PROCEEDINGS OF THE XI. DANUBE - EUROPEAN CONFERENCE, POREC, 1998

Geotechnical Hazards, Marić, Lisac & Szavits-Nossan (eds) © 1998 Balkema, Rotterdam, ISBN 90 5410 957 2

Experiences on stabilisation of landslide in South Black Forest

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ABSTRACT: This paper presents the experiences on a redevelopment of a landslide in South Black Forest. A big part of a hillside was sliding with velocities up to 90cm/year downstream and endangered a building located above the creep zone. To reduce the movement of the soil masses, a doweling of the hillside was executed. The redevelopment consists of a serie of piles, that are embedded in the stable underground and anchored backwards at the pile caps. Due to the support at both ends of the pile, the load distribution is advantageous and enables an economic design of the piles. The analytical formulations used to determine the forces in the dowels will be reflected and the success of the redevelopment will be verified by results of measurements and calculations with the FEM.

1 INTRODUCTION

In Spring 1991 a landslide in South Black Forest was realized. The area affected by the landslide is located uphill the country road No.132 between the villages Badenweiler and Sehringen. The moving soil mass on the hillside covers an area about 80 m in North-South and 50 m in West-East direction and creeps in dependence of the intensity of precipitation with creep velocities between 10 and 90 cm/year. The resulting movement of the hillside became so large, that a redevelopment was necessary, in particular, a building on the hillside was in danger to suffer damages.

The concept of the redevelopment provides constructional reinforcements to reduce the creep movement of the bed load on an acceptable degree.
This report describes the landslide that appeared before the redevelopment was executed. The effectiveness of the redevelopment will be analyzed with numerical calculations with the FEM and compared with present measurements.

2 LANDSLIDE

The concerned area is situated between the country road 132 in the west at a height of 497 m NSL and a hospital in the east at 522 NSL. The hillside has an inclination of 13°, the situation is illustrated in Figure 1. Simplifying, the formation has a structure of two layers: a loose soil layer, which forms the creeping soil, and clay stones, which forms the deeper stable underground.

The thickness of the loose soil layer is between 9 and 16 m and is made of clayey soil in the upper 4 to 5 m, which has less coarse grain particles with mainly stiff, partially plastic or semi-solid consistency. The deeper section of the loose soil layer down to the claystone consists of loam and/or debris with fine fractions of clay, sand-clay or sand-silt mixtures. The loam and/or debris is partial soaked and softened due to water supply. The stable underground is formed by clay stone of the opalinus-clay (Braunjura alpha). The stratigraphical sequence is a serie of uniform dark-grey foliated clay stones, which could not be divided by petrography. The clay stone in the upper 3 m is softened to greybrown clay in semi-solid and solid consistency. Several slickensides were determined in the clay stone, which indicate significant tectonic pretensions by the mountain.

The hillwater was found in different levels. It flows above the watertight layer of claystones in the creeping bed load to downstream.

The movement of the bed load is recorded by inclinometer - measurements since October 1991. The measurements indicate that the creeping bed load demarcates itself legible from the stable underground.

The movement of the soil mass takes place on a thin sliding plane, that is located more or less parallel to the surface of the hillside. The depth of the sliding plane for a characteristic profile of the hillside is illustrated in Figure 2.
The boundary line of the creeping soil upstream is