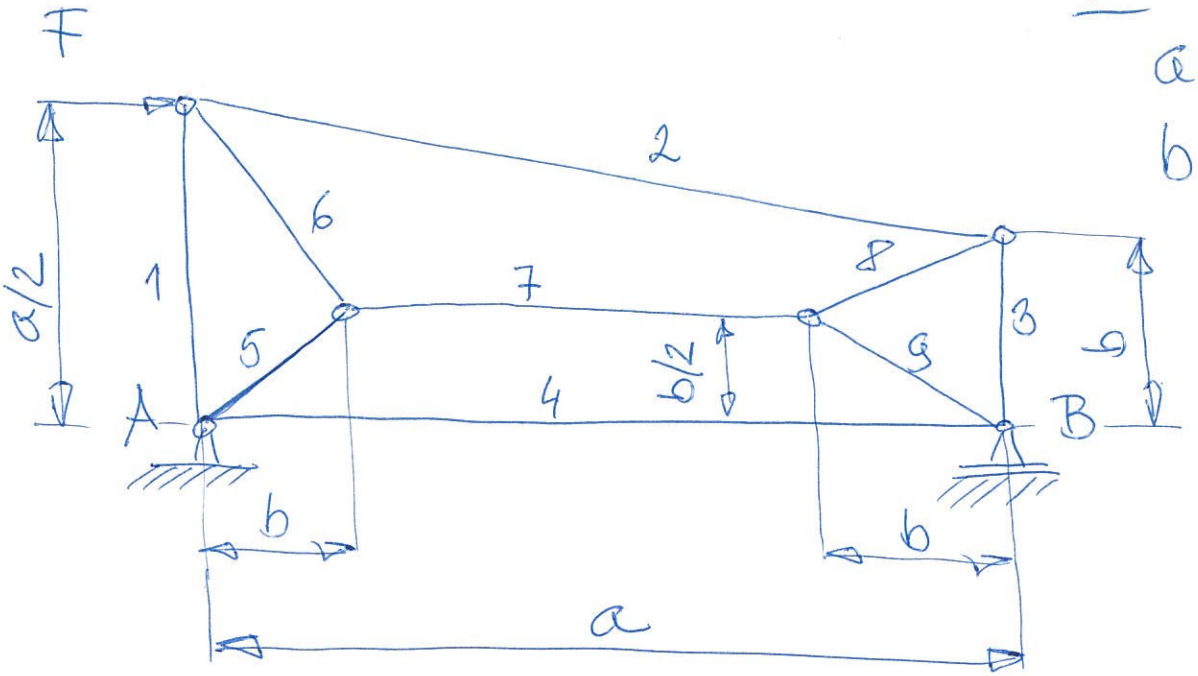
(STA Ř. PŘ. 5.2/6)

D: F = 1500 N

a = 8 m

b = 2 m

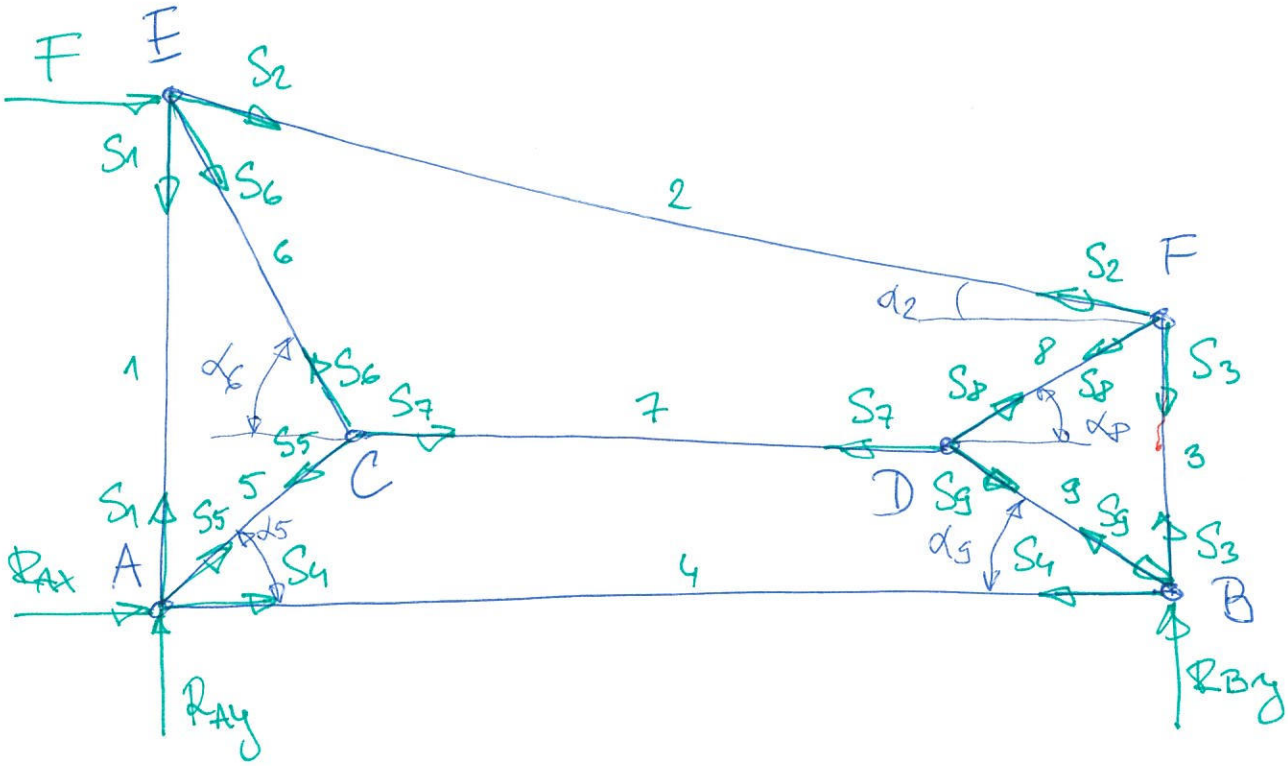


Ú: • statickou a kinematickou určitost

• reakce R_A, R_B

• síly v prutech 1 až 9 (styčn. met.)

• síly v prutech 2, 7, 4 průsečnou metodou

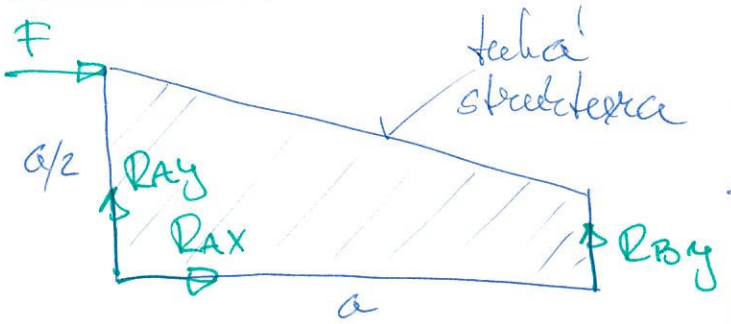


Statická a tvarová určitost

$2 \cdot s - p = 3$

$2 \cdot 6 - 9 = 3 \Rightarrow$ staticky i tvarově určitá pr. soust.

Reakce



$x: F + R_{Ax} = 0$

$y: R_{Ay} + R_{By} = 0$

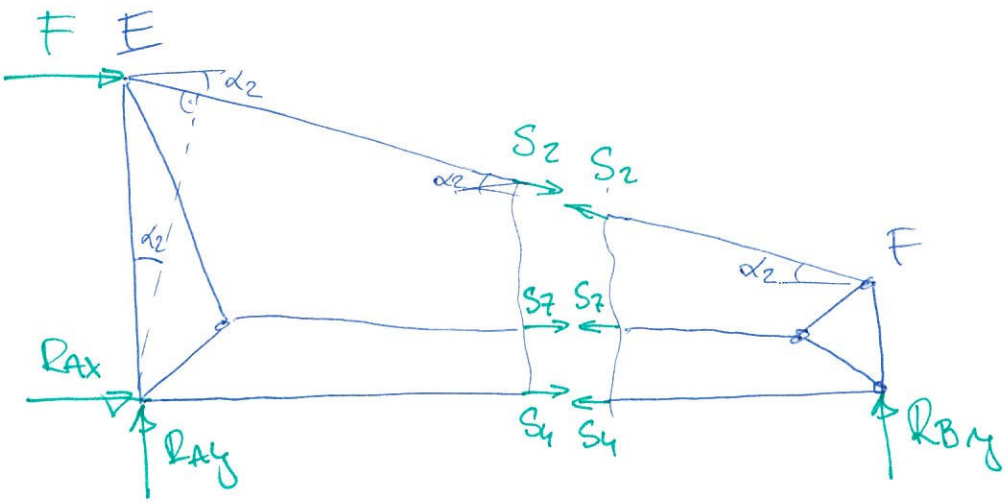
$M_A: R_{By} \cdot a - F \cdot a/2 = 0$

$R_{By} = \frac{F}{2}$

$R_{Ay} = -R_{By} = -\frac{F}{2}$

$R_{Ax} = -F$

Průsečná metoda (pruty 2,7,4)



Řešení levé části

$x: F + S_2 \cos\alpha_2 + R_{AX} + S_4 + S_7 = 0$

$y: R_{Ay} - S_2 \sin\alpha_2 = 0$

$M_A: -F\, a/2 - S_7 \cdot b/2 - S_2 \cdot \frac{a}{2} \cos\alpha_2 = 0$

lépe z bodu E

$M_E: R_{AX} \cdot a/2 + S_4 \cdot a/2 + S_7 \left(\frac{a}{2} - \frac{b}{2}\right) = 0$

Řešení pravé části

$x: -S_4 - S_7 - S_2 \cos\alpha_2 = 0$

$y: R_{By} + S_2 \sin\alpha_2 = 0$

$M_F: -S_7 \cdot \frac{b}{2} - S_4 \cdot b = 0$

Maticový zápis - levá část (S_2, S_4, S_7)

$$\begin{bmatrix} c\alpha_2 & 1 & 1 \\ -s\alpha_2 & \emptyset & \emptyset \\ -\frac{a}{2}c\alpha_2 & \emptyset & -b/2 \end{bmatrix} \cdot \begin{bmatrix} S_2 \\ S_4 \\ S_7 \end{bmatrix} = \begin{bmatrix} -R_{Ax} - F \\ -R_{Ay} \\ F\,a/2 \end{bmatrix}$$

nebo $$\begin{bmatrix} \emptyset & a/2 & \frac{a}{2} - \frac{b}{2} \end{bmatrix} \cdot \begin{bmatrix} S_2 \\ S_4 \\ S_7 \end{bmatrix} = \begin{bmatrix} -R_{Ax}\frac{a}{2} \end{bmatrix}$$

Maticový zápis - pravá část

$$\begin{bmatrix} -\cos\alpha_2 & -1 & -1 \\ \sin\alpha_2 & \emptyset & \emptyset \\ \emptyset & -b & -\frac{b}{2} \end{bmatrix} \begin{bmatrix} S_2 \\ S_4 \\ S_7 \end{bmatrix} = \begin{bmatrix} \emptyset \\ -R_{By} \\ \emptyset \end{bmatrix}$$

Levá část - vyjádření sil

$$S_2 = \frac{R_{Ay}}{\sin\alpha_2} = \frac{-F/2}{\sin\alpha_2} \quad ✓$$

$$S_7 \cdot \frac{b}{2} = -F a/2 - S_2 \frac{a}{2} \cos\alpha_2$$

$$S_7 \cdot \frac{b}{2} = -F\frac{a}{2} + \frac{F}{2} \cdot \frac{a}{2} \cdot \frac{\cos\alpha_2}{\sin\alpha_2} = F\frac{a}{2}\left[\frac{\cot g\,\alpha_2}{2} - 1\right]$$

$$S_7 = F \cdot \frac{a}{b}\left[\frac{1}{2}\cot g\,\alpha_2 - 1\right] \quad ✓$$

$$S_4 = -F - S_2\cos\alpha_2 - R_{Ax} - S_7$$

$$= \cancel{-F} + \frac{F}{2} \cdot \frac{\cos\alpha_2}{\sin\alpha_2} \cancel{+F} - F\frac{a}{b}\left[\frac{1}{2}\cot g\,\alpha_2 - 1\right]$$

$$= F\left[\frac{1}{2}\cot g\,\alpha_2 - \frac{a}{b}\frac{1}{2}\cot g\,\alpha_2 + \frac{a}{b}\right] \quad ✓$$

Pravá část

$$S_2 = -\frac{R_{By}}{\sin\alpha_2} = \frac{-\frac{F}{2}}{\sin\alpha_2} = -\frac{F/2}{\sin\alpha_2}$$

$$-S_4 - S_7 + \frac{F/2}{\sin\alpha_2} \cdot \cos\alpha_2 = 0 \Rightarrow S_4 = -S_7 + \frac{F/2}{\sin\alpha_2} \cdot \cos\alpha_2$$

$$= -F \cdot \frac{1}{\tan\alpha_2} + \frac{F}{2\tan\alpha_2}$$

$$= -\frac{F}{2\tan\alpha_2} \quad ✓$$

$$-S_7 \cdot \frac{b}{2} + S_7 \cdot b - F/2 \cdot b \cdot \cot g\,\alpha_2 = 0$$

$$S_7\left[b - \frac{b}{2}\right] - F/2\, b \cot g\,\alpha_2 = 0 \Rightarrow S_7 = \frac{F}{2} b \cot g\,\alpha_2 \cdot \frac{2}{b}$$

$$S_7 = F \cdot \cot g\,\alpha_2 \quad ✓$$

Styčníková metoda

A: x: $R_{Ax} + S_4 + S_5 \cos\alpha_5 = 0$

y: $S_1 + R_{Ay} + S_5 \sin\alpha_5 = 0$

B: x: $-S_4 - S_9 \cos\alpha_9 = 0$

y: $R_{By} + S_3 + S_9 \sin\alpha_9 = 0$

C: x: $S_7 - S_6 \cos\alpha_6 - S_5 \cos\alpha_5 = 0$

y: $S_6 \sin\alpha_6 - S_5 \sin\alpha_5 = 0$

D: x: $S_8 \cos\alpha_8 + S_9 \cos\alpha_9 - S_7 = 0$

y: $S_8 \sin\alpha_8 - S_9 \sin\alpha_9 = 0$

E: x: $S_2 \cos\alpha_2 + S_6 \cdot \cos\alpha_6 + F = 0$

y: $-S_1 - S_6 \sin\alpha_6 - S_2 \sin\alpha_2 = 0$

F: x: $-S_2 \cos\alpha_2 - S_8 \cdot \cos\alpha_8 = 0$

y: $-S_3 - S_8 \sin\alpha_8 + S_2 \sin\alpha_2 = 0$

$$tg\,\alpha_2 = \frac{(a/2 - b)}{a} \qquad tg\,\alpha_6 = \frac{\frac{a}{2} - \frac{b}{2}}{b} \qquad tg\,\alpha_9 = \frac{\frac{b}{2}}{b}$$

$$tg\,\alpha_5 = \frac{b/2}{b} \qquad tg\,\alpha_8 = \frac{b/2}{b}$$

$$
\begin{array}{c}
\\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12
\end{array}
\begin{array}{c}
\begin{array}{cccccccccccc}
S_1 & S_2 & S_3 & S_4 & S_5 & S_6 & S_7 & S_8 & S_9 & R_{Ax} & R_{Ay} & R_{By}
\end{array} \\
\begin{bmatrix}
\emptyset & \emptyset & \emptyset & 1 & \cos\alpha_5 & \emptyset & \emptyset & \emptyset & \emptyset & 1 & \emptyset & \emptyset \\
1 & & & & \sin\alpha_5 & & & & & & 1 & \\
 & & & -1 & & & & & -c\alpha_9 & & & \\
 & & 1 & & & & & & s\alpha_9 & & & 1 \\
 & & & & -c\alpha_5 & -c\alpha_6 & 1 & & & & & \\
 & & & & -s\alpha_5 & s\alpha_6 & & & & & & \\
 & & & & & & -1 & c\alpha_8 & c\alpha_9 & & & \\
 & & & & & & & s\alpha_8 & -s\alpha_9 & & & \\
 & c\alpha_2 & & & & c\alpha_6 & & & & & & \\
-1 & -s\alpha_2 & & & & -s\alpha_6 & & & & & & \\
 & -c\alpha_2 & & & & & & -c\alpha_8 & & & & \\
 & s\alpha_2 & -1 & & & & & -s\alpha_8 & & & &
\end{bmatrix}
\end{array}
\begin{bmatrix}
S_1 \\ S_2 \\ S_3 \\ S_4 \\ S_5 \\ S_6 \\ S_7 \\ S_8 \\ S_9 \\ R_{Ax} \\ R_{Ay} \\ R_{By}
\end{bmatrix}
=
\begin{bmatrix}
\emptyset \\ \emptyset \\ \emptyset \\ \emptyset \\ \emptyset \\ \emptyset \\ \emptyset \\ \emptyset \\ -F \\ \emptyset \\ \emptyset \\ \emptyset
\end{bmatrix}
$$