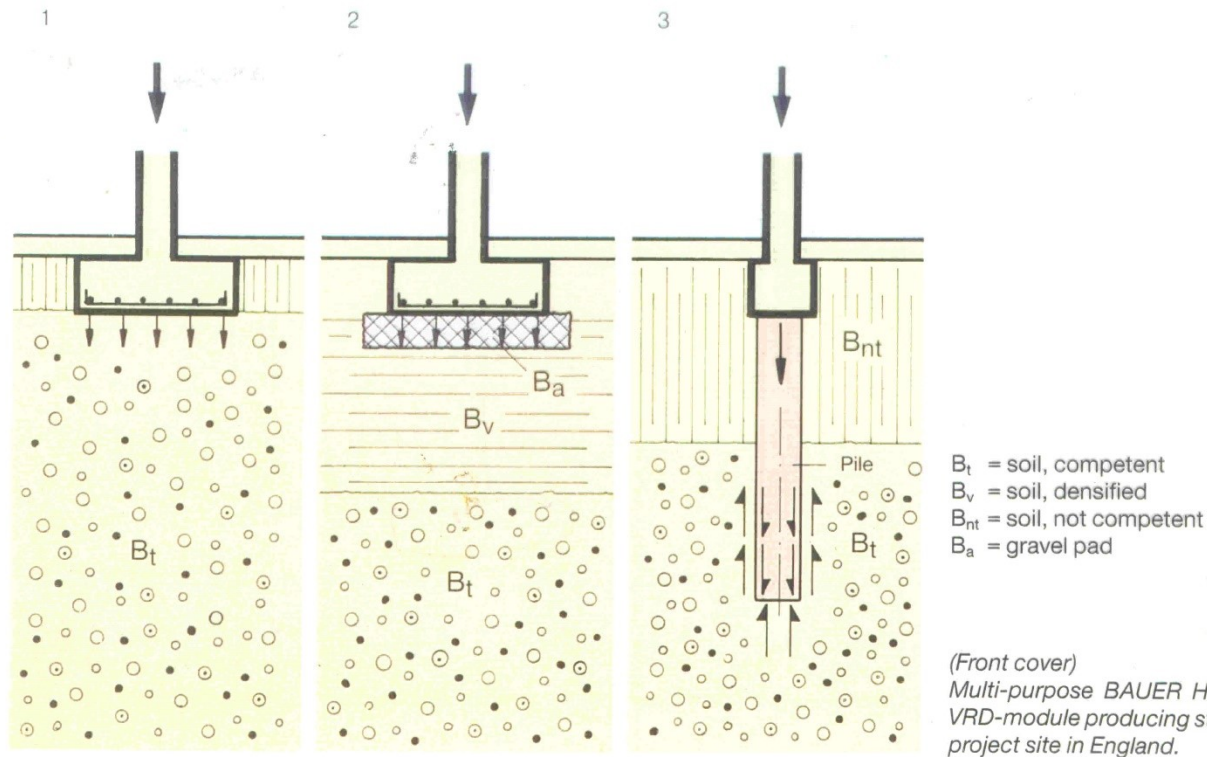


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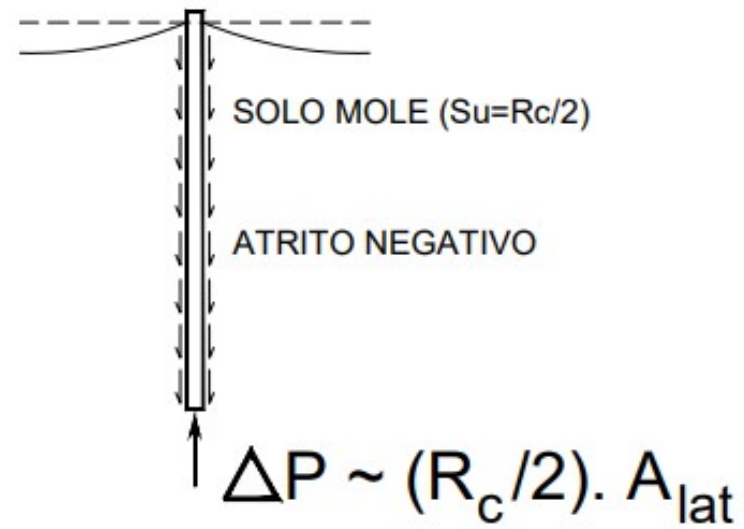
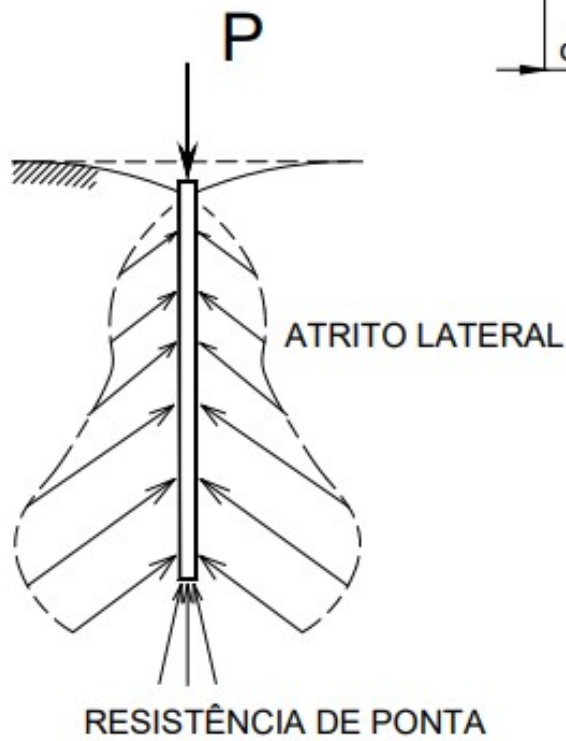
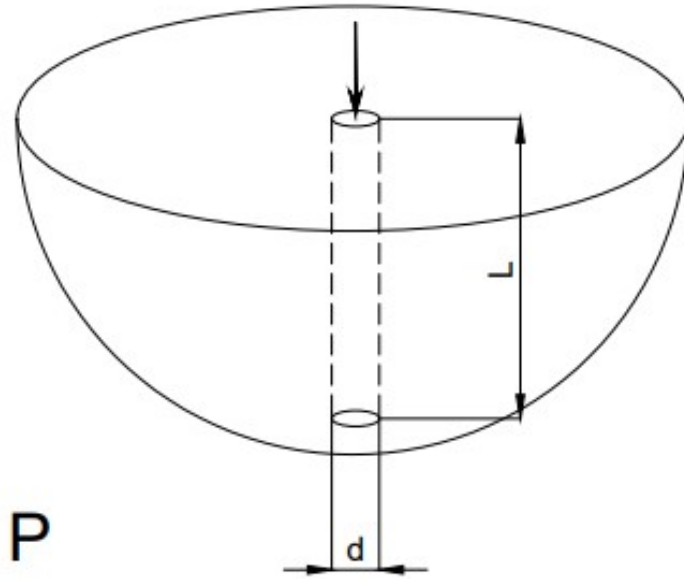
Fundações Profundas

Conceitos iniciais

ELU / ELS



- Transferem esforços axiais de compressão: ponta e lateral
- Carga de ruptura: - ruptura estrutura ou do solo
- $P_r = P_p + P_l$
- Estacas também podem suportar esforços de tração ou horizontais.



Poulos & Davis (Cap.13)

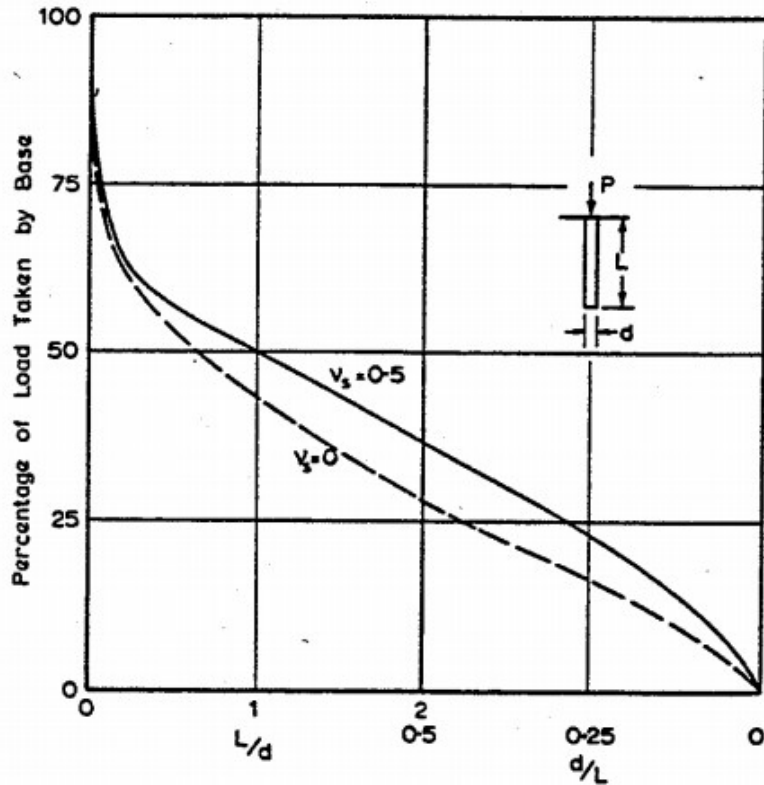


FIG.13.2 Proportion of applied load transferred to base of incompressible pile.

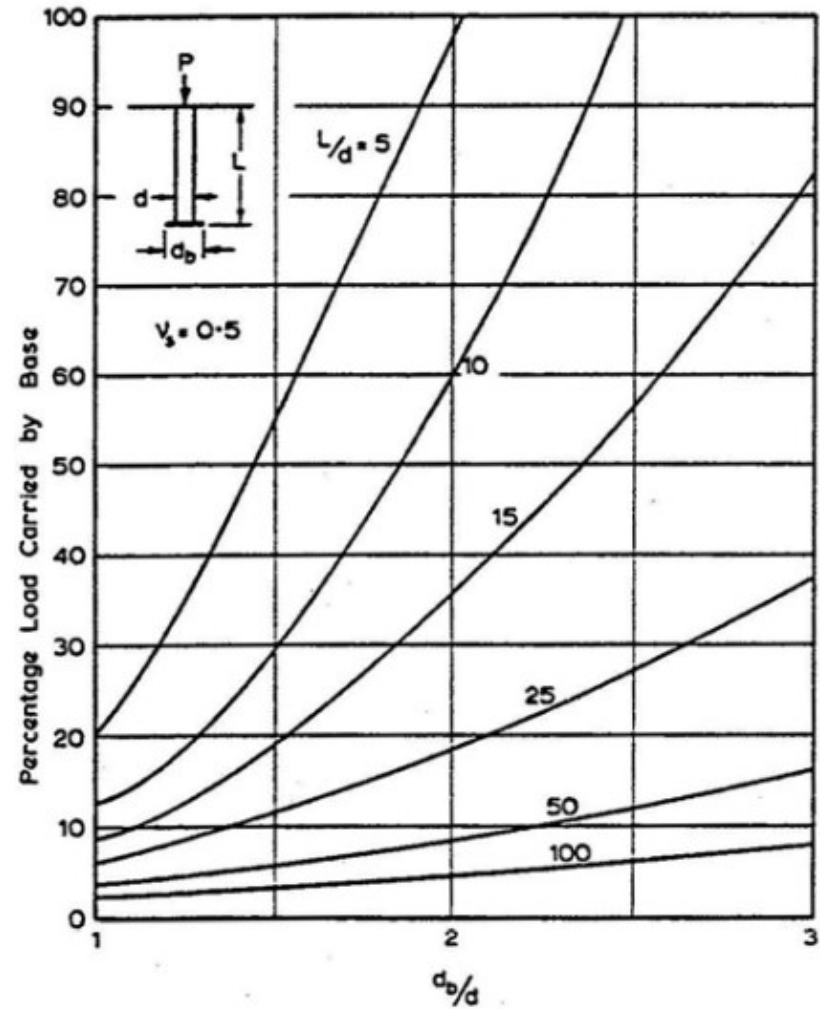
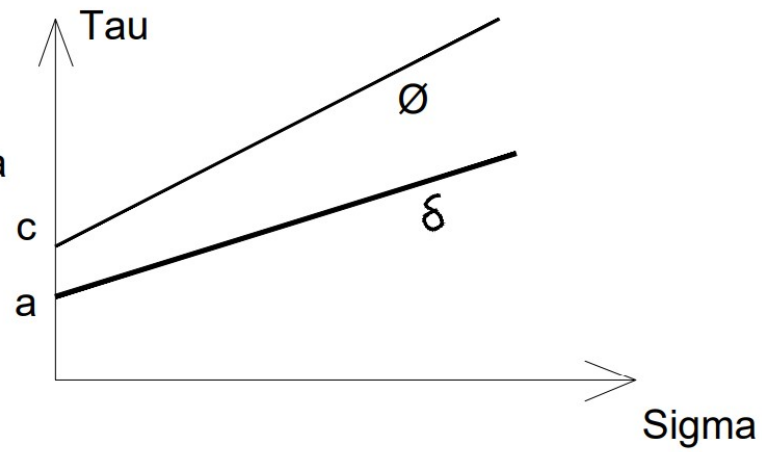
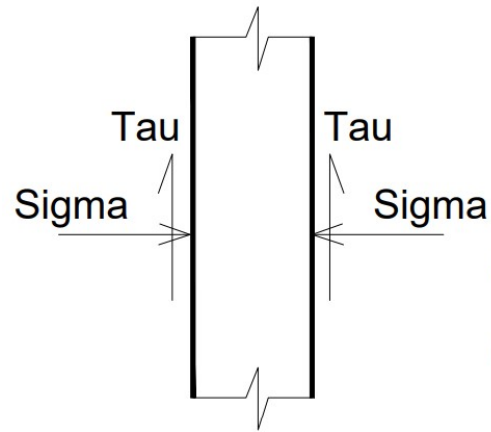
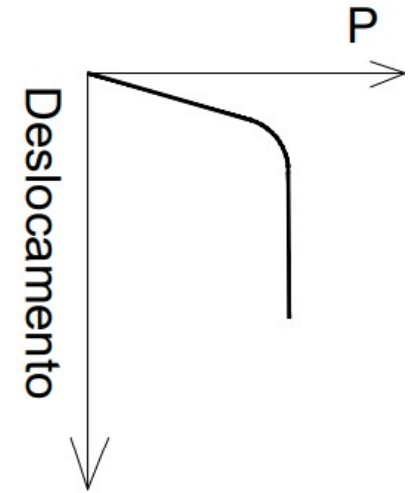
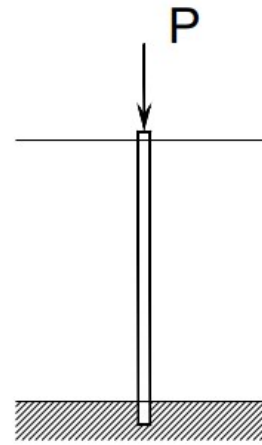
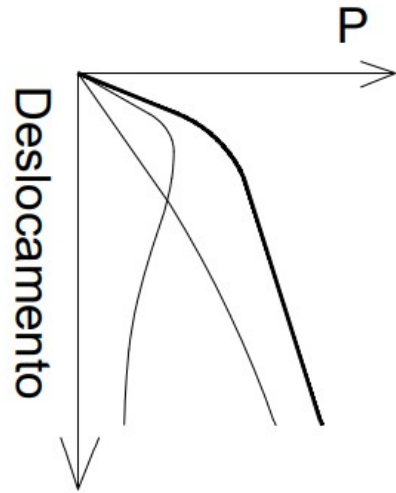
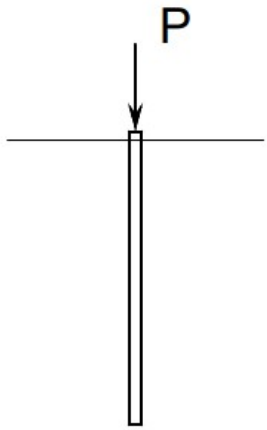
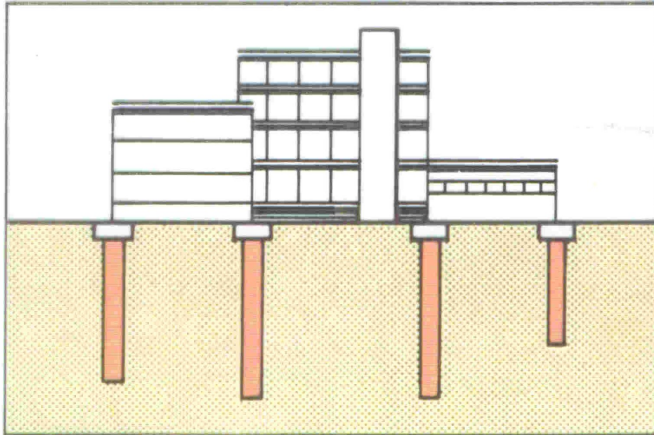
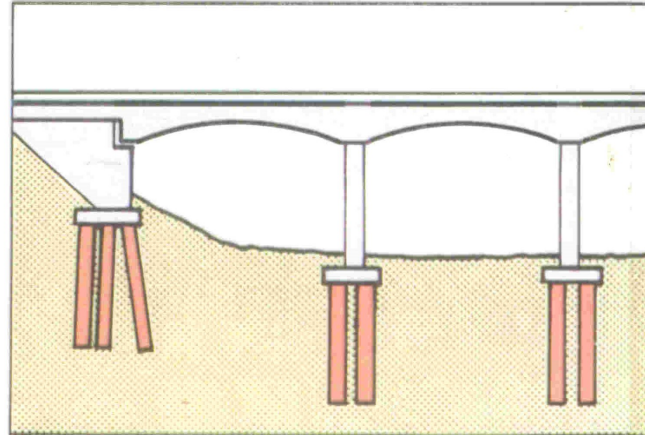


FIG.13.7 Effect of enlarged base on proportion of load transferred to pile base.

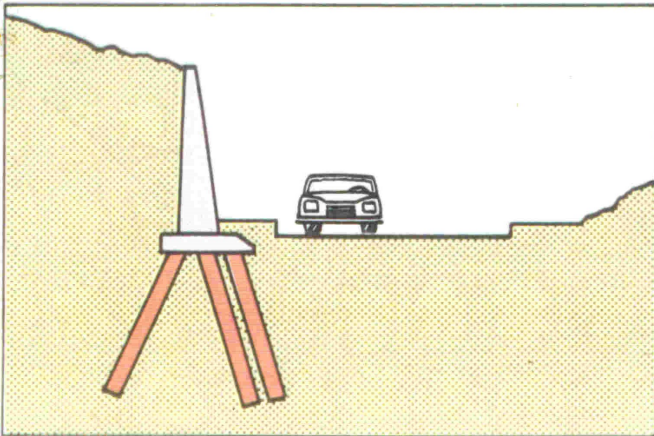




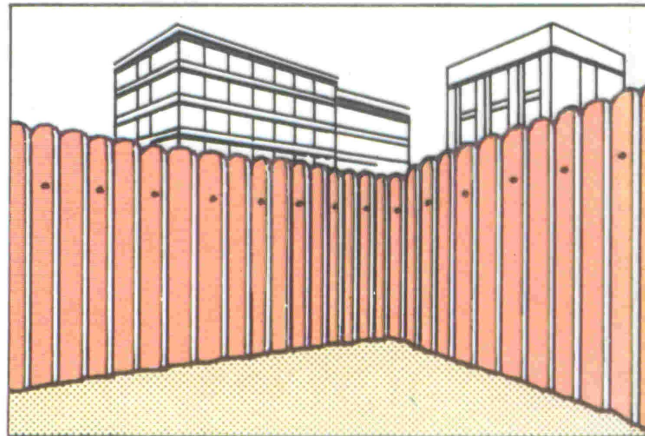
Single piles



Pile groups



Vertical and raked piles



Piled wall

Estacas

- CONCEITO BÁSICO DE PROJETO
- Carga admissível
- a) **ELU** - $P_{adm} = Pr / FS$ onde FS de 1,5 a 3,0
- b) **ELS** - P_{adm} que provoca recalques admissíveis

Tipos de Estacas

- Madeira
- Aço
 - Perfis metálicos laminados
 - Perfis de chapas soldadas ou trilhos
- Concreto:
 - Pré-moldadas
 - Concreto armado (simples/centrifugado)
 - Concreto protendido
 - Segmentos (Mega)
 - Moldadas
 - Broca
 - Strauss
 - Franki
 - Hélice contínua
 - Escavacas de pequeno diâmetro
 - Escavadas de grande capacidade (estacões/barret)
- in loco

Tipos de estacas

- **Mistas**
 - Madeira-concreto
 - Aço-concreto
 - Concreto pré-moldado/moldado in loco
- **Especiais**
 - Estacas-raíz
 - Estacas-colunas

} JG
CCP

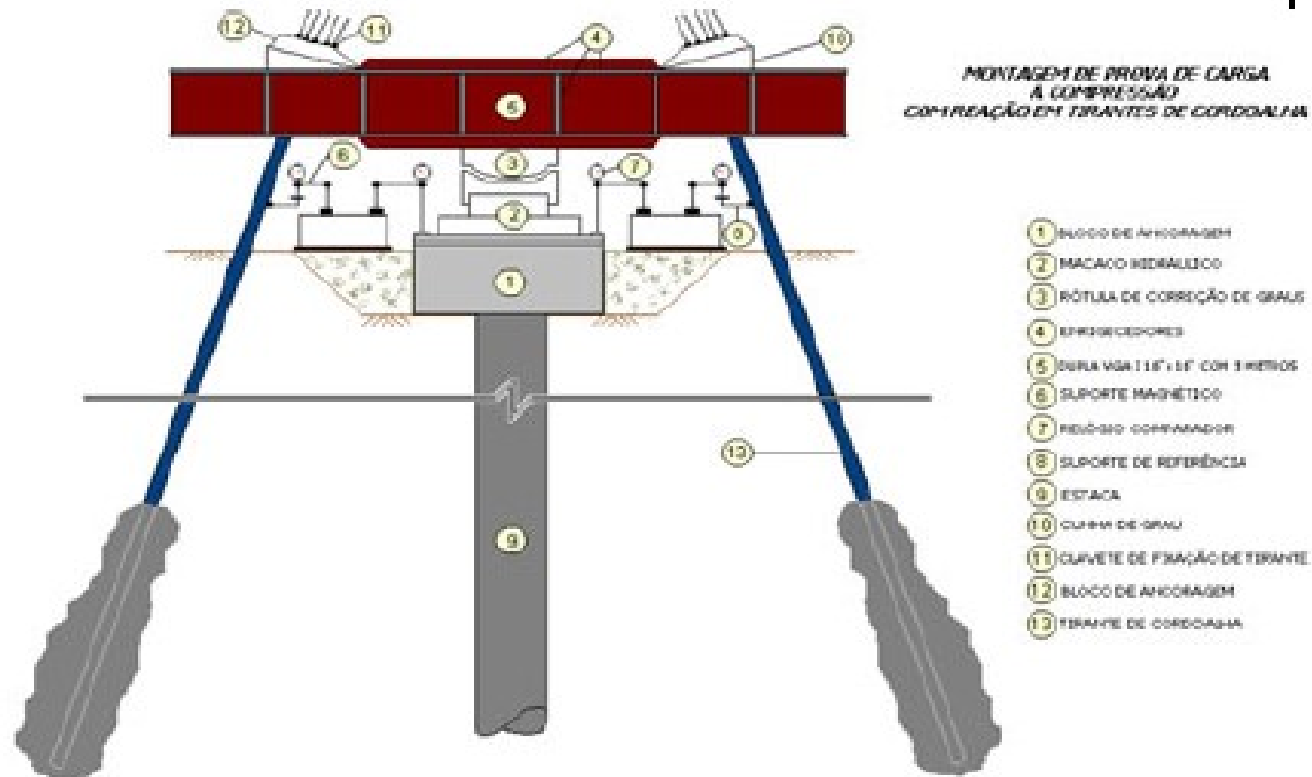
Classificação geral

- Estacas de grande deslocamento lateral: pré-moldadas, Franki
- Estacas de pequeno deslocamento lateral: metálicas H ou I
- Estacas sem deslocamento lateral: Strauss, escavadas

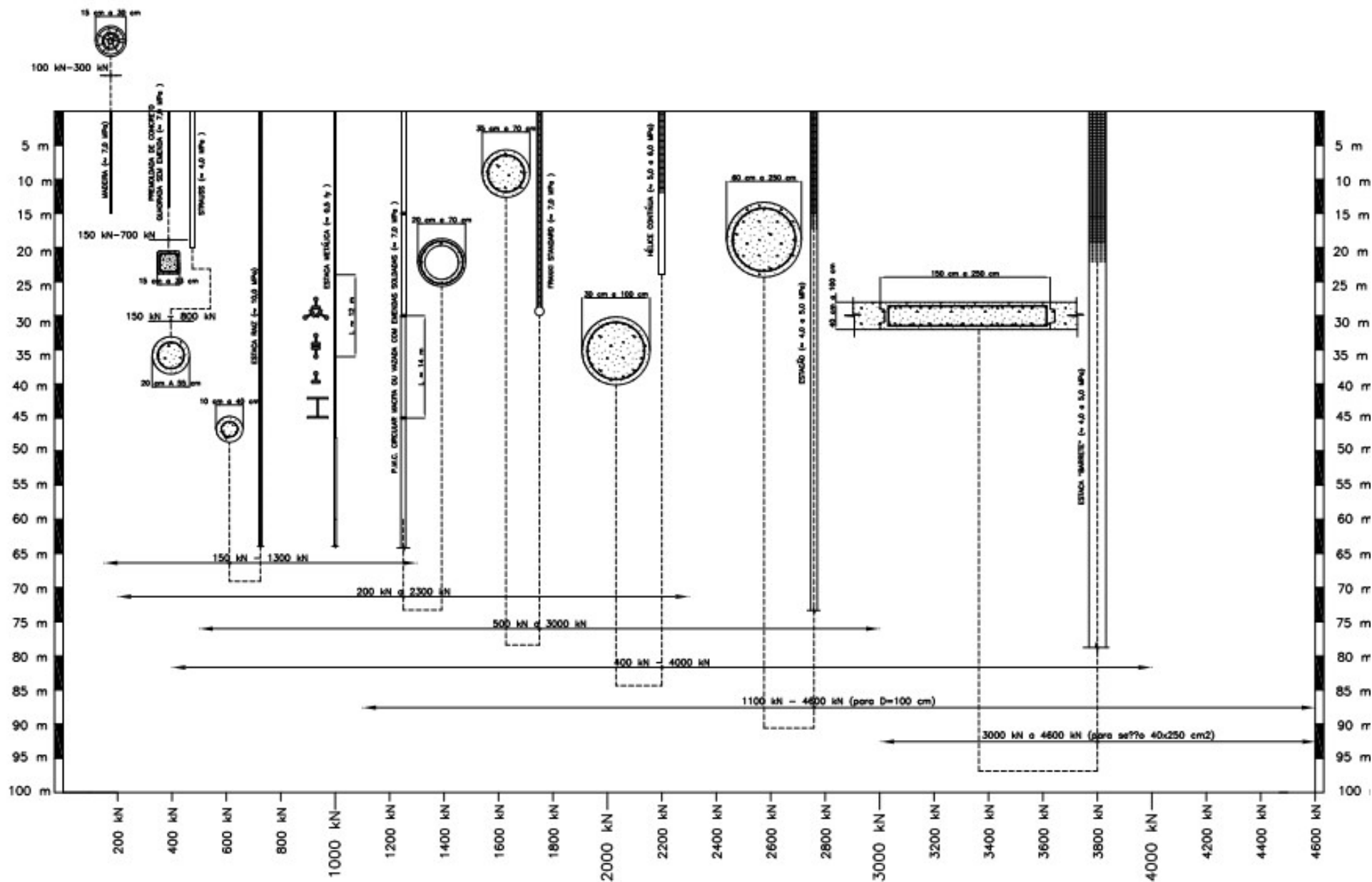
Métodos de Implantação

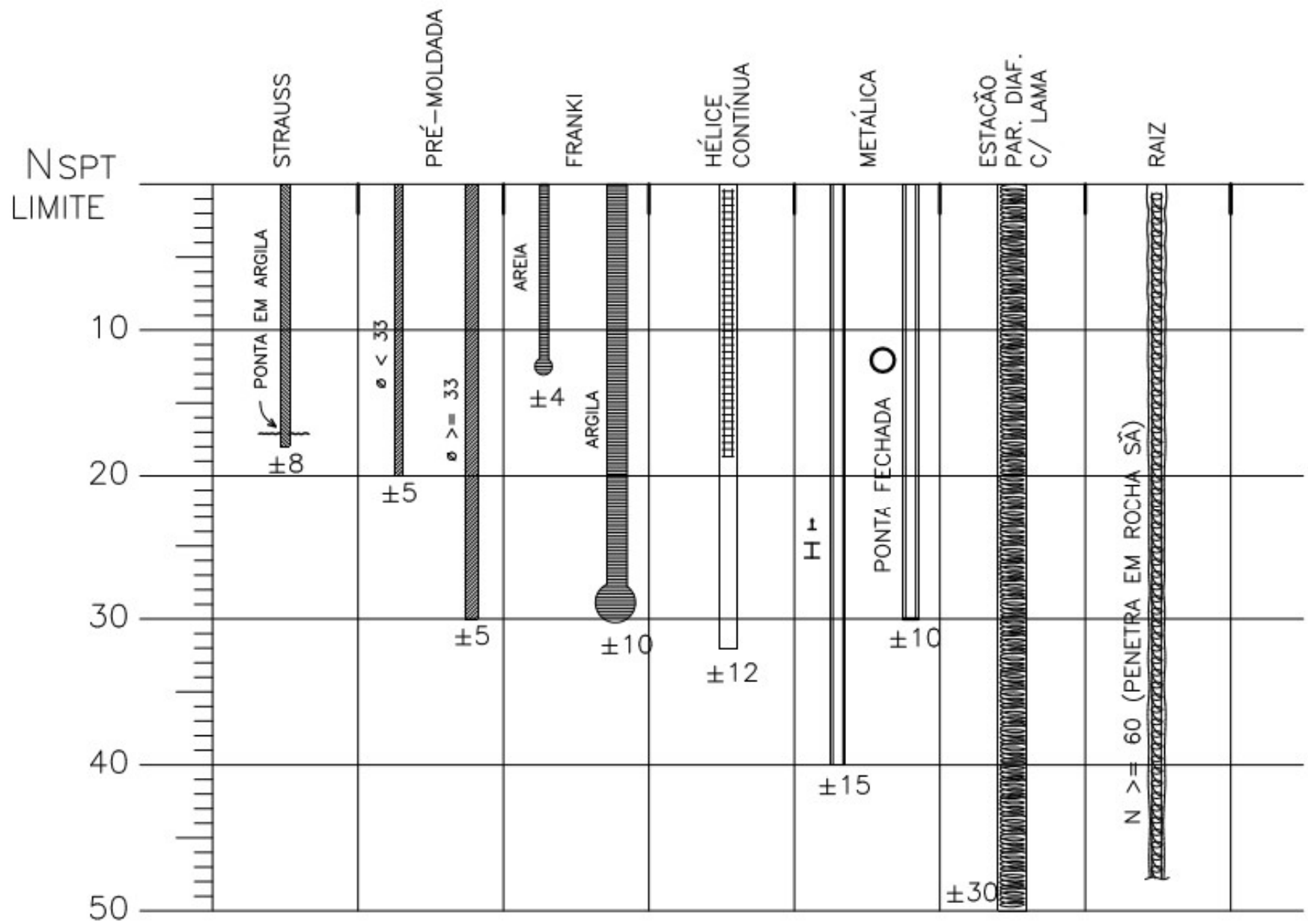
- Dinâmica
 - Impacto: martelos em queda livre com 1,5 a 5,0tf e $H=0,5$ a 1,0m; simples ou duplo efeito (diesel)
 - Vibração: martelo vibratório (em areias ou argilas moles)
- Estática: por prensagem ou escavação e concretagem in situ

Prova de carga



PEF 3405 – AUXILIAR PARA ESCOLHA DE ESTACA SUJEITA A COMPRESSÃO
 (USAR JUNTAMENTE COM TABELAS DOS PRINCIPAIS TIPOS DE ESTACAS)

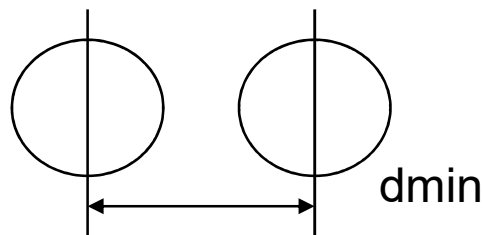




FONTE: CINTRA & AOKI, 2010 – P. 48

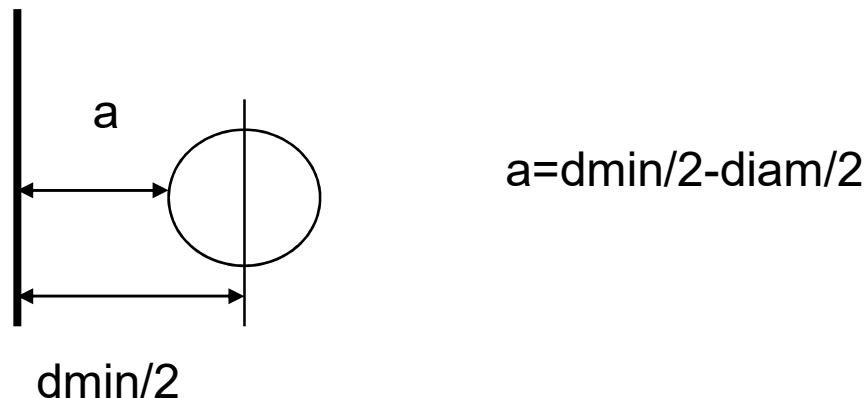
Dimensionamento de estacas em planta

- Número=carga pilar/ P_{nom} estaca
- $CC=CG$
- Mesmo tipo e diâmetro em um bloco
- Espaçamento:
 - pré-moldadas: $d_{min}=2,5$ diam.
 - Moldadas in loco: $d_{min}=3,0$ diam.



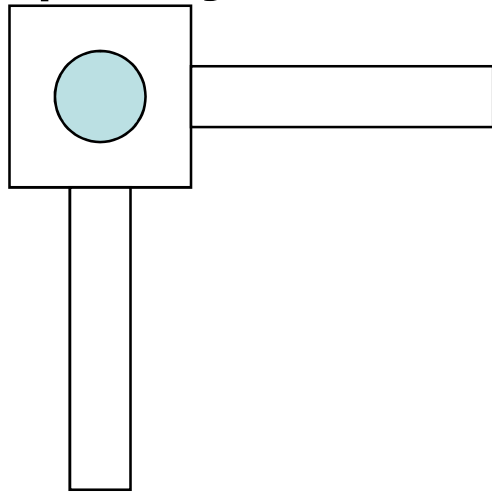
Dimensionamento de estacas em planta

- Distância à divisa
 - pré-moldadas: $d_{min}=2,5 \text{ diam.}$
 - Moldadas in loco: $d_{min}=3,0 \text{ diam.}$

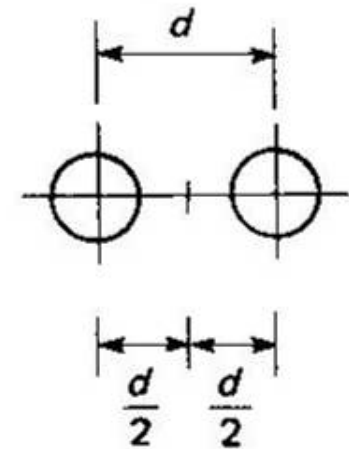
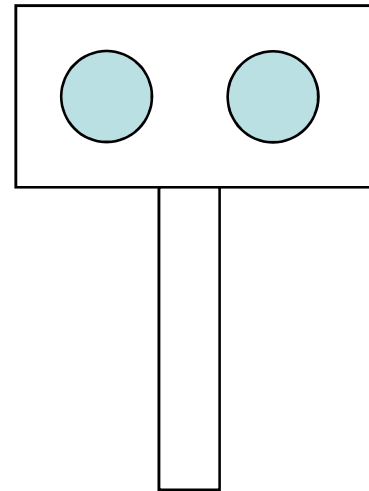


Dimensionamento de estacas em planta

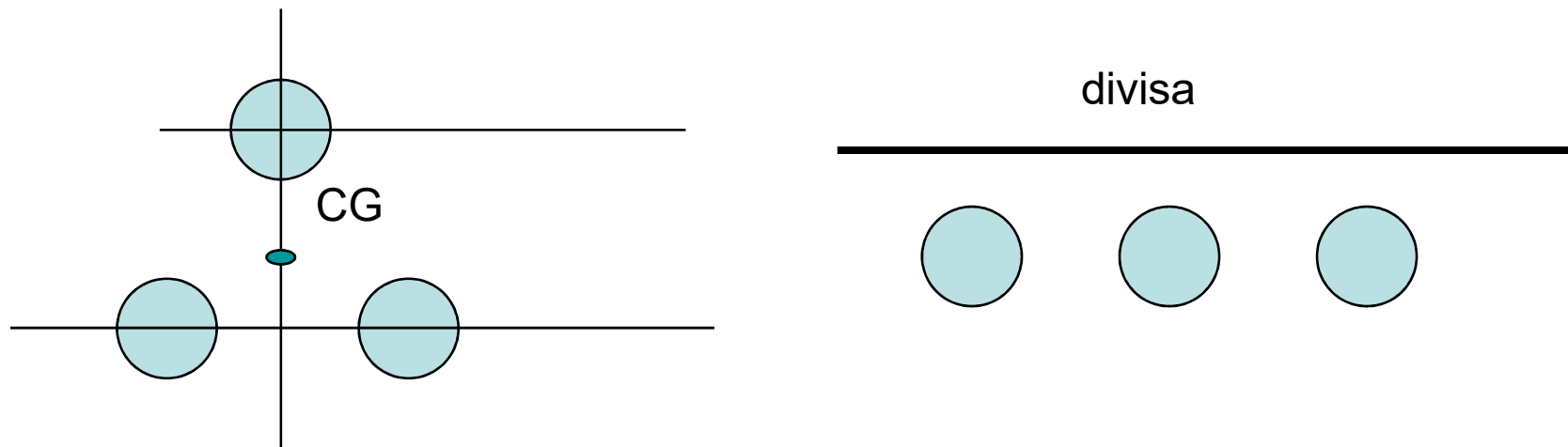
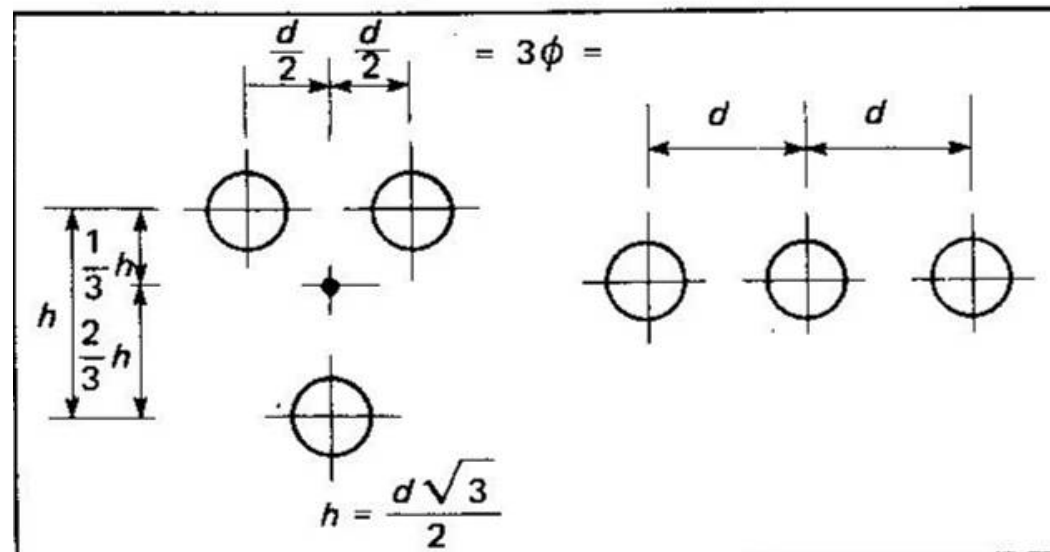
- Disposição



Viga baldrame

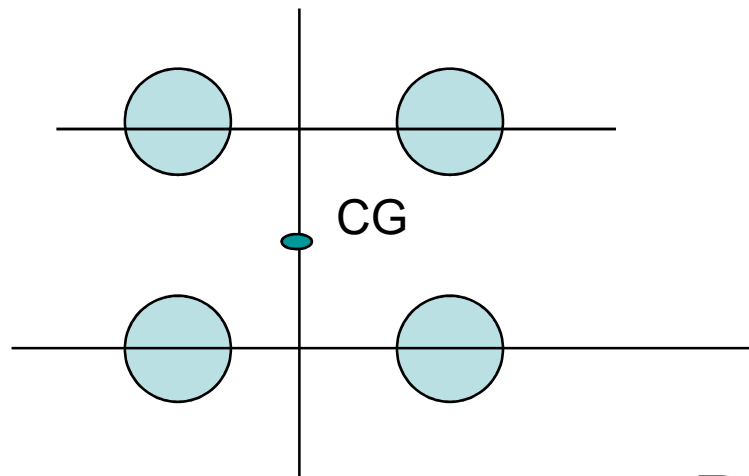
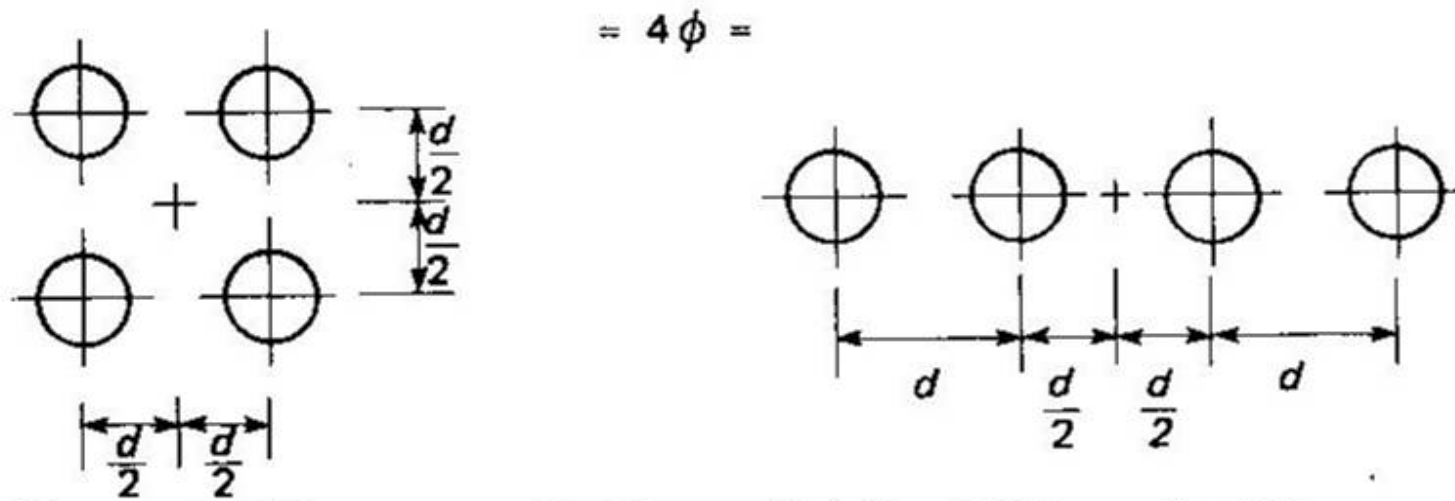


Bloco sobre três estacas

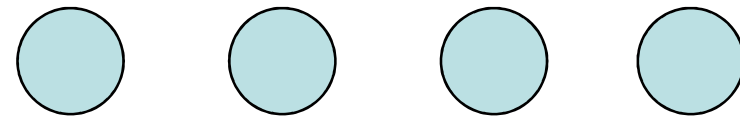


- Disposição

Bloco sobre 4 estacas

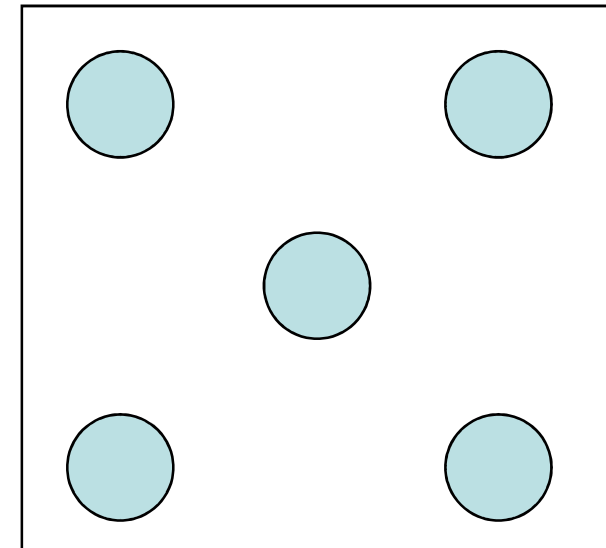
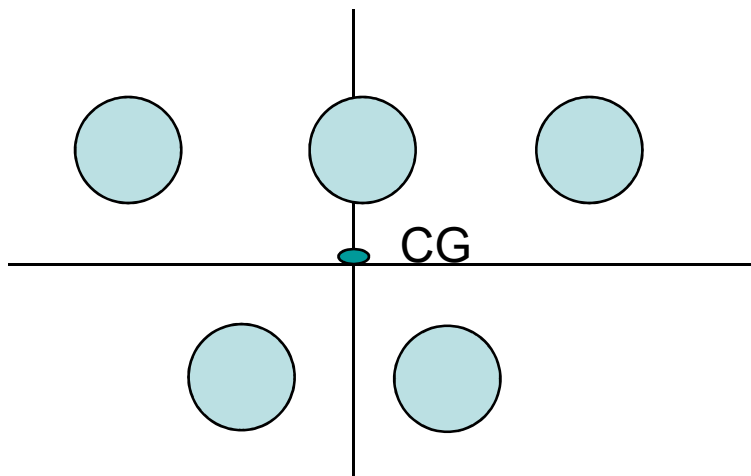
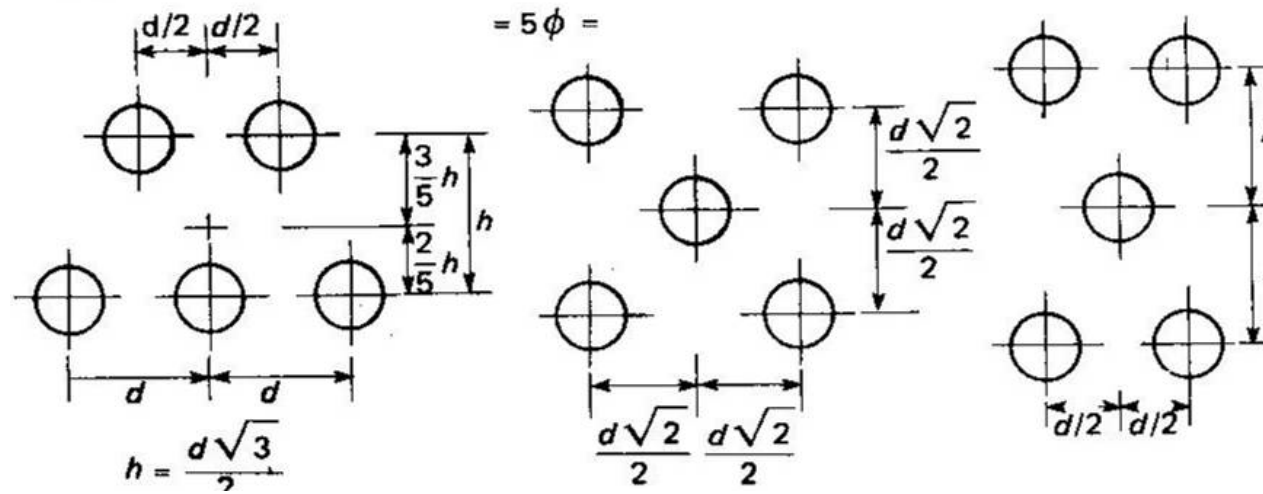


divisa

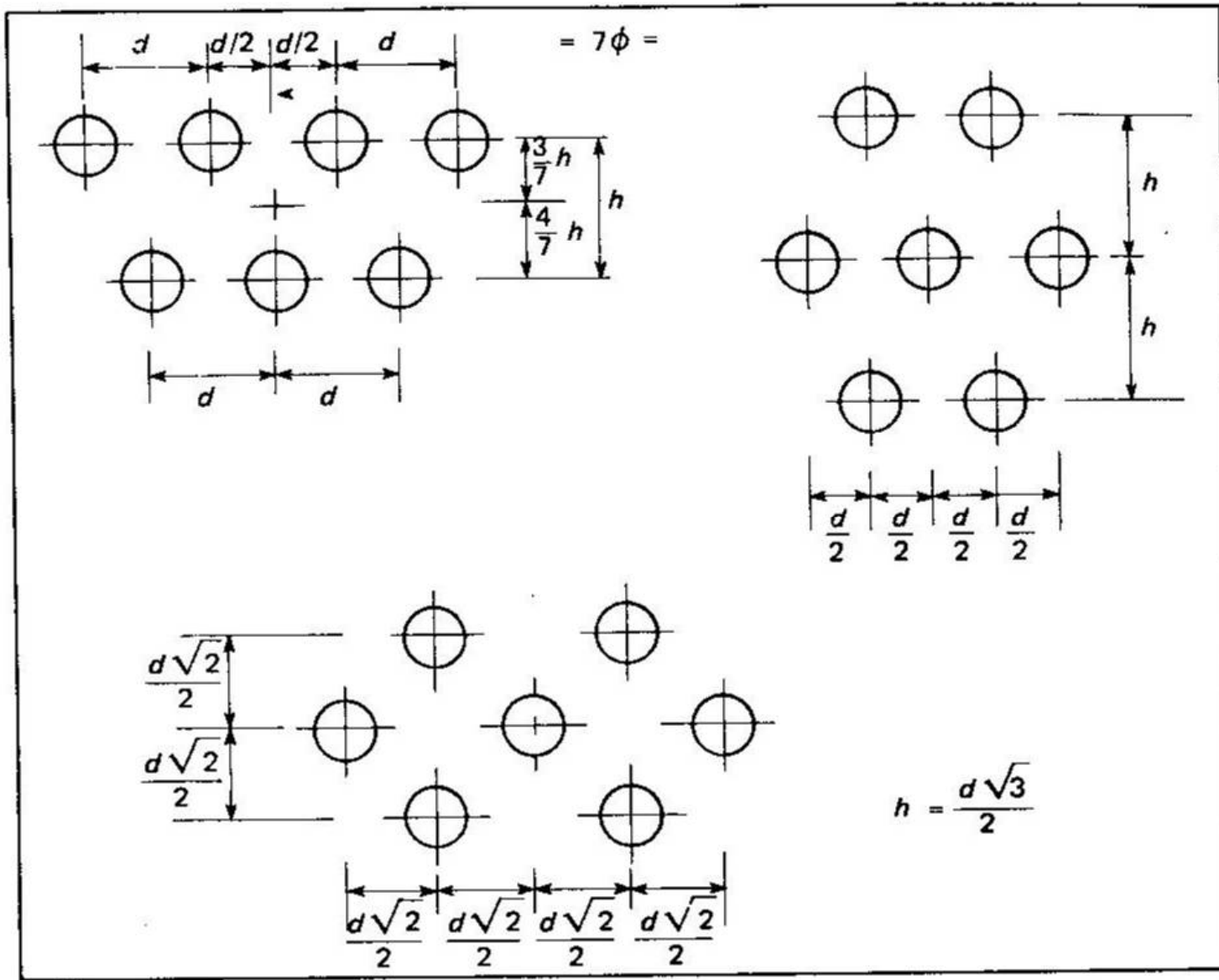


- Disposição

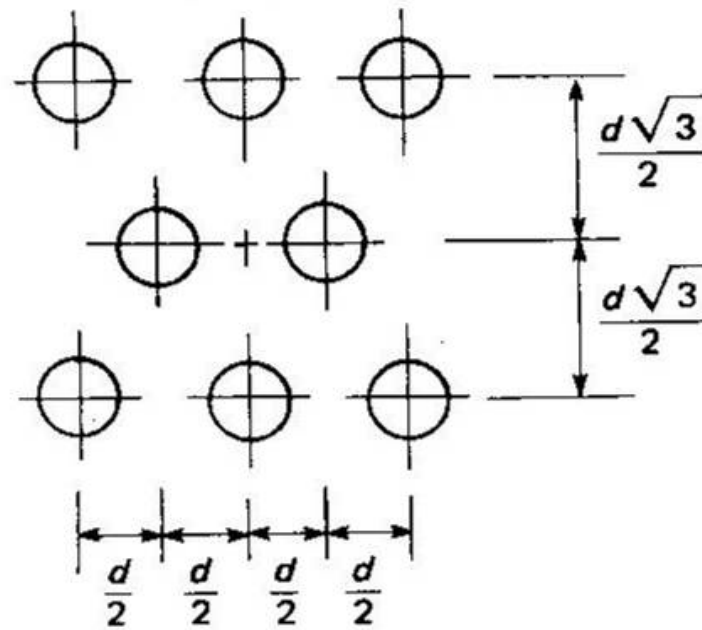
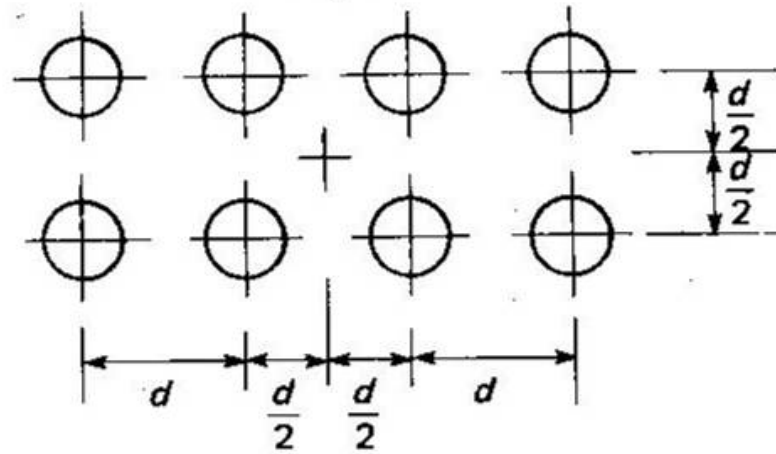
Bloco sobre 5 estacas



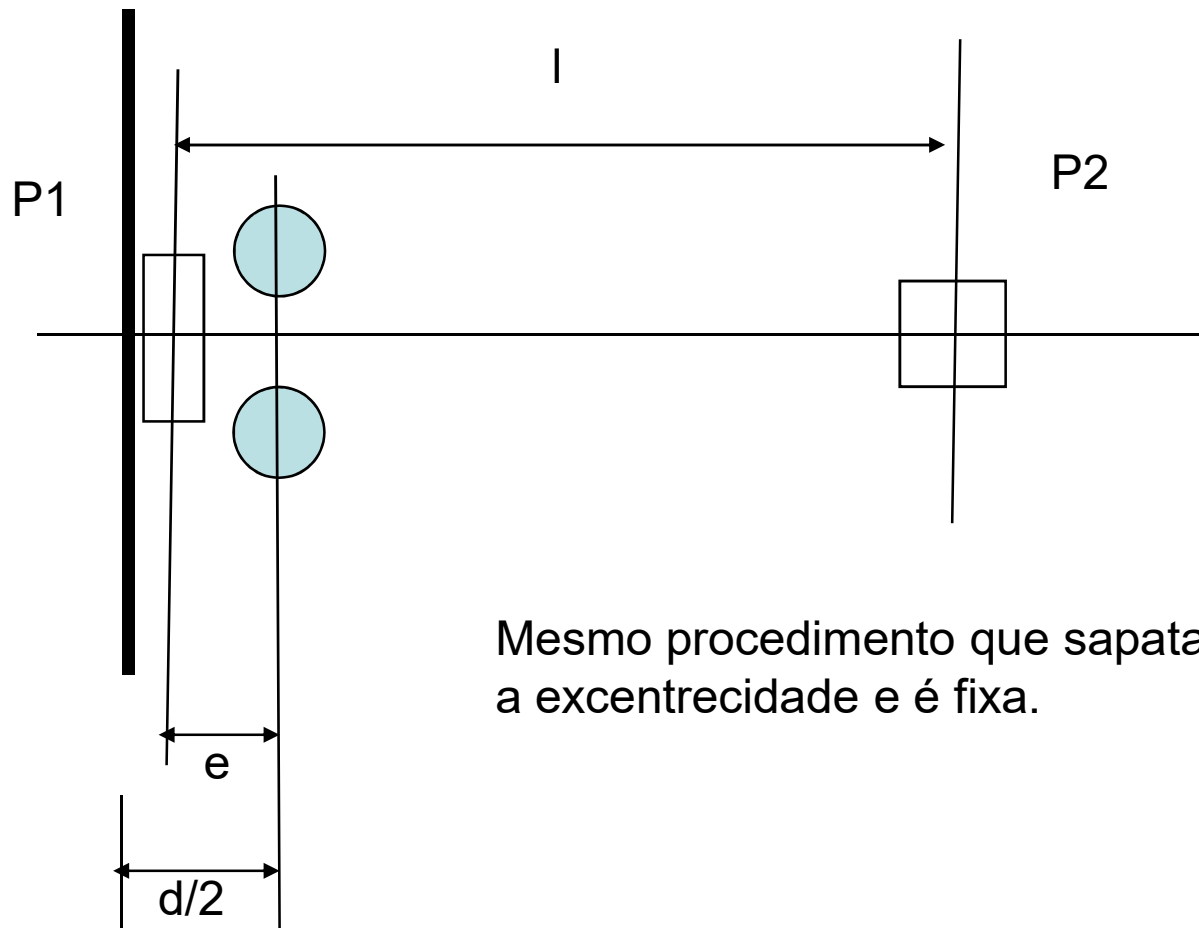
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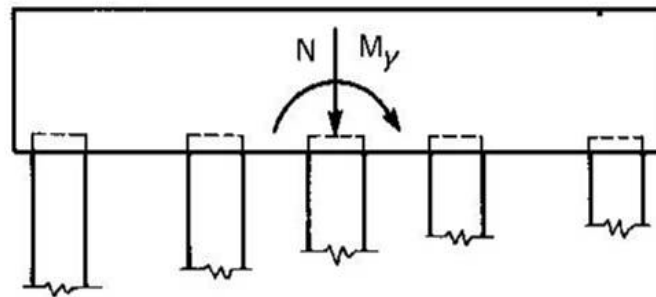
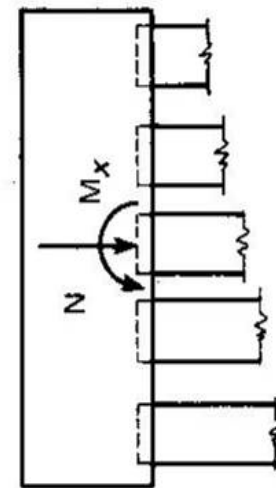
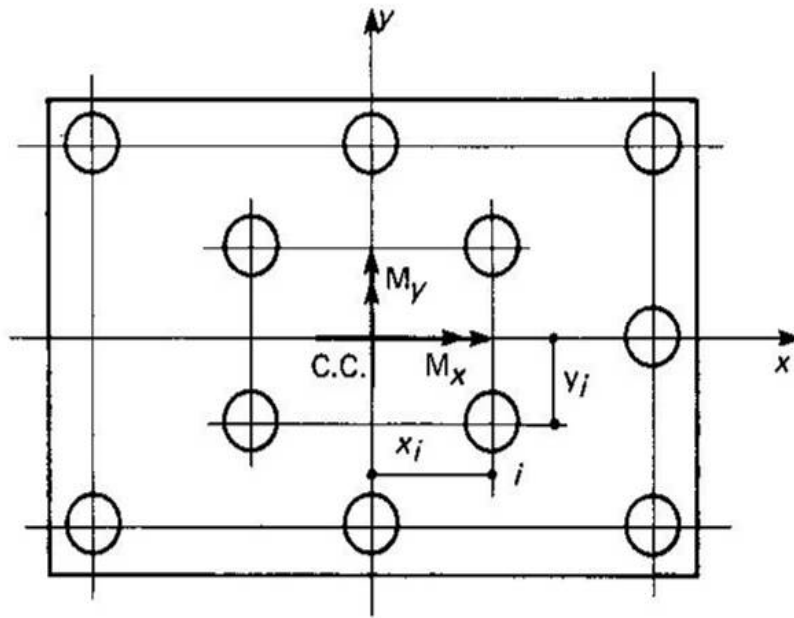
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Pilares de divisa



Blocos com momento

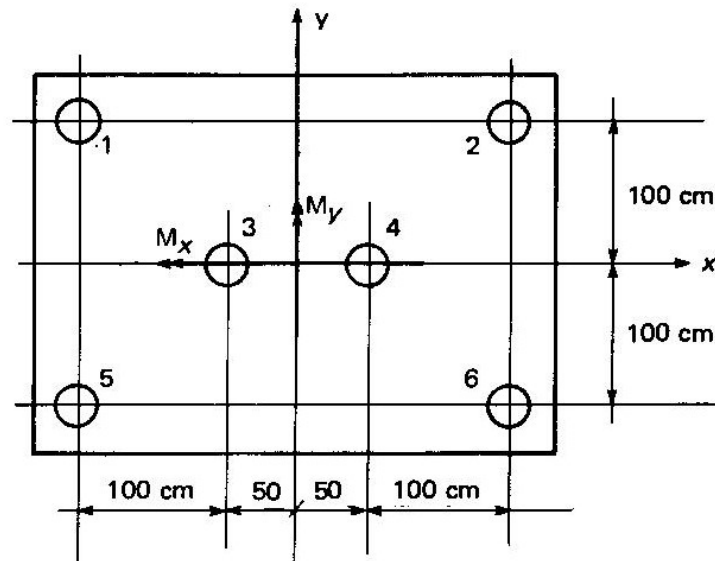


$$P_i = \frac{N}{n} \pm \frac{M_y x_i}{\sum x_i^2} \pm \frac{M_x y_i}{\sum y_i^2}$$

Exercício: Calcular a carga atuante nas estacas do bloco abaixo, sabendo-se que no mesmo atuam as seguintes cargas (consideradas na cota de arrasamento):

$$\begin{aligned} N &= 2\,000 \text{ kN} \\ M_x &= -500 \text{ kN} \cdot \text{m} \\ M_y &= +400 \text{ kN} \cdot \text{m} \end{aligned}$$

Desprezar o peso próprio do bloco



Solução: $\Sigma x_i^2 = 4 \times 1,5^2 + 2 \times 0,5^2 = 9,5 \text{ m}^2$
 $\Sigma y_i^2 = 4 \times 1^2 = 4 \text{ m}^2$

Carga nas estacas

$$P_i = \frac{N}{n} \pm \frac{M_y x_i}{\Sigma x_i^2} \pm \frac{M_x y_i}{\Sigma y_i^2}$$

$$P_1 = \frac{2\,000}{6} - \frac{400 \times 1,5}{9,5} + \frac{500 \times 1}{4} = 395 \text{ kN}$$

$$P_2 = \frac{2\,000}{6} + \frac{400 \times 1,5}{9,5} + \frac{500 \times 1}{4} = 521 \text{ kN}$$

$$P_3 = \frac{2\,000}{6} - \frac{400 \times 0,5}{9,5} = 312 \text{ kN}$$

$$P_4 = \frac{2\,000}{6} + \frac{400 \times 0,5}{9,5} = 354 \text{ kN}$$

$$P_5 = \frac{2\,000}{6} - \frac{400 \times 1,5}{9,5} - \frac{500 \times 1}{4} = 145 \text{ kN}$$

$$P_6 = \frac{2\,000}{6} + \frac{400 \times 1,5}{9,5} - \frac{500 \times 1}{4} = 271 \text{ kN}$$

Estimativa de Comprimento e capacidade de carga de estacas

Estimativa preliminar: Fórmulas de V. Mello:

- Estacas de ponta

$$N_{\text{SPT-ponta}} = 0,5\sigma_c \text{ (kgf/cm}^2\text{)}$$

- Estacas de ponta e atrito lateral

$$\text{Somatória } N_{\text{SPT-fuste}} = 1,5\sigma_c \text{ (kgf/cm}^2\text{)}$$

Onde σ_c = tensão admissível à compressão do concreto armado

Método de Décourt-Quaresma

- $P_r = R_p + R_l = K' \cdot N_p \cdot A_p + 10 \cdot p \cdot (1 + N_l/3) L$ (kN)

Onde:

K' =tabela

N_p =SPT da ponta

A_p =área da ponta da estaca

p =perímetro da estaca

N_l =SPT médio lateral (<50)

L =comprimento da estaca

Método de Décourt-Quaresma

Tipo de solo	K' (kN/m ²)	
	Estacas pré-moldadas de concreto, metálicas, Strauss, Franki, Raiz	Estacas escavadas com lama bentonítica
Argilas	120	100
Siltes argilosos	200	120
Siltes arenosos	250	140
Areias	400	200

Método de Aoki-Veloso

- $P_r = K \cdot N_p \cdot A_p / F_1 + (p / F_2) \sum (\beta \cdot N_l \cdot \Delta l)$ (kN)

Onde:

F_1 , F_2 , K e β =tabela

N_p =SPT da ponta

A_p =área da ponta da estaca

p =perímetro da estaca

N_l =SPT médio lateral (<50)

Δl =comprimento dos segmentos

Método de Aoki-Veloso

Solo		K (kPa)	β (kPa)
Argila	-	200,0	8,5
	Siltosa	220,0	
Silte	Argiloso	230,0	
Argila	Arenosa	350,0	12,0
Silte	-	400,0	
	Arenoso	550,0	
Areia	Argilosa	600,0	16,0
	Siltosa	800,0	
	-	1000,0	

Método de Aoki-Veloso

Tipo de estaca	F1	F2
Franki	2,5	5,0
Aço	1,75	3,5
Pré-moldada concreto	1,75	3,5
Escavada	3,5	6,0

Fatores de Segurança

- Pequeno diâmetro ($d \leq 50\text{cm}$): global

$$P_{adm} = P_r / FS \text{ onde } 2 \leq FS \leq 3$$

- Grande diâmetro ($d > 50\text{cm}$): parciais

$$P_{adm} = P_p / F_{Sp} + R_I / F_{SI} \text{ onde:}$$

$$4 \leq F_{Sp} \leq 5 \text{ e}$$

$$1,3 \leq F_{SI} \leq 1,5$$

ELS

- Em geral, menos crítico;
- Apresentam-se aqui apenas algumas expressões da Teoria da Elasticidade (Poulos & Davis);

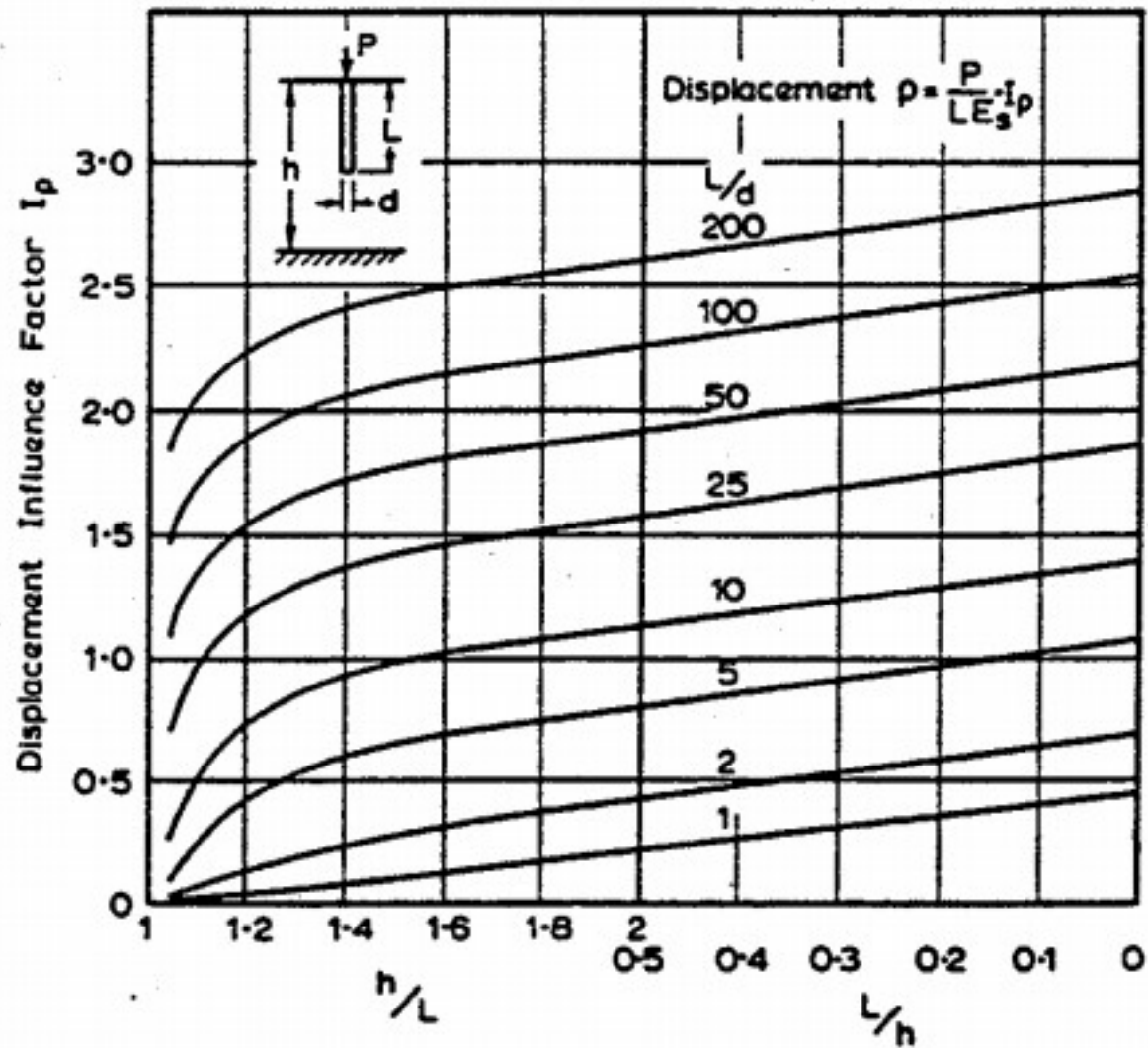


FIG.13.6 Displacement of incompressible pile in finite layer. $\nu_s = 0.5$.

The compressibility of the pile in relation to the soil is expressed by a pile stiffness factor K where

$$K = \frac{E_p}{E_s} R_A \quad \dots (13.1)$$

where E_p = Young's modulus of pile

E_s = Young's modulus of soil mass

R_A = area of pile section / $\frac{\pi d^2}{4}$

The displacement ρ is given by

$$\rho = \frac{P}{L E_s} I_\rho \quad \dots (13.2)$$

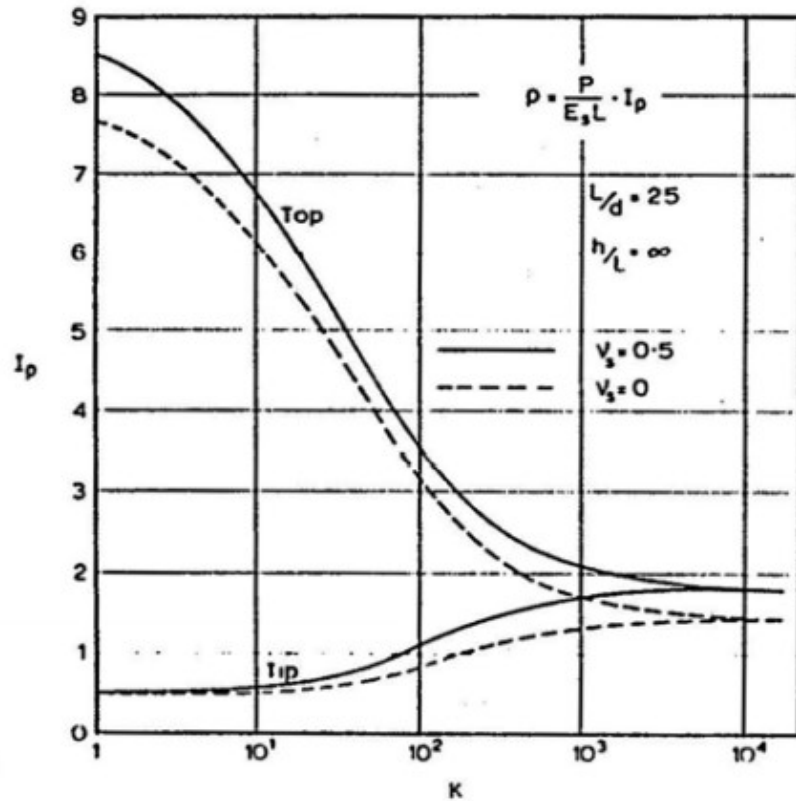


FIG.13.11 Top and tip displacements of compressible floating pile (Mattes and Poulos, 1969).

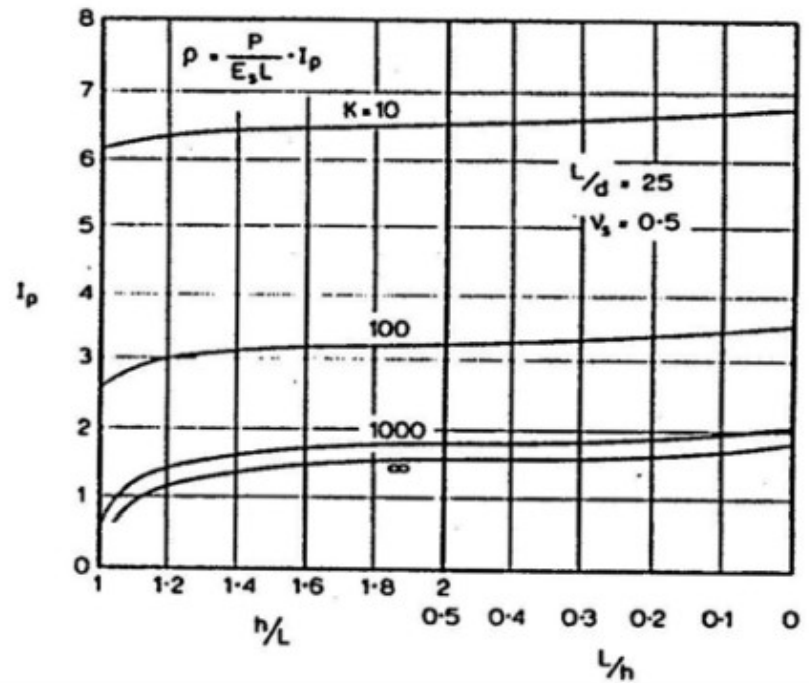


FIG.13.13 Effect of finite layer depth on pile displacement (Mattes and Poulos, 1969)

TABLE 19.5 TYPICAL RANGE OF VALUES FOR MODULUS OF ELASTICITY.

<i>Type of Soil</i>	<i>Modulus of Elasticity</i>	
	<i>psi</i>	<i>kp/cm²</i>
Very soft clay	50-400	3.5-30
Soft clay	250-600	20-50
Medium clay	600-1,200	40-80
Hard clay	1,000-2,500	70-180
Sandy clay	4,000-6,000	300-400
Silty sand	1,000-3,000	70-200
Loose sand	1,500-3,500	100-250
Dense sand	7,000-12,000	500-800
Dense sand and gravel	14,000-28,000	1,000-2,000
Wood	1,200,000-1,500,000	80,000-100,000
Concrete	2,800,000-4,000,000	200,000-300,000
Steel	30,000,000	2,150,000

Note: kp/cm^2 = kilopond/sq. cm.; numerically equal to kg/sq. cm.