STRUTTURA IPERSTATICA

ACCIAIO STRUTTURALE Fe 510

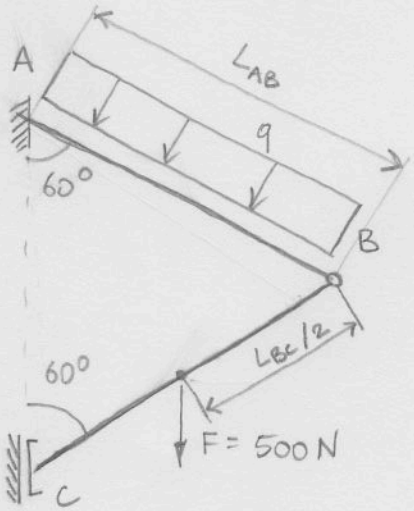
$E = 208 GPa$

$\nu = 0,3$

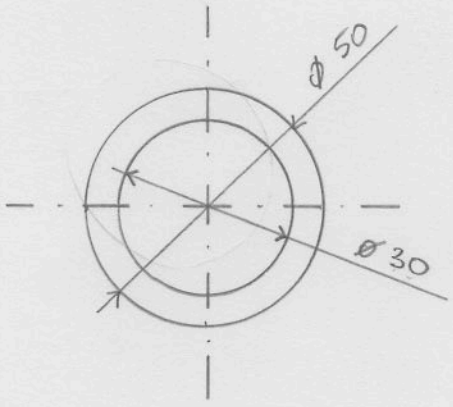
$G = 80 GPa$

$q = 5\ N/mm$

$L_{AB} = 500$



SEZIONE



$A = \frac{\pi}{4}(D^2 - d^2) =$

$= 1256.6371\ mm^2$

$J = \frac{\pi (D^4 - d^4)}{64} =$

$= 267035.3756\ mm^4$

NODO	GDV
A	3
B	2
C	2
TOT	7

7 GDV 6 GDL

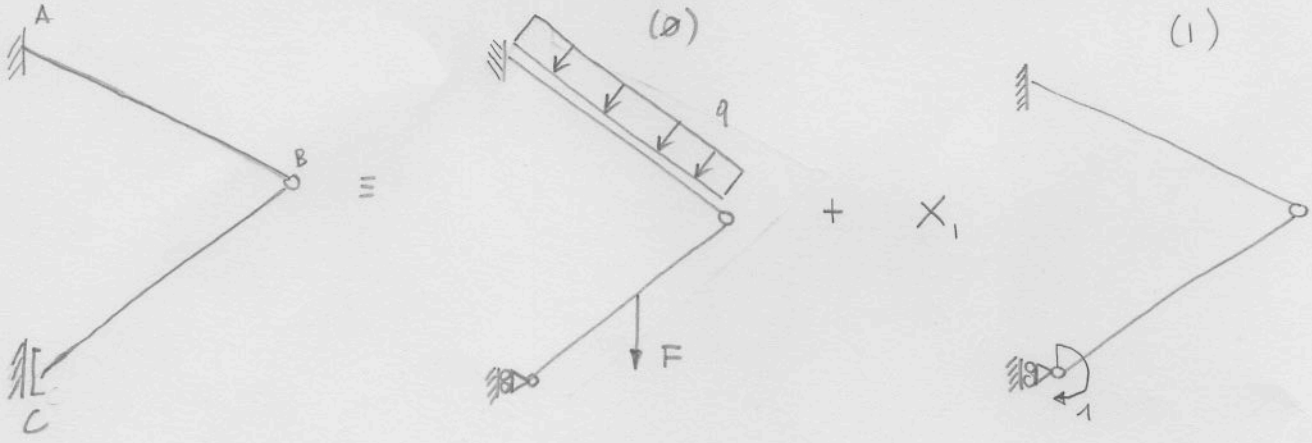
IPERSTATICA

1 VOLTA

Utilizzo le equazioni di Müller-Breslau:

1) Rendo isostatica la struttura (sego momento incognito).
2) Applico il principio di sovrapp. degli effetti
3) Risolvo con le eq^{ni} di M-B.

ISOSTATICA ASSOCIATA → CARRELLO CON MOMENTO IN C



$N = N_0 + X_1 N_1$

$T = T_0 + X_1 T_1$

$M = M_0 + X_1 M_1$

N_0

T_0

M_0

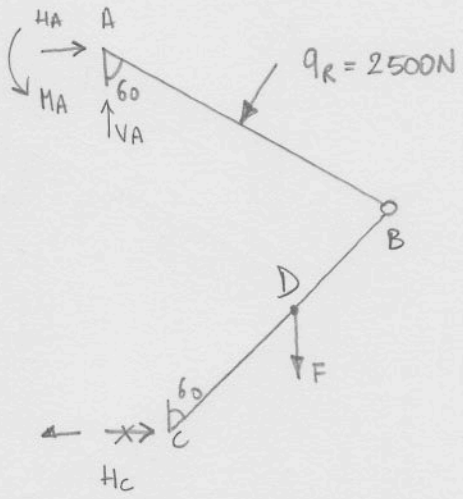
N_1

T_1

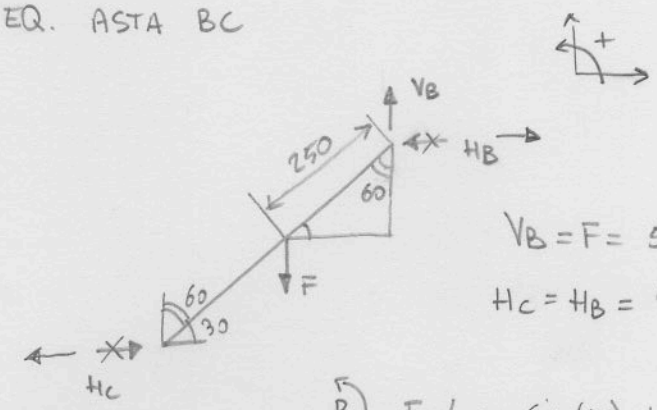
M_1

$$\boxed{M_1 = M_{10} + X_1 M_{11}} \rightarrow \text{EQ}^{\text{ne}}\ \text{MÜLLER-BRESLAU}$$

STRUTTURA (0) EQUILIBRIO



EQ. ASTA BC



$V_B = F = 500N$

$H_C = H_B = 433.0127$

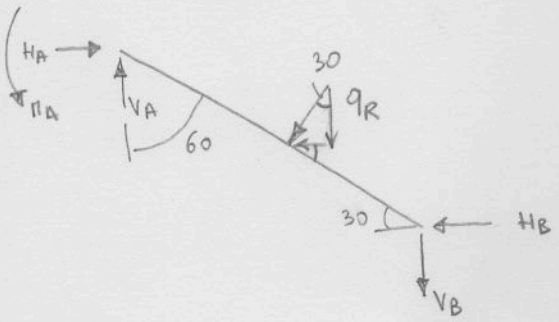
B) $F \cdot \frac{L_{AB}}{2} \cdot \sin(60) + H_C L_{AB} \cdot \cos(60) = \emptyset$

$$H_C = \frac{-F \cdot \frac{L_{AB}}{2} \cdot \sin(60)}{L_{AB} \cos(60)} = -433.0127\,N$$

Cambio segno e verso di H_C

$H_C = 433.0127N$

EQ. ASTA AB



↑ $V_A - V_B - q_R \cdot \cos(30) = \emptyset$

$V_A = V_B + q_R \cos(30) = 2665.0635\,N$

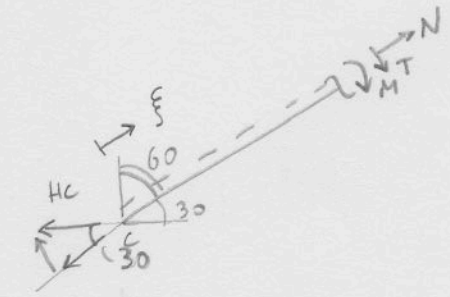
$H_A - H_B - q_R \cdot \sin(30) = \emptyset \quad H_A = H_B + q_R \cdot \sin(30) = 1683.0127\,N$

A) $+M_A - q_R \cdot \frac{L_{AB}}{2} - V_B \cdot L_{AB} \cdot \sin(60) - H_B \cdot L_{AB} \cdot \cos(60) = \emptyset$

$M_A = q_R \frac{L_{AB}}{2} + V_B L_{AB} S_{60} + H_B L_{AB} C_{60} = 949\,759.5264$ Nmm

TRATTO C-B

$0 < \xi < \frac{L_{BC}}{2} = 250$

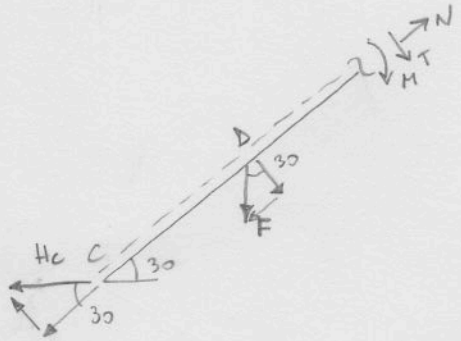


$N_{ØCD} = H_C \cdot \cos(30) = 375\ N$

$T_{ØCD} = H_C \cdot \sin(30) = 216.5064 N$

$M_{OCD} = -H_C \cdot \sin(30) \cdot \xi$ → $M(0) = Ø$, $M(250) = -54126.5877\ Nmm$

$\frac{L_{BC}}{2} < \xi < L_{BC} = 500$



$N_{ODB} = H_C \cdot \cos(30) + F \sin(30) = 625 N$

$T_{ODB} = H_C \cdot \sin(30) - F \cdot \cos(30) = -216.5064 N$

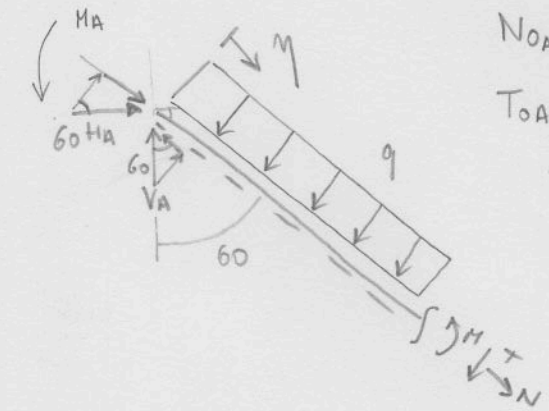
$M_{ODB} = -H_C \cdot \sin(30)\,\xi + F \cdot \cos(30)\left(\xi - \frac{L_{BC}}{2}\right)$

$M(L_{BC}/2) = -54126.5877\ Nmm$

$M(L_{BC}) = Ø$

TRATTO A-B

$0 < \eta < L_{AB} = 500$



$N_{OAB} = -H_A \cdot \sin(60) + V_A \cdot \cos(60) = -125 N$

$T_{OAB} = H_A \cdot \cos(60) + V_A \cdot \sin(60) - q\eta$

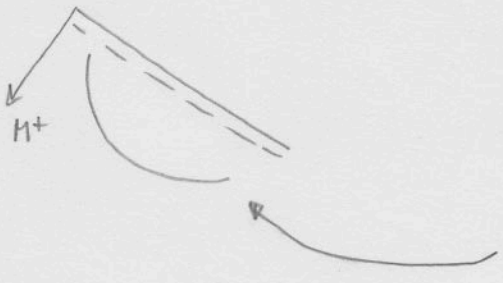
$T(0) = 3149.5191 N$

$T(L_{AB}) = 649.5191 N$

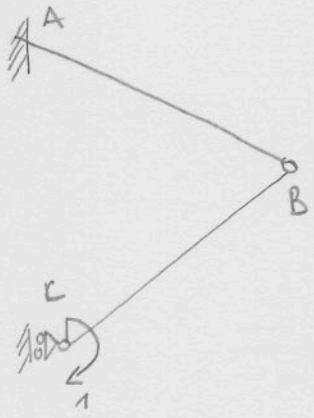
$M_{OAB} = -M_A + H_A \cdot \cos(60)\,\eta + V_A \cdot \sin(60)\,\eta - \frac{q\eta^2}{2}$

$M(Ø) = -M_A = -349759.5264\ Nmm$

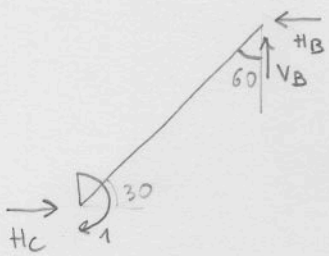
$M(L_{AB}) = Ø$



$\frac{d^2M}{d\eta^2} = -q < Ø$ CONCAVA



EQ. TRATTO C-B



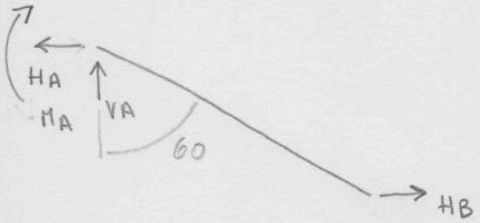
$\overset{B}{\curvearrowleft}\; -1 + H_C \cdot L_{BC} \cos(60) = \emptyset$

$H_C = \dfrac{1}{L_{BC}\, C_{60}} = 0{,}004\,N$

$H_B = H_C = 0.004\,N$

$V_B = \emptyset$

EQ. TRATTO A-B



$H_A = H_B = 0.004\,N$

$V_A = \emptyset$

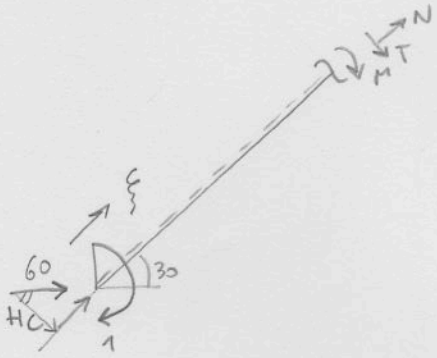
$\overset{A}{\curvearrowleft}\; -M_A + H_B \cdot L_{AB} \cdot \cos(60) = \emptyset$

$M_A = H_B \cdot L_{AB} \cdot \cos(60) = 1\,N\text{mm}$

AZIONI INTERNE

TRATTO C-B

$0 < \xi < L_{BC} = 500$

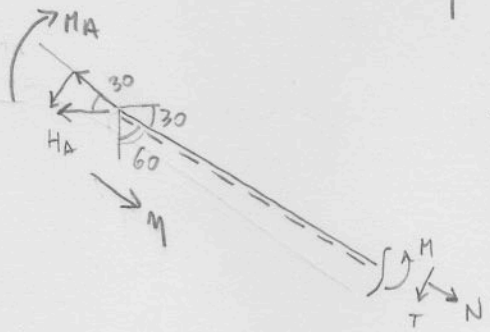


$N_{ICB} = -H_C \cdot \sin(60) = -0.003464\,N$

$T_{ICB} = -H_C \cdot \cos(60) = -0.002\,N$

$M_{ICB} = -1 + H_C \cdot \cos(60)\,\xi$ → $M(0) = -1\,N\text{mm}$; $M(L_{AB}) = \emptyset$

TRATTO A-B $\quad 0 < \eta < L_{AB} = 500$



$N_{IAB} = H_A \cdot \cos(30) = 0.003464\,N$

$T_{IAB} = -H_A \cdot \sin(30) = -0.002\,N$

$M_{IAB} = M_A - H_A \cdot \sin(30)\,\eta$ → $M(0) = 1\,N\text{mm}$; $M(L_{AB}) = \emptyset$

CALCOLO INCOGNITA IPERSTATICA $\chi_0 = 2$

$$\eta_{10} = \int_0^{\frac{L_{BC}}{2}} \frac{N_{0CD} N_{1CD}}{EA} + \chi \frac{T_{0CD} T_{1CD}}{GA} + \frac{M_{0CD} M_{1CD}}{EJ} d\xi + \int_{\frac{L_{BC}}{2}}^{L_{BC}} \frac{N_{0DB} N_{1DB}}{EA} + \chi \frac{T_{0DB} T_{1DB}}{GA} + \frac{M_{0DB} M_{1DB}}{EJ} d\xi +$$

$$+ \int_0^{L_{AB}} \frac{N_{0AB} N_{1AB}}{EA} + \chi \frac{T_{0AB} T_{1AB}}{GA} + \frac{M_{0AB} M_{1AB}}{EJ} d\eta =$$

$$= 7.7812E\text{-}5 + 4.0687E\text{-}5 - 0.002420 = -0.002301$$

$$\eta_{11} = \int_0^{L_{BC}} \frac{N_{1CB}^2}{EA} + \chi \frac{T_{1CB}^2}{GA} + \frac{M_{1CB}^2}{EJ} d\xi + \int_0^{L_{AB}} \frac{N_{1AB}^2}{EA} + \chi \frac{T_{1AB}^2}{GA} + \frac{M_{1AB}^2}{EJ} d\eta =$$

$$= 3.0634E\text{-}9 + 3.0634E\text{-}9 = 6.1268E\text{-}9$$

$\eta_{11} = \emptyset$ perché i vincoli non hanno cedimenti e in generale il lavoro esterno è nullo.

$$0 = \eta_{10} + X_1 \eta_{11} \quad \rightarrow \quad X_1 = -\frac{\eta_{10}}{\eta_{11}} = 375590.7107 \text{ Nmm}$$

EQUAZIONI AZIONI INTERNE

TRATTO CD $0 < \xi < 250$

$N_{CD} = N_{0CD} + X_1 N_{1CB} = -926.0844 N$

$T_{CD} = T_{0CD} + X_1 T_{1CB} = -534.6751 N$

$M_{CD} = M_{0CD} + X_1 M_{1CB} = -Hc \sin(30)\, \xi + 751.1814\, \xi - 375590.7107$

$M(0) = -375590.7107 Nmm$

$M\left(\frac{L_{BC}}{2}\right) = -241921.9431 Nmm$

AZIONI INTERNE

TRATTO D-B

$250 < \xi < 500$

$N_{DB} = N_{\emptyset DB} + X_1 N_{1CB} = -676.0844 N$

$T_{DB} = T_{\emptyset DB} + X_1 T_{1CB} = -967.6878 N$

$M_{DB} = M_{\emptyset DB} + X_1 M_{1CB} = -Hc \cdot \sin(30)\,\xi + F \cdot \cos(30)\left(\xi - \frac{L_{BC}}{2}\right) + 751.1814\,\xi - 375590.7107$

$M\left(\frac{L_{BC}}{2}\right) = -241921.9431 \text{ Nmm}$

$M(L_{BC}) = \emptyset \approx 7.716 E-12 \text{ Nmm}$

TRATTO A-B

$0 < \eta < 500$

$N_{AB} = N_{\emptyset AB} + X_1 N_{1AB} = 1176.0844 N$

$T_{AB} = 2388.3376 - 5\eta$ — $T(0) = 2388.3376 N$; $T(L_{AB}) = -101.6624 N$

$\eta^* = \frac{2388.3376}{5} = 479.6675 \text{ mm} \rightarrow T = \emptyset$

$M_{AB} = M_{\emptyset AB} + X_1 M_{1AB} = -574168.8157 + 2388.3376\,\eta - \frac{5\,\eta^2}{2}$

$M(0) = -574168.8157 \text{ Nmm}$

$M(\eta^*) = 1033.5237 \text{ Nmm}$

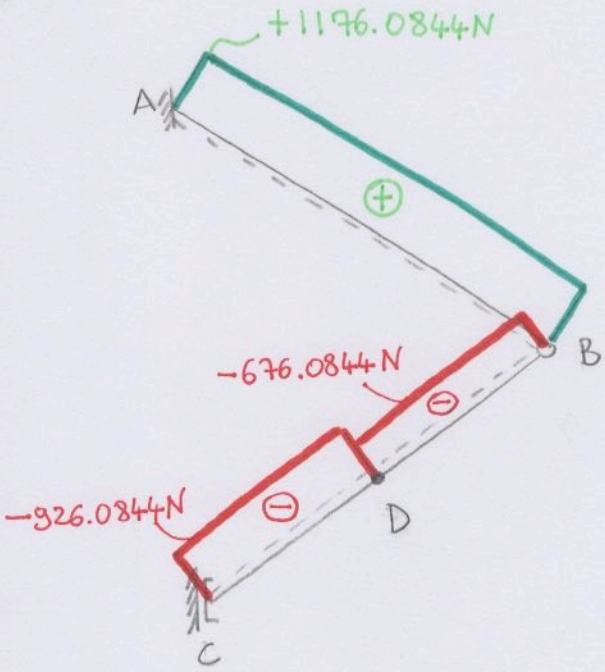
$M(L_{AB}) = -5.4569 E-11 \approx \emptyset$

$M_{AB} = \emptyset$ in $\eta^{**} = 459.3351 \text{ mm}$

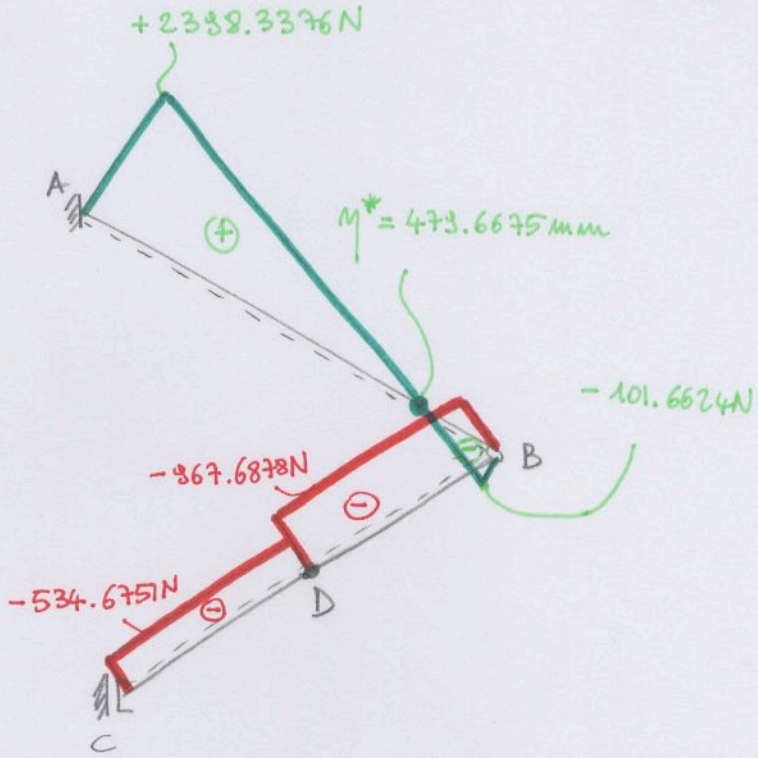
$\frac{d^2M}{d\eta^2} = -5 < \emptyset$ CONCAVA.

DIAGRAMMI AZIONI INTERNE

N



T



M