A Reinforced Sealing System to Remediate Contaminated Sites

D. Genske
Delft University of Technology, The Netherlands

B. Thamm
Bundesanstalt für Strassenwesen, BAST, Germany

ABSTRACT: This paper introduces a technique to seal and reinforce the ground on contaminated sites by using geosynthetics. A sealing system is presented which consists of geosynthetics (geogrids, geotextiles and geomembranes) and soil. The system is applied to remediate a contaminated site: an abandoned coal mine facility in the German coal mining district, the "Ruhrgebiet". The performance and cost effectiveness of this remediation method is discussed.

1 INTRODUCTION

Contaminated sites, industrial wasteland, and land recycling are key issues for industrial nations and will become quite interesting to developing countries soon. This is not only because of the environmental problems caused by the contamination, but also because of the shortage of land available for the development of new industrial complexes or residential areas.

A good example for the importance of land recycling is the German "Ruhrgebiet", a major industrial belt with an area of about 5000 km^2 and a population of 5 million. The development of this industrial region started in the middle of the last century with the commercial exploitation of the vast coal resources. The mining activities also initiated a great variety of secondary industries, such as coal refinement plants, steel industries, chemical plants. Today, due to the decline of the mining industry in Germany, a large number of factories are abandoned and have turned into industrial wasteland. Because of the economical risks connected with the remediation work prospective investors are discouraged from purchasing these sites. If there was an economical and effective method to remediate derelict sites, large areas could be recycled and reused.

Land recycling is quite a challenge to geotechnical engineers, as well as to environmental and financial experts. In this paper it will be shown how geosynthetics can be integrated in a cost effective remediation technique.

2 THE REMEDIATION TECHNIQUE CHOSEN

When remediating a derelict industrial site one common approach is to remove the contaminated soil and replace it with clean material. In Germany, however, dumping of contaminated soil is too expensive since prices are up to US $ 500 for one cubic meter of contaminated material. Consequently, in most land recycling projects the excavation and dumping of contaminated material would exceed the available budget, even if additional governmental funding can be obtained. Furthermore, the German government has issued a number of recommendations and amendments to instigate the research on alternative remediation techniques.

To comply with these efforts the "Deutsche Montan Technologie" (DMT) introduced a remediation technique, which combines the sealing of a contaminate location with hydraulic measures such as recovering wells to flush the contaminated ground. The key question of this approach was how to seal the contaminated ground in a way compatible to both economical and ecological restrains. A special reinforced sealing system was introduced which takes advantage of the sealing and reinforcing capabilities of geosynthetics. This system was designed (fig. 1) to meet three tasks:

- waterproofness to prevent the precipitation to penetrate into the contaminated ground,
- gasproofness to stop the migration of toxic gas to the surface,
- stiffness to allow streets and structures to be built on.

The third aspect accounts for the fairly inhomogeneous ground conditions. Typically, massive fragments of the foundations of the dismantled buildings have remained in the subground next to loose fillings, thus causing severe structural problems as to the possible differential settlement of future structures. As depicted in fig. 1 the reinforced sealing system introduced is composed of three elements arranged in a "sandwich" manner: a lower supporting layer using geogrids as reinforcing elements, a drainage and sealing layer including a geomembrane, and an upper reinforced layer with geogrids to account for the permanent and/or non-permanent loads.

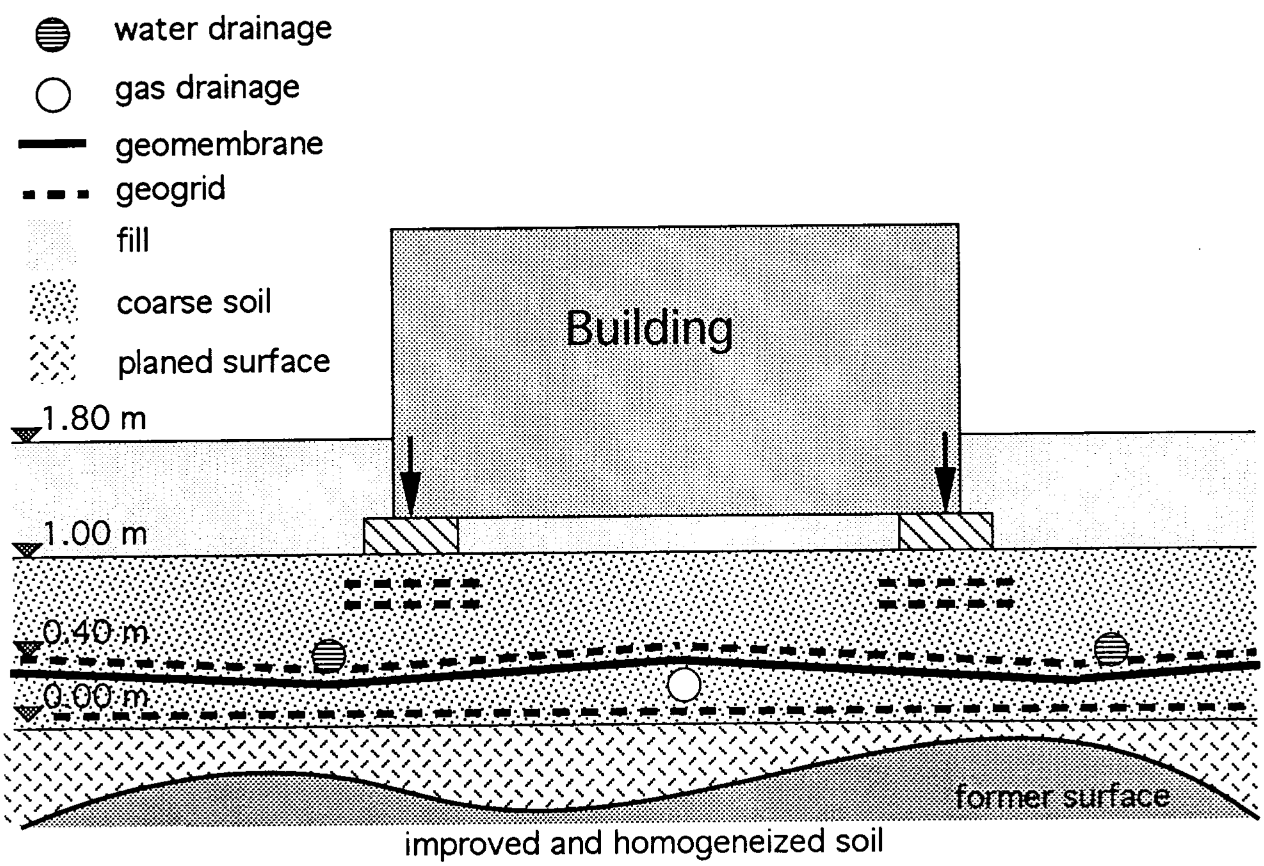

Fig. 1: A geosynthetic 'sandwich' system to seal and reinforce contaminated soil consisting of geogrids, geotextiles, a geomembrane, and soil.

3 CASE HISTORY AND TEST FIELD

A city of the "Ruhrgebiet", Gladbeck, decided to have one of their derelict contaminated sites remediated with this new technique. In fact, Gladbeck was the first German community to take advantage of this land recycling approach. The site under consideration was the former "Graf Moltke" coal mine, which was established in 1873 and closed down after the world wide fall of the coal prices in 1971. It covers an area of about 350.000 m². The European Community funded this project as part of the forthcoming international city planning fair (IBA) with a budget of some 13 million US $. A risk assessment carried out in 1992 indicated that because of a former coking plant, benzol- and ammonia factories, about 40% of the site have to be considered as highly contaminated (fig. 2).

As already mentioned, the application of a reinforced sealing system to a former coal mine was new in German land recycling strategies. To comply with the restrictive German building codes and because the technique chosen is a rather innovative one it became necessary to install a test field on the site. The test field location was chosen at an area were the subsoil conditions were representative for the whole site. Figure 3 illustrates the placing of the geogrids and the geomembranes on the site. A large scale load test was executed (fig. 4) to study the structure-soil interaction, especially the deformation of the "sandwich" layers and the stresses induced into the geomembrane. The results of this field test are presented in detail in a report prepared by DMT (Genske et al. 1992) and discussed elsewhere (Genske et al 1993). The most significant results are:

- for maximum loading (as expected from future buildings) the largest strains within the geogrid just above the geomembrane were registered with about 1,5% (fig. 5),
- however, the maximal strains for the geomembrane at the same load were as low as 0,05% (see also fig. 5),
- the maximum settlements were with 0,4 cm almost four times lower than they would be without a reinforcement.

4 SPECIFICATIONS

After the field test results had been fully evaluated and discussed specifications were set up for this new technology and approved by authorities of the German "Bundesland" North Rhine Westfalia that are responsible for the remediation project. It was estimated that about US $ 60 of remediation costs had to be raised for every square meter. Although this square meter price appears to be rather high it is still considered to be reasonable if compared with the exceptionally high land prices in the densely populated German "Ruhrgebiet", and if compared with the costs for dumping of the contaminated soil excavated on the site. It is furthermore expected that with a broader application of this technique the square meter price will decrease considerably.

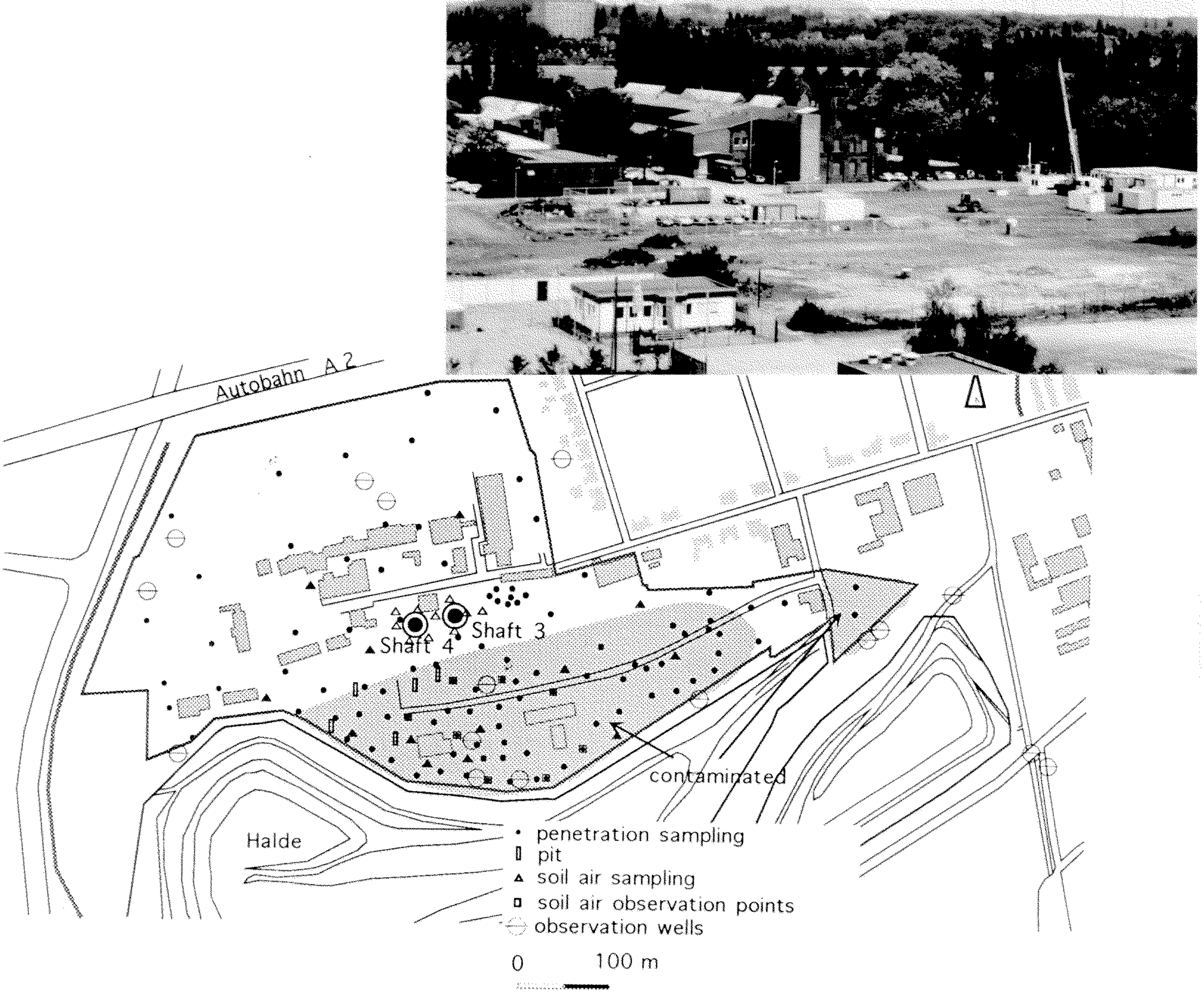

Fig. 2: Sampling points and contaminated sectors on the "Graf Moltke" site. The contaminated sectors were covered with the geosynthetic "sandwich" system. The photo gives the situation on the site in 1993.

5 CONCLUSION

The application of geosynthetics to the remediation of contaminated sites seems to be a promising perspective. The idea to combine reinforcing geogrids with sealing geomembranes may be a fair strategy if assisted with hydraulic measures such as remediation wells. Another positive aspect is that recycling material may be used instead of soil for the reinforced "sandwich". After the remediation of the Gladbeck site it will be rather interesting to monitor the performance of comparable geosynthetic "sandwich" systems in the next couple of years. If this remediation technique proofs valid also for other cases it would offer an opportunity to avoid large amounts of contaminated excavation from the standard excavate-and-dump procedure, and, perhaps even more important, it would halt the excessive land consumption of growing industries since they could reestablish their business on the land already used.

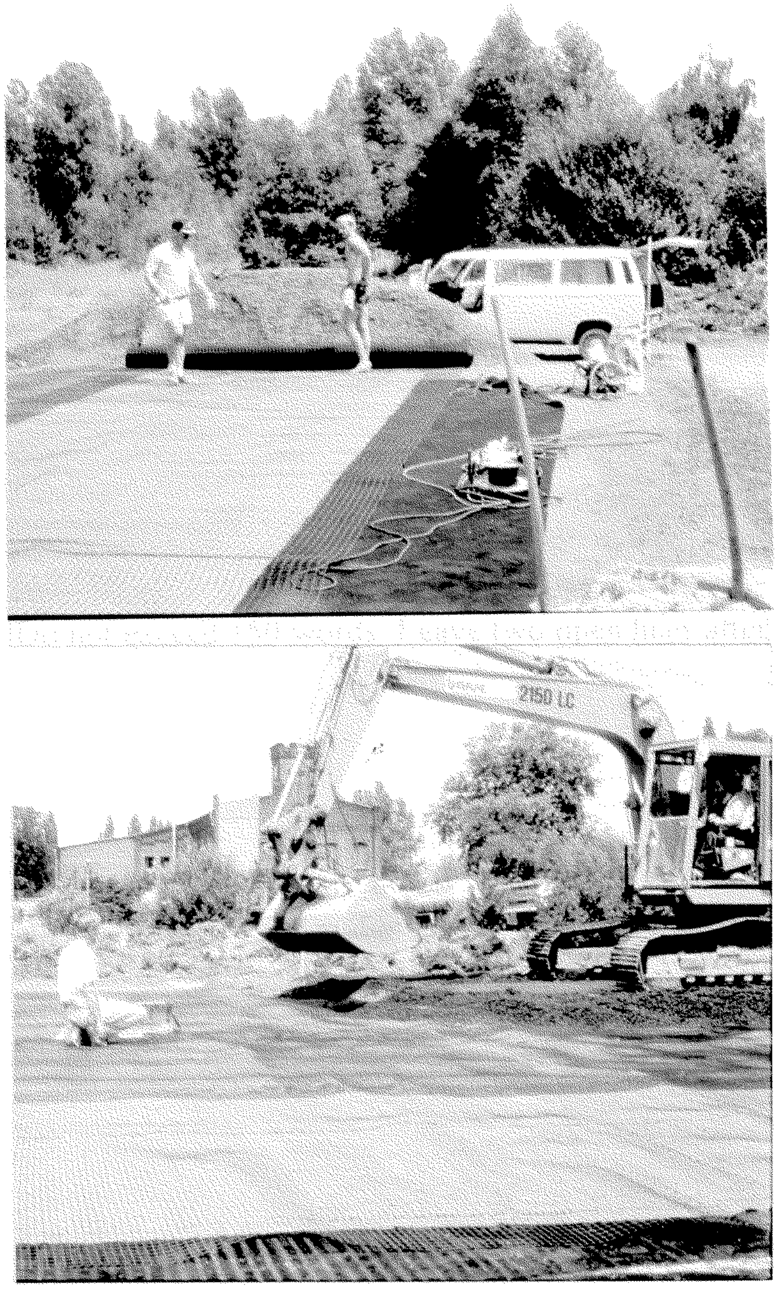

Fig. 3: Placing of geogrids and geomembranes.

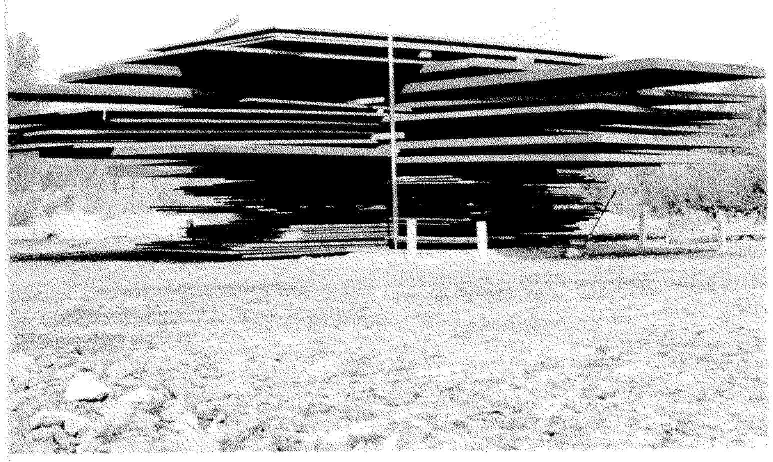

Fig. 4: Large scale on site loading test.

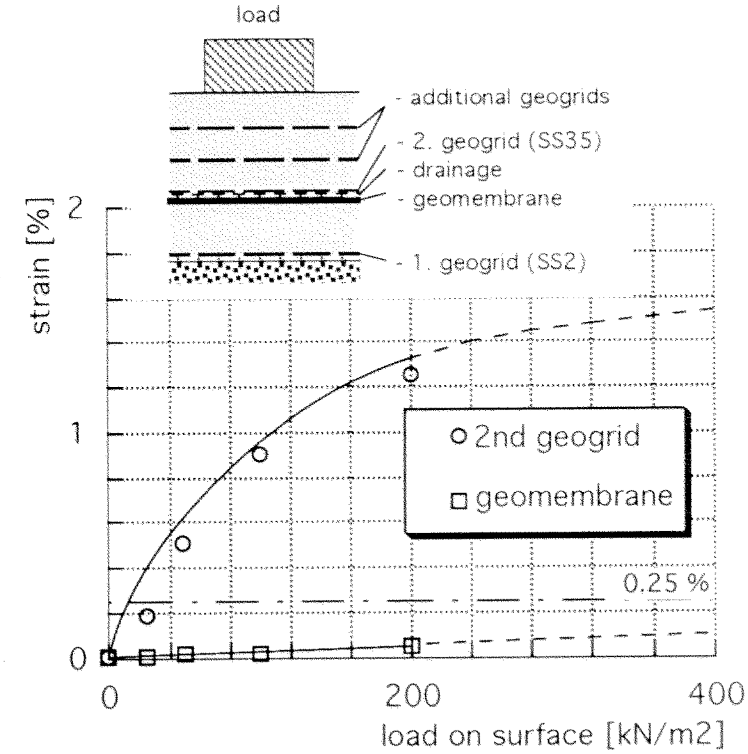

Fig. 5: Comparison of stress-strain behavior of geogrid and geomembrane.

REFERENCES

Genske, D.D., M. Lepique & A.Heim-Redecker (1992) Testfeld zur Dimensionierung bewehrter Gründungspolster auf Industriebrachen, *Bericht der Deutschen Montan Technologie Gesellschaft für Forschung und Prüfung mbH*, Essen, unpublished.

Genske, D.D., H. Klapperich, P. Noll & B. Thamm (1993) Surface Confinement Techniques of Derelict Industrial Sites, *Geoconfine'93 International Symposium on the Geology and Confinement of Toxic Wastes*, Montpellier, France, 319-323.