City University
Construction Processes in Geotechnical Engineering

Design of stone columns

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Design Considerations

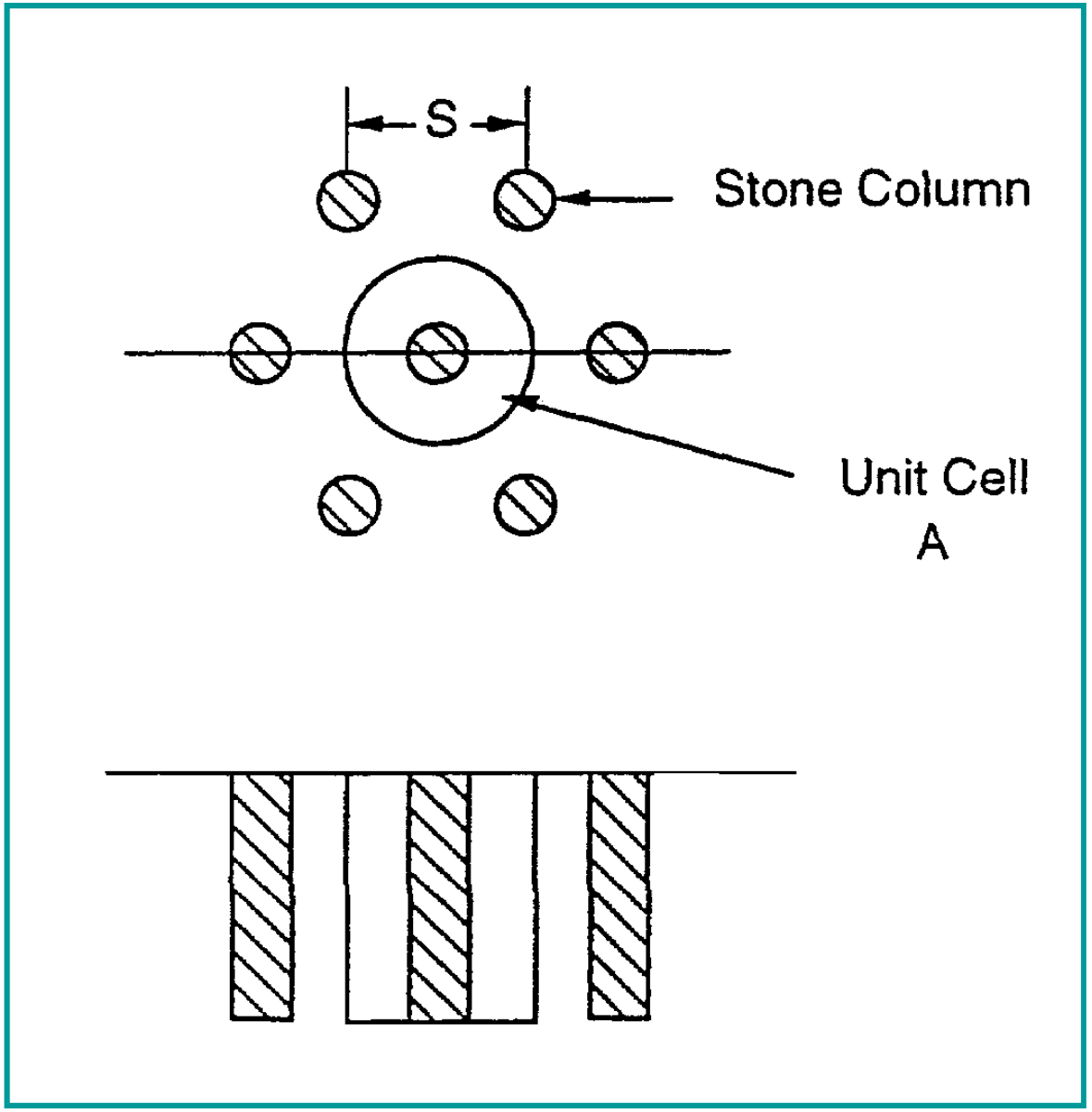
- Will use of stone columns reduce potential settlements to a tolerable level?
- Is there sufficient bearing capacity provided by stone columns?

Design Methods

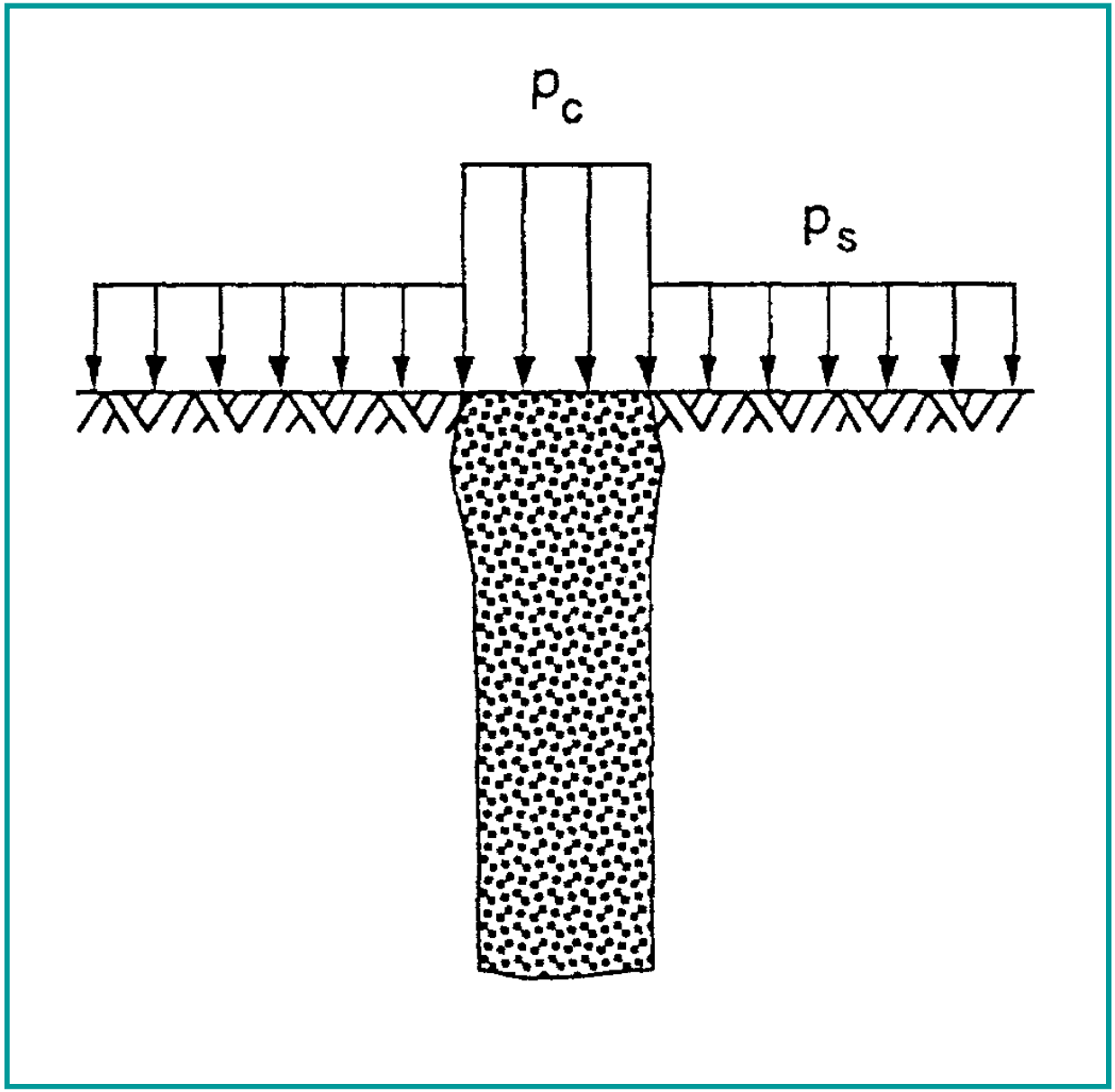
- Reduction in settlement:
  - Baumann & Bauer (1974)
  - Priebe (1976, 1988 & 1995)

- Bearing Capacity of columns:
  - Hughes & Withers (1974)

Concept of Unit Cell Area



Load Share Between Column & Soil



Reduction in Settlement

Baumann & Bauer Method

Canadian Geotechnical Journal, Volume 11, 1974, 509-530

Baumann & Bauer - Equations

$$\frac{Pc}{Ps} = \frac{\left(1 + 2\frac{Es}{Ec}Ks.\ln\frac{a}{r_0}\right)}{\left(2\frac{Es}{Ec}Kc.\ln\frac{a}{r_0}\right)}$$

$$P.A = Pc.Ac + Ps.As$$

$$a = \sqrt{\frac{A}{\square}}$$

P	bearing stress
r_0	radius of the stone column
A	foundation area
K	earth pressure coefficient
E	stiffness
c	denotes column properties
s	denotes soil properties

Reduction in Settlement

Priebe Method

Die Bautechnik, 53, 1976, 160-162
Die Bautechnik, 65, 1988, 23-26
Ground Engineering, Volume 28, Number 10, December 1995, 31-37

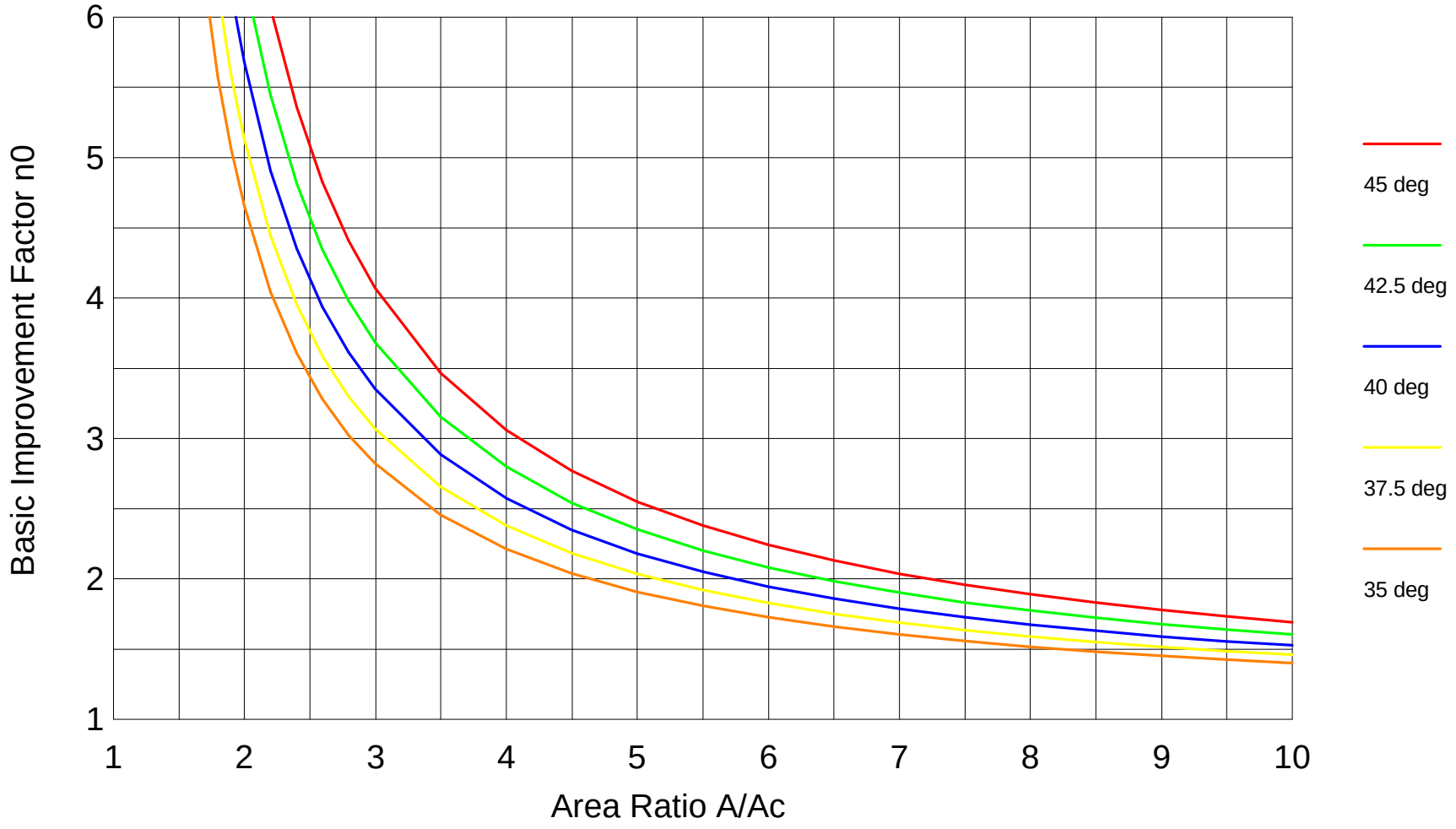
Priebe - Equations

$$n_0 = 1 + \frac{A_c}{A}\left[\frac{0.5 + f\left(\nu_s, \frac{A_c}{A}\right)}{K_{ac}.f\left(\nu_s, \frac{A_c}{A}\right)} - 1\right]$$

$$f\left(\nu_s, \frac{A_c}{A}\right) = \frac{1-\nu_s^2}{1-\nu_s-2\nu_s^2}\,\frac{(1-2\nu_s)\left(1-\frac{A_c}{A}\right)}{1-2\nu_s+\frac{A_c}{A}}$$

n_0	soil improvement
A_c	stone column area
A	foundation area
K_{ac}	active earth pressure coefficient
ν_s	Poisson's ratio

Priebe - Basic Improvement n_0



Bearing Capacity of Columns

Hughes & Withers

Ground Engineering, Volume 7, Number 3, May 1974, 42-49

Hughes & Withers

$$P_c = K_{pc}(K_s . \sigma v' + 4c_u)$$

Pc	stress on top of column
K_{pc}	column passive earth pressure coefficient
K_s	soil earth pressure coefficient
c_u	Undrained shear strength

K_s usually taken as 1 in clays or K_p in granular soils

Conclusions

- Column Parameters
  - ϕ' friction angle for stone column
  - Stiffness E_c
- Soil Parameters
  - ϕ' friction angle or c_u undrained strength for soil
  - Stiffness E_s
  - Poisson's Ratio ν_s
  - Representative earth pressure coefficient K_s

Conclusions

- Column Parameters
  - Little evidence for usual design values
  - Need quality test results
- Soil Parameters
  - Friction angle and stiffness rarely measured
  - Representative K_s needs quality test results