

German national report on 'braced excavation in soft ground'

A. Weissenbach
Dortmund University, Germany

H.-G. Kempfert
Konstanz Polytechnic, Germany

SYNOPSIS: In this national report, the calculation methods and types of construction commonly used in Germany for braced excavations in soft ground are presented. Information is given on experiences made with projects carried out mainly in Southern Germany.

1 SOFT GROUND OCCURRENCE

There are two main regions in the Federal Republic of Germany (FRG), where normally consolidated soft ground is found with the following geological description:

a) Sea Silt: young, mostly very rich, soft clay, to be found in the coastal areas and in the marshes of the rivers Ems, Weser and Elbe. The sea silt contains organic components. Its consistency is mainly soft, water content is up to over 100%, drained shear parameters are $\varphi' = 15-20^\circ$ and $c' = 5-15$ kPa, its undrained shear strength is $c_u = 10-30$ kPa.

b) Lacustrine Clay: silty clay to sandy silt in the Lake Constance and South Bavarian lake area. They often have thixotropic properties. The consistency is soft to very soft, water content is up to 25-50%, drained shear strength $\varphi' = 22,5-25^\circ$ and $c' = 0$ kPa, undrained shear strength is $c_u = 10-40$ kPa.

The main emphasis of the following report lays on experiences with braced excavations in lacustrine clay, because these soft grounds are found in a great amount also in urban areas. On the other hand, these experiences also apply to sea silt in many respects.

2 EXCAVATION TYPES

When excavating soft ground, the wall types preferred are sheet pile walls and bored diaphragms. Tie-back anchored or braced systems are used depending on regional subsoil layering. The following systems are preferably used:

a) Depth of open cut up to 4 m approximately and homogeneous soft ground as well as small plan dimensions: Within the excavation walls, a cut of 2 or 3 meters in width each, is made with unbraced slopes during one working day, beginning at the narrow end of the excavation, and a bracing strip of blinding concrete (0,2 - 0,4 m thick) is made under the foundation level of the future building. The strip of blinding concrete can be made of drained concrete, if there is water occurrence. During this state, the loads acting from outside on the side walls in the range of the excavated strip have to be carried over to better supported areas by horizontal beams along the side walls. Through continuous casting of the strips, a bracing

footing slab is obtained in the height of the foundation level. The side walls are approximately twice as long as the excavation depth.

b) Depth of open cut from 3 to 6 m and homogeneous soft ground: To begin with, the side wall is supported by a berm using a top-down construction, and the foundation slab of the building or its ground floor is made in the central region of the total future excavation. As a second step, an intermediate bracing is carried out against the foundation part accomplished in the central region, the berm is removed and the bracing slab elongated to the excavation sides. Thus, a continuous lower bearing is constructed for the wall. If the excavation is not very deep, the upper bracing can usually be omitted, or, for greater depths, a new bracing following the progress of the construction must be installed.

c) Deep excavations in homogenous soft ground: Prior to start of excavation, a bracing foundation slab is cast underneath the final foundation level, for example using the HDI (high pressure injection) method. The excavation and further bracing of the side walls is carried out as a top-down construction with struts.

d) Excavations in soft ground with sand or gravel layers on top: These conditions often require a tie-back anchoring in the sand or gravel layer. In this case, the anchorage must be made very long, so that a sliding of a major part of the cohesionless layer, including the anchorage, on the soft clay into the excavation is prohibited.

3 CONSTRUCTION RULES AND DESIGN

3.1 General

Special codes of practice or standards for excavations in soft ground are not available. The German recommendations of the Committee for excavations (EAB 1988) deal with excavations in soft ground only in regard to an increased factor of safety against earth resistance (factor of safety $FS > 2,0$) in order to reduce deformations of the lower end of the wall. In the following, the basic elements are given for the evaluation of the relevant soil parameters and earth pressure assumptions in Germany.