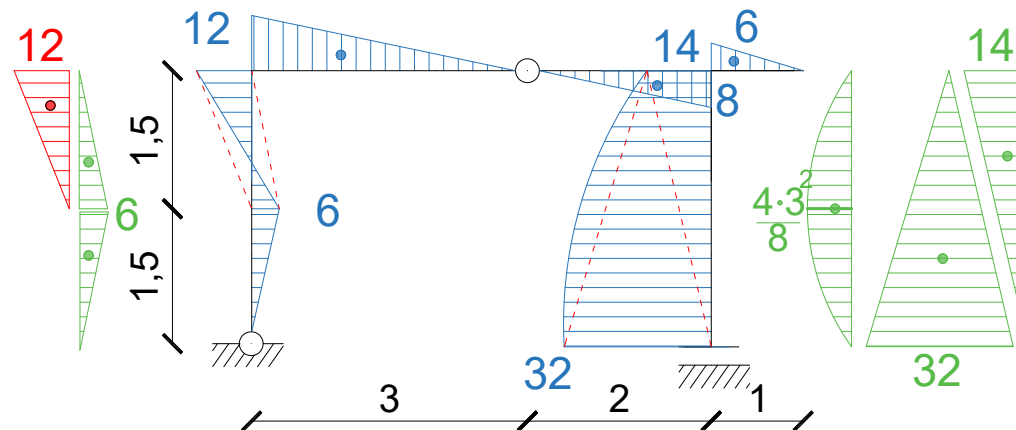
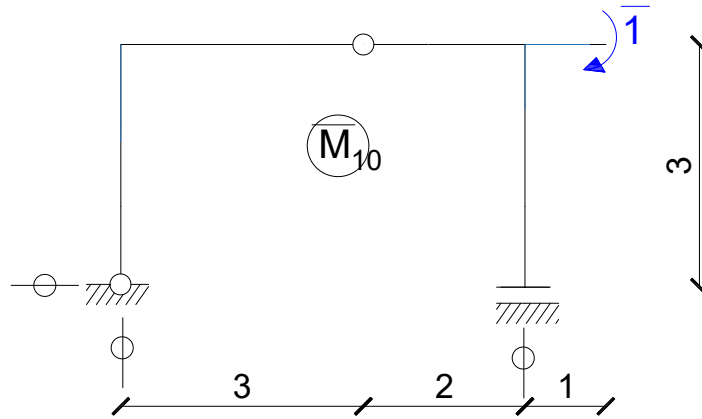
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



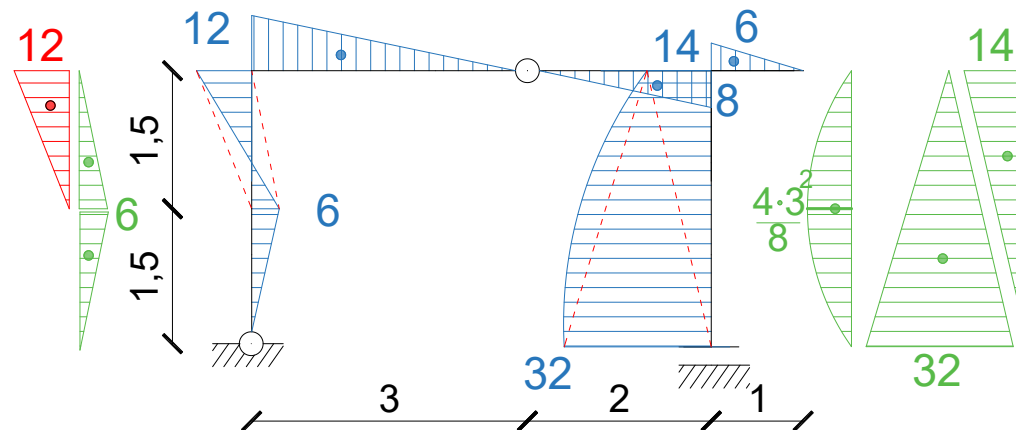
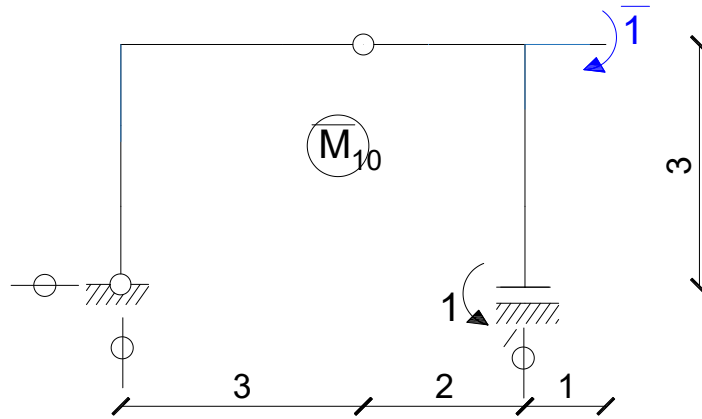
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



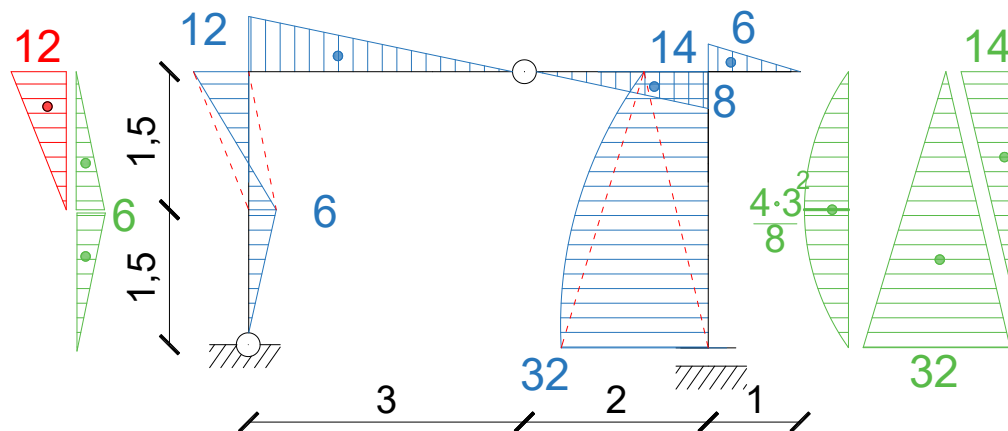
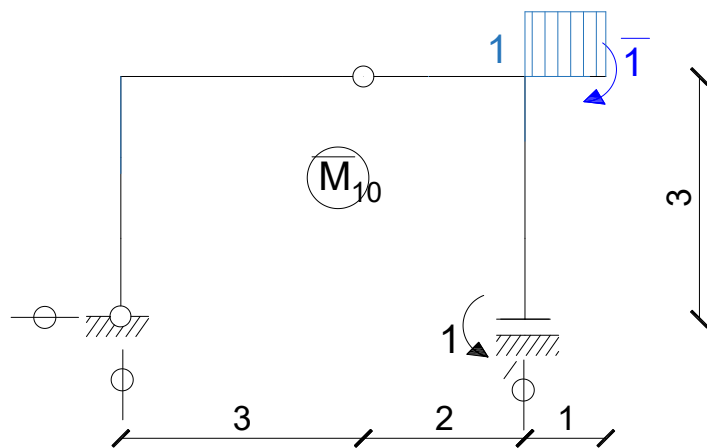
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



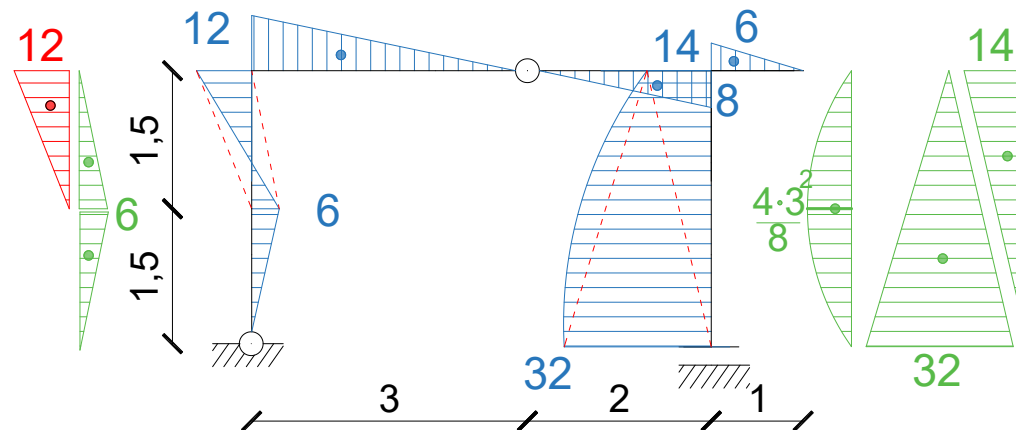
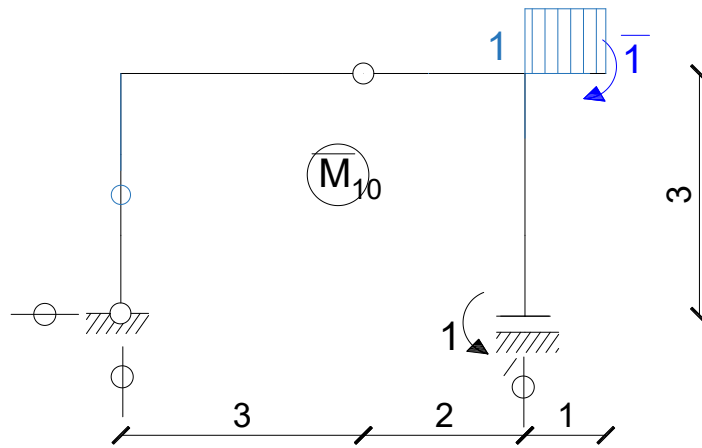
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



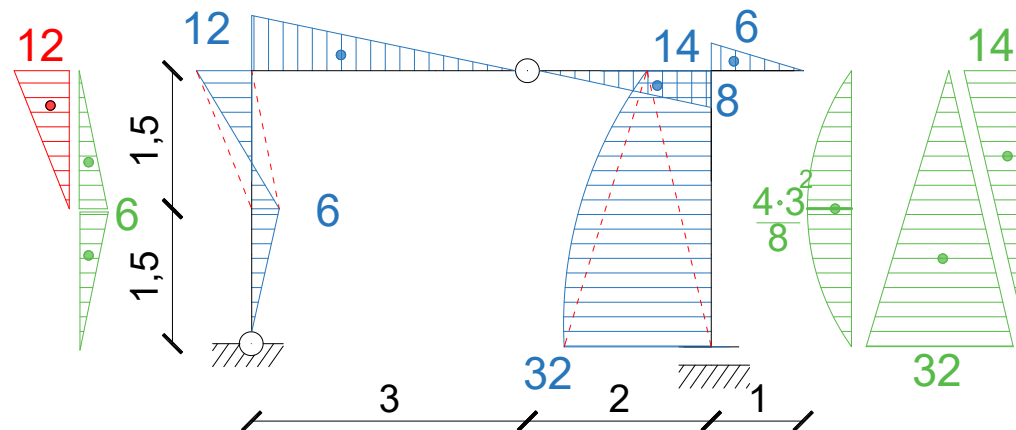
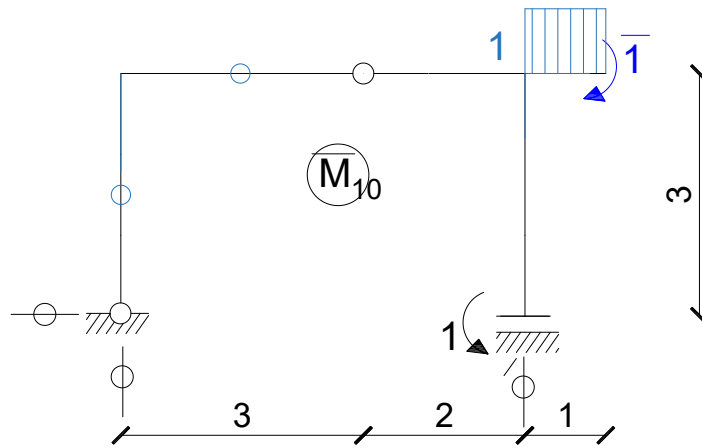
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



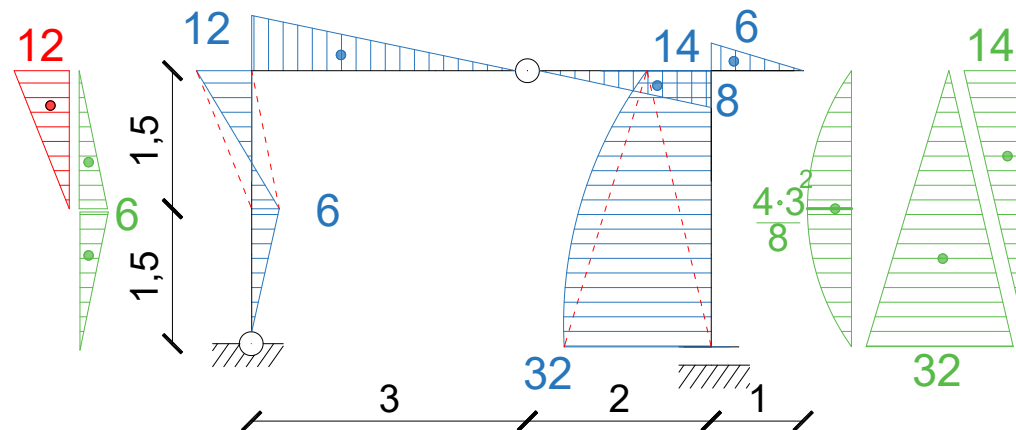
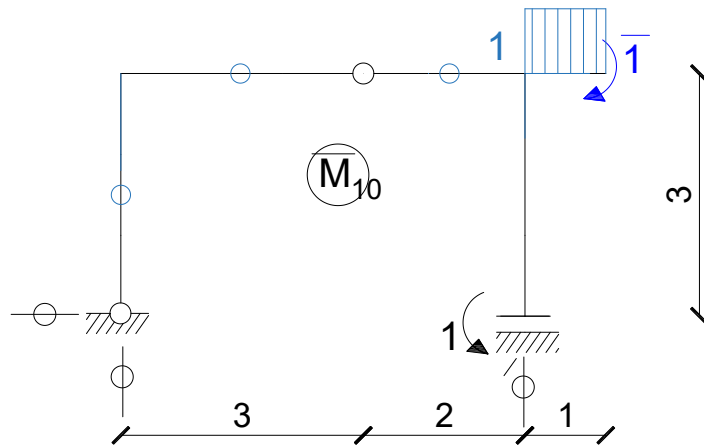
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



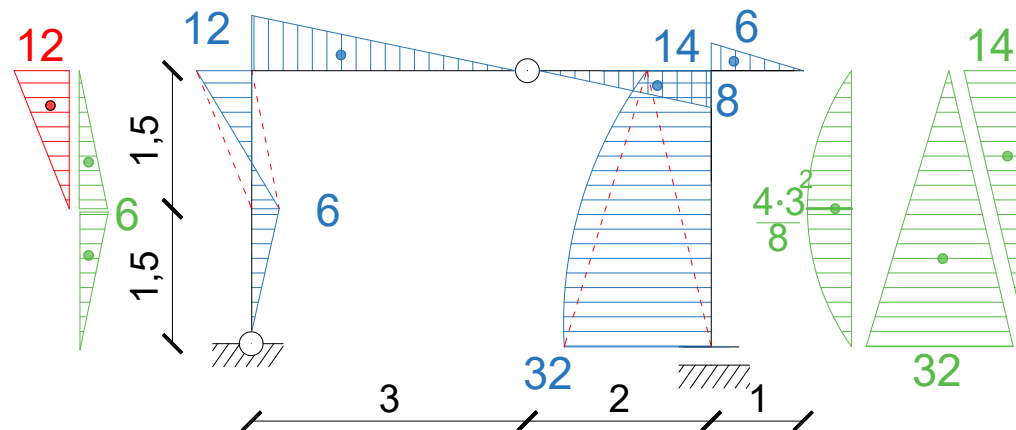
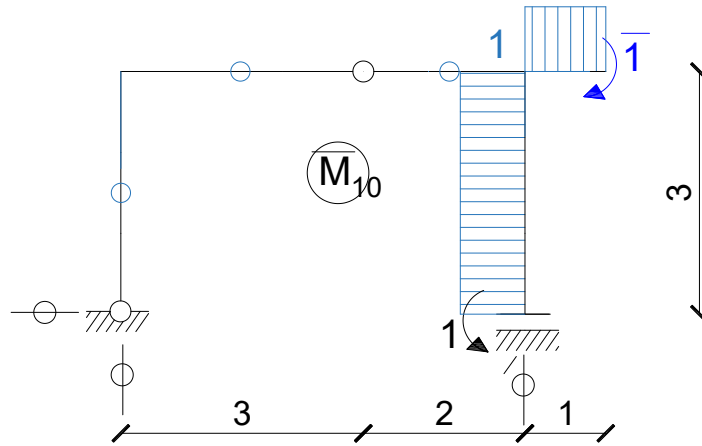
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:



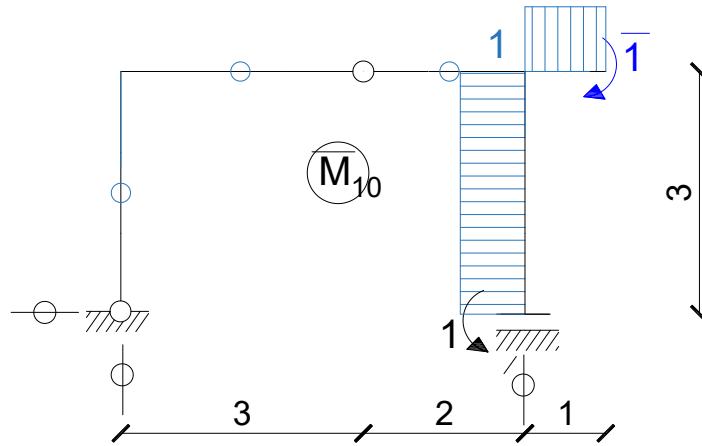
dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:

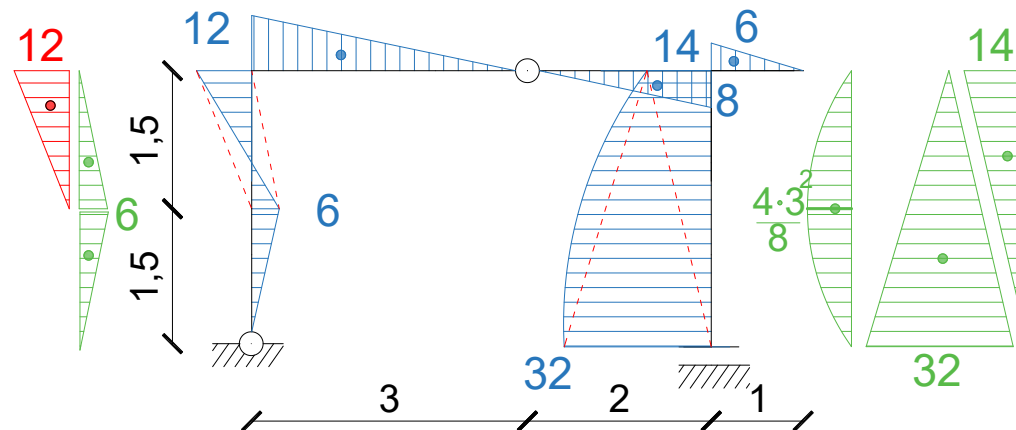


dr inż. Hanna Weber

Wyznaczenie przemieszczeń z zasady prac wirtualnych:

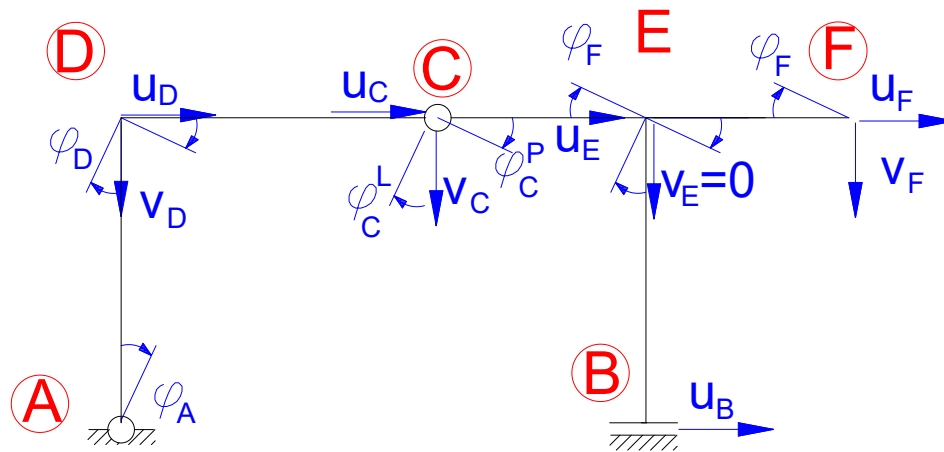


$$\varphi_F = \frac{78}{EI} + \frac{1}{EI} \frac{1}{2} \cdot 6 \cdot 1 \cdot 1 = \frac{81}{EI}$$



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Odształcona postać ramy:



$$v_C = -\frac{500}{3EI}$$

$$u_C = u_D = u_E = u_F = -\frac{635}{3EI}$$

$$u_B = -\frac{2053}{6EI}$$

$$v_F = \frac{80}{EI}$$

$$\varphi_A = -\frac{608}{9EI}$$

$$\varphi_D = -\frac{608}{9EI}$$

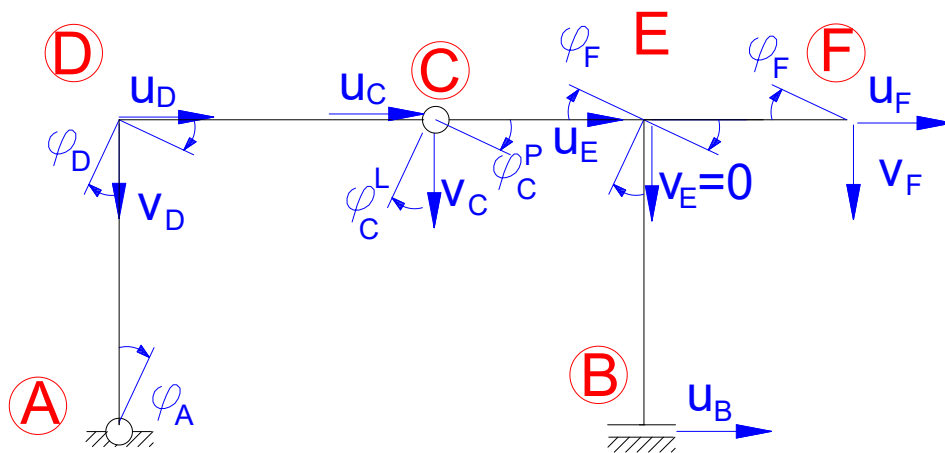
$$\varphi_C^L = -\frac{446}{9EI}$$

$$\varphi_C^P = \frac{86}{EI}$$

$$\varphi_E = \frac{78}{EI}$$

$$\varphi_F = \frac{81}{EI}$$

Odształcona postać ramy:



Założenie $1/18EI = a \rightarrow$

$$v_C = -\frac{500}{3EI} = -\frac{3000}{18EI}$$

$$u_C = u_D = u_E = u_F = -\frac{635}{3EI} = -\frac{3810}{18EI}$$

$$u_B = -\frac{2053}{6EI} = -\frac{6159}{18EI}$$

$$v_F = \frac{80}{EI} = \frac{1440}{18EI}$$

$$\varphi_A = -\frac{608}{9EI} = -\frac{1216}{18EI}$$

$$\varphi_D = -\frac{608}{9EI} = -\frac{1216}{18EI}$$

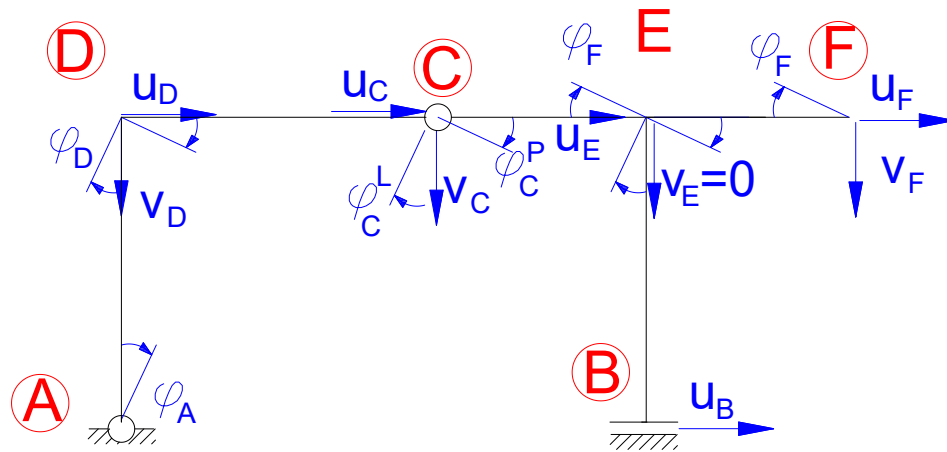
$$\varphi_C^L = -\frac{446}{9EI} = -\frac{892}{18EI}$$

$$\varphi_C^P = \frac{86}{EI} = \frac{1548}{18EI}$$

$$\varphi_E = \frac{78}{EI} = \frac{1404}{18EI}$$

$$\varphi_F = \frac{81}{EI} = \frac{1458}{18EI}$$

Odkształcona postać ramy:



$$v_C = -3000 a$$

$$u_C = u_D = u_E = u_F = -3810 a$$

$$u_B = -6159 a$$

$$v_F = 1440 a$$

$$\varphi_A = -1216 a$$

$$\varphi_D = -1216 a$$

$$\varphi_C^L = -892 a$$

$$\varphi_C^P = 1548 a$$

$$\varphi_E = 1404 a$$

$$\varphi_F = 1458 a$$

Założenie $1/18EI=a \rightarrow$

$$v_C = -3000 a$$

$$u_C = -3810 a$$

$$u_B = -6159 a$$

$$v_F = 1440 a$$

$$\varphi_A = -1216 a$$

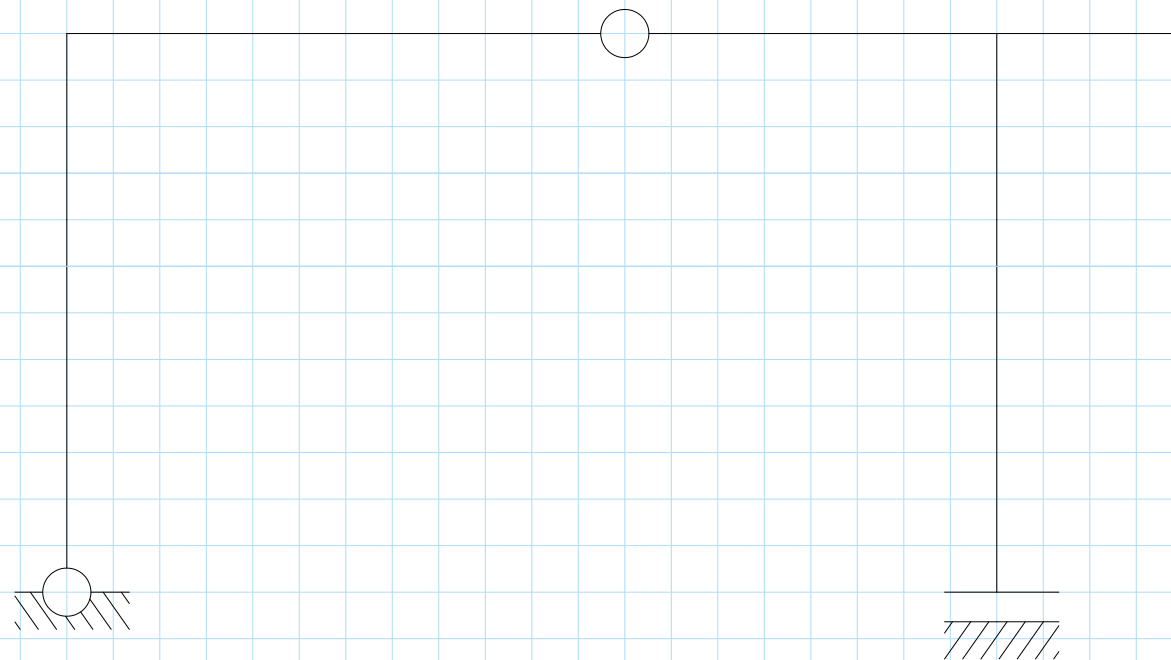
$$\varphi_D = -1216 a$$

$$\varphi_C^L = -892 a$$

$$\varphi_C^P = 1548 a$$

$$\varphi_E = 1404 a$$

$$\varphi_F = 1458 a$$



$$1000a = 5\text{mm}$$

$$1\text{m ramy}$$

$$v_C = -3000 a$$

$$u_C = -3810 a$$

$$u_B = -6159 a$$

$$v_F = 1440 a$$

$$\varphi_A = -1216 a$$

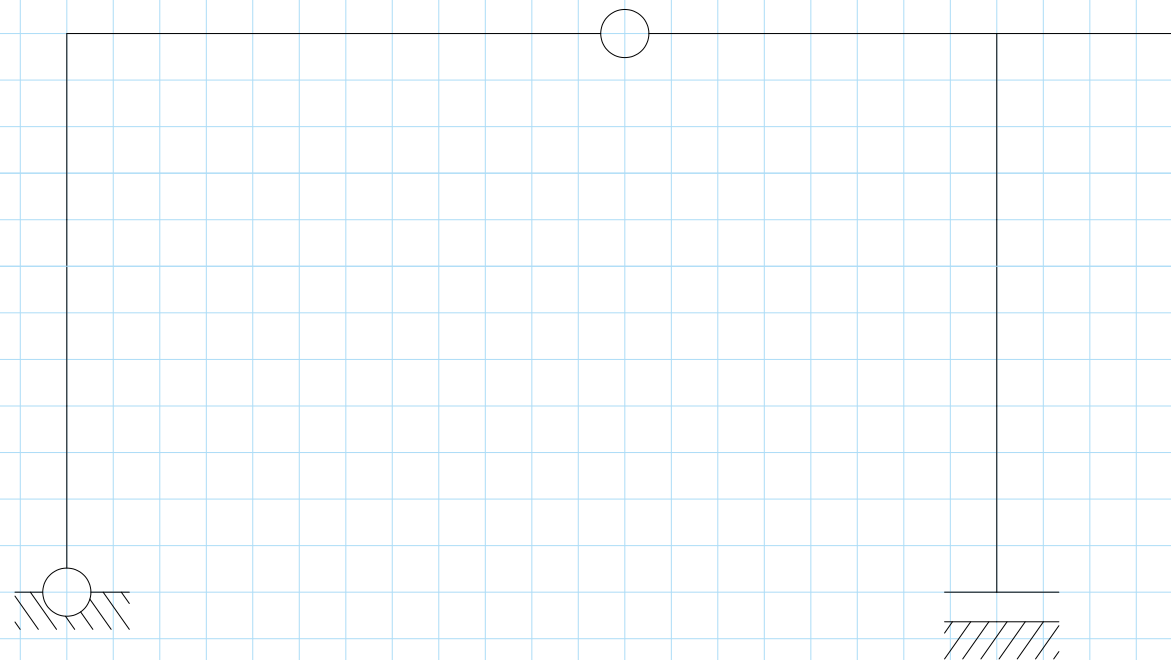
$$\varphi_D = -1216 a$$

$$\varphi_C^L = -892 a$$

$$\varphi_C^P = 1548 a$$

$$\varphi_E = 1404 a$$

$$\varphi_F = 1458 a$$



1000a=5mm

6159a

1m ramy

$$v_C = -3000 a$$

$$u_C = -3810 a$$

$$u_B = -6159 a$$

$$v_F = 1440 a$$

$$\varphi_A = -1216 a$$

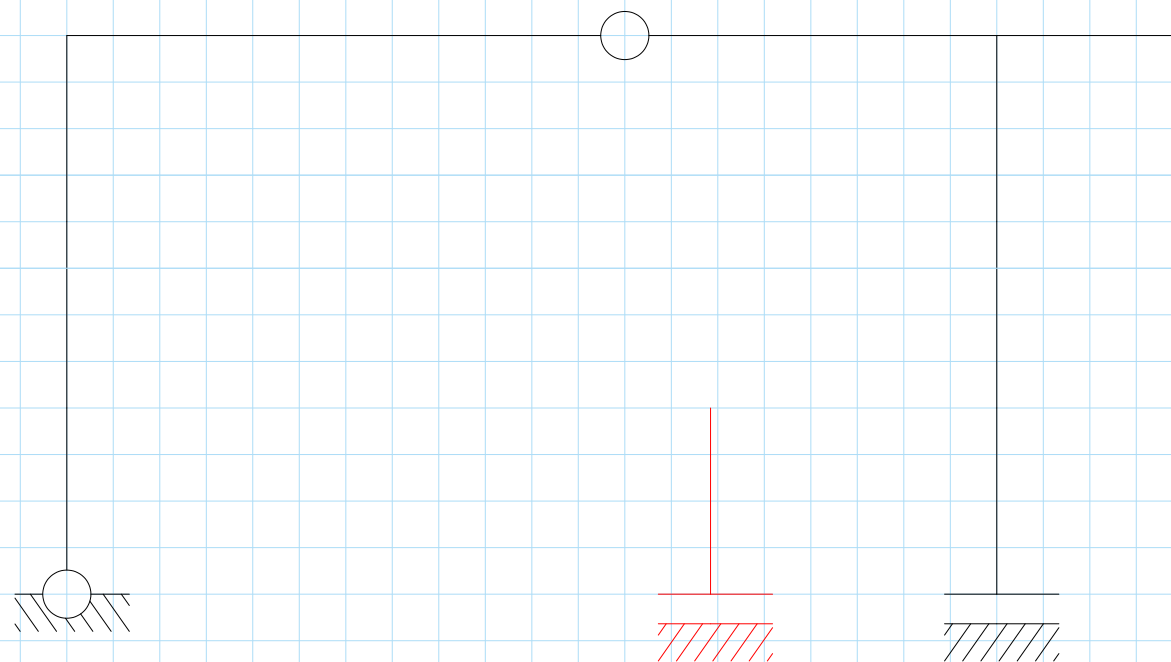
$$\varphi_D = -1216 a$$

$$\varphi_C^L = -892 a$$

$$\varphi_C^P = 1548 a$$

$$\varphi_E = 1404 a$$

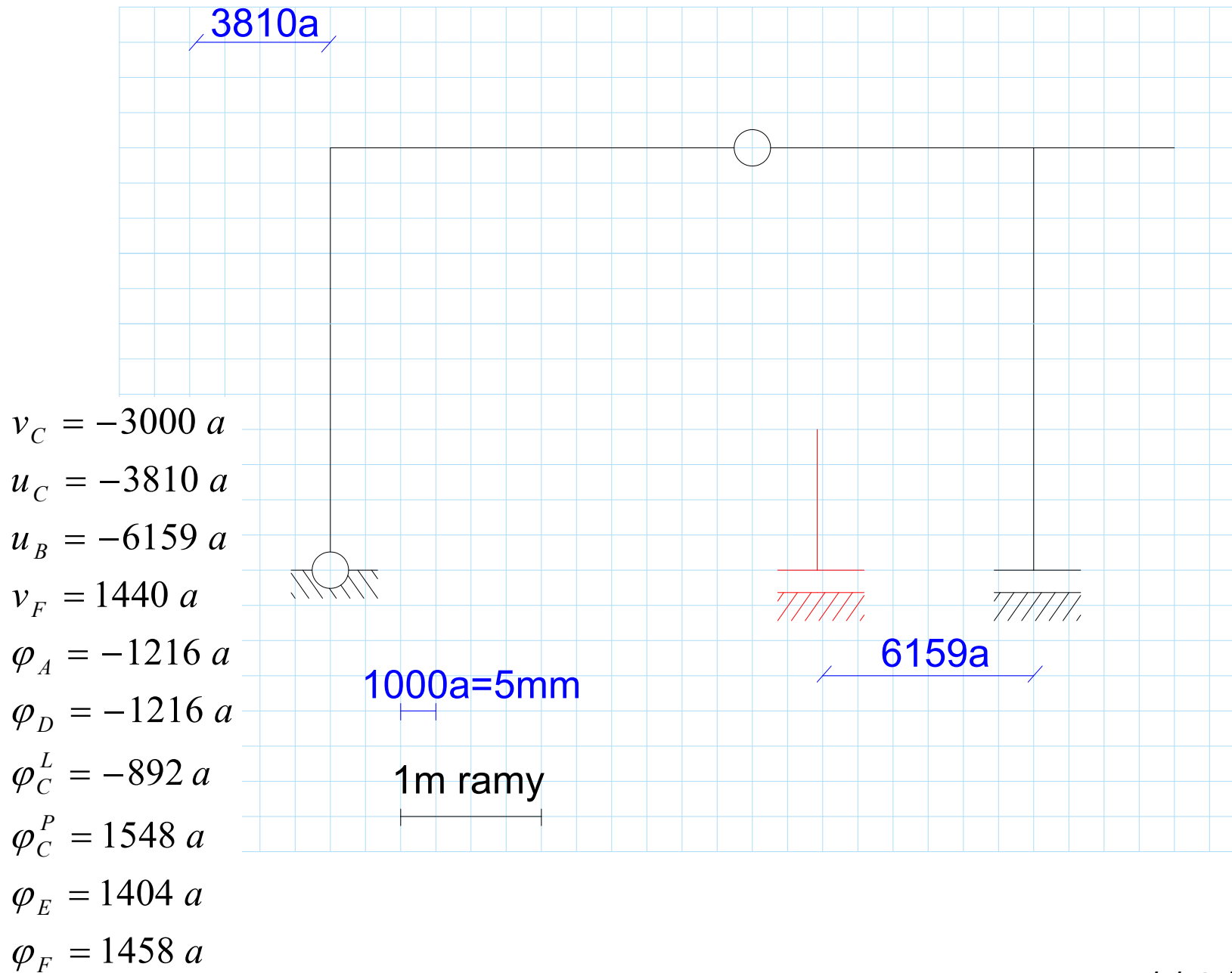
$$\varphi_F = 1458 a$$

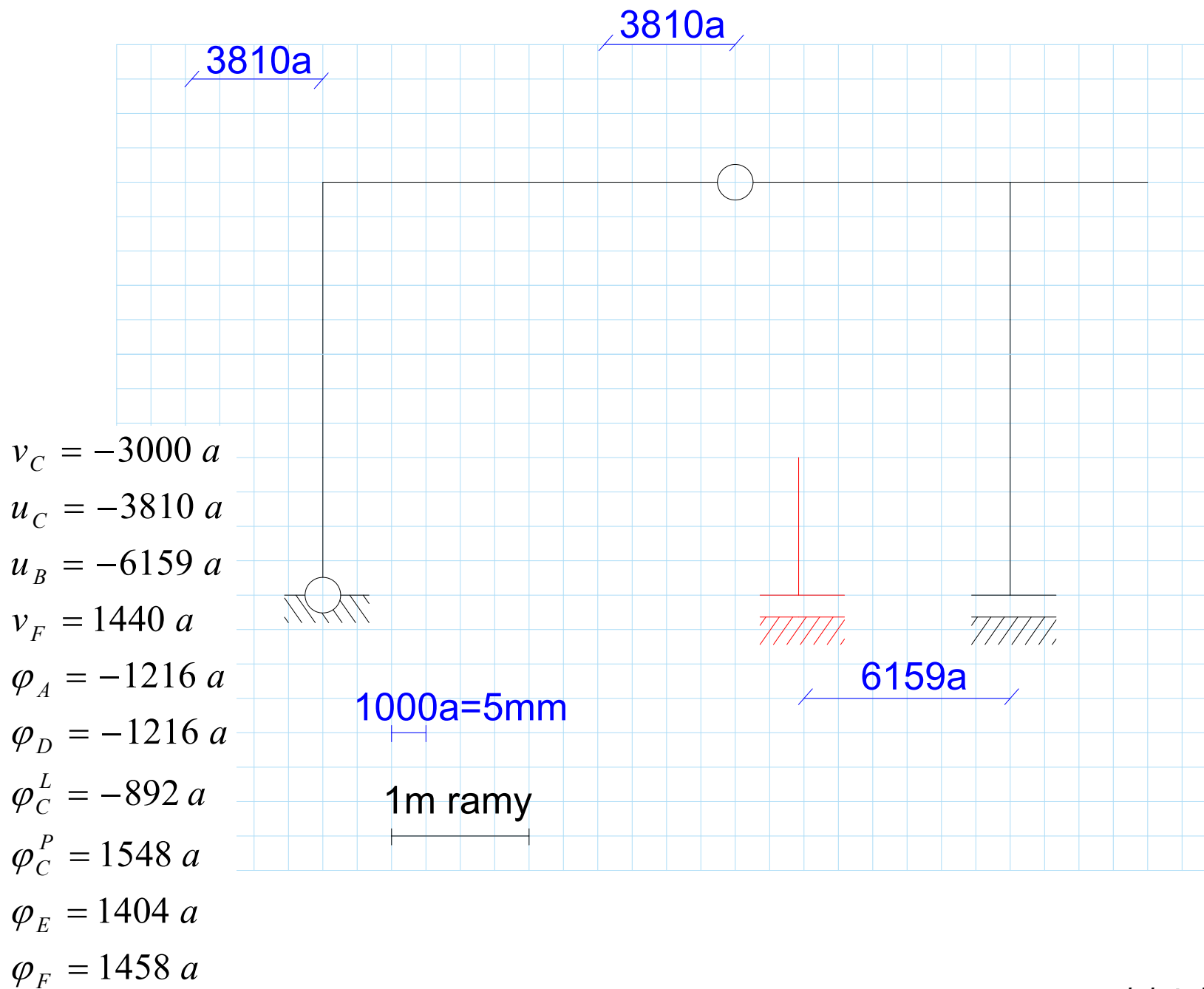


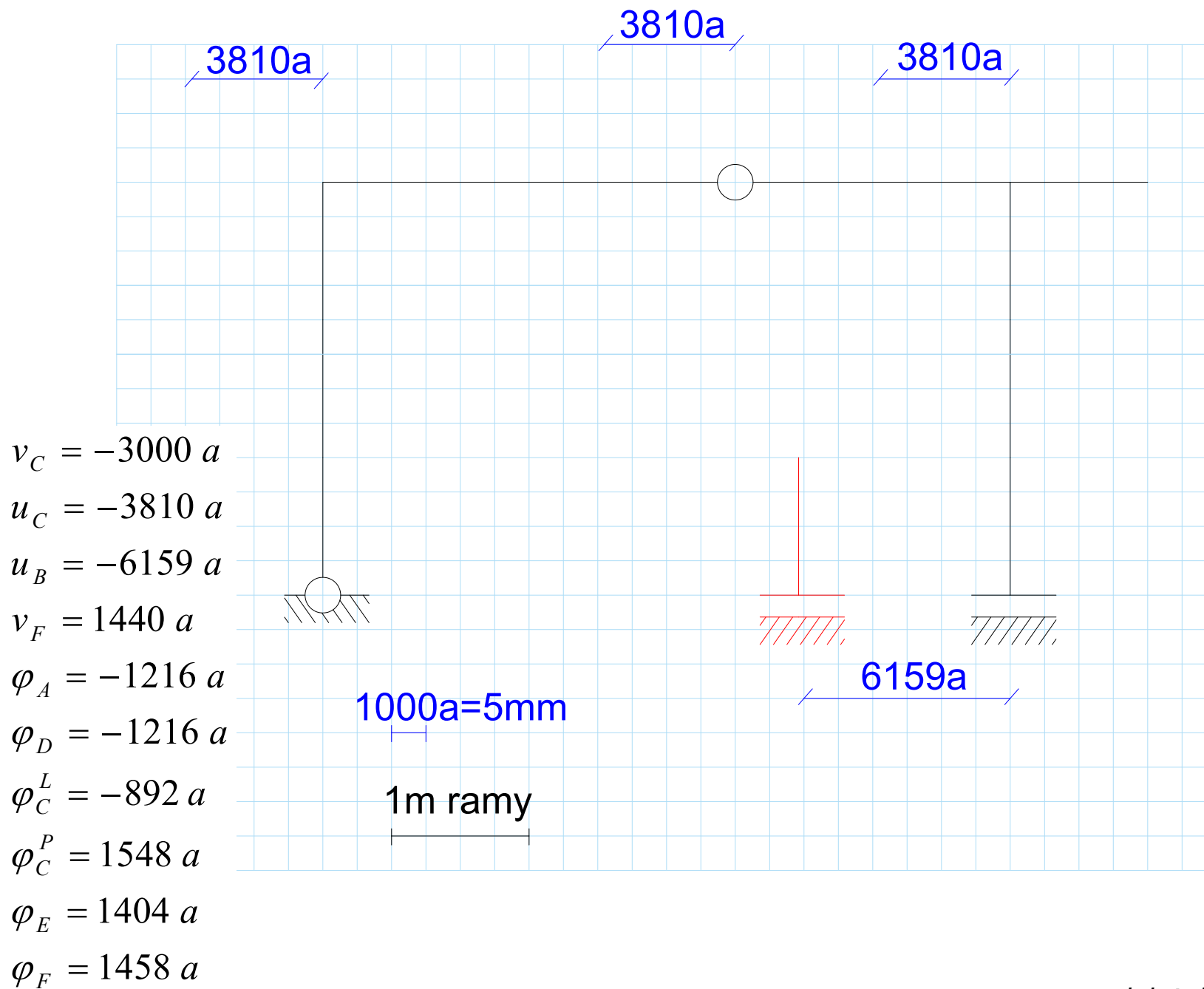
1000a=5mm

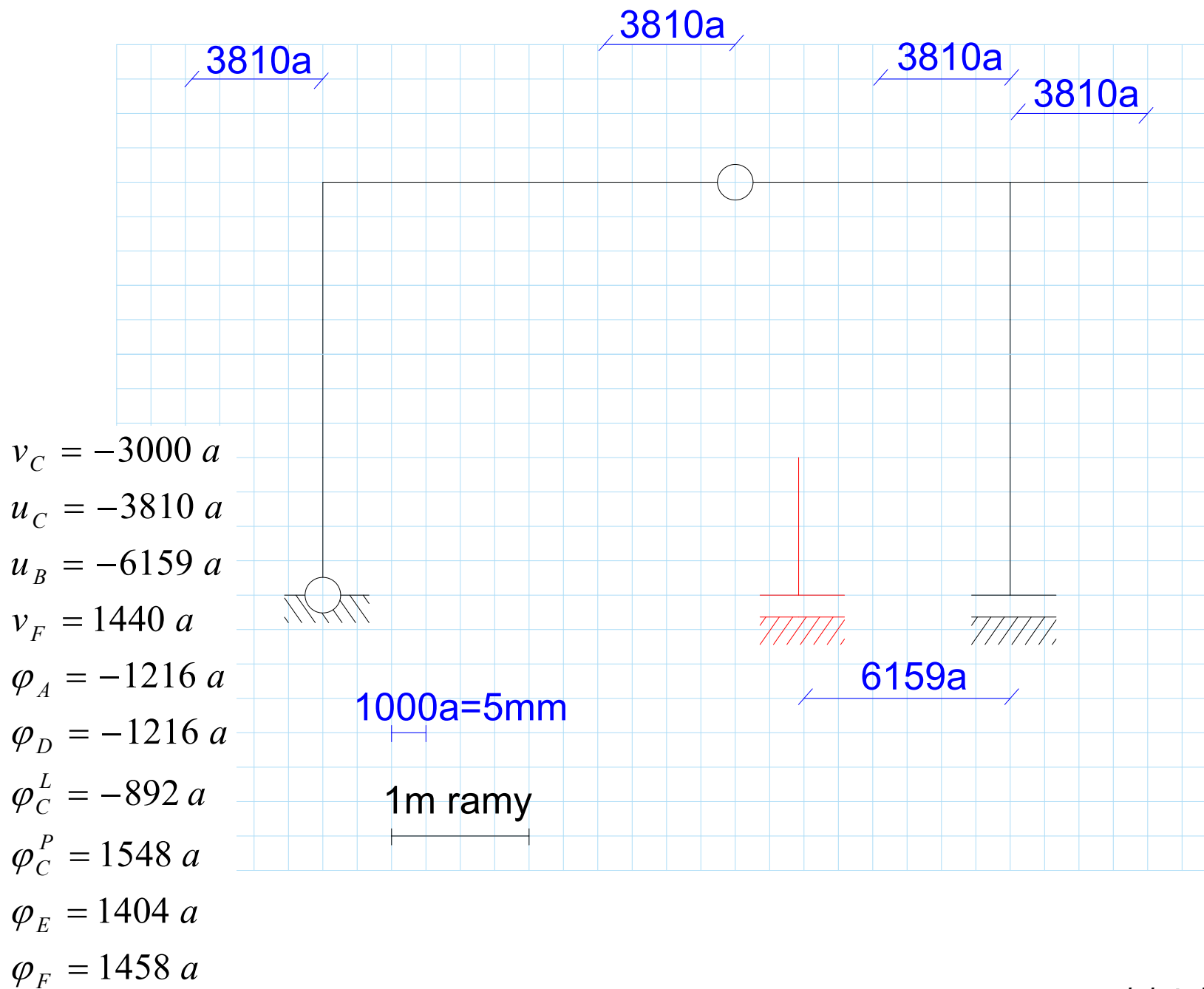
6159a

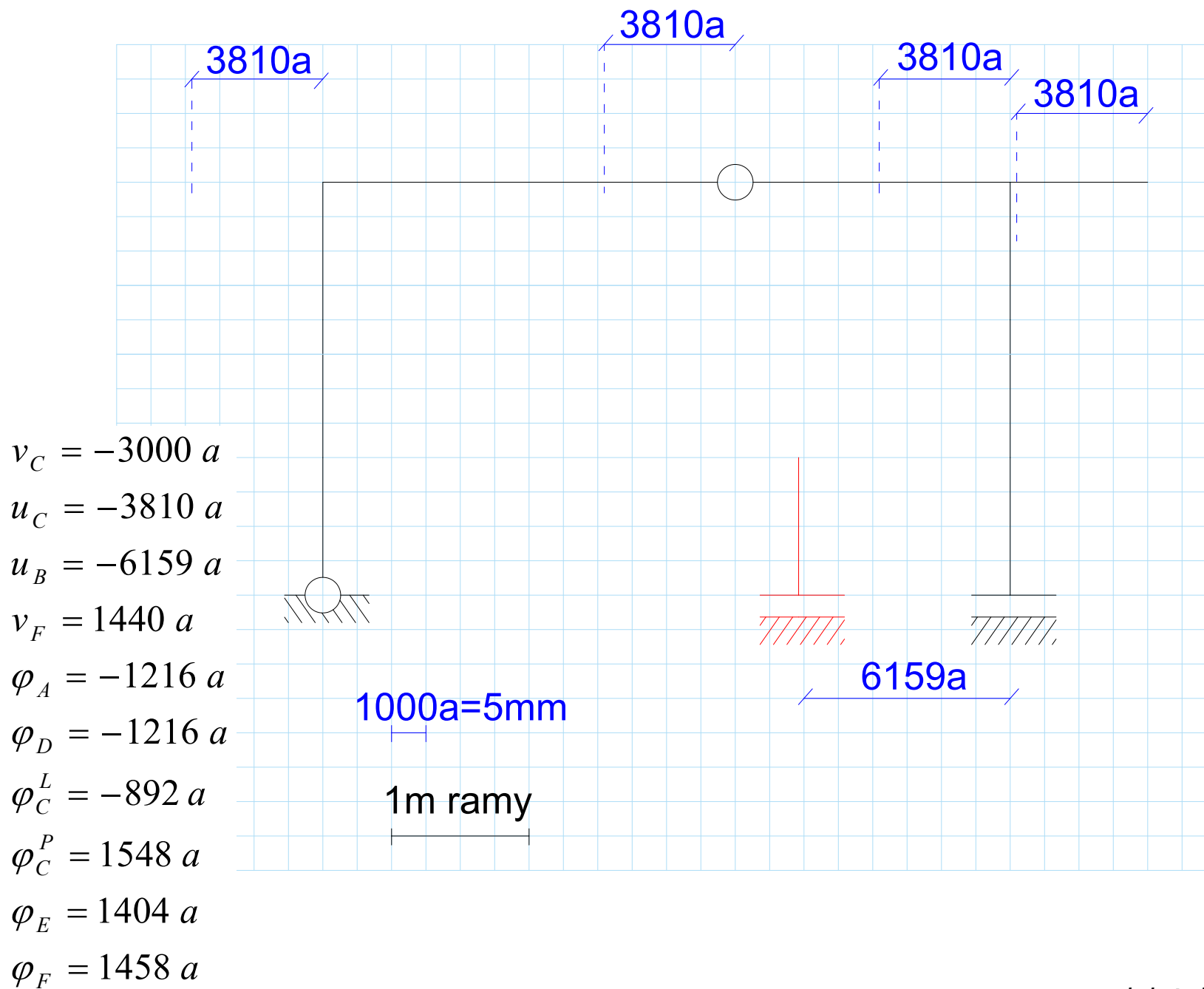
1m ramy

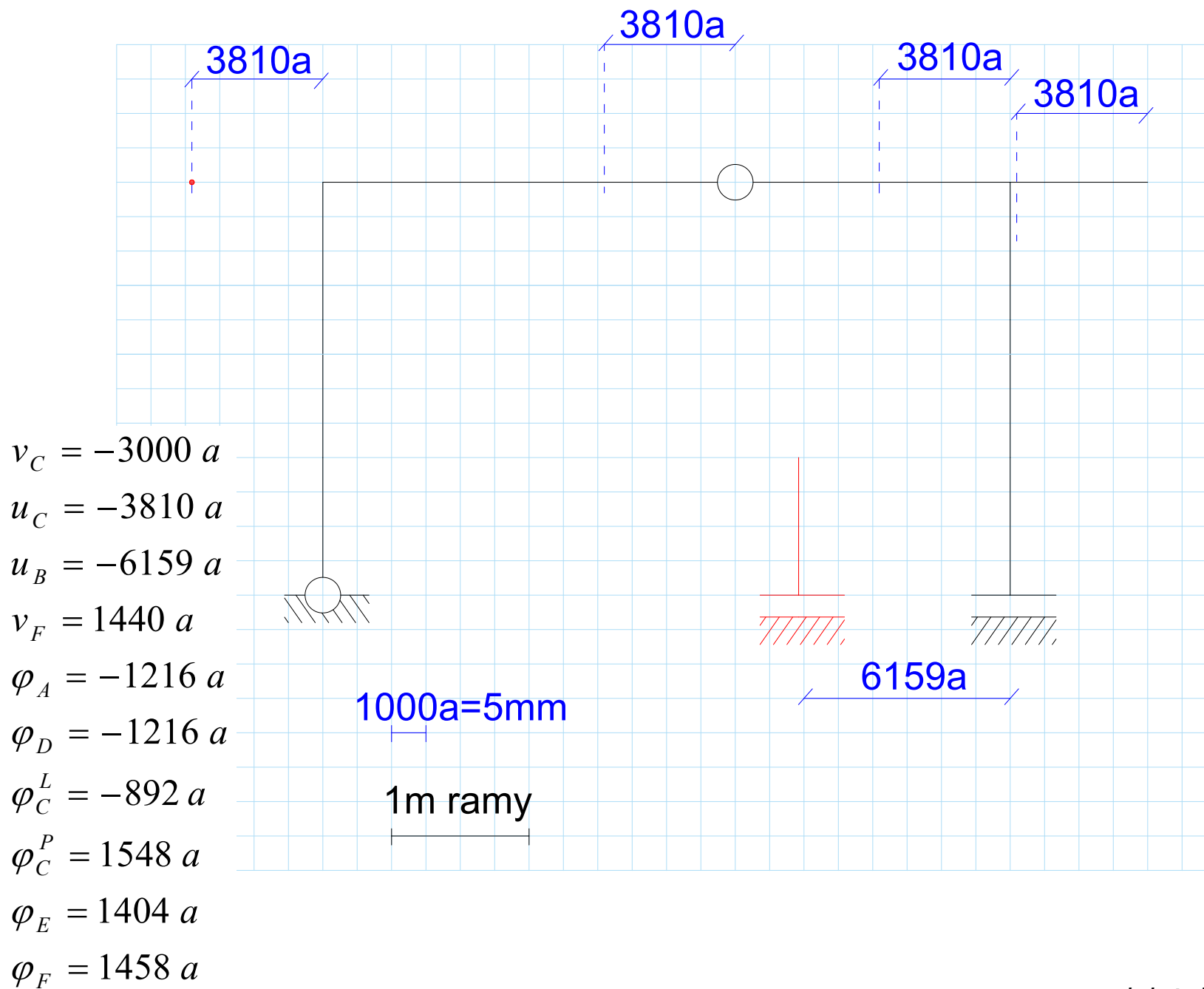


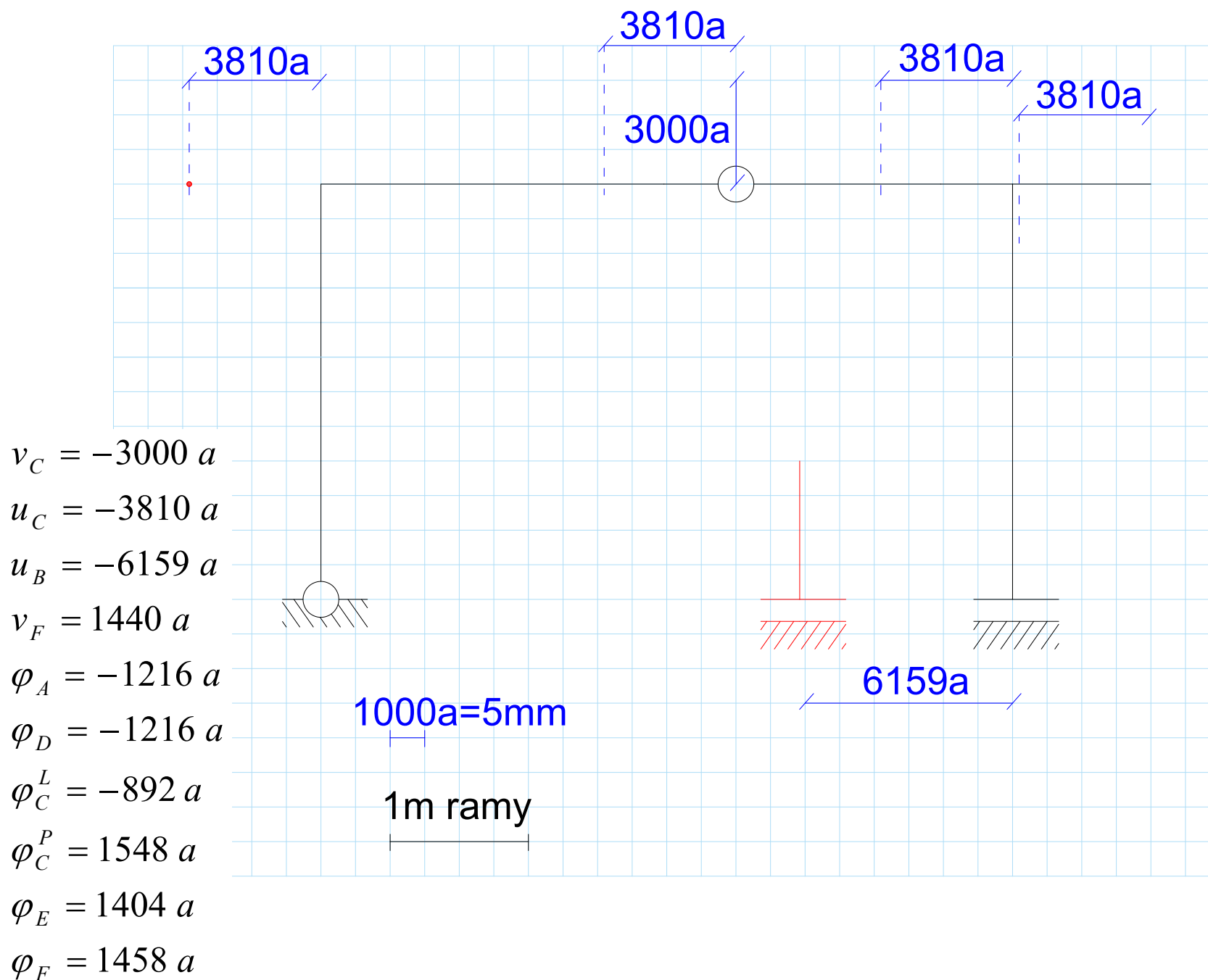


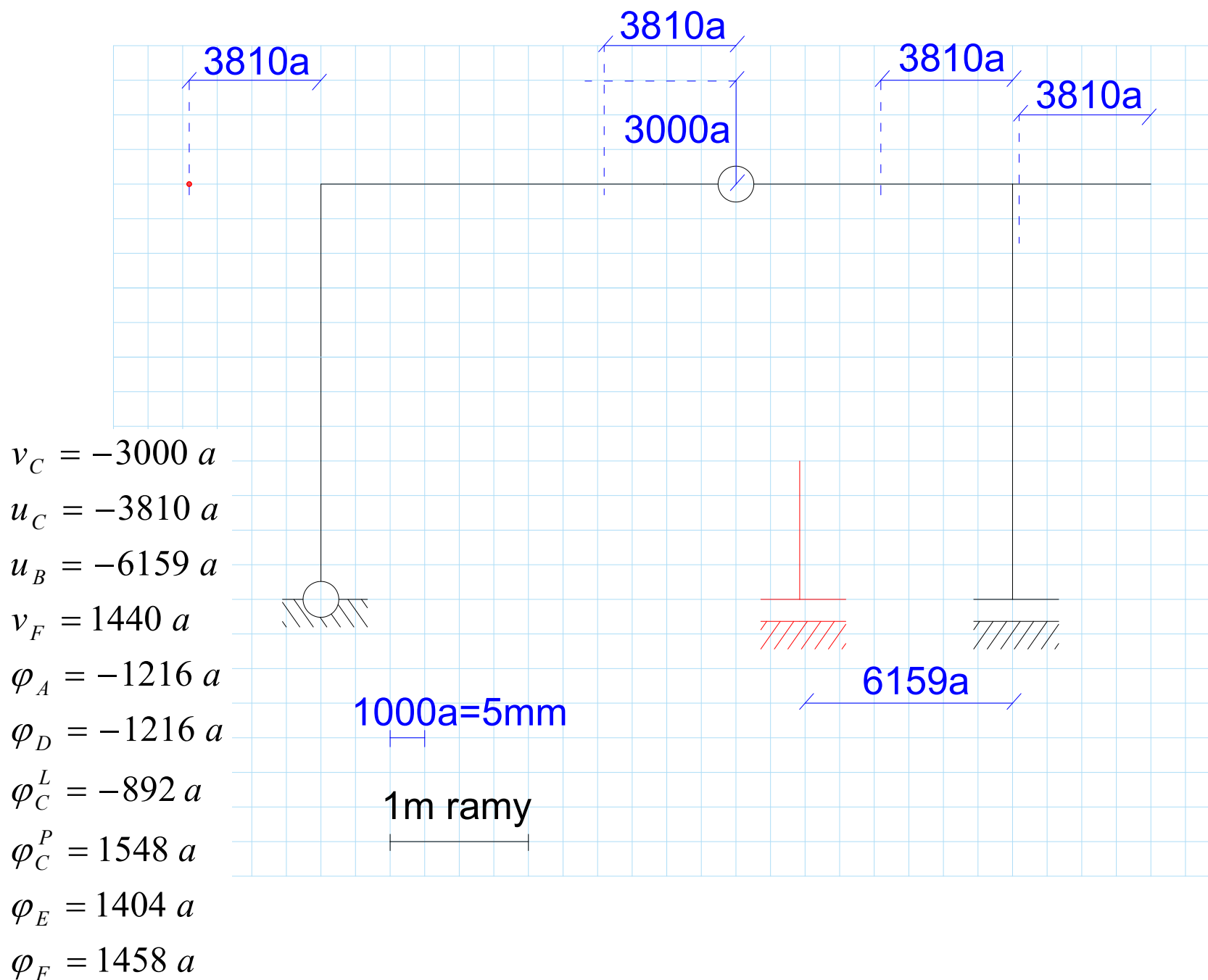


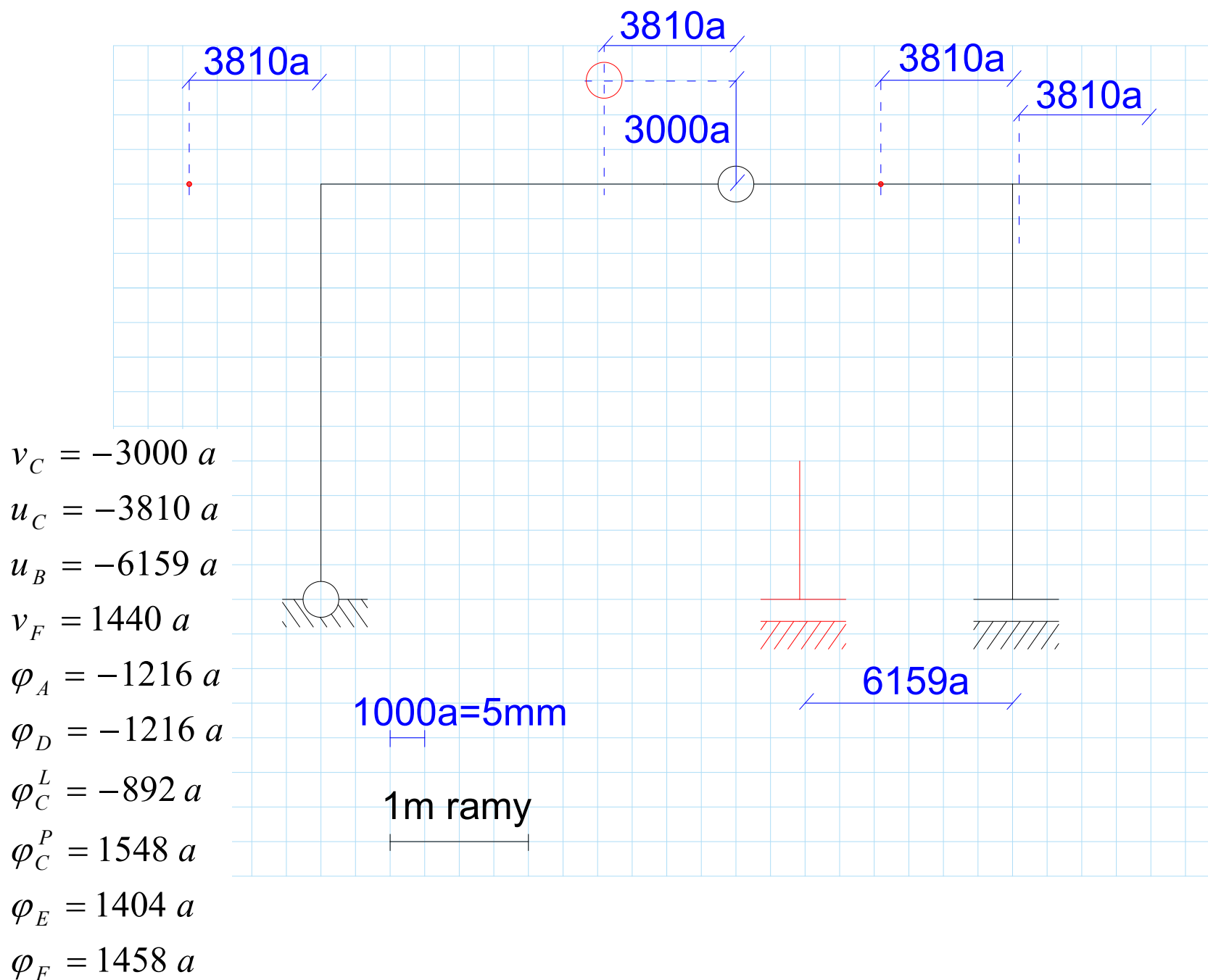


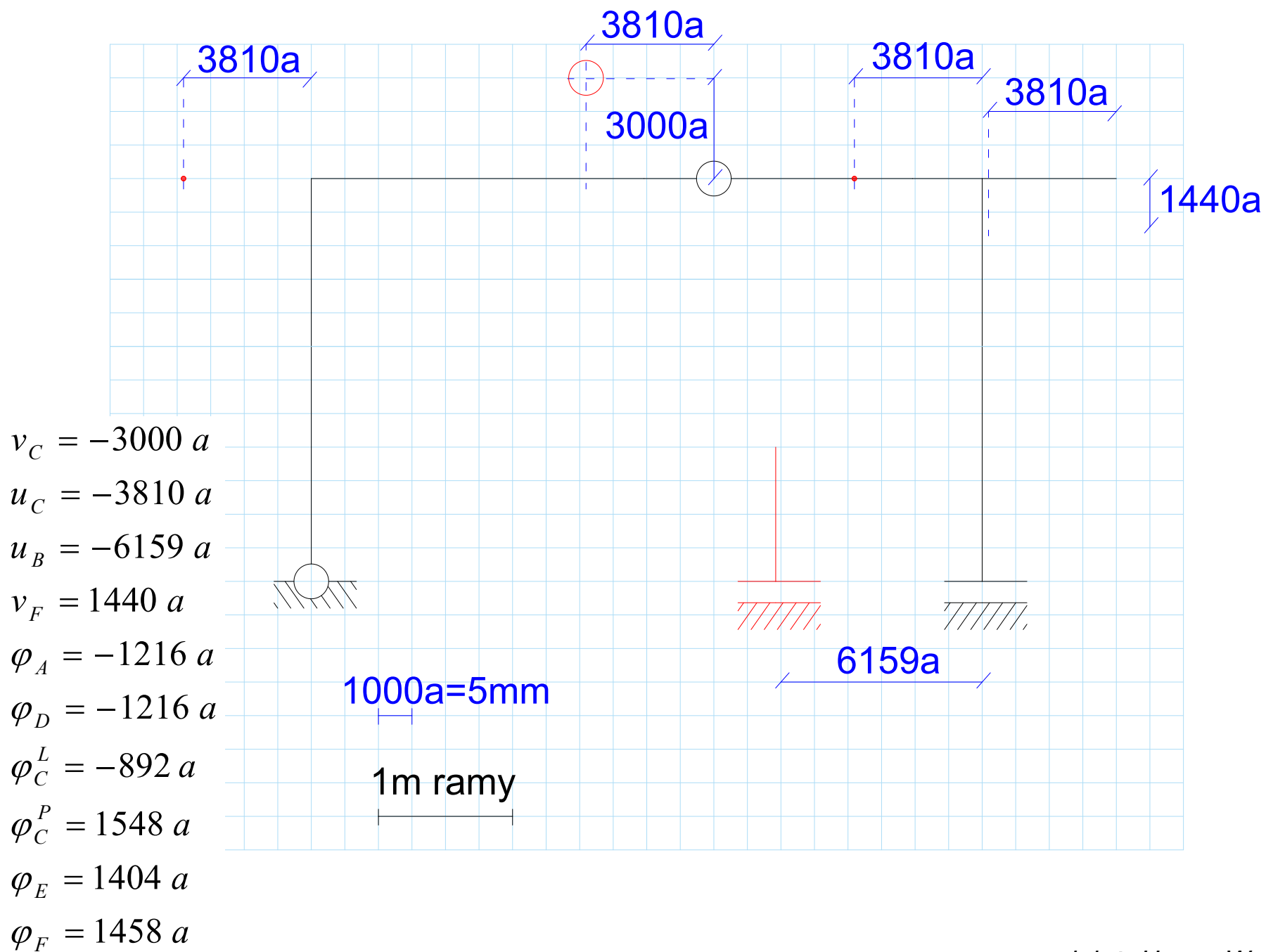






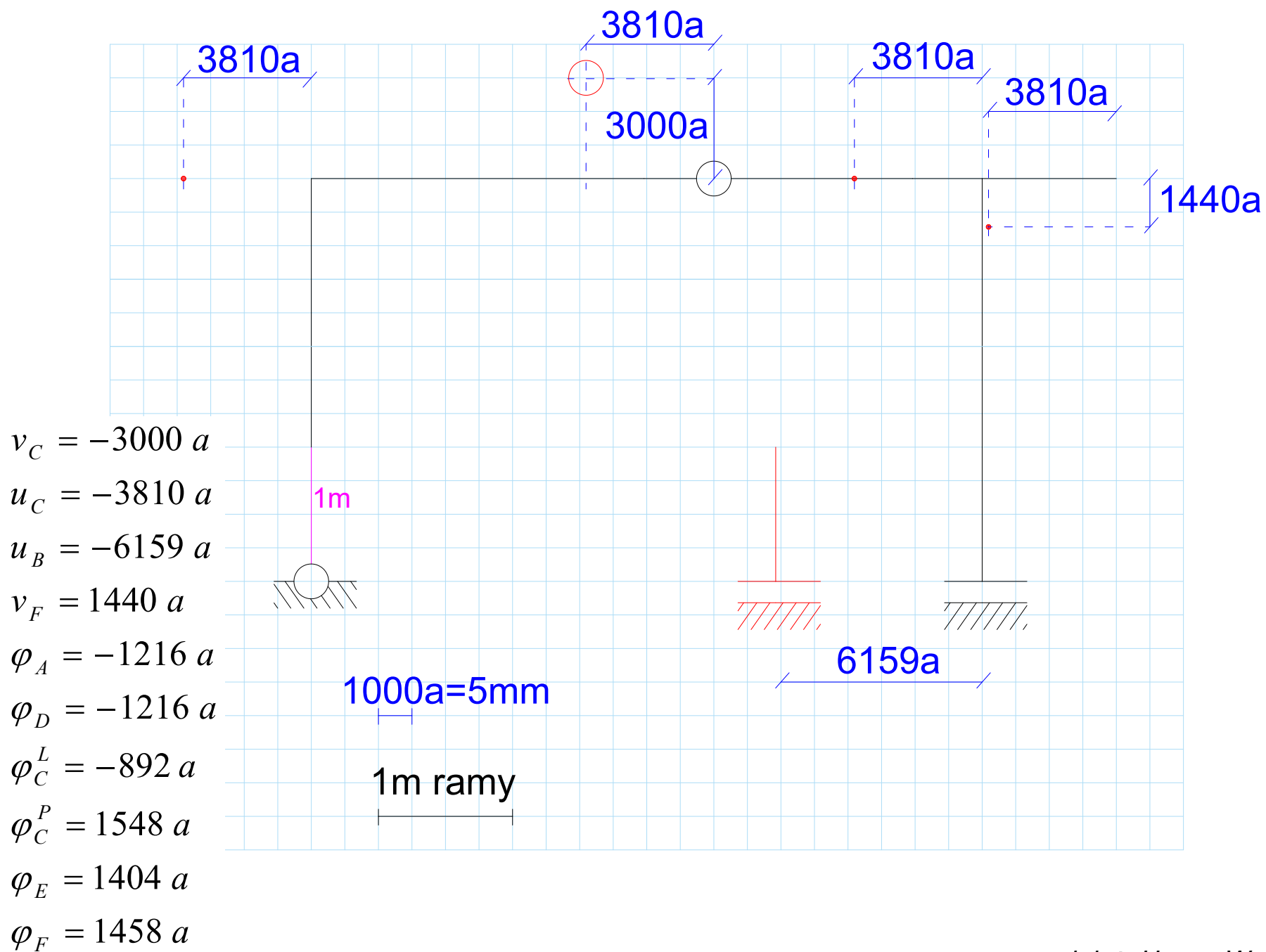


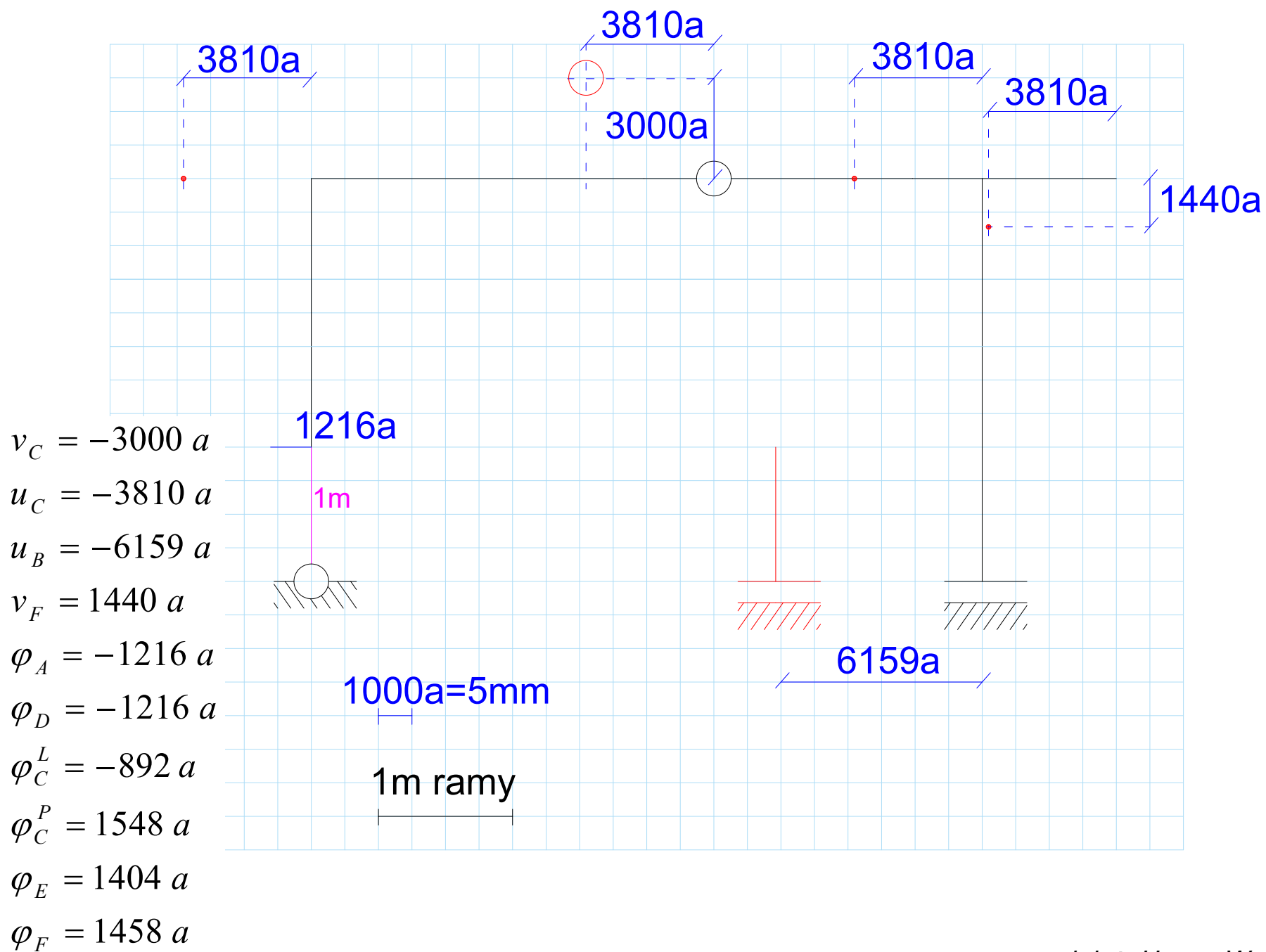


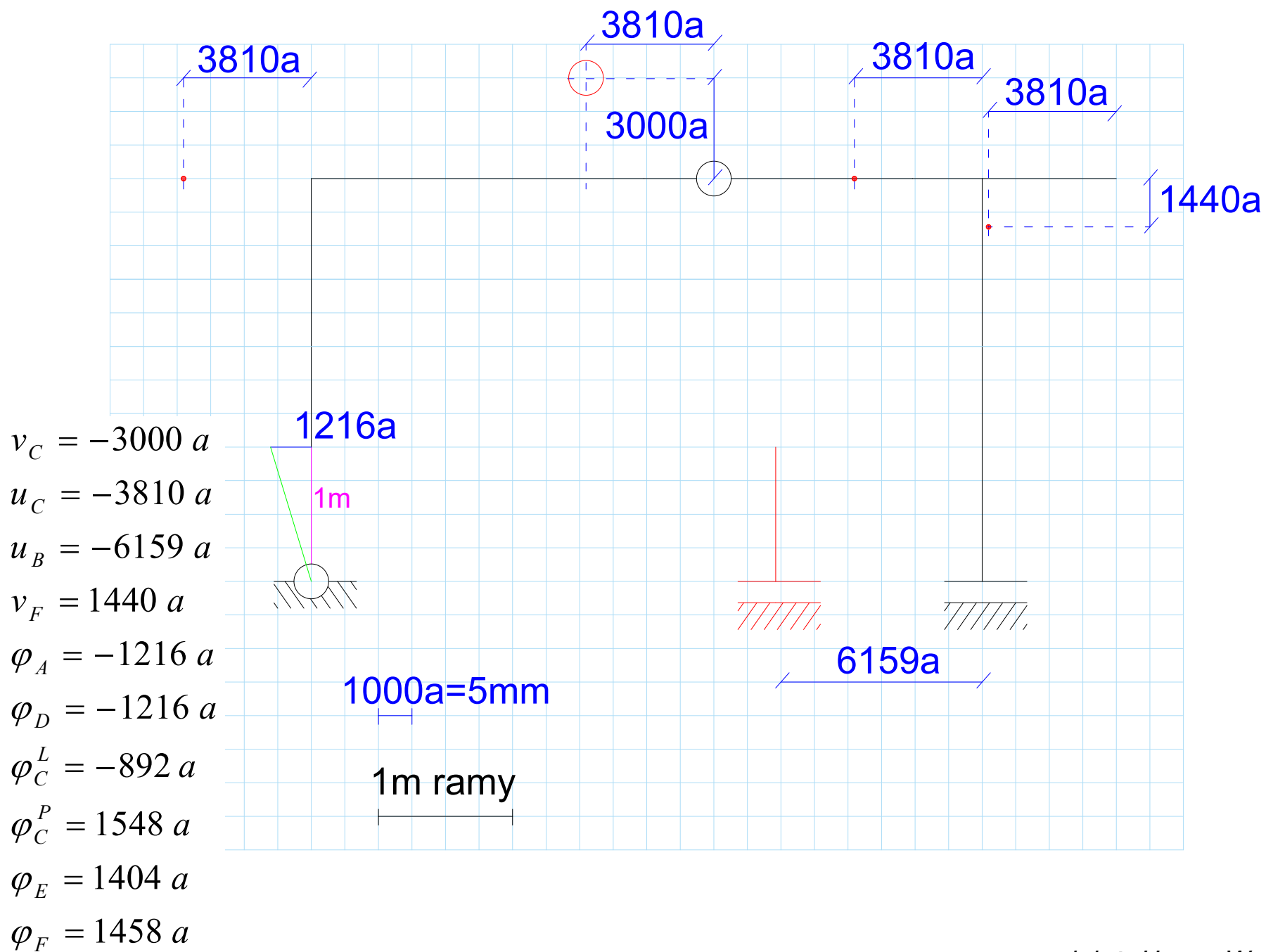


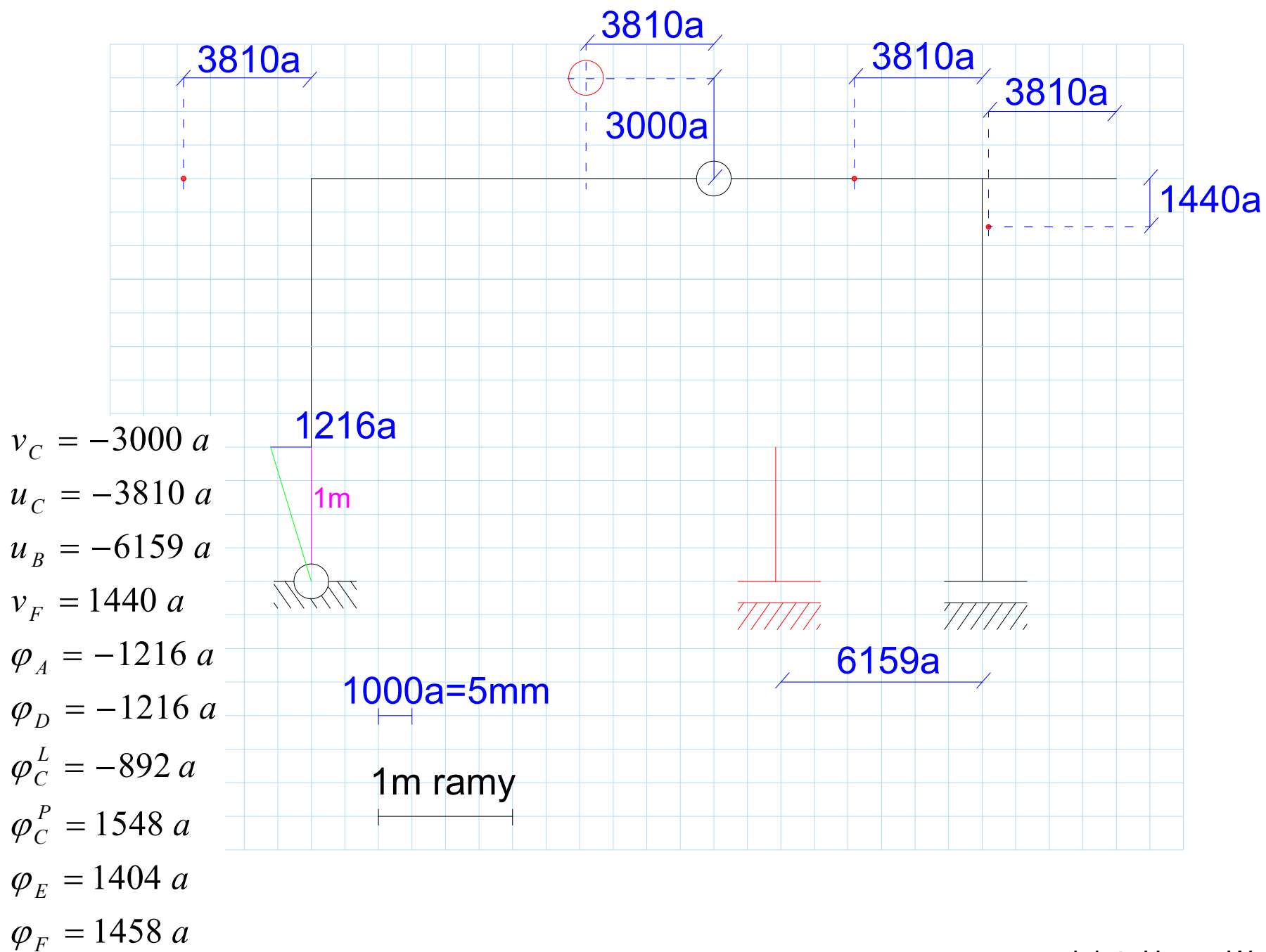


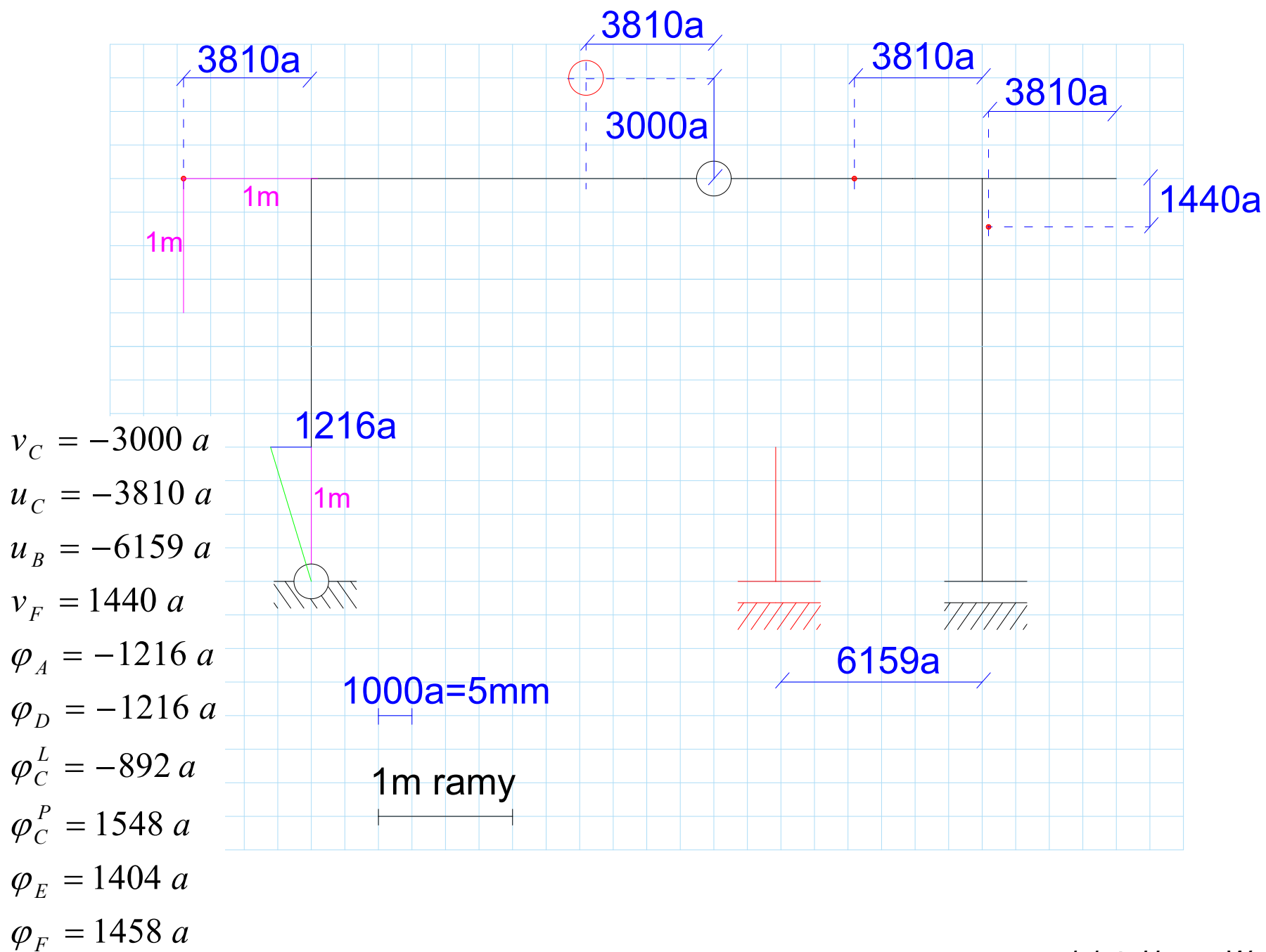


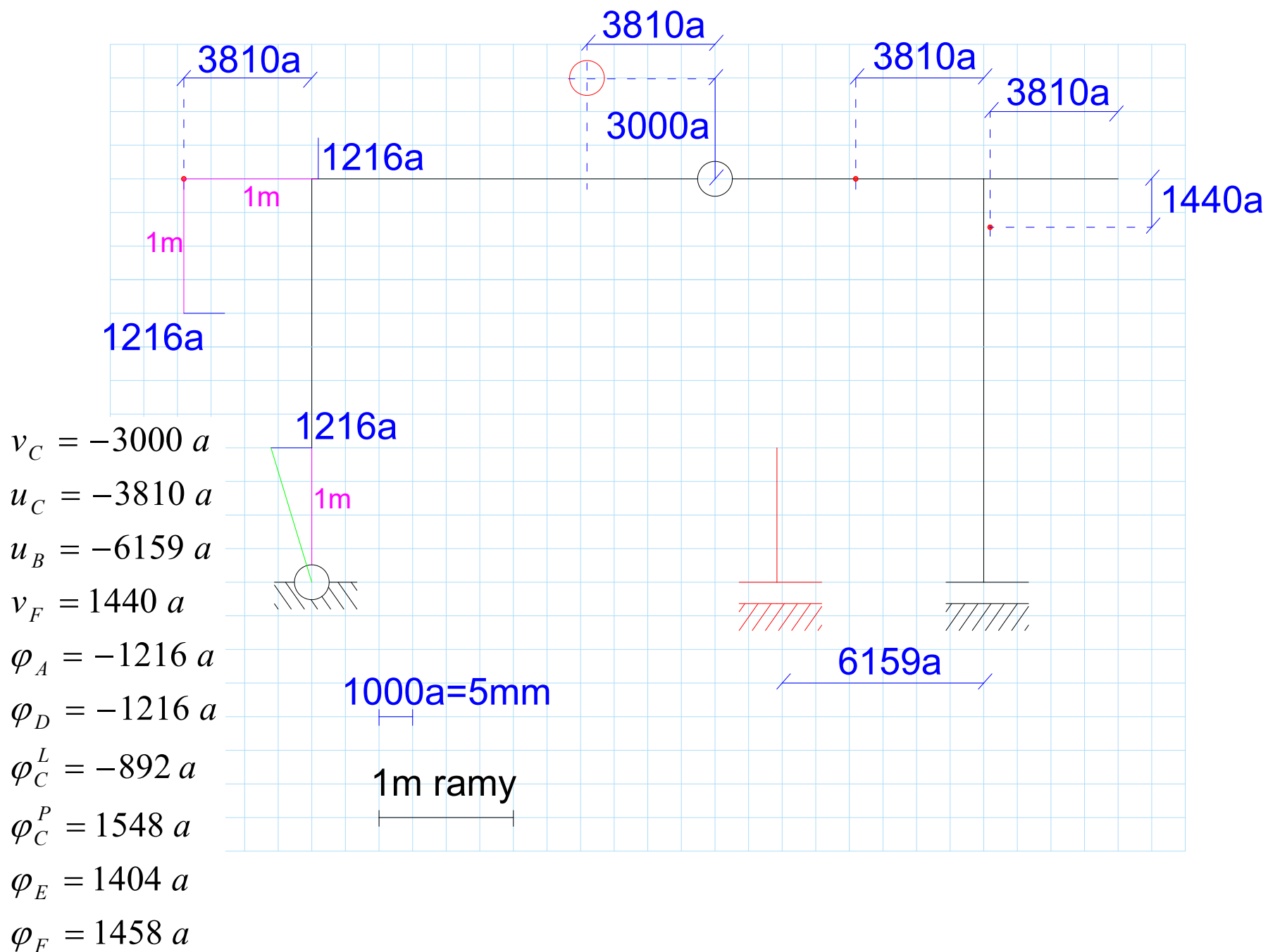


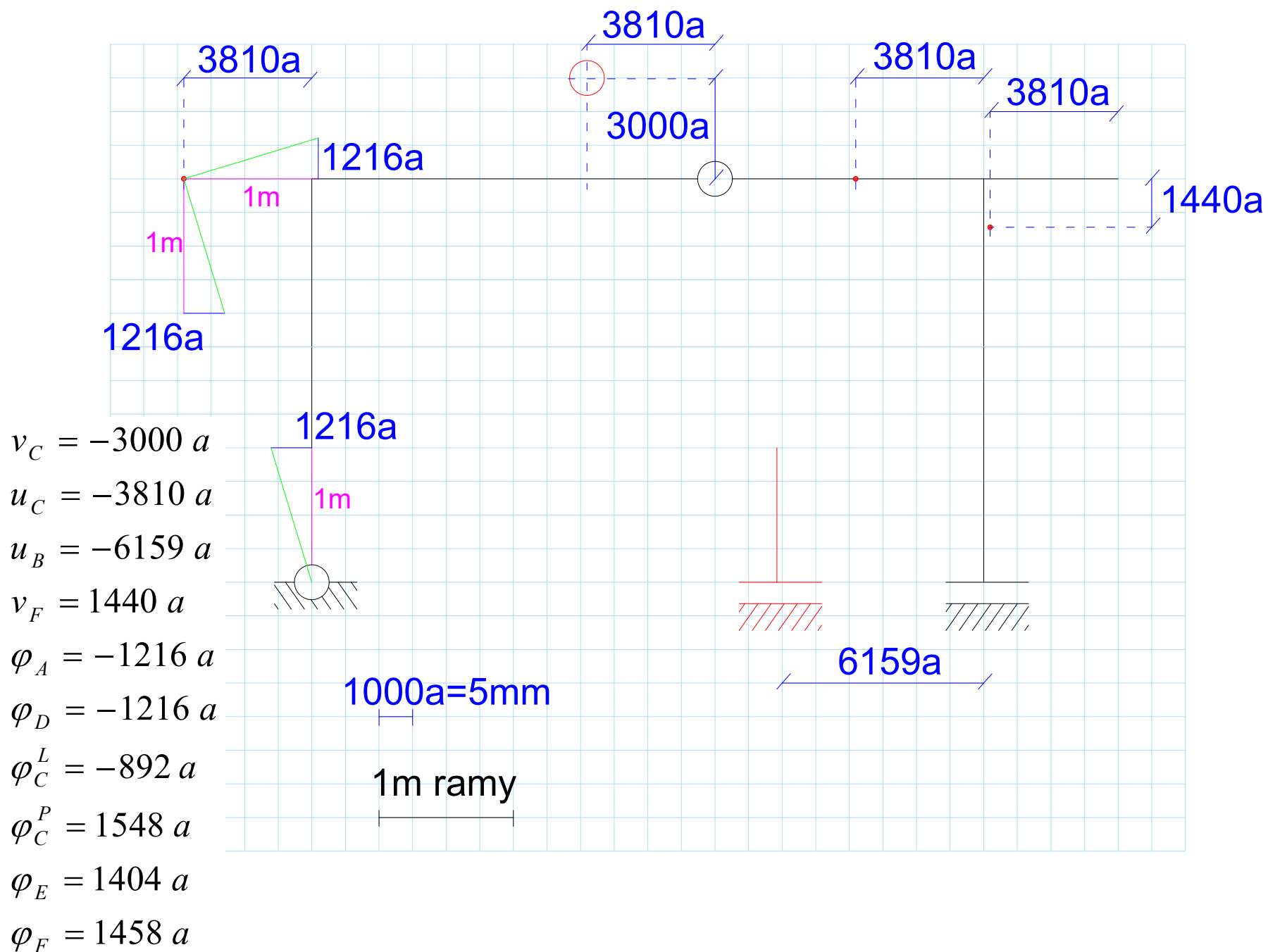


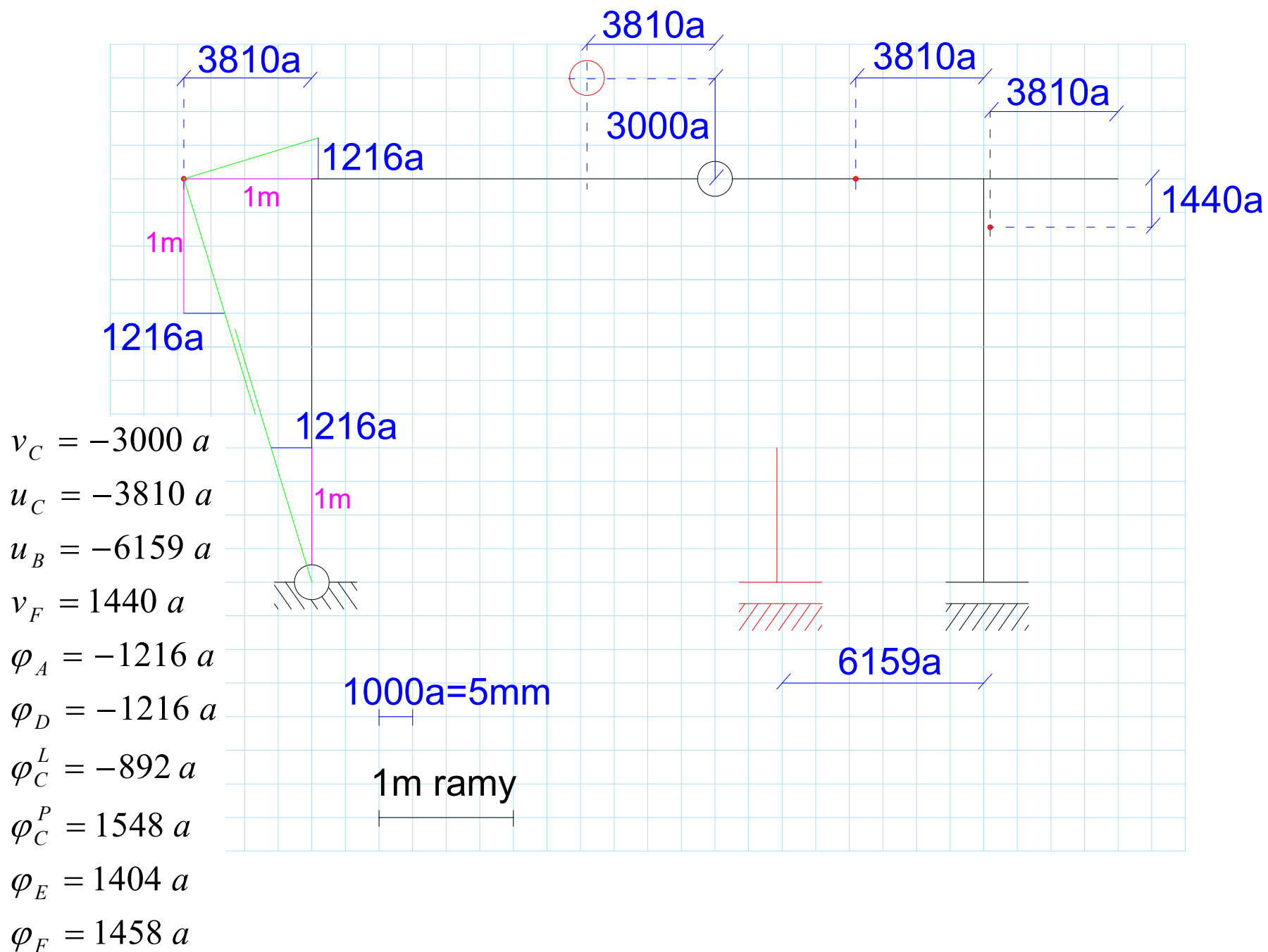


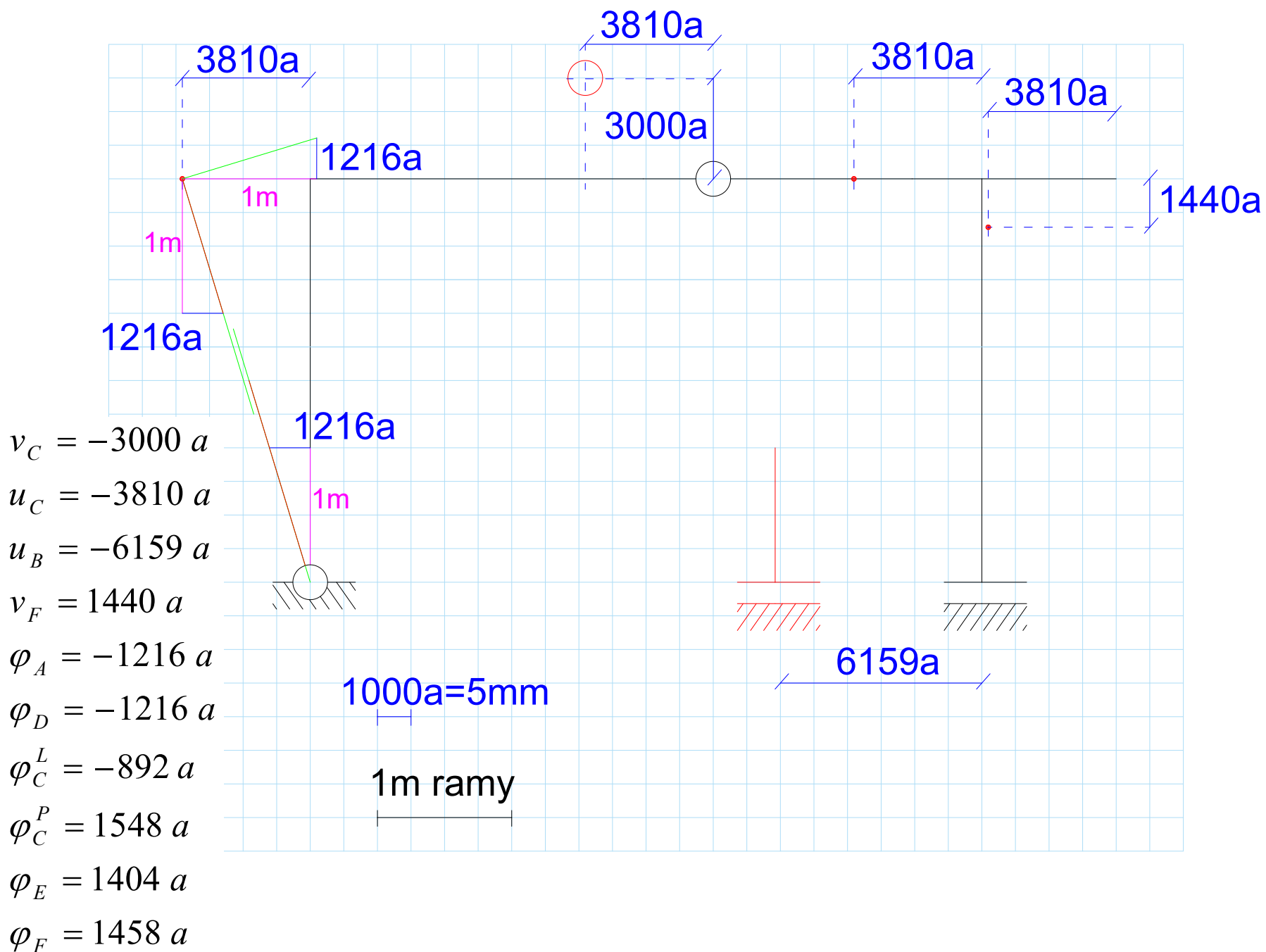


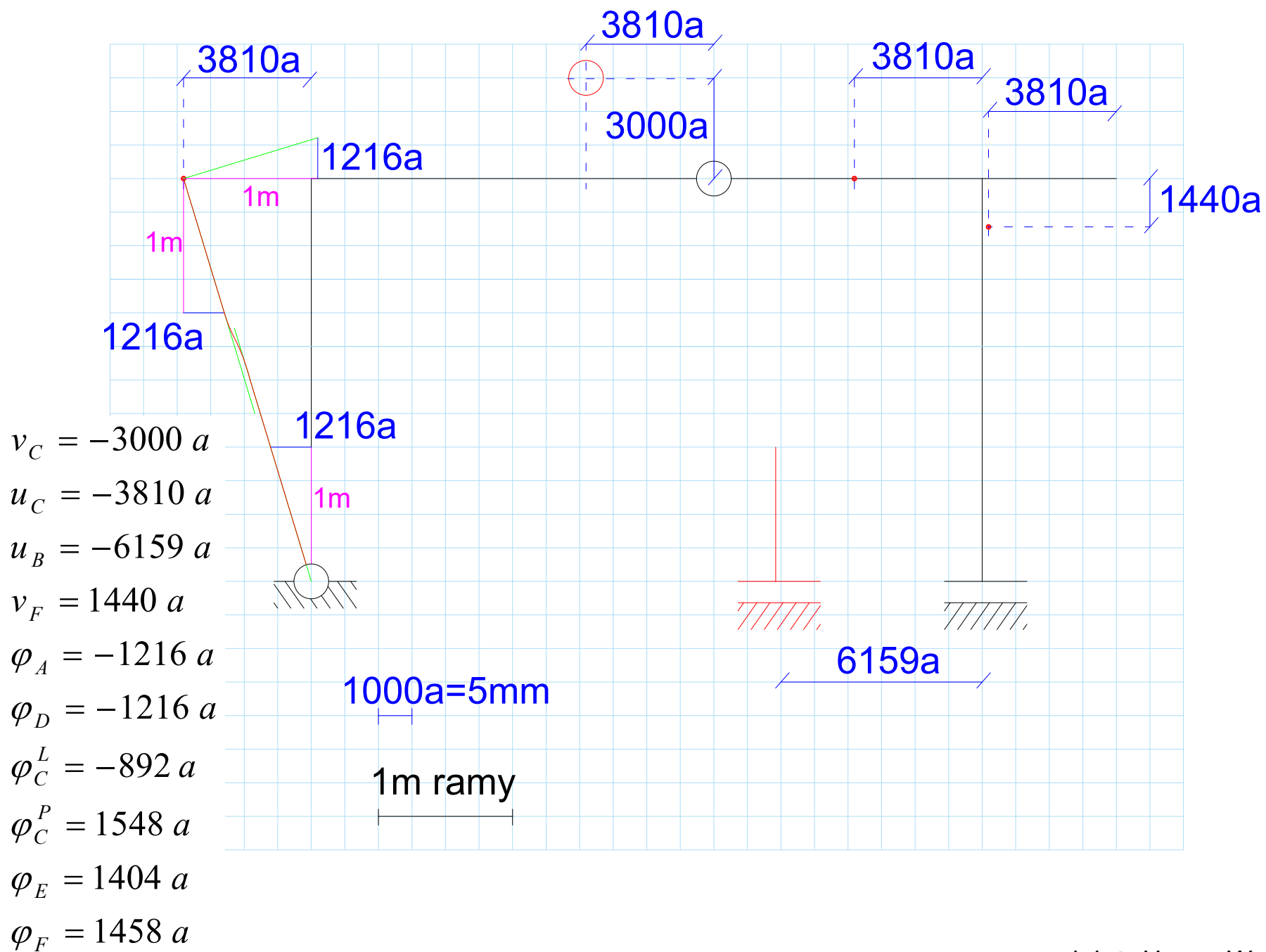


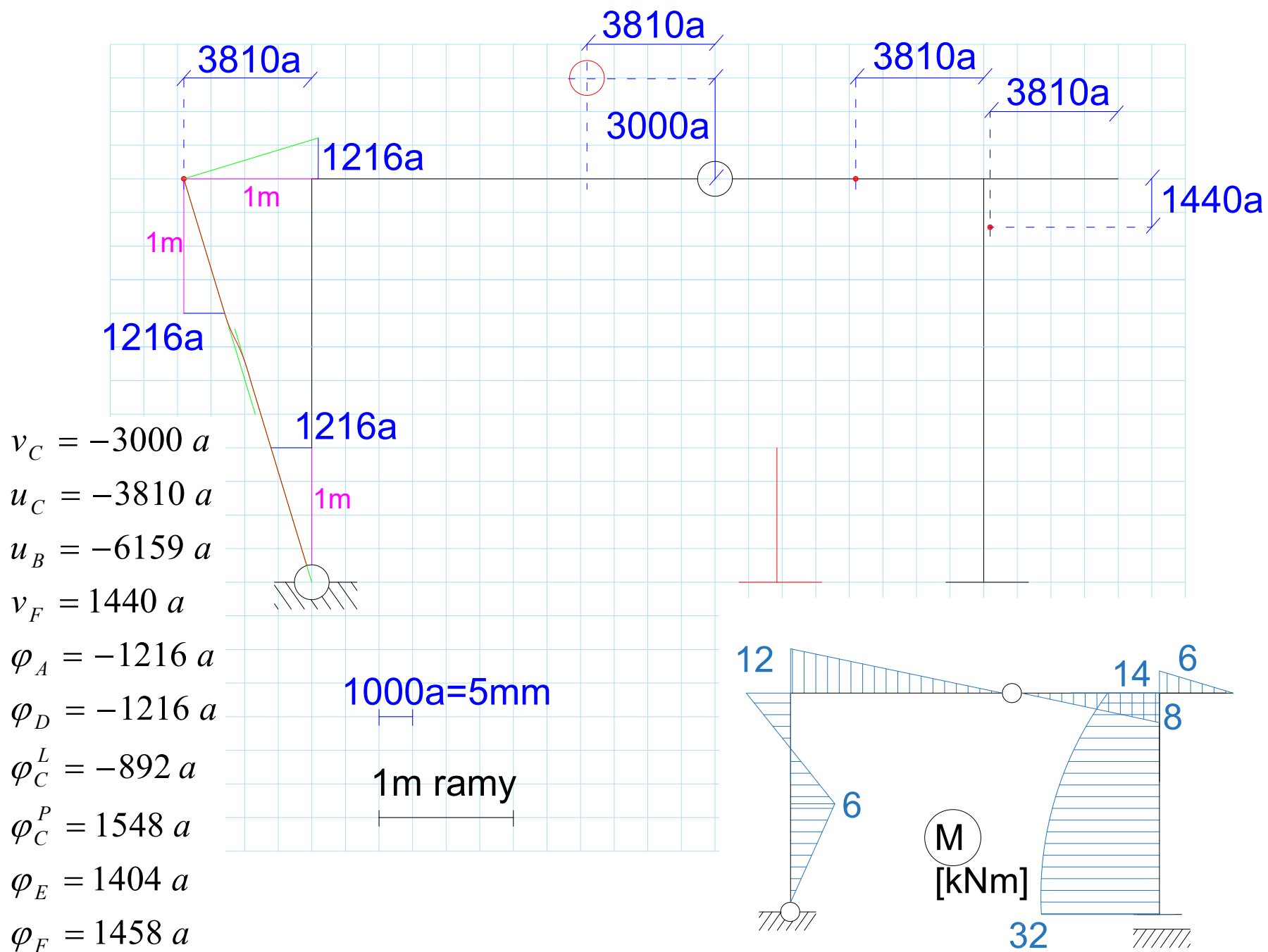


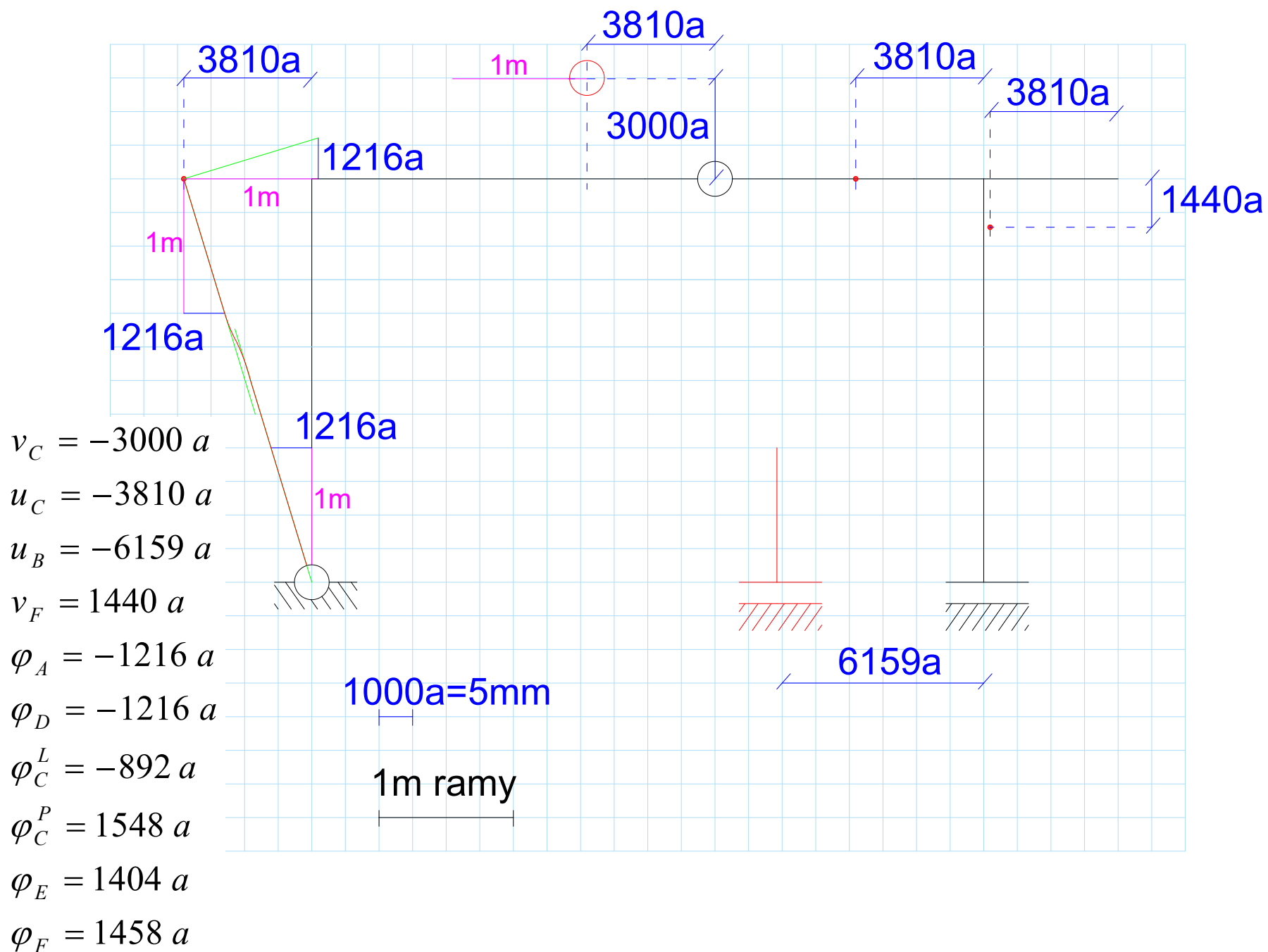


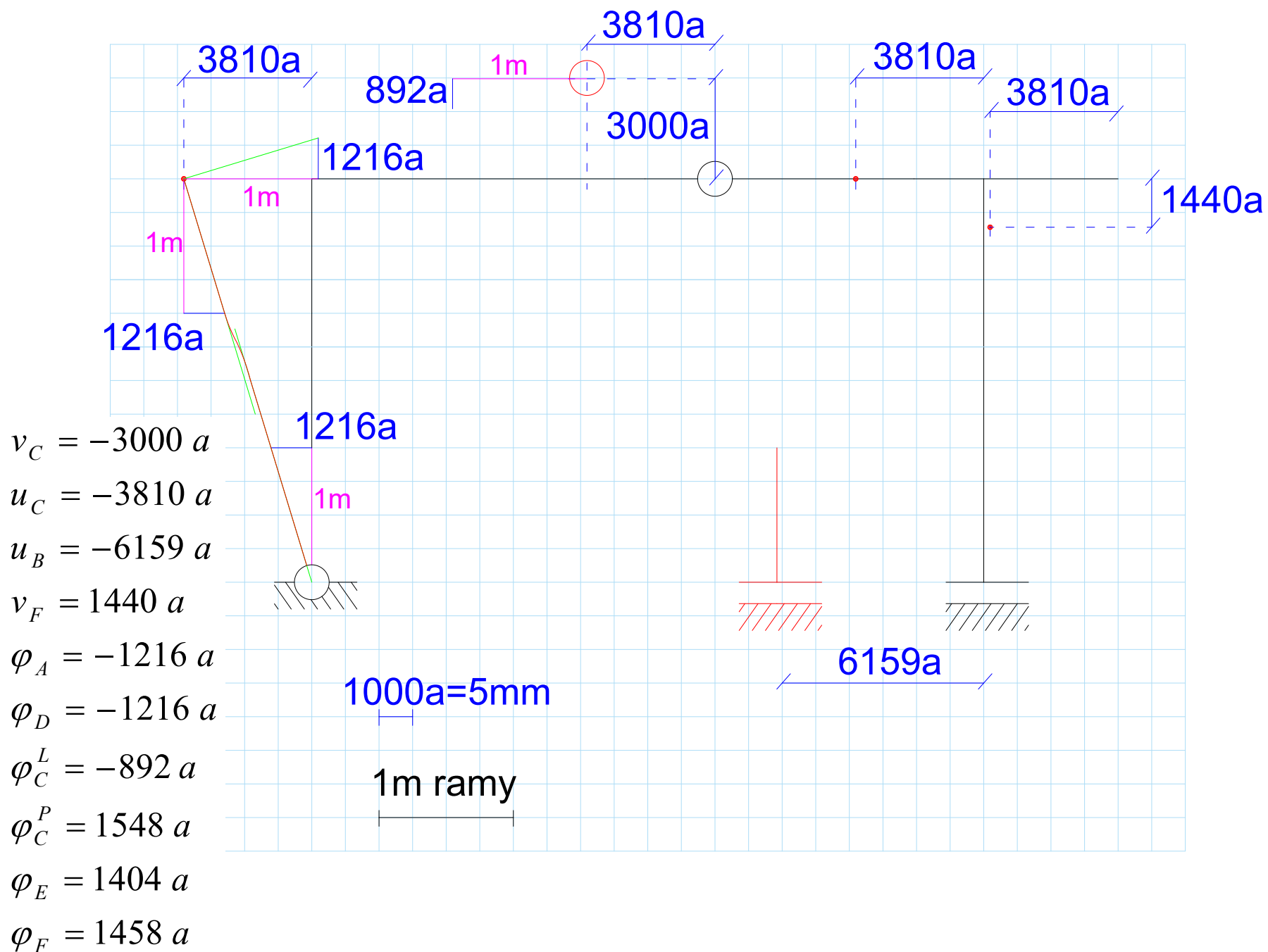


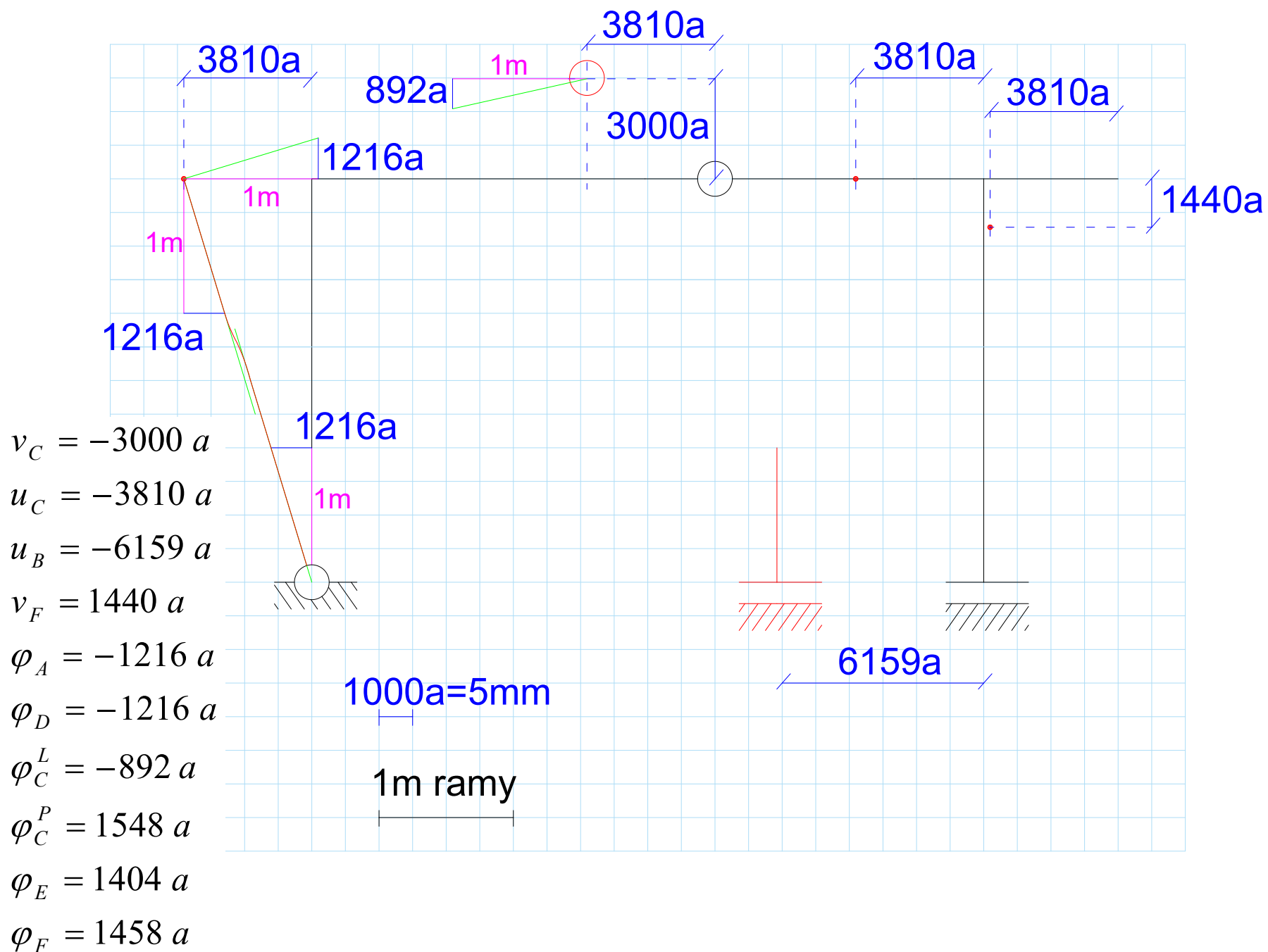


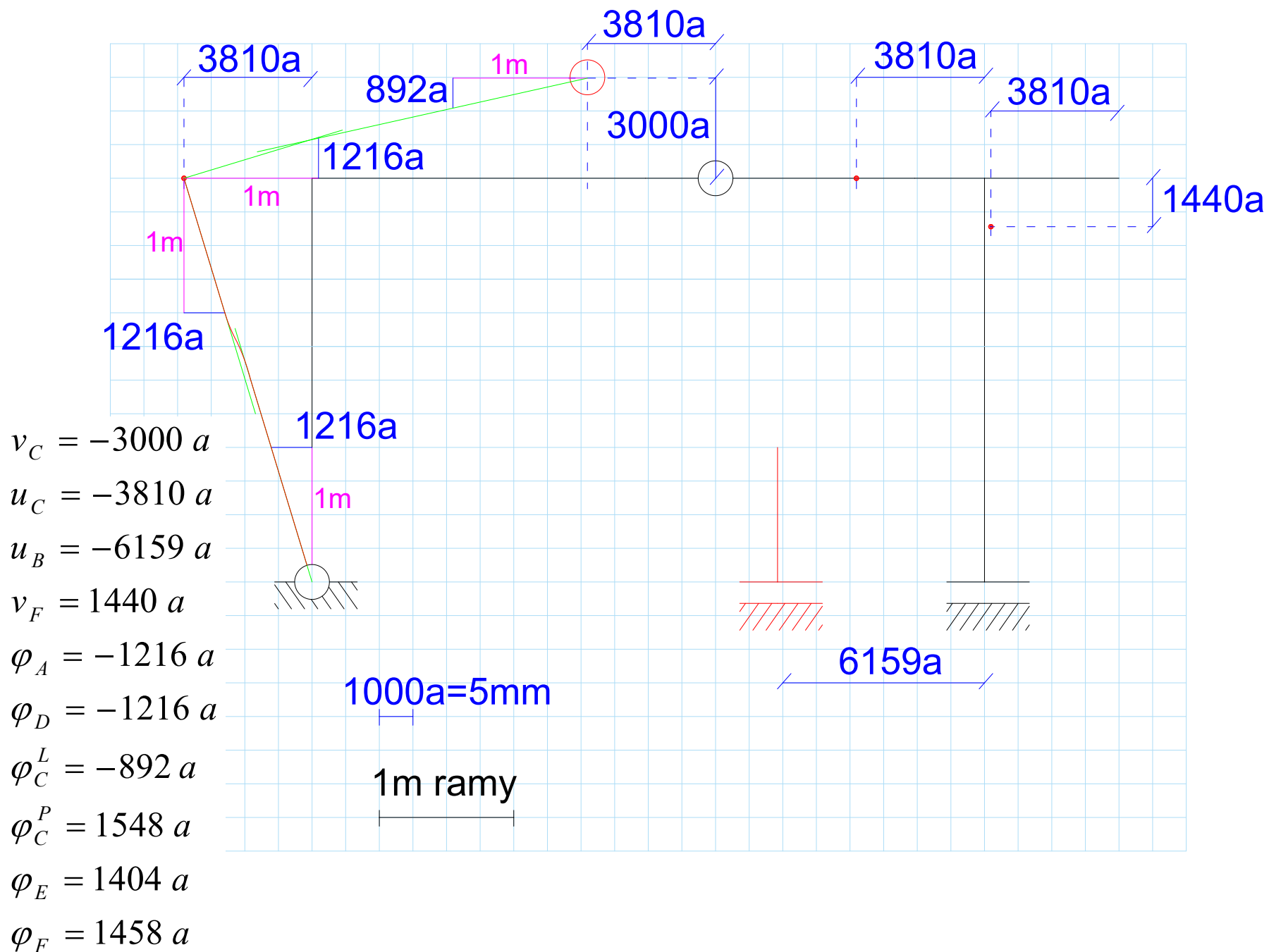


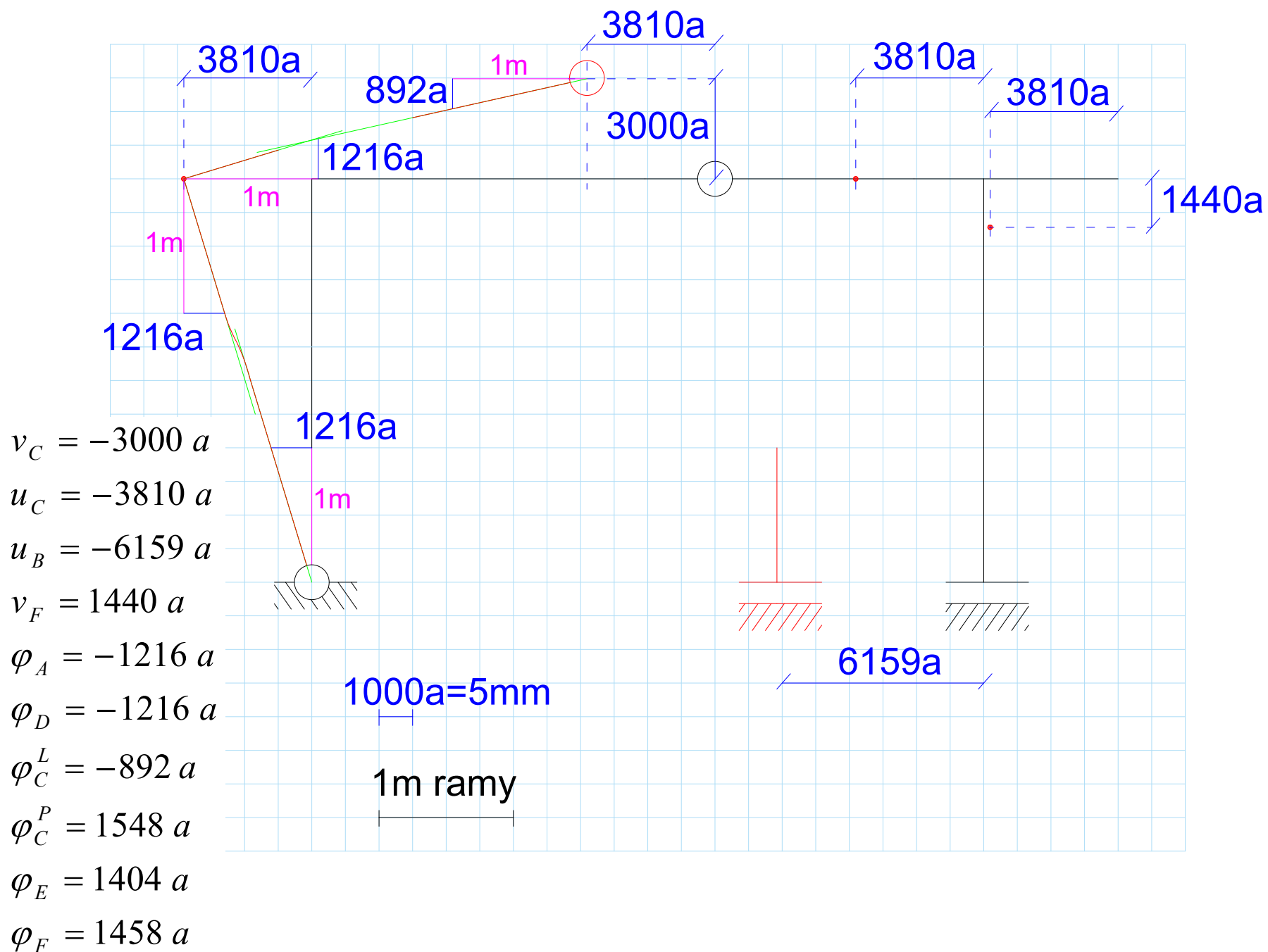


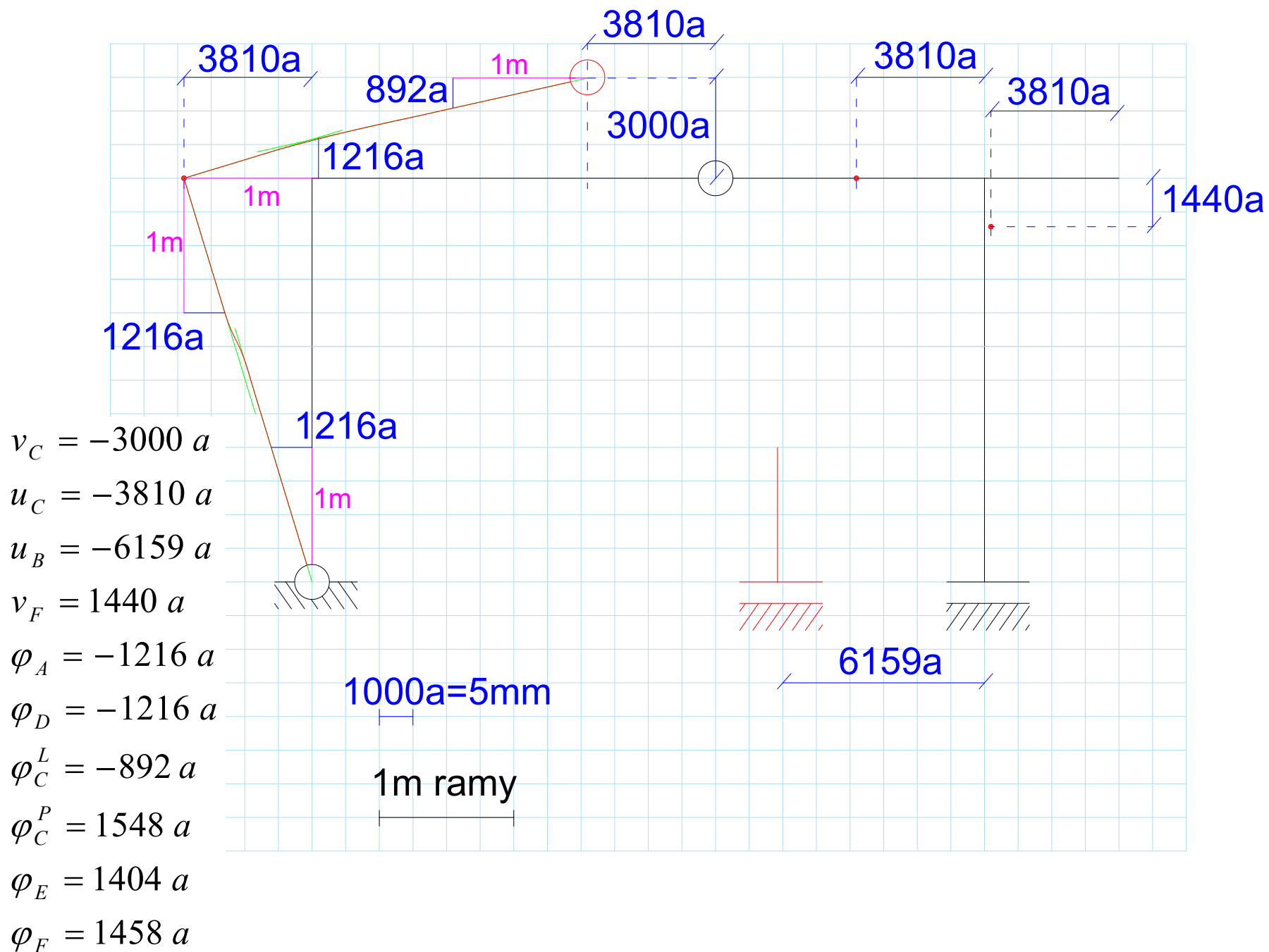


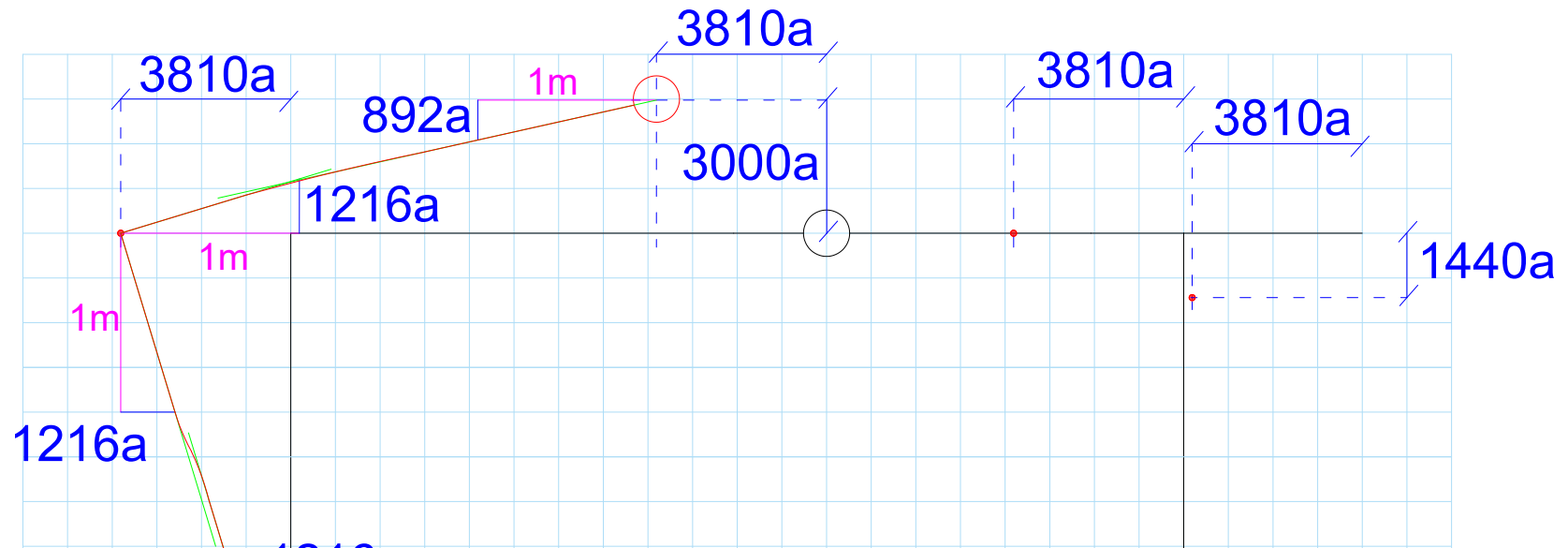












$$v_C = -3000 a$$

$$u_C = -3810 a$$

$$u_B = -6159 a$$

$$v_F = 1440 a$$

$$\varphi_A = -1216 a$$

$$\varphi_D = -1216 a$$

$$\varphi_C^L = -892 a$$

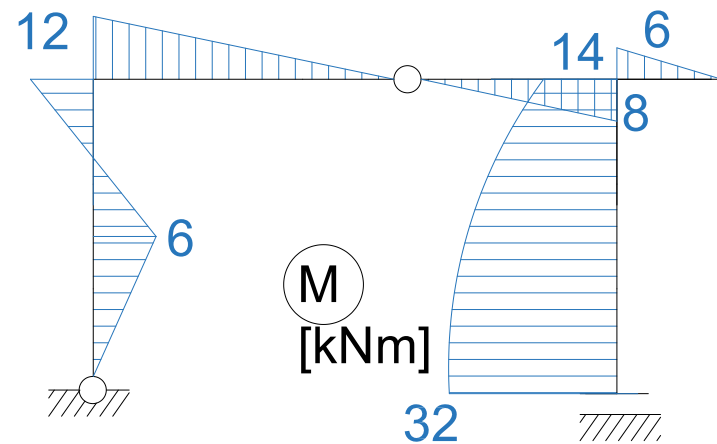
$$\varphi_C^P = 1548 a$$

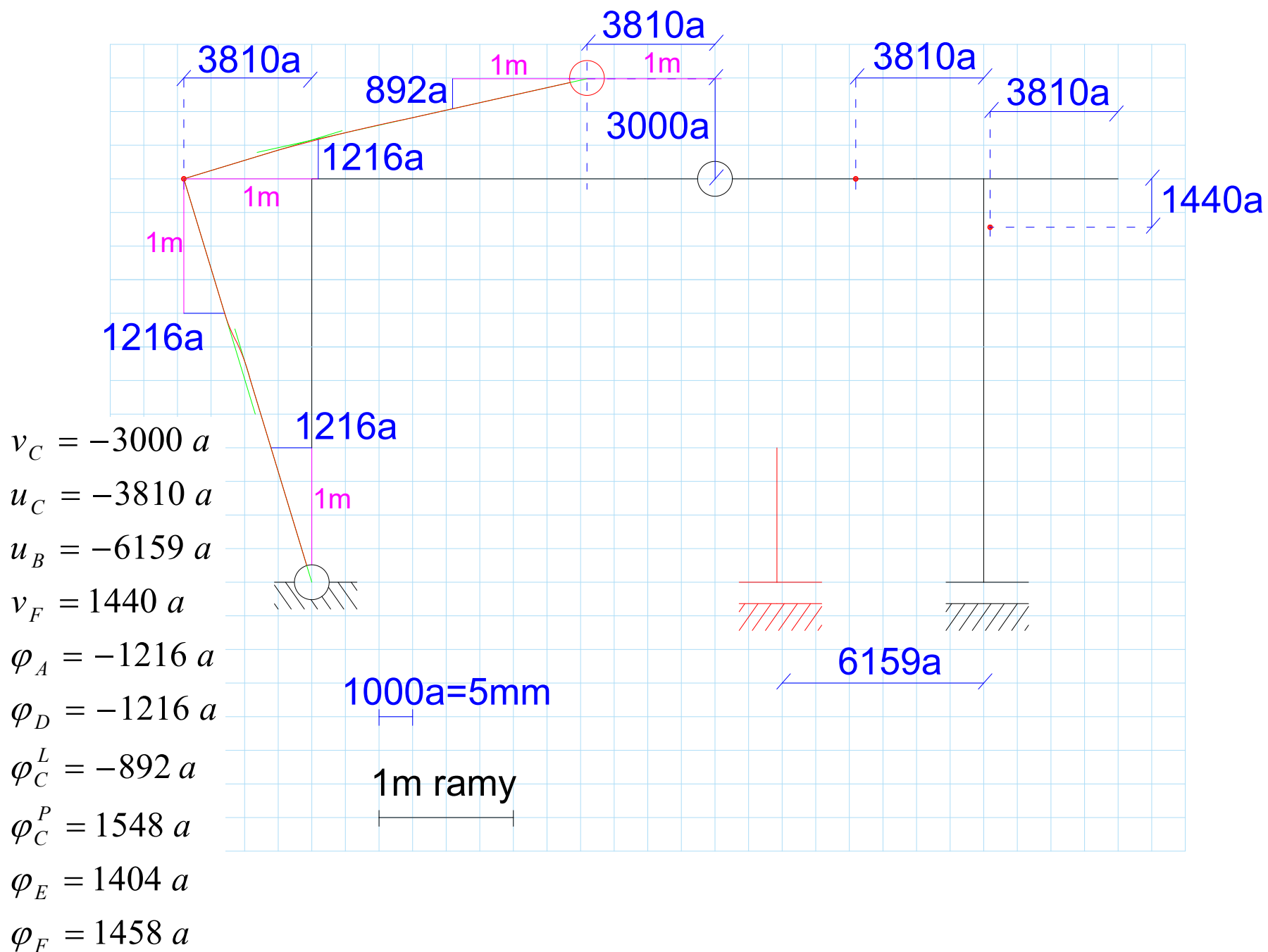
$$\varphi_E = 1404 a$$

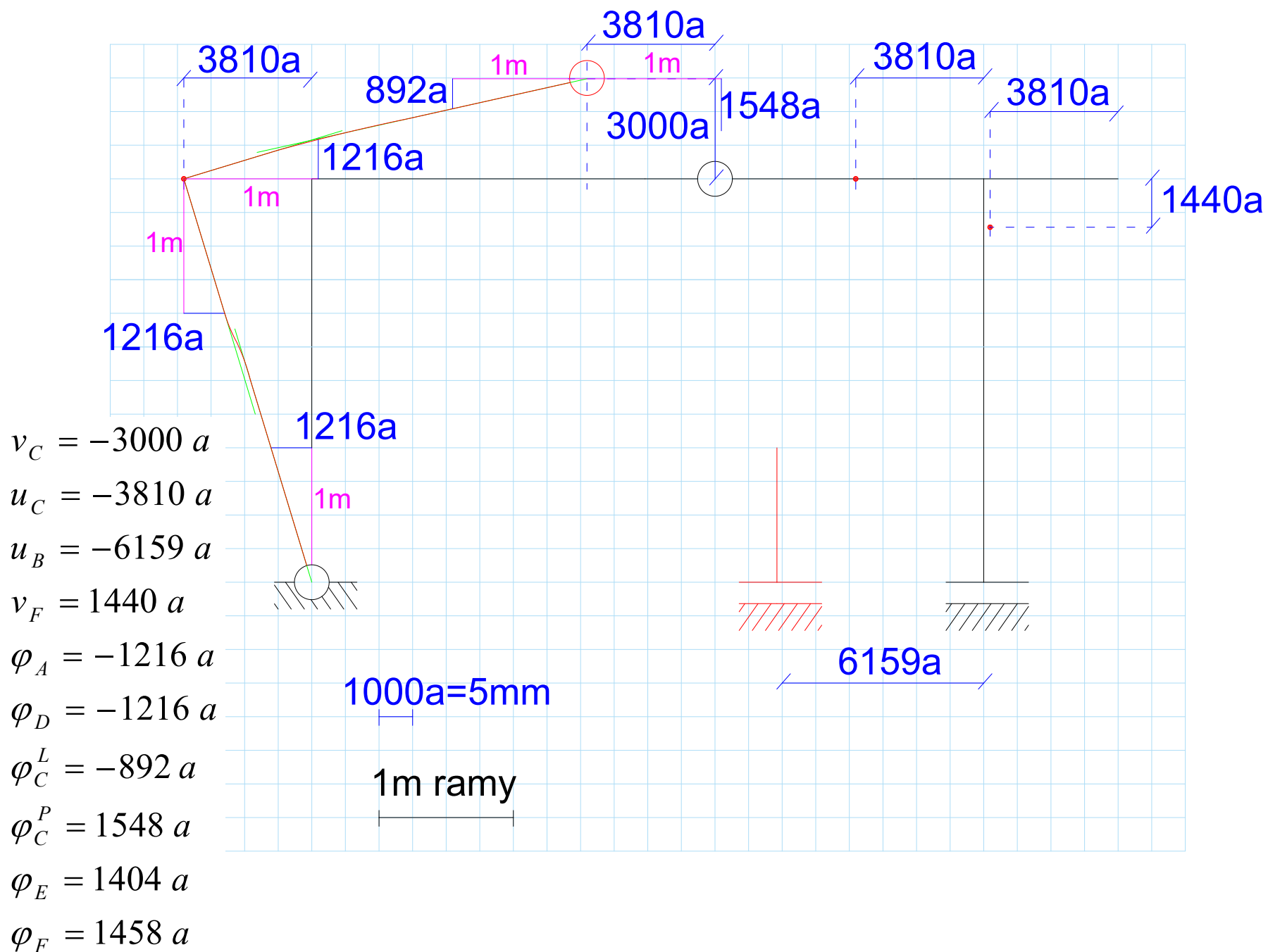
$$\varphi_F = 1458 a$$

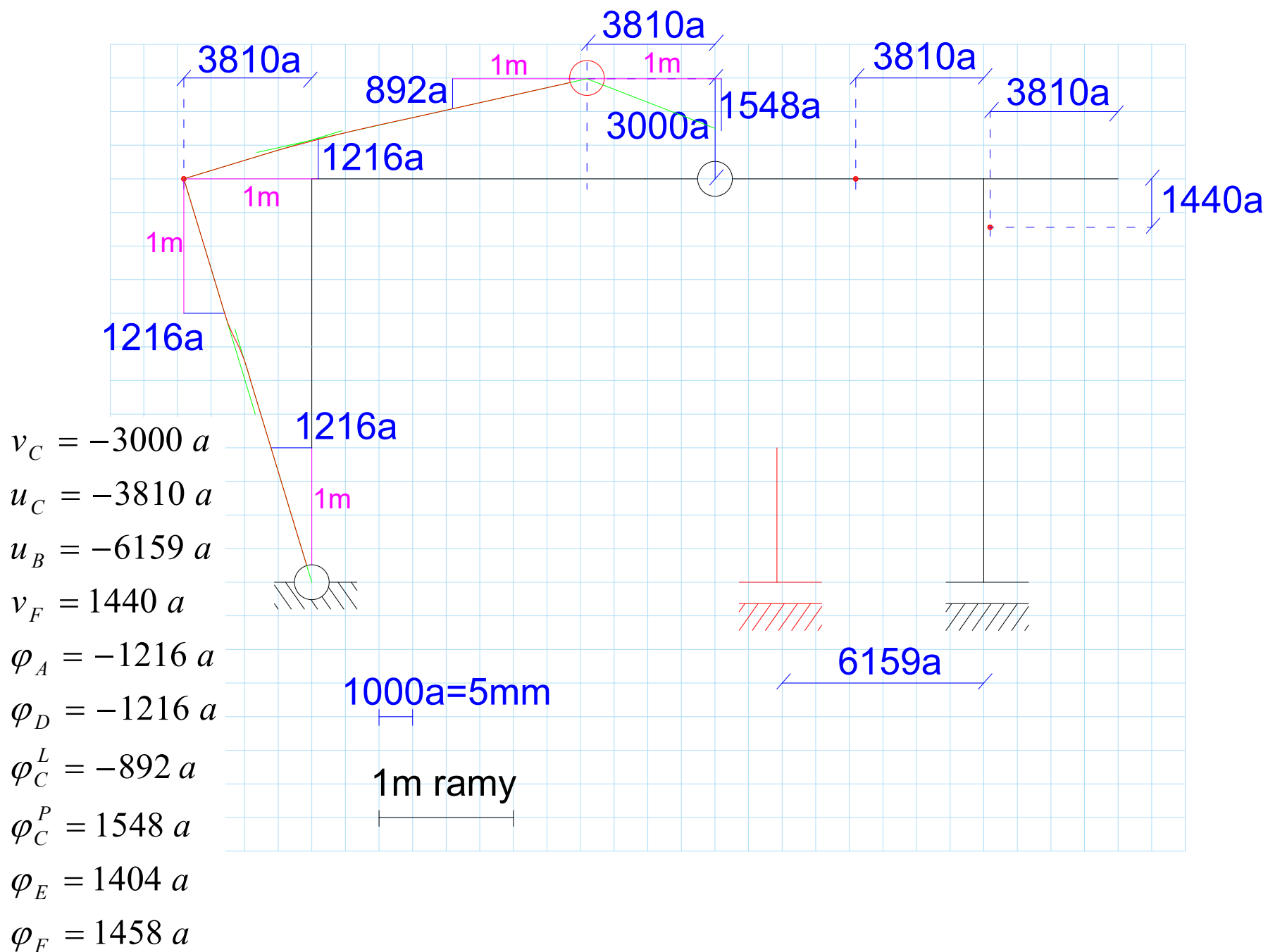
$$1000a = 5mm$$

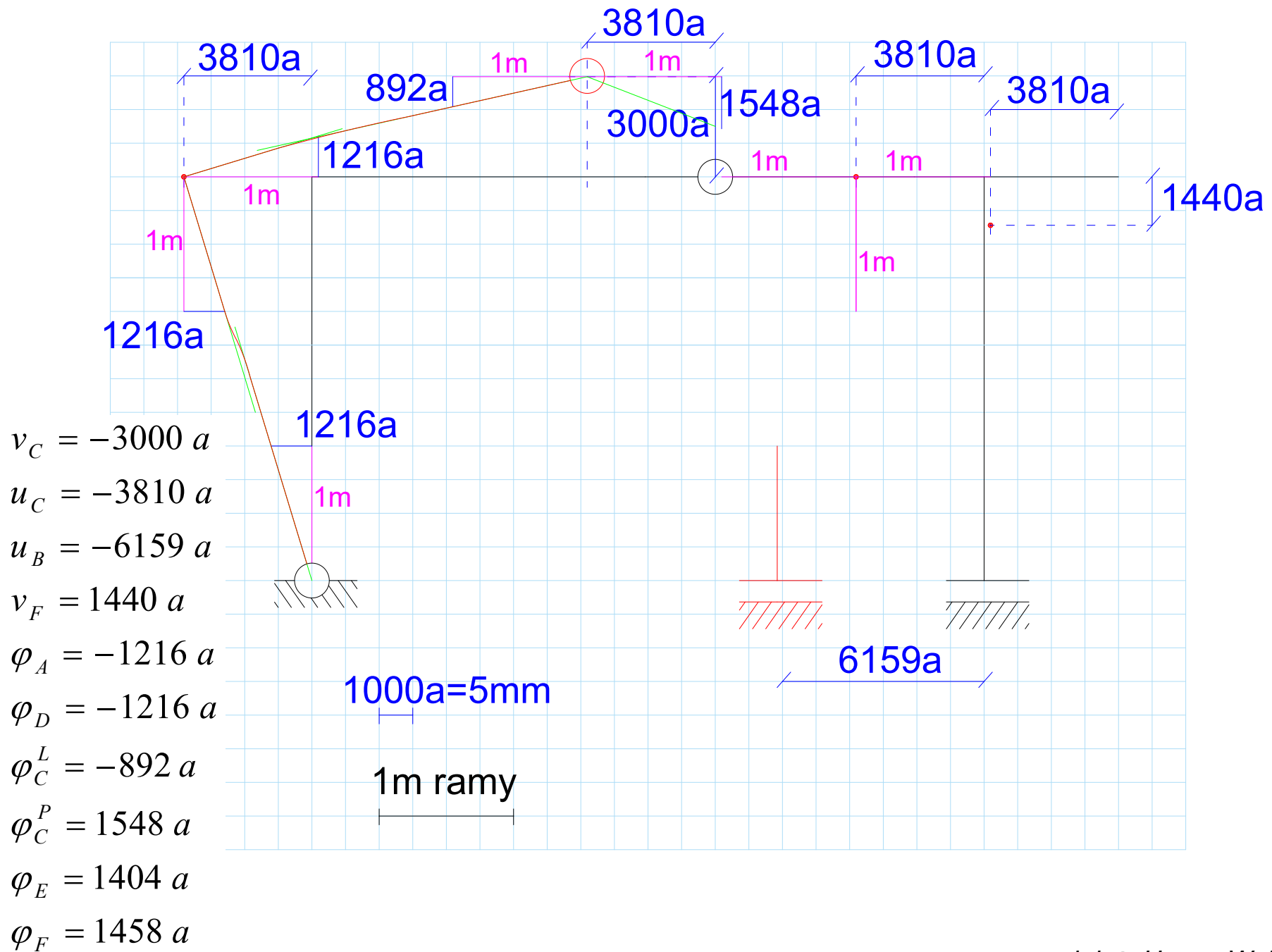
$$1m \text{ ramy}$$

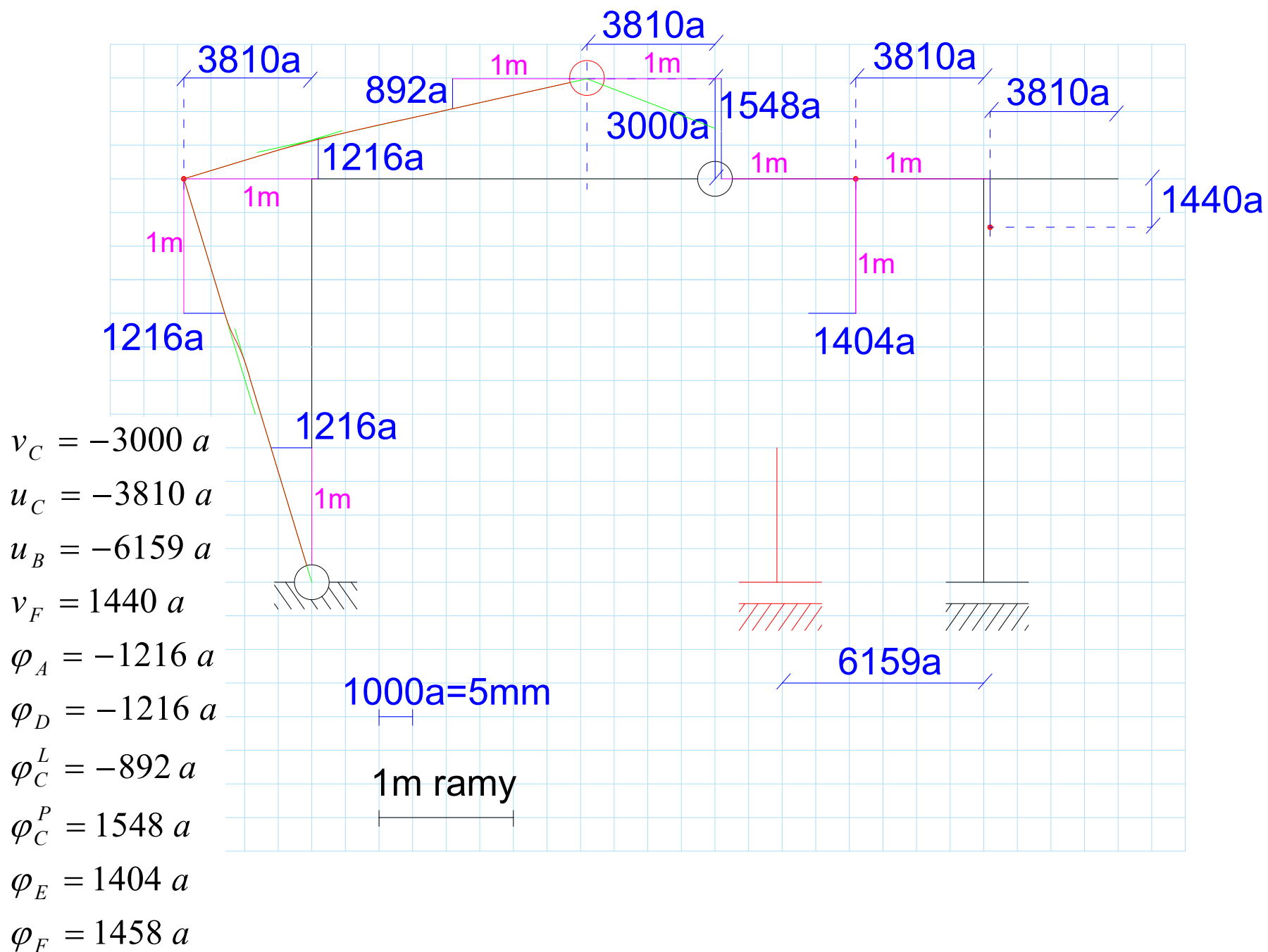


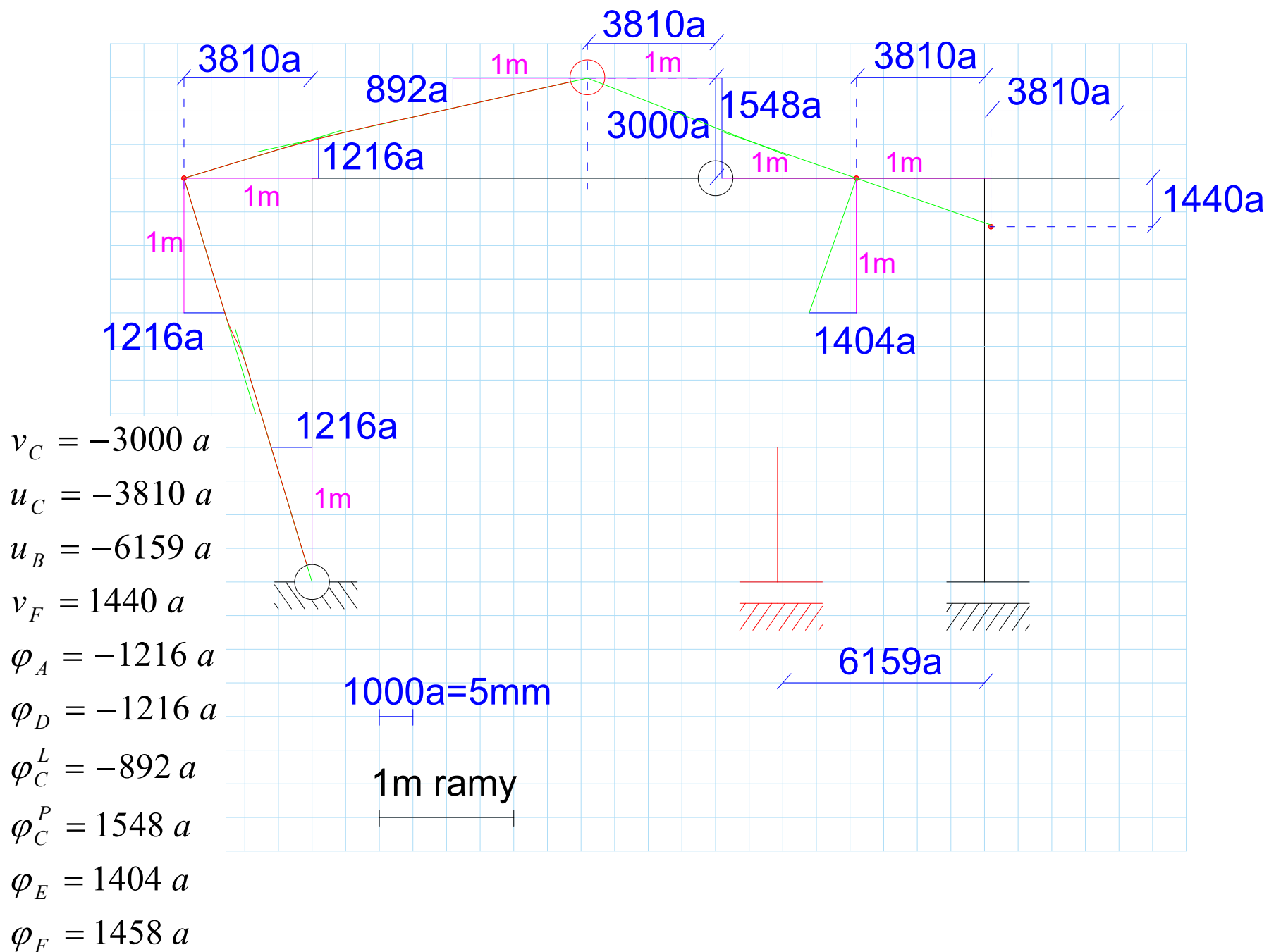


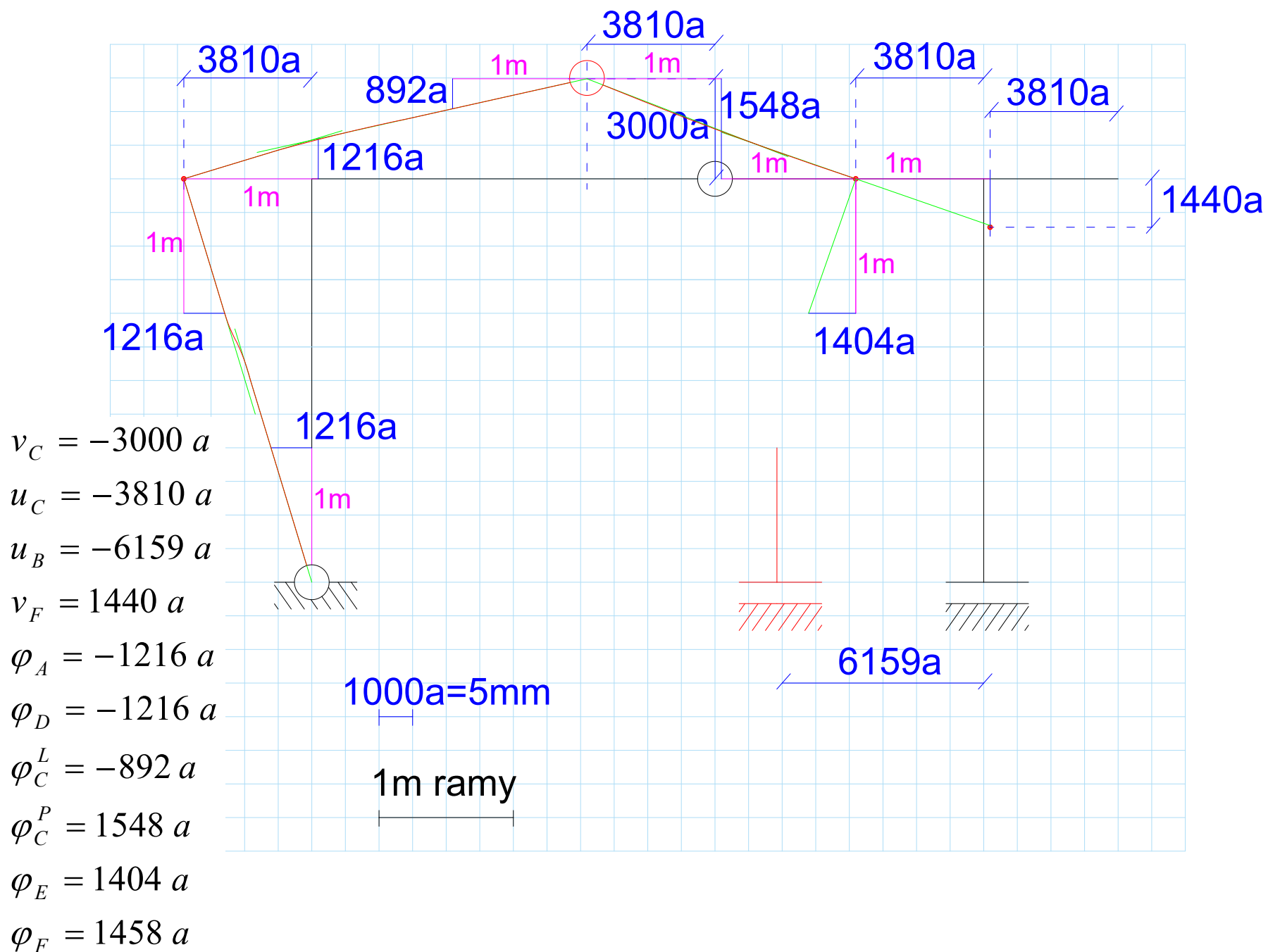


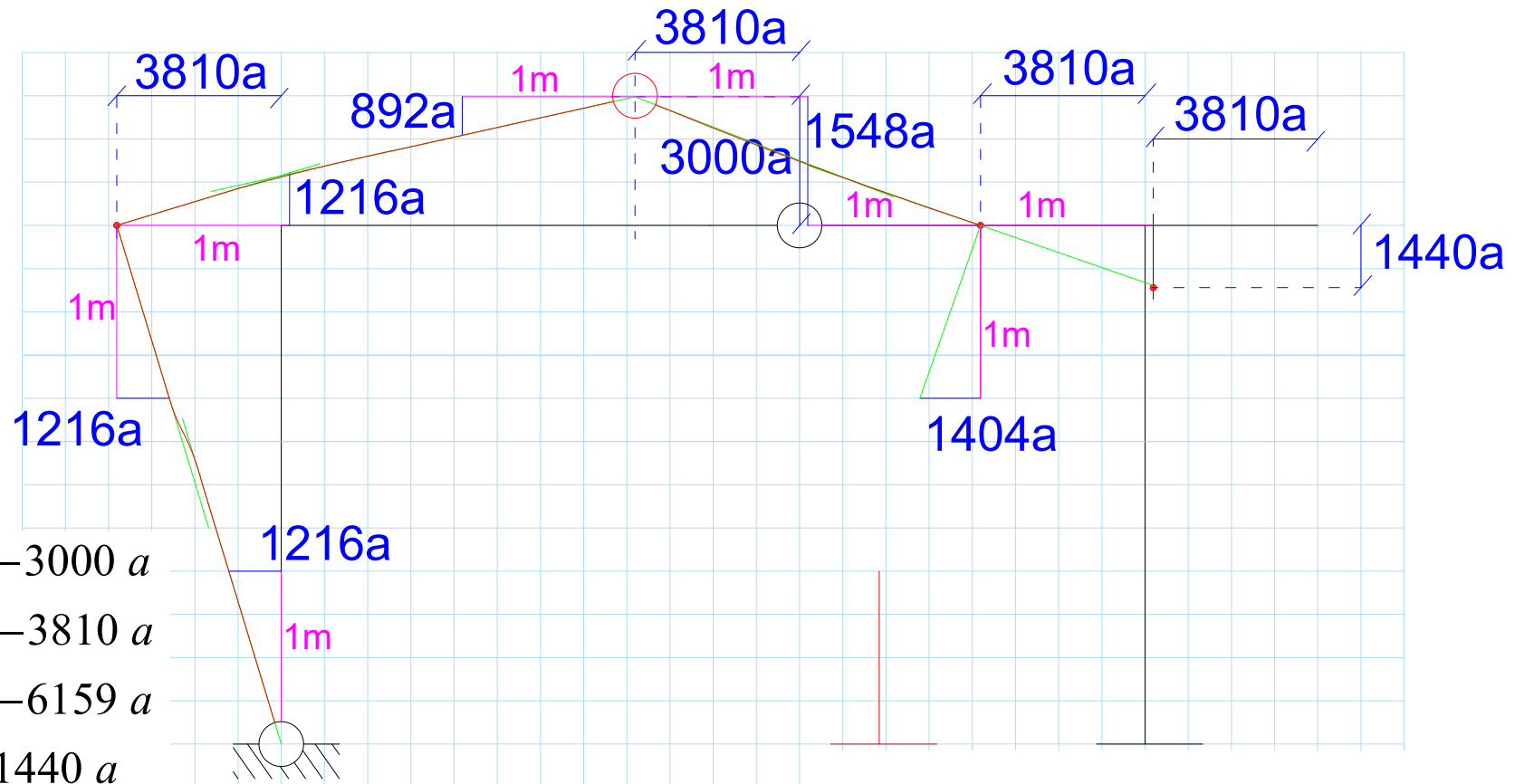












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$$\varphi_D = -1216 a$$

$$\varphi_C^L = -892 a$$

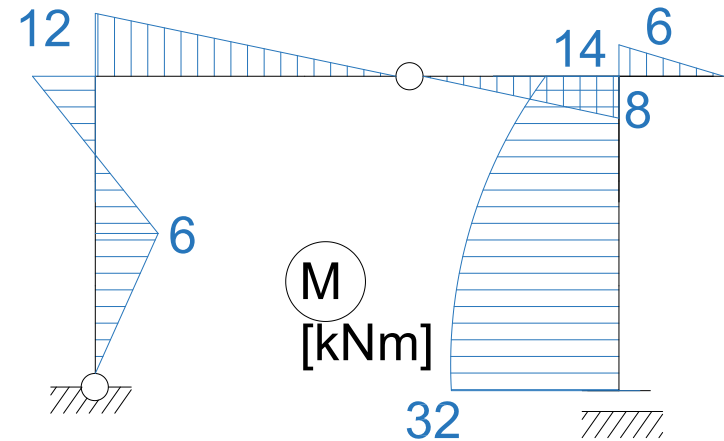
$$\varphi_C^P = 1548 a$$

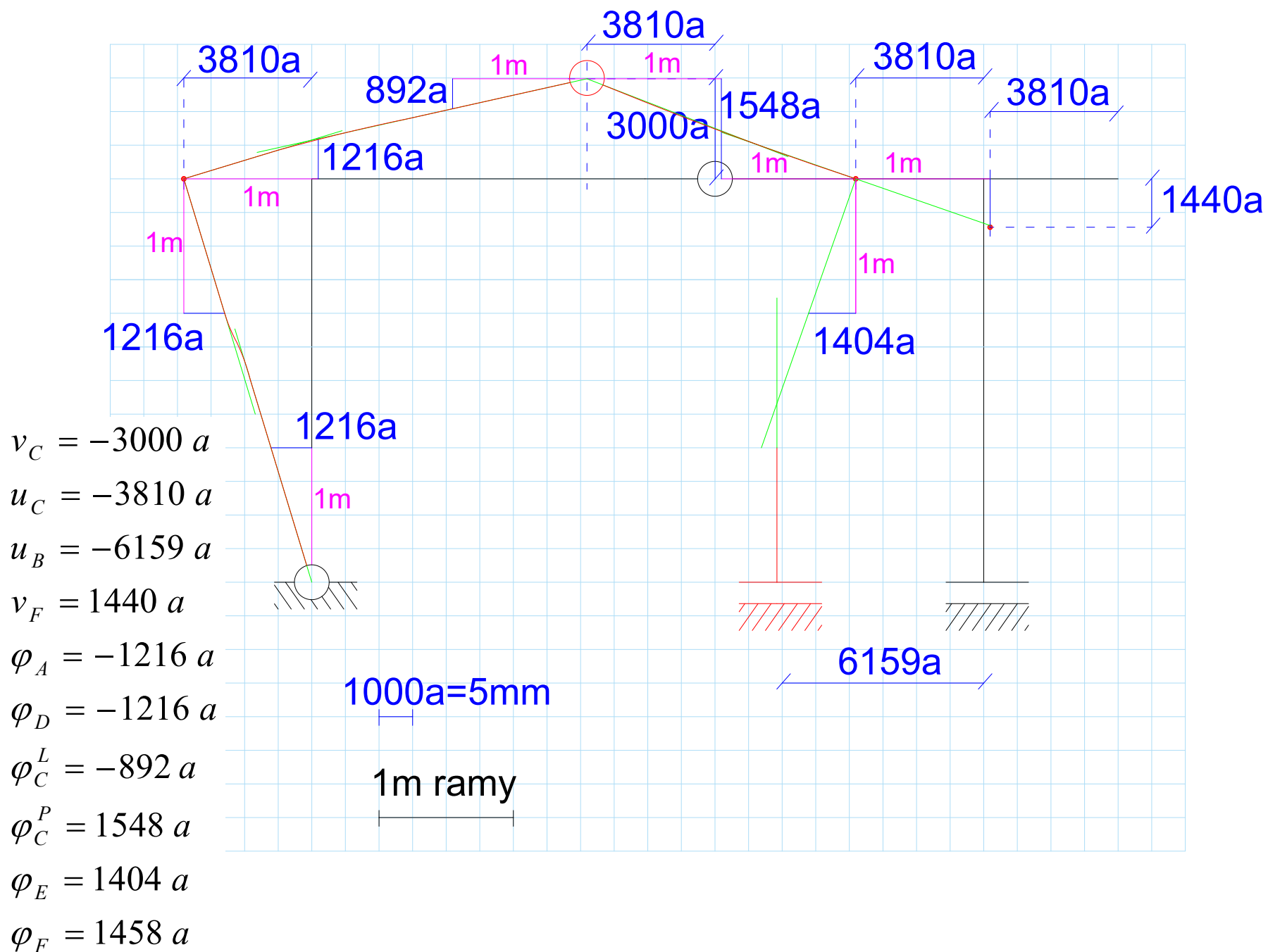
$$\varphi_E = 1404 a$$

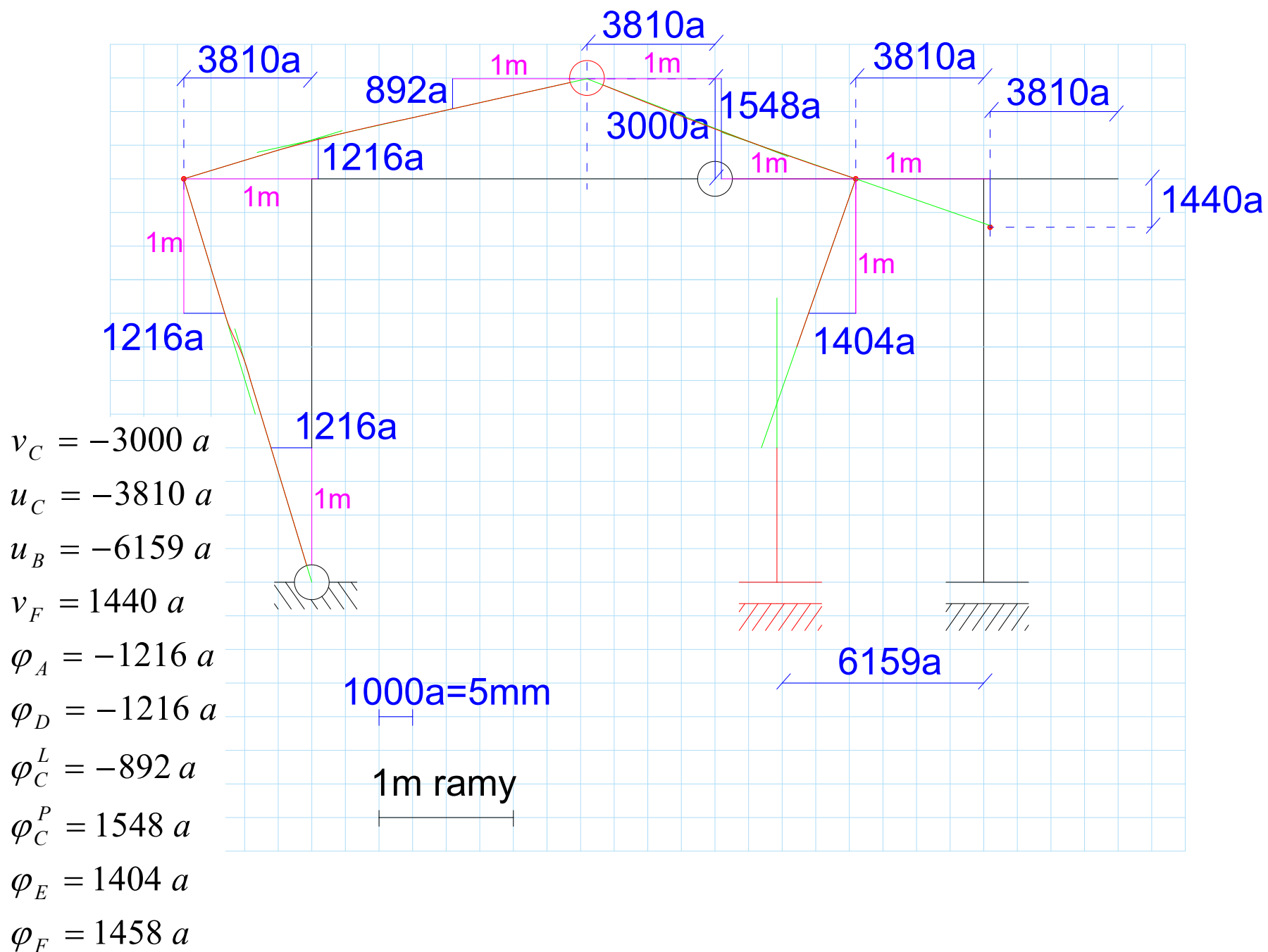
$$\varphi_F = 1458 a$$

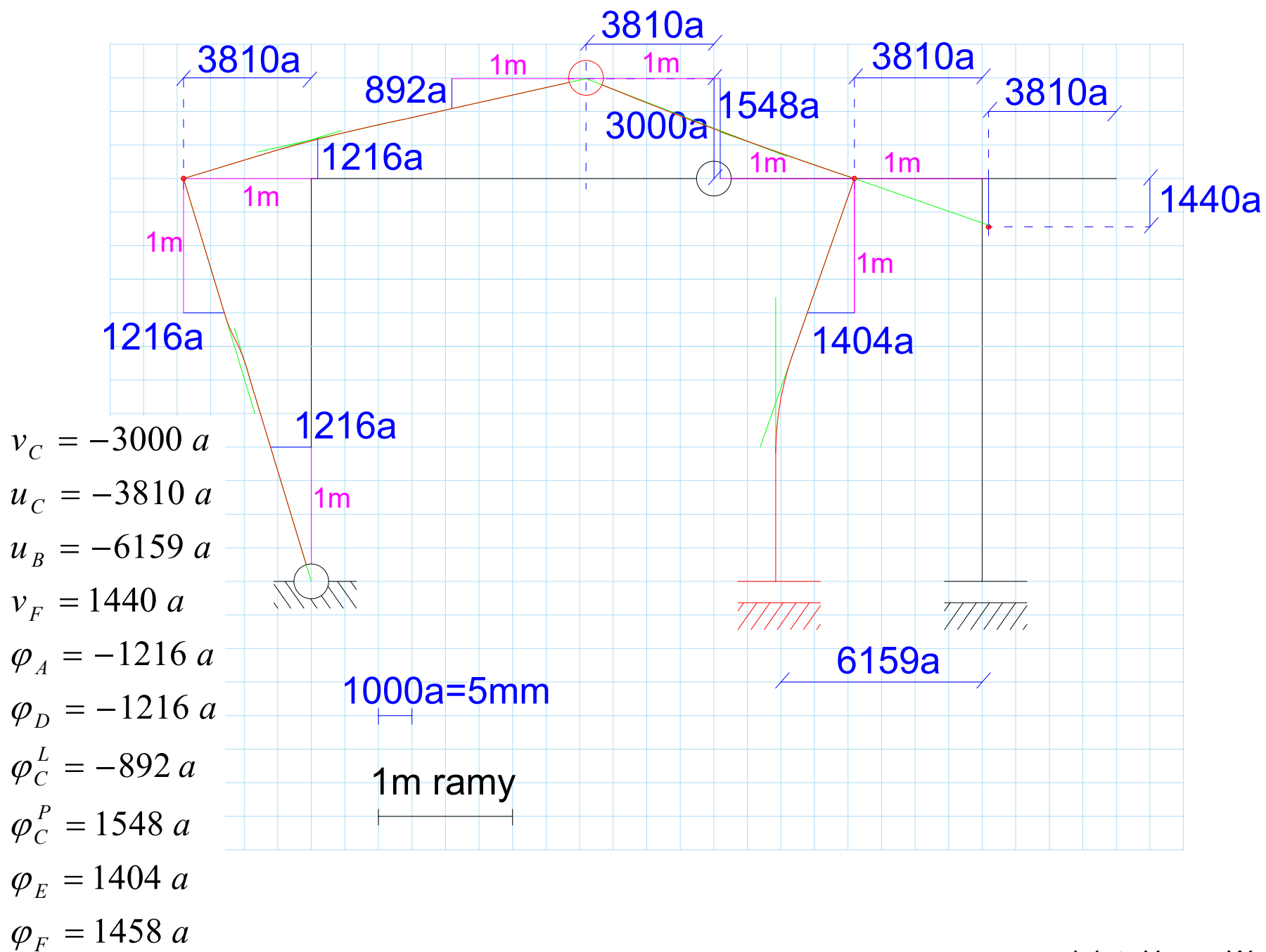
$$1000a = 5\text{mm}$$

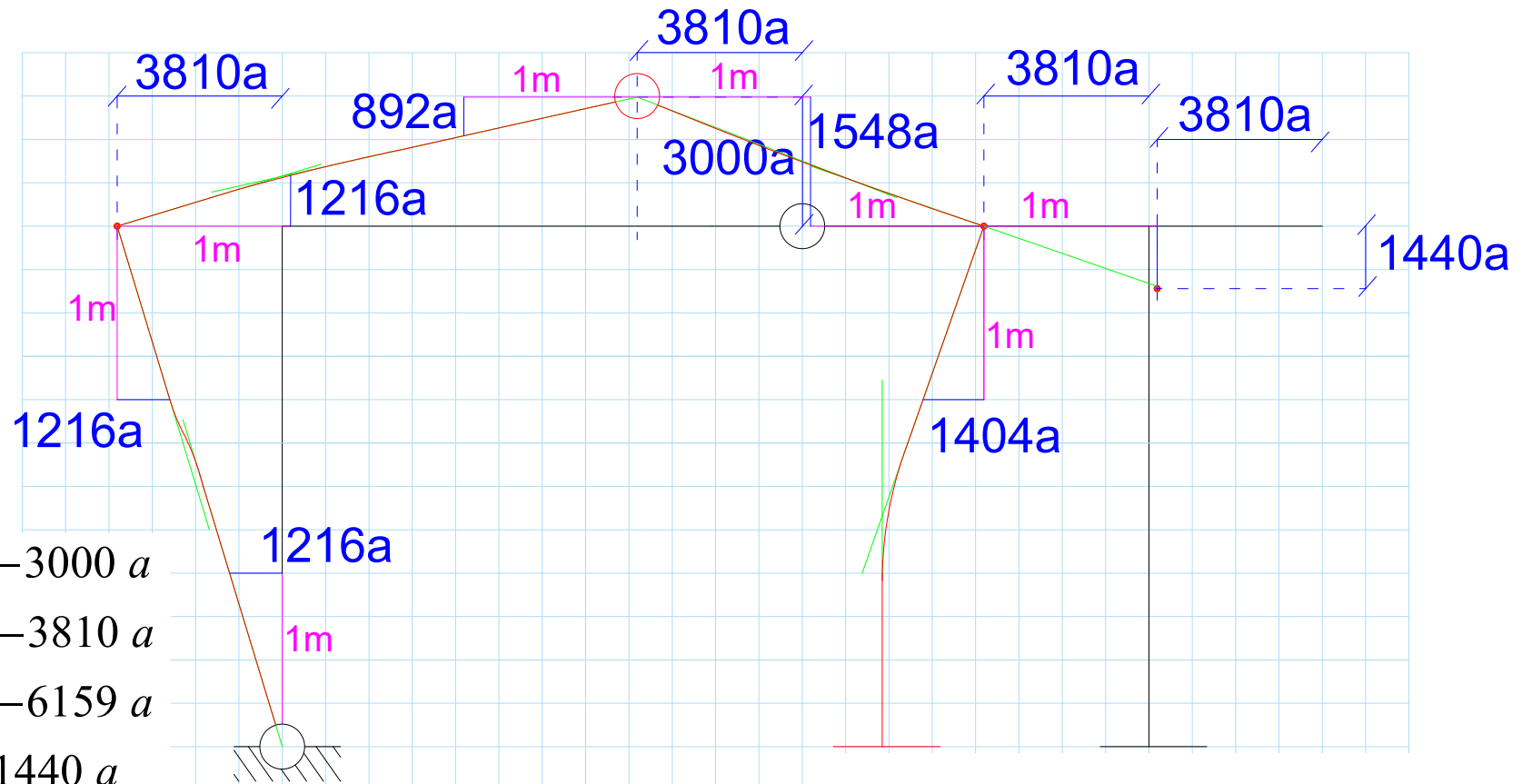
$$1\text{m ramy}$$











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$$\varphi_D = -1216 a$$

$$\varphi_C^L = -892 a$$

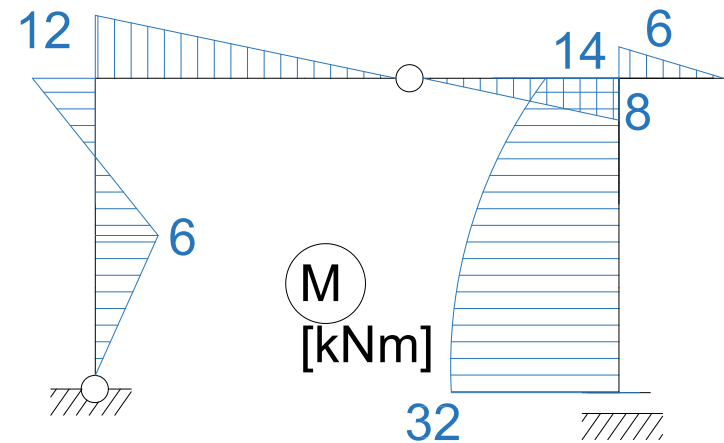
$$\varphi_C^P = 1548 a$$

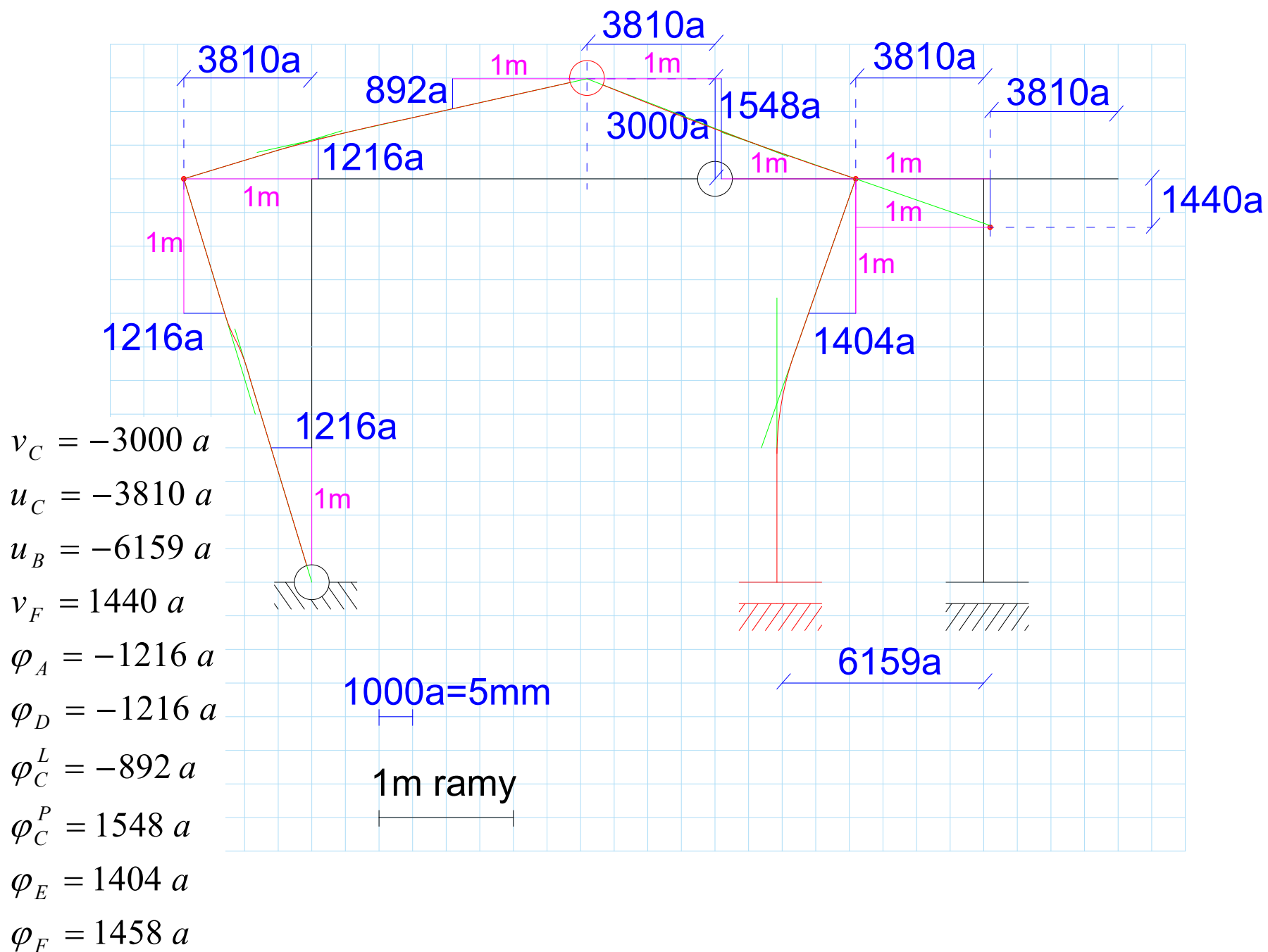
$$\varphi_E = 1404 a$$

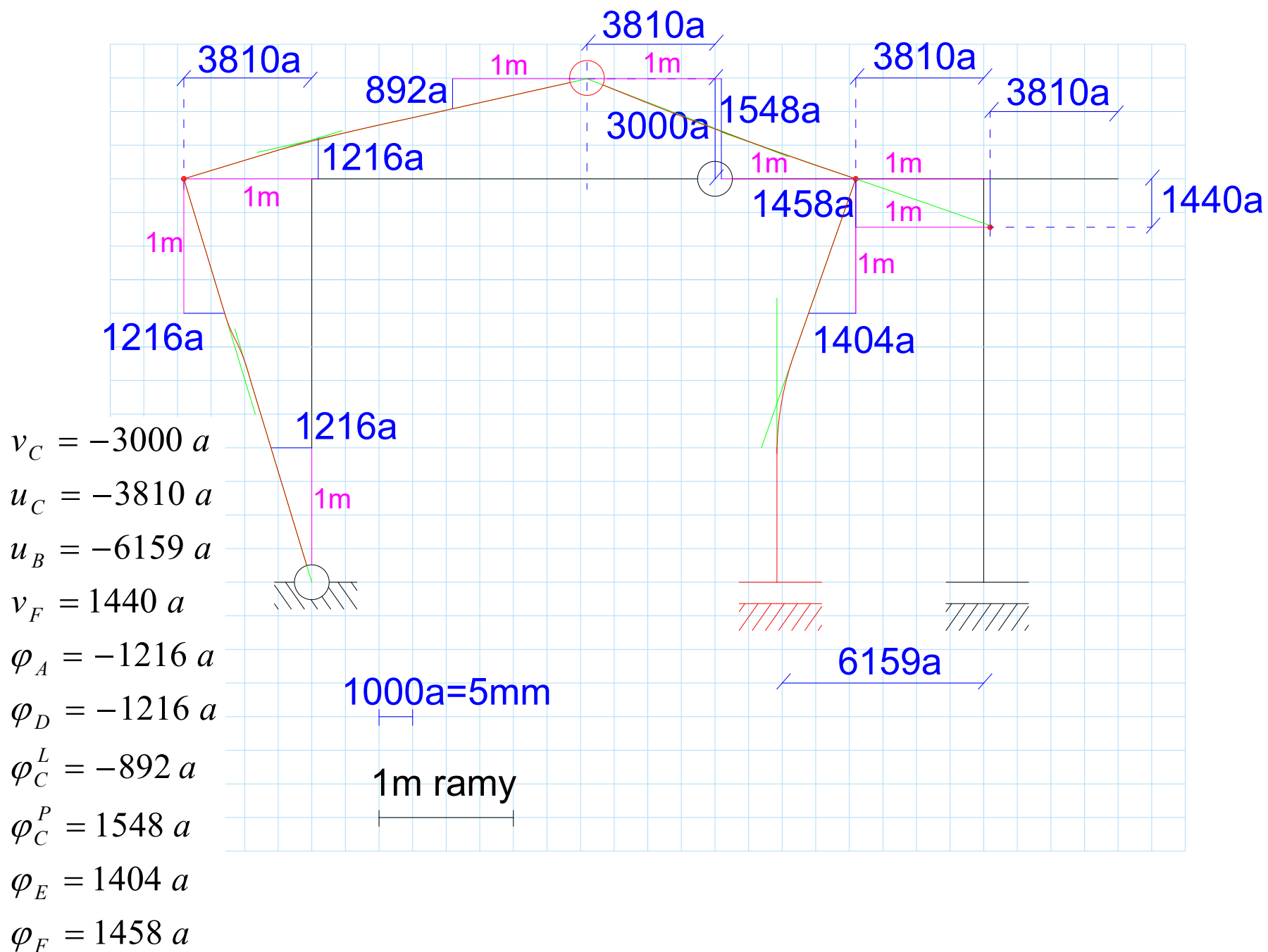
$$\varphi_F = 1458 a$$

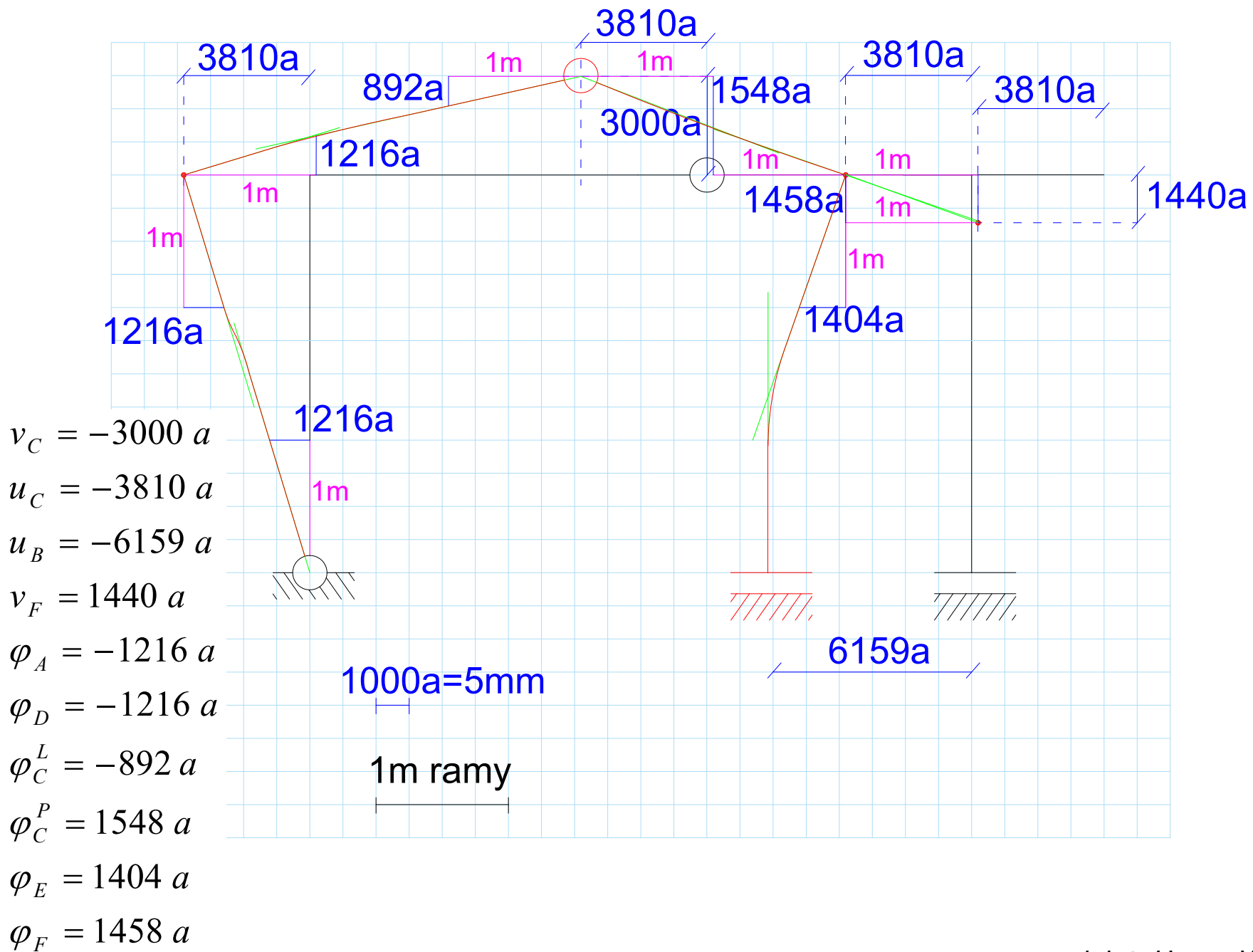
$$1000a = 5\text{mm}$$

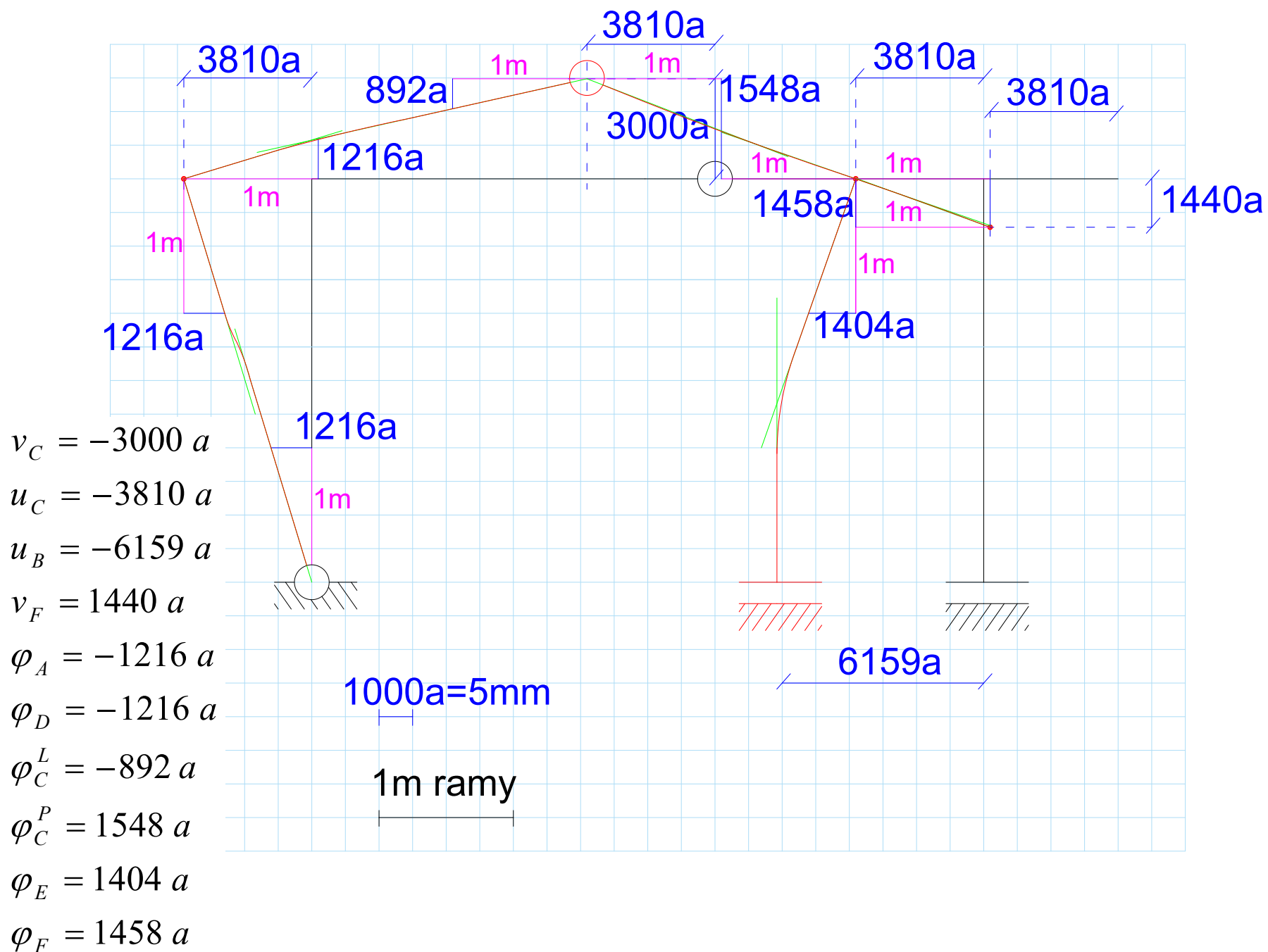
1m ramy

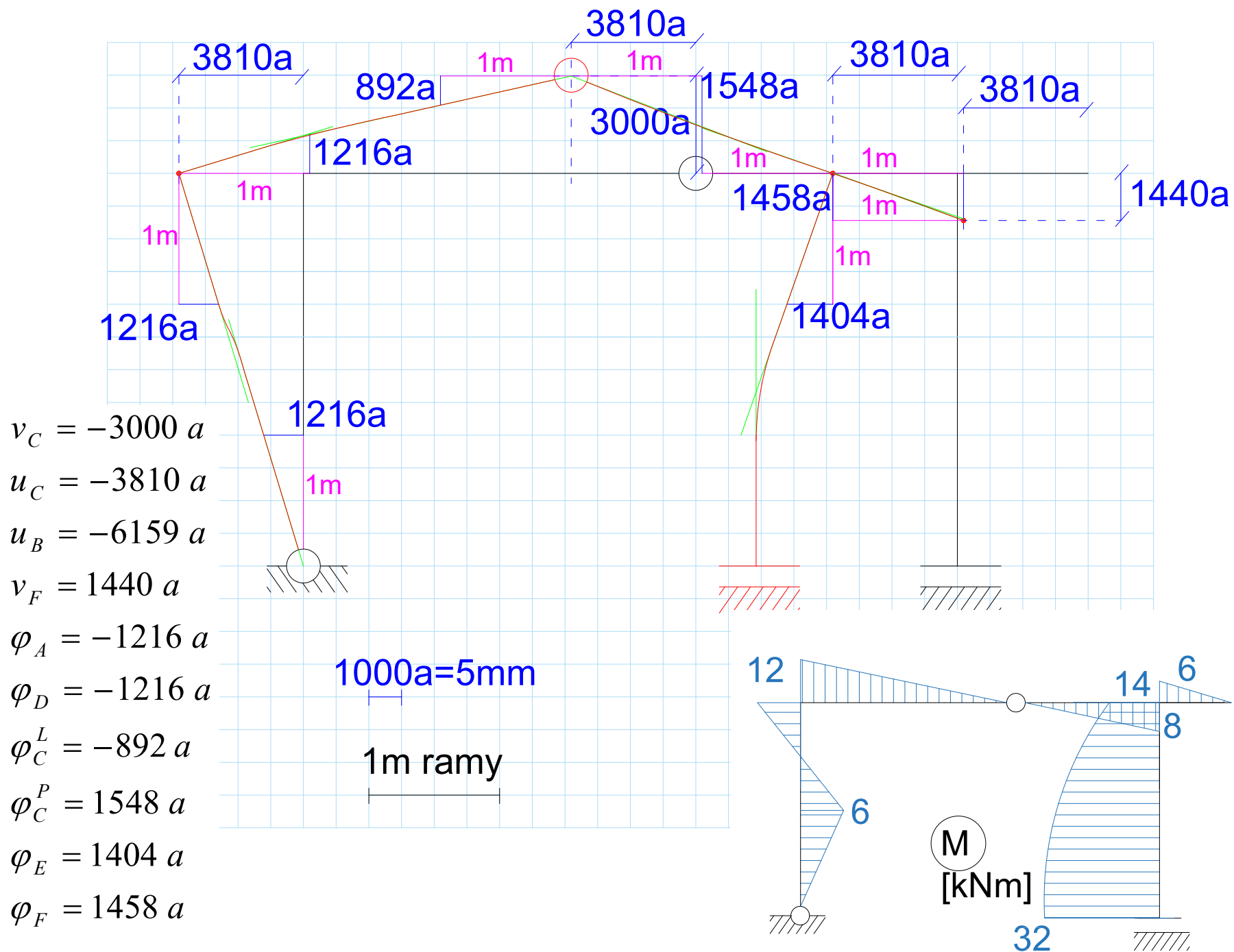












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$$\varphi_D = -1216 a$$

$$\varphi_C^L = -892 a$$

$$\varphi_C^P = 1548 a$$

$$\varphi_E = 1404 a$$

$$\varphi_F = 1458 a$$

