MICROPILE FOUNDATION – THE EASY WAY

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ABSTRACT

Micropiles are an upcoming foundation element and many colleagues – designers as well as contractors - are surprised about the possibilities.

But Micropiles are not something new – they have been used already for a very long time as foundation elements. What´s new are the materials used. Very simple and easy to use are Ductile Iron Cast Piles, which are in use in Europe since the beginning of the 90-ties – especially in Austria. Admissible bearing capacity varies between 300 kN up to 1100 kN depending on diameter and wall thickness. The main part of the pile system is the coupling, which enables an "unlimited" length and besides that no wasted piece of ductile iron cast pile. Combined with a reinforcement bar the piles can also be used for tension piles.

1. SHORT GLIMPSE ON HISTORY

In historic times, micropiles were widely used as foundations for prehistoric buildings to protect them against flooding, wild animals and neighbours. These piles were timber logs – diameter around 15 cm and lengths between 3-5 meters, depending on the needs and water level. To protect the piles against wave impacts blocs of stone were placed around the foundation.

Buildings on pile foundations can be traced back to the Neolithic age and are in use up to present.

World famous examples of pile foundation made of timber logs are Venice in northern Italy, Amsterdam or Hamburg.

At the beginning of the past century micropiles made of steel – pipes or steel girders -, reinforced concrete – precast or made in place – replaced the wooden piles.

After a technology transfer – licence agreement – in 1986 between Gustavsberg AB and TRM Ductile Iron Cast Piles were developed in Austria, where the story of success began.

2. SYSTEM DESCRIPTION

Basic material developed in early 1960 provided everything a rugged pile system needed – ductility, corrosion resistance, impact strength and easy handling were part of the story of success. Within 30 years more than 7 million m of pile pipes were produced and installed all over the world.

Core element is the patented coupling, which enables a varying length without limitation. The Ductile Iron Pile has a coupling, which is bending resistant and friction locked. Assembling can be done without tools or welding. Piles can be driven by hydraulic blow hammers mounted on excavators and filled with mortar working as end bearing piles or in addition the ring gap was injected with mortar and the piles working as friction piles. In addition, the Ductile Iron Piles are corrosion resistant and environmentally compatible and due to recyclability sustainable in a high aspect.

Figure 1 – coupling of DIP after 30 years

Figure 2 – excavated pile after 30 years of use

Admissible bearing capacity varies between 300 kN to 1100 kN depending on diameter and wall thickness.
Specially designed driving shoes for different types of soil depending whether the pile will be injected or noninjected provide ideal adaption to the needs on site.
Parts such as coupling sleeves, pile-caps, pipe support shoes are available for the system.

Figure 6 – special parts

Depending on ground properties ductile piles can be prepared as grouted and concrete filled friction piles or nongrouted either filled with concrete or not end bearing piles.
The pile shoe is the base for the pile tubes which are inserted into the conical socket of the element before pile driving. The full displacement pile is driven to the final depth, which can be fixed on site during execution - based on pile testing parameters. Excess length is cut off and can be reused so no debris and disposal costs, no reworking of pile heads, no trimming losses and no unusable sections. Besides that, groundwater balance is not changed while driving from above.
Another advantage is the short construction time – 200-400 m per day can be installed.

3. STRUCTURAL AND GEOTECHNICAL DESIGN

Design can be done per Eurocodes – EN 1990, EN 1991-2, EN 1992-2, EN 1993-2, EN 1997-1, EN 1537, EN 14199, national regulations concerning bridges released by FSV and approvals – or other national codes and standards. European codes allow the design following the semi probabilistic safety concept using partial safety coefficients. Due to class of importance and complexity EN 1990 demands for geotechnical design and execution at least an independent check of both. Following this 4-eye principle – design independently checked and released - and special site supervision provides required safety of foundation system. Driving criteria can be fixed based on test results either for end bearing piles – no further movement of pile while hammering or max 10 mm movement within 20 second in dense non-cohesive and stiff cohesive soils.

In medium dense or loose non-cohesive soils a friction pile is the choice. In medium dense soils the bearing capacity of ductile piles varies between 90 kN/m for a 118-mm pile with 190 mm shoe and 118 kN/m for a 170-mm pile with 250 mm shoe.

Due to minor stiffness micropiles may only be charged by axial loads – horizontal loads can be taken by installing battered piles.

4. EXAMPLES OF DUCTILE IRON PILES FOUNDATIONS

Some examples will show the versatile use of the ductile iron pile system.

4.1 Bridge foundation

To meet the safety demands of the aviation authority the runway of Innsbruck Airport had to be elongated and therefore the riverbed of nearby river Inn had to be moved. To meet the logistic challenges of the huge excavation transport necessary for the move of the riverbed a temporary bridge suitable for a maximum capacity of 50-ton dump truck had to be erected. With a total length of 63 m and two spans of 30 and 33 meters the two abutments and one bridge pier had to be built. The contractor awarded with the earthworks for the airport chose the proposition of IB-Brandner to use the ductile iron cast system as foundation for the abutments and the pier. As the site was at the border of the water protection and conservation area for the City of Innsbruck water supply the use of concrete and injection was not allowed. Ground conditions showed a layer system of river deposits of silty sand, sand, sandy gravel with a medium density.

Design and burdens had to be coordinated with the waterways authority. During construction period the foundation had to meet the demand of a 25-year flooding and ice impact. To protect the piles from washout and wave impact, boulders of 2 tons per piece were grouped round the pilecap of the pier and the pilecaps for the abutments.

Figure 7 – Pile driving for pier foundation

Figure 8 – driven piles – straight and battered

To manage the horizontal loads battered piles were provided and for tension piles a reinforcement bar was inserted after piledriving was finished and grouting was executed.

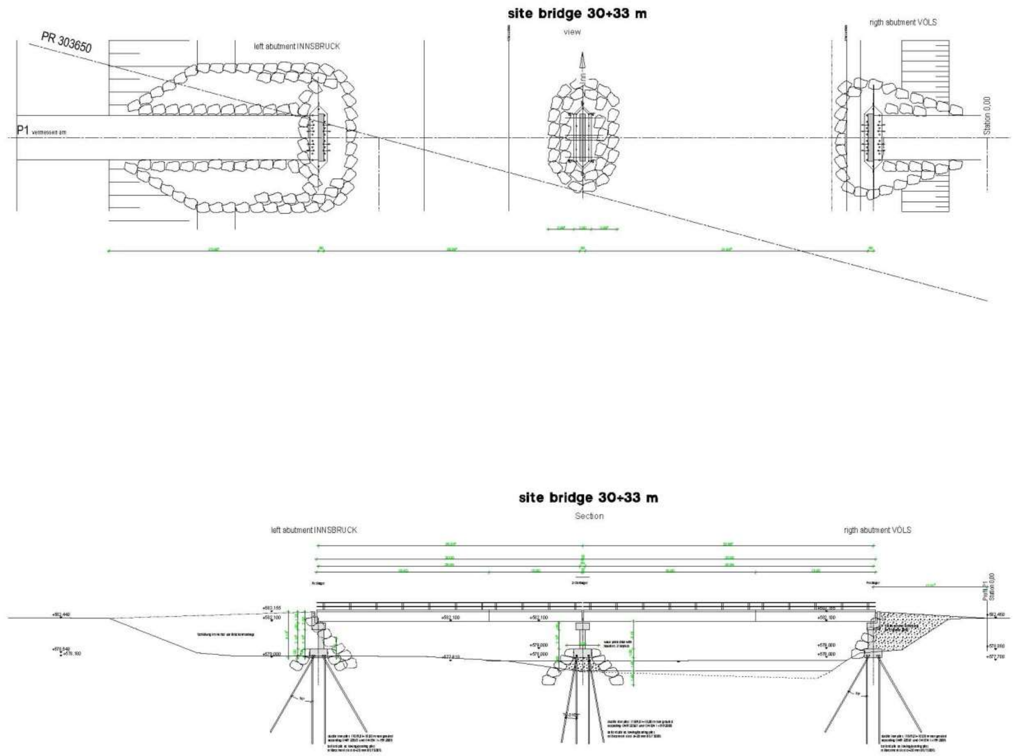

Figure 9 – Bridge foundation – view and section

Pile driving works for the pier was done from the left abutment side, where only little backfill had to be done for enabling the excavator to reach the piling platform. All foundation work was executed during low water season – autumns and early winter – and the bridge could be opened after a short construction period of 2 months due to a prefabricated steel superstructure.

After the move of the riverbed was finished the bridge including foundation had to be dismantled, the piles were cut by an excavator mounted hydraulic cutter at the bottom of riverbed.

4.2 Slope Stabilization

Near Vienna at the S1 highway around the city a slope slide occurred after completion of earthworks and recultivation. Access to the site was restricted as the highway could not be closed completely but traffic was deviated.

To stabilize the slide a dowel system was chosen using ductile iron piles instead of GEWI-piles. Piledriving was done in a few days with an excavator mounted hydraulic hammer on a slope with 30° inclination.

Figure 11 a+b – Slope stabilization on S1 highway Austria

4.3 Noise protection Wall Foundation

Along a railway line in France a noise protection wall had to be erected. As foundation system, ductile iron piles were chosen to meet the needs of design to carry the loads and the time schedule. Two piles for each foundation had to be driven close to the railway line and the electric supply lines. Due to the flexible installation, the challenges could be managed in a technically outstanding and commercially competitive way. As there occurred also tension in the piles a reinforcement bar was provided to take up this impact.

Figure 12 a+b – noise protection wall foundation France

Piles were grouted friction piles of 5 m length.

4.4 Foundation of a residential building

At a slope above Innsbruck a residential building was to be erected. Ground conditions were rather complex – beneath a manmade backfill of 1,50 m a 2,50-m layer of peat covered the final dense sand layer. Below the peat permanent surface water flow lead to saturated sand, which became soft and tricky while disturbing it. In an alternative design IB-Brandner changed the proposed foundation with drilled micropiles to the ductile iron pile system. Pipes with 170 mm diameter and 9 mm thickness were used to take the foundation loads of the building and leading these loads to a stable ground. Space was restricted on site, so work was done with one excavator for the earthworks as well as for piling.

Figure 12 a+b – piling works residential building

Figure 13 – preparation of foundation level

Piles were grouted friction piles of up to 15 m length depending on depth of stable ground. The choice of this pile system saved in total € 65.000 , of which the contractor got 50% and made a good deal.

4.5 Foundation of electric power line

To strengthen the reliability of the electric power supply in Austria a new HT power line had to be erected. As an alternative proposal for the foundation of the towers, the contractor suggested to use ductile iron piles. As the piles were alternating load piles tension had to be considered. The solution was to insert reinforcement bars into the grouted pile.

Figure 14 a+b – piling works electric power line HT

Piles were grouted friction piles of up to 15 m length depending on depth of stable ground. Executed lengths were fixed on site per driving progress. Advantage was the simple and cheap installation and flexibility on site.

4.6 Pit lining for a residential building

General Contractor BODNER awarded IB-Brandner just 3 weeks ago, with the design of a pit lining for a residential building in Innsbruck. As neighbors, did not agree to anchoring into their property and stiffening would hinder the contractor from effective excavation and concrete works, a slender and rigid solution had to be designed. Space available was just 35 cm for the whole pit lining system. For the first time the ductile iron pile system was used not as a foundation system but was used for pit lining in combination with shot concrete.
Ground conditions showed beneath a layer of backfill 1 m, a layer of dense silty sand covering the final ground consisting of medium dense sandy gravel.

Figure15 – ground conditions

After the first 2 piles, it came out that the provided shoes did not work for this kind of work – the necessary rigid clamping length of the pile to work as a cantilever beam could not be reached. So, it was decided to leave the shoe off and the piles were driven without a shoe into the ground. With this method, we could meet the design requirements and could excavate the pit without a stiffening beam construction. The space between the piles was filled with a reinforced concrete arch.

Figure 16 a+b – pit lining piles and shot concrete arches

To meet these requirements for pit linings as well and to create a new field IB-Brandner works together with the pipe producer on the design of a new driving shoe, which enables the pile driving to greater depth.

5. SUMMARY

The development of ductile iron cast piles as an additional market for pipes, starting in the 80s, was the right decision. A "simple to use" system showing advantages against other pipe type piles - technically as well as commercially was born. The system is ideal for sites anywhere on the globe and suitable for any project size – from small to big.
The examples shown demonstrate the versatility of the ductile iron pile system and the advantages compared to other driven steel piles:

- Corrosion resistant pile material (better than regular steel pipe)
- Impact resistant
- Simple and reliable rigid connection in the coupling
- No waste pipe on site – flexible length
- Recyclability of pipe material
- Environmentally non hazardous
- High capacity for a micropile
- Easy to work with – hydraulic hammer, excavator, grouting pump

- Low noise production
- Low vibrations
- Commercially competitive – 200-400 m/day

References:

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