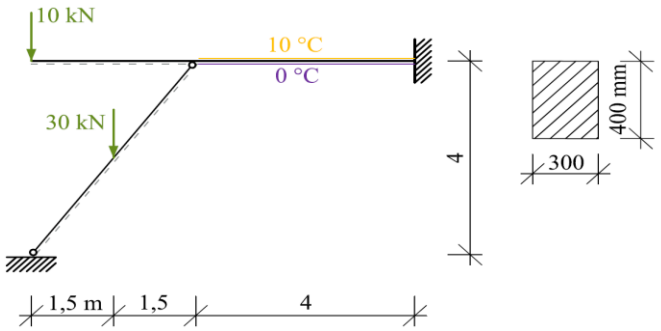
Na zadané prutové konstrukci pomocí obecné deformační metody vykreslete průběhy vnitřních sil.

$E = 25$ GPa

$\alpha_T = 1 \cdot 10^{-5}\ °C^{-1}$



1) Výpočtový model, n_p = 2

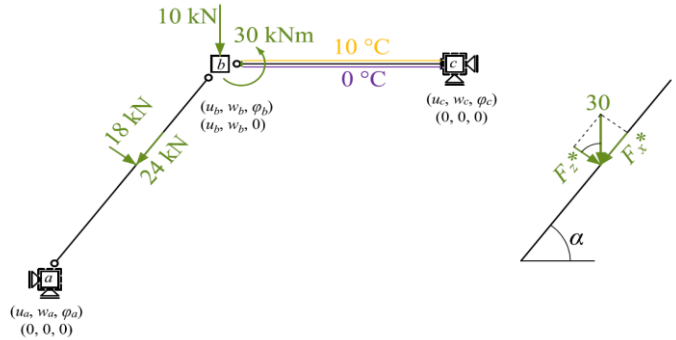
$l = \sqrt{3^2 + 4^2} = 5$ m

$\sin\alpha = \frac{4}{5} = 0{,}8$

$\cos\alpha = \frac{3}{5} = 0{,}6$

$F_x^* = F \cdot \sin\alpha = 24$ kN

$F_z^* = F \cdot \cos\alpha = 18$ kN



jednotky: [m, rad, kN, kPa]

{r}

u_b
w_b

{S}

0	***X_b***
10	***Z_b***

Analýza prutů -- PRIMÁRNÍ ÚČINKY

Prut a-b

gamma	5.3558901	**[rad]**	306.8699 [deg]
sin gamma	-0.80		
cos gamma	0.60		
b	0.30	[m]	
h	0.40	[m]	
delka	5	[m]	
E	2.50E+07	[kPa]	
A	0.12	[m2]	
I	1.60E-03	[m4]	
EA	3.00E+06	[kPa*m2]	
EI	4.00E+04	[kPa*m4]	

[T_ab]

0.60	-0.80	0	0	0	0
0.80	0.60	0	0	0	0
0	0	1	0	0	0
0	0	0	0.60	-0.80	0
0	0	0	0.80	0.60	0
0	0	0	0	0	1

[T_ab]^T

0.60	0.80	0	0	0	0
-0.80	0.60	0	0	0	0
0	0	1	0	0	0
0	0	0	0.60	0.80	0
0	0	0	-0.80	0.60	0
0	0	0	0	0	1

d) kloub-kloub

[k_ab]*

u_ab	*w_ab*	*phi_ab*	***u_ba***	***w_ba***	*phi_ba*	
600000.00	0.00	0.00	**-600000.00**	**0.00**	0.00	*X_ab*
0.00	0.00	0.00	**0.00**	**0.00**	0.00	*Z_ab*
0.00	0.00	0.00	**0.00**	**0.00**	0.00	*M_ab*
-600000.00	0.00	0.00	**600000.00**	**0.00**	0.00	***X_ba***
0.00	0.00	0.00	**0.00**	**0.00**	0.00	***Z_ba***
0.00	0.00	0.00	**0.00**	**0.00**	0.00	*M_ba*

[k_ab]

u_ab	*w_ab*	*phi_ab*	***u_ba***	***w_ba***	*phi_ba*	
216000.00	-288000.00	0.00	-216000.00	288000.00	0.00	*X_ab*
-288000.00	384000.00	0.00	288000.00	-384000.00	0.00	*Z_ab*
0.00	0.00	0.00	0.00	0.00	0.00	*M_ab*
-216000.00	288000.00	0.00	**216000.00**	**-288000.00**	0.00	***X_ba***
288000.00	-384000.00	0.00	**-288000.00**	**384000.00**	0.00	***Z_ba***
0.00	0.00	0.00	0.00	0.00	0.00	*M_ba*

Prut b-c

gamma	0	**[rad]**	0 [deg]
sin gamma	0.00		
cos gamma	1.00		
b	0.30	[m]	
h	0.40	[m]	
delka	4	[m]	
E	2.50E+07	[kPa]	
A	0.12	[m2]	
I	1.60E-03	[m4]	
EA	3.00E+06	[kPa*m2]	
EI	4.00E+04	[kPa*m4]	

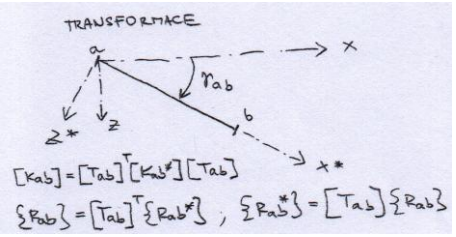
[T_bc]

1.00	0.00	0	0	0	0
0.00	1.00	0	0	0	0
0	0	1	0	0	0
0	0	0	1.00	0.00	0
0	0	0	0.00	1.00	0
0	0	0	0	0	1

[T_bc]^T

1.00	0.00	0	0	0	0
0.00	1.00	0	0	0	0
0	0	1	0	0	0
0	0	0	1.00	0.00	0
0	0	0	0.00	1.00	0
0	0	0	0	0	1

$$T_{ab} = \begin{bmatrix} \cos\gamma_{ab} & \sin\gamma_{ab} & 0 & 0 & 0 & 0 \\ -\sin\gamma_{ab} & \cos\gamma_{ab} & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & \cos\gamma_{ab} & \sin\gamma_{ab} & 0 \\ 0 & 0 & 0 & -\sin\gamma_{ab} & \cos\gamma_{ab} & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$



c) kloub-vetknutí

[k_bc]*

u_bc	***w_bc***	*phi_bc*	*u_cb*	*w_cb*	*phi_cb*	
750000.00	**0.00**	0.00	-750000.00	0.00	0.00	***X_bc***
0.00	**1875.00**	0.00	0.00	-1875.00	-7500.00	***Z_bc***
0.00	**0.00**	0.00	0.00	0.00	0.00	*M_bc*
-750000.00	**0.00**	0.00	750000.00	0.00	0.00	*X_cb*
0.00	**-1875.00**	0.00	0.00	1875.00	7500.00	*Z_cb*
0.00	**-7500.00**	0.00	0.00	7500.00	30000.00	*M_cb*

[k_bc]

u_bc	***w_bc***	*phi_bc*	*u_cb*	*w_cb*	*phi_cb*	
750000.00	**0.00**	0.00	-750000.00	0.00	0.00	***X_bc***
0.00	**1875.00**	0.00	0.00	-1875.00	-7500.00	***Z_bc***
0.00	**0.00**	0.00	0.00	0.00	0.00	*M_bc*
-750000.00	**0.00**	0.00	750000.00	0.00	0.00	*X_cb*
0.00	**-1875.00**	0.00	0.00	1875.00	7500.00	*Z_cb*
0.00	**-7500.00**	0.00	0.00	7500.00	30000.00	*M_cb*

[k_ab]=[T_ab]^T *[k_ab]* *[T_ab]

Fx	n	M	t0				
Fz	q		t1/h				
a		a	alpha_t				
b		b	EA				
l	l	l	EI				
-24	0	0	0				
18	0		0				
2.5		0	0				
2.5		0	3.00E+06				
5	5	5	4.00E+04				
{Rp_ab}*	12.00	0.00	0.00	0.00	0.00	**12.00**	*X_ab*
	-9.00	0.00	0.00	0.00	0.00	**-9.00**	*Z_ab*
	0.00	0.00	0.00	0.00	0.00	**0.00**	*M_ab*
	12.00	0.00	0.00	0.00	0.00	***X_ba***	***X_ba***
	-9.00	0.00	0.00	0.00	0.00	***Z_ba***	***Z_ba***
	0.00	0.00	0.00	0.00	0.00	**0.00**	*M_ba*

{Rp_ab}	**0.00**	*X_ab*
	-15.00	*Z_ab*
	0.00	*M_ab*
	0.00	***X_ba***
	-15.00	***Z_ba***
	0.00	*M_ba*

Fx	n	M	t0				
Fz	q		t1/h				
a		a	alpha_t				
b		b	EA				
l	l	l	EI				
0	0	30	5				
0	0		-25				
0		0	0.00001				
0		4	3.00E+06				
4	4	4	4.00E+04				
{Rp_bc}*	0.00	0.00	0.00	150.00	150.00	***X_bc***	***X_bc***
	0.00	0.00	-11.25	-3.75	-15.00	***Z_bc***	***Z_bc***
	0.00	0.00	0.00	0.00	0.00	**0.00**	*M_bc*
	0.00	0.00	0.00	-150.00	-150.00	**-150.00**	*X_cb*
	0.00	0.00	11.25	3.75	15.00	**15.00**	*Z_cb*
	0.00	0.00	15.00	15.00	30.00	**30.00**	*M_cb*

{Rp_bc}	**150.00**	***X_bc***
	-15.00	***Z_bc***
	0.00	*M_bc*
	-150.00	*X_cb*
	15.00	*Z_cb*
	30.00	*M_cb*

{R_ab}=[T_ab]^T * {R_ab}*

Soustava rovnic

	u_b	***w_b***	
[K]	966000.00	-288000	***X_b***
	-288000	385875	***Z_b***

{Rp}	150.00	***X_b***
	-30	***Z_b***

{F}	-150.00	***X_b***
	40	***Z_b***

{F}={S}-{R}

{r}	-1.5997E-04	***u_b***	[m]
	-1.5734E-05	***w_b***	[m]

[K]*{r}={F} --> {r}=[K]^(-1) * {F}

Analýza prutů -- SEKUNDÁRNÍ ÚČINKY

Prut a-b

{r_ab}	0	*u_ab*
	0	*w_ab*
	0	*phi_ab*
	-1.5997E-04	***u_ba***
	-1.5734E-05	***w_ba***
	0	*phi_ba*

{Rs_ab}	**30.02**	*X_ab*
	-40.03	*Z_ab*
	0.00	*M_ab*
	-30.02	***X_ba***
	40.03	***Z_ba***
	0.00	*M_ba*

{Rs_ab}*	**50.04**	*X_ab*
	0.00	*Z_ab*
	0.00	*M_ab*
	-50.04	***X_ba***
	0.00	***Z_ba***
	0.00	*M_ba*

CELKOVÉ ÚČINKY

{R_ab}	**30.02**	*X_ab*
	-55.03	*Z_ab*
	0.00	*M_ab*
	-30.02	***X_ba***
	25.03	***Z_ba***
	0.00	*M_ba*

{R_ab}*	**62.04**	*X_ab*
	-9.00	*Z_ab*
	0.00	*M_ab*
	-38.04	***X_ba***
	-9.00	***Z_ba***
	0.00	*M_ba*

Prut b-c

{r_bc}	-1.5997E-04	***u_bc***
	-1.5734E-05	***w_bc***
	0	*phi_bc*
	0	*u_cb*
	0	*w_cb*
	0	*phi_cb*

{Rs_bc}	**-119.98**	***X_bc***
	-0.03	***Z_bc***
	0.00	*M_bc*
	119.98	*X_cb*
	0.03	*Z_cb*
	0.12	*M_cb*

{Rs_bc}*	**-119.98**	***X_bc***
	-0.03	***Z_bc***
	0.00	*M_bc*
	119.98	*X_cb*
	0.03	*Z_cb*
	0.12	*M_cb*

CELKOVÉ ÚČINKY

{R_bc}	**30.02**	***X_bc***
	-15.03	***Z_bc***
	0.00	*M_bc*
	-30.02	*X_cb*
	15.03	*Z_cb*
	30.12	*M_cb*

{R_bc}*	**30.02**	***X_bc***
	-15.03	***Z_bc***
	0.00	*M_bc*
	-30.02	*X_cb*
	15.03	*Z_cb*
	30.12	*M_cb*

{R_ab}*=[T_ab] * {R_ab}

Vykreslení vnitřních sil