BUTE Department of Construction Management and Technology

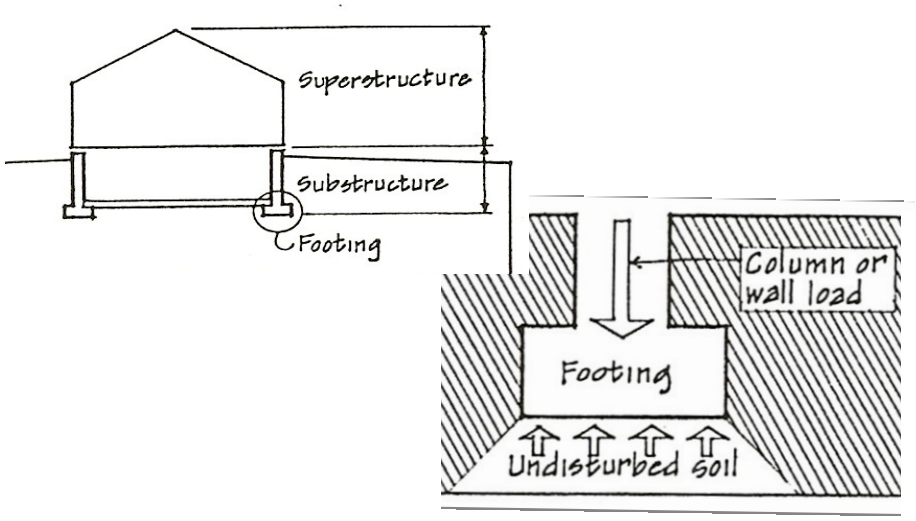
Foundations

27.10.2015

What is the foundation?

- Definition 1: **Foundation:** The structure, that transmits the load of the building to the soil
- Definition 2: **Load bearing soil (strata):** The soil layer, that has the sufficient load bearing capacity in relation to the chosen foundation type
  - The primary design concerns are settlement (total settlement and differential settlement) and load bearing capacity.

What is the foundation?



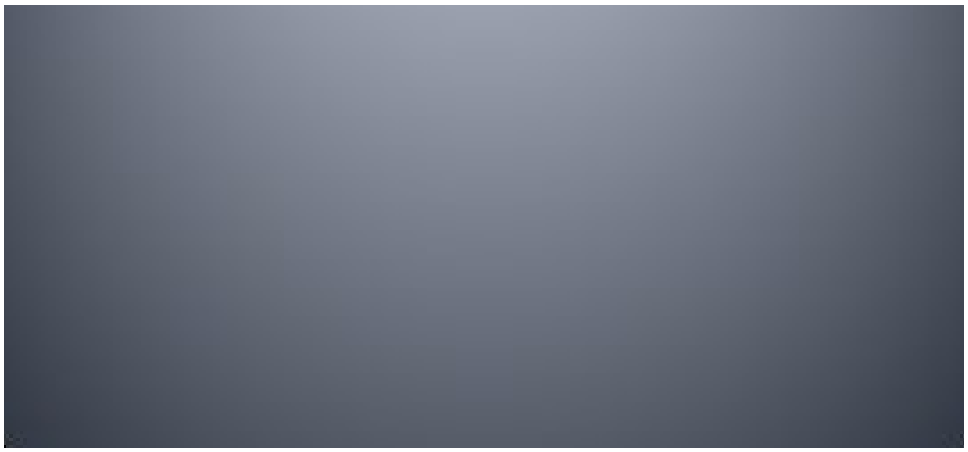
What is the foundation?

- Choosing a kind of foundation depends on:
  - the ground conditions
  - the groundwater conditions
  - the site, the environment (the buildings nearby)
  - the structure of our building
- Requirements:
  - structural requirements: safe, be able to carry the load of the building
  - constructional requirements: schedule, minimal resources, minimal cost

What is the foundation?

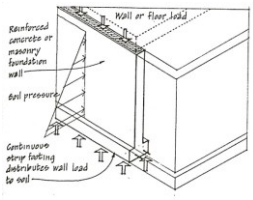
- The specialities:
  - it is expensive and difficult to repair
  - usually it is constructed under the ground, so it is out of sight
  - an bad/ misapplied foundation could demolish the building
- The mistakes:
  - construction technology mistakes
  - bad or not proper info on soil (always necessary!!!)
  - planning mistakes: the type of foundation is inadequate for the ground layers / for the building

Types of foundations

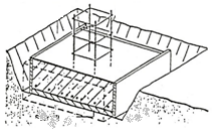


Spread (shallow) foundations

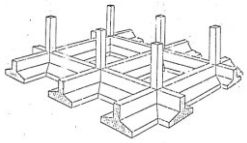
- strip foundation (wall footing)



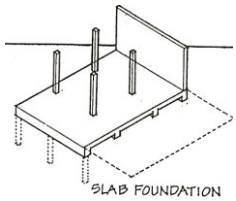
pad foundation



(beam) grillage foundation

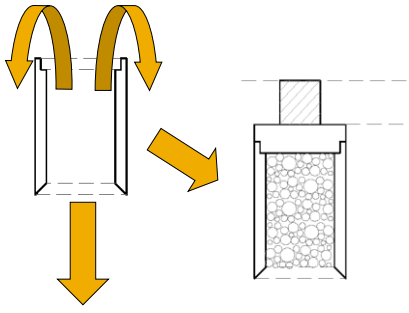


mat (slab) foundation

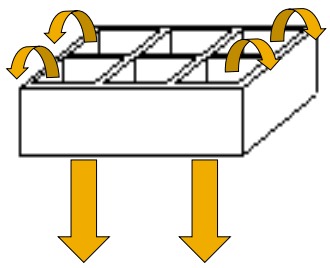


Transitional (semi-deep) foundations

well foundation / caisson

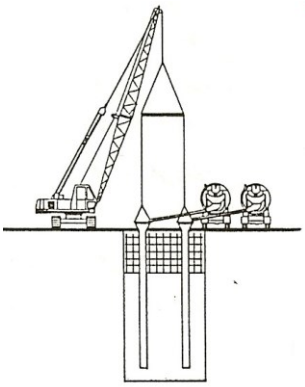


foundation framework / cofferdam

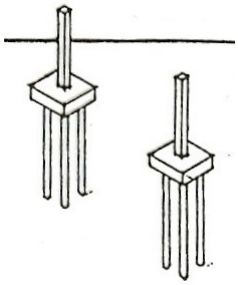


Deep foundations

slurry wall



pile foundations

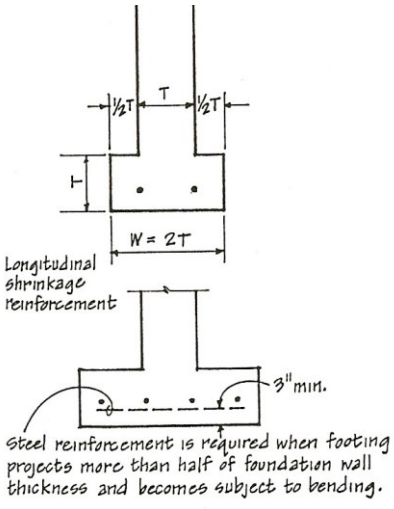


Spread (shallow) foundations

Spread (shallow) foundations

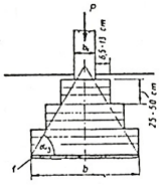
- When is it applicable?
  - The load-bearing layer is near to bottom floor level
  - The loads of the building are light-medium
- Types
  - Strip foundations
  - Pad foundations – Bucket foundations
  - Beam foundations
  - Mat (slab) foundations

Strip foundations

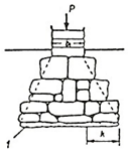


Strip foundations

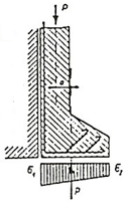
- Materials



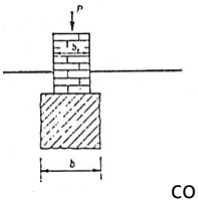
brick

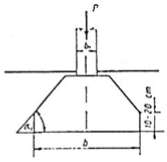


stone

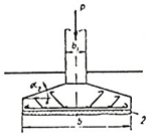


in case of asymmetrical load

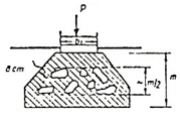




concrete

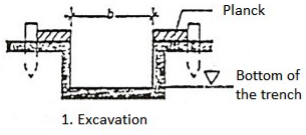


reinforced concrete

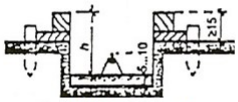


lightweight concrete

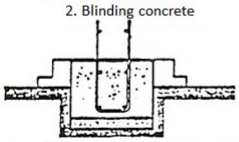
Strip foundations - construction



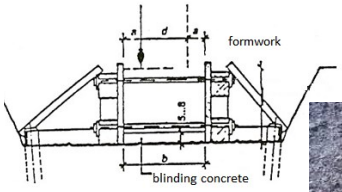
1. Excavation



2. Blinding concrete



3. Reinforcing, casting of concrete



Loose soil (sand, gravel)

Dense soil (clay, rock)

- In-situ (reinforced) concrete

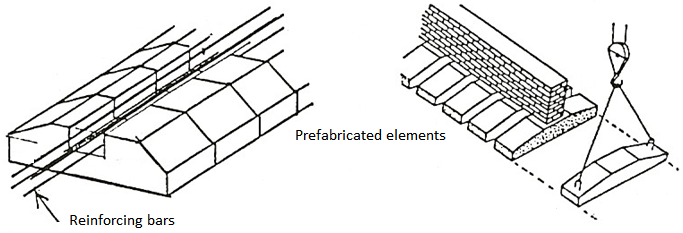
Strip foundations - construction

Strip foundations - construction

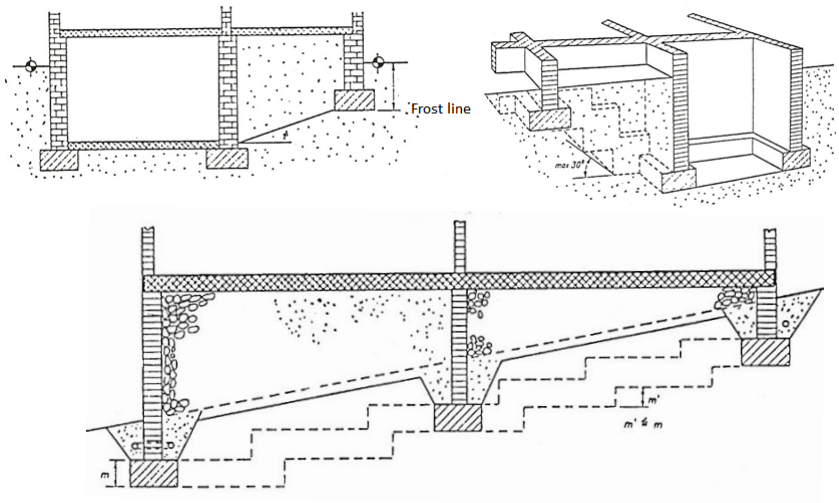
Strip foundations - construction

Strip foundations - construction

- Prefabricated reinforced concrete

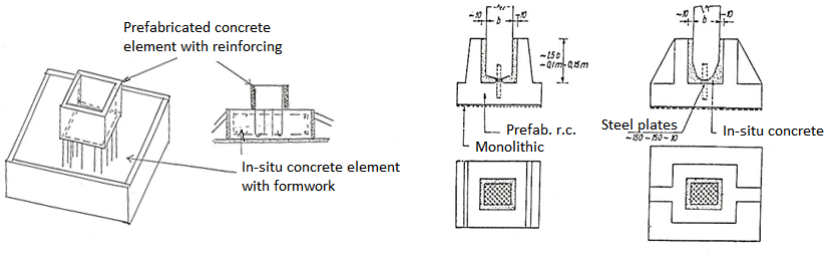


Strip foundations - construction



Pad foundations - construction

- Partly in-situ pad foundation and prefabricated pocket footing

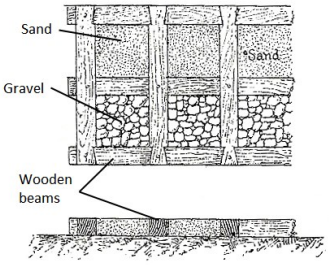


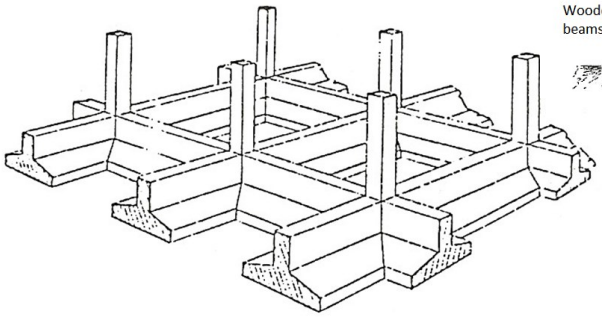
Pad foundations - construction

Pad foundations - construction

Beam foundation - foundation grillage

- Materials:
  - (Wood)
  - Monolithic reinforced concrete

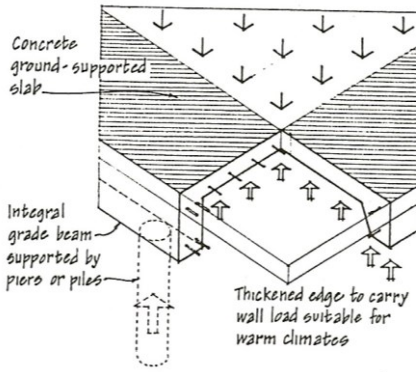


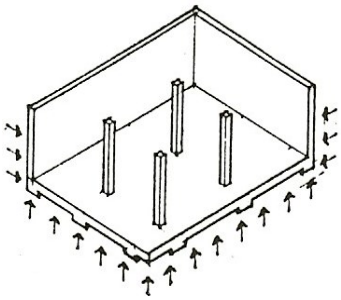


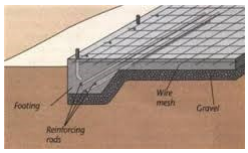
Beam foundation - foundation grillage

Mat (slab) foundation

- Design

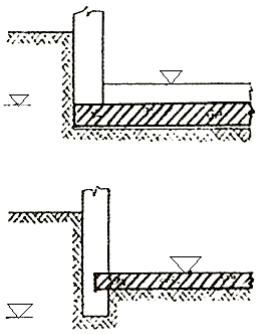






Mat (slab) foundation

- Design



Mat (slab) foundation - construction

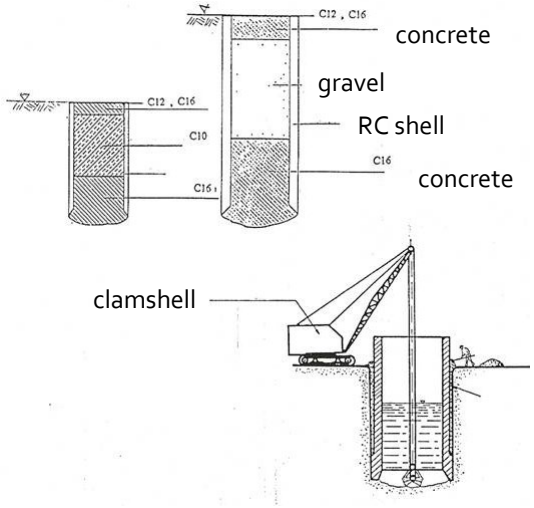
Mat (slab) foundation - construction

Mat (slab) foundation - construction

Transitional (semi-deep) foundations

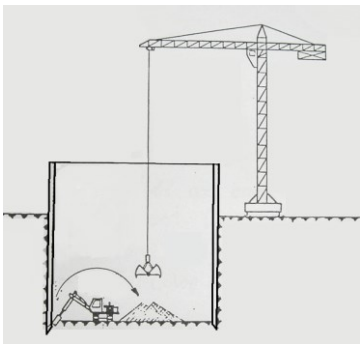
Well foundation – caisson, cofferdam

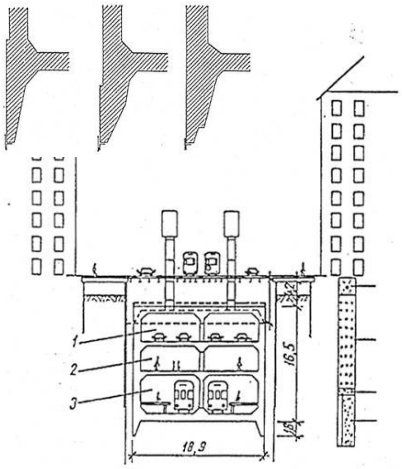
- Large, open-ended compartments – shell or box with cutting edge at the bottom
- Sunk into the ground by digging the soil out of the centre and loading the walls
- Filled with concrete (and compacted gravel)



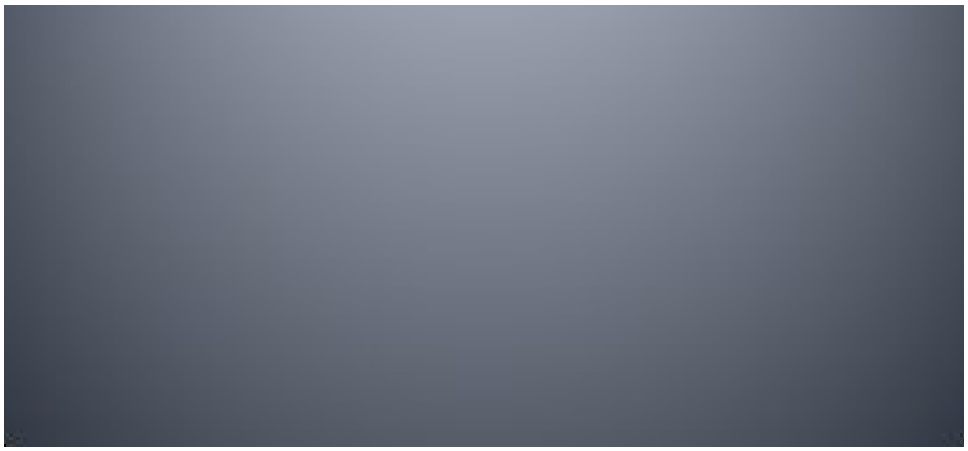
Well foundation – caisson, cofferdam

- Cutting edge types
- Creating an underground station





Deep foundations

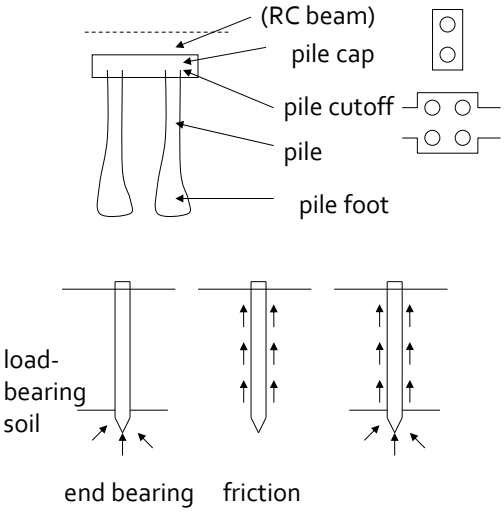


Deep foundations

- When is it necessary?
  - The load-bearing layer is in deeper location
  - The loads of the building are too heavy
  - Other special cases
- Types
  - Piles
  - Slurry wall
  - Other

Piles

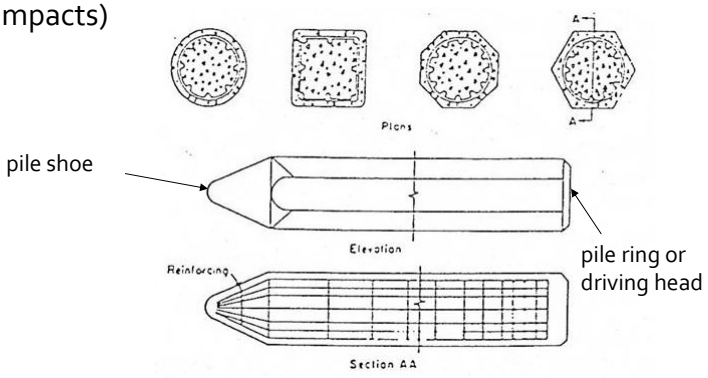
- Material: wood, steel, concrete, reinforced concrete
- Geometry: length>5D, D>60 cm (large-diameter), D<30 cm (Micro-pile)
- Direction: vertical or leaning
- Construction: prefabricated or cast-in-place



Piles - construction

Prefabricated piles

- Hammered, grouted, vibrated, twisted
- (dynamic impacts)



Piles - construction

- Precast pile

Piles - construction

Cast-in-place piles
- Shell-type or shell-less type
- Many different technologies

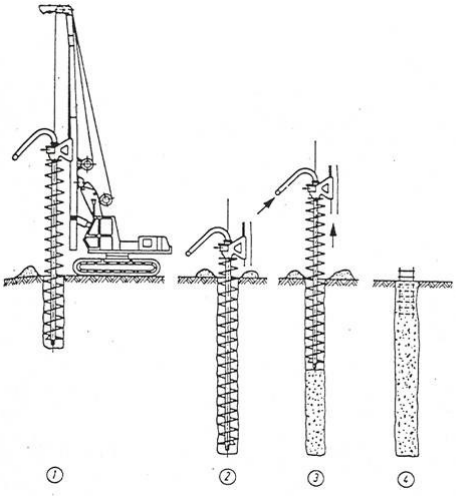
Constructing the foundation
- 0. alignment
- 1. creating a test-pile
- 2. checking the load-bearing capacity (endurance test)
- 3. making the piles
- 4. removing the top of the piles
- 4. constructing the pile caps
- 5. connecting the pile caps with RC beams if necessary

Piles - construction

CFA technology

- Drilling continuously until planned depth (using guiding tube if necessary)
- Placing the concrete and removing the drill
- Placing reinforcement (vibration)

(CFA= Continuous Flight Auger)



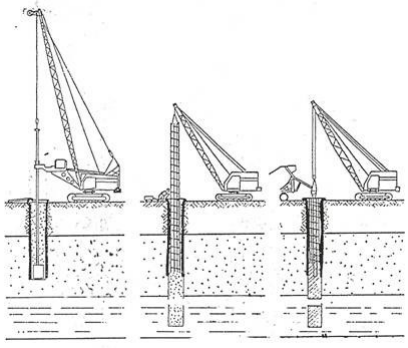
Piles - construction

CFA technology

Piles - construction

Soil-Mec technology

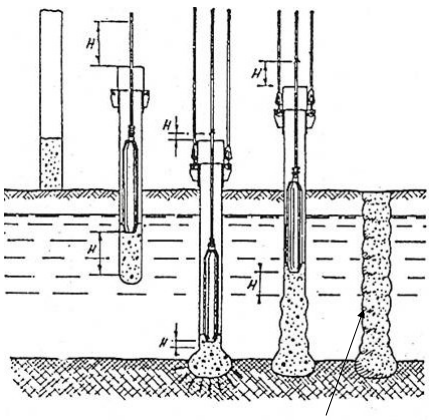
- Boring until planned depth (using a guiding tube)
- Using bentonite mud (slurry) under the groundwater level
- Placing reinforcement
- Placing the concrete and removing the guiding tube



Piles - construction

Franki technology (bulb pile or compacted concrete pile)

- Filling concrete in a steel pipe (creating a plug)
- Pushing down the pipe using a heavy drop hammer
- Fastening the pipe and creating the foot
- Placing the concrete and compacting while removing the pipe (reinforcing)

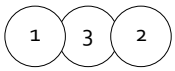


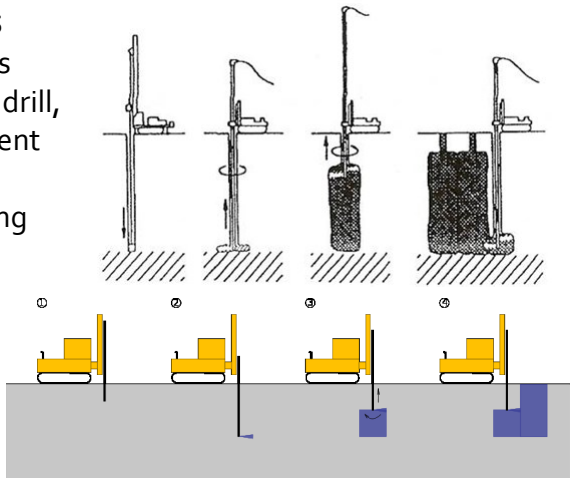
Corrugated sides

Piles - construction

Other technologies

- Compacted soil piles
- Micro-piles (using a drill, grouting with different pressures)
- Jet-grouting (creating soil-concrete piles)
- Pile-wall





Piles - construction

Pile group and

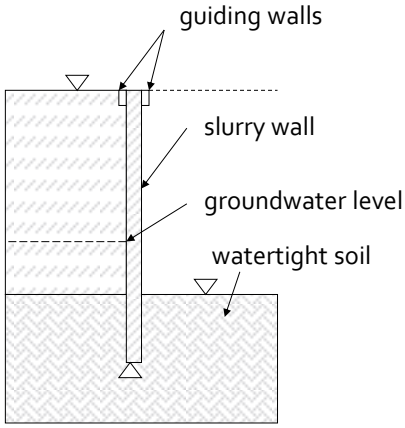
Concrete slurry walls

What is…?

- A deep, narrow trench filled with concrete (and reinforcement)

Functions

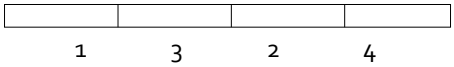
- Retaining wall during excavation (can be watertight)
- Foundation
- Wall of the basement

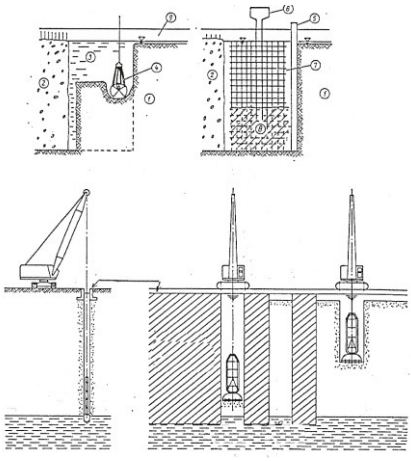


Concrete slurry walls - construction

Creating panels (w:40-120 cm, l: 8-10 m)

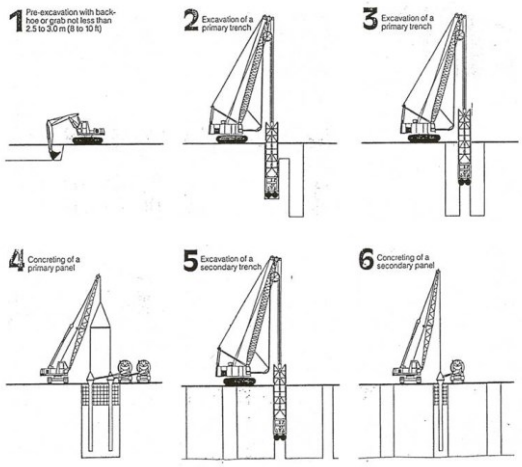
- Creating the guiding walls
- Excavating the soil from the trench and piping in bentonite slurry (placing end pipes)
- Placing the reinforcement
- Placing concrete (by tremie method) displacing slurry (can be reused)
- (withdrawing end pipes)





Alternating building method

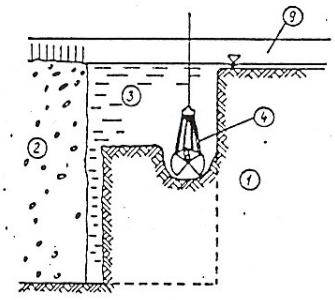
Concrete slurry walls - construction



Concrete slurry walls - construction

What is bentonite slurry?

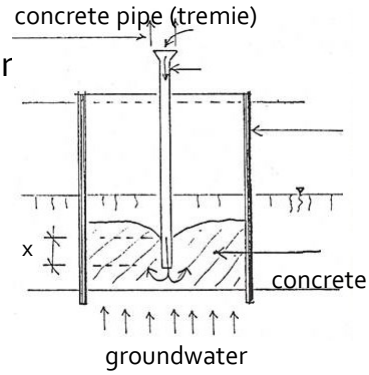
- A mixture of bentonite and water (a dense fluid)
- Produces a positive static pressure on the walls of the trench avoiding soil and water to enter the trench (supporting the surface of the soil)
- Piped in while excavating the trench, piped out while placing the concrete
- Can be reused after filtering (removing soil particles)

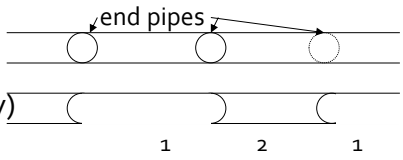


Concrete slurry walls - construction

Placing the concrete (underwater concreting)

- Using concrete pipe
- Start filling in the concrete at the bottom
- Pulling out the concrete pipe with the speed of filling in the concrete so that the end of the pipe is constantly under the level of the concrete
- x=60 cm
- (meantime piping out the slurry)

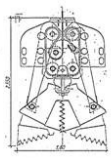


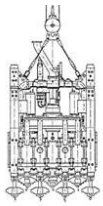


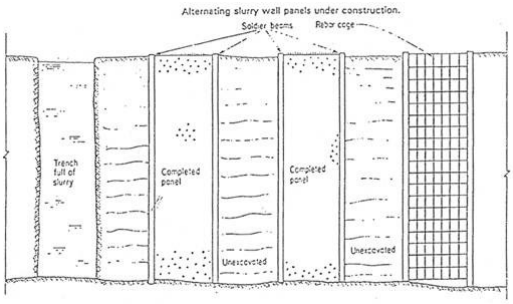
Concrete slurry walls - construction

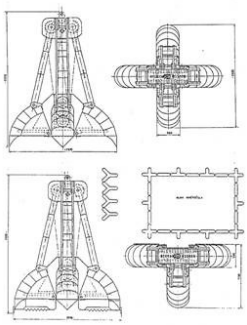
Excavation

- Using clamshell buckets
- Hydrofraise technology









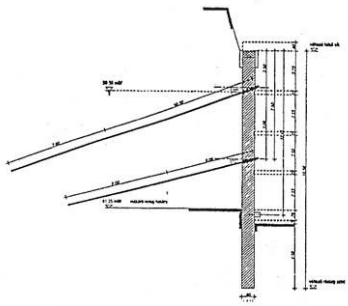
Concrete slurry walls - construction

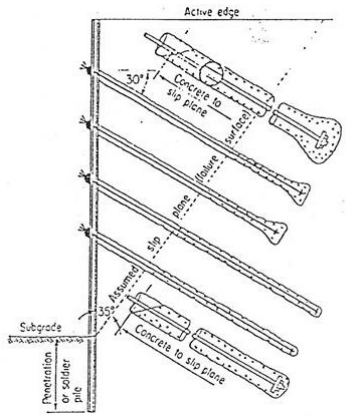
Concrete slurry walls - construction

Concrete slurry walls - construction

Tie-back

- Anchorage to brace against earth and water pressure
- Steel and concrete ties



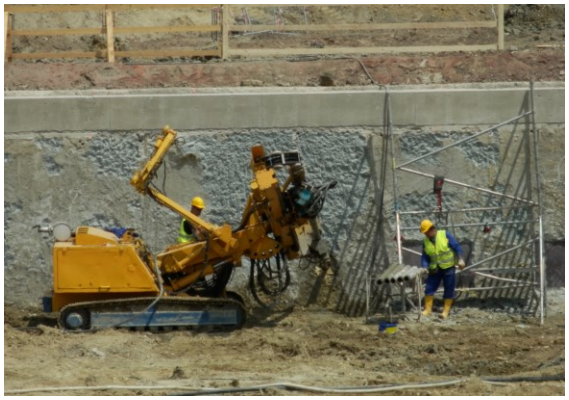


Concrete slurry walls - construction

- Tie-backs

Concrete slurry walls - construction

- Tie-backs

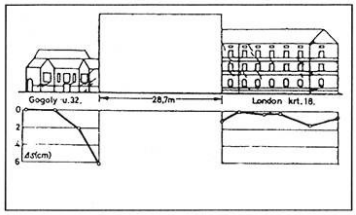


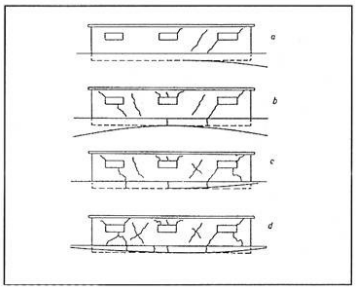
Building next to existing constructions

Building next to existing constructions

Strengthening foundations

- The new construction means extra loads
- Cracks can appear on neighbouring buildings
- To avoid that the existing foundations have to be harmonised with the new ones
- Strenghtening existing foundations may be necessary

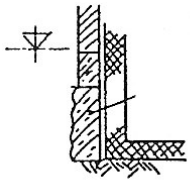


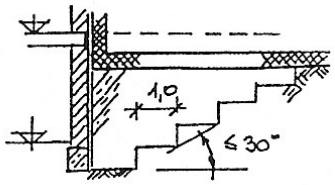


Building next to existing constructions

Harmonising foundation levels

- If the existing foundations would be deeper than the new ones: place the new foundation at the same level as the old ones
- If the existing foundations are higher: extra structures needed

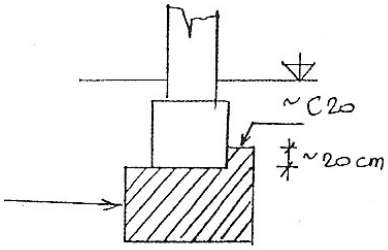


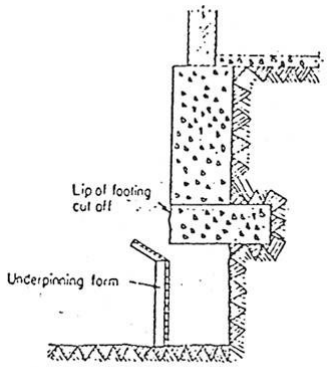


Building next to existing constructions

Deepening the foundation level

- Placing strip foundation under the existing one
- Made of masonry or concrete
- Constructed in stages (0,8-1,5 m)



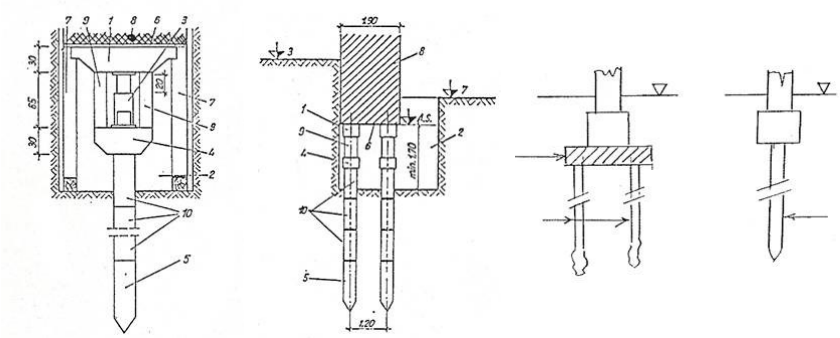


Short underpinning form.

Building next to existing constructions

Deepening the foundation level

- Using prefabricated piles or micro-piles
- Pressed (hydraulic press) or drilled

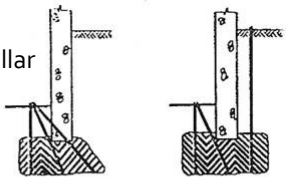


Building next to existing constructions

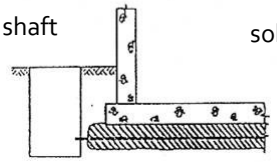
Deepening the foundation level

- By grouting methods
- Jet grouting (soil-concrete piles)

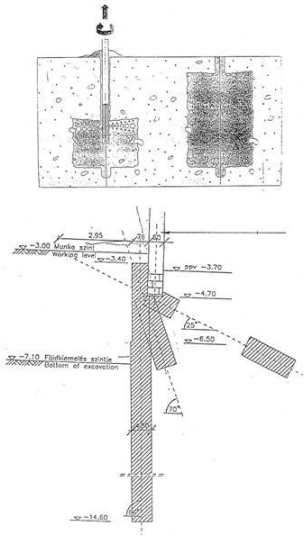
from the cellar



from a shaft



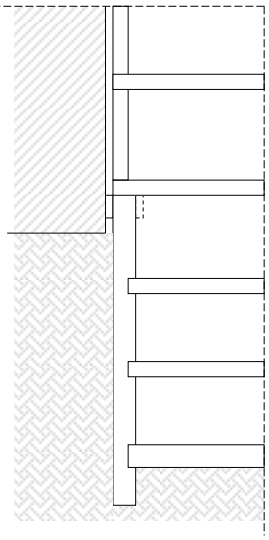
solidifying the soil



Building next to existing constructions

Securing the neighbouring buildings with slurry walls or pile-walls

- Placing slurry walls or pile-walls straight next to the existing building so that the excavation and the loads of the new construction does affect the soil under the existing building
- Cracks can appear during building the slurry wall or pile walls



References

- http://cee.engr.ucdavis.edu/faculty/boulanger/
- http://en.wikipedia.org/wiki/Foundation_(engineering)
- http://www.foundationengineering.info/photo_galleries/08/footing_construction/
- http://www.uwe.port.ac.uk/cracking/substructure/section1.htm