Application of Micropiles
European Review and Potential

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1. Present State of Knowledge

This 3rd IWM provides the opportunity to set up a synopsis of the two preceding ones in Seattle (1) and UBE (2) and the state-of-practice review of the FHWA (3). Micropiling still is performed by a confined group of specialists. This allows to collect the experiences made so far, compile them and distribute them to committees of governmental bodies, to specialist contractors and consultants. It may assist to provide background information for those who establish guide lines, manuals or standards for those who do the design work and the contractors who execute the works.

2. Development during the Past Half Century

For the purpose of retrofitting historical buildings in Italy F. Lizzi conceived the root pile in 1952. The idea proved to be a tool which at that time provided for a really small diameter bore a surprisingly high bearing capacity. The reinforcement of the ground by closely located piles increased its bearing capacity substantially and allowed a control of movement for foundations of historical stone and brick buildings which had high tendency to open cracks at even small settlements.

The success of the first application with already basic concepts for the composite action of ground and reinforcement quickly spread to other countries like Germany, France and U.K. New types of micropiles like the GEWI-Pile (Fig. 1) with an extremely high steel/borehole content emerged (1971) and new applications were found. The 1st

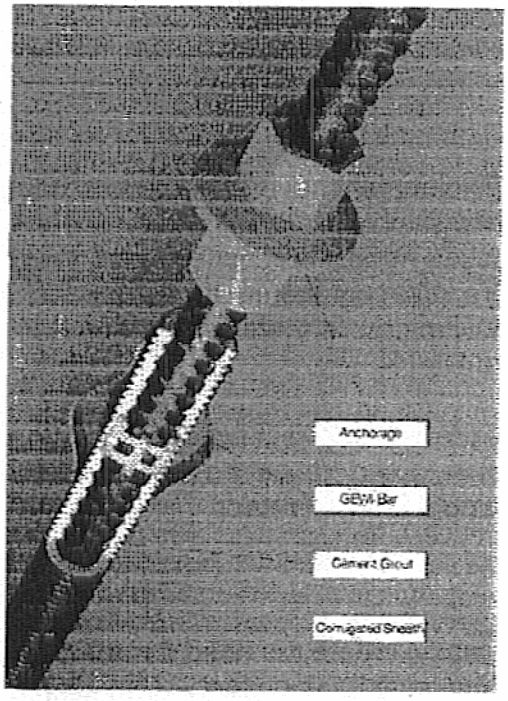

Fig. 1 GEWI – Pile with double corrosion protection

standard on micropiles was already issued as early as 1978 by the German DIN as DIN 4128. Such a standard encouraged many designers to use micropiles and soon it turned out that they could replace former reinforced concrete bored piles up to 500-600 mm dia. In particular specialized anchor contractors were keen to use them as drilling and grouting equipment and methods were basically the same as for ground anchors. GEWI-bars and tubes of various sizes with bond enhancement like cold rolled on threads nowadays are the main steel reinforcements and working loads of 1 MN and more become increasingly frequent if ground conditions allow it.

As the used steel grades are in the range of high stress steels with reasonable ductility and usual cross sections and wall thicknesses are substantial, the problem of sudden failure due to corrosion is less stringent than for ground anchors. Nevertheless the designer takes a high responsability in judging the durability of permanent installations which often have to support costly superstructures for a design life of over 100 years. The proposed new CEN Standard obliges him to judge by himself if corrosion protection is sufficient for a considered application and the installation ground and hazards. Published rates for surface corrosion are of limited value in this case as axially loaded reinforcements deal mainly with pitting corrosion. Up to now in Germany this investigation has been delegated to expert committees of the DIBt which then upon satisfaction initiated a general certificate of approval for a micropile system focusing on all details which concern the bearing characteristics, permanency and safe execution. The double corrosion protection for GEWI-Piles stands typical for an extremely high corrosion barrier at low additional costs (Fig.1).

Manufactures have adapted drill rigs to the various fields of application for highest installation efficiency. Basic systems are rotary drilling with percussion, driving and jacking.

The choice of micropiles device is mainly governed by local and regional geological conditions. If bedrock as bearing structure is overlaid by soft layers of clay like in Scandinavia development of micropiles takes a quite different direction. There the classical point bearing piling system with small diameter is the solution and shaft bearing takes only a small part depending on the settlement requirements.

3. Fields of Application

These landmarks in development have to be known to understand the large field of application and their geographically differing distributions. Geological and geographical requirements, construction needs, precriptions and design rules, marketing efforts and knowledge of designers influence the main applications. Thus different countries may stand for different typical micropile systems and applications. Reference to early applications is made in Lit. (1-3).

The starting point was the retrofitting of historical buildings in Italy. Whilst many applications are common to and frequent in each country or region, geological conditions yield a varying pattern of needs.

Geological Needs

- High groundwater tables create the need for uplift securing if no counterweight is available even during construction phase.

- Lowering of groundwater may decay existing wooden piles which have to be replaced.
- Glacial or erosion deposits with big boulders or underlying bedrock require rock bits for drilling. The small diameter boreholes of micropiles are the answer.
- Mountainous and hilly areas require light weight and easy to lift drill rigs frequently with rock tools.
- Seismic retrofitting is restricted to a few areas in southern Mediterranean Europe, but is a huge challenge worldwide.

4. New Construction Methods with Incorporated Micropiles

- Sometimes the NATM tunnelling method is used for wide span tunnels in poor ground. Settlement of the crown heading and the ground above may be prevented by forming a console which consists of a vertically inclined micropile and a horizontal soil (rock) nail at the footing of the arched lattice girders. This avoids more costly auxiliary bottom invert slabs which slow down the advance. Such solutions have been successfully used in Italy, France, Austria and in Japan. These micropiles act as protection of the sidewalls of the bench excavation as well.
- Jet-grouted horizontal diaphragms as water tight bottom slab for underwater excavations incorporate micropiles for uplift securing. They are executed together with the diaphragm using the same drilling and grouting equipment.
- Potential exists for jet-grouted soil bodies which incorporate micropiles beyond their own dimensions. If they are confined inside them bars may act as reinforcement only.
- The „Reinforced Soil" concept tends to distribute micropiles equally to change the overall characteristics of the ground body. If it takes into account the special loading conditions preferential positioning and inclinations of micropiles are identified. It still has a high potential for more frequent use and is known as Case II application. With such a concept evenpile-ground composite structures are conceived which act as retaining walls or blocks for slope stabilization. If free standing faces exist soil nails may be combined.

Conclusion

Experience shows that most designers wait until new applications have been tried by others to avoid own disappointments with the first trial. For this reason the extension of the range of application needs more publications on case histories. A data base on micropiles would be very helpful.

Literature:

(1) 1st IWM, Seattle 1997 Proceedings

(2) 2nd IWM, UBE 1999 Proceedings

(3) Bruce D.A., Juran I.
Drilled and Grouted Micropiles: State-of-Practice Review,
DOT, FHWA-RD-96-016, Washington DC, 1997

Fig. 2 Fields of Application of Micropiles

- Underpinning
- Execution under confined working conditions
- Upgrading of load bearing capacity
- Seismic retrofitting

- Settlement control
- Foot support of tunnel headings
- Side wall strengthening of tunnel benches

- Uplift securing
- Controlled underwater drilling and grouting
- Tie down for horizontal jet grouted diaphragms
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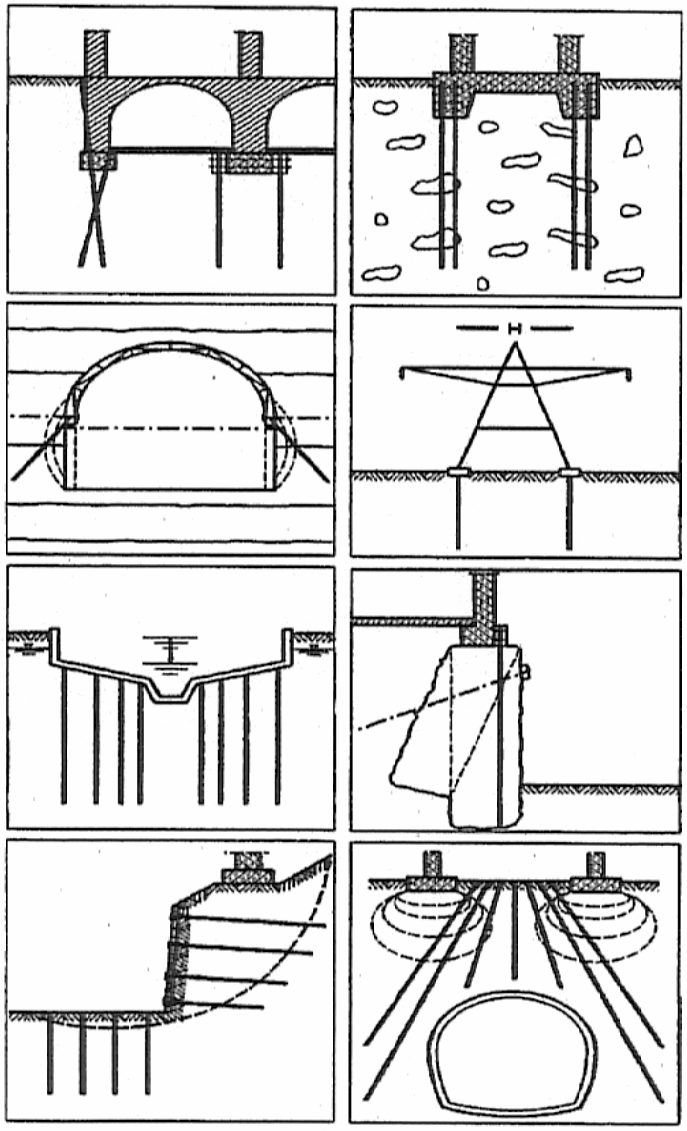
- Slope and embankment stabilization
- Combination with soil nailing



- New foundations
- Difficult ground conditions
- Light weight drilling rigs
- Any inclination
- Environmentally sensitive conditions: ground water, noise, excavation disposal

- Alternating compression and tension loads
- Easy connection to superstructures

- Combination of micropile installation with jet grouting
- Retaining structures

- Reinforced soil
- Strengthening of ground properties

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