Panel discussion: Landfill construction on top of a 70 m thick loose fill of a former open coal mining area

Débat de spécialistes: Construction d'une décharge sur un remblai lâche de 70 m d'épaisseur dans une mine de charbon à ciel ouvert abandonnée

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1 INTRODUCTION

To the south of the town of Leipzig the Cröbern landfill construction project is currently underway. The facility is being built on top of a 70 m thick loose fill of a former open coal mining area at Espenhain.

My paper deals with the design and the construction of the landfill, our reflexions to identify the main elements for the landfill design, and finally on some of the results obtained from the settlement measurements carried out.

When, immediately after reunification, we were asked whether we would be prepared and able to do the design for this landfill project within an extremely short deadline, we ourselves asked whether it was really necessary to build the facility on top of a 70 m high uncompacted fill. All other prerequisites for the landfill location were ideally provided: traffic connection, distance to neighbouring build-up, etc. The then client presented the envisaged concept convincingly and with a high degree of personal commitment. In addition, the concept was corroborated by early initial investigations by the expert Dr. Jolas on the expected settlements and differential settlements. Backed by a broad-based experience gathered on other mining dumps, Jolas forecast overall settlements at the landfill of about 3 m. But he also claimed convincingly that the expected settlements and differential settlements were altogether controllable. The proposal to verify the empirical values obtained from a large-scale test fill fianlly removed all doubts of engaging in an uncalculable risk.

2 LANDFILL CONCEPT

In accordance with the provisions on waste management, the 21 million cubic metre landfill was designed for a service life of 35 years and required to fulfill every aspect of the German Technical Regulations on Waste (TA-Abfall). The site available for waste disposal was a 800 x 1,200 m large triangle (Fig. 1).

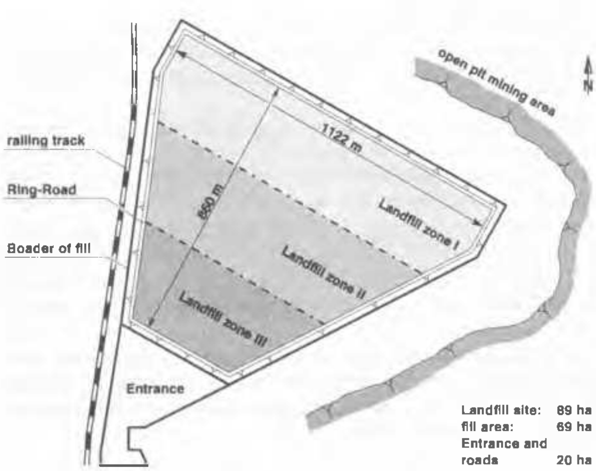

Figure 1. Layout of landfill site.

Our design is based on a maximum 300 m flushing length for the sewage pipes with access on either side. This had far-reaching consequences in that 2 sewage tunnels had to be provided below the landfill (Fig. 2).

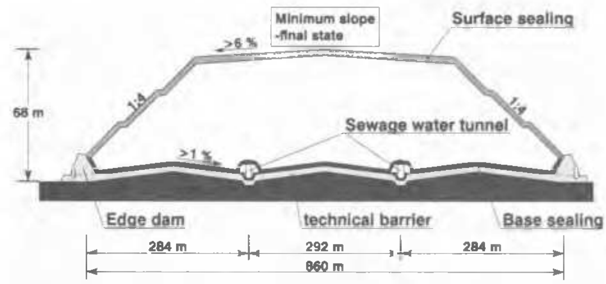

Figure 2. Section of landfill.

In view of the particular subgrade situation, we have attached special attention to the layout of certain elements in the landfill design.

A edge dam of 10 to 15 m height has been provided around the entire landfill (Fig. 3). One of the important tasks which the seemingly overdimensioned advanced edge dam fulfills is the protection of the landfill against horizontal deformations from expansion stresses.

Figure 3. Construction of edge dam and technical barrier.

Since the site has no natural geotechnical barrier which would fulfill the requirements of the Technical Regulations on Waste, a 3 m thick man-made barrier has been provided below the protective bottom lining (Fig. 4). At the same time it acts as settlement padding. Different settlements from unhomogeneities in the subgrade are thus quite considerably reduced. The geotechnical barrier constitutes an important structural element to control different settlements.

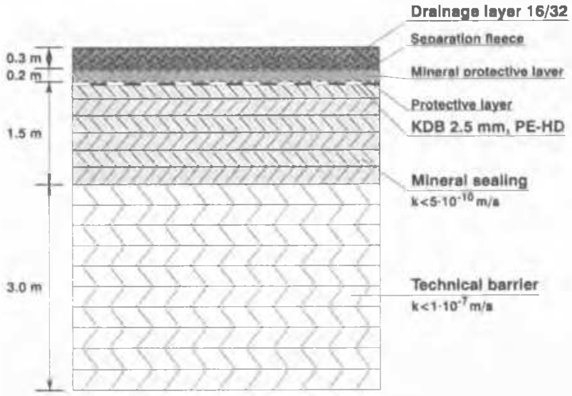

Figure 4. Section of the base sealing.

Another advantage of the barrier is the possibility of using the load from the 3 m thick layer to verify our own settlement prognosis prior to placing the mineral sealing layer for the bottom lining.

As the landfill construction on an open cast fill meant entering new technical ground and since despite all care taken residual uncertainties remain attached to the settlements, the observational method has been applied throughout. As early as during the design phase and for the event that fixed tolerance limits for the settlements were being exceeded, an extensive catalogue of measures had been established extending from a partial deep compaction of the subgrade to instructions and limitations for the operation of the landfill.

Even more important for the landfill design than the absolute settlements were the differential settlements. Here two influences - load-dependent and subgrade-dependent - were differentiated. I would like to explain this by means of the design of the gradient for shaping the base sealing system.

For the base sealing system the Technical Regulations on Waste specify a final longitudinal gradient of > 1 % and a cross gradient of > 3 %. From the geometry of the landfill body load-dependent differential settlements result. The gradient from this settlement portion had been obtained from the relevant settlement calculations. Differential settlements are also caused by the inhomogeneities of the subgrade as well. The gradient from subgrade-dependent differential settlements was obtained by evaluating the inclinometer measurements made during a large scale test fill. The longitudinal gradient and cross gradient which were finally laid down were those obtained from the total of these three portions.

In accordance with the Technical Regulations on Waste the design of the bottom profile allows the sewage to be evacuated in a continous gradient. The sewage tunnels are dispositioned below the base sealing (Fig. 5).

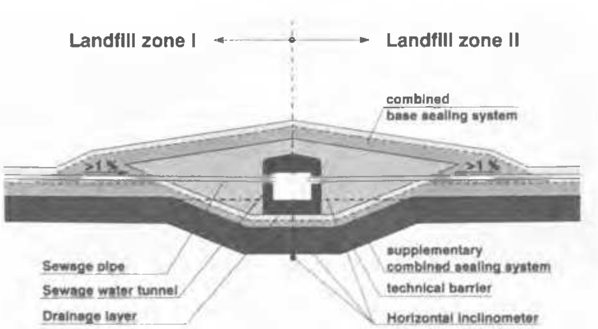

Figure 5. Dispositioning of the sewage water tunnel within the base sealing.

With block lengths of between 6 and 8 m they were laid out as a segment chain throughout. The individual tunnel blocks have no load transmitting connection. When considering the tunnel, it is very important not to view it isolated but in connection with the overall soil package built up around the tunnel and which, together with the latter, forms a structural entity. The backfill around the tunnel is of particular significance. This material had to be of low permeability, small compressibility and high shear strength.

In answer to these requirements, we have selected a mixed grain soil with oblong grain distribution. Another reason for the correct choice of this backfill soil being vital is the fact that the point where the sewage pipe enters the tunnel is the most critical point of the entire landfill.

The drainage above the lower sealing is a compromise to the demand of monitoring and controlling. The disadvantages of this drainage layer weigh more heavily than the advantages. We as the authors of the design would have preferred not to build this drainage layer.

3 SETTLEMENTS

Finally, I would like to add a few remarks on the settlement behaviour of the landfill. A very important element of the landfill design is the 3 m thick barrier. Owing to the padding effect of this layer the subgrade-dependent differential settlements are reduced quite considerably (Fig. 6). The radii of curvature of the settlement trough above and below the barrier as measured by means of inclinometers are shown in the figure. The significant increase in size of the radii of curvature of the settlement trough on account of the cushioning effect can be read off clearly.

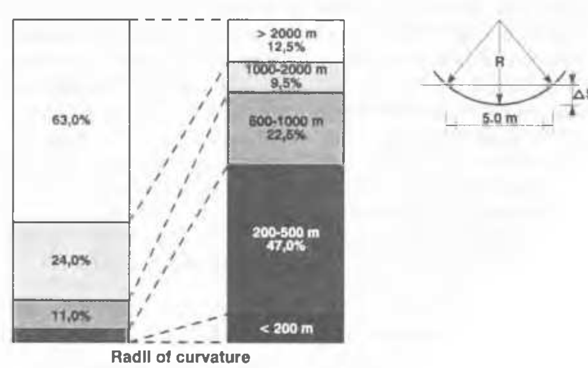

Figure 6. Effect of a compacted „padding fill" on the settlements of a base sealing, evaluation of measurements by horizontal inclinometers.

The overall situation of the landfill can best be described on the example of the settlement behaviour of the tunnel.

The figure shows the settlements in a cross section of the tunnel at different times i.e. with varying surcharge through earth fill (Fig. 7).

The settlements were measured at the beginning and at the end of each tunnel block i.e. the settlement curves shown consist of a dense sequence of measured values. Significant findings can be obtained from the figure. It is above all revealed that in the areas where a uniform surcharge is placed over the tunnel, the tunnel elements have settled uniformly. This confirms that the 70 m thick uncompacted backfill behaves in a homogeneous manner. The settlements are in fact more homogeneous than we had expected them to be.

As explained earlier, the tunnel is designed throughout as a segment chain. Yet, the settlement curves run entirely straight and with settlements of up to 70 cm no stagger has occurred between any two tunnel blocks.

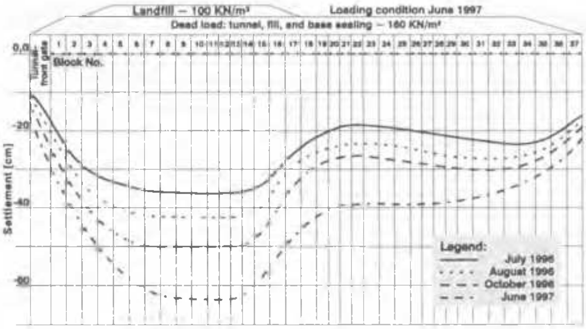

Figure 7. Settlement in the center line of the sewage water tunnel.

The sewage pipes inside the tunnel are of course adjustable. So far, though, no adjustment has been necessary. The reason therefor in my opinion is that the tunnel elements literally float inside the total soil package around the tunnel. It is therefore important for the tunnel not to be considered isolated. The tunnel and the surrounding soil have to be seen as a structural entity. The soil built in around the tunnel provides a structural element which allows us to control the deformation behaviour of the tunnel even in the form of a segment chain. Nor have so far any differential settlements occurred at the points where the sewage pipes enter the tunnel - the most critical point of the entire landfill.

At this point in time, preparations are underway to implement the second construction stage of the landfill. It is difficult for a new construction stage to be fitted to the existing stage. Settlements expected to occur in the connection area must be predicted with a high degree of precision. For this reason, the areas of the tunnel and of the edge dam are being pre-loaded (Fig. 8). Preloading in the tunnel area corresponds to the load from the entire soil package built up around the tunnel. In the edge dam area the pre-load corresponds to the surcharge from the 10 m high edge dam.

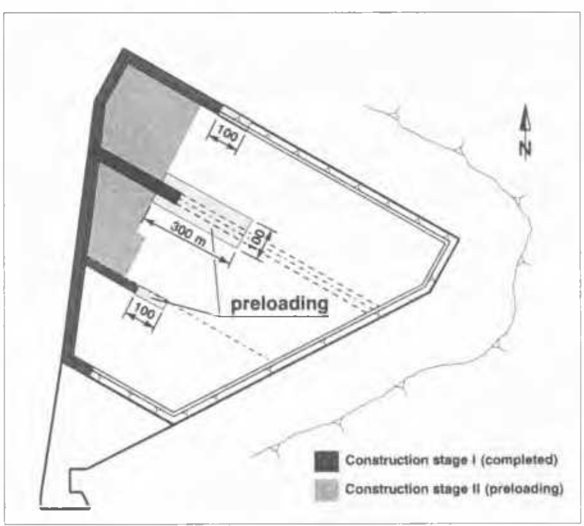

Figure 8. Construction phases I and II, preloading condition.

Proceeding in this manner has two dinstinct advantages: Preloading has the effect of anticipating a portion of the settlements. We can use them to verify and enhance our subgrade model for the calculation of the settlements in line with the observational method.

The experience gathered so far on the Cröbern landfill project proves that settlements occurring in landfill constructions on open cast dumps can be controlled (Fig. 9).

Figure 9. Construction stage I.

The picture shows how the ravaged dump site around the landfill has been transformed (Fig. 10).

Figure 10. Site area.

Apart from the access area to the landfill and the sewage treatment plants, separate facilities for building rubble treatment and other recycling facilities have been erected. More than 200 permanent jobs have been created at the landfill location.

I would like to take this opportunity to thank Dr. Jolas and his team. Dr. Jolas is responsible for the geotechnics and settlement forecasts and he has done an excellent job. My thanks also go to the client, Gesellschaft Zentraldeponie Cröbern, for their trust and good cooperation. Without teamwork based on trust and confidence it would not have been possible to carry through the project.