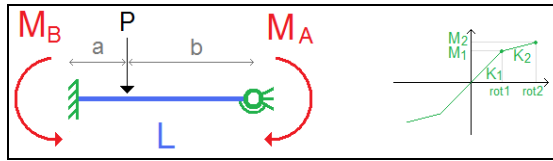


CURAN: BEAMS (HERMITIAN)	TEST 022	rev.1 21/10/13	version 10.70
VALIDATION, CROSS CHECKS, RELIABILITY, BENCHMARK	Tested by: Marco Croci - Checked by: Paolo Rugarli		



MODEL		
MODEL NAME	OUTPUT FILE	ANALYSIS TYPE
curanBE_022.WSR	curanBE_022.CS1.EEN	nonlinear static (Curan)

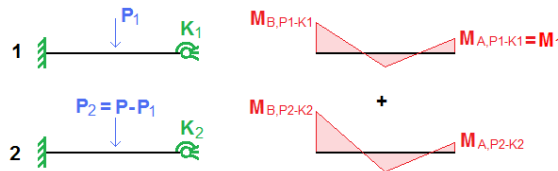
L [mm]	P [N]	a [mm]	b [mm]	E [N/mm ²]	I [mm ⁴]	K ₁ [Nmm/rad]	M ₁ [Nmm]	K ₂ [Nmm/rad]
1000	1000	500	500	210000	6.667E+03	4.200E+06	4.000E+04	4.200E+05

THEORETICAL COMPUTATION

Beam material is linear elastic (fibers are not modeled).

Final condition is the sum of two schemes:

- 1) stiffness equal to K_1 with a force equal to P_1 (the force causing $M_A=M_1$);
- 2) stiffness equal to K_2 with a force equal to $P_2=P-P_1$ (residual force).



To get moment values with P_1 , it is possible to compute the scheme (1) considering an indefinitely linear elastic spring and the full load P : the ratio between P_1 and P is equal to the ratio between M_1 and $M_{A,P-K1}$.

$$M_{A,P-K1} = \frac{r_1 PL}{4-r_1} \frac{a}{L} \frac{b}{L} \left[3 \left(1 - \frac{a}{L} \right) \right] \quad r_1 = \frac{1}{1 + \frac{3EI}{K_1 L}} = 0.5 \quad P_1 = P \frac{M_1}{M_{A,P-K1}}$$

$$P_2 = P - P_1 \quad M_{B,P1-K1} = \frac{P_1 L}{4-r_1} \frac{a}{L} \frac{b}{L} \left[2 \left(1 + \frac{a}{L} \right) - 0.5 \left(2 - \frac{a}{L} \right) \right]$$

$$M_{A,P2-K2} = \frac{r_2 P_2 L}{4-r_2} \frac{a}{L} \frac{b}{L} \left[3 \left(1 - \frac{a}{L} \right) \right] \quad M_{B,P2-K2} = \frac{P_2 L}{4-r_2} \frac{a}{L} \frac{b}{L} \left[2 \left(1 + \frac{a}{L} \right) - 0.5 \left(2 - \frac{a}{L} \right) \right]$$

$$r_2 = \frac{1}{1 + \frac{3EI}{K_2 L}} = 0.09 \quad M_{A,total} = M_1 + M_{A,P2-K2} \quad M_{B,total} = M_{B,P1-K1} + M_{B,P2-K2}$$

CROSS-CHECK

End Moment	Theory [Nmm]	Sargon [Nmm]	% difference (S-T)/T*100
$M_A=M_{1,limit}$	4.221E+04	4.254E+04	0.8
$M_B=M_{B,total}$	1.664E+05	1.662E+05	-0.1

NOTES

- L force is parallel to web (strong axis bending).
- Formulae for M_A and M_B computation given in *Practical Analysis of Semi-Rigid Frame Design*, Editor: W F Chen, World Scientific Publishing.
- $r_1=0$: hinge; $r_1=1$: fixed. Shear area: not considered. Beam elements number: 2