Note to actual design of micropiles under axial cyclic loading in Germany according to DIN 1054 and further guidelines

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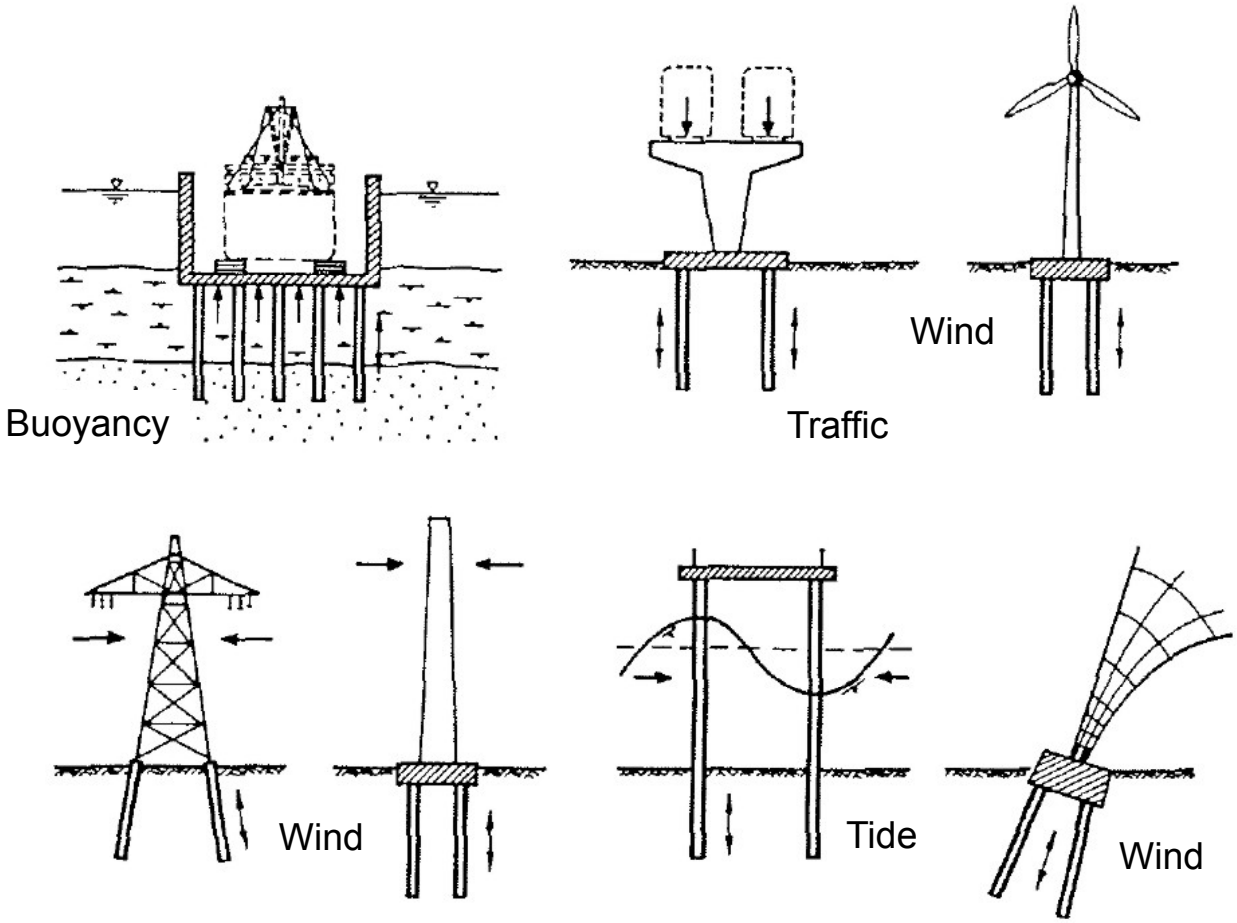
Outline

- Motivation
- Definitions
- Design guidelines in DIN 1054:2005-01 and EA-Pfähle
- Conclusion and outlook

Motivation

- Micropiles are often subjected to cyclic loads

Motivation



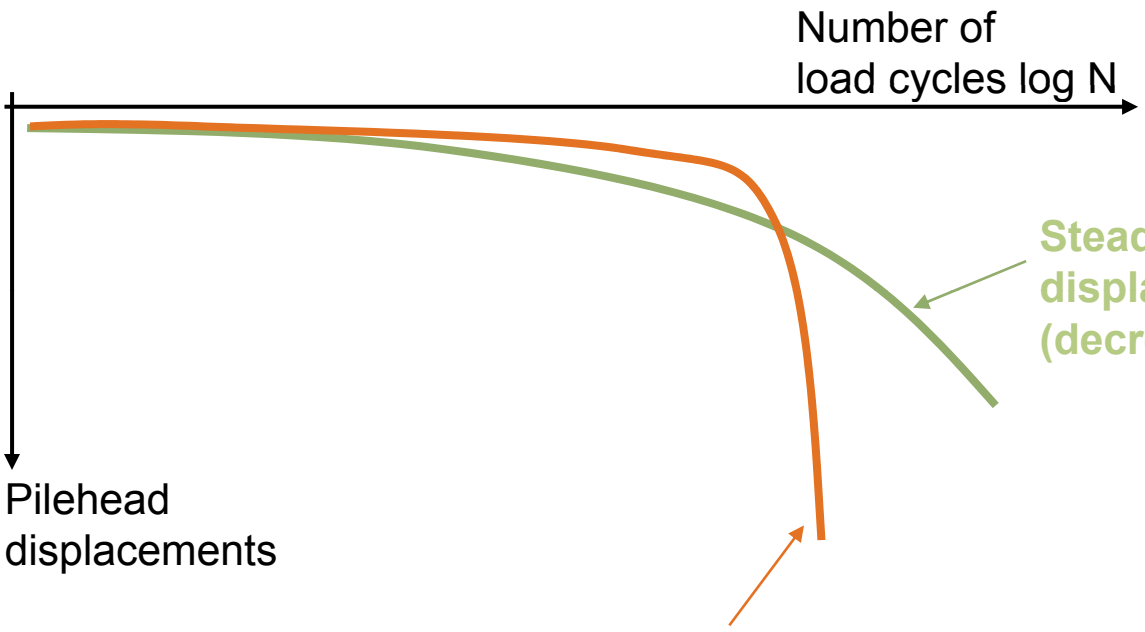
Motivation

- Micropiles are often subjected to cyclic loads

- Field tests:

  Accumulation of deformations or sudden failure after a certain number of load cycles - although cyclic loads are far away from static capacity of the micropile

Motivation



Tests of e.g.

- NGI (1980s)
- Schwarz (1982 - 1989)
- Lehane (2003)

Motivation

- Micropiles are often subjected to cyclic loads

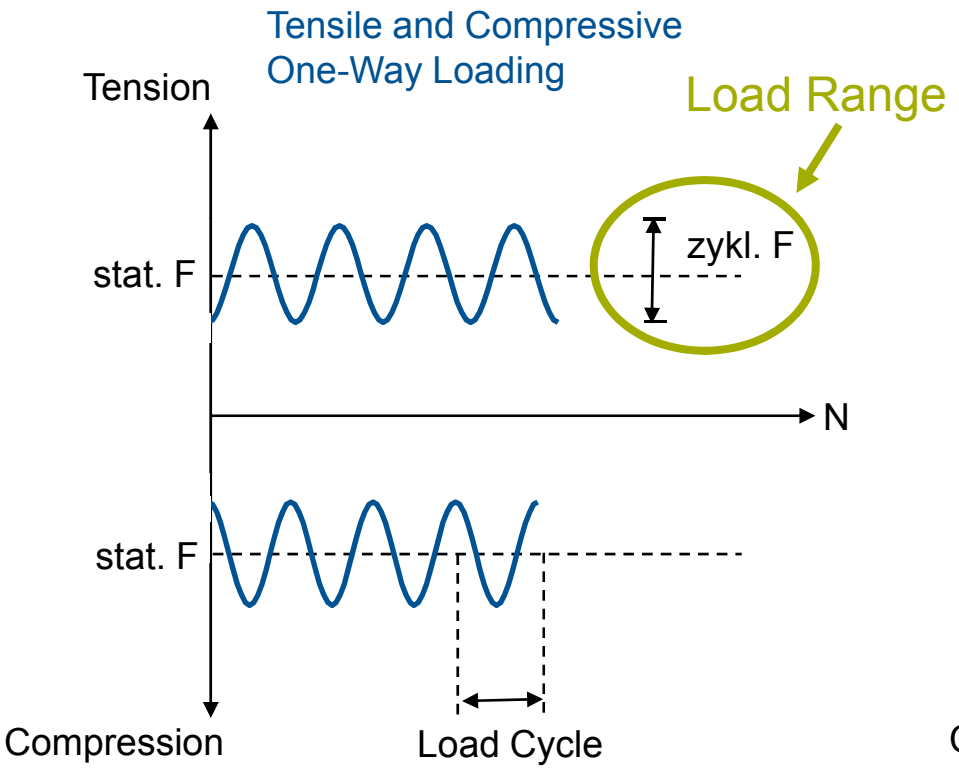
- Field tests: Accumulation of deformations or “sudden failure“ after a certain number of load cycles

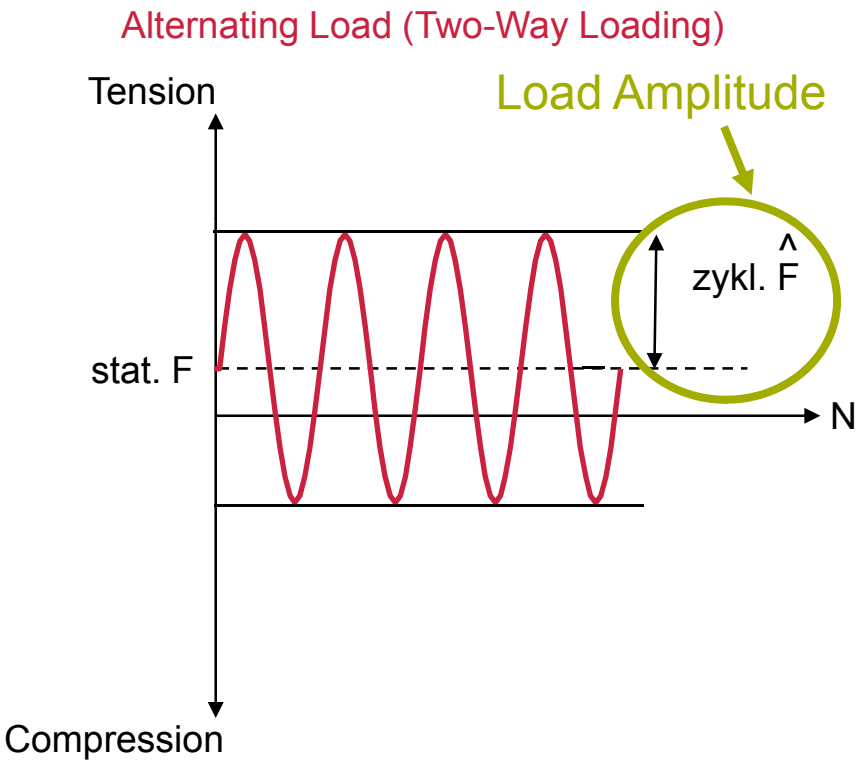
➡ Capacity of micropiles under cyclic loads decreases

depending on

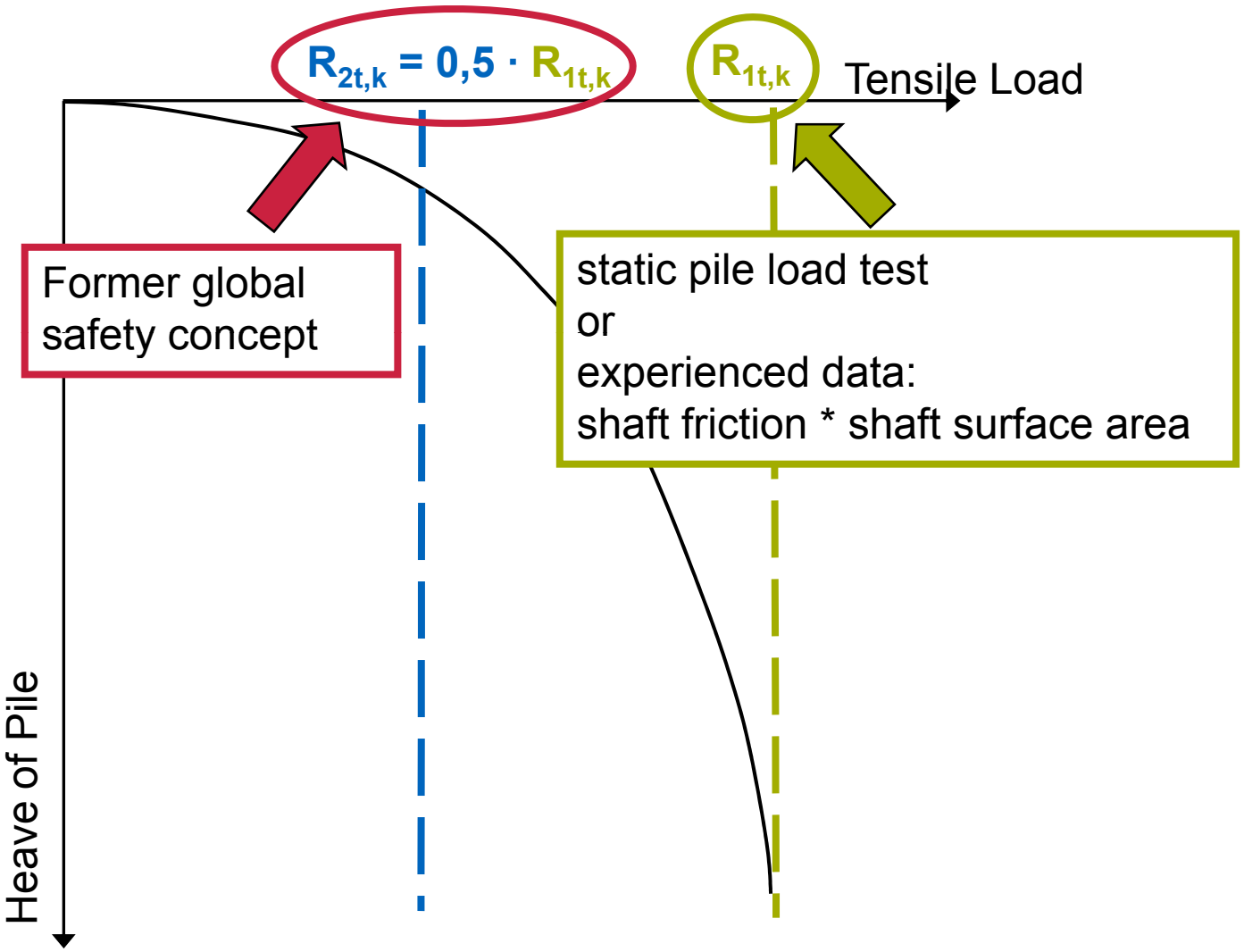
  - Number of load cycles
  - Load amplitude / load range of cyclic loads
  - Type of soil

Definitions





Definitions



Design guidelines – DIN 1054:2005-01 / EA-Pfähle

- General:
  - Consideration of cyclic loads if load amplitude > 20 % of $R_{2t,k}$
  - only regulation of **axial** cyclic loads

- **Serviceability Limit State:**

(1) zykl. $F \leq x \cdot R_{2t,k}$

(2) stat. F + zykl. $\hat{F} \leq R_{2t,k}$

valid for:
grouted micropiles in non-cohesive soils above groundwater level

Expected number of load cycles N	Characteristic load range
1	$1{,}00 \cdot R_{2t,k}$
100	$0{,}80 \cdot R_{2t,k}$
10.000	$0{,}68 \cdot R_{2t,k}$
100.000	$0{,}56 \cdot R_{2t,k}$
≥ 1.000.000	$0{,}40 \cdot R_{2t,k}$

Design guidelines – DIN 1054:2005-01 / EA-Pfähle

- **Ultimate Limit State:**
  not yet regulated

  Proposal:

  (1) zykl. $F \cdot \gamma_{cyclic,Load\ Range} \leq x \cdot R_{1,k} / \gamma_{t,cyclic}$

  (2) stat. $F \cdot \gamma_G$ + zykl. $\hat{F} \cdot \gamma_Q \leq R_{1,k} / \gamma_t$

Partial factors have to be defined based on field tests

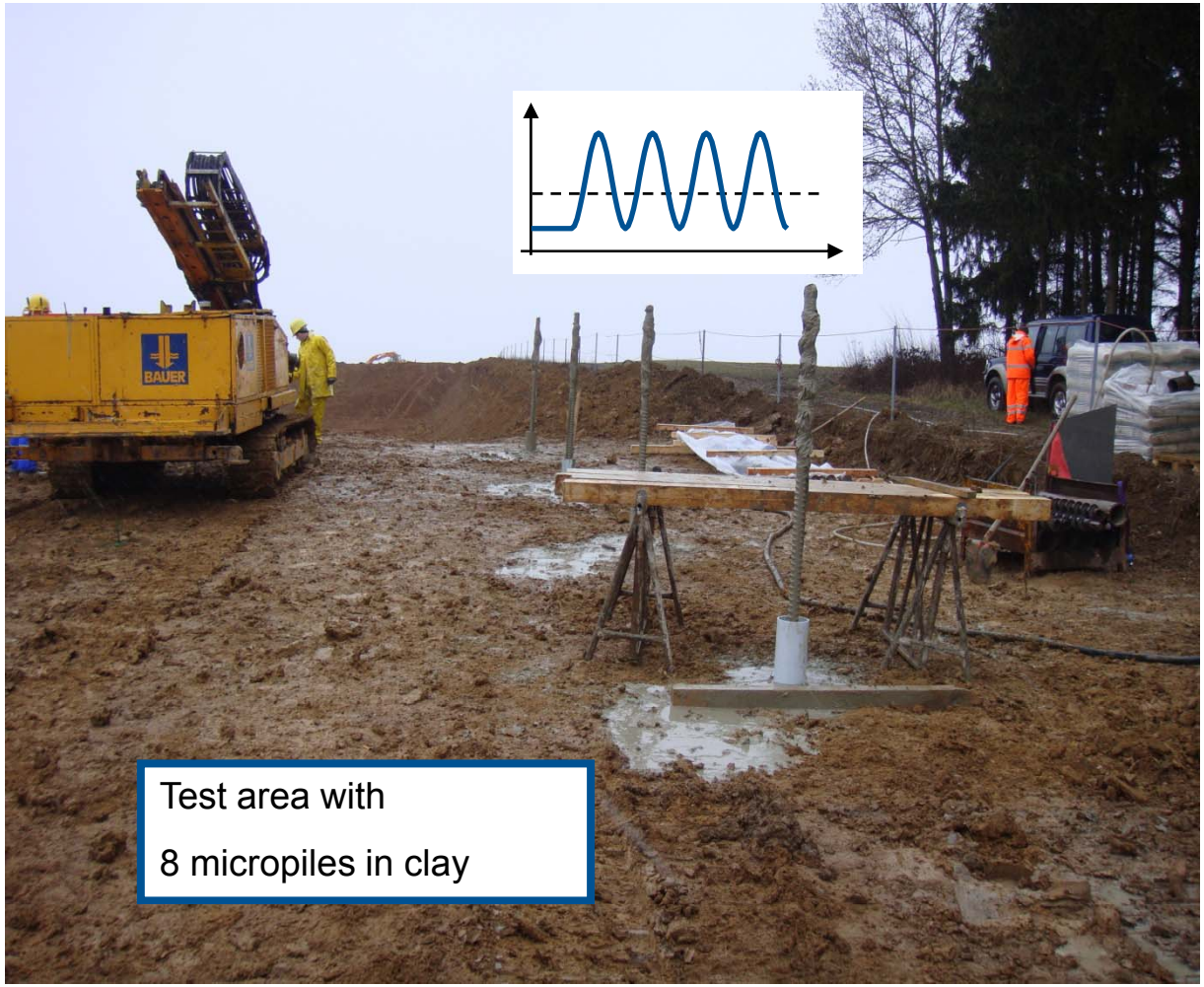
Conclusion and Outlook

- Capacity of micropiles under cyclic loads decreases

  ➡ Design guidelines for micropiles under cyclic loads are necessary

- Up to now:
  - Only regulation of Serviceability Limit State for axial cyclic loads
  - Reference values only for grouted micropiles in non-cohesive soils above groundwater level
- Outlook:
  - Regulation of Ultimate Limit State
  - Reference values for different type of soils for both limit states

Outlook



Test area with

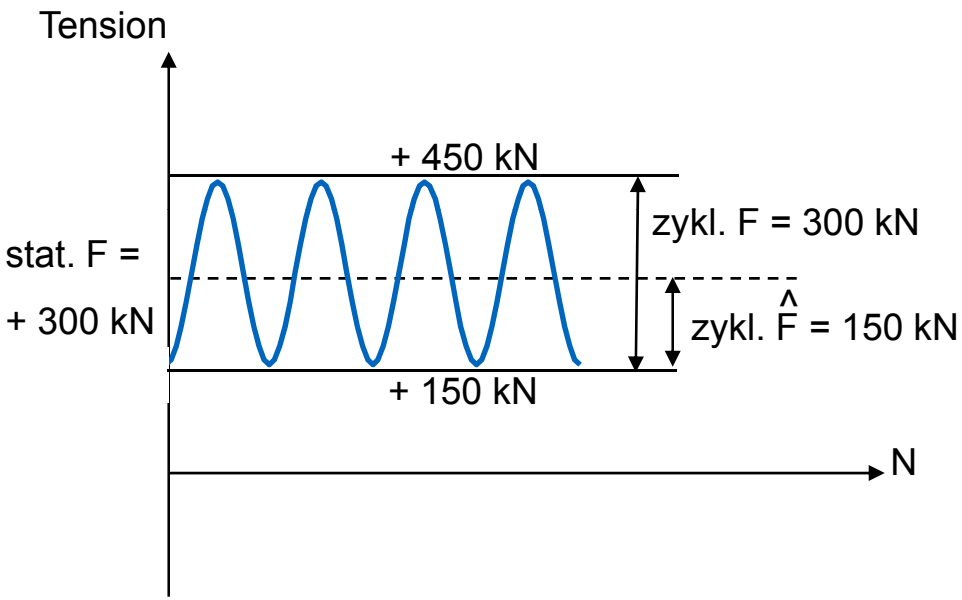
8 micropiles in clay

TUM Research Project 2009 / 2010:

“Capacity of axial cyclic loaded micropiles in cohesive soils“

Example (design with experienced data)

- Pile diameter:
  D_s = 0,2 m
- Soil: Sand
  shaft friction
  $q_{s1,k}$ = 0,15 MN/m²
- Number of load cycles:
  100.000



Example

Serviceability Limit State:

(1) zykl. $F \leq x \cdot \mathbf{R_{2t,k}}$

Pile Length

$R_{1,k} = q_{s1,k} \cdot \pi \cdot D_s \cdot l$

$R_{2t,k} = 0{,}5 \cdot R_{1,k}$ (former global security concept)

$R_{2t,k} = 0{,}5 \cdot 150 \cdot \pi \cdot 0{,}2 \cdot l$

$x = 0{,}56$ (N = 100.000)

$300 \leq 0{,}56 \cdot 0{,}5 \cdot 150 \cdot \pi \cdot 0{,}2 \cdot l$

$l \geq 11{,}4$ m

Example

Serviceability Limit State:

(2) stat. F + zykl. $\hat{F} \leq R_{2t,k}$

$\Rightarrow$ $300 + 150 \leq 0{,}5 \cdot 150 \cdot \pi \cdot 0{,}2 \cdot l$

$l \geq 9{,}6$ m

Maximum of (1) and (2) decisive:

necessary pile length l = 11,4 m