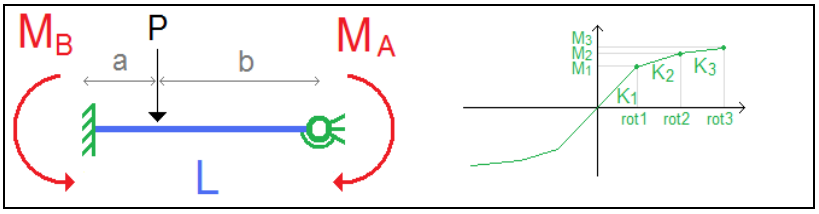
CURAN: BEAMS (HERMITIAN)	TEST 023	rev.1 21/10/13	version 10.70
VALIDATION, CROSS CHECKS, RELIABILITY, BENCHMARK	Tested by: Marco Croci - Checked by: Paolo Rugarli		



MODEL

MODEL NAME	OUTPUT FILE	ANALYSIS TYPE
curanBE_023.WSR	curanBE_023.CS1.EEN	nonlinear static (Curan)

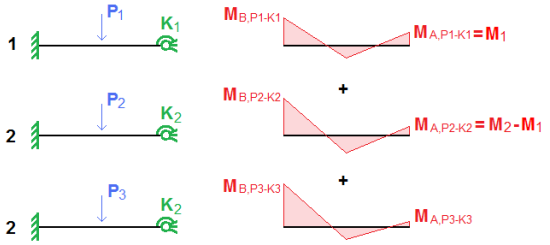
L [mm]	P [N]	a [mm]	b [mm]	E [N/mm^2]	I [mm^4]	K_1 [Nmm/rad]	M_1 [Nmm]	K_2 [Nmm/rad]	M_2 [Nmm]	K_3 [Nmm/rad]
1000	1000	500	500	210000	6.667E+03	4.200E+06	4.000E+04	4.200E+05	4.000E+04	4.200E+05

THEORETICAL COMPUTATION

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

Final condition is the sum of 3 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 (the force causing $M_A=M_2-M_1$);
2) stiffness equal to K_3 with a force equal to $P_3=P-P_1-P_2$ (residual force).



This case is similar to the one in the previous test, where a bilinear law was assumed instead of a trilinear one. See previous case for computation details; in this case the load is divided into three steps instead of two.

$$M_{A,P_i-K_1}=\frac{r_i P_i L}{4-r_i}\frac{a}{L}\frac{b}{L}\left[3\left(1-\frac{a}{L}\right)\right] \qquad M_{B,Pi-Ki}=\frac{P_i L}{4-r_i}\frac{a}{L}\frac{b}{L}\left[2\left(1+\frac{a}{L}\right)-0.5\left(2-\frac{a}{L}\right)\right]$$

$$r_i=\frac{1}{1+\frac{3EI}{K_i L}}=0.5 \qquad P_1=P\frac{M_1}{M_{A,P-K1}} \qquad P_2=(P-P_1)\frac{(M_2-M_1)}{M_{A,(P-P1)-K2}} \qquad P_3=P-P_1-P_2$$

$$M_{A,total}=M_2+M_{A,P3-K3} \qquad M_{B,total}=M_{B,P1-K1}+M_{B,P2-K2}+M_{B,P3-K3}$$

CROSS-CHECK

End Moment	Theory [Nmm]	Sargon [Nmm]	% difference (S-T)/T*100
$M_A=M_{limit}$	4.142E+04	4.154E+04	0.3
$M_B=M_{B,total}$	1.668E+05	1.667E+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_i=0: hinge; r_i=1: fixed.
- shear area: not considered. Beam elements number: 2