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CONSTRUCTION OF A HIGHWAY EMBANKMENT ON THICK MARSHY GROUND

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Abstract

A section of a bypass motorway north of Kaposvár, South Hungary, was to traverse a fishpond in a length of 150 metres field up with thick (up to 7 meters), fresh, water-logged, organic sediments. Removal of the thick, soft soil was disregarded of enormous costs. In order to prevent base failure stage construction has been adopted using counter-weight berms. By continuous monitoring of settlements, it has been possible to control construction and reliably predict final consolidation settlements.

Keywords: organic sediment, embankment, stage construction, monitoring of settlements.

1. Introduction

Construction of earthworks on soft ground has become an acute problem in Hungary. Understandably so. Times have long gone when the Civil Engineer was in a comfortable position to select 'competent' site to accommodate his project. Nowadays, he has to accept what ground conditions there are, he often has to make compromises and, at best, he tries to find a both technically and economically sound solution.

2. Site Characterization

In Southern Hungary, near the town of Kaposvár, a 17 km long by-pass road has been constructed in 1999 to 2003. A section of the line, was to traverse several wide valleys, with thick peat deposits at the valley floor. The subsoil at such places consisted of very soft, waterlogged marshy deposits, which were impassable even to wading on the surface. At one of these sites the road was to cross a fishpond in a length of 150 metres (*Fig. 1*). Site exploration was carried out by simple weight sounding. The soil was so soft that the sounding rod sank almost unimpeded under its own weight. The thickness of the peat layer varied from 5,5 to 7 metres. At two sections TUBOSIDER culverts had to be built. At both ends of the peat section, the line continued in deep cuts where ample mass of soil suitable for embankment construction was available.

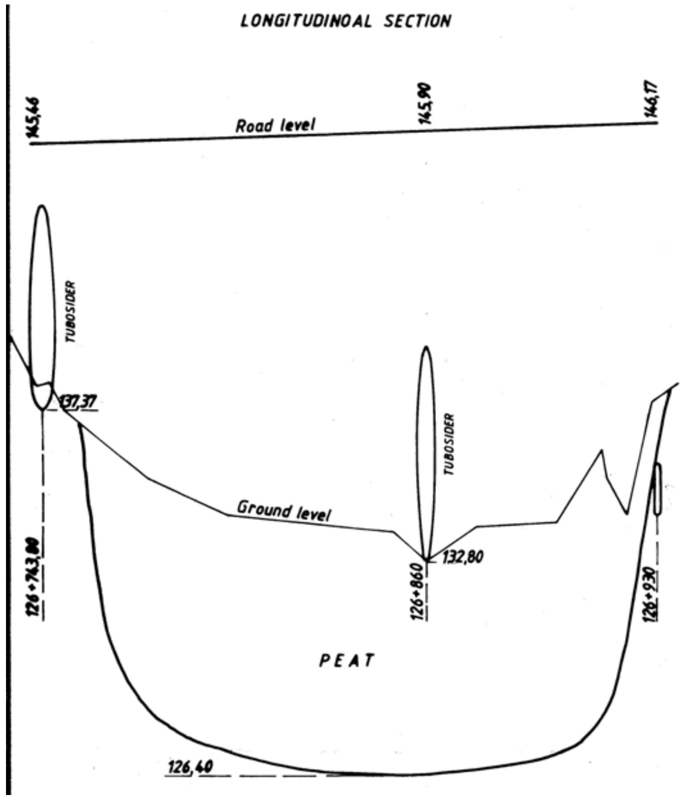

Fig. 1. Longitudional section

Representative undisturbed soil samples were taken from trial excavations made by a light machine. Moisture contents varied from 260 to 500%, dry densities from 0.19 to 0.24 t/m^3. The peat was far too soft and compressible to be tested in the oedometer. Realistic values for the modulus of compressibility, E, have only been obtained from back-calculation of measured settlements. The E-values of the rather inhomogeneous peat varied between 400 to 900 kPa depending on the stress level applied.

The undrained shear strength of the peat determined by triaxial compression tests was found to vary between $\tau_u = 20$ to 25 kPa in the natural state. After consolidation under the full load of the planned fill it is expected to increase. Interestingly, the peat showed rather brittle behaviour in the triaxial tests in that it failed at a moderate strain of 5 to 6 per cent [1]. Previous experience on the behaviour of high embankment built on peat in the same region suggests that the peat may undergo under constant load secondary consolidation leading to increased settlements over the years [2].

3. Options for Construction

Given the very unfavourable ground conditions, several options for crossing the valley were considered. The construction of a viaduct, an obvious option, was omitted on account of comparatively high costs. Removal of the thick peat layer and replacing it with firm soil on which to build an embankment was also judged uneconomical. Blasting away of the peat was not permissible for reasons of envi-romental specifications. Eventually, it was decided to leave the peat layer in place and construct an embankment over it by stages. Similar construction in the region has proved feasible and cost-effective. So the financing bodies, fully aware of the implications, eventually opted for this solution. The construction was so scheduled to start work first on the peat section allowing sufficient time for advanced consolidation.

4. Construction of the Embankment by Stages

Because of the enormous hight of the fill up to 12 metres, there was danger of base failure provoked by rapid construction. Before construction the fishpond was temporarily dewatered. Since the ground was impassable by construction machinery, a mat consisting of coarse angular minewaste material was first laid over the ground by forward dumping in a thickness of $\sim$ 1.5 m. This layer sank almost to half of its thickness in the soft ground. In order to prevent lateral spread of the peat layer, side counter-weight berms, some 8 metres wide and placed in a preexcavated trench three metres deep were constructed – using the same coarse material – prior to placement of the main fill (*Fig. 2*). On the joint level surface of the mat and adjacent berms a geotextile sheet was placed for seperation purpose. On top of it a gravel layer 1 m thick reinforced with geogrid was built in. Raising of the main fill was continued with same coarse minewaste material up to level which was estimated to stay – once consolidation is over – somewhat higher then the water level in the fishpond. At this level a 1 m thick gravel interceptor drain was placed for protection against rising capillary water. The rest of the embankment was built of local soil amply available from adjacent cuts.

5. Settlement Predicions

In order to monitor the process of consolidation as closely as possible, a simple settlement measuring device was installed. A steel plate, 1 m by 1 m, to which a long, expandable steel rod was welded, was placed on the levelled surface of the peaty ground considered to be the reference level, and the top of the protruding rod was levelled at frequent intervals. The protruding bar may have caused some nuisance during construction but the contractor managed to overcome the problem.

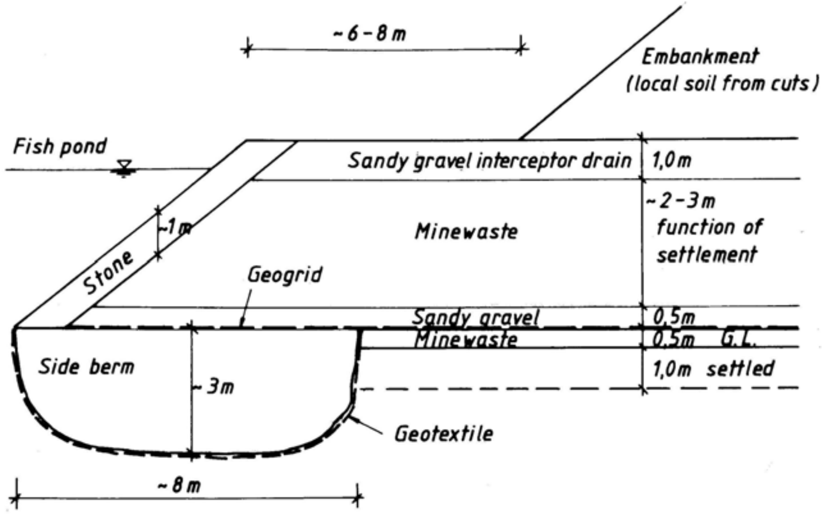

Fig. 2. Cross-section of the embankment base

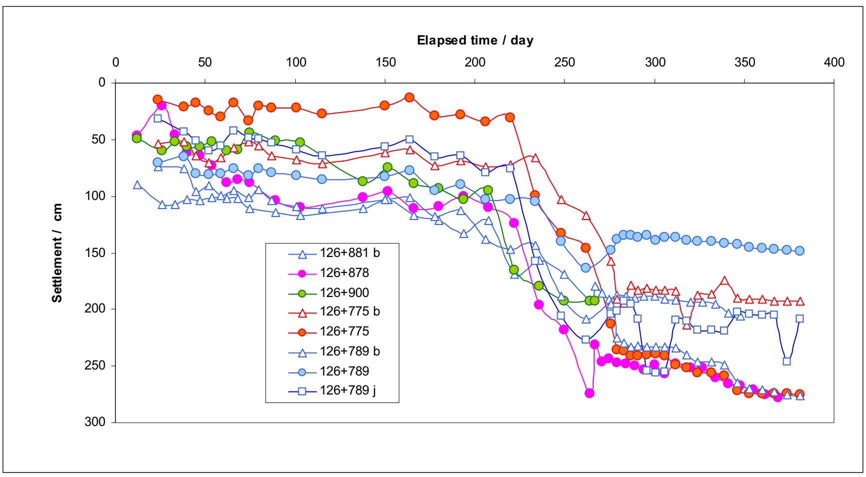

Fig. 3. Typical time /settlement curves

The consolidation was continuously monitored and placement of the next stage was only permitted when sufficiently advanced consolidation had been reached. This technique permitted cautious raising of the embankment in stages without triggering of failure in the soft base. On the average, approximately 20–25% extra fill was necessary to make up for the total subsidence of the embankment. Since both consolidation settlements and secondary time effects were likely to continue even after completion of the embankment and placing the road structure, it was decided to provide the road with a temporary flexible pavement, which once significant soil movements are over, can be replaced by the final structure.

Typical time /settlement graphs are shown in *Fig. 3*. Fairly rapid construction is reflected by the steep sections of the curves. After accomplition of the fill, the curves show a normal consolidation trend. Load/Settlement graphs (*Fig. 4*) show the character of the confined compressions indicating that the vertical displacements are mainly due to vertical compression, whereas lateral displacement is negligible. This favourable condition is clearly due to the beneficial lateral buttressing effect of the counter-weight berms. Without such measure based failure was bound to have occurred.

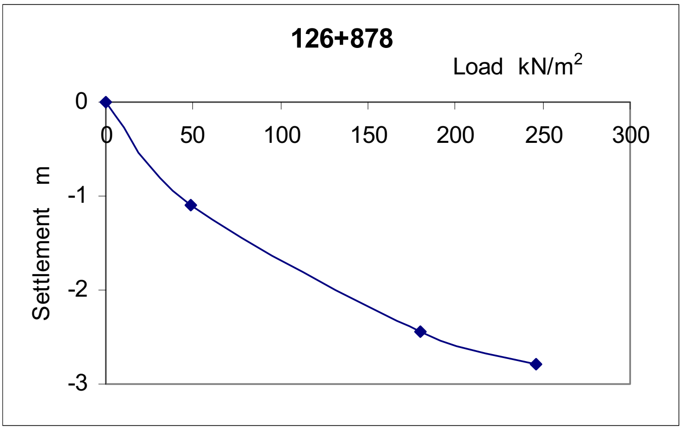

Fig. 4. Load/Settlement graph

The embankment was completed with the suggested measures of overfill. At this stage a temporary pavement was suggested to be placed. The road was commissioned in October 2003. Pavement levels have been continuously checked afterwards. After a while when the rate of settlements will be found to have essentially slowed down to a tolerable value, the final pavement may be placed. In the long run, minor movements are still likely to occur, but these can be handled by ordinary maintenance works.

6. Summary

Along the mentioned motorway, the road crossed four different valleys length of up to 450 metres with similar unfavourable soil conditions. The height of the embankments varied from 5–12 metres. Summarizing the experiences of the applied monitoring controlled stage construction, at higher embankments with the aid of counter-weight berms, both during construction and post construction (we have now experiences for more than five years), it can be pointed out that if there is enough time for construction, this can be the most economical solution. The settlements coming from the secondary consolidation effects can be controlled after the construction and the maintenance cost also can be managed. The settlements can be quite accurately predicted.

References

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