Mixed-in-place - A technique for the construction of subterranean walls and foundations

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Abstract: The beginning of this innovative development was marked by the invention in 1958 by Dr. Karl-Heinz Bauer of the injection anchor which today is employed all over the world. Subsequently, a plant and the equipment for specialist foundation construction was developed, such as heavy duty rotary drilling rigs and diaphragm wall cutters. Based on the continuous flight auger (CFA) piling technique, which has been extensively employed over many years, the Mixed-in-place (MIP) process has been developed and patented by BAUER engineers and designers.

Key words: foundations, retaining walls, flight auger pies.

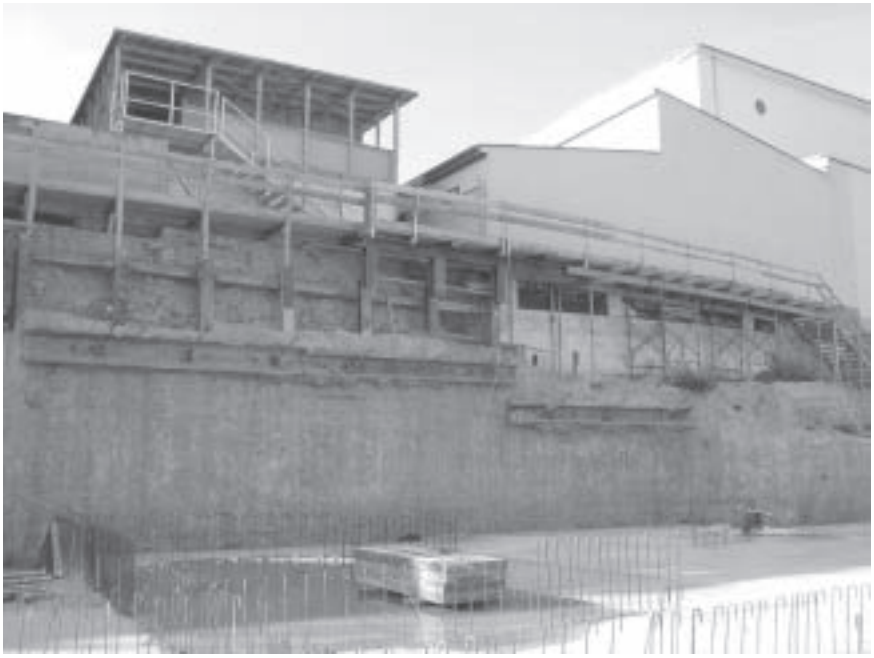
Principle

The Mixed-in-place process, in short „MIP“, is a method of improving the engineering performance of a soil by mechanically mixing or blending it „in - place“ or in situ with a binding agent. By breaking up and reconstituting the grain structure during mixing, the existing pore spaces within the soil mass are filled with slurry. This process results in the formation of “concrete” in which the soil is being used as aggregate.

Applications

MIP columns can be utilised for the construction of cut-off walls, which have no or only a very limited structural function, for applications such as sealing the substrata beneath dams or encapsulating landfill sites. Further areas of application are structural MIP retaining walls for deep excavations, which are either reinforced with steel H piles / universal beams or sheet piles inserted into the MIP columns.
Another retaining wall alternative is a combination of MIP panels with secant or contiguous bored piles, and also the installation of mesh reinforcement.
Horizontal loads are either transferred by a free-standing wall, or by a system of struts inside the excavation, tie-backs or ground anchors. Horizontal earth pressures acting on an MIP wall are transferred to the structural members inside the wall, such as universal columns or bored piles, by axial compressive thrust due to arching.
Another area of application is the construction of foundations for buildings in the form of wallpanels (barrettes), box foundations, or individual columns. The MIP process can also be employed in the field of environmental technology where it is used primarily for the immobilisation of contaminated landfill sites.
Depending always upon the specific use of the process, MIP can be employed in a broad range of soils with grain sizes ranging from clay fractions to coarse gravel.

Scientific paper



CONSTRUCTION SEQUENCE

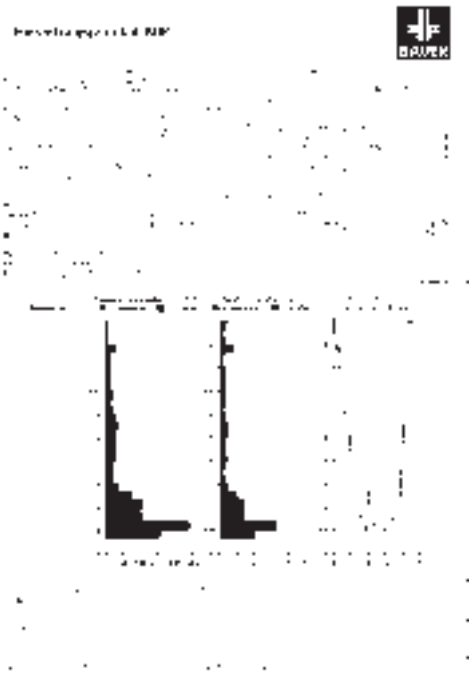
The drilling rig, which has been specially developed for this process, is first set up over the MIP-position. It then drills the triple continuous flight auger assembly mounted at the front-end of the rig into the ground whilst slurry is being injected continuously through the central starter auger sections. By reaching the specified final depth, mixing and homogenisation of the soil material is carried out by vertical (upward and downward) and rotational movements of the auger unit.
By constructing overlapping MIP panels in the so-called „double 'Pilger' step sequence watertight walls are formed below ground. Steel H piles or universal columns are inserted into the still soft MIPcrete as structural reinforcement.

WALL PROPERTIES – TYPES OF SLURRY

The mechanical properties of MIP walls depend essentially on the physical properties of the in situ soil material, which is used as aggregate, and on the materials used in the slurries. Mix designs are mainly cement based or consist of a blend of cement and bentonite. Slurries comprising cement, bentonite and a filler, or a ready-mixed product can also be used. The compressive strength of the MIP – Concrete achievable in structural MIP walls is 5 to 20 N/mm^2. Cut-off walls generally produce a compressive strength of up to 1.0 N/mm¸ and a coefficient of permeability between 1 x 10^{-8} and 1 x 10^{-10} m/sec, with a modulus of elasticity of 30 to 60 MN/m^2.

The quality of an MIP wall face is very much dependent upon the in situ soil structure and generally comparable to that of a diaphragm wall.

Documentation



All relevant production parameters required for Quality Assurance (QA) purposes - such as drilling depth, volume of slurry placed and processing times - are automatically recorded by the MEDEF System (Measuring and Electronic Data Acquisition System) for each MIP element and displayed graphically together with all geometric data. In addition, the density of the fresh slurry is intermittently checked at the mixing plant. Samples taken from completed MIP wall elements are retained for testing to establish the attained compressive strength values and coefficients of permeability. Core sample taken from the finished wall complete the internal quality assurance program.

Plant and Equipment

The plant and equipment employed stands out by its compact design. This results in very short set-up periods on site and also minimal requirements of space. All plant and equipment involved in the MIP process has been manufactured in-house.
MIP walls can currently be installed to depths of up to 25 m and thickness of approximately 90 cm.

SUMMARY

To date, more than 100,000 m^3 of MIPcrete have been produced on a world-wide basis. Based on the experience, we believe that the advantages of the MIP process are:

- Small amount of drill spoil
- Vibration free process
- Resistant to chemical attack
- Retention system with low deformation characteristics
- Stage excavation can be reduced to a minimum
- Can be employed in contaminated soils
- Cost-effective.