**Foundations**

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**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?

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
  - a 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

- Prefabricated reinforced concrete
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

- 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

- 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

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**

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)
Other technologies

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

Pile group and pile cap
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

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
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
- $x=60\ \text{cm}$
- (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
- Strengthening existing foundations may be necessary

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)

- 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

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