Repair and early management measures for the disposal of residual matter - Case study

La réparation et les premières mesures de gestion pour la disposition des rejets - Une étude de cas

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SYNOPSIS: In the course of the development of a project for maintenance and extension of a municipal waste disposal site solutions had to be found to present it from being a permanent source of contamination of the groundwater. It was recognized that the potential environmental hazard of a waste disposal facility depends to a large degree on the given geological and hydrogeological environment. Consequently, as shown in this cas study, a layout and protection system was chosen for long term effectiveness and with special regard to the subsoil conditions of the site.

1 INTRODUCTION

About 7 km north of the city of Salzburg, adjacent to the river Salzach, the Salzburger Muellbeseitigung Ges.m.b.H. operates a composting and a waste-disposal plant. The sewage treatment plant of the city is also located within the area, Fig.1.

The area is a flat plane within the flood zone of the river. Originally the site was used for gravel excavation, but the gravel pits were later filled in with structural debris but no waste.

After re-cultivation (1976) the area has been used as a domestic waste disposal dump and was later approved for the disposal of residual matter of a composting plant. These were mainly non-decomposing residuals screened from the compost but also contained debris and other waste which could not be processed in the plant. Raw compost which, even after final decomposition, could not be sold was also deposited. By 1986 the volume of the fill had reached 700.000 m3 with a predicted yearly increase of 130.000 m3.

In the early days the residuals were deposited without regard to environmental protection especially of the groundwater. From yearly water analyses, it was established that organic and inorganic pollution was increasing gradually both in amount and extent.

A first attempt was made to stop groundwater pollution by installing a thin slurry cut-off wall enclosing the fill area. Water-level measurements carried out in observation wells, installed inside and outside the wall, indicated leakage of this wall. Visual observation of the wall in excavation pits showed that major parts of the wall were defective and that repair was not possible.

The need for containment of the pollution and the urgent need to extend the permitted disposal capacity required a comprehensive waste management scheme.

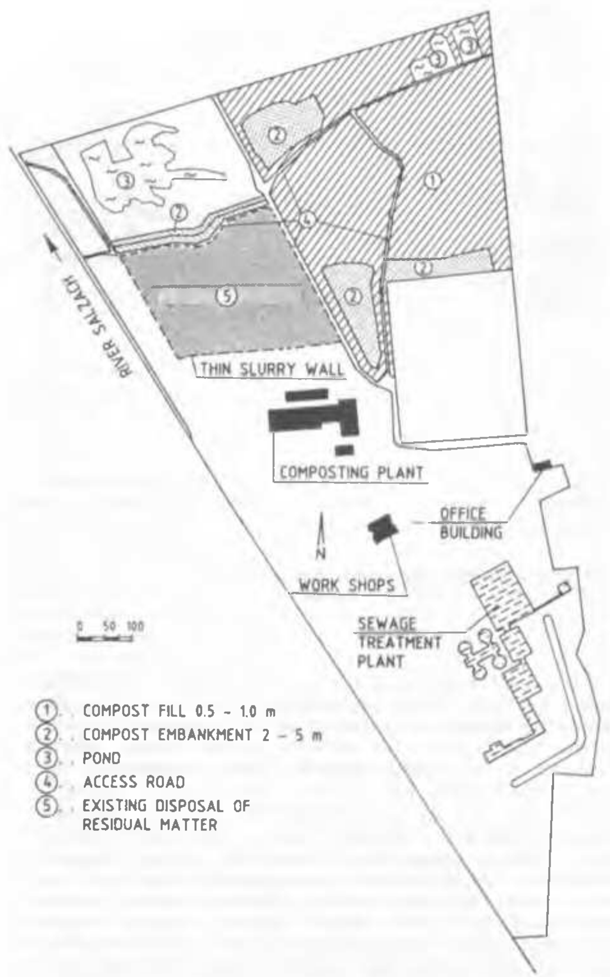

Figure 1. Plan of existing buildings and plants

The design principles for this project were as follows:

a) protection of the groundwater in the long term.

b) flood proof design of the whole disposal area.

c) collection and management of leachate and polluted subsurface water.

d) avoidance of uncontrolled release of gas.

e) immediate and continuing measures for re-cultivation of the final fill surface, including the slopes, landscaping.

f) long term control and supervision programme.

g) adequate management and shaping of the temporary and final surface in order to optimize the available capacity.

2 SUBSOIL CONDITIONS

Subsoil conditions were investigated by means of an extensive drilling and testing programme. Soil conditions were typical for the location of the area in the Salzburg basin, which was created in the late and post glacial period by lacrustine and fluvial deposits, Fig.2.

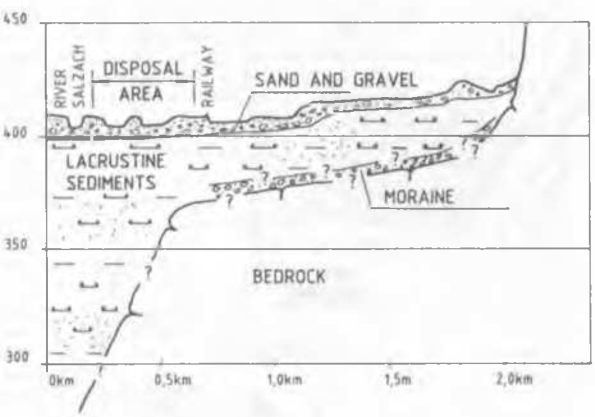

Figure 2. Geology, section E-W

Below a top layer of sand and silt (meadow sands) of 1 m thickness fluvial gravel layers with an average thickness of 5 m were encountered. According to grain size they were classified as sandy gravel. The permeability was in the range of 1.E-2 to 1.E-3 m/sec. Underlying the gravel layer were the lacrustine sediments, which were uniform sandy silts. The minimum thickness of this layer was about 30 to 40 m. Low plasticity and a water content close to the liquid state were characteristic for this layer. Grain size decreased with depth from 'fine sand coarse silt' to 'fine medium silt'. Clay content was between 0 and 10 percent. From confined consolidation tests overconsolidation ratio was found to be about one, but there were incidents of underconsolidation of the deep layers. In accordance with the grain size, permeability decreased with depth, from about 1.E-6 to 1.E-7 m/sec, close to the surface of the silt, to about 1.E-8 to 1.E-9 at larger depths. Occasionally 1 to 2 m thick layers of higher permeability (about 1.E-7 m/sec) were found at larger depths, but in general permeability decreased continuously.

Underlying the sediments was the bed rock (Flysh). The depth of the bed rock was about 40 m at the eastern end of the disposal area and dropping from E to W (in direction to the river) to about 120 m. The base rock is most likely overlayn by thin morain layers. Neither the bedrock nor the morain layers were reached by the deeper boreholes, with depths of 30 m to 50 m. The lacrustine sediments were classified as thick and rather homogeneous layer of low permeability.

(1) Ground water

The top gravel layer acts as the aquifer and the silty sediments as the aquiclude of a wide but not very thick groundwater stream. Because of gravel excavation, groundwater conditions were monitored for a period of about 10 years in a large area. For the last three years the monitoring was intensified with the result that flow conditions for low an high ground water and river water tables were well established.

The groundwater stream following the river is being charged from the hills east of the river. The direction of flow is northwest towards the river. Based on groundwater observation and model studies no reverse flow (away from the river) even at high river water levels will occur.

Seasonal change of the ground water level was between about 400 m and 403 m above sea level. The ground surface is between 403 and 404 m. During extremely dry periods the ground water table was below high points of the underlying aquiclude.

The mean river water level was at 400.8 m. The water level of a flood with a 100 years return period was calculated to be at 408.7 m or about 4 to 5 m above the ground. In that case the river banks which are above average ground level would be overtopped by about 2 m.

3 PROJECT

The overall design of the project was based on a 20 years operation period. The operation period might increase to 30 years if other additional measures could be established in the future.

The first construction phase, Fig. 3, was based on a five year operation time.

The design covered the following construction parts:

a) enlargment of the fill area and increase of the fill height.

b) separate disposal area for REA (sulfur adsorbents) and homogenous matter.

c) emergency slurry ponds.

d) water cut-off walls enclosing the whole area.

e) flood embankment to provide a flood protection for a 100 years return-period.

f) horizontal waterstop at the subgrade of the extension area consisting of a double liner system (soil-layer and impermeable HDPE sheet).

g) leachate collection by means of drainage pipes placed in a gravel layer above the horizontal water stop. Drainage of the leachate to a buffer basin from where it is discharged to the treatment plant.

h) construction of two separate dewatering systems for the existing disposal area and the extension zone. Discharge of the polluted groundwater into the leachate basin and of clean groundwater, via a control basin, into the river.

i) control of gas release from the refuse dump by construction of a gas collection system. Collection and combustion of the gas. The possibility of using the gas had to be studied.

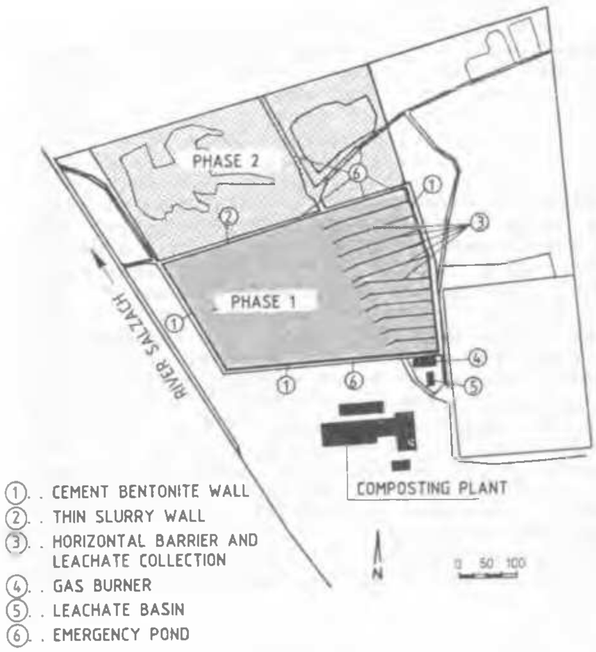

Figure 3. Site layout

3.1 Major components of the design layout

A cross section through the toe of the slope of the fill shows the main components of the protective measures, Fig. 4.

(1) Vertical cut-off wall

For the vertical cut off walls three different tasks were defined:

a) Repair of the existing disposal dump

'Construction of a watertight cut off wall, enclosing the existing fill, confines the polluted subsurface water. Retarded seepage of leachate through and underneath the wall can be prevented by a permanently operated dewatering system.'

b) Protection against heave water pressure

'After installation of horizontal water-stop layers for the extension area it is necessary to prevent any uplift water pressure.' In the case of a possible high flood level and high permeability of the gravel layer, this was provided by the cut-off wall and dewatering. Lifting of the base level above the design flood level would have otherwise been necessary, resulting in a substantial loss of fill capacity.

c) Minimizing the environmental hazard of the site location

'Design guidelines of the authority do not permit the location of waste disposals above groundwater areas. By installation of a watertight 'pot', seepage (in or out) is prevented and a deviated flow of ground water is created'. For this reason both the existing and extension area had to be enclosed by a water tight cut-off wall.

As cut-off wall a 60 cm thick non rigid cement-bentonite wall was constructed by using the one-phase method. Penetration depth was based on the actual soil conditions with a minimum of 5 m penetration into the aquiclude.

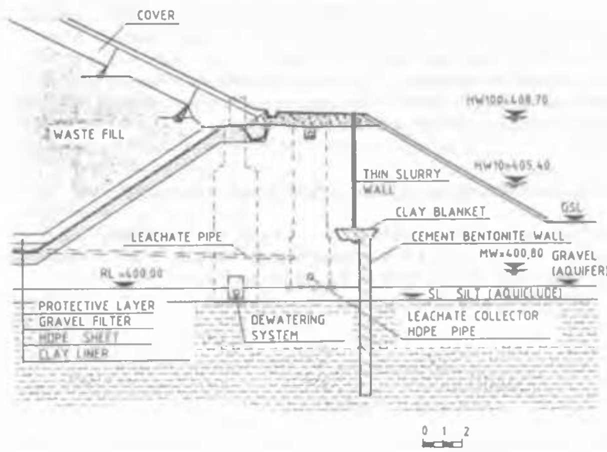

Figure 4. Cross section through toe of the fill

(2) Flood protection

Because of the design flood level the whole disposal area was enclosed by a flood embankment of sufficiently high crown level (above design flood level). The seepage requirements above ground surface were different to the requirements below surface. For this reason seepage was prevented by installation of a thin cut-off wall connected by means of a short clay blanket to the underground cut-off wall. The wall was constructed by driving an H-shaped steel pile into the ground and filling the space during extraction of the pile with a cement-bentonite mixture.

(3) Horizontal water stop

For the extension areas a double liner system was provided by means of a clayey layer of 60 cm minimum thickness placed below a HDPE sheet. Aside from the permeability requirements, the horizontal water-stop layers have to withstand relatively large deformations due to surface settlement. For this reason a mixture of natural clayey soil and bentonite, providing high plasticity, was used for the soil liner. The liner system was extended along the inner slope of the embankment up to crown level.

(4) Dewatering system

For a fully proof and long lasting protection of the surrounding groundwater, the installed water-stop components were complemented by a dewatering system. An essential design criterium was the achievement of a permanent hydraulic gradient towards the higher polluted ground water. Additional considerations were given to the following items:

a) different quality of subsurface water below existing and new disposal area.

b) relatively small thickness of the aquifer.

c) seasonal variation and temporary low level of the outside ground water table.

d) variable permeability of the aquifer over short distances.

e) avoidance of uplift water pressure to the liner system.

The dewatering system consisted of drainage pipes enclosing the existing and the extension area seperately. The operation of the system required a hydraulic head between the surrounding groundwater table and the subsurface water table of the extension area and also between the extension area and the existing disposal area.

3.2 Slope stability and deformation control

A cross section of the fill is shown in Fig.5. The soil parameters used for the calculation are given in Table 1.

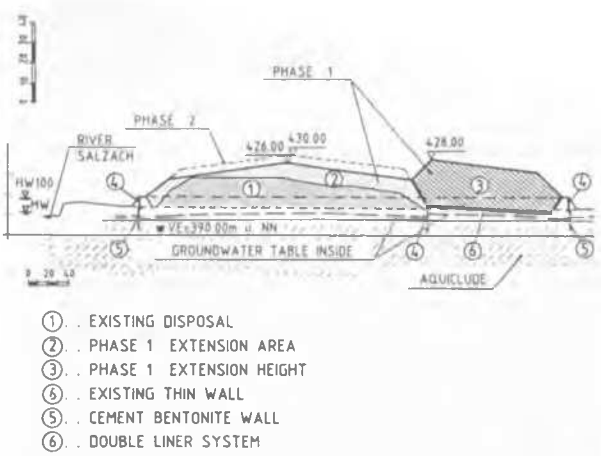

Figure 5. Section E-W

The existing and future fill areas were seperated only by a horizontal liner system below the extension area. The maximum height at the shoulder of the fill was about 20 m while the overall maximum fill heigth was about 26 m above ground surface. The average slope angle was 1:2.5 (vertical:horizontal) with a maximum slope angle of 1:2.

According to the subsoil conditions, stability investigations included failure along the base and failure through the silt layer below the gravel.

Table 1

	t	ø	c'	E
LAYER	kN/m3	deg	kN/m2	MN/m2
FILL	12	25	5 10 15	0.75-2.5
GRAVEL	22	35	0	7.5
SILT	20	27	0	7.5-30

The water-level inside the fill was assumed to be 11 m above the ground water level. If cohesion was assumed to be 5 kN/m2, the lowest factor of safety (FSmin) is 1.3 , for a failure plane within the slope, while for the failure along the base FS = 1.6. Failure planes reaching the gravel or the silt layer resulted in much higher factors of safety. According to the actual conditions, cohesion could be assumed to be greater than 15 kN/m2. This was proved by existing slopes of 1:1 and by 10 m high vertical slopes which remained stable over several months. An unstable situation would definitely result from a too high water table within the fill. Control of the filling plan and observation of the water table inside the fill is therefore important.

Horizontal and vertical deformation of the fill and the ground were modelled using a FE model. Upper and lower values for the Modulus of Elasticity showed the possible range of deformation. Based on these assumptions and neglecting preconsolidation by the existing fill, the maximum settlement of the base of the fill was 70-130 cm and at the toe of the slope 10 to 20 cm. For the surface of the fill, settlements of about 400 cm were calculated if intermediate refill of depression zones was neglected.

Horizontal deformation was computed to be 10 to 20 cm at the surface and 20 to 30 cm at 15 m depth.

4 CONCLUSION

For the design of repair measures and extension of a waste disposal already under operation, a variety of boundary conditions must be considered. In the case study described, the dominant factors for the selection of water stop and dewatering systems were both, observance of standard requirements and the existing location and layout. During the five year operation period of the first extension phase the effectiveness of the measures will be checked by a comprehensive observation programme. With the design as described an adequate protection of the environment particularly the ground water is expected.