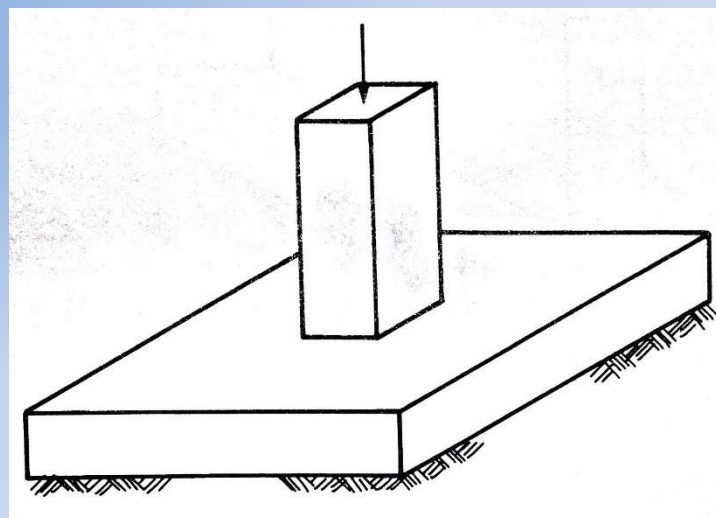




ESCOLA POLITÉCNICA DA USP



Elementos de Fundação

PEF 2304

Prof. Henrique Campelo Gomes

Outubro de 2016

➤ Tipos de Fundação:

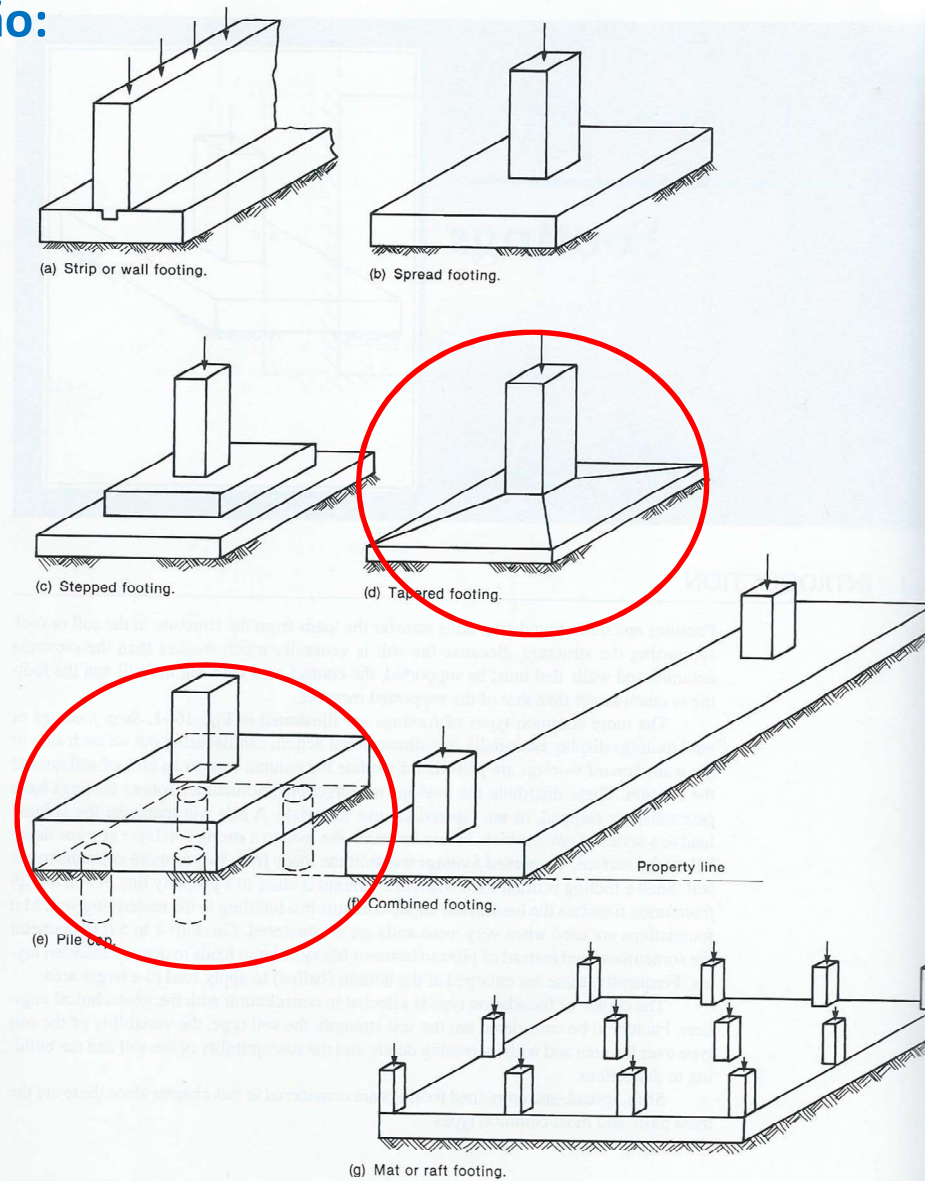


Fig. 16-1
Types of footings.

Fig. 16-2
Pressure distribution under footings.

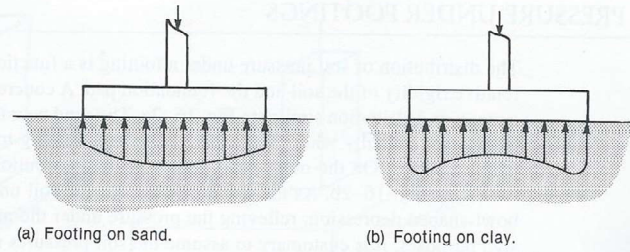


Fig. 16-3
Bearing failure of footing.

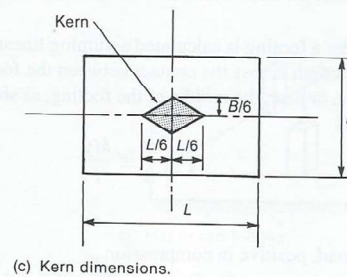
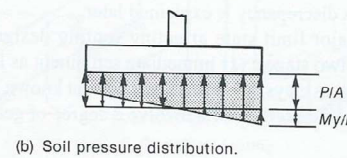
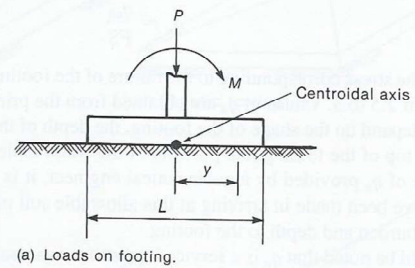
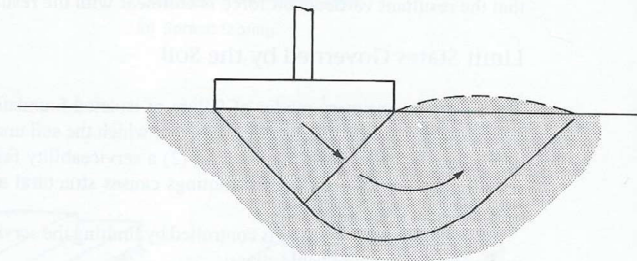
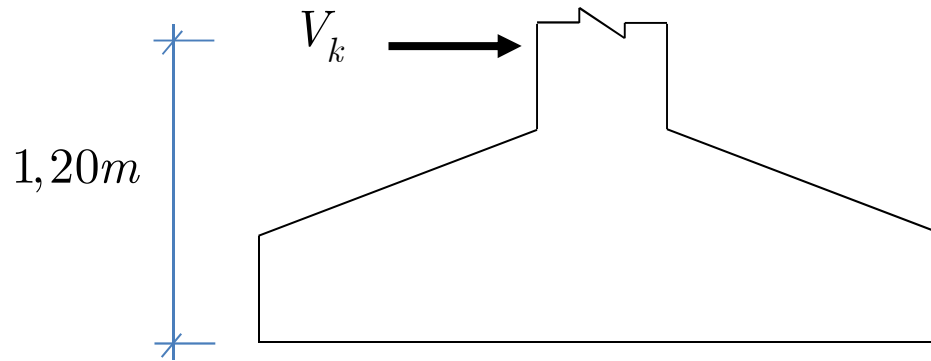


Fig. 16-4
Soil pressure under a footing:
loads within kern.

➤ Dimensionar sapata para um pilar 60x60cm com $\phi_l=25.0\text{mm}$ e esforços abaixo:

$$\begin{aligned} N_k &= 2.460 \text{ kN} \\ V_k &= 100 \text{ kN} \\ M_k &= 600 \text{ kN.m} \end{aligned}$$



Concreto C25

$$l_b = 38\phi$$

$$\sigma_{adm} = 200 \text{ kPa (solo)}$$

Na base:

$$\begin{cases} N_k = 2.460 \text{ kN} \\ M_k = 600 + 100 \cdot 1,2 = 720 \text{ kN.m} \end{cases}$$

1) Dimensões da base (suponto e kernel)

$$\sigma_{\max} = \frac{2.460}{a^2} + \frac{6 \cdot 720}{a \cdot a^2} \leq 1,3 \cdot 200 \text{ kPa} \quad \text{e} \quad \sigma_{\text{médio}} = \frac{2.460}{a^2} \leq 200 \text{ kPa}$$

$$a = 4,0\text{m} \quad \Rightarrow \quad \sigma_{\max} = 221,3 \text{ kPa} \quad \text{e} \quad \sigma_{\text{médio}} = 153,8 \text{ kPa}$$

$$a = 3,9\text{m} \quad \Rightarrow \quad \sigma_{\max} = 234,5 \text{ kPa} \quad \text{e} \quad \sigma_{\text{médio}} = 161,7 \text{ kPa}$$

$$a = 3,8\text{m} \quad \Rightarrow \quad \sigma_{\max} = 249,1 \text{ kPa} \quad \text{e} \quad \sigma_{\text{médio}} = 170,4 \text{ kPa}$$

$$a = 3,7\text{m} \quad \Rightarrow \quad \sigma_{\max} = 265 \text{ kPa} \quad \text{e} \quad \sigma_{\text{médio}} = 179,2 \text{ kPa}$$

$$\sigma = \frac{2.460}{3,8^2} + \frac{6 \cdot 720}{3,8 \cdot 3,8^2} = 170,4 \pm 78,7 \left\{ \begin{array}{l} \sigma_{\max} = 249,1 \text{ kN} / \text{m}^2 \\ \sigma_{\min} = 91,7 \text{ kN} / \text{m}^2 \\ \sigma_{cg} = \frac{\sigma_{\max} + \sigma_{\min}}{2} = 170,4 \text{ kN} / \text{m}^2 \end{array} \right.$$

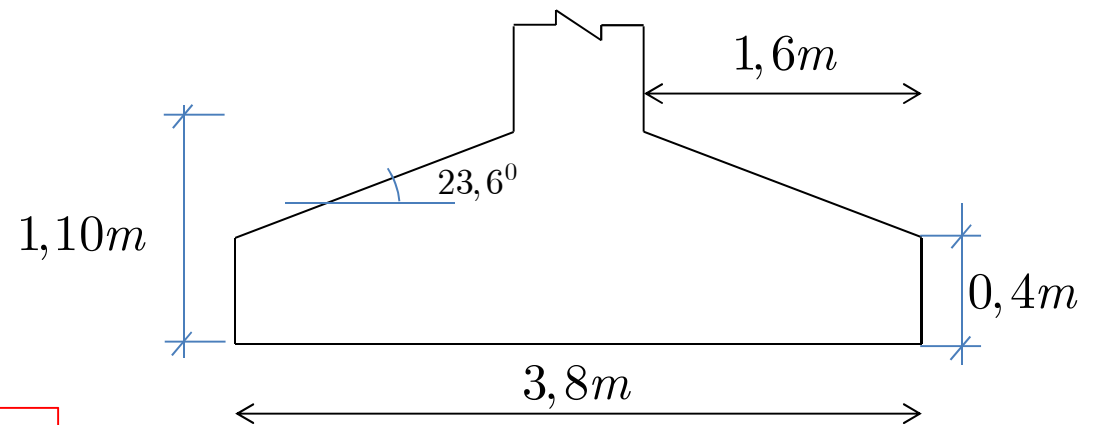
2) Demais dimensões

$$h \geq \left\{ \begin{array}{l} \frac{a - a_p}{3} = \frac{3,8 - 0,6}{3} = 1,07\text{m} \\ 0,8 \cdot 38\phi = 0,8 \cdot 38 \cdot 0,025 = 0,76\text{m} \\ 0,25\text{m} \end{array} \right.$$



$$h = 1,10\text{m}$$

$$h_0 \geq \left\{ \begin{array}{l} \frac{1,10}{3} = 0,37\text{m} \\ 0,20\text{m} \end{array} \right. \Rightarrow h_0 = 0,40\text{m}$$



3) Verificação do Concreto

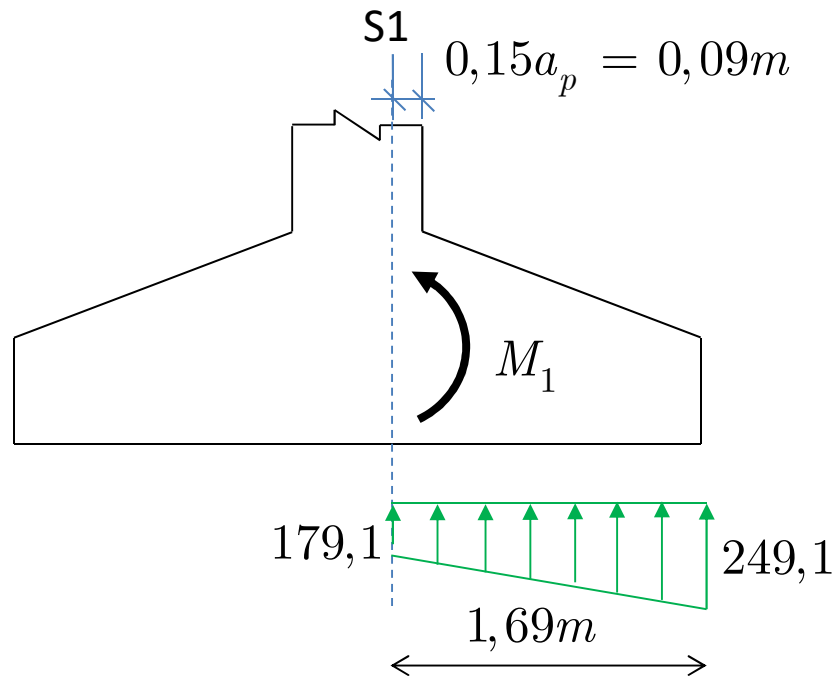
$$\sigma^* \geq \left\{ \begin{array}{l} \frac{\sigma_{\max} + \sigma_{cg}}{2} = 209,8 \text{ kN} / \text{m}^2 \\ \frac{2}{3} \sigma_{\max} = 166,1 \text{ kN} / \text{m}^2 \end{array} \right.$$

$$P_d^* = 1,4 \cdot 209,8 \cdot 3,8^2 = 4240 \text{ kN}$$

$$\tau_{sd} = \frac{P_d^*}{u \cdot d} = \frac{4240}{2,4 \cdot 1,05} \quad (\text{adotando } c=4\text{cm e } \phi/2=1\text{cm})$$

$$\tau_{sd} = 1682,5 \text{ kN} / \text{m}^2 \leq 0,27 \cdot \overbrace{0,9}^{\alpha_{V2}} \cdot \frac{25000}{1,4} = 4339,3 \text{ kN} / \text{m}^2 = \tau_{Rd2}$$

4) Armaduras



$$M_{1k} = 179,1 \cdot \frac{1,69^2}{2} + 70 \cdot \frac{1,69}{2} \cdot \frac{2}{3} \cdot 1,69$$

$$M_{1k} = 322,4 \text{ kN.m / m}$$

(momento característico para uma faixa com largura $b=1m$)

$$A_s = \frac{M_{1d}}{0,8d \cdot f_{yd}} = \frac{1,4 \cdot 322,4}{0,8 \cdot 1,05 \cdot 43,5}$$

$$A_s = 12,35 \text{ cm}^2 / m$$

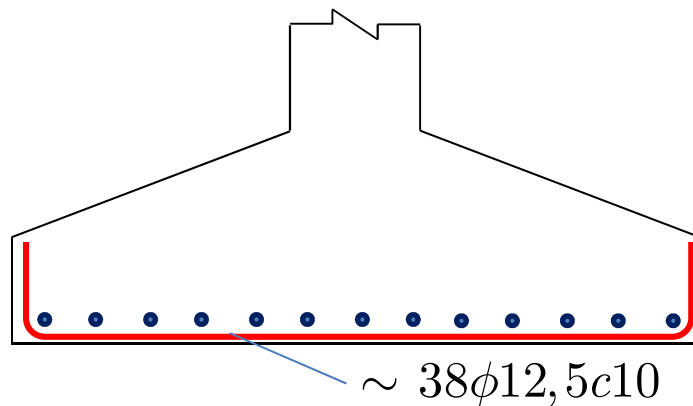
$$\left\{ \begin{array}{l} \phi 12,5c10cm \\ \phi 16c16cm \end{array} \right.$$

$$d'_{ef} = 4cm + \frac{\phi}{2} = 4,63cm$$

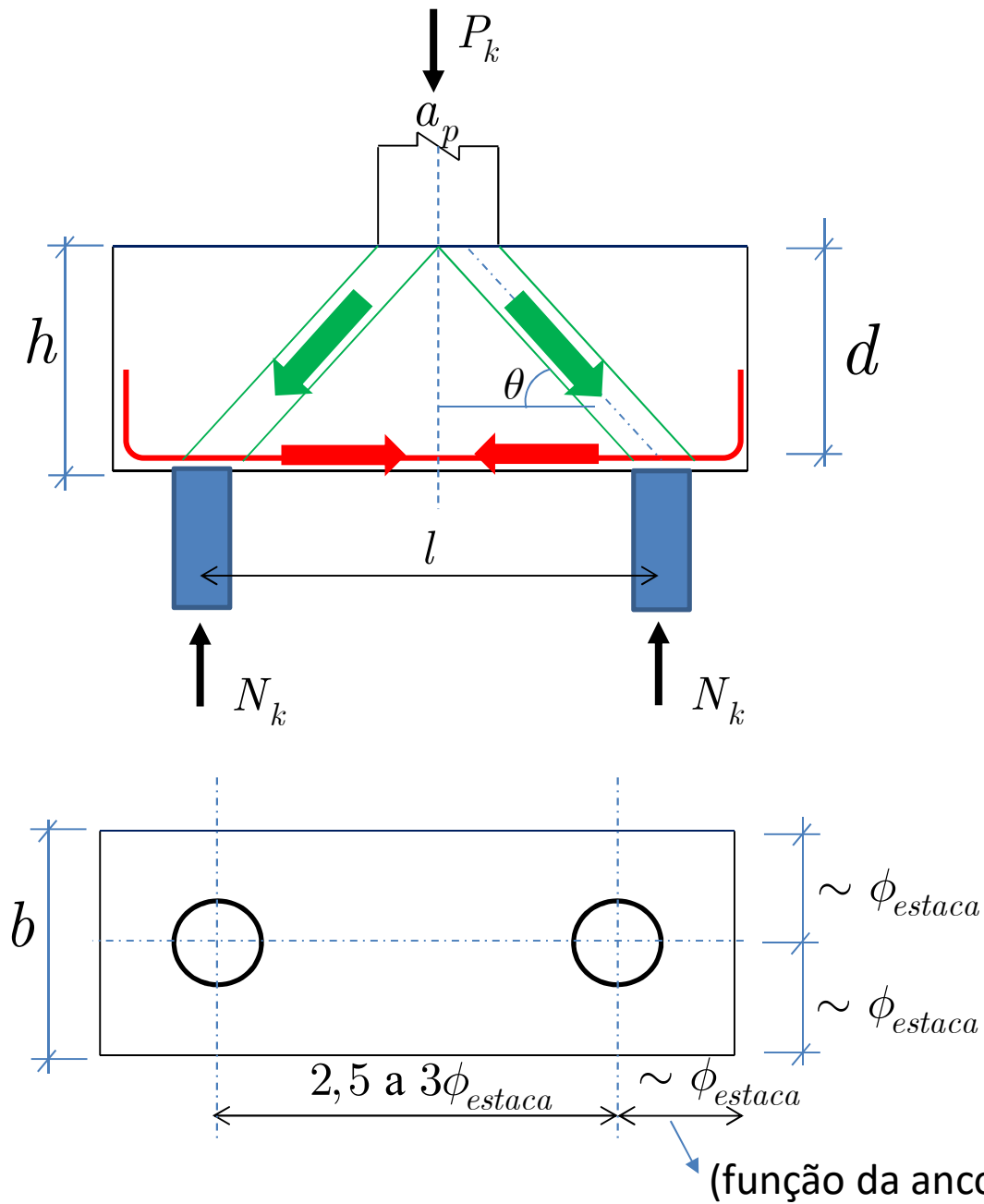
(a favor da segurança, não precisa corrigir A_s)

$$A_{s,min} = 0,10\% \cdot 100 \cdot 110$$

$$A_{s,min} = 11 \text{ cm}^2 / m \text{ (OK)}$$



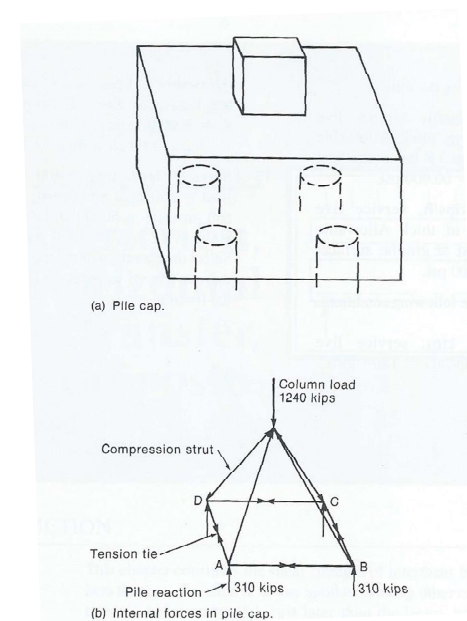
➤ Bloco sobre Estacas (Rígidos)

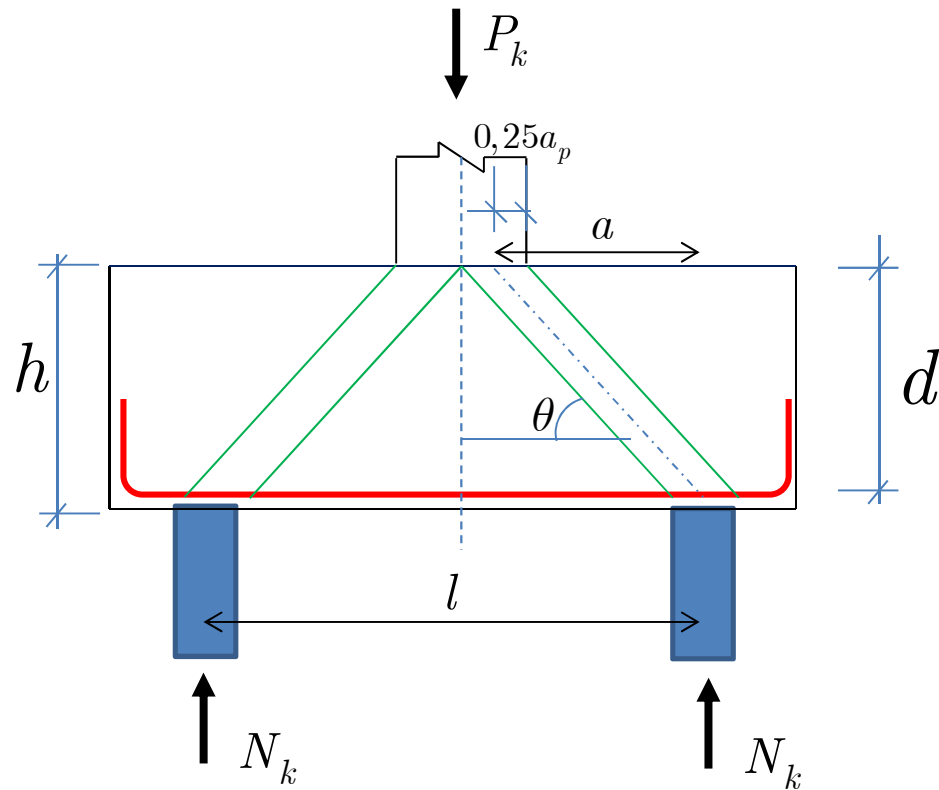


$$\theta = \arctan \left[\frac{d}{\left(\frac{l}{2} - \frac{a_p}{4} \right)} \right]$$

$$45^0 \leq \theta \leq 55^0$$

$$h \geq 0,8l_b \quad (\text{ancoragem da armadura do pilar})$$





1) Verificações do Concreto:

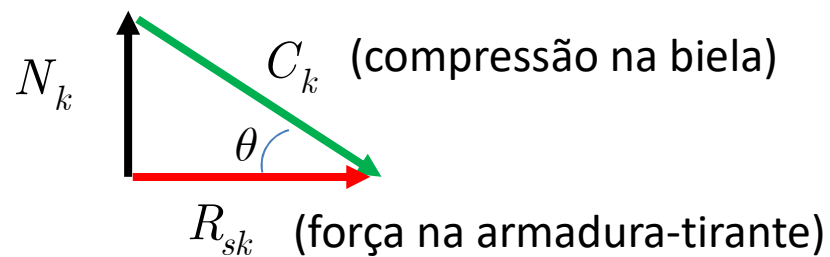
a) Junto ao Pilar:

$$\sigma_{cpd} = \frac{P_k \cdot 1,4}{a_p \cdot b_p \cdot \sin^2 \theta} \leq \begin{cases} 1,4f_{cd} \text{ (2est.)} \\ 1,75f_{cd} \text{ (3est.)} \\ 2,1f_{cd} \text{ (} \geq 4\text{est.)} \end{cases}$$

b) Junto às Estacas:

$$\sigma_{ced} = \frac{N_k \cdot 1,4}{A_{est} \cdot \sin^2 \theta} \leq 0,85f_{cd}$$

2) Dimensionamento da Armadura:



$$R_{sk} = N_k \cdot \frac{a}{d}$$

$$A_s = \frac{1,4R_{sk}}{f_{yd}} = \frac{R_{sd}}{f_{yd}}$$

3) Recomendações:

