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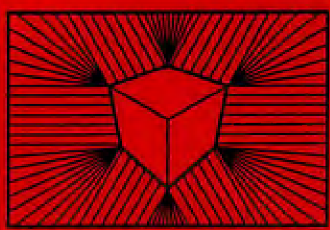

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Correspondentie adres:

Redactie Nieuwsbrief IngeoKring
sectie Ingenieursgeologie
faculteit der Mijnbouwkunde en Petroleumwinning
postbus 5028
2600 GA Delft
tel: 015-784751
fax: 015-784891

USING GEOTECHNOGENIC MASSIF AS FOUNDATION OF ENGINEERING CONSTRUCTIONS ON LOESS

Buu-Long Nguyen

Section of Engineering Geology
Faculty of Mining and Petroleum Engineering
Delft University of Technology

Abstract. The paper presents a new loess improvement method developed by Russian researchers. The so-called geotechnogenic massif would provide adequate bearing capacity and stability to collapsible loess and can serve as base for even heavy engineering constructions. Collapsibility of loess is intimately connected with its structural characteristics. Based on analyses of microstructure of natural objects, the cellular structure was chosen as a model for the development of a geotechnogenic massif in loess. In accordance with the developed physical model technological solutions were found for loess masses in Rostov province and Volgodonsk (Russia). The concept of equivalent homogeneity should be used to estimate effective properties of geotechnogenic massif and simulation techniques carried over from mechanics of composite materials would be to good purpose.

Key words: Geotechnogenic massif, loess collapsibility, loess improvement, cellular structure, effective properties, composite material

Introduction

Loess and loess-like soils are widespread in the former Soviet Union, China, the United State, Bulgaria, Rumania, Poland, Germany, Brazil, Australia and a number of other countries in all parts of the globe. They have varied origin but what unites them is their collapsibility at saturation caused by overburden or by the additional load of the installations [2]. In building codes and textbooks on engineering geology and soil mechanics, loess is usually discussed in the same group with mud, peat, expansive clay and artificial non-consolidated soils under the common heading of structurally unstable soils.

The unfavourable properties of loess cause great difficulties for civil engineers and the development of loess improvement methods is therefore of significant importance. This is especially relevant for the former Soviet Union where considerable civil, power industry and military constructions had been accomplished in region of widespread collapsible loess of large thickness [5]. That is why loess research related to construction has developed most extensively in that country. By the end of the last decade a new loess improvement method employing the concept of geotechnogenic massif had been developed in Russia which provides the same or even higher bearing capacity and stability to the loess massif by less expenditure of labour and materials as existing improvement methods.

Geotechnogenic massif might be created under new constructions, by reconstruction of existing buildings or to stabilize engineering structures tending to collapse.

The purpose of the present paper is to introduce to the readers the concept of geotechnogenic massif as well as its application for loess masses.

Geotechnogenic massif

By the term "geotechnogenic massif" we mean a rational complex of technogenic elements (compacted and consolidated zones or layers, concrete or ground-cement blocs, plates, etc.) created within the soil mass which form together with natural elements a single three-dimensional structure possessing high bearing capacity.

Three main principles must be realized by creating geotechnogenic massifs: (a) maximally using the bearing capacity of the natural soil mass by its minimum modification; (b) the load imposed by the engineering construction should be uniformly distributed to the whole massif so that formation of zones of high stress concentration is avoided; (c) the geotechnogenic structure created within the natural soil mass should uniformly carry the load.

In the design of a geotechnogenic massif (figure 7), its upper horizontal bearing element would uniformly distribute the load imposed by the engineering construction to the underlying massif. Detailed design of the horizontal bearing element will be discussed later in this paper.

Under the horizontal bearing element the middle layer of soil is improved with technogenic elements. We distinguish three structures types of the middle layer: *(1) matrix structure, (2) pseudo-completed structure* and *(3) completed structure* (figure 1).

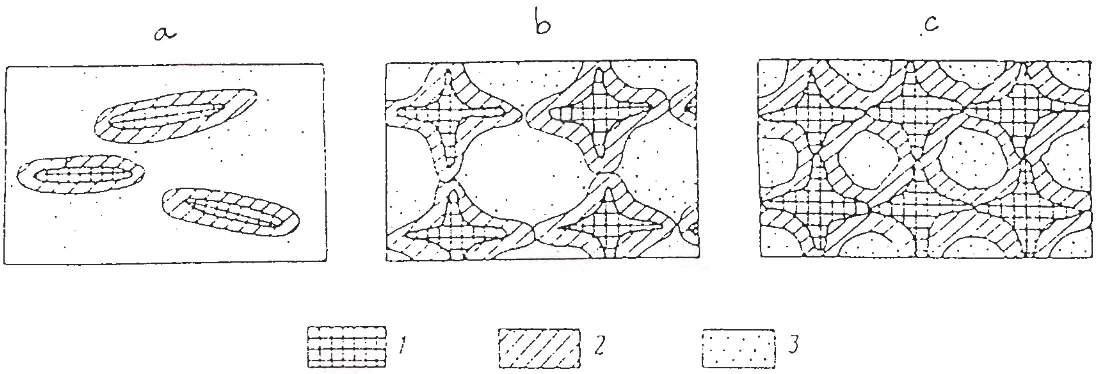


Figure 1. Structure types of the middle layer of geotechnogenic massif: a. matrix structure, b. pseudo-completed structure, c. completed struc-ture; 1. technogenic element (inclusion), 2. impact zone of technogenic element, 3. undisturbed soil.

The first type is the simplest and requires the less expenditure on creating it. Such a structure is formed with separated inclusions within the soil mass (figure 1,a). The form of the inclusions is of importance: the greatest effect will be achieved when inclusions have a tabular form [1].

Around the geotechnogenic elements (inclusions) impact zones occur within which the natural soil is compacted and strengthened due to penetration of binding materials, temperature influence as well as compaction effects. By increasing the inclusion content and decreasing the distance between them, their impact zones reach each other and the so-called *pseudo-completed structure* is formed (figure 1,b).

Further increase in inclusion content leads to formation of a three-dimensional *completed structure* within the soil mass where technogenic elements immediately are in contact with each other figure 1,c).

Structural characteristics of loess

The main structural features of loess soils are

1. On grain size distribution loess is a typical silty deposit which contains at an average 20 - 30 % quartz grains, no less than 50% silt and no more than 15 - 20% clay particles.
2. Clay particles and carbonate, which usually exist in loess, are concentrated on the surface of quartz grains and form a siliceous-carbonate-clayey jacket complex in structure and composition.
3. Silt particles and a part of the clay form together clayey-silty globular aggregate having a size comparable with that of a quartz grain.
4. Structural cohesion of collapsible loess arises mainly due to point contact of clayey-silty aggregates with quartz grains and their siliceous-carbonate-clayey jacket. It is of importance to note that in loess there is practically no frictional apparent cohesion bonding like "quartz grain - quartz grain" as it can be observed by pure sand, and all structure bonds are of electrostatic or chemical nature. Moreover, the principal role in bonding formation appertains to the clay matter.
5. Loess skeleton consists of structure elements (grains and aggregates) of almost the same size (0.01 - 0.1mm) as shown in figure 2. Such a structure can not form any system with high degree of interspace filling. That is why loess soils commonly display a high porosity (45 - 50%) and high heterogeneity in pore size.

Figure 2. Skeleton microstructure of loess soils

As a result of structural features, collapsibility of loess on saturation under load is associated with two principal phenomena:

- Its completed structure changes into uncompleted when clayey-silty aggregates are decayed: A model of completed structure of loess at low saturation is shown in figure 3,a. all grains and aggregates are in contact with each other and form a unified skeleton structure, which should carry all additional load and could be deformed as solid. By saturation part of non-water-resistant aggregates break down. This leads to defects in the structure and the latter becomes uncompleted (figure 3,b). The strength of loess dramatically decreases and very large deformation can occur under overburden or additional load of construction. By compaction after collapse quartz grains and unbroken aggregates form a completed structure again and the compressibility of the system decreases.

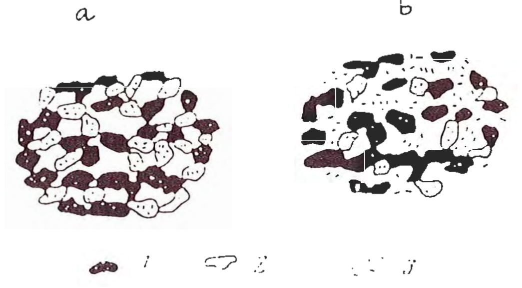


Figure 3

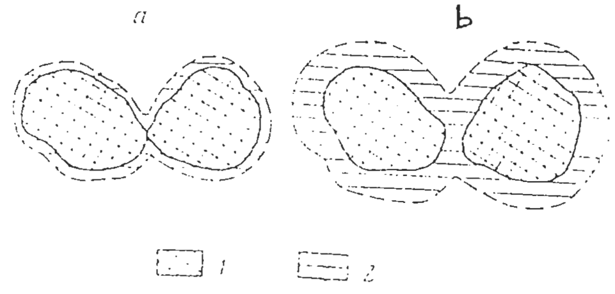


Figure 4

Figure 3. Model of completed structure of loess before saturation (a), and uncompleted structure after saturation (b): 1. quartz grains, 2. Clayey-silty aggregates, 3. clay and silt particles in dispersed state.

Figure 4. Contact transformation in loess by saturation: a. point contact in loess with low water content, b. coagulation contact in saturated loess. 1. particles, 2. bound water film.

- Another important phenomenon is abrupt decrease in bonding energy between structure elements when point contacts are transformed into coagulation ones. Point contacts are characterized by immediate touch between two elements on a bonding point (figure 4,a). The bonding is caused by chemical or electrostatic forces [6]. In the first case point contact occurs when loess particles are cemented with carbonates, iron oxides and sulphates (if there is gypsum in the environment). The electrostatic bonding between clay particles is widespread in most of loess soils when the water content is low. In both cases the value of attraction force between particles is about 10^{-7}N. Point contacts are unstable. By saturation, the cement dissolves and interparticle bonds are ruptured. By electrostatic bonding, saturation leads to large increasing of repulsion forces between adjacent clay particles. In both cases, point contacts become hydrated, the distance between particles increases, that leads to formation of coagulation contact (figure 4,b). There is a thin film of bound water with a thickness of from several nm to dozens nm between particles. Attraction force between particles, as a rule, does not exceed 10^{-8}N, i.e. by an order of magnitude less than that on point contact [6]. That is why by formation of coagulation contacts on saturation the strength of loess suddenly decreases that in turn causes its large deformation (collapse).

Development of a physical model for geotechnogenic massif in loess

The purpose of loess improvement methods is to increases its bearing capacity. That might be achieved by:

a. creating in the loess mass technogenic (artificial) element
b. stabilization of the existing structure in loess
c. uniformly distribution of imposed load in the whole volume of the loess mass.

Geotechnogenic massif is a combination of all the above mentioned measures based on the preliminarily developed physical model. Such a model should provide a optimum geometrical composition of technogenic elements (compacted and strengthened loess, ground-cement bloc, etc.) which form together with natural elements a solid structure which is stiff enough, taking into account vertical changeableness in loess collapsibility.

Extensive analyses of microstructure of biological and geological objects show that most of them like a cereal stem, a bone and other, which are characterized by low density and relative high mechanical strength, have a cellular microstructure (figure 5). Amongst geological objects similar structure is encountered at young clay deposits which are not subjected to lithogenetic consolidation yet. (figure 6,a). These examples indicate that cellular structure is a universal structural composition possessing high bearing capacity by minimal use of structure element.

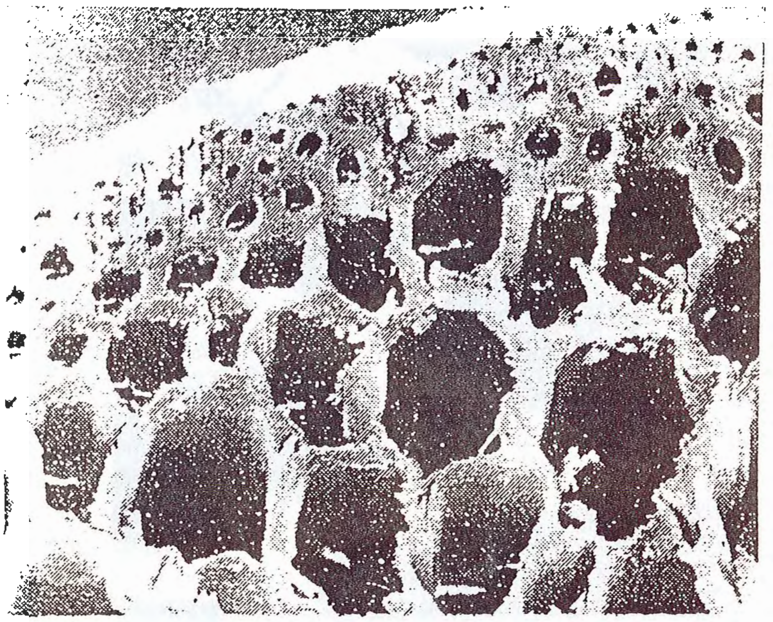


Figure 5. Cellular microstructure of a cereal stem

That statement can be proved by a simple experiment on structure formation in clay suspension. It is known that suspension of low concentration of clay minerals in weakly alkaline environment tends to maintain its stability for long time. The reasons are the low particle concentration and a fairly developed diffusion layer of ions. Subsequently acidifying environment and increasing salt concentration lead to fast aggregation with formation of bulk structure by minimum particle concentration from several fractions of a percent for montmorillonite to 3 - 10 % for kaolinite. The microstructure formed in this process also has a cellular pattern [6]. Figure 6,b shows a cellular structure formed from 1 % montmorilonite suspension with 0.5 N NaCl solution. Amongst a lot of natural cellular structures, the microstructure of cereal stem has been chosen as physical model for geotechnogenic massif because of its originality.

The outer fabric of the cereal stem is dense and is able to carry large stresses. Its internal parts are less dense and the cell size gradually increases with increasing distance from the outer fabric and with decreasing stress (figure 5). As can be seen later in figures 8 and 9, in a geotechnogenic massif the upper horizontal bearing element and the middle layer would model the outer fabric and the internal part of cereal stem, respectively.

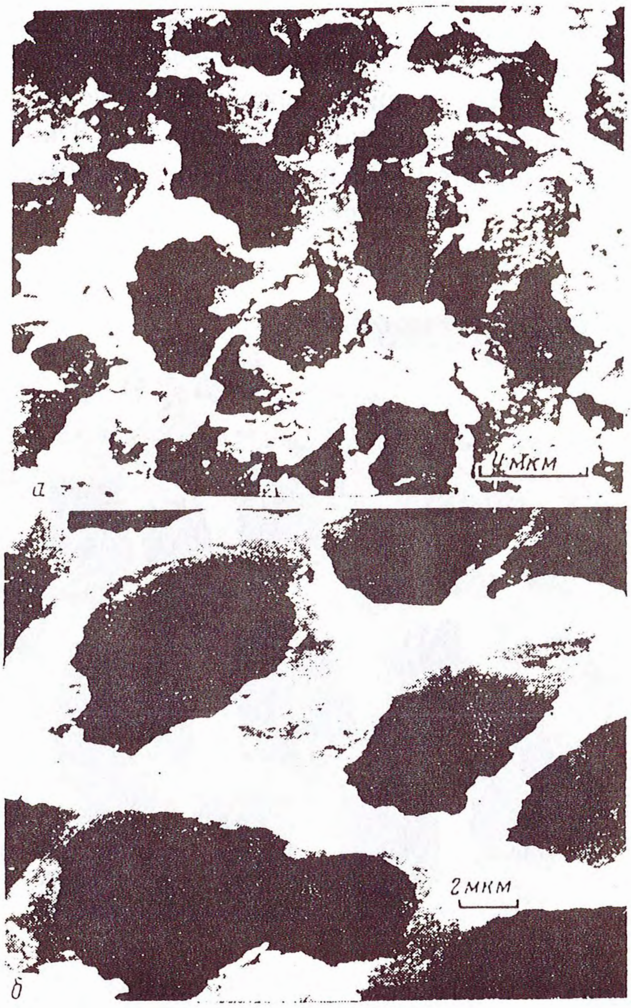


Figure 6. Cellular microstructure of (a) marine clay mud and (b) artificial sediment, formed from 1% Na-montmorillonite suspension with 0.5N NaCl solution (after Melnikov et al.,1985).

The cellular structure possesses high elasticity and strength because imposed load is carried by structure nodes as a result of arch effect. Simulations performed by techniques carried out from mechanics of composite materials and field tests on experiment site confirmed this statement.

Technological solution for geotechnogenic massif in loess

In natural condition loess soils can compose masses with a thickness from several metres to 100m or more [5,8]. Only the upper part of these masses (up to 30 - 40m) shows collapsibility. Technological solutions are found for non-cyclic loess masses in the South of Rostov province where loess masses of 30 - 50m thickness are encountered. The collapsible part of these masses extends up to the depth of 25 - 30m, and for cyclic loess masses from the Volgodonsk region where some loess profiles consist of 14 horizons, amongst which seven collapsible horizons alternate with almost uncollapsible or absolutely uncollapsible ones.

A general layout of a geotechnogenic massif is shown in figure 7. It has a form of a three-layer asymmetrical sheet: the upper layer, which is a horizontal bearing element, operating as a base plate with a large area; the middle layer, which is a part of the loess mass improved in some manner; and the lower (underlying) uncollapsible layer.

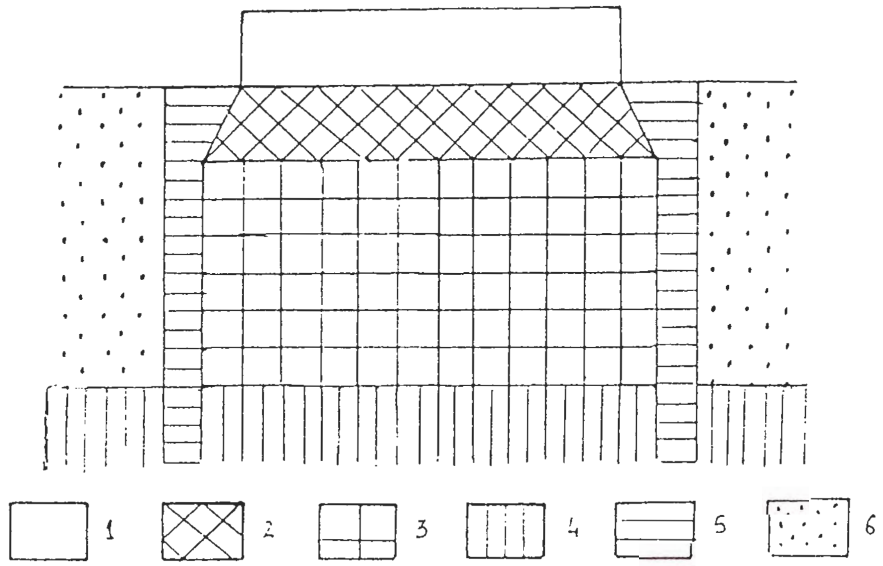


Figure 7. General layout of geotechnogenic massif: 1. Engineering construction, 2. horizontal bearing element, 3. middle layer of improved loess, 4. layer of uncollapsible loess, 5. outline casing, 6. surrounding collapsible loess.

The geotechnogenic massif is isolated from surrounding loess (which still can collapse by saturation changes) by an outline casing. In some cases , especially when industry constructions are designed, the upper horizontal bearing element could be used to accommodate communication facilities.

Operations to create geotechnogenic massif are performed in the following sequence: (1) creating the outline casing, (2) excavation of foundation pit, (3) preliminarily compaction of loess at the bottom of excavation to prevent sudden collapse during operations, (4) improvement of the middle loess layer, (5) construction of the upper horizontal bearing element.

The outline casing is designed to protect the foundation from negative impact of the surrounding loess in the case if the latter subsides by saturation. The casing can be created by injecting soil-water pulp into boreholes on perimeter of the designed geotechnogenic massif. It is known by experience that a row of boreholes with intervals of 6m is adequate.

Excavation of foundation pit is carried out with conventional methods. Moreover, settlement due to the subsequent compaction must be taken into account. *The preliminary compaction* of the loess at the pit bottom might be carried out by heavy ramming and should extend to a depth of 1.8m.

The middle layer of improved loess might be designed on two schemes: (1) create a geotechnogenic structure in the whole volume, and (2) complete the existing natural structure with technogenic elements.

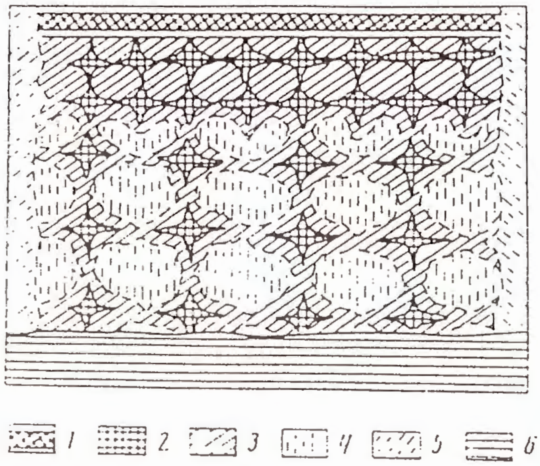


Figure 8

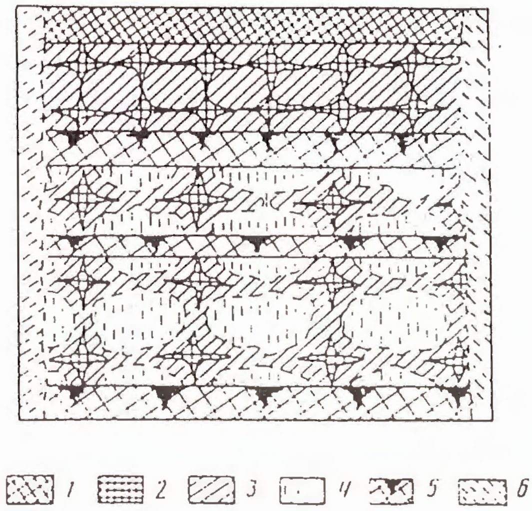


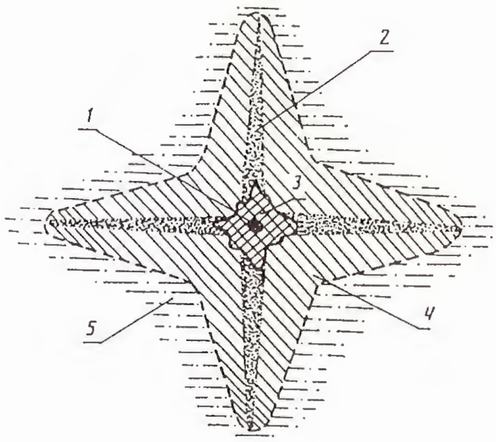
Figure 9

Figure 8. Conceptual design of geotechnogenic massif in non-cyclic homogeneous loess mass: 1. horizontal bearing element, 2. technogenic element, 3. impact zone of technogenic element, 4. undisturbed loess,5. outline casing, 6. layer of uncollapsible loess.

Figure 9. Conceptual design of geotechnogenic massif in cyclic heterogeneous loess mass: symbols from 1 to 4 as in figure 8, and 5. horizon of uncollapsible loess (usually coincided with buried soils), 6. outline casing.

The first design should be applied for non-cyclic homogeneous loess mass which does not include any layers, lenses or other inclusions with different mechanical properties. As can be seen on the conceptual layout of the structure of geotechnogenic massif in non-cyclic homogeneous loess mass shown in figure 8, its middle layer has two distinct parts: the upper part (up to one-third by the thickness of the collapsible layer) has a *completed structure* while the lower part has a *pseudo-completed* one. To create the middle layer, from the bottom of the foundation pit, a pipe is driven into the loess on a square grid with 6m spacing. Through the pipe soil-water pulp (80 - 85% water and 15 - 20% soil) is injected by vertical interval of 3m under a pressure of 30 - 40 atm. The lower end of the driven pipe has a special construction - the so-called *"pikobur" (пикобур)*, so that injection of pulp under high pressure leads to hydraulic fracturing in four orthogonal directions. The pulp gives the water to the loess. The latter becomes saturated and locally compacted. At the mean time the solid phase of the pulp occupies the free space between structure elements of saturated loess as well as the cavities formed by hydraulic fracturing. To get higher bearing capacity, injection of sand-cement mixture is designed at the same points. That would complete the compaction of loess in the saturated zone and of solid phase in hydrofractured cavities as well. The *completed structure* of the upper part requires additional injection of soil-water pulp and sand-cement mixture. For that, at the centre of each square of the previous grid, the pipe is driven into the upper part and injection is effected as described above. After solidifying, sand-cement forms together with the solid phase a ground-cement technogenic element with high stiffness at each structure node (i.e. at each injection point).

Figure 10. Idealized form of a technogenic structure node created in the middle layer (view from above): 1. injection point, 2. hydrofractured cavity filled with solid phase, 3. sand-cement core, 4. zone of saturated compacted loess dispossessed collapsibility, 5. undisturbed loess.



Such a element has a form of four orthogonal hydrofractured cavities 1 - 1.5m height, several centimetres wide and 3 - 4m in length filled with solid phase from soil-water pulp, and a sand-cement core in its centre (figure 10). Around the technogenic element is a zone of saturated and compacted loess which is not collapsible any more. Thickness of this zone depends on the technology used and varies from several centimetres to 1m (in both side of the hydrofractured cavity). Volume of soil-water pulp and sand-cement mixture required by injection depends on construction requirements and initial density of loess.

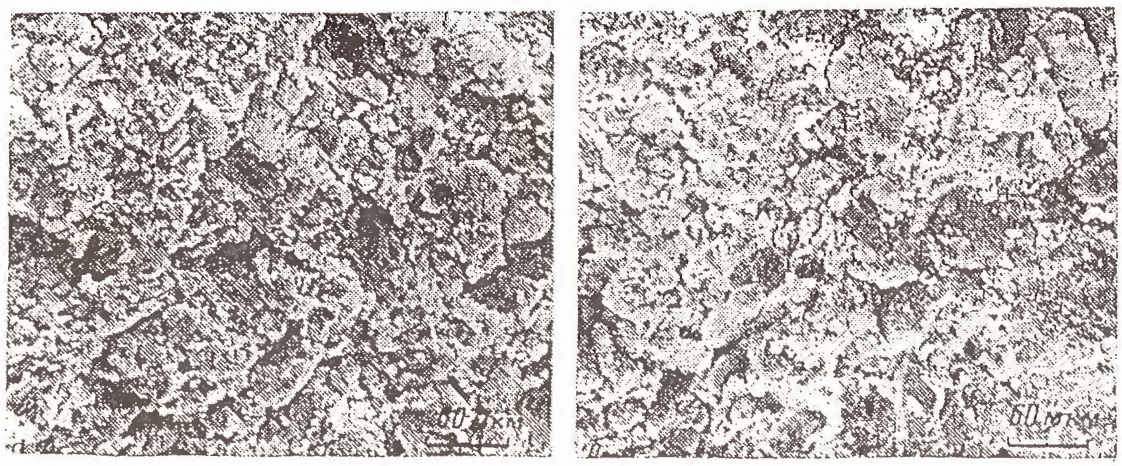


Figure 11. Microstructure of undisturbed loess (left) and saturated compacted loess from the impact zone of technogenic element (right) (after Osipov, 1989)

Microscope study of the microstructure of undisturbed loess and saturated-compacted loess close by hydrofractured cavity shows that the latter has an higher density (figure 11). Quantitative analysis of pore distribution on microstructure images in scanning electron microscope reveals large changes in pore space in loess being in the impact zone of technogenic element. As it can be observed in figure 12, there are pores measuring to 65μm in the sample of undisturbed loess, while the maximal pore size in the sample taken from the impact zone does not exceed 25μm, but the number of pores with a size less than 1μm considerably increased.

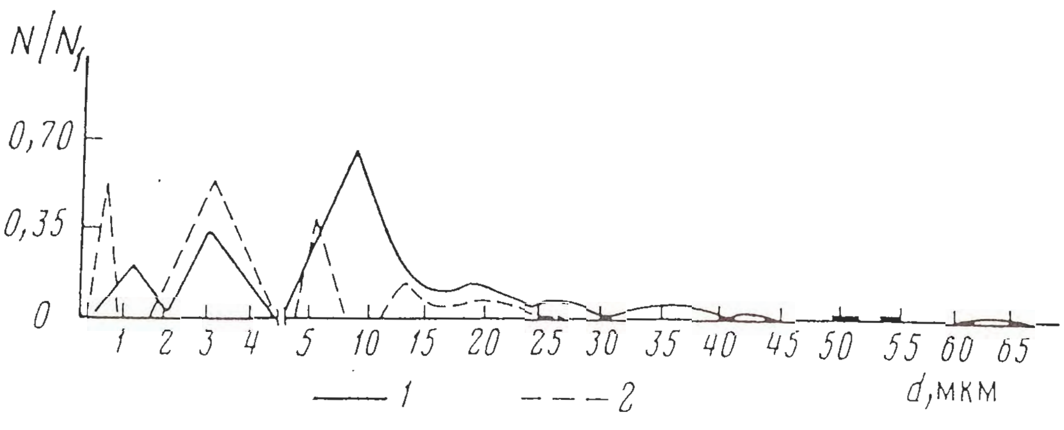


Figure 12. Pore-size distribution plots: 1. undisturbed loess, 2. loess from the impact zone of technogenic element., N/N_1 probability (after Osipov, 1989)

<u>The second scheme</u> of the middle layer is applicable for loess profiles with alternating collapsible and uncollapsible horizons. The latter are coinciding with horizons of buried soil which possesses higher density and rigidity compared with the rest. It is fair to consider such uncollapsible horizons as natural bearing slabs that could be used in combinations with technogenic elements [7]. The task is to create in collapsible horizons fragments of technogenic structure which form together with uncollapsible horizons a multistorey geotechnogenic structure (figure 9). Moreover, in the first collapsible horizon a *completed geotechnogenic structure* should be created, while in the lower horizons a *pseudo-completed structure* would be adequate.

The upper horizontal bearing element - For purposes of saving basic construction materials without worsening bearing capacity, instead of a solid ferroconcrete plate the horizontal bearing element under heavy and/or susceptible constructions can usually be made in the form of a three-layered design, and consists of a upper ferroconcrete slab, an intervening ground layer and a lower ferroconcrete membrane (figure 13).

Depending on the value of external load, thickness of the upper slab, the intervening layer and the lower membrane can vary between 0.2 - 1.0m, 0.5 - 3m, and 0.1- 0.3m respectively. After the lower ferroconcrete membrane was created at the bottom of the foundation pit, ground is poured out on it and compacted subsequently by rolling. To apply a compressive prestress to all layers of the bearing element, the upper slab and the lower membrane should be bonded with each other by tendons arranged on a rectangular grid of 3x6m. A tendon is a bunch of four steel bars. The distance between the bars is 100mm. The tendons must be placed before pouring out and compaction of the intervening ground layer. After that, the upper ferroconcrete slab will be cast, so that there is a small hole at the centre of each tendon-grid rectangle for injection pipe. The grout injected under a pressure of 30 - 40m forms after solidifying ground-cement blocs in the layer which are surrounded by a zone of compacted and strengthened ground due to grout penetration.

For light construction the model of geotechnogenic massif can be simplified: the upper horizontal bearing element could then have a two-layered structure (without the lower membrane and tendons), and the technogenic elements in the middle layer of the massif might not have a sand-cement core (i.e. there will be only injection of soil-water pulp and ground grout).

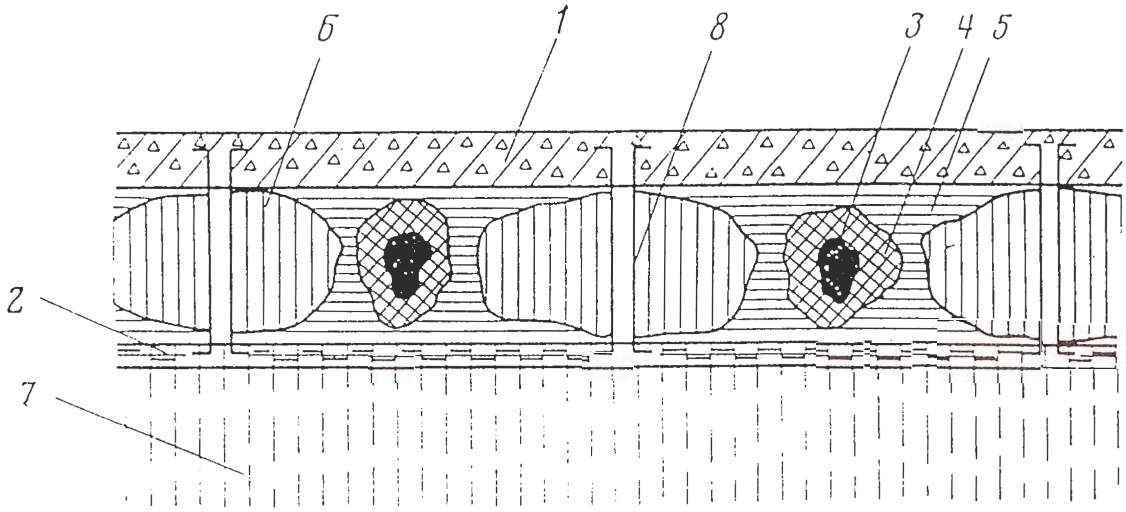


Figure 13. Design of the horizontal bearing element of geotechnogenic massif: 1. upper ferroconcrete slab, 2. lower ferroconcrete membrane 3. ground-cement bloc, 4. ground strengthened by penetrating ground-cement mixture, 5. zone of highly compacted ground, 6. zone of normally compacted ground, 7. layer of loess preliminary compacted before construction works, 8. tendons binding upper and lower ferroconcrete slabs.

Estimation of effective properties of geotechnogenic massif

A geotechnogenic massif created in the described way is a heterogeneous medium consisting of elements with substantially different mechanical properties. Mathematical description of its behaviour under external load and stresses is difficult, but it might be realized by employing the theory of composites. A composite is defined as material which consists of two or more different materials and has properties which the original material does not possess. A composite usually has a filler (disperse phase) and a binder (matrix). The properties of composites are decisively influenced by the filler [3]. For the middle layer of geotechnogenic massif the loess can be considered the matrix and the inclusions formed by injecting sand-cement mixture and soil-water pulp can be considered the filler [4]. The behaviour of a composite can be described by means of effective properties which consider the properties of all phases of the heterogeneous medium and their interaction [1].

One of hypotheses used in composite material simulations is the concept of equivalent homogeneity which suggest that a heterogeneous medium should be idealized (homogenized) in such a way that it could be considered as homogeneous with identical properties at all points of the medium [7]. The concept requires that the external load should be uniformly imposed on an area which is much large than the characteristic size of the constituent elements of the medium considered. Because the middle layer of the geotechnogenic massif conforms this requirement we can use an averaging procedure for predicting its effective properties through the properties of the phases and some of their geometric characteristics. We also are able to employ solutions of fundamental problems of heterogeneous media obtained within the framework of mechanics of composite materials [4,7]. The most of these solutions are based on the assumption of linearly elastic behaviour of the material which allows us to realistically describe the behaviour of a wide class of materials. This does not, however, rule out the possibility of using more complicated solutions for non-linear kinematics.

Below some relations obtained from the theory of composite materials are presented. They might be used to calculate effective properties of geotechnogenic massif with *pseudo-completed* and *completed* structure [7]. If the portion of inclusions is small, and their rigidity is much more than that of the matrix, as in the case of created geotechnogenic massif, the expressions for effective coefficient of volume compressibility K and effective shear modulus μ have the form [01]

$$K = K_m + \frac{2CE_p}{9(1 - \nu_p)} \tag{1}$$

$$\mu = \mu_m + \frac{C}{30}\frac{7 - 5\nu_p}{1 - \nu_p^2}E_p \tag{2}$$

where C is the volume portion of the inclusions, the subscripts p and m indicate that the values refer to the inclusions and the matrix, respectively.

To determine the effective modulus of deformation and the Poissson's ratio the following expressions can be used:

$$E = \frac{9K\mu}{K + \mu} \tag{3}$$

or

$$E = \frac{9\left\{\frac{E_m}{(1 - 2\nu_m)} + \frac{2CE_p}{9(1 - \nu_p)}\right\}\left\{\frac{E_m}{2(1 + \nu_m)} + \frac{7 - 5\nu_p}{30(1 - \nu_p^2)}CE_p\right\}}{\frac{3E_m}{2(1 - 2\nu_m)(1 + \nu_m)} + \frac{(9 + 5\nu_p)CE_p}{10(1 - \nu_p^2)}} \tag{4}$$

and

$$\nu = \frac{3K - 2\mu}{2(3K - \mu)} \tag{5}$$

In the case when $CE_p >> E_m$ (which corresponds to the case of the designed geotechnogenic massifs [4]) expression (4) is transformed into a simplified form convenient for practical use [1]

$$E \approx \frac{CE_p}{2} + E_m \tag{6}$$

Modulus of deformation of the middle layer of a geotechnogenic massif created in an experimental area in the industrial zone of Volgodonsk (Russia) had been calculated using the effective moduli of the theory of composites and the settlement of the lower surface of the horizontal bearing element, which can be regarded as a rigid square plate [4].

According to the theory of elasticity, the settlement of a rigid square plate is determined by the formula:

$$S = 0.88B\frac{(1 - \nu_o^2)}{E_o}P \tag{7}$$

hence

$$E_o = \frac{0.88B(1 - \nu_o^2)P}{S} \tag{8}$$

where B is the width of the bearing element and P is the load imposed.

With S = 3.92 cm, P = 0.892 kg/cm^2, B = 30m, ν_o = 0.38 the value of E_o = 514 kg/cm^2 = 51.4 MPa.

To calculate the effective modulus of deformation, the approximate formula (6) had been used: $E_e \approx CE_p/2 + E_m$.

With values of the modulus of deformation of the conclusions E_p = 19,000 MPa; the modulus of deformation of the matrix (with consideration of injected pulp) E_m = 12 MPa; and the volume fraction of inclusions C = 0.003 we have E_e = 40.5 MPa. Comparison of the values of E_o and E_e shows fairly good reliability of the estimation of effective properties based on the theory of composites.

The relationships between the effective properties and the properties of the phases together with the calculation of actual design lie at the basis of optimization of designs. So, we can estimate the contribution of each component and understand the role which the individual components play in the formation of the macroscopic behaviour of composite (in our case it is the geotechnogenic massif), which makes it possible to select their optimal combinations and obtain composite with properties specified beforehand.

Conclusions

Geotechnogenic massif is a conceptually new loess improvement method which enables us to create foundations with the same or even higher bearing capacity by less expenses compared with existing methods, especially for loess profiles with large thickness.

Depending on the load imposed and structural characteristics of the loess mass, various designs can be used to make the most economical decision.

In each particular case of engineering construction and loess mass, based on the theory of composite materials, we are able to determine beforehand the content of inclusions to be created in the soil mass and their mechanical properties as well in order to optimize the design.

It might be supposed that the concept of geotechnogenic massif also could be applied for other problem soils such as peat, very soft soils, etc.. However, for each particular case an appropriate physical model and technological solution are required.

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ENGINEERING GEOLOGICAL HIGHLIGHTS

MARINE TRADITIONS

This section of the IngeoKring Nieuwsbrief is devoted to developments in the Netherlands that can have which have significance for engineering geologists. "Engineering Geological Highlights" is in this instance devoted to marine engineering geology which is a significant export product of engineering geology from the Netherlands but has never been highlighted. This is not surprising as most geologists scamper towards mountainous areas to embrace the exposed geology. Yet the Netherlands' traditions are with the sea and this is especially so with the Civil Engineering industry. In the Netherlands the term "Weg en Waterbouw" '*roads and water-construction*' is synonymous with Civil Engineering reflecting this strong watery tradition. In engineering geology in the Netherlands the "*waterbouw*" does not have a central position or does it?

Amsterdam and Lisbon: maritime traditions

The 1990 6th IAEG congress was held in Amsterdam followed by Lisbon this year which hosted the 7th Congress. Both congresses had excursions involving tours of their estuaries, though, within the themes few contributions were presented at both congresses concerning marine engineering geology. Most "marine" papers concerned coastal morphological processes and landfill schemes. Only one or two papers could be considered true marine engineering geological ones pertaining to offshore artificial islands and submarine slope stability due to earth-quakes. The Amsterdam conference fared a little better: thematic symposia helped group and highlight a few articles under "Coastal Protection and Erosion" and "Engineering Geology in the Oil Industry". If one looked at the Dutch contributions: none at the Lisbon conference (we have all become confirmed landlubbers) and, at most, about five contributions in Amsterdam.

What is the matter? If one looks at engineering geological education there are very few, I dare say almost no university staff who have had offshore experience. Hence the only way an engineering geologist can obtain knowledge in this sphere is by gaining experience with an engineering company involved in this field such as oil companies, marine site investigation companies, marine structures contractors and consultants, as well as, the dredging industry. Perusing through the papers on the workshop devoted to engineering geological education 7th IAEG-Congress revealed little scope for this subject.

If one looks at the investment, that takes place in the marine environment it is almost galling that we as engineering geologists almost ignore this branch in education.

Origins of Marine Engineering Geology

In 1988 Adrian Richards began a course at the Faculty of Mining and Petroleum Engineering of the TU Delft titled "Marine Engineering Geology". The course is attended by both students specializing in petroleum engineering and in engineering geology. Adrian gave the course pro-deo up to the time he reached the age of 65. He may not have worked on traditional Dutch marine type projects but he certainly has been involved a very long time in marine geology and engineering geology. In 1977 I purchased[1] a second-hand book, published ten years previously, titled "Marine Geotechnique, proceedings of the International Research Conference on Marine Geotechnique, May 1-4 1966". The editor and one of the contributors was none other then Adrian Richards. Adrian is unique in having witnessed marine engineering geology from its birth.

Netherlands contribution

It was also in the mid-sixties, that marine engineering geology started to become a significant industry in the Netherlands: a combination of the Delta works and the hydro-carbon developments in the North Sea played a major role. Two companies which were started in the Netherlands in this field were Fugro and another CESCO. Fugro began with cone penetration testing techniques in the marine environment and CESCO with shallow reflection seismic surveys. The results they produced then are still outstanding by today's standards, the major change being that the costs have reduced considerably and work in more extreme environments has been made possible. Fugro and CESCO also have undergone numerous changes, including for a number of years being one company. CESCO, since its separation from Fugro, existed a number of years with other com-panies such as OSIRIS and then later returned with still a few original staff to Fugro under the guise of a number of name changes. One significant marriage was that of Fugro with McClelland engineers. McClelland was

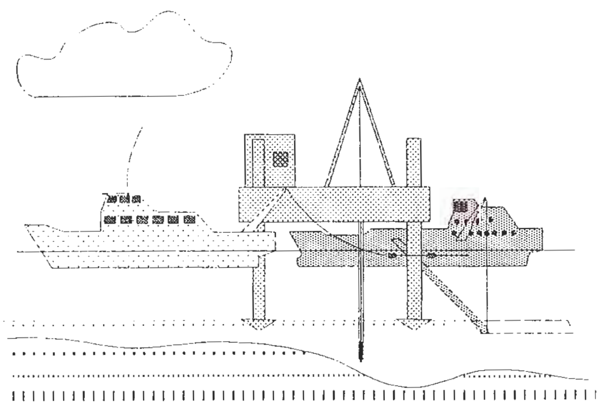
[1] *The bookshop I purchased the book from was Joseph Poole & Co. Ltd. of Charing Cross Road, London. Poole and its more illustrious neighbour, Messrs Marks Co., also a secondhand bookshop -to which a BBC television film was made "84 Charing Cross Road"- have since gone.*

one of the contributors to Adrian's conference in 1966. There were then none from Holland. Familiar names, besides that of McClellands, that are still active today in offshore activities from Europe are NGI (Norwegian Geotechnical Institute) and Imperial College. The latter, in combination with University College London and together with TU Delft, MIT and Trondheim University organise in turn, on a three yearly cycle a BOSS (Behaviour of Offshore Structures) conference. This year the 7th conference was held at MIT, which I believe had more contributions from the Netherlands on marine engineering geological aspects then the 7th IAEG in Lisbon. In three years time the conference is due back in Delft.

The contributions from Holland, though, do not involve authors having an engineering geological qualification. Hopefully by 1997 this will not be so.

The Pacific Rim

By 1998 there should be more contributions on marine engineering geology for the 8th IAEG congress. Another famous harbour city has been chosen for this congress: Vancouver on the Pacific Rim. It is also on the Pacific Rim where the Dutch dredging industry is making it largest impact: Hong Kong, Taiwan, Malaysia and Singapore. Not only the contractors, but also associated consultants such as DEMAS and GeoCom are active there.



The latter consultancy is headed by Ben Degen who could be said to have given the only Dutch marine engineering geology contribution at the 7th IAEG in Lisbon. As an invited panel member for Workshop A, Information Technologies Applied to Engineering Geology, he presented examples of computer uses in marine seismic surveys: automation of survey controls, survey data processing and interpretation and mapping. Appropriately, it was also GeoCom and Fugro which had stands at the 7th IAEG trade-fair and which were involved in the marine site investigation works for the River Tagus crossing.

WOT

At Delft Marine Engineering Geology is entering a post-Adrian Richards period. With my limited, but now significant, offshore background the burden has befallen to me to continue Adrian's pioneering efforts. To do the course full justice requires others who can make contributions towards maintaining the course's depth and breadth by increasing its scope. I look to the industry that practices offshore to make this contribution. Efforts are underway to integrate the course within Delft's WOT: Werkgroep Offshore Technologie wherein the faculties Civil Engineering, Mechanical Engineering and Marine Technology and Mining and Petroleum Engineering belong under the stewardship of the Chair in Offshore Technology at Civil Engineering.

Professor J.H. Vugts has taken up the chair since the beginning of last year. He hails from the oil industry. As the pretroleum graduates from the Faculty of Mining and Petroleum Engineering are potential representatives for the principal clients of the offshore industry it is important that the contribution from the faculty towards WOT should be expanded to increase its importance. It is also important for the Netherlands that it holds and maintains a leading position in the world in offshore technology.

Engineering geology should build on what was set up by Adrian Richards, to ensure the course becomes central to the education of the engineering geology and not, as it is at present, somewhere on the periphery. We have a marine tradition in the Netherlands, why not take advantage of it?

Mathematics of Marine Geology

Another highlight I had hoped to say more about was the GeoInfo V conference held in Prague last July. It is not totally disconnected with the above theme, though the reason for attending was to give a presentation on our plans for a Seismic Engineering Information System (SEIS- see the abstracts next issue Nieuwsbrief!). By coincidence, one of the GeoInfo delegates, John Harff, Professor of Marine Geology at the Institute for Baltic Sea Research, Warnemünde, Germany, was lobbying for more interest for the International Association of Mathematical Geology (IAMG). The outcome is that, before long, CompuTerra (see a special issue of June 1990) will become the Netherlands national group of the IAMG.

P.M. Maurenbrecher, 30 Sept. 1994

I

Extension of U-2 Subway Line

M.Huisman

1.1 Introduction

In the process of the reunification of the D.D.R. (the German Democratic Republic) and the B.R.D. (the Federal Republic of Germany), the public transport facilities of East- and West-Berlin are linked again. A number of these facilities in the former East part of the city have to be adapted to the new requirements of the public. One of the projects involved is the extension of the subway line U-2, from the former end station in the Vinetastraße further to the north, to the old centre of the Pankow quarter.

At the visited site, the first part of this extension is now being constructed underneath the Berliner Straße, stretching from the Maximilianstraße up to the Granitzstraße. The tunnel is constructed using a traditional open-pit method, known as the "Berliner Bauweise" (the "Berlin Construction Method"). This tunnel section has a length of 145 metres, a width of 20-25 metres and a depth of 13 metres. The construction costs of this part of the project are estimated at about 38 million D-marks; it will be finished in October of 1994.

The visited tunnel runs parallel to the Berliner Straße. To limit the influence by the construction process on the traffic, this construction phase will be executed rapidly until the tunnel is out from underneath this street. Meanwhile, the construction pit is covered by concrete plates, over which the traffic can be diverted.

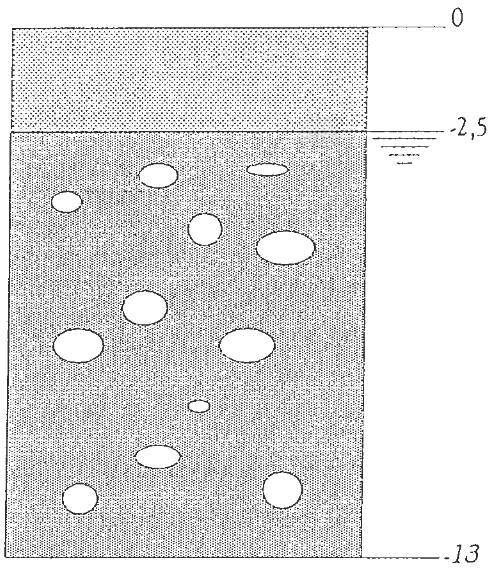
This tunnel will not be used for the coming years. It is constructed while awaiting the final permissions to construct the rest of the planned extension, providing two extra public stations and probably one maintenance station; this final stage of the project is expected to commence in 1996. The extended line has to be completed in the year 2003 or 2004.

At the site, explanations were given by mr. Reck and mr. Rupprecht of the constructing R.A.U.L.F. company.

1.2 *Geology of Site*

The geology of the construction site is determined by glacial deposits, which are common in this part of Germany. The uppermost soil layer down to a depth of about 2,5 metres mainly consists of sands; below that level, glacial loam is found, containing boulders with a diameter of up to 2,5 metres. The groundwater level has been determined to be exactly on the division between the sands and the loam; this seems rather questionable. It is likely that the water found on that boundary surface is hanging water, forced upwards by capillary pressures in the clayey parts of the loam. The level of zero pressure would then be considerably deeper, as the capillary rise in clays can be up to more than one metre.

The geological column of the area is given in figure 1.1. The geology has been determined using cone penetration tests and core borings.



Sands, with relatively high permeability.

Glacial ground morene deposits, locally refered to as "Mergel". Grain size ranges from claysize up to boulder size.

The measured groundwater level is possibly the top of the capillary water.

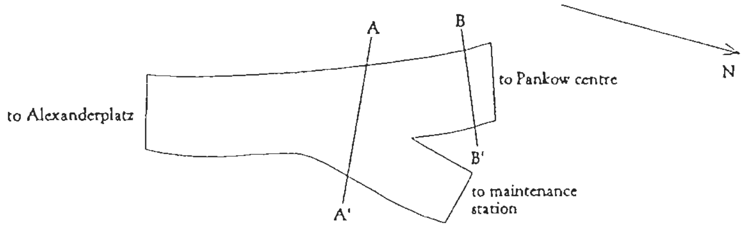
Permeability is generally very low.

figure 1.1 - a geological column through the site

1.3 *Design of Construction*

The tunnel will contain four tracks; two of those will lead to a maintenance station, the other two will be used for public transport towards and from the centre of Pankow. The layout of this tunnel section is best explained by figure 1.2. One of the tracks used for public transport runs underneath the two tracks that go to the maintenance station; this track will come to the same level as the westernmost track, further to the north.

Plan:



Section:

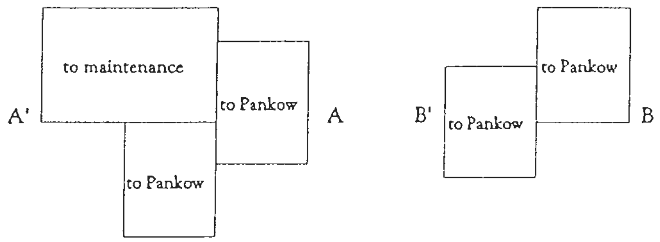


figure 1.2 - the layout of the construction

1.4 *Construction Method*

The construction method used is the so-called Berliner Bauweise, or Berlin Construction Method. In this open-pit construction method, H-shaped steel profiles are driven into the ground along the outline of the planned construction pit, in specially drilled holes with a diameter of 60 cm, which are filled with sand and gravel. The H-profiles could not be driven in the loam, because of the large boulders present. Then, while excavating, wooden planks are placed in between these profiles, and secured by wedges, as is drawn in figure 1.3.

In this way, the support is made from the top downwards, during the excavation. When the excavation is completed, the formwork for the concrete is placed against this wooden wall, after adding a special lining, which has the main function of keeping groundwater out. This lining is shown in figure 1.4. The thin metal liner around the H-profiles prevents these becoming attached to the concrete, and ensures their retrievability.

The bituminous layer forms a water-tight seal on the outside of the tunnel wall, to prevent future water influx. The bitumen has a reinforcing copper mat in it, which makes a thicker layer possible. This is necessary because of the relatively low active ground pressure of the loam; without the mat, only a thin layer would be possible, and this would be easily damaged, as it would not be pressed tightly to the concrete. The black bitumen is painted white after attaching it to the shotcrete; this prevents excessive heating of the bitumen by the sun, and facilitates the recognition of any damages by the construction of the tunnel wall reinforcement.

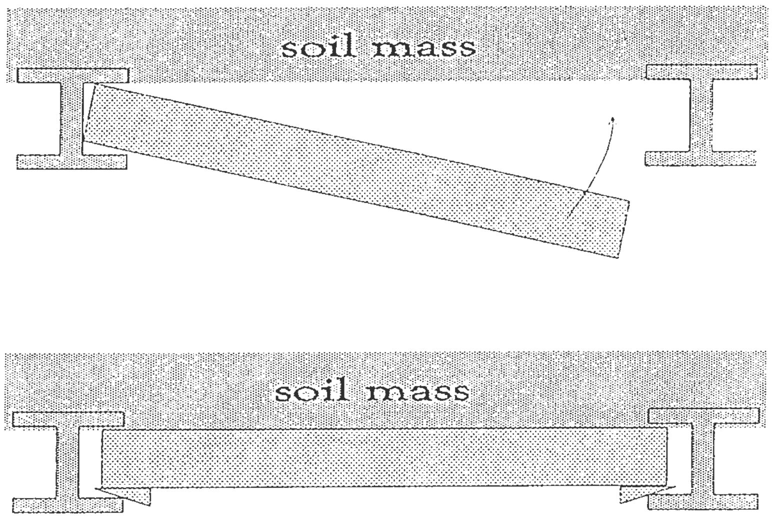


figure 1.3 - support method in Berliner Bauweise

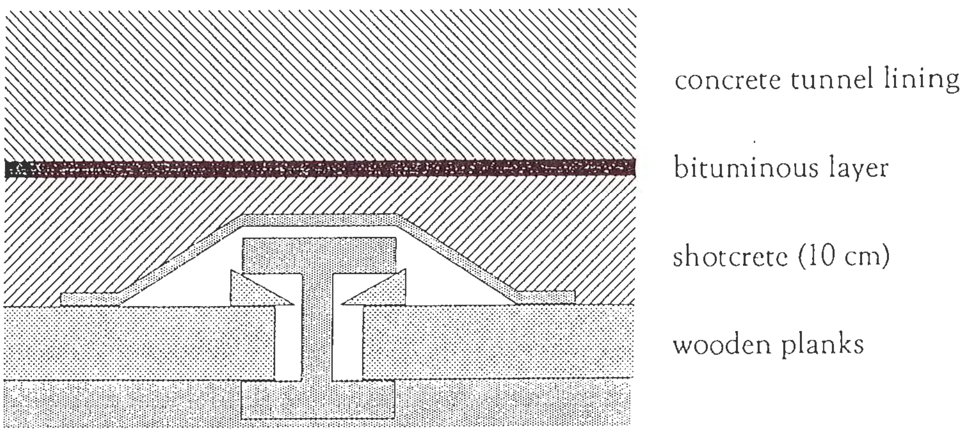


figure 1.4 - construction of tunnel lining

When the tunnel wall is completed, the steel profiles are retrieved; the wooden wedges are pushed outward into the open hole, which is filled with a sand-water slurry. The wood stays in place; because it will remain underneath the water table, it will not desintegrate, as experience with this method proves.

1.5 *Lowering of Groundwater Table*

As the wooden lining used in the Berliner Bauweise is not water tight, lowering of the groundwater table around the construction pit is necessary; this is achieved using a conventional well-pump. Some problems have risen because of the pumping; before the construction was started, groundwater samples taken at the site showed that no contaminations were present. However, when the pumping was initiated, oil contaminations which originate from some location near the site were drawn towards it; these were possibly present at a factory along the Berliner Straße. Who is to finance the cleaning of the pumped water, which is compulsory in Germany, still remains undecided; the principle of "the pollutor pays" would bring the former East-German company to a certain bankrupcy, because of its weak financial position. The water is cleaned on-site, and then pumped into a nearby river.

From a civil engineering point of view, the groundwater lowering did not give rise to any problems. The surrounding buildings are not founded on wooden piles (which would desintegrate because of the lowering), but directly on the sand and loam. The sand is by nature not vulnerable to compaction; the loam has been thoroughly compacted by the ice caps that have deposited it. In the radius of influence of the pumping (about 1,5 km), no damage to the housing has been recorded.

1.6 *Conclusions*

The project did not present any serious problems, although it is quite complicated; this indicates good planning and design. Nevertheless, some question marks could be placed next to the site investigation results; as the former German Democratic Republic has a certain reputation to keep up when it comes to contamination of industrial sites, the groundwater quality should not only have been tested at the construction site, but at the surrounding industries as well. This would probably not have prevented the need to clean the pumped water, but at least it would have been known in advance.

A second questionable site investigation result is the determined ground water table. As this is assumed to be exactly on the boundary between a highly permeable upper layer, and an underlying layer with low permeability, the water found at this level is most likely to be hanging water, either coming from the sand, and not fully taken up by the loam, or water coming from the loam, drawn upward by capillary forces. The real water table is quite important, not only to determine the required rate of pumping, but also because the wooden lining, which remains in place, is thought to be underneath the natural groundwater level. This would prevent its desintegration; however, when the groundwater table is lower than the top of this lining, it would quickly desintegrate, leaving an open space, which would allow deformation of the overlying pavement, and the surrounding buildings.

II

Site Investigation Concerning "Regierungsviertel"

2.1 *Introduction*

When the former republics of East- and West-Germany had been reunited, it was decided to move the parliament of West-Germany from Bonn to Berlin, and to reinstall Berlin as the capital of the whole of Germany. This would involve the reconstruction of the Reichstag building, and the development of a new government quarter, the "Regierungsviertel", around the "Spreebogen", a curve of the Spree river (see figure 2.1).

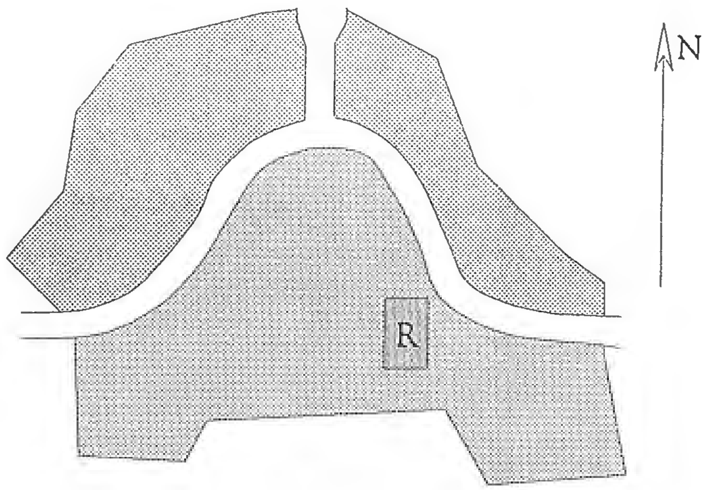


figure 2.1 - the new government quarter around the river Spree
"R" indicates the existing Reichstag building

This project involves the construction of four tunnels; one for a road, and three for railways. These tunnels will roughly divide the Spreebogen in two halfs, running north-south.

As the proposed building site was in the centre of the Nazi capital-to-be "Germania", which was designed by Hitler's architect Albert Speer, it was expected to contain several underground constructions, which would have to do largely with the planned Great Hall, a 300 metres high cupola to be built on the top of the Spree curve. To determine the location and extent of these structures, a special site investigation project was initiated, carried out by the companies G.u.D.-Consult and D.M.T..

2.2 *Historical Researches*

It was found that the first stage of the foundation construction of the Great Hall had already been started. At the end of the 1930's at least three trial caissons were said to having been sunk into the subsurface. These caissons were the first part of two concentric caisson rings, which were to carry the Great Hall. Another part of this immense project was a diffiection of the Spree, which would cut the curve, on which the hall was to be built, from it. The Spree would then be going underground just north of the Reichstag, to come to the surface again after a straight stretch to the west. This underground "Spree-durchstich", with a width of 90 metres, would be navigatable. From documents it was found that construction had been going on for at least half a year. Aerial photographs, taken in March 1945 by the U.S. Air Force, confirm this, showing the flooded construction pit (see figure 2.2).

figure 2.2 - the construction pit near the Spreebogen and the Reichstag building (March 1945)

Also visible on these photographs is a construction trench bending to the south; this was the construction site of a subway tunnel, which was to be a part of the planned public transport net, with a centre just to the south of the Spreebogen.

These were not the only problematic sites expected after the historical research; a photograph taken shortly after the final battle for Berlin shows a concrete structure somewhere in front of the Reichstag building. It was not known whether this was an entrance of a bunker, or for the subway. As was also gathered, the caissons of the Great Hall's foundation were said to be used as shelters during the war, possibly containing ammunition and explosives. Furthermore, several other shelters and bunkers were to be expected.

2.3 *Site Investigations*

To determine the locations and dimensions of these structures, various geophysical methods were used, including (electro-)magnetics, ground penetrating radar and seismics, applied to a depth of about 20 metres. Especially the electromagnetic method proved to be very useful, as the major magnetic anomalies at this site are formed by the steel reinforcements of the concrete structures in the subsurface (see figure 2.3).

Only one of the trial caissons was found, to the northwest of the Reichstag, with a dimension of 6x6 metres; the other two had apparently never been made. The construction of the Spree-difflection had been carried out to a surprising extent; in the middle of the planned tunnel foundation, a part with a length of 185 metres, a width of 11 to 16 metres and a height of 5 metres had already been completed. To the south of this, two subway tunnels were found, of which one was constructed in the trench visible in figure 2.2. The other proved to be a two story tunnel, with a length of 220 metres, possibly filled with ammunition. In addition, several smaller constructions were found.

Apart from these structural obstacles, samples proved that the subsurface was invariably contaminated by lead, copper, arsenic, mercury and zinc. Ammunition storages were not found, and only at two stations at the Platz der Republik, the square in front of the Reichstag, T.N.T. was encountered.

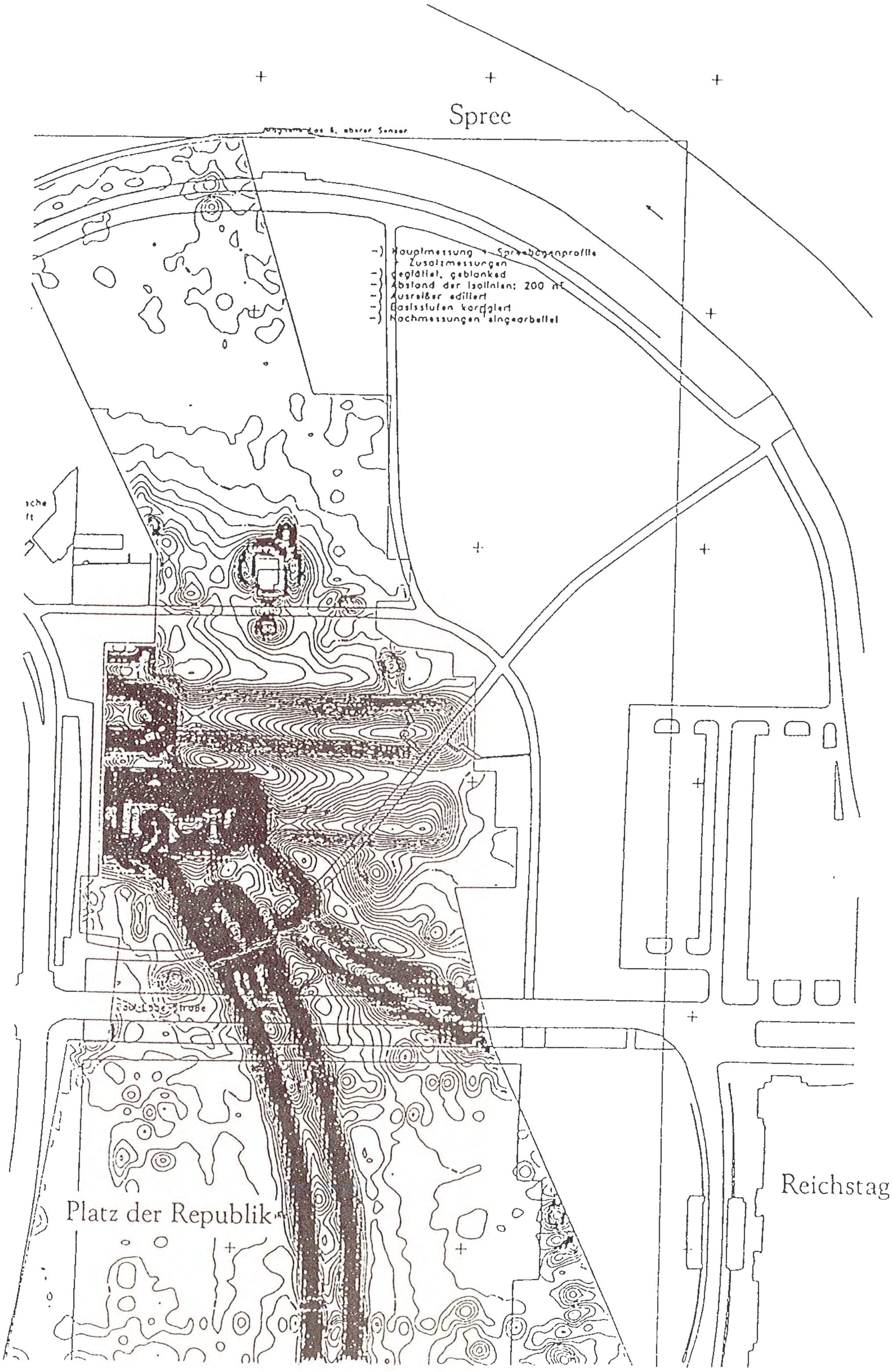


figure 2.3 - the results of the electromagnetic measurements in the Spreebogen

2.4 *Conclusions*

As can be concluded from the geophysical measurements, extensive underground constructions are present near the Spreebogen. Being made out of reinforced concrete, these are considerable hindrances to the proposed road and railway tunnel alignments, and for future construction pits for the new government quarter.

The two story tunnel just to the south of the Spree-difflection is currently being destroyed; it is being drilled to pieces, and the open space formed in this way is backfilled with sand. Regrettibly, there is no time for historical researches in this tunnel, due to the great hurry to complete the works.

2.5 *References*

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Environmental Geotechnics

by Dieter D. Genske, Faculteit Mijnbouwkunde en Petroleumwinning, Postbus 5028, 2600 GA Delft

Environmental protection and mining traditionally seem to contradict each other. In Europe, vast areas have been affected by mining. In the past, public awareness towards the preservation of nature was not an issue at all. Today, the attitude has changed: the interests of the mining industry are harmonised with the concerns of environmentalists on the basis of environmental impact studies. According to European legislation environmental impact studies are now obligatory for all major projects affecting the geo- and biosphere.

This is a good development, indeed. Spending money on the environment in an early stage of a project is, in fact, the most cost effective solution for society, since the costs caused by long term impacts are always higher. For the mining engineer this means that there are two major tasks: (1) which aspects have to be considered in environmental impact studies for future mining projects, and (2) how can we restore land formerly affected by mining?

Both tasks can only be solved on the basis of an interdisciplinary approach. The mining engineer plays here a central role: only she/he has the background knowledge necessary to understand the special aspects of all kinds of mining activities, only she/he has studied an interdisciplinary curriculum with topics from engineering and earth science, and based on this only she/he can develop a practical view on how to remediate damaged sites or minimise the environmental impact of future projects.

There is, indeed, a big market for 'environmental miners'. The European Community, for example, has raised special funds to restore distorted mineland, such as the 'European Fund for Regional Development', that have been used extensively to remediate derelict mining sites in the German Ruhr District. The interest of the scientific community in this subject has also increased. A large number of international congresses on the environmental impact of mining have been initiated. However, it surprises to see that mining engineers who could contribute a lot to this issue seem to be outnumbered by civil engineers and other disciplines.

The Engineering Geology Group Delft, a joint project of the engineering geologists of the Faculty of Mining and Petroleum Engineering of the Technical University and the

International Training Centre ITC Delft, pays close attention to all aspects of environmental mining. The route towards environmental issues was already prepared by David Price, who retired this year from active teaching at the TU Delft. Environmental geotechnics will play a major role in research and teaching of his successor (the author of this article). At a number of international conferences, a list of which you find below, the Engineering Geology Group Delft presented and discussed their research results. Furthermore, a number of MSc-theses dealing with topics of environmental geotechnics have been submitted to the Engineering Geology Group Delft. Their contributions are also included in the list below. Together with engineering consultants like Delft Geotechnics, Heidemy, IWACC, Geofox, R&E Consult, to name only a few, the Engineering Geology Group Delft has been working to improve site investigation and sampling techniques on contaminated sites. Also within the Faculty of Mining and Petroleum Engineering the interest in environmental issues has lead to co-operation. An example is the MSc-thesis of Bun Long Nguyen on the behaviour of non aqueous phase liquid contaminants in heterogeneous subsoils, a work that was done in close co-operation with the Petroleum Engineering Section of the TU and Delft Geotechnics.

Another initiative to stress the importance of environmental geotechnics is the introduction of the journal "Recycling Derelict Land/Brachflächenrecycling" edited by D.D. Genske, P. Noll and E. Trinkaus (Glückauf-Verlag, Essen). The first two issues have already been published. A third special issue dealing with an abandoned coal mining site in the Ruhr District will be on the market in December. For 1995 four issues are planned. The article of S. Slob and R.D. Koster (both graduates of engineering geology of Delft University of Technology) with the title "Mining and Rehabilitation Planning in the Karviná District, Czech Republic - A GIS Application" has just been accepted for publication. Research groups, consulting bureau's, and individuals interested to publish their ideas on land recycling and remediation should contact the author of this article.

Facing the environmental problems we have in the Netherlands and in Europe it can certainly be stated that there is considerable potential for future work of mining engineers in the field of environmental geotechnics, including quite a number of exciting challenges, too.

The following list gives the MSc-theses and contributions to conferences and journals of the Engineering Geology Group Delft dealing with environmental geotechnics of the year 1994:

van Brussel, B.W. 1994: Development of a portable Photo Ionisation Detector system for field assessment of polluted soils. MSc. thesis, Faculty of Mining and Petroleum Engineering, Engineering Geology Group, Delft Technical University.

Bun Long Nguyen 1994: Distribution behaviour of non aqueous phase liquid contaminants in heterogeneous subsoils. - MSc. thesis, Faculty of Mining and Petroleum Engineering, Engineering Geology Group, Delft Technical University.

Genske D.D., P. NOLL, & C. SCHEU 1994: Innovative Methoden zum Flächenrecycling - das Geosandwich. *BrachFlächenRecycling/ Recycling Derelict Land*, 1/94, 54-59, Glückauf Verlag.

Genske D.D. & J. Thein: 1. Recycling Derelict Land. - International Congress on Environmental Geotechnics, 10.-15.07.1994, Edmonton, Canada.

Genske D.D. & P.Noll: Managing Land Recycling - Examples from the German Coal Mining District. - 3. International Conference on Environmental Issues and Waste Management in Energy and Mineral Production, 29.08-01.09.1994, Perth, Australia.

Genske D.D., T. Kappernagel & P. Noll: Computer-Aided Remediation of Contaminated Sites. - 7. Congress of the International Association of Engineering Geology, 05.-09.09.1994, Lisbon, Portugal.

Genske D.D. & B. Thamm: The Use of Geotextiles for the Remediation of Industrial Wasteland. -5. International Conference on Geotextiles, Geomembranes and Related Products, 05.-09.09.1994, Singapore.

Genske D.D., P. Noll & E. Trinkaus: Land Use, Abuse, and Remediation: Digital Tools of Visualisation. - International Conference on Computational Methods in Structural and Geotechnical Engineering, 12.-14.12.1994, Hongkong.

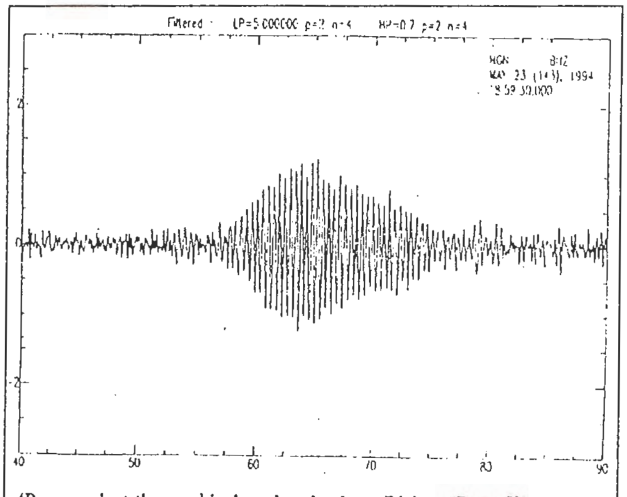
Koster R.D. and S. Slob: Mining and rehabilitation planning in the Karviná District, Czech Republic - a GIS application. - MSc. thesis, Faculty of Mining and Petroleum Engineering, Engineering Geology Group, Delft Technical University.

Messemaekers van de Graaff, C.A. 1994: Onderzoek naar de toepasbaarheid van horizontaal gestuurd drainageboren ten behoeve van grondwatersanering en -beheersing. - MSc. thesis, Faculty of Mining and Petroleum Engineering, Engineering Geology Group, Delft Technical University.

EUROCK '94 - From an Engineering Geological Point of View

The EUROCK '94 conference was held at the auditorium of the Delft University OF Technology and organized by both the society of petroleum engineers (SPE) and the international association of rock mechanics (ISRM). The theme of the congress this time: '*Rock Mechanics in Petroleum Engineering*.'

The opening of this conference involved a speech of the director general of the department of energy from the ministry of economical affairs, dhr. Dessens. Somewhat surprised that he was going to speak at a conference on rock mechanics instead of a rock concert, he proudly presented the new report on seismic activity in the northern part of the Netherlands. Shortly indicating that rock mechnics and rock concerts are closely related by showing the seismographic registration of the Pink Pop preformance of 'Rage against the Machine' by the KNMI (see below).



'Rage against the machine' op de schaal van Richter (Bron: KNMI)

This seismic risk study involved detailed analysis of the reservoir compaction mechanisms at the 'Eleveld'-field as a possible source of seismic activity in the area. It was quite appropriate to present this report at EUROCK '94, not only because of the origin of the seismic activity (gas retrieval) but because of the type of research involved in the study as well (mainly rock mechanics). A pity, because the possible damage at the surface due to this seismic activity is also depending on the behaviour of the ca. 1 km thick soft sediment layers in the area. Especially the relatively large variation of the sedimentary deposits is contradictory to the generalization of the behaviour of the soft sediments for the whole area. But maybe a follow-up study with some engineering geologist and dynamic soil mechanic specialists could supply this type of information in the future.

The program of the conference was quite restricted to the direct vicinity of reservoirs, used for retrieval of hydrocarbons on one hand or for injection of wastes on the other. The seven themes of the conference were: 1. Rock characterization and behaviour, 2. Stability of wellbores and excavations, 3. fracture mechanics, 4. rock mass response to hydrocarbon production and mining, 5. Storage, waste disposal and environmental applications, 6. chalk and 7. in-situ stress, down-hole probes, acoustic emission.

Of course some of the nice presentations could not be followed all because of the parallel sessions, but below I will reflect the contents of those presentations closest to my interest.

THEME III: Fracture mechanics

J. Shlyapobersky et al.: '*Review of Recent Developments in Fracture Mechanics with Petroleum Engineering Applications.*' Give indeed a nice overview of fracture properties like roughness etc. It should be noted that experience in this field might easily be found in rock slope stability research and publications, while problems of slope stability are mainly dominated by joint direction, density, strength and roughness. Specially the mentioning of the use of fractal dimension to describe roughness is something that is at this moment more like an initial idea than a worked out and ready to use application.

THEME IV: Rock Mass Response to Hydrocarbon Production and Mining

In general this theme was interesting while most of the oil or gas producing countries are strongly financially dependent on the selling of these products to foreign countries. However, if subsidence or seismicity becomes a social problem the oil and gas producing companies and the government are forced to evaluate the danger against the profits. Diplomacy and tact are important factors while doing this research and the bias on the result might be large while much is at steak.

E. Mobach et al.: '*In-Situ Reservoir Compaction Monitoring in the Groningen Field.*' This is a clear case where before any production took place in the Groningen field calculation were done to estimate the likely surface subsidence due to reservoir compaction. This was of mayor importance while Groningen is a near shore area below sea level and sea protection facilities are influenced by this subsidence.

Improving the model of subsidence by actually measuring the subsidence in the boreholes (using radio active bullets) the estimated maximum subsidence changed from over 1 meter to ca. 40 cm ! However, measuring the distance between bullets was obscured by systematic and random errors that could only partially corrected. This article is a nice example to show where generalization can lead to and what the value of real field data is.

J.P.A. Roest et al.: '*Geomechanical Analysis of Small Earthquakes at the Eleveld Gas Reservoir.*' This article is part of the multidisciplinary study on seismic risk in the Groningen area in the Netherlands, as was previously discussed. The approach was to model the compaction mechanism in the computer program FLAC and to quantify the stress and strain development at the faults that determine the structure of the gas field. In this case a quasi-statically model was used with an elasto-plastic Mohr-Coulomb behaviour of the rock. The amount of yielded strain due to depletion of the reservoir is an indication of maximum energy release of the fault. This then can be directly related to the maximum magnitude. It is very important to select the correct parameters for the fault segment involved in the stick-slip displacement causing the earthquake. Length, height of the fault and shear modulus of the surrounding rock together with the amount of displacement during the event are the main determining factors. Also other fault characteristic like friction angle of the surrounding material and roughness of the fault surface may contribute to variations in the result. Taking into account that research in the Netherlands enters a new field, with few experience and using models that may not be the most appropriate but are the best we can do due to lack of data, again field data is a mayor important factor to obtain estimates that are near reality.

The latter part seems to be a problem for all low-seismic risk areas, as was clearly pointed out by prof. Luis Gonzalez de Vallejo from Spain, at the 7th IAEG congress in Lisbon, Portugal. There may not be enough data to support some type of statistical approach for predicting seismic risk and/or hazard. On the other hand the recognition of this field of research is close to none and the priority of establishing the risk due to earthquake is low.

THEME V: Storage, Waste Disposal & Environmental Applications

In general this theme presented some articles that discuss the technology and field observations of the storage of oil/gas and waste in old mines, reservoirs or salt domes.

The field test described by Schneefuss et al. is very interesting giving some real measurement on the response of rock salt to artificial heat sources in respect to storage of radio active waste. A part that was missing in the first phase of the OPLA-report on the possibilities of retrievable storage of radiactive waste in salt dome in the northern part of the Netherlands. Of course the large scale tests require a lot of money, which is something the engineering geologist most of the time do not have.

Concluding on the total impression of this conference I would like to say that there seems to be some lack of contact between researchers in general rock mechanics and those in rock mechanics for petroleum engineering. Some of the results published looked quite familiar and seemed a repeat of what had been done before.

Maybe a closer cooperation will be forced on both parties when less money is available in the petroleum industry and data available from other disciplines is needed to complete the total picture.

ir. Ard den Outer
(department of engineering geology; faculty of mining and petroleum engineering; Delft University of Technology; The Netherlands)

Invitation

The dean of the Faculty of Mining and petroleum Engineering of Delft University of technology is pleased to announce that by resolution of the Board of Directors of the University dated January 11, 1994

Dr. ir. D.D. Genske

has been appointed Professor in the Faculty of Mining and Petroleum Engineering to work in the field of Engineering Geology.

The inauguration lecture of Professor Genske will be entitled:

" Bridging the gap: Engineering Geology between the disciplines "

The inauguration takes place at 15.00 hours on Wednesday December 14, 1994 in the Auditorium of Delft University of Technology,
Mekelweg 5, Delft.

The Dean of the faculty invites all who are interested to attend this lecture.

Announcement

The D.I.G. (Student chapter Engineering Geology) in cooperation with the section Engineering Geology is planning a study tour to Japan in september 1995. A group of at most 20 persons will travel through Japan visiting several projects and Universities. The theme of the study tour will be Geotechnical engineering in Japan. With this trip it will be tried to intensify the bond between research in Delft and Japan and to stimulate research and development ideas in the Netherlands.The D.I.G. would like to ask the members of the Ingeokring for their support and cooperation to achieve this study tour.

A.K. Ghose: Small-scale mining - a global overview
(Proc. int. conf. on small-scale mining, Calcutta 1991)
Rotterdam, Balkema 1994

Book review by ir. P.A. Rossouw, TU Delft

This book of 372 pages comprises 35 chapters. These are grouped into six parts covering respectively general perspectives; geological aspects; small-scale mining in seven countries worldwide from Brazil to Japan; small-scale mining in India, Bangladesh, Bhutan and Nepal; Technical (mainly related to blasting) and economic considerations, and finally some conference speeches and recommendations.

Some conspicuous chapters cover subjects ranging from "Landsat" observations of a soapstone mining area in India (chapter 8) to various aspects of small-scale mining in countries such as India (chapters 6, 8, 19 and 25), Zambia (where emeralds and copper ore feature among the minerals mined - chapters 11, 16, 18 and 23) and Brazil (chapters 9, 15 and 26). Two chapters discuss explosives and blasting (chapters 27 and 28) and four chapters are about economic aspects. Interesting in European context is chapter 10 on small-scale mining in Italy, covering products like dimension stone, feldspar, alumino-hydrosilicates (for tiles), limestone, sand, gravel and clay. Due to the fact that the subject of the book is a very broad one to fit into a publication of under 400 pages, some chapters are rather concise. Of the 35 chapters, eleven are shorter than six pages apiece. This is compensated for by nine long chapters taking up 15 to 23 pages each, thus covering their subjects in more detail.

As an overview of non-European small-scale mining this is a successful publication. It is a pity that the European contribution at the conference where the book originated was apparently limited to Italy, considering that small-scale projects are becoming increasingly important to the future of European mining. The book concludes with nine recommendations of this 1991 International Conference. The first five recommendations stress five needs, respectively for sufficiently defining small-scale mining, for

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rationalization of rules and procedures, for cooperative licensing, for cooperation and assistance from the private and public sectors and for promoting an adequate marketing system. The remaining four recommendations advocate using remote sensing for environmental monitoring, establishing a data bank to assess small-scale mining development, rendering research and training assistance and finally developing a small-scale mining forum for a number of countries.

Heping Xie: **Fractals in Rock Mechanics**, Geomechanics Research Series 1; A.A. Balkema, P.O. BOX 1675, 3000 BR Rotterdam, The Netherlands. 453 pp. Price Fl.143,10

General

Having done research in the application of fractals in describing surface roughness of discontinuities and encountering a lot of problems when applying this theory in practice, I was surprised by the amount of fields that use fractals and the easy of the application. This books has interested me even more in this field of mathematics.

The textbook, which is used for and based upon lectures on 'Fractals-Rock Mechanics' by the author, gives a good overview of the definitions most often used in applying fractal theory.

Contents

Being a textbook used for lecturing the book indeed covers all important fields involved with applying fractal theory.

The first chapters give, in clear but typical mathematical symbolic English, an introduction into the mathematics behind the fractal theory. The definitions of a measure and self-similarity are discussed and a lot of the well known examples of fractals are given. Also different methods to quantify the fractal behaviour of a feature (the fractal dimension) are given. All these mathematical explanations are illustrated with practical examples.

The applications of fractals in rock mechanics is discussed in the second part of the book and covers well over half of the volume.

The fields of applications that are discussed are damage mechanics in rock, fragmentation of rock, pore and particles of rock and soils, micro-fractures, analysis of rock damage and fractures, roughness description of rock joints and clustered systems. Indication the wide field of applications of fractals.

The book gives in this second part a overview of research done on applications of fractals and is commented upon by the author.

Specific comments

The chapter on describing joint roughness with fractal dimension has interested me specifically for reasons mentioned earlier.

The practical problems that I have encountered during the research of this problem have a lot to do with making the step from the infinite theoretical world in which fractal theory has been developed towards the finite practical world. It is very difficult to fulfil all the rules implied by the theory in this finite world.

All the most important publications are overviewed in this chapter, however the somewhat positive attitude towards the validity of the approach used is not criticized. Most methods have somewhere the remark 'Suppose the data set is fractal and thus self-similar,' which might very well not be the case. Strictly spoken a finite data set, with respect to sample number or interval, can never be fractal. The data set can show fractality on a limited range of scale, which does have useful implications. However, the fact that the method gives a constant fractal dimension over some range does not prove self-similarity of the data set.

Still the definition and method to calculate the fractal dimension of a finite data set is well described and therefore can be a good tool.

Finally

'Fractals in Rock Mechanics' gives a good impression of the importance of the properties of fractals and their use in rock mechanics. However, there is still a big gap between the theory and its application that can cause a lot of problems. This gap causes a restricted range of validity for several applications of the fractal theory and these limits should be known while using the theory. For those who are more interested in these restrictions I would like to refer to an article on these problems soon to be published in the 'Journal of the International Society of Rock Mechanics.'

ir. A. den Outer,
Department of Engineering Geology,
Centre of Technical Geoscience
Delft University of Technology.

Internationaler Colloquium "Kreiden und Schiefer"
International Colloquium "Chalk and Shales"

Vorläufiges Anmeldungsformular - Preregistration form

☐ Dr. ☐ Prof. ☐ Herr - Mr ☐ Frau - Ms

Familienname - Family name : ______________________________

Vorname - Christian name : ______________________________

Stellung - Position : ______________________________

Organisation - Organization : ______________________________

____

Anschrift - Adress : ______________________________

____

Tel - Phone : ____________ Fax : ____________

☐ Ich beabsichtige am Internationalen Colloquium "Kreiden und Schiefer" teilzunehmen
I intend to participate at the International Colloquium "Chalk and Shales"

☐ Ich werde einen Beitrag präsentieren
I will present a paper.

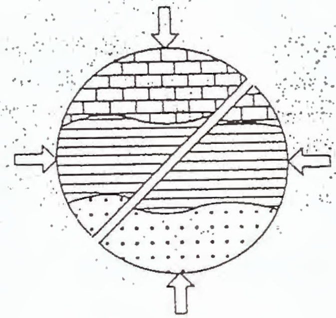
Thema - Theme : ______________________________
(anbei eine zusammenfassug von max. 500 Wörter - joint a summary of max. 500 words)

☐ Bitte schicken Sie mir das Bulletin Nr. 2
I wish to receive Bulletin No 2

COLLOQUIUM MUNDANUM

Craies et Schistes
Krijt en Leisteen
Kreiden und Schiefer
Chalk and Shales

GBMR
Groupement Belge de Mécanique des Roches



BVRM
Belgische Vereniging voor Rotsmechanica

Mens agitat molem

Bruxelles, les 20 et 21 mars 1995
Brussel, 20 en 21 maart 1995
Brüssel, 20. und 21. März 1995
Brussels, March 20 and 21, 1995

1

BVRM Belgische Vereniging voor Rotsmechanica

INTERNATIONAAL COLLOQUIUM "KRIJT EN LEISTEEN"

Belgisch Colloquium beschermd door de Internationale Vereniging voor Rotsmechanica (IVRM).

1. Doelstelling van het Colloquium

Krijt en leisteen bezitten zeer specifieke fysische, chemische en mechanische eigenschappen, waarvan verscheidene aspecten nog steeds het onderwerp vormen van onderzoek en discussie.
Krijt heeft een zeer complex rheologisch gedrag, dat onder andere functie is van de aangelegde belastingen.
Leisteen, met een zeer sterk anisotrope structuur, heeft een specifiek geomechanisch gedrag met een sterke invloed van de schaal grootte.
Daarenboven combineren de metamorfose varianten van krijt en leisteen in verschillende mate deze eigenschappen.
De BVRM roept ingenieurs en wetenschappers die betrokken zijn bij de verschillende aspecten van ontwerp en uitvoering van uitgravingen in deze rotsachtige materialen op, om hun ervaringen op het gebied van studie en uitvoering met elkaar te confronteren.

2. Wetenschappelijke Commissie

Voorzitter : E. LOUSBERG (Université Catholique de Louvain)

Leden : P. CHARLEZ (Total, France)
O. de CROMBRUGGHE (Katholieke Universiteit Leuven)
A. MONJOIE (Université de Liège)
J. NUYENS (Université Libre de Bruxelles)
O. STEPHANSSON (Kungl Tekniska Högskolan, Stockholm
Ondervoorzitter IVRM voor Europa)

3. Organisatie Commissie

Voorzitter : P. J. HUERGO (Université Libre de Bruxelles)
Secretaris : B. FROMENT (Faculté Polytechnique de Mons)
Schatbewaarder : G. SIMON (Ministère Wallon de l'Equipement et des Transports)

Leden : F. BONNECHERE (Université de Liège)
R. CHARLIER (Université de Liege)
J.- P. MICHEL (Tractebel Engineering)
Ch. SCHROEDER (Université de Liège)
J.- F. THIMUS (Université Catholique de Louvain)
A. VERVOORT (Katholieke Universiteit Leuven)
P. WELTER (Ministère Wallon de l'Equipement et des Transports)

4. Datum en Plaats van het Colloquium

Het Colloquium zal plaatsvinden aan de "Université Libre de Bruxelles", in Brussel, op 20 en 21 maart 1995.

5. Talen van het Colloquium

De talen van het Colloquium zijn deze van het IVRM : Frans, Engels en Duits, plus Nederlands. Simultaanvertaling is niet voorzien.

6. Wetenschappelijk Programma

- Geologische kenmerken van leisteen en krijt.
- Experimentele bepaling van de mechanische eigenschappen.
- Formulering van rheologische wetten ; plastische vervorming, constante en cyclische belastingen.
- Viscositeit, anisotropie, poriën-mechanica, niet-verzadigde materialen, effect van capilaire spannigen, thermische effecten, fysisch-chemische koppeling.
- Breukmechanica, localisatie van vervorming en breukvorming, breuken, beschadiging, micromechanica, effect van textuur en schaal effect.
- Aspecten verbonden met de omgeving : stabiliteit van taluds, verzakking en opslag van afval.
- Ontwerp van kunstwerken
    a. oppervlakte structuren; ophogingen, uitgravingen, versterkingen
    b. ondergrondse kunstwerken
    c. funderingen
    d. boringen, putten, stuwmeren.

Belgische en buitenlandse bekende sprekers worden uitgenodigd om aan het Colloquium doel te nemen.

7. Inschrijvingen en schriftelijke mededelingen

Alle briefwisseling bestemd voor het Colloquium moet gezonden woerden aan het secretariaat, waarvan het adres hieronder is vermeld.
De personen die wensen deel te nemen aan het Colloquium worden verzocht om het inschrijvingsformulier voor 30.09.1994 terug te sturen.
De personen die een voordracht wensen te geven moeten een geschreven samenvatting (maximum 500 woorden) in de gekozen taal en in het Engels opsturen voor 30.09.1994.
De volledige tekst van de bijdrage moet uiterlijk op 31.12.1994 toekomen.

Correspondentie adres : Colloquium "Krijt en Leisteen"
t.a.v. Dhr B. Froment
Faculté Polytechnique de Mons (FPMs)
Laboratoire Forages Profonds et Mécanique des Roches
Rue du Joncquois, 53
B-7000 Mons (Belgique)

Telefoon : +32 2 6502737 (ULB)
Fax : +32 65 374600 (FPMs)

8. Praktische inlichtingen

De deelnemers kunnen genieten van voordelige tarieven in hotels die kort bij de plaats van het Colloquium zijn gelegen. De reservatie van de kamers wordt door de deelnemers zelf gedaan met behulp van formulieren die hen worden toegestuurd na de voorlopige inschrijving door het dienstencentrum "ULB Congrès".

Het inschrijvingsgeld bedraagt 12 000 BEF (8 000 BEF voor studenten en onderzoekers). Daarin zijn de koffiepauses, de middagmalen en de bijdragen van het Colloquium begrepen.

De definitieve inschrijving gebeurt door overschrijving op rekening 001-1207087-95 van de ASLK bank, in België, op naam van "Colloquium 95 GBMR-BVRM".

BVFM Belgischer Verband für Felsmechanik

INTERNATIONALER COLLOQUIUM "KREIDEN UND SCHIEFER"

Belgischer Colloquium unterstütz durch die IGFM, Internationale Geselschaft fur Felsmechanik.

1. Ziel des Colloquiums

Kreiden und Schiefer besitzen physikalische, chemische und mechanische Eigenschaften, die in vieler Hinsicht noch zu erforschen und zu diskutieren sind.
Kreiden haben ein komplexes rhéologisches Verhalten, das unter anderem von der Art der Beanspruchung abhängt.
Schiefer, mit Ihrer ausgeprägt anisotropen Struktur, zeigen ein spezifisches geomechanisches Verhalten, das durch starke Masstabwirkungen geprägt ist.
Dazu kommen Gesteine, wie zum Beispiel die Marne, die als Übergangsmaterialien zwischen Kreide und Shchiefer angesehen werden können, da sie in gewissen Massen deren charakteristische Eigenschaften verbinden.
Der belgische Verband der Felsmechanik möchte sich an alle Ingenieure und Wissenschaftler wenden, die Bauwerke in diesen Gesteinen zu entwerfen und auszuführen haben, mit dem Ziel, Erfahrungen auszutauschen, die sie in ihren Untersuchungen und auf der Baustelle sammeln konnten.

2. Wissenschaftlicher Beirat

Präsident : E. LOUSBERG (Université Catholique de Louvain)

Mitglieder : P. CHARLEZ (Total, France)
O. de CROMBRUGGHE (Katholieke Universiteit Leuven)
A. MONJOIE (Université de Liège)
J. NUYENS (Université Libre de Bruxelles)
O. STEPHANSSON (Kungl Tekniska Högskolan, Stockolm, Vice-Präsident IGFM für Europa)

3. Ausführendes Commitee

Präsident : P. J. HUERGO (Université Libre de Bruxelles)
Sekretär : B. FROMENT (Faculté Polytechnique de Mons)
Schatzmeister : G. SIMON (Ministère Wallon de l'Equipement et des Transports)

FOR LISTING

The Third International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics will be held April 2-7, 1995 in St. Louis, Missouri, USA.

More than 200 papers have been accepted from over 30 countries for discussion during the conference. Also, 15 State-of-the-Art lectures will be presented by authors from Canada, Germany, Greece, Italy, Japan, Mexico, Switzerland and the United States.

"Early bird" registration is being offered now. You may obtain registration material by contacting:

Professor Shamsher Prakash
Conference Director
Civil Engineering Department
University of Missouri
Rolla, MO 65401
Fax: (314) 341-4992/341-4729

St. Louis • 1995

FOR LISTING

The Third International Short Course on Dynamics of Structures and Structure-Foundation Soil Systems will be held November 14-18, 1994 in San Francisco, California, USA.

The objectives of this course are: (1) to provide an understanding of the manner in which structures and structure-foundation-soil systems respond to earthquakes and other sources of dynamic excitation; and (2) to review available methods for analyzing and designing such systems. Emphasis will be placed on the effects of soil-structure interaction and of the associated radiational and hysteretic energy dissipation in the supporting medium, and on identifying the conditions under which these effects are of sufficient importance to warrant consideration in design.

The course will begin with a discussion of the response of simple systems to relatively simple excitations, building upon the knowledge gained from consideration of the simpler conditions. In addition to sophisticated, computer-oriented methods of analysis, simpler approaches will be described which are of special value in preliminary design and for the verification of the results of more elaborate analyses. Special attention will be given to the physical aspects of the problems examined. Examples of application will be selected from the design of buildings, machine foundations and nuclear containment structures. Elementary knowledge of structural dynamics and soil structure interaction will be beneficial for the participants.

For further information, please contact:

Professor Shamsher Prakash
Course Director
Civil Engineering Department
University of Missouri
Rolla, MO 65401
Fax: (314) 341-4992/341-4729

an equal opportunity institution

KIvI afdeling Mijnbouw

Symposium ' De Mijnbouwtechnische aspecten van ondergrondse opslag en terughalen van radioactief afval '.

Donderdag 10 november 1994, aanvang 17.00 uur,
ITC gebouw, Kanaalweg 3, Delft.

Sinds het begin van de jaren tachtig wordt in Nederland en de ons omringende landen onderzoek gedaan naar de mogelijkheden om radioactief afval ondergronds op te bergen in steenzoutformaties. In dit kader zijn door verschillende onderzoeks- instellingen voornamelijk geologische en geohydrologische studies verricht. Alhoewel het eindrapport van het OPLA-onderzoek inmiddels is verschenen, is de eindberging van radioactief afval nog niet aan de orde. Hoe een eventueel vervolgonderzoek, onder andere naar terughaalbaarheid, eruit moet zien, hangt voor een groot deel af van de verdere ontwikkelingen van de kernenergie in Nederland.

Een zestal sprekers zal tijdens dit symposium aan de hand van een aantal studies die in Nederland verricht zijn de typische mijnbouwkundige aspecten belichten die bij de opslag en eventuele terughaalbaarheid van radioactief afval een belangrijke rol spelen. Het uitgangspunt van het symposium is dat opslag noodzakelijk is en dat aan de voorwaarde van terughaalbaarheid moet worden voldaan. Het is niet de opzet om een discussie te voeren over de noodzaak van opslag en het al dan niet terughalen van radioactief afval.

Het programma is als volgt :

17.00 - 17.05	H.W.Verschuur, voorz. Mijnbouw	Opening
17.05 - 17.20	P.H.van der Kleyn, Cotinco	Randvoorwaarden en struktuur voor mijnplanning.
17.20 - 17.40	J.J.Heijdra, ECN	Temperatuurverloop tijdens opslag HW afval
17.40 - 18.00	W.G.M.T.v.d.Broek, TUD	Opslag in vertikale boorgaten
18.00 - 19.00	Maaltijd	
19.00 - 19.20	J.H.M.M.Valk, Deilman & Haniel	Ontwerp en bouw schachten opslagmijn Gorleben.
19.20 - 19.40	J.van der Gaag, ECN	Kostenraming tijdelijke ondergrondse opberging en terughalen.
19.40 - 20.00	B.P.Hageman, OPLA	Vervolgonderzoek in Nederland.
20.00 - 20.25	*Vragen en discussie olv. B.P.Hageman*	

Bijzonderheden.

Deelnemingskosten bedragen voor leden f 30,-, voor studenten f 15,- en voor niet leden f 40. Aanmelden voor 4 november door overmaken van de kosten op girorekening 7864 tnv. Afd. Mijnbouw onder vermelding van 'OPLA'.
Meer informatie bij T.Dröge, tel. 03440-32171 (pr.) of H.W.Verschuur, tel.070-3172404 (k).