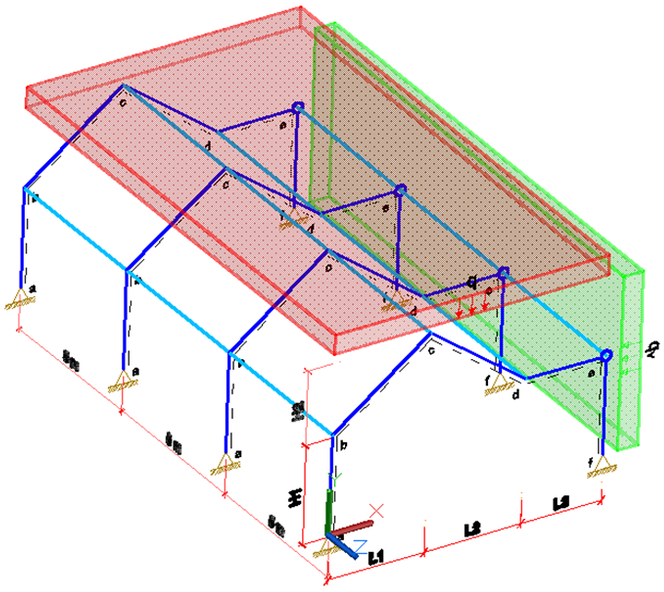
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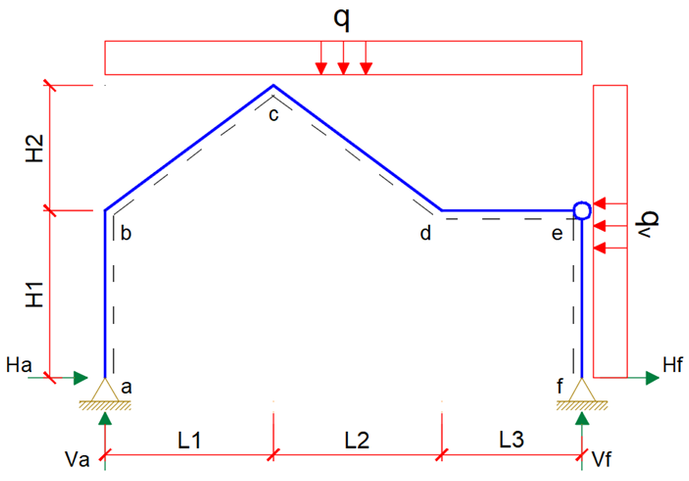
Esboçar os Diagramas M, V e N das barras "bc" e "cd" da cobertura modelada abaixo.

-Distância entre os Pórticos : B = 5,0 m (transversal)
-Carga de Manutenção (q_area) : 4 kN/m²
-Carga de Vento (qv_area) : 2 kN/m²

Modelo Estrutural Tridimensional:



Modelo Estrutural Plano:



$L1 := 3,5\ m$ $L2 := 3,5\ m$ $L3 := 3,0\ m$

$H1 := 3,20\ m$ $H2 := 2,40\ m$

Cálculo das Cargas por Metro Linear:

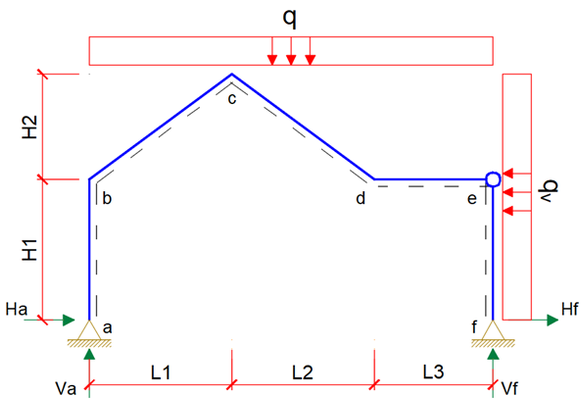
$B := 5,0\ m$ $q_area := 4\ kN/m^2$ $qv_area := 2\ kN/m^2$

$q := q_area \cdot B = 20\ kN/m$ $qv := qv_area \cdot B = 10\ kN/m$

Reações de Apoio:

ΣMe = 0 (olhando para "f") (+) antihorário
Hf.H1-qv.H1.H1/2 = 0

$$Hf := \frac{1}{H1} \cdot \left(\frac{qv \cdot H1^{\,2}}{2} \right) = 16\ kN$$



ΣFh = 0 (+) para direita
Ha + Hf - qv.(H1+H2) = 0

$$Ha := -Hf + qv \cdot (H1 + H2) = 40\ kN$$

ΣMa = 0 (+) Antihorário

Vf.(L1+L2+L3)-q.(L1+L2+L3)^2/2 + qv.(H1+H2)^2/2 = 0

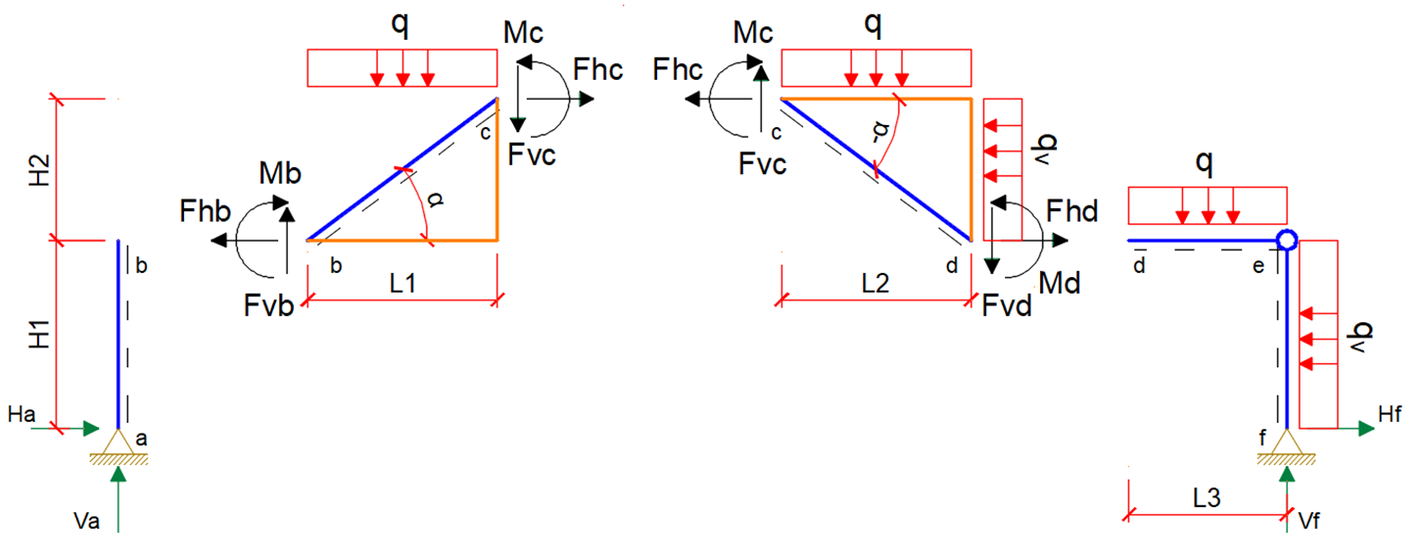
$$Vf := \frac{1}{L1 + L2 + L3} \cdot \left(q \cdot \frac{(L1 + L2 + L3)^2}{2} - qv \cdot \frac{(H1 + H2)^2}{2} \right) = 84,32\ kN$$

ΣFv = 0 (+) para cima

Va + Vf - q.(L1+L2+L3) = 0

$$Va := -Vf + q \cdot (L1 + L2 + L3) = 115,68\ kN$$

Equilíbrio Individual das barras "bc" e "cd" no sistema horizontal vertical:



Esforços em sistema horizontal e vertical no ponto "b" da barra "bc":

$Fvb := Va = 115,68 \ \text{kN}$

$Fhb := -Ha = -40 \ \text{kN}$

$Mb := -Ha \cdot H1 = -128 \ \text{kNm}$

Esforços em sistema horizontal e vertical no ponto "c" da barra "cd":

$Fvc := Va - q \cdot L1 = 45,68 \ \text{kN}$

$Fhc := -Ha = -40 \ \text{kN}$

$Mc := -Ha \cdot (H1 + H2) + Va \cdot L1 - \frac{q \cdot L1^2}{2} = 58,38 \ \text{kNm}$

Esforços em sistema horizontal e vertical no ponto "d" da barra "cd":

$Fvd := q \cdot L3 - Vf = -24,32 \ \text{kN}$

$Fhd := Hf - qv \cdot H1 = -16 \ \text{kN}$

$Md := Vf \cdot L3 + Hf \cdot H1 - \frac{q \cdot L3^2}{2} - \frac{qv \cdot H1^2}{2} = 162,96 \ \text{kNm}$

Projeção das Forças nos eixos Paralelo e Perpendicular:

Relações Trigonométricas:

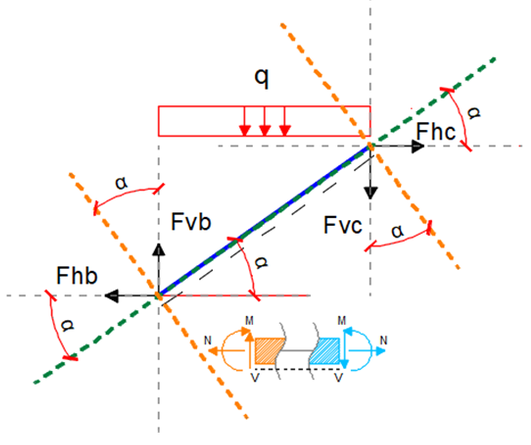
V = VER.cosα + HOR.senα
N = -VER.senα + HOR.cosα

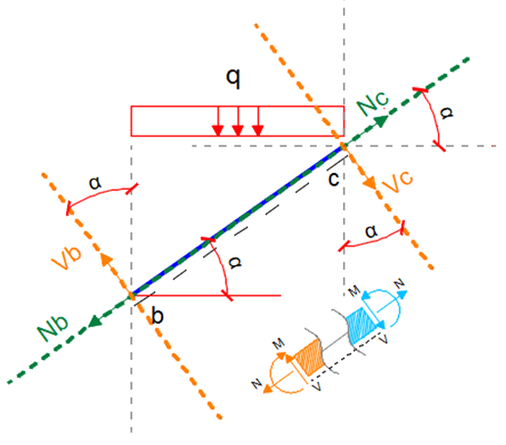
$Lbc := \sqrt{L1^2 + H2^2} = 4,2438$

$Lcd := \sqrt{L2^2 + H2^2} = 4,2438$

$cos\alpha := \frac{L1}{Lbc} = 0,8247$

$sen\alpha := \frac{H2}{Lbc} = 0,5655$



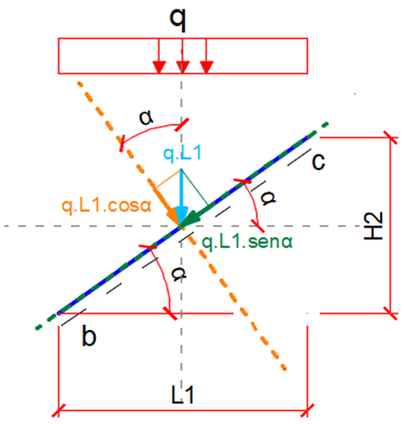


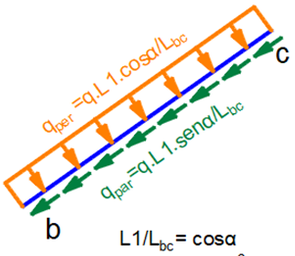
$Vb := Fvb \cdot cos\alpha + Fhb \cdot sen\alpha = 72,7835 \ \text{kN}$

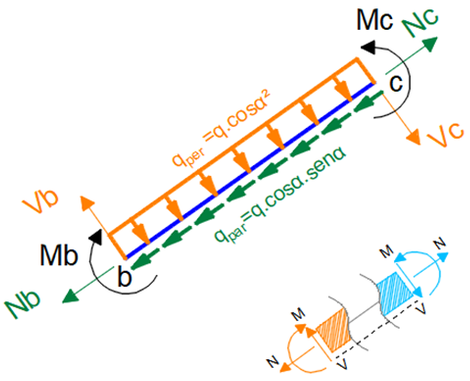
$Nb := -Fvb \cdot sen\alpha + Fhb \cdot cos\alpha = -98,4095 \ \text{kN}$

$Vc := Fvc \cdot cos\alpha + Fhc \cdot sen\alpha = 15,0525 \ \text{kN}$

$Nc := -Fvc \cdot sen\alpha + Fhc \cdot cos\alpha = -58,8225 \ \text{kN}$







$qbc_per := \frac{q \cdot L1 \cdot cos\alpha}{Lbc} = 13,6036 \text{ kN/m}$ $qbc_per1 := q \cdot cos\alpha^{2} = 13,6036 \text{ kN/m}$

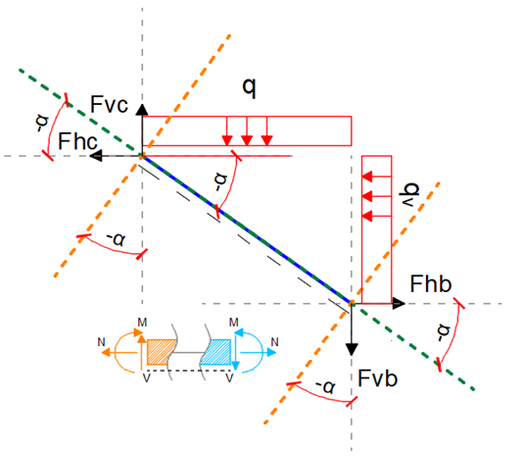
$qbc_par := \frac{q \cdot L1 \cdot sen\alpha}{Lbc} = 9,3282 \text{ kN/m}$ $qbc_par1 := q \cdot cos\alpha \cdot sen\alpha = 9,3282 \text{ kN/m}$

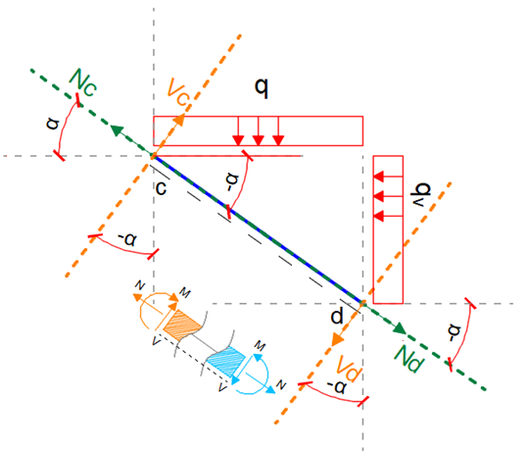
$Vbc(x) := Vb - qbc_per \cdot x$ $Vbc(0) = 72,7835$ $Vbc(Lbc) = 15,0525$

$Nbc(x) := Nb + qbc_par \cdot x$ $Nbc(0) = -98,4095$ $Nbc(Lbc) = -58,8225$

$Mbc_xhor(x) := Mb + Fvb \cdot x + Fhb \cdot x \cdot \frac{H2}{L1} - \frac{q \cdot x^{2}}{2}$

$Mbc(x) := Mb + Vb \cdot x - \frac{qbc_per \cdot x^{2}}{2}$





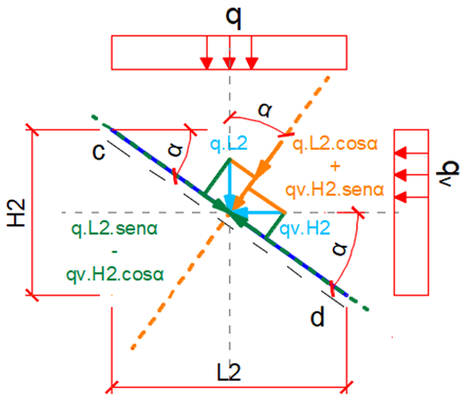
* o ângulo α é negativo, logo cos(α)=cos(-α), porém -sen(α)=sen(-α)

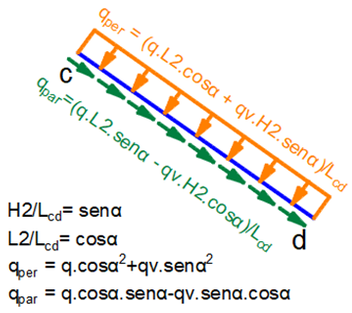
$Vc := Fvc \cdot cos\alpha + Fhc \cdot (-sen\alpha) = 60,2947 \text{ kN}$

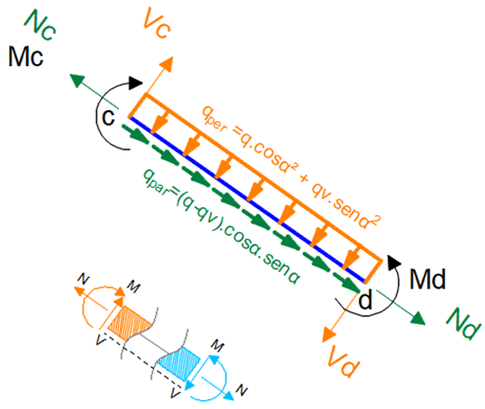
$Nc := -Fvc \cdot (-sen\alpha) + Fhc \cdot cos\alpha = -7,1558 \text{ kN}$

$Vd := Fvd \cdot cos\alpha + Fhd \cdot (-sen\alpha) = -11,009 \text{ kN}$

$Nd := -Fvd \cdot (-sen\alpha) + Fhd \cdot cos\alpha = -26,9493 \text{ kN}$







$$qcd_per := \frac{q \cdot L2 \cdot cos\alpha + qv \cdot H2 \cdot sen\alpha}{Lcd} = 16,8018\ kN/m \qquad qcd_per1 := q \cdot cos\alpha^{2} + qv \cdot sen\alpha^{2} = 16,8018\ kN/m$$

$$qcd_par := \frac{q \cdot L2 \cdot sen\alpha - qv \cdot H2 \cdot cos\alpha}{Lcd} = 4,6641\ kN/m \qquad qcd_par1 := (q - qv) \cdot cos\alpha \cdot sen\alpha = 4,6641\ kN/m$$

$$Vcd(x) := Vc - qcd_per \cdot x \qquad Vcd(0) = 60,2947 \qquad Vcd(Lcd) = -11,009$$

$$Ncd(x) := Nc - qcd_par \cdot x \qquad Ncd(0) = -7,1558 \qquad Ncd(Lcd) = -26,9493$$

$$Mcd(x) := Mc + Vc \cdot x - \frac{qcd_per \cdot x^{2}}{2} \qquad Mcd(0) = 58,38 \qquad Mcd(Lcd) = 162,96$$

Traçado dos Diagramas das Barras "bc" e "cd":

Diagrama de Axiais (kN):

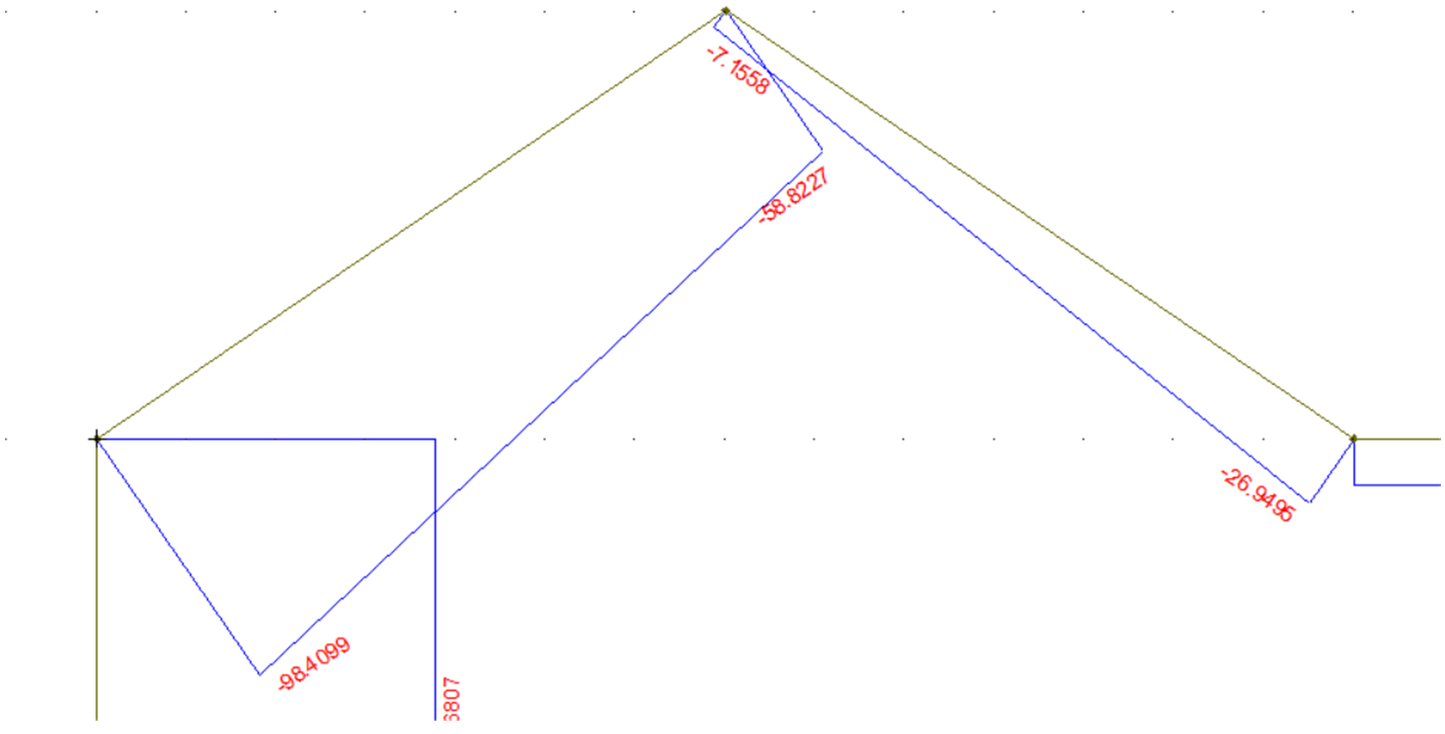


Diagrama de Cortantes (kN):

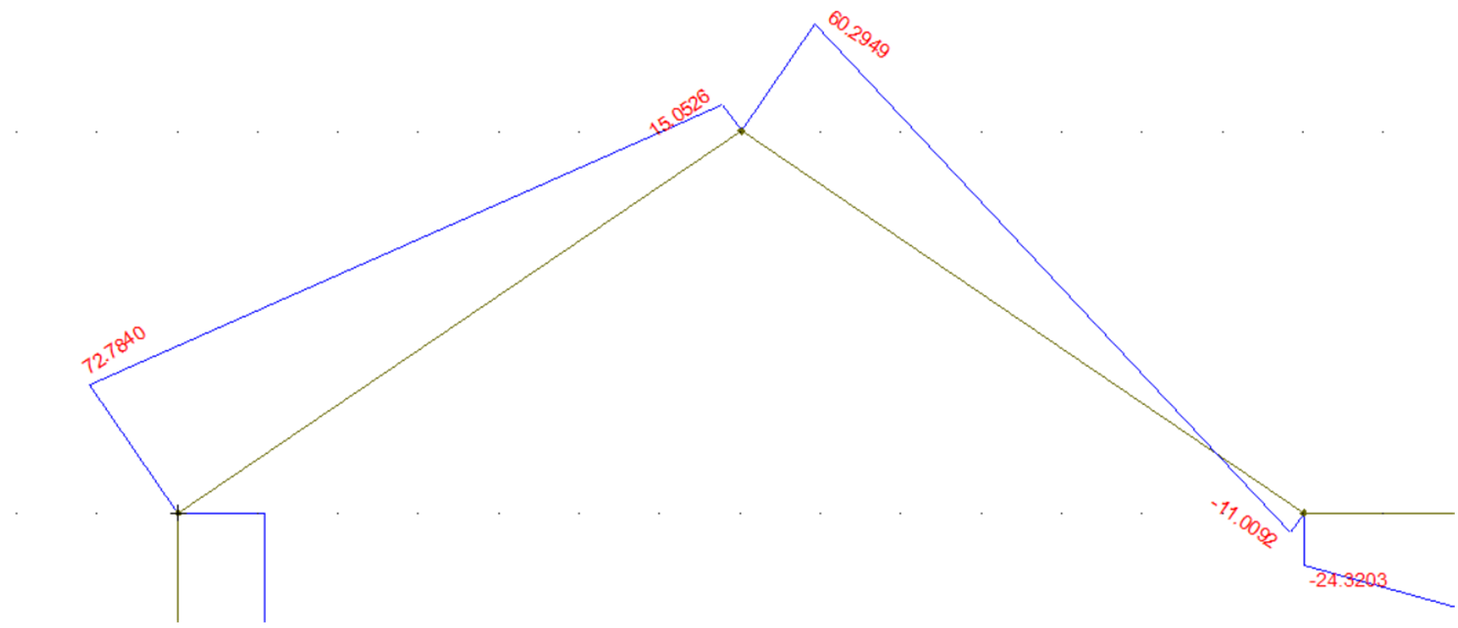


Diagrama de Momentos (kNm):

