Large-diameter bored piles and Large-hole drillings
Applications

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Large-diameter bored piles and large-hole drillings

In-situ concrete piles with diameters of 0.3 m up to 3.0 m are referred to as large-diameter bored piles. For their construction hollow spaces are made in the soil by means of drilling equipment. Depending on soil conditions the excavation is carried out under the protection of a casing or without casing. Subsequently the drilling holes are filled with concrete; according to static requirements a rebar cage is placed before concreting.

**Large-diameter bored piles** have a broad scope of application:

They are used as

- foundation elements for carrying vertical building loads
- foundation elements for retaining walls
- temporary building pit walls
- components of the final structure
- protection against uplift and for taking up tension loads
- slope security and
- energy piles

**Large-hole drillings** are applied for

- the construction of large-diameter bored piles
- the construction of a soldier wall with lagging
- the construction of wells
- removing obstacles in planned retaining wall or diaphragm wall lines
- underground demolition of structures under groundwater
- soil replacement in order to improve the soil and
- soil replacement in order to remediate contamination

1. Bored pile wall underground parking Goetheplatz, Frankfurt

2. Obstacle drillings Europakai, Hamburg
Large-diameter bored piles as foundation elements for carrying vertical building loads

If the building ground for a spread foundation is not stable enough, large diameter bored piles, which can transfer heavy building loads into deeper and more sustainable soil layers, are placed as foundation elements. The transfer of the loads into the soil takes place via end-bearing under the pile bottom and via skin friction along the shaft area. The centering and transfer of the building loads into the piles usually takes place via pile caps, pile cap beams, pile cap grids and via a continuous concrete slab.

Measures to reduce settlements resp. to increase the pile load bearing capacity

With pile foundations next to built-up areas sensitive to settlement, the adjacent settlements must be minimized by the deformation of the piles. The same applies if the settlement difference of adjacent foundations is restricted.

On the other hand the measures to increase the load bearing capacity can reduce the pile diameter and / or the pile length.

a) Increasing the pile diameter and / or increasing the pile length

With the increase of the pile diameter the point pressure is reduced quadratically and the shaft friction raises linear to the increase. The settlements can be reduced.
b) Shaft grouting

With shaft grouting, the shaft friction is increased by additional selective injections into the pile shaft area. For this purpose a thin plastic tube with valve is attached to the rebar cage for each injection point. When the pile concrete starts hardening the concrete cover of the valves is blasted with water high pressure and subsequently injected with cement slurry.

On blasting the concrete cover of the rebar cage is partially shifted against the soil. The gap is „cured“ by cement slurry, so that the concrete steel is secured against corrosion.

c) Pile base grouting

During pile base grouting a pressure bag, a pressure bubble or a pressure box at the bottom of the rebar cage is injected with cement slurry by an injection tube after construction of the piles. This measure extends the pile base injection facility and therefore causes a preload of the soil under the pile base (anticipation of the settlement) before the building load is placed.

d) „Additional“ shaft grouting

For the rehabilitation of bored piles with a non-sufficient load bearing capacity it is possible to carry out injection drillings around the piles and to inject grout. This corresponds to a pile cross-section enlargement and increases the load bearing capacity.

e) Pile base enlargement

For mainly base bearing piles a pile base enlargement for increasing the load bearing capacity can be recommended.
Primary columns for top-down construction

The top-down construction method was first applied for underground railway construction. In these constructions the covers (concrete slabs) were used to maintain the traffic on the building site and to ensure a continuous working flow, as excavations and construction, under the cover. Moreover the covers were used for the bracing of building pits. In recent years the top-down construction method has been applied more often for bracing large building pits. The construction period for building construction sites can be reduced by this technology as after completion of the top or cover slab (ground level slab) simultaneous upwards and downwards construction is possible.

Before construction of the top slab the bearings or supports must be provided. Usually the slabs rest at the building pit edge on the building pit boundary wall and on primary columns within the building pit. For the construction of the primary columns drillings are carried out up to the required maximum depth and concreted up to the planned final building pit bottom slab. Elements of steel profiles or precast concrete elements are integrated in the borehole with the exact required position and level. The remaining ring space within the drilling is filled with appropriate material.
Large-diameter bored piles as foundation elements for retaining walls

Building pits for the construction of foundations for spread founded retaining walls are sometimes very elaborate. Frequently due to adjacent building structures there is not sufficient space available for the construction of the spread foundation elements. To solve this problem laterally soil supported large-diameter bored piles for the foundation of retaining walls are recommended.

**Bored pile walls**

Bored pile walls are executed as single, contiguous or secant pile walls.

In the case of the secant bored pile wall every second, third or fourth pile is reinforced as supporting secondary pile, the primary piles in between are without reinforcement.

In the case of the single and contiguous pile wall all piles are supporting and thus reinforced. The interspaces of the single bored pile wall are generally closed by shotcrete laggings, which can be drained.

**Bored pile walls as temporary building pit walls**

Bored pile walls are used as temporary building pit walls for the construction of building pits. Because of the high stiffness, compared to soldier walls with lagging or sheet pile walls, it is called a building pit wall with low deformation. Bored pile walls are chosen when in the area of the building pit construction buildings or other structures are to be protected against settlements.
Secant bored pile walls are used for "watertight" building pits and apart from their function as building pit walls also used as impermeable walls. Therefore they must reach up to an artificial impermeable bottom slab or they should be socketed in a natural impermeable layer.

Impermeable walls of secant large-diameter piles have been executed by Bilfinger Spezialtiefbau GmbH as seepage barriers against seepage water contaminated with heavy metals and micro-elements. As sealing material a cement-free, very solid sealing compound was used, fully developed by Bilfinger Spezialtiefbau GmbH.

The upper 1 to 2 m of bored pile walls are often designed as walls with inserted beam support. In the case of pile construction this depth is executed as empty drilling and in the reinforced piles in the pile cap area steal beams are built in, which end at the ground surface. During excavation between the vertical beams a horizontal lagging of wood or shotcrete is carried out. This sheeting can be dismounted more easily for later activities like underground facilities.

Bored pile walls, which are to be passed through by a tunnel boring machine (TBM), so called "spectacle walls" are reinforced with a glass fibre reinforcement in the passage area (so called soft-eye construction). This reinforcement material is so brittle and easy to cut through that no damage to the TBM is to be expected.
In many cases for "watertight" building pits a **groundwater communication** under the bottom slab must take place again after completion of the structure. To this end Bilfinger Spezialtiefbau GmbH developed and applied successfully the **"Essener Dichtlamelle"** (sealing membrane) for the underground railway, lot 25 in Essen as a replacement for partial freezing. Every 10th pile was executed as sealing membrane under the excavation bottom level.

During the building period this membrane was sealed and after completion of the structure reopened by a tube set in concrete over the membrane.

**Bored pile walls as components of the final structure**

Bored pile walls are not only used as temporary building pit walls but also as components of the final structure or as final independent structures.

In underground railway or underground parking construction a watertight concrete cover wall is generally carried out on the inside of the bored pile wall. During the construction period the pile wall has to transfer the earth and water pressure loads, but after completion only earth load - the water load is carried by the concrete wall.

In Munich at several underground stations the secant bored pile wall is a component of the final structure as a visual supporting element.

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1. **Essener Dichtlamelle**

2. **Secant bored pile wall as component of the final construction, underground railway Munich**

3. **Contiguous pile wall as component of the final structure, slope securing Beuersberger Strasse, Wolfratshausen**
Large diameter piles against uplift and for transferring tension loads

Large-diameter piles are often used as foundation elements for alternating loads (pressure and tension). These alternating loads occur due to the system on cantilevering hall or stadium roofs. In the case of pile foundation of high-rise buildings tension loads from uplift can appear during the construction period, if the dewatering for the building pit is turned off, the building pit is flooded and the weight of the building is not yet sufficient due to the degree of completion. In the final state these piles support like pressure piles.

Large-diameter piles as slope securing

Large-diameter piles are applied for slope securing in different versions.

The stability is increased by active elements like:

• bored pile walls as retaining walls
• bored pile walls as supporting shear walls
• bored piles for dowelling

A further possibility for securing slopes against sliding exist in the construction of deep drain trenches. To this end large-diameter secant, tangential or contiguous drillings are carried out vertically to the main gradient of the slope. On the bottom slab, a bottom drain tube is installed for the effluent overflow and the drillings are filled with filter material.
Large-diameter piles as energy piles

For new structures the regenerative usage of energy is growing incrementally. The heat of the earth close to the surface as part of the geothermal energy, is used for the climate control of buildings. The substratum is suited as a store for heat and cold, the required quantities depend on the time of day and year.

By using necessary static building parts (no additional parts required) such as in-situ piles of the foundation or building pit piles as energy piles the investment costs for the usage of energy can be kept low.

Heat exchanging pipes fixed to the rebar cage are installed in the in-situ piles. In these pipes a heat transfer medium flows for the temperature balance between the earth store and the interior rooms.

In recent years Bilfinger Spezialtiefbau GmbH has executed the pile foundations as energy piles for the highrise buildings in Frankfurt „Main Tower, „Gallileo“ and „Mainforum“, for the building project FrankfurtHochVier, for the building project Rheinauhafen in Cologne as well as for the underground lot 2/1 in Vienna.
Large-diameter drillings

Large-diameter piles are executed for the construction of all sorts of piles, for the construction of soldier walls with lagging and of wells for dewatering.

Obstacle drillings

For the removal of obstacle drillings in diaphragm and sheet pile wall alignments, which lay very deep beneath the groundwater, Bilfinger Spezialtiefbau GmbH carries out replacement drillings and even drills solid reinforced concrete using the wash over method with self-developed rock augers. Subsequently the drilling is filled.

Large-diameter drillings for underground demolition of concrete and reinforced concrete structures in the groundwater

The demolition of concrete and reinforced concrete structures in the building ground under the groundwater level, if the ground water cannot be lowered, generally requires a "watertight" building pit with impermeable walls and impermeable slab. Bilfinger Spezialtiefbau GmbH has developed the patented method of demolition by wash-over drilling method with cased borings and executed this method for the building project "Traffic facilities in the central area of Berlin, site clearing lot A, B and C". These lots comprised the underground demolition of an underground tunnel, a test caisson and a middle wall foundation of reinforced concrete surrounded by steel sheet pile retaining walls. After completion of the drilling it is filled and the filling material is compacted after the casing is pulled out.
Replacement drilling to improve the building ground

For large areas of soil replacement of deeper non-load bearing soil layers, also in the groundwater, secant replacement drillings are appropriate. Excavation of the building pit, securing of the building pit and any dewatering which may be required are now unnecessary. The drillings are drilled up to the maximum depth and filled with suitable material. This filling becomes compacted after the drilling pipe is pulled out.

Replacement drillings for removing the contamination

Simultaneously with the soil rehabilitation using secant replacement drillings, contaminated soil is substituted by soil free from contaminants. According to the contamination degree a “blackwhite-plant” has to be erected and the work is carried out under full protection.