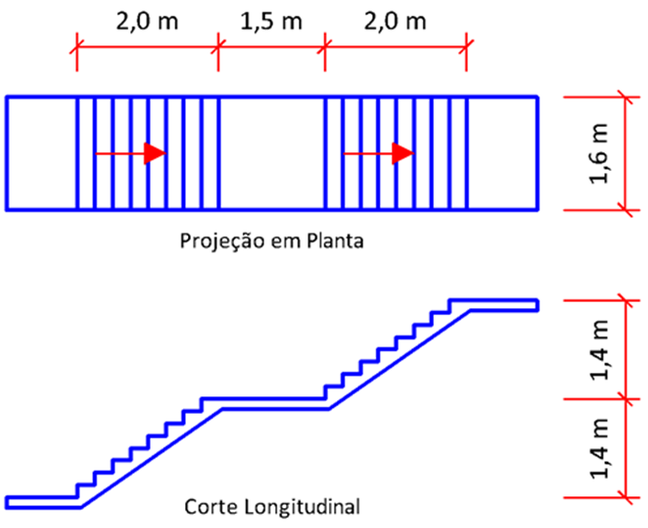
# TE1_E06-02

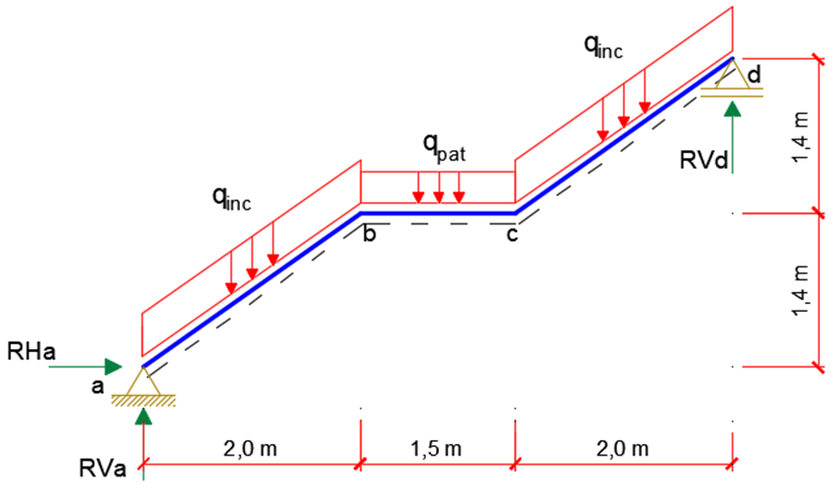
A escada abaixo será feita em concreto armado ( Y = 25 kN/m³ ) sendo que o trscho inclinado possui uma espessura média de 20 cm e o patamar uma espessura de 15 cm.

Componha um modelo estrutural aplicando como carregamento apenas o peso próprio da estrutura e trace os diagramas de momento fletor, esforço cortante e esforço axial.




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## Modelo Estrutural com Carregamento de Peso Próprio:




$B := 1,6\ m$

$h_{inc} := 0,20\ m$

$h_{pat} := 0,15\ m$ (espessura do patamar)

$\gamma := 25\ \frac{kN}{m^3}$

$q_{pat} := B \cdot h_{pat} \cdot \gamma = 6\ \frac{kN}{m}$

$q_{inc} := B \cdot h_{inc} \cdot \gamma = 8\ \frac{kN}{m}$

## Cálculo das Reações de Apoio:

$Lhab := 2,0\ m$ $Lbc := 1,5\ m$ $Lhcd := 2,0\ m$ $Lvab := 1,4\ m$ $Lvcd := 1,4\ m$

$Lab := \sqrt{Lhab^2 + Lvab^2} = 2,4413\ m$ $Lcd := \sqrt{Lhcd^2 + Lvcd^2} = 2,4413\ m$

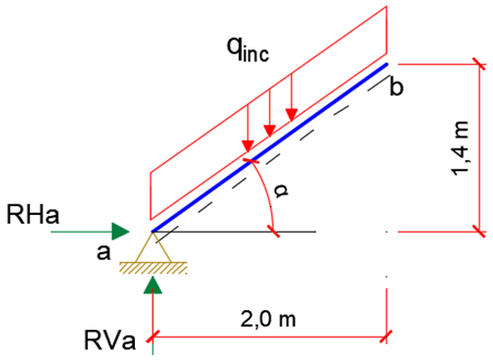
$\Sigma Fh := 0$ $RHa := 0$

Pela simetria do carregamento e da geometria em projeção horizontal:

$$RVa := \frac{q_{inc} \cdot Lab + q_{pat} \cdot Lbc + q_{inc} \cdot Lcd}{2} = 24,03\ kN$$

$RVd := RVa = 24,03\ kN$

Trecho "ab":



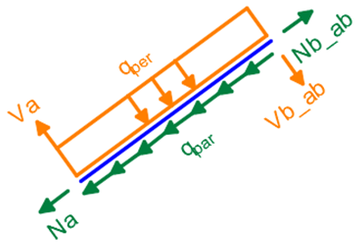

$cos\alpha := \frac{Lhab}{Lab} = 0,8192$

$sen\alpha := \frac{Lvab}{Lab} = 0,5735$

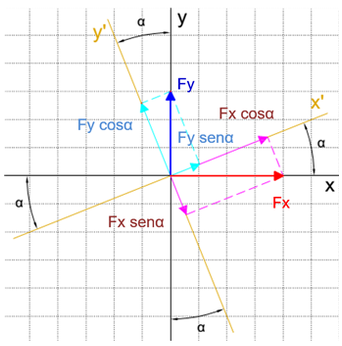
Decomposição do carregamento qinc:

$q_{per} := q_{inc} \cdot cos\alpha = 6,5539 \ \frac{kN}{m}$

$q_{par} := q_{inc} \cdot sen\alpha = 4,5877 \ \frac{kN}{m}$




Decomposição de Forças no ponto "a":




$Fx' = Fx\ cos\alpha + Fy\ sen\alpha$

$Fy' = -Fx\ sen\alpha + Fy\ cos\alpha$

Adaptando para a conveção de sinais de diagramas:

$Na := -RHa \cdot cos\alpha - RVa \cdot sen\alpha$

$Na = -13,7806 \ kN$

$Va := -RHa \cdot sen\alpha + RVa \cdot cos\alpha$

$Va = 19,6865 \ kN$

Equações de Esforços:

$Vab(x) := Va - q_{per} \cdot x$

$Vb_ab := Vab(Lab) = 3,6865 \ kN$

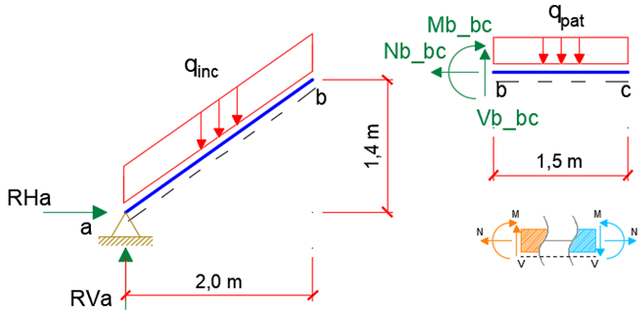
$Nab(x) := Na + q_{par} \cdot x$

$Nb_ab := Nab(Lab) = -2,5806 \ kN$

$Mab(x) := Va \cdot x - \frac{q_{per} \cdot x^2}{2}$

$Mb_ab := Mab(Lab) = 28,5305 \ kN\ m$

Trecho "bc":




$Mb_bc := Mb_ab = 28,5305 \ kN\ m$

Verificando :

$Mb_bc := RVa \cdot Lhab - RHa \cdot Lvab - q_{inc} \cdot Lab \cdot \frac{Lhab}{2}$

$Mb_bc = 28,5305 \ kN\ m$

$Vb_bc := RVa - q_{inc} \cdot Lab = 4,5 \ kN$

$Nb_bc := RHa = 0$

Equações de Esforços Internos:

$Vbc(x) := Vb_bc - q_{pat} \cdot x$

$Vc_bc := Vbc(Lbc) = -4,5 \ kN$

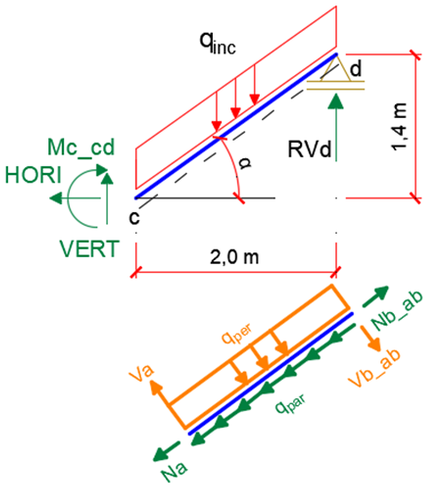
$Nbc(x) := 0$

$Nc_bc := Nbc(Lbc) = 0 \ kN$

$Mbc(x) := Mb_bc + Vb_bc \cdot x - \frac{q_{pat} \cdot x^2}{2}$

$Mc_bc := Mbc(Lbc) = 28,5305 \ kN\ m$

Trecho "cd":




*** o ângulo α é o mesmo do trecho "ab"

$$\Sigma Fv = 0$$

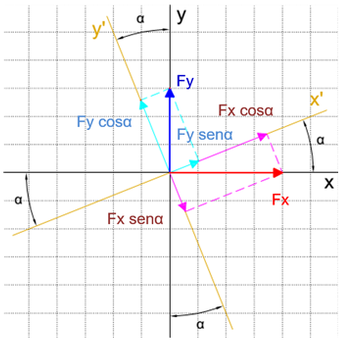
$$RVd + VERT - q_{inc} \cdot Lcd = 0$$

$$VERT := q_{inc} \cdot Lcd - RVd = -4,5 \text{ kN}$$

$$\Sigma Fh = 0$$

$$HORI := 0$$

$$Mc_cd := RVd \cdot Lhcd - q_{inc} \cdot Lcd \cdot \frac{Lhcd}{2} = 28,5305 \text{ kN m}$$




$$Fx' = Fx\ cos\alpha + Fy\ sen\alpha$$

$$Fy' = -Fx\ sen\alpha + Fy\ cos\alpha$$

Fórmula Enlatada para Decomposição de Forças VERT e HORI em Esforço Axial (N) e Esforço Cortante (V)

$$N := -HORI \cdot cos\alpha - VERT \cdot sen\alpha$$

$$V := -HORI \cdot sen\alpha + VERT \cdot cos\alpha$$

$$Nc_cd := -HORI \cdot cos\alpha - VERT \cdot sen\alpha = 2,5806 \text{ kN}$$

$$Vc_cd := -HORI \cdot sen\alpha + VERT \cdot cos\alpha = -3,6865 \text{ kN}$$

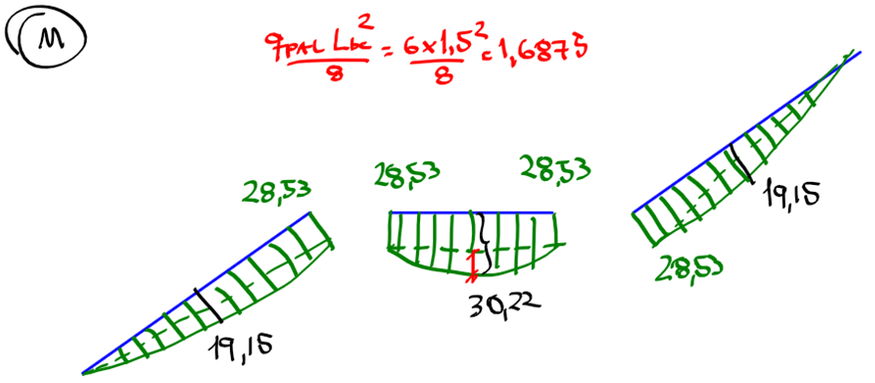
$$Ncd(x) := Nc_cd + q_{par} \cdot x \qquad Nd := Ncd(Lcd) = 13,7806 \text{ kN}$$

$$Vcd(x) := Vc_cd - q_{per} \cdot x \qquad Vd := Vcd(Lcd) = -19,6865 \text{ kN}$$

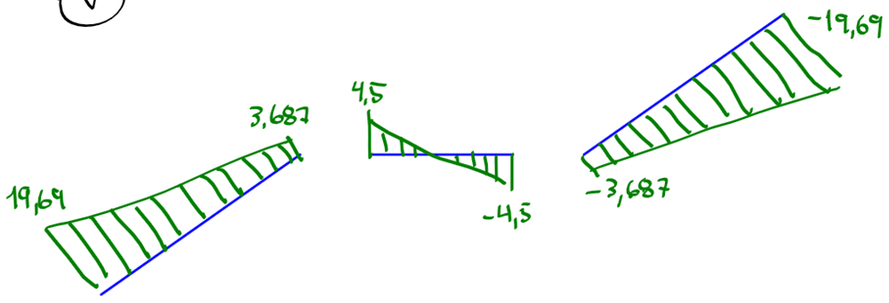
$$Mcd(x) := Mc_cd + Vc_cd \cdot x - \frac{q_{per} \cdot x^2}{2} \qquad Mcd(Lcd) = -5,9609 \cdot 10^{-14} \text{ kN m}$$

$$Mcd\left(\frac{Lcd}{2}\right) = 19,1479 \text{ kN m}$$

| | | | |
|---|---|---|---|
| $Ma := 0$ | $Mb_ab = 28,53 \text{ kN m}$ | $Mc_bc = 28,53 \text{ kN m}$ | $Md := 0$ |
| | $Mb_bc = 28,53 \text{ kN m}$ | $Mc_cd = 28,53 \text{ kN m}$ | |
| $Va = 19,69 \text{ kN}$ | $Vb_ab = 3,687 \text{ kN}$ | $Vc_bc = -4,500 \text{ kN}$ | $Vd = -19,69 \text{ kN}$ |
| | $Vb_bc = 4,500 \text{ kN}$ | $Vc_cd = -3,687 \text{ kN}$ | |
| $Na = -13,78 \text{ kN}$ | $Nb_ab = -2,581 \text{ kN}$ | $Nc_bc = 0,000 \text{ kN}$ | $Nd = 13,78 \text{ kN}$ |
| | $Nb_bc = 0,000 \text{ kN}$ | $Nc_cd = 2,581 \text{ kN}$ | |



V




N

