

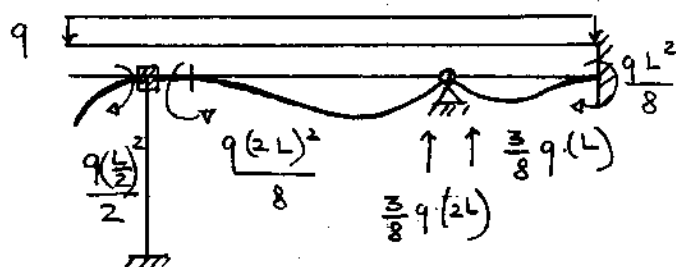
$$P = 500 \text{ Kg}$$

$$H = 300 \text{ cm}$$

$$65 \text{ mm} = 2400 \frac{\text{Kg}}{\text{cm}^2}$$

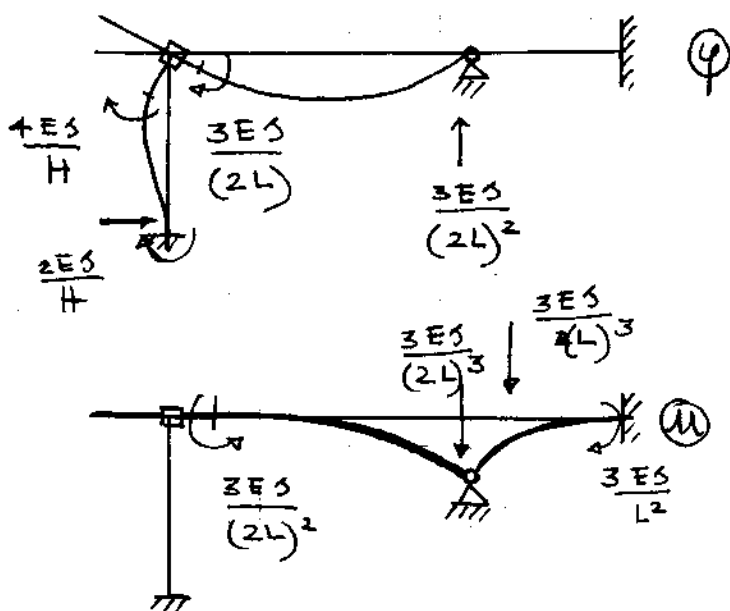
A) PROGETTARE LA STRUTTURA CON $P = 0$

PROVA A	PROVA B		
250	200	L	cm
10	15	q	Kg/cm



$$ES \begin{bmatrix} \frac{3}{2L} + \frac{4}{H} & -\frac{3}{4L^2} \\ -\frac{3}{4L^2} & \left(\frac{3}{8} + 3\right) \frac{1}{L^3} \end{bmatrix} \begin{bmatrix} \varphi \\ u \end{bmatrix} =$$

$$= \begin{bmatrix} \left(\frac{1}{2} - \frac{1}{8}\right)L \\ \frac{6}{8} + \frac{3}{8} \end{bmatrix} qL = \begin{bmatrix} 3 \\ 9 \end{bmatrix} \frac{qL}{8}$$



PROVA A

$$\Rightarrow \begin{cases} \varphi ES = +2,09263 \cdot 10^7 \text{ Kg} \cdot \text{cm}^2 \\ u ES = +1,41834 \cdot 10^{10} \text{ Kg} \cdot \text{cm}^3 \end{cases}$$

MOMENTI:

$$\circlearrowleft M_{AE} = \frac{2ES}{H} \varphi = 139509 \text{ Kg} \cdot \text{cm}$$

$$M_{EA} = \frac{4ES}{H} \varphi = 279017 \text{ Kg} \cdot \text{cm}$$

$$M_{ED} = \frac{qL^2}{8} = 78125 \text{ Kg} \cdot \text{cm}$$

$$\circlearrowleft M_{EF} = \frac{3}{2L} ES \varphi - \frac{3}{4L^2} ES u - \frac{qL^2}{2} = -357143 \text{ Kg} \cdot \text{cm}$$

$$\circlearrowleft M_{LF} = \frac{qL^2}{8} + \frac{3}{L^2} ES u = 758929 \text{ Kg} \cdot \text{cm}$$

PROVA B

$$\Rightarrow \begin{cases} \varphi ES = 1,875 \cdot 10^7 \text{ Kg} \cdot \text{cm}^2 \\ u ES = 8,83 \cdot 10^9 \text{ Kg} \cdot \text{cm}^3 \end{cases}$$

$$M_{AE} = 125000 \text{ Kg} \cdot \text{cm}$$

$$M_{EA} = 250000 \text{ Kg} \cdot \text{cm}$$

$$M_{ED} = 75000 \text{ Kg} \cdot \text{cm}$$

$$M_{EF} = -325000 \text{ Kg} \cdot \text{cm}$$

$$M_{LF} = 737500 \text{ Kg} \cdot \text{cm}$$

TAGLI:

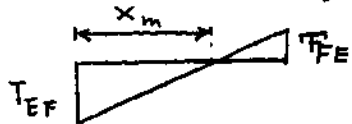
$$T_{AE} = \frac{6ES\psi}{H^2} = 1395 \text{ Kg}$$

$$T_{EA} = T_{AE} = 1395 \text{ Kg}$$

$$T_{ED} = \frac{qL}{2} = 1250 \text{ Kg}$$

$$T_{EF} = \frac{5}{8} q(2L) - \frac{3}{(2L)^2} ES\psi + \frac{3}{(2L)^3} ES\psi = 3214 \text{ Kg}$$

$$T_{FE} = \frac{3}{8} q(2L) + \frac{3}{(2L)^2} ES\psi - \frac{3}{(2L)^3} ES\psi = 1785,7 \text{ Kg}$$



$$\frac{x_m}{2L} = \frac{T_{EF}}{T_{EF} + T_{FE}} = 0,643 \Rightarrow x_m = 321,4 \text{ cm}$$

$$M_m = T_{EF} x_m - \frac{q x_m^2}{2} - M_{EF}$$

$$M_m = 159439 \text{ Kg}\cdot\text{cm}$$

$$T_{FL} = T_{FE}$$

$$T_{LF} = \frac{5}{8} qL + \frac{3}{L^3} ES\psi = 4285,71 \text{ Kg}$$

SFORZO NORMALE

$$N_{EA} = -\left(\frac{qL}{2} + \frac{5}{8} q(2L) - \frac{3}{(2L)^2} ES\psi + \frac{3}{(2L)^3} ES\psi\right)$$

$$N_{EA} = -4464 \text{ Kg}$$

$$N_{LC} = 2\left(\frac{5}{8} qL + \frac{3}{L^3} ES\psi\right) = -8571 \text{ Kg}$$

PROGETTO:

$$M_{max} = M_{LF} = 758929 \text{ Kg}\cdot\text{cm}$$

$$\Rightarrow W_{min} = \frac{M_{LF}}{6\sigma_{amm}} = 316 \text{ cm}^3$$

$$\Rightarrow \text{IPE 240 } (W_x = 324 \text{ cm}^3) \quad J_{xx} = 3892 \text{ cm}^4$$

$$A2) T_{max} = T_{LF} = 4285,71 \text{ Kg}$$

$$\tau_{max} = \tau_0 = \frac{T_{LF} S_{xx}}{5 J_{xx}} = 307 \frac{\text{Kg}}{\text{cm}^2}$$

$$T_{AE} = 1250 \text{ Kg}$$

$$T_{EA} = T_{AE}$$

$$T_{ED} = 1500 \text{ Kg}$$

$$T_{EF} = 3812,5 \text{ Kg}$$

$$T_{FE} = 2187,5 \text{ Kg}$$

$$x_m = 254,17 \text{ cm}$$

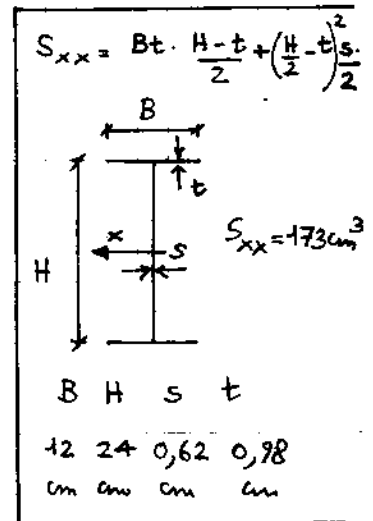
$$M_m = 159505 \text{ Kg}\cdot\text{cm}$$

$$T_{FL} = T_{FE}$$

$$T_{LF} = 5187,5 \text{ Kg}$$

$$N_{EA} = -5312,5 \text{ Kg}$$

$$N_{LC} = -10375 \text{ Kg}$$



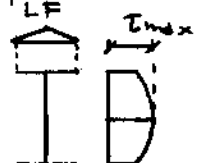
$$M_{max} = M_{LF} = 737500 \text{ Kg}\cdot\text{cm}$$

$$\Rightarrow W_{min} = \frac{M_{LF}}{6\sigma_{amm}} = 307 \text{ cm}^3$$

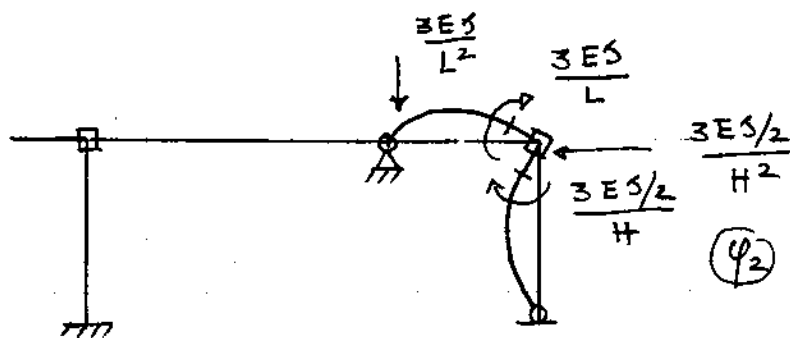
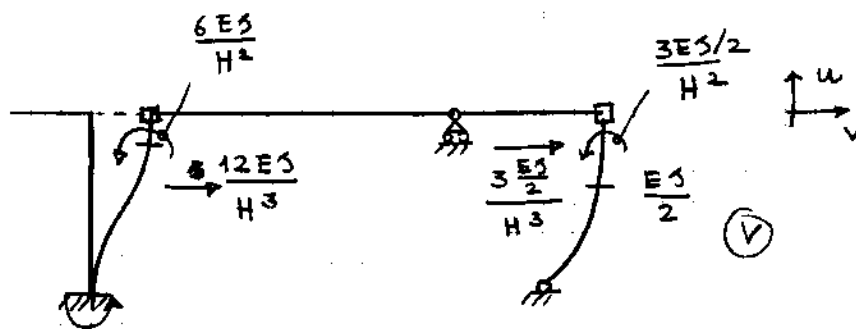
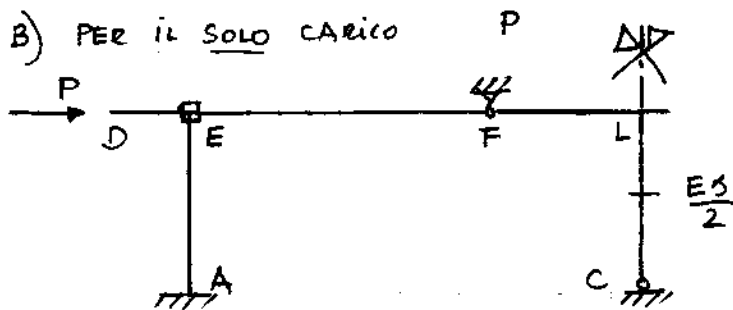
$$\Rightarrow \text{IPE 240 } (W_x = 324 \text{ cm}^3)$$

$$A2) T_{max} = 5187,5 \text{ Kg} = T_{LF}$$

$$\tau_{max} = 372 \frac{\text{Kg}}{\text{cm}^2}$$



B) PER IL SOLO CARICO P



$$ES \begin{bmatrix} \frac{3}{2L} + \frac{4}{H} & -\frac{3}{4L^2} & 0 & -\frac{6}{H^2} \\ -\frac{3}{4L^2} & \left(\frac{3}{8} + 3\right) \frac{1}{L^3} & \frac{3}{L^2} & 0 \\ 0 & +\frac{3}{L^2} & \frac{3}{L} + \frac{3}{2H} & -\frac{3}{2H^2} \\ -\frac{6}{H^2} & 0 & -\frac{3}{2H^2} & \left(12 + \frac{3}{2}\right) \frac{1}{H^3} \end{bmatrix} \begin{bmatrix} \varphi_1 \\ u \\ \varphi_2 \\ v \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ P \end{bmatrix}$$

PROVA A:

$$\Rightarrow \begin{cases} \varphi_1 ES = 6,71053 \cdot 10^6 \text{ Kg} \cdot \text{cm}^2 \\ u ES = -1,53509 \cdot 10^8 \text{ Kg} \cdot \text{cm}^3 \\ \varphi_2 ES = 2,36842 \cdot 10^6 \text{ Kg} \cdot \text{cm}^2 \\ v ES = 1,97368 \cdot 10^9 \text{ Kg} \cdot \text{cm}^3 \end{cases}$$

$$M_{AE} = \frac{6ES}{H^2} v - \frac{2ES}{H} \varphi_1 = 86842 \text{ Kg} \cdot \text{cm}$$

$$M_{EF} = -\frac{3ES}{2L} \varphi_1 + \frac{3}{(2L)^2} ES u = -42105 \text{ Kg} \cdot \text{cm}$$

PROVA B

$$\begin{cases} \varphi_1 ES = 5,83 \cdot 10^6 \text{ Kg} \cdot \text{cm}^2 \\ u ES = -3,7037 \cdot 10^7 \text{ Kg} \cdot \text{cm}^3 \\ \varphi_2 ES = 1,6 \cdot 10^6 \text{ Kg} \cdot \text{cm}^2 \\ v ES = 1,83 \cdot 10^9 \text{ Kg} \cdot \text{cm}^3 \end{cases}$$

$$M_{AE} = 83333,3 \text{ Kg} \cdot \text{cm}$$

$$M_{EF} = -44444,4 \text{ Kg} \cdot \text{cm}$$

$$M_{LF} = \frac{3}{L} ES \varphi_2 + \frac{3}{L^2} ES u = 21052,6 \text{ Kg.cm}$$

$$M_{LF} = 22222,2 \text{ Kg.cm}$$

$$M_{LC} = 2 \left(\frac{3}{2H} ES \varphi_2 - \frac{3}{2H^2} ES v \right) = 42105 \text{ Kg.cm}$$

$$M_{LC} = 2 M_{LF} = 44444,4 \text{ Kg.cm}$$

TAGLI:

TAGLI

$$T_{EA} = T_{AE} = \frac{12}{H^3} ES v - \frac{6}{H^2} ES \varphi_1 = 429,8 \text{ Kg}$$

$$T_{EA} = T_{AE} = 425,9 \text{ Kg}$$

$$T_{EF} = \frac{3}{(2L)^2} ES \varphi_1 - \frac{3}{(2L)^3} ES u = 84,21 \text{ Kg}$$

$$T_{EF} = 111,1 \text{ Kg}$$

$$T_{LC} = \frac{3}{H^2} ES \varphi_2 - \frac{3}{H^3} ES v = -140,3 \text{ Kg}$$

$$T_{LC} = 148,1 \text{ Kg}$$

SFORZO NORMALE:

SFORZO NORMALE

$$N_{DE} = -P = -500 \text{ Kg}$$

$$N_{DE} = -500 \text{ Kg}$$

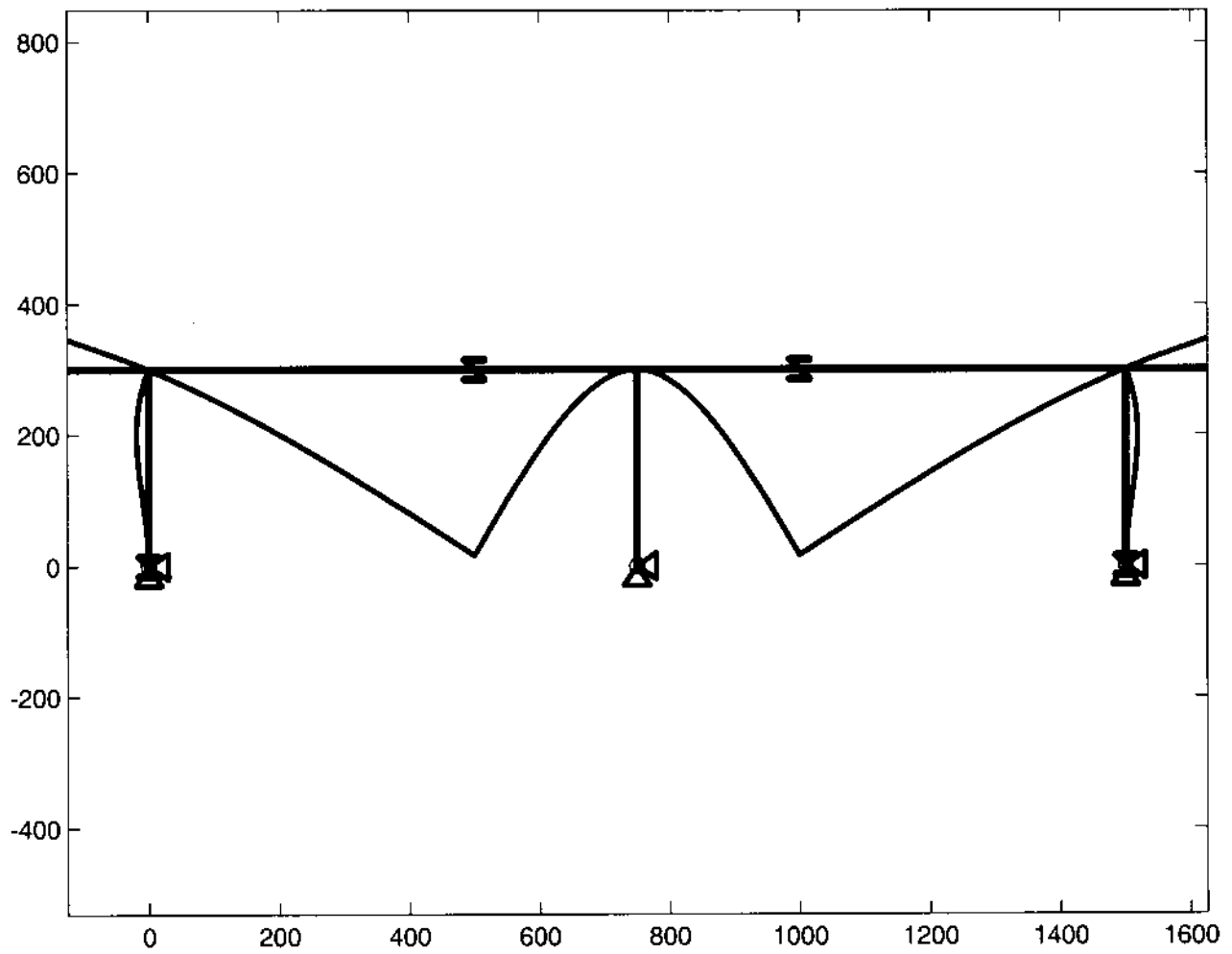
$$N_{EA} = T_{EF} = +84,21 \text{ Kg}$$

$$N_{EA} = T_{EF} = 111,1 \text{ Kg}$$

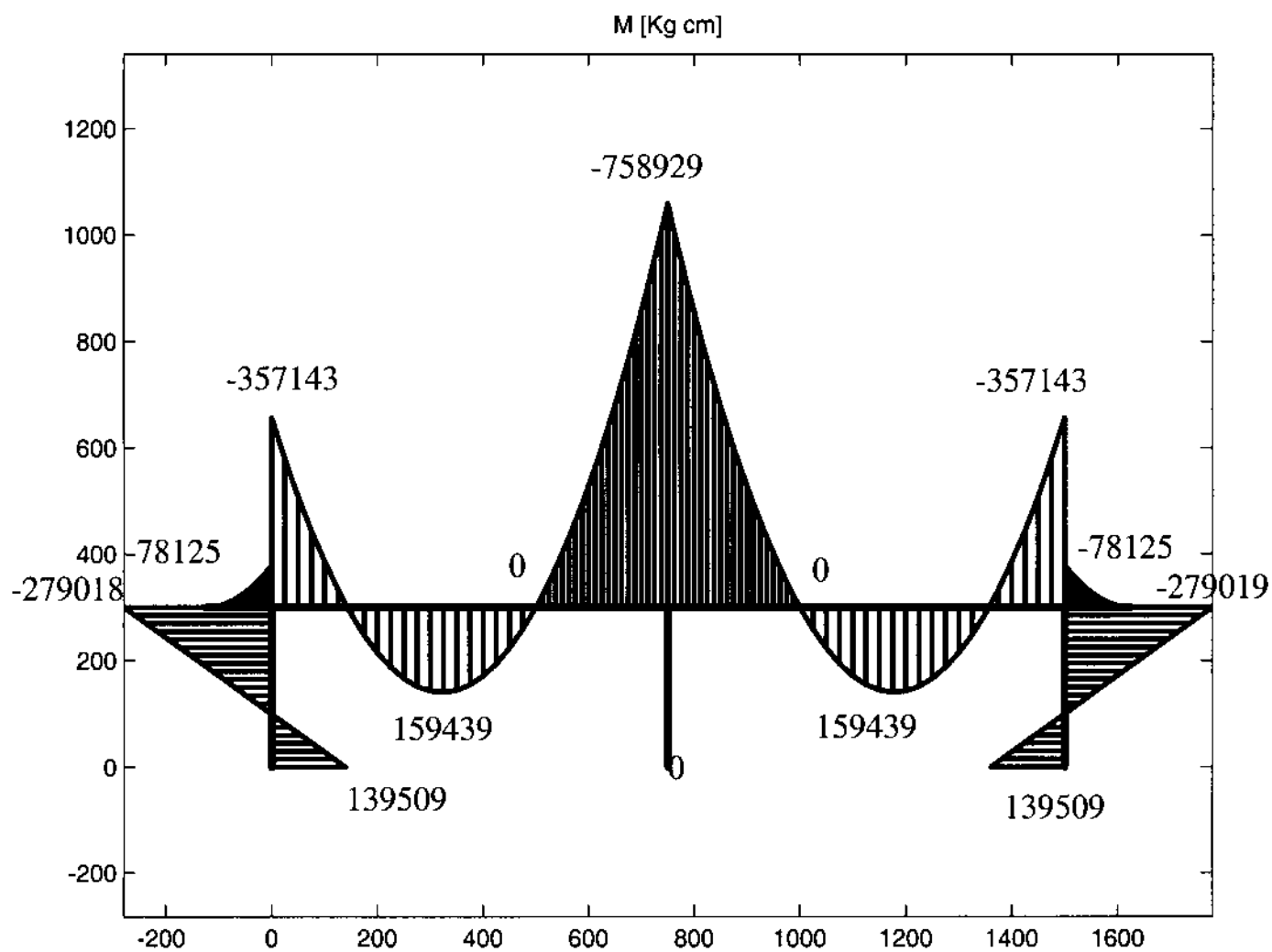
$$N_{EF} = T_{EA} + N_{DE} = -71,2 \text{ Kg}$$

$$N_{EF} = T_{EA} + N_{DE} = -74,1 \text{ Kg}$$

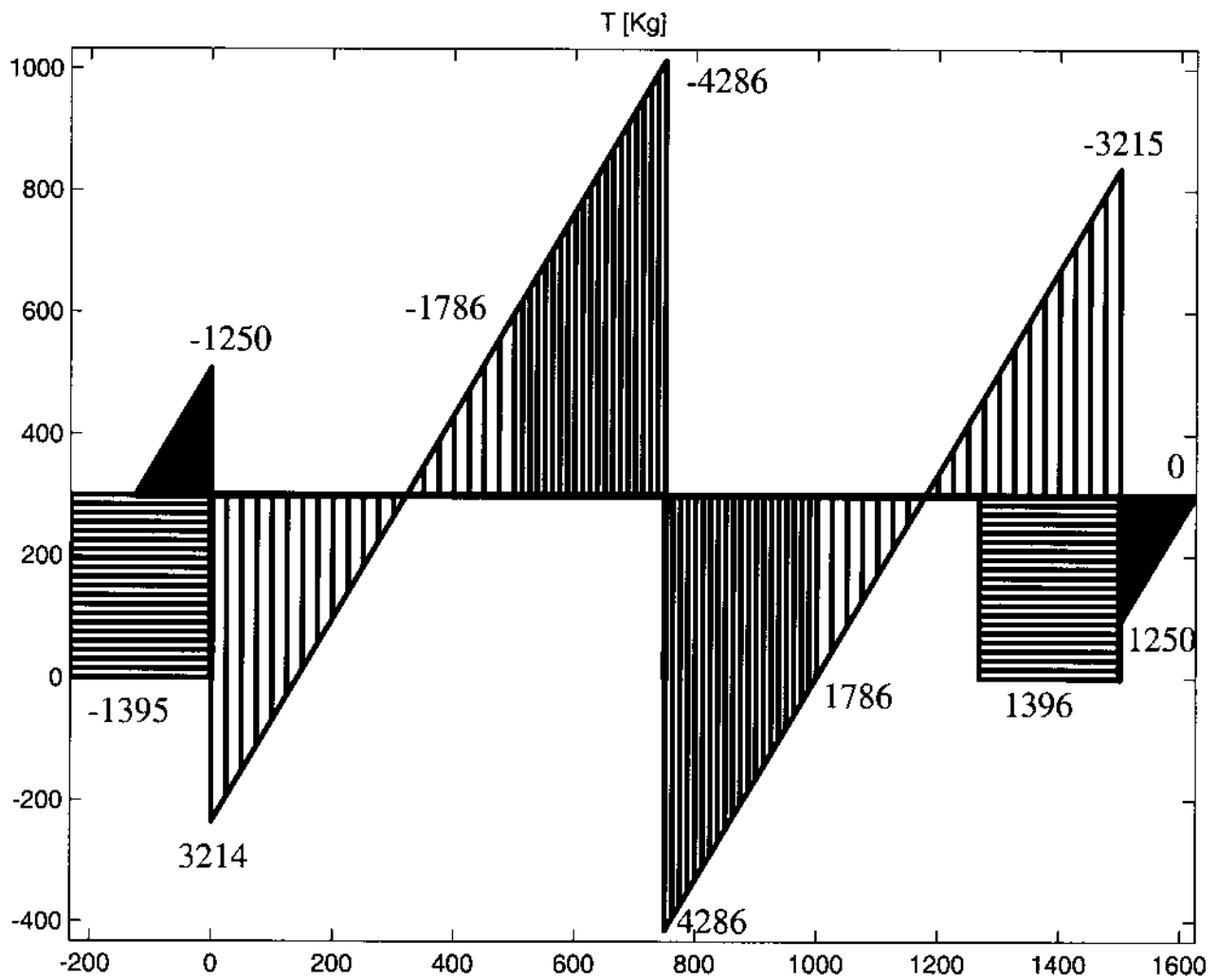
DEFORMATA Pto A1



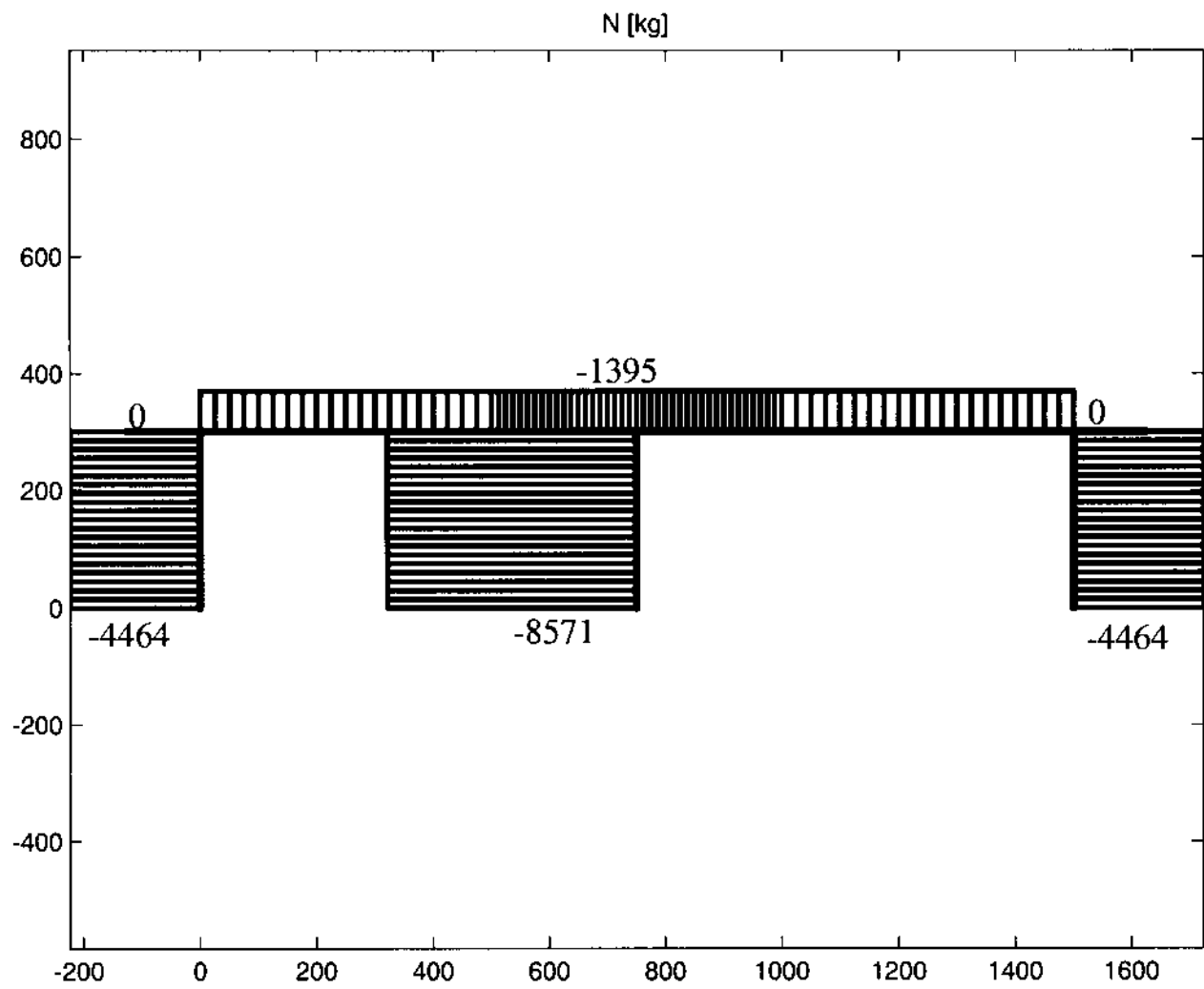
PROVA A pto A1



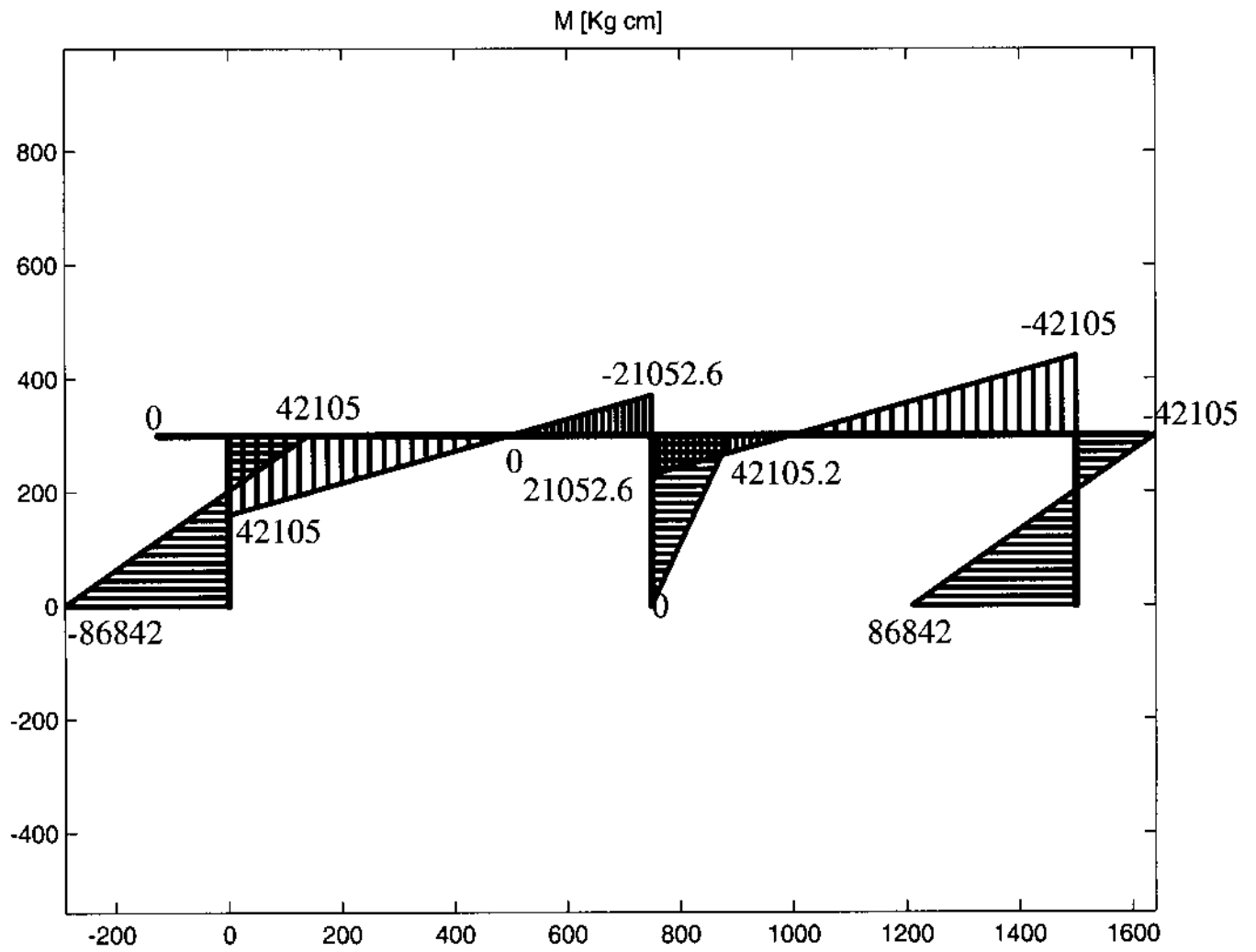
PROVA A PTO A1



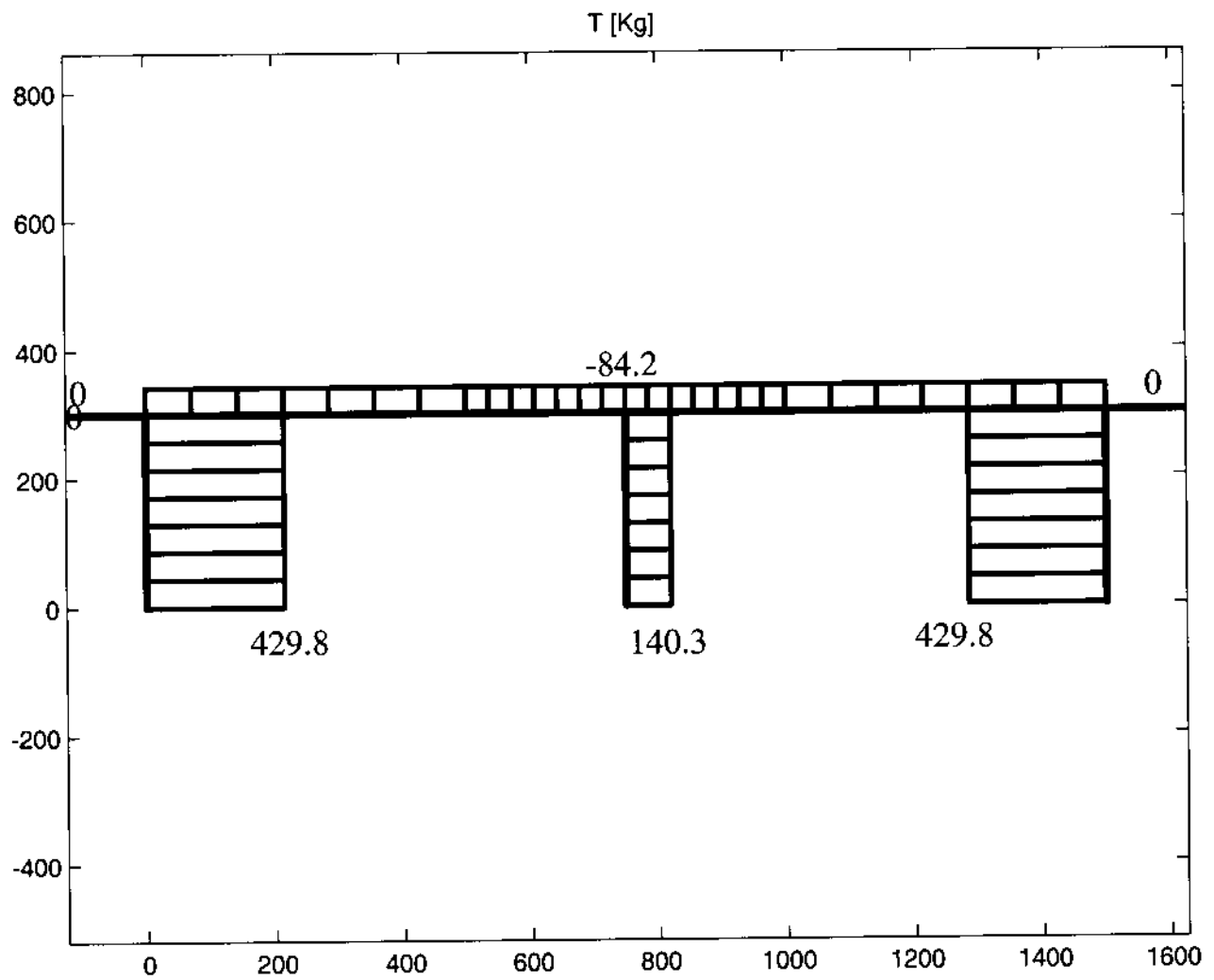
PROVA A PTO A1



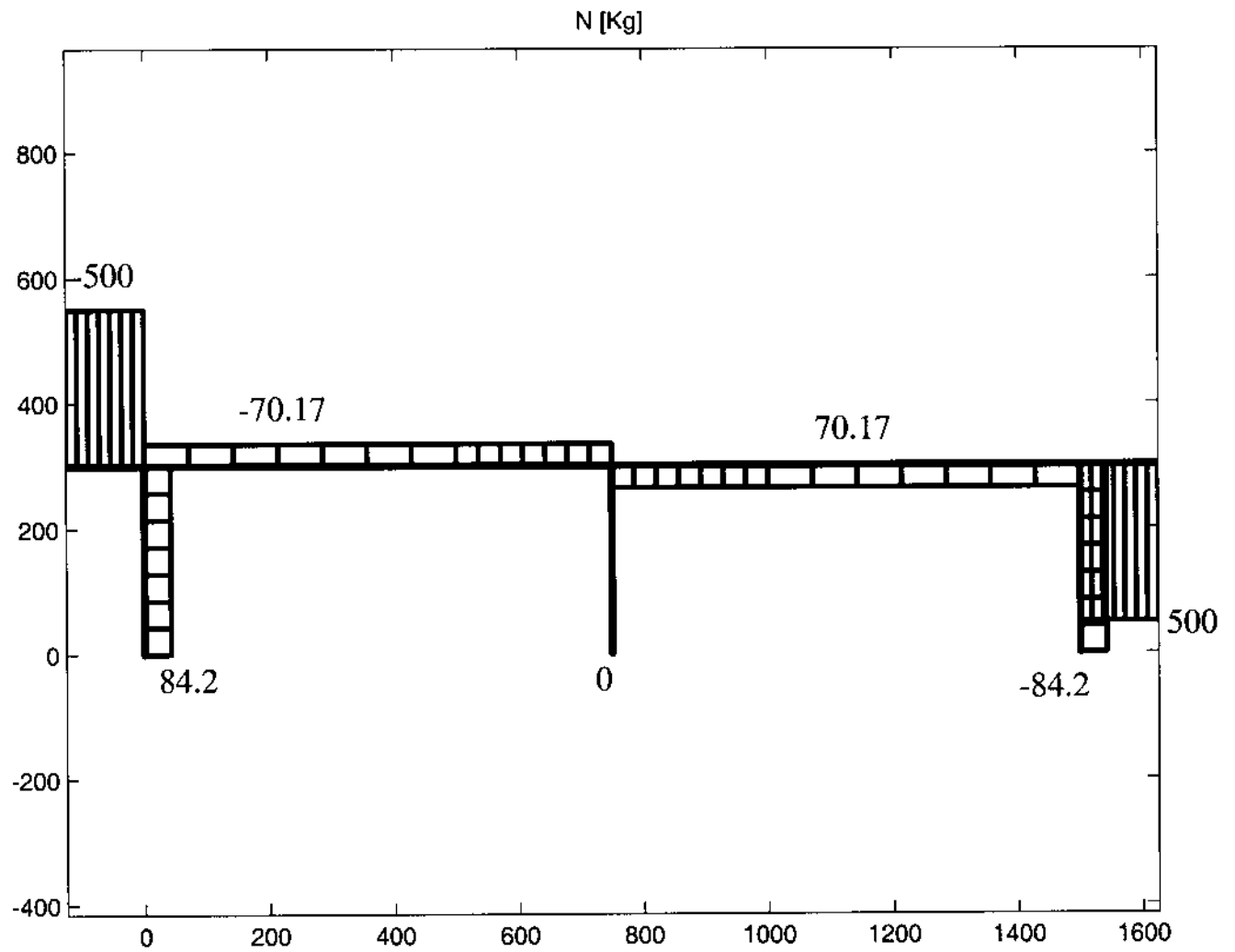
PROVA A PTO B

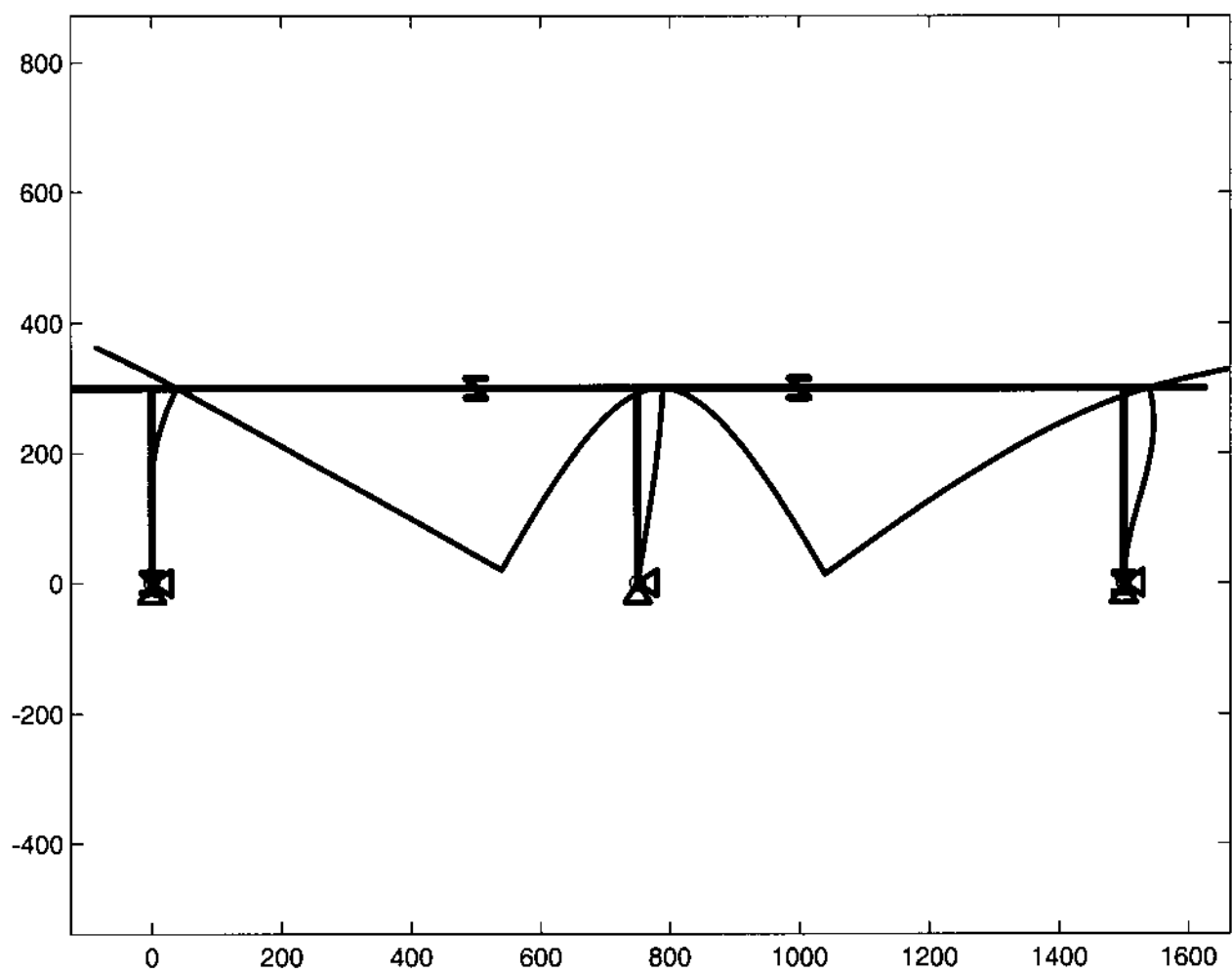


PROVA A PTO B

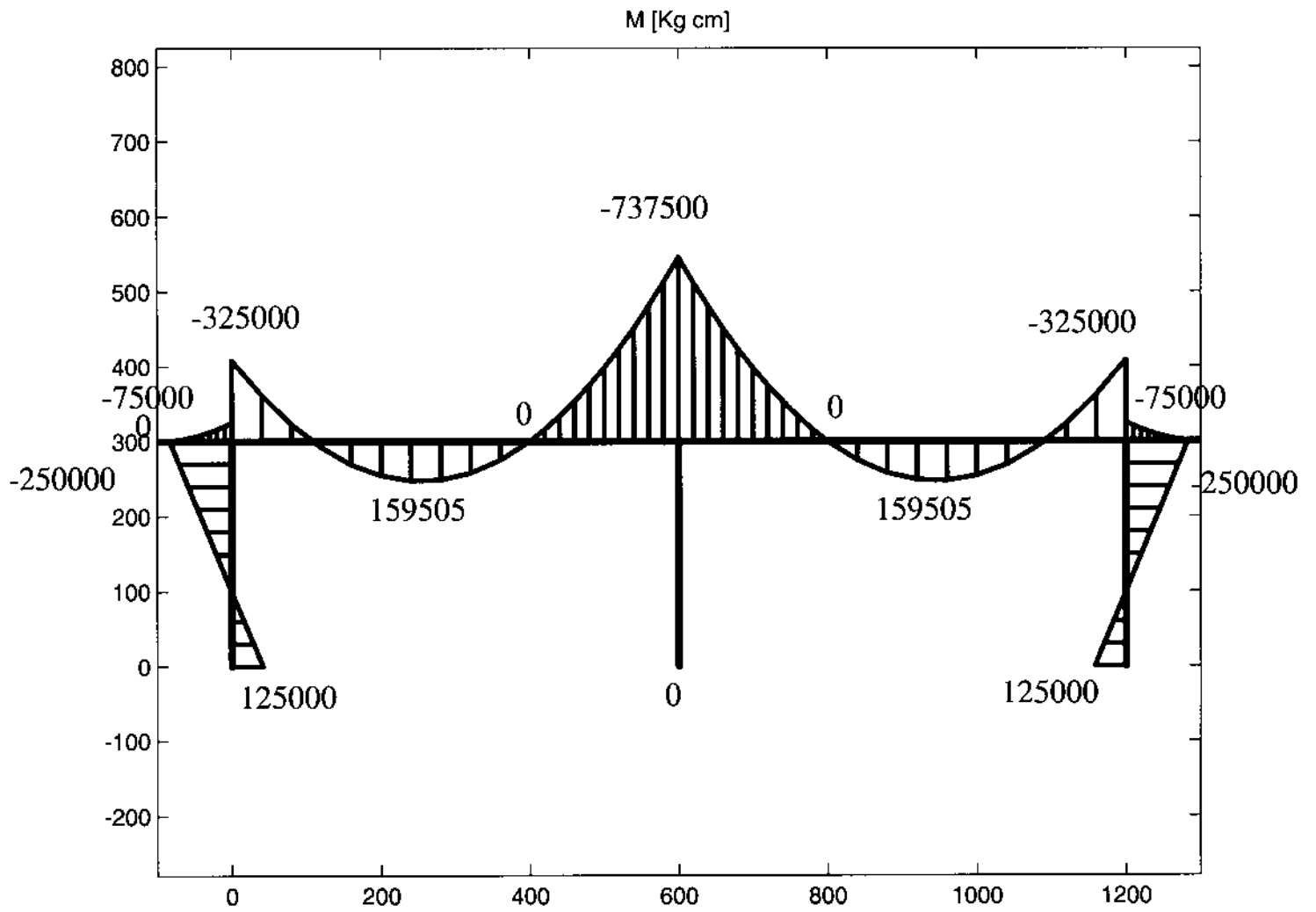


PROVA A PTO B

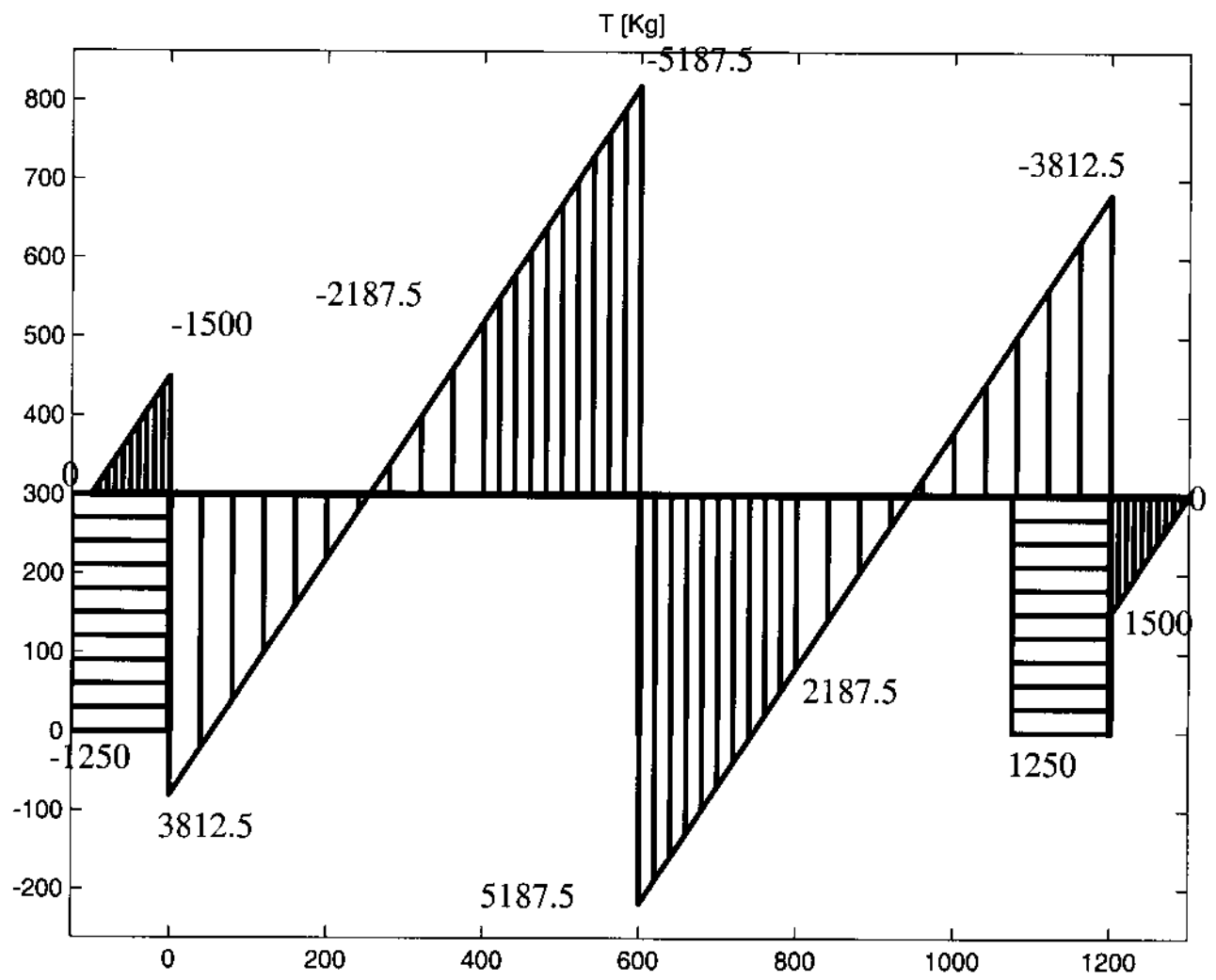




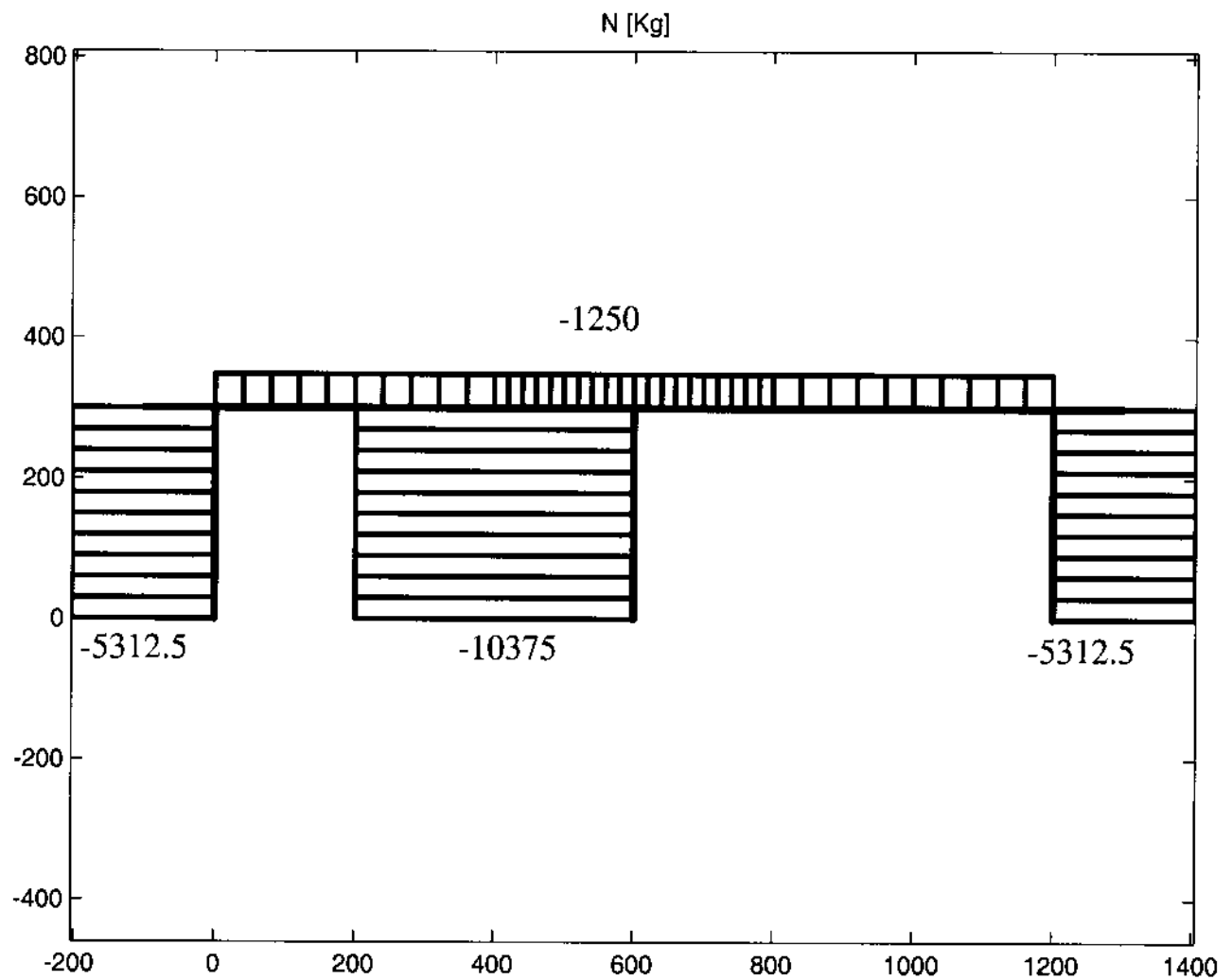
PROVA B PTO A1



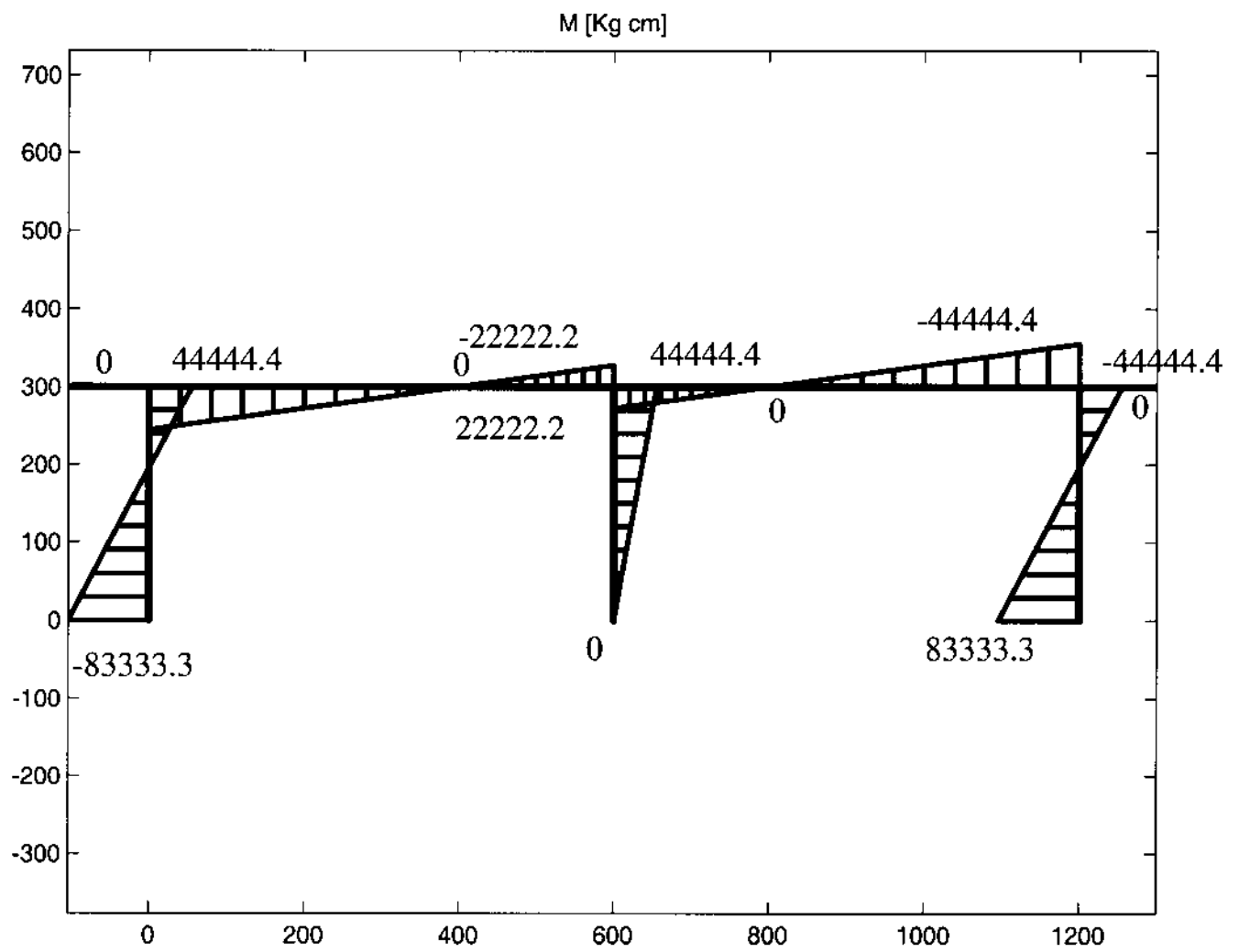
PROVA B PTO A1



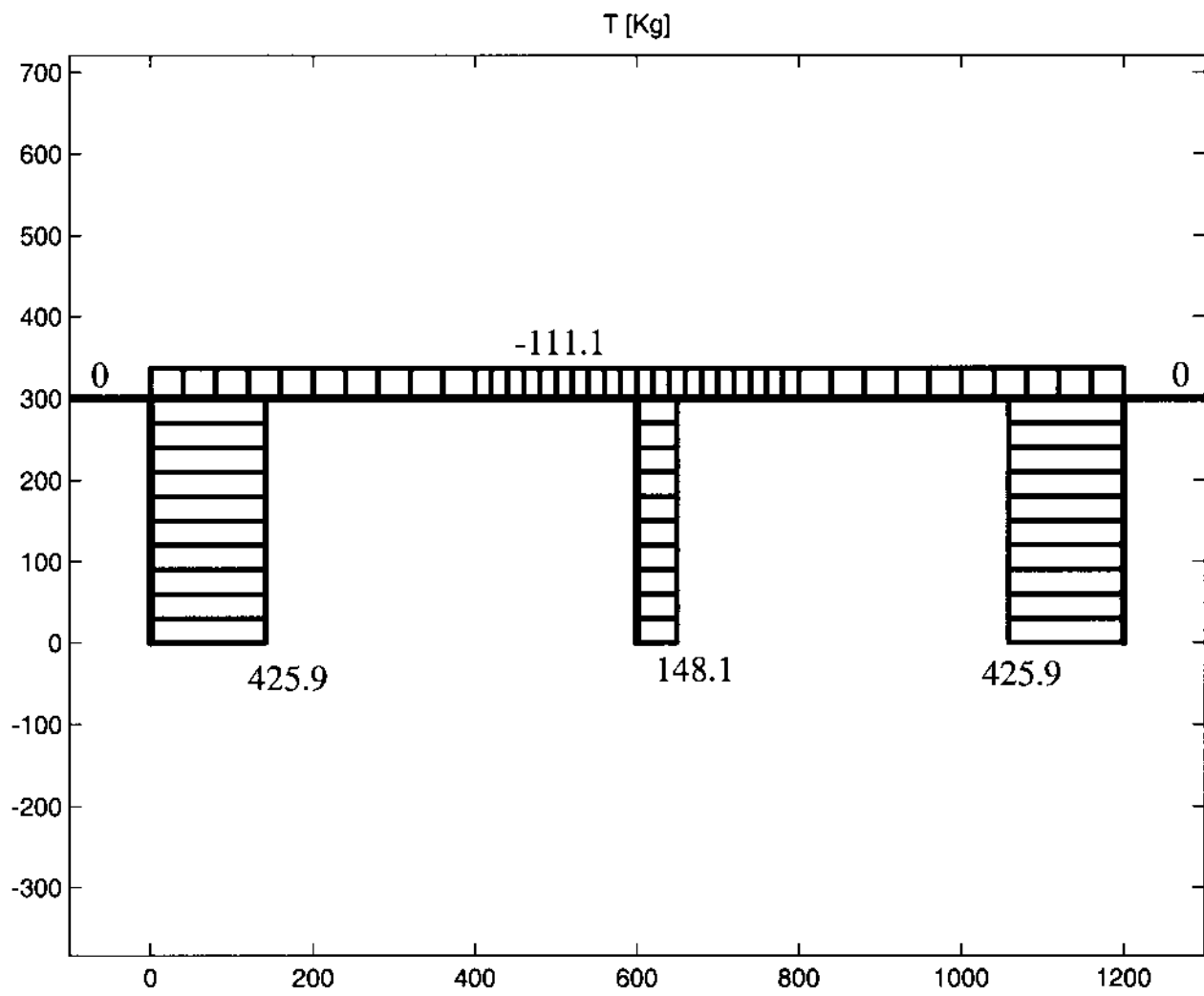
PROVA B PTO A1



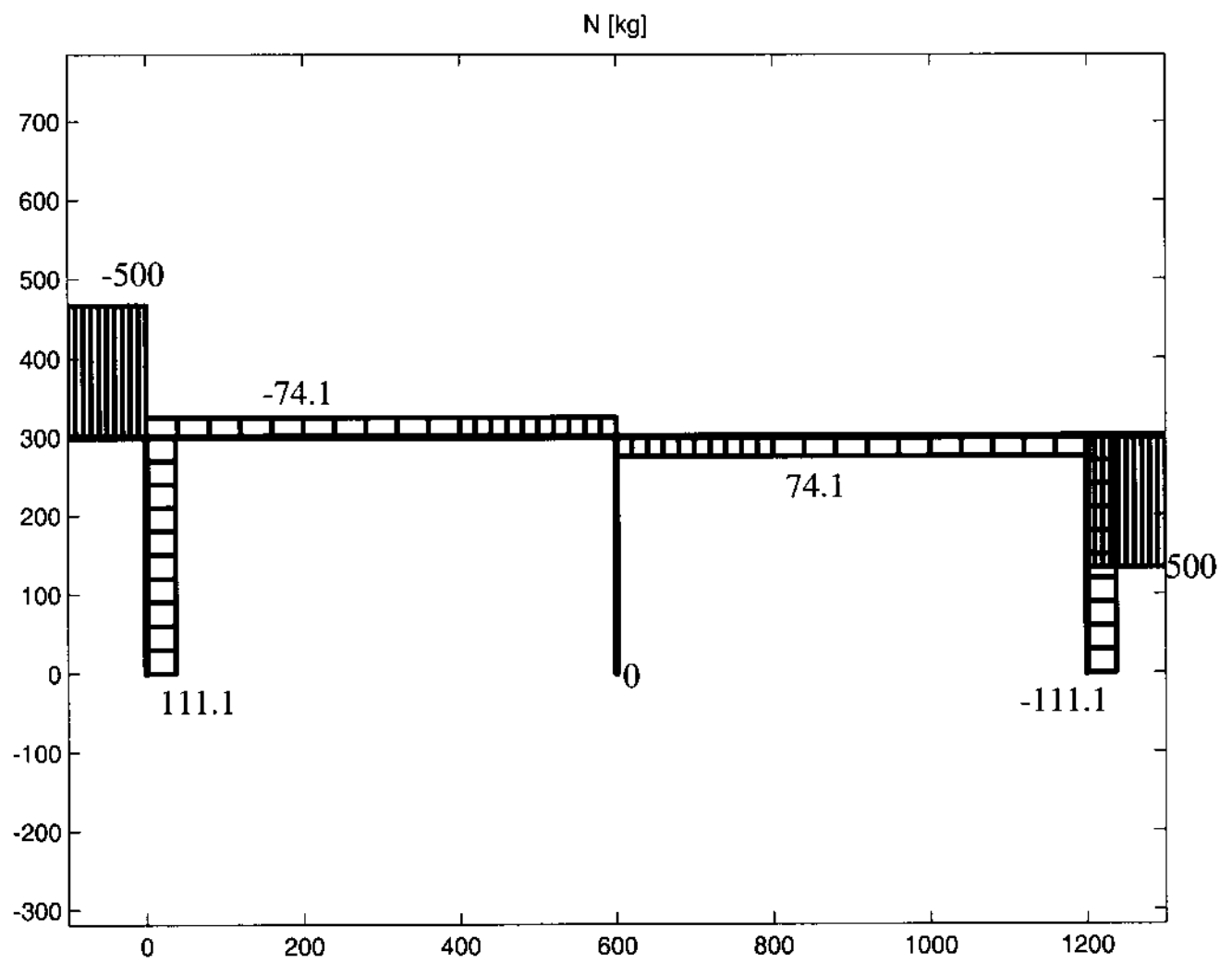
PROVA B Pto B

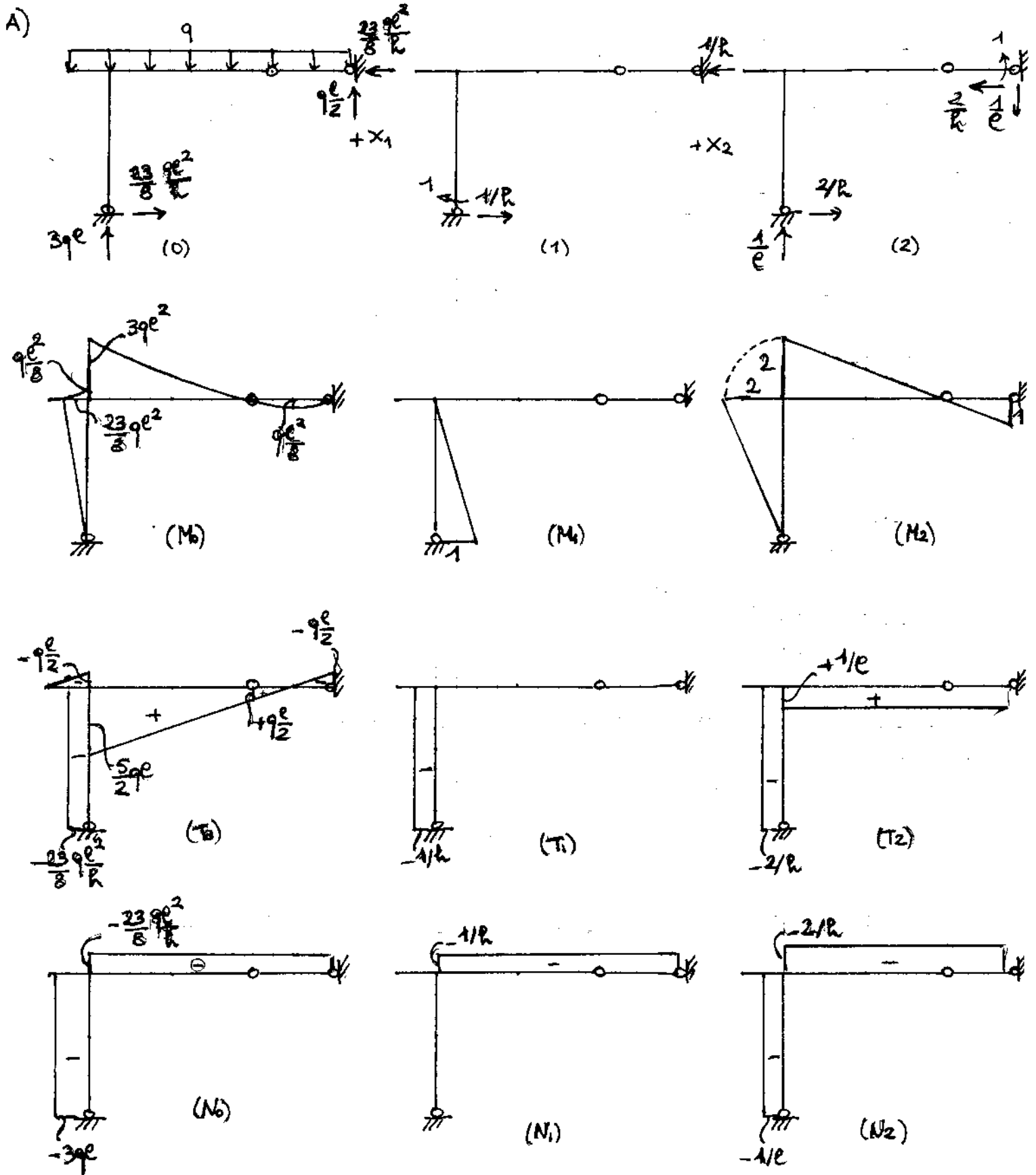


PROVA B PtoB



PROVA B Pto B





Coefficienti:

$$EJ\eta_{10} = -\frac{1}{6}R\left(\frac{23}{8}q\ell^3\right)(1) = -\frac{23}{48}q\ell^3R = -8825 \text{ kgm}^2$$

$$EJ\eta_{20} = +\frac{1}{3}R\left(\frac{23}{8}q\ell^3\right)(2) + \int_0^{\ell} \left(q\frac{\ell}{2}x - q\frac{x^2}{2}\right)\left(1 - \frac{x}{\ell}\right)dx = \frac{23}{12}q\ell^3R + \frac{27}{8}q\ell^3 = 75000 \text{ kgm}^2$$

$$EJ\eta_{11} = \frac{1}{3}R \cdot 1 = \frac{R}{3}$$

$$EJ\eta_{12} = -\frac{1}{6}R \cdot 1 \cdot 2 = -\frac{R}{3} = -$$

$$EJ\eta_{22} = \frac{1}{3}R \cdot 4 + \frac{1}{3}2\ell \cdot 4 + \frac{1}{3}R \cdot 1 = \frac{1}{3}(9\ell + 4R) =$$

$$\eta_1 = 0 = \eta_2$$

Si trova:

$$\begin{cases} x_1 = \frac{15q\ell^3}{16(R+3\ell)} \\ x_2 = -\frac{(54q\ell^3 + 23qR\ell^3)}{16(R+3\ell)} \end{cases}$$

Con i dati del tema A, si ha:

$$\begin{cases} x_1 = 1395 \text{ kgm} \\ x_2 = -7589 \text{ kgm} \end{cases}$$

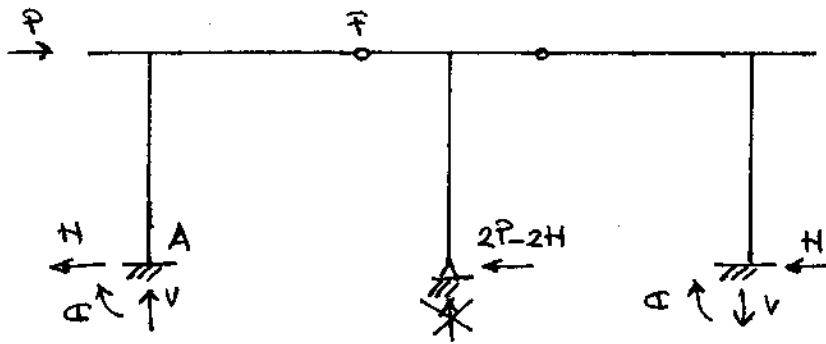
" " " " B, " "

$$\begin{cases} x_1 = 1250 \text{ kgm} \\ x_2 = -7375 \text{ kgm} \end{cases}$$

Diagrammi quotati: vedi risoluzione con il metodo degli spostamenti.
e punto (A2)

B) Si risolve la struttura in presenza del solo carico P (carico antisimmetrico).

I diagrammi in presenza sia di q che di P si ottengono successivamente per sovrapposizione dei diagrammi trovati al punto A1 con quelli che ora andiamo a determinare.



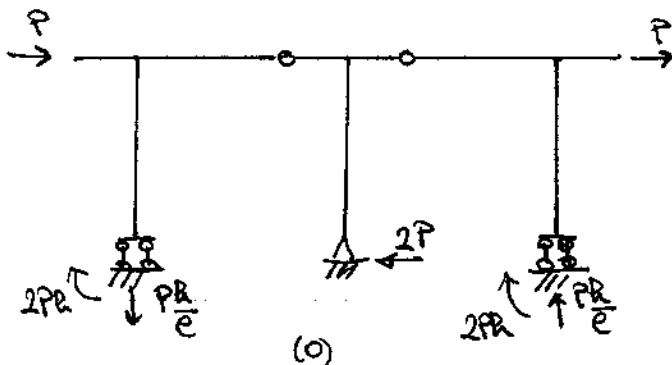
L'antisimmetria viene alle eq. in di equilibrio e alle eq. ve della scostamento in E , ci dice che:

$$V = (H - P) \frac{h}{e}$$

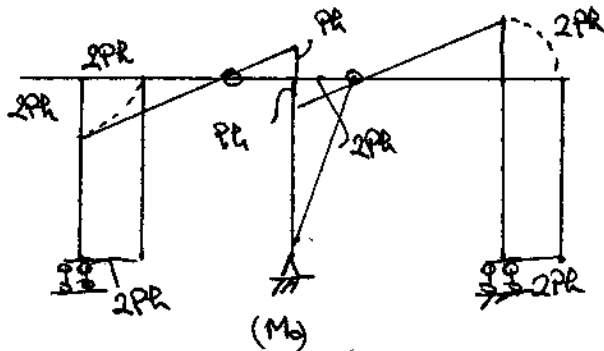
$$C = -3Hh + 2Ph$$

→ struttura 1 volta static. indet.

Come incognita iperstatica si sceglie: $X_1 = H$

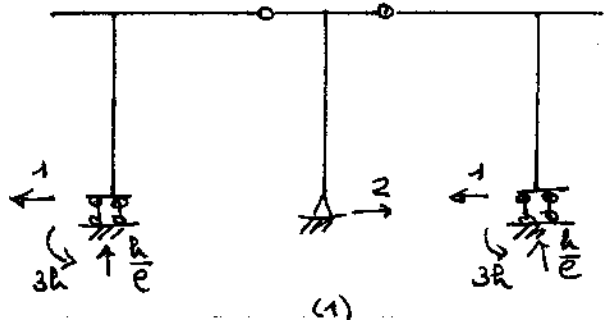


(0)

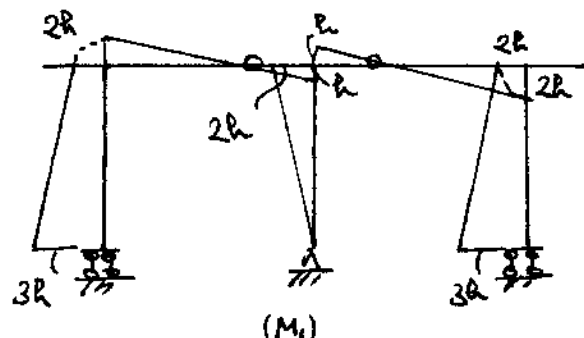


(M₀)

+ X₁



(1)



(M₁)

$$\gamma_{10} + \gamma_{11} X_1 = M_A = 0$$

$$EJ \gamma_{10} = -2 \left[2Ph (3h + 2h) \frac{h}{2} + \frac{1}{3} 2e 2Ph 2h + \frac{1}{3} e Ph h \right] - \frac{1}{3} h 2Ph 2h = -\frac{34}{3} Ph^3 - 6 Ph^2 e$$

$$EJ \gamma_{11} = 2 \left[\int_0^h (3h - 2)^2 dz + \frac{1}{3} 2e 4h^2 + \frac{1}{3} e h^2 \right] + \frac{1}{3} h 4h^2 = 14h^3 + 6h^2 e$$

$$X_1 = \frac{\frac{34}{3}PR^3 + 6PR^2e}{14R^3 + 6R^2e} = \begin{cases} \textcircled{A} & 429.8 \text{ kg} \\ \textcircled{B} & 425.9 \text{ kg} \end{cases}$$

④

Diagrammi quotati: vedi risoluzione con il metodo degli spostamenti