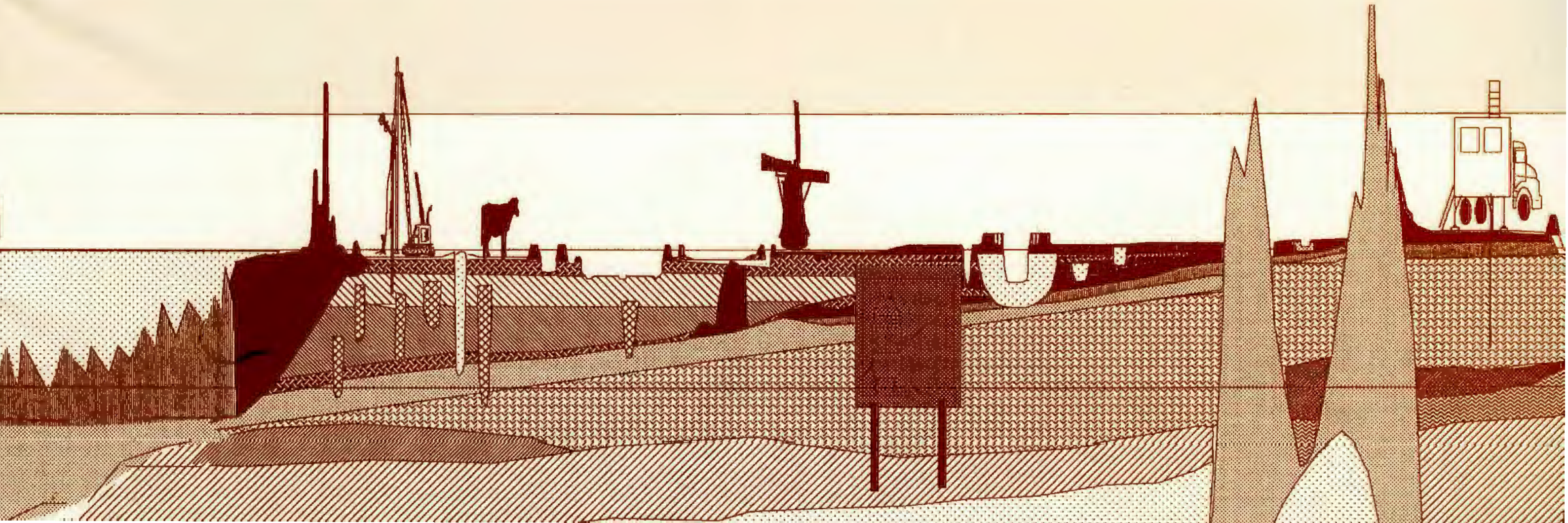
nl-iaeg ingeo kring

news letter

No. 3 Autumn 1996



Objective of the Newsletter

The objective of the Newsletter is to inform the members of the Ingeokring, and other interested parties, on topics related to engineering geology and the developments in this field. The Newsletter wants to make engineering geology better known by improving the understanding of the different aspects of engineering geology.

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Notes for the authors

- Authors should send their contributions with their names and addresses, as a WP 5.1 text file to the editorial board.

- Authors are free in choosing the subject of their contribution with the following restraints:
  - The subject is related to engineering geology.
  - The manuscript is not a commercial advertisement (announcements are allowed).

- Layout
  - All figures and tables should be handed in as hard copies of high quality, each printed separately on A4 size. The author should remember that figures will be reduced in size.
  - Drawings can be delivered as a separate Drawperfect file or PCX file,or a high quality hardcopy
  - When photographs are used, the originals should be handed in (these will be returned)
  - The article should be delivered as a WP5.1 text, without any formatting or layout-codes, accompanied by a hard copy.
  - Each article must be accompanied by a short abstract (<100 words).

Cover: section through The Netherlands and the North Sea from the Achterhoek to the East coast of England.

From the board of the Ingeokring

Dear Ingeokring members,

Last months you could join many Ingeokring activities. In August, Prof. Dr. Louis Ribeiro e Sousa of the Laboratório Nacional de Engenharia Civil, Lisbon, Portugal, was at ITC to give a lecture on the interpretation of the monitored behaviour of a large underground powerhouse using back analysis techniques.

In October two excursions and two lectures followed. The first autumn activity was an international excursion organised in co-operation with our Belgian colleagues. On the 10th of October a group of about 30 persons visited several underground constructions that will be part of the TGV tunnel to the airport of Brussels. On the 24th of October Mr. Van Meulen, of Boskalis International BV, gave a presentation with the title "Establishment and operation of the Pasir-Panjang Quarry in Kerteh, Terengganu, Malaysia (a dedicated armour stone quarry in the Malaysian jungle)."

The second excursion provided a unique opportunity to see the first large-diameter tunnelling machine operating in The Netherlands. It will dig a traffic tunnel in the soft sediments under the Oude Maas, South of Rotterdam, the so called Tweede Heinenoord Tunnel. Because of extensive monitoring during the tunnelling process, a wealth of information concerning tunnelling in soft soil will become available. This project is an important step forward in a discipline relevant to engineering geologists. A detailed report of the project is enclosed in this Newsletter.

Finally, Dr. John Hutchinson, emeritus professor in Civil Engineering at Imperial College in London, gave two lectures titled: "An influence line approach to the stabilisation of slopes using cuts and fills" and "Failures, including flow slides, from coastal chalk cliffs in north-western Europe."

Another event worth mentioning, is the doctoral degree of the chairman of the Ingeokring, Robert Hack. On the 31st of October he successfully defended his PhD research on slope stability probability classification (SSPC). More than a hundred engineering geologists and others attended this last phase of many years of hard work. On behalf of the board and the members: congratulations, dr. Hack!

The next Ingeokring activity will be the presentation of the *Netherlands students award for engineering geology*. This will take place during the annual meeting in the spring of 1997. The winner of the award will give a presentation about the thesis research. The award is sponsored by the Ingenieursgeologische Kring, Boskalis Westminster BV, Fugro Engineers BV, Ballast Nedam Engineering, IWACO, Rijks Geologische Dienst and Geocom Consultants.

Carrying on the recent tradition of successful study tours (remember the Eastern Europe and Japan tour), the DIG is intending to organise a study tour to South Africa. Members of Ingeokring who are interested in supporting or co-operation to realise this study tour, are kindly requested to contact the DIG.

I hope you have enjoyed the Ingeokring activities and will enjoy reading this Newsletter. I would like to take the opportunity to urge all members to contribute to the Newsletter. If you have an interesting article or announcement for the next edition, please contact the editorial board. Meanwhile, the Ingeokring board continues to anticipate and react to future trends regarding engineering geology. Issues such as international professional organisations for engineering geologists, and the future position of Dutch engineering geologists have our full attention. We will keep you informed.

The board wishes you a merry Christmas and all the best for 1997!

Bernice Baardman

Engineering geology highlights: Down to earth geophysics

P.M. Maurenbrecher, Delft University of Technology, Faculty of Applied Earth Sciences, Section Engineering Geology, PO Box 5028, 2600 GA Delft.

Environmental and Engineering Geophysics have taken root in Europe in the shape of the EEGS-ES: Environmental and Engineering Geophysics Society- European Section. About two years, ago a small group of enthusiasts sent a mailing to attract members to the newly established European branch of the International Environmental and Engineering Geophysical Society. The initial reaction to such a mailing is, "very interesting such an initiative. About time too. On the other hand: yet another membership to a scientific/ engineering society, and yet more literature to consume". Many of the names on the EEGS committee were however familiar: they were all active in shallow geophysics.

WHAT IS SHALLOW GEOPHYSICS?

Shallow geophysics is geophysics for civil engineering and environmental site investigation, extending from depths of a few centimetres to usually forty meters. Deeper depths are investigated when concerned with ground water and hazards such as voids that can collapse and cause surface subsidence, both natural and man made.

GEOPHYSICS FOR THE ENGINEER

The EEGS-ES second European "workshop", in fact a complete congress, was held this year in Nantes, which is located on the estuary of that famous wine river the Loire. The incentive was sufficient to become member of EEGS-ES and participate in their activities, especially in a year that seemed to be deficient of conferences in the engineering geology field.

One of the first objectives is to make geophysics more amenable to the engineers who are involved in site investigation. Geophysics does not sell when one is confronted by talks and papers having titles as (my excuses to those who have obviously spent a lot of time and effort doing, I am sure very useful, experimental and analytical research):

- *Excitation of electromagnetic waves in a one-dimensionally inhomogeneous environment by a localized, pulsed source*
- *The application of modern Fourier and functional integral methods to theoretical and computational problems in direct and inverse wave propagation modelling.*
- *Energy Densities Beyond Time-Frequency: Overview and Synthesis.*
- *Efficient Krylov subspace methods to compute functions of large sparse symmetric matrices.*
- *Velocity Optimization by Genetic Algorithm.*
- *Use of wavelet transform in seismic filtering.*
- *Parametric inversion for the prediction of sound pressure distributions in arbitrarily shaped enclosures.*
- *Finite Difference Modelling of Acoustic Wave Propagation with Losses: a space-convolutional approach.*
- *Characterizing the irregularity of measurements by means of the wavelet transform. A preliminary discussion on the implications of scaling/nondifferentiability on the dynamics of waves.*

The society therefore has started with a very impressive European Journal of Environmental and Engineering Geophysics under the editorship of a very charming Professor Angela Davis from the School of Ocean Sciences, University of Wales, Bangor. To quote what I think is the most pertinent statement of the journal's raison d'être: "the journal should be a means of communication between geophysicists and those who have to use geophysical data. It places particular emphasis on environmental, geotechnical, engineering and hydrological aspects, as well as soil- and rock-mechanical related properties.

The papers published in the journal should be understandable to *those who use geophysical data but are not necessarily geophysicists*". The italics are not mine but that of the journal: in other words they do not want papers from geophysicists who want to show off their computational dexterity nor papers related to hydrocarbon exploration. Hopefully the initiative of the EEGS will lessen the Cinderella status that shallow geophysics has within the field of site investigations especially when geophysics is used on land and in many cases also in over-water situations.

CATCH-22 FOR GEOPHYSICS

Geophysics is seldom included in site-investigation specifications; often because the few times it is used it has not added significantly to information that had been obtained through other methods. To put it more bluntly a "catch 22" situation governs the market position of geophysics in site investigation: either the work is carried out by operators who have a rudimentary knowledge of geophysics, or by geophysicists who are not familiar with the demands and requirements of site investigation practice (i.e. engineering geology).

In both instances the results of a geophysical survey are often pretty dismal and the civil engineer who has to make use of the results files them away in waste paper basket. Most of geophysical research in the Netherlands is aimed at the oil industry and, at most a luke warm effort is made to the less glamorous world of shallow geophysics in slack periods of oil exploration, hardly a satisfactory platform to encourage development in shallow geophysical site investigation.

SHELL RESEARCH UK: CHAMPIONS FOR SHALLOW GEOPHYSICS

To a certain extend, the conference at Nantes both substantiated and contradicted my foreboding. There were geophysicists from the Netherlands, surprisingly from the University of Utrecht, who I would have thought to be more interested in the esoteric world of deep geophysics extending to the centre of the earth.

A few papers were from the Netherlands. For example, a presentation on a case history showed some promising work by a small ground-radar survey company called Map Environmental Research BV from Arnhem. The papers looked at contaminant flow, especially from petrol stations. This was almost a direct response to V.T. Nguyen of the "Pervasive Technology Department" at Shell Research Ltd., in Thorton UK. He intimated that for LNAPL and DNAPL leakage geophysical methods should be used not only to define the extent of the contamination, but also its concentration. The Map Environmental Research paper was presented by Ms. P.H. Stam (v.d. Roest et al.) and seemed to produce the results Mr. Nguyen of Shell Research was asking for.

DUTCH CONTRIBUTIONS IN NANTES

There were only three other papers from the Netherlands: "Chirp survey of Ketelmeer contaminated sediments" from TU Delft/GeoCom, a promising paper from OYO CAG on "The use of Vibratory sources in shallow shear-wave investigations", and a paper from University of Utrecht/ TNO-IAG "Source-depth optimisation of high resolution seismics"

I recollect that OYO CAG had carried out a reflection survey on the sand bank in the Westerschelde as part of the site investigation for the Westerschelde Tunnel. Yet, despite such initiatives, little geophysics survey work has been done for the remainder of the tunnel using over-water seismic reflection profiling or for that matter along the underwater sections of the second Heinenoord Tunnel or the Botlek Railway Tunnel. Seismic reflection profiling had been carried out for the Channel Tunnel. Hence to start a correspondence column I would like to know from readers nearest to the fires involving site investigation why such (relatively inexpensive) have been not been, at least, tried?

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Book review

Large plastic deformations

C. Teodosiu, J.L. Raphanel, F. Sidoroff (editors), (1993), A.A. Balkema, Rotterdam/Brookfield. pp.475. ISBN 90 5410 3175. Price 185 NLG.

This book contains the proceedings of the fifth MECAMAT International Seminar, which took place at Fontainebleau (7-9 Aug'91). This seminar has the intention to promote a multidisciplinary approach in the Mechanics of Materials, both from a fundamental and from an applied perspective.

The book bundles 50 papers dealing with deformations of highly plastic metallic materials. The focus on large plastic deformations is in agreement with the title of the book. Since rocks are generally considered as brittle, the book has not so much relevance for rock mechanics and engineering geology. Nevertheless, we may often assume that the occurrence of many fractures in a rock, located in a relatively small-scale spatial volume, can be described by a kind of plasticity on scales that are larger than the fine scale. This is often called the "smeared crack" approximation, in which the large-scale geomechanical parameters are considered as "effective" parameters. For that case some theoretical contributions presented in the book may become relevant to rock mechanics too. Some theories might give insight into processes that occur also in rocks, or will offer paths to solutions of theoretical/numerical problems that play a part in rock mechanics.

To exemplify this, we mention a few topics discussed in the book:

1) The change of mechanical parameters, including induced anisotropy, caused by external loadings (Baltov; Hoinard & Franciosi; Jamal et al.; Luo & Mazilu; Prantil et al.). The change in parameter values by external loading may also be an important topic in seismics, where an accurate determination of the velocity field plays a key role. 2) Strain localization caused by softening material behaviour. In that case narrow bands of localized plastic shear are formed and gliding surfaces may even occur (Canova & Kubin; Theodosiu & Raphanel; Tomita & Mimura). Also "smeared crack" may be represented by softening.

3) Creep, or viscous flow processes (Doltsinis; Kouddane et al.). This type of rheology is not only important for the description of rocksalt, but also for the understanding of large geological deformations that have been formed during geological time scales.

4) How to use and improve numerical finite element approximations, and how to avoid unacceptably long computation times? (Bennani et al.; Makinouchi). One answer is to apply distributed computations on parallel hardware systems (Doltsinis). Also the question how to implement finite element grids moving with large displacements (Lagrangian finite elements) (Ghosh), is important for "after failure" geomechanics.

5) The description of finite plastic strains (Teodosiu et al.). In that case the stress tensor is no longer symmetric. This non-symmetry is in common with the Cosserat description of granular media (porous or fractured rock) that is often advocated and used in the context of borehole stability analyses.

6) The study of slip rotations (plastic spin concept) and shape changes of grain components in polycrystalline metals (Tokuda & Havlicek; Zaoui & Raphanel; McDowell et al.). Especially local-scale solutions in which the compatibility conditions are no longer satisfied at distinct "slip" surfaces are discussed to find explanations of the large-scale behaviour. Again there is some relationship with granular media, for which the Cosserat description holds.

To read the book, fluency in the "languages" of tensor analysis, partial differential equations and finite element methods (functional analysis) is of great help in understanding the message. From that point of view the book is a good example of the way the mechanical (steel) engineering community generally mixes the following three ingredients: (1) mathematical and numerical physics, (2) laboratory experiments, and (3) applications. In the "steel community" the balance is much more on the mathematical/numerical side than is common in the rock mechanical and engineering geology community.

Dr. Wouter Zijl, TNO Institute of Applied Geoscience, Department of Geo-Energy

In focus: Joost van der Schrier

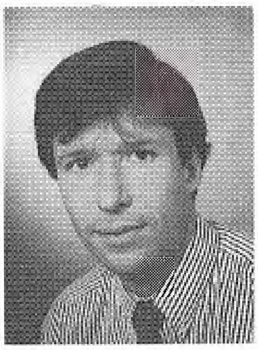
J. Dankelman & Y.van Velsen

Joost van der Schrier (34) started studying Engineering Geology in 1980 and graduated in 1988. After working at Delft Geotechnics for about seven years, he recently started to work at Haskoning Consulting Engineers and Architects.

Joost van der Schrier graduated on a new index test to determine rock strength and on a comparison between statically determined rock properties (in the laboratory) and dynamically determined rock properties (in the field) using a sonic log. For the latter study he received the study award 1988 of the Faculty of Mining and Petroleum Engineering.

In 1989, Joost joined Delft Geotechnics.The first one and a half year he was employed at a Research Division where he investigated the soil structure interactions developing during the boring of a small 3 m diameter tunnel using the finite element method.

He then worked for 3 years as a Consultant in one of Delft Geotechnics Operational Divisions. There he handled different types of projects (e.g. piled and raft foundations, tank foundations, sheet pile walls, etc.). In 1994 he became head of the Delft Geotechnics centrifuge. With this experimental facility he investigated complex 3D soil structure interactions using scale models (using a geotechnical centrifuge the acceleration of gravity acting on a small scale model is increased to obtain the correct (stress) boundary conditions; the stress-strain relationship of the soil is similar to the one in the prototype). Examples of experiments he worked on are the determination of the bearing capacity of an oil platform on dense sand under cyclic wave loading, the influence of tunnelling close to (displacement) piles, and the prediction of the face stability of a large tunnel boring machine in soft soil. The latter project was performed as a part of an important study started recently by the Centre for Underground Space Technology (the COB in Dutch). Together with participants from industry, building contractors, consultancy offices, the government, etc. a large tunnel boring project (Second Heinenoordtunnel) is monitored. With a diameter of 8.5 m., the Second Heinenoordtunnel is the first large diameter tunnel to be bored in the Netherlands (see the article on page 7 - ed.). In spite of the relative high costs, he believes that tunnelling (going underground) will be a serious alternative to be considered for the densely populated areas of the Netherlands. Of course the influence of under ground building onexisting and future infrastructure must be known.



Ir. Joost van der Schrier

Since two months Joost works for Haskoning Consulting Engineers and Architects. He wanted to go back into consultancy (instead of applied research). In his opinion Haskoning offers the opportunity to work on many interesting jobs (in the Netherlands and abroad). He hopes to stay involved in underground building projects as well.

The last one and a half years he is active in the board of the Ingeokring, keeping himself informed of the latest news in Engineering Geology. He believes that the study Engineering Geology offered a balanced chosen set of course options. An Engineering Geologist is in general capable of overseeing a full project (although a little more knowledge of construction engineering should be helpful). An engineering geologist is trained to think for himself and he understands the importance of a proper soil investigation programme. For instance, he specializes himself in the schematization from prototype to calculation model, taking every possible failure mechanism into account and using the correct input parameters while checking for "snakes in the grass". The broad education possibilities gives the oncoming Engineering Geologist the opportunity to plan his own career (in the field in stead of only at a desk). You will find your future colleagues working in different companies in many disciplines and technologies.

Visit to the first bored tunnel in the Netherlands: The second Heinenoord Tunnel

P.M. Maurenbrecher, Delft University of Technology, Faculty of Applied Earth Sciences, Section Engineering Geology, PO Box 5028, 2600 GA, Delft.

The Netherlands has been known internationally for their tunnel projects. Dutch contractors have constructed tunnels in Boston, USA and Medway, England are two examples of recently completed projects. The latest project involving Dutch tunnel contracting is for the Øresund bridge and tunnel project connecting Denmark to Sweden. These tunnels, though, are all of the immersed type: large caissons are floated into place, sunk into a dredged channel and then covered over with ballast. The Netherlands cannot even claim that they were the first to construct tunnels in this way, but they do export this tunnel technology. For the first time the Netherlands is now embarking on large diameter bored tunnels. Interest in this tunnel technique has resulted primarily in the proposed tunnel under the Westerschelde, the estuary of the Schelde River from the Port of Antwerp. In urban centres this type of tunnelling is thought to be even more advantageous as it reduces the extensive disruption which is caused by the cut and cover/sunken tunnel method. When disruption costing is made, it soon becomes apparent that bored tunnels would be no more expensive then the cut and cover, or put it conversely: the industry, commerce and those living along a proposed tunnel route had to suffer not only the disruption but also the financial consequences. Since then, probably due to the continual disruption construction seems to cause in urban centres, tolerance and goodwill have substantially diminished by those living or working along a proposed route for transport or utilities. Hence, the option to keep the works as much as possible hidden from view, means making use of bored tunnels.

INTRODUCTION

Bored tunnels in the very soft and loose sediments of the Netherlands seemed to be almost an impossibility, though having seen such tunnels being made in Japan meant that bored techniques would have to be a serious option for proposed new tunnels. Many new schemes exist in the Netherlands from High Speed Railway line development, new rail lines to service the industrial heartland of Germany from Rotterdam and metro lines in Amsterdam so that the new technology could not have come at a more opportune moment. Surprisingly it is being tried out for the second Heinenoord tunnel to alleviate congestion through the first tunnel (sunken modules). Heinenoord, though is an ideal location (see location figure 1) for a sunken tunnel as the bored tunnel costs cannot be offset as there is no urban area to contend with; only river traffic (which could use alternative routes) is not disrupted. A bored tunnel further needs to be deeper which means a longer section underground and longer or steeper approach ramps; especially disadvantageous for the "slow" traffic the tunnel is intended for: pedestrians, cyclists and agricultural traffic. So why a bored tunnel? Both the IngeoKring and the Netherlands Member's Association of the Institution of Civil Engineers payed visits on the 25th and the 28th of October to find out why. Read on!

A BORED TUNNEL WAS CHOSEN BECAUSE IT WAS DEEMED A PRACTICE PROJECT

The question posed in the introduction and answered in the subtitle was given by Ms. Martien de Boer, who is with the Tunnelcombinatie Heinenoord and explained by way of introduction that the objective of the project was not only to ensure a transport tunnel connecting the river banks of the Oude Maas but to develop knowledge and experience about the use of bored tunnels in the soft and loose soils of the Netherlands. Despite the project costing more than the traditional cut and cover methods (and

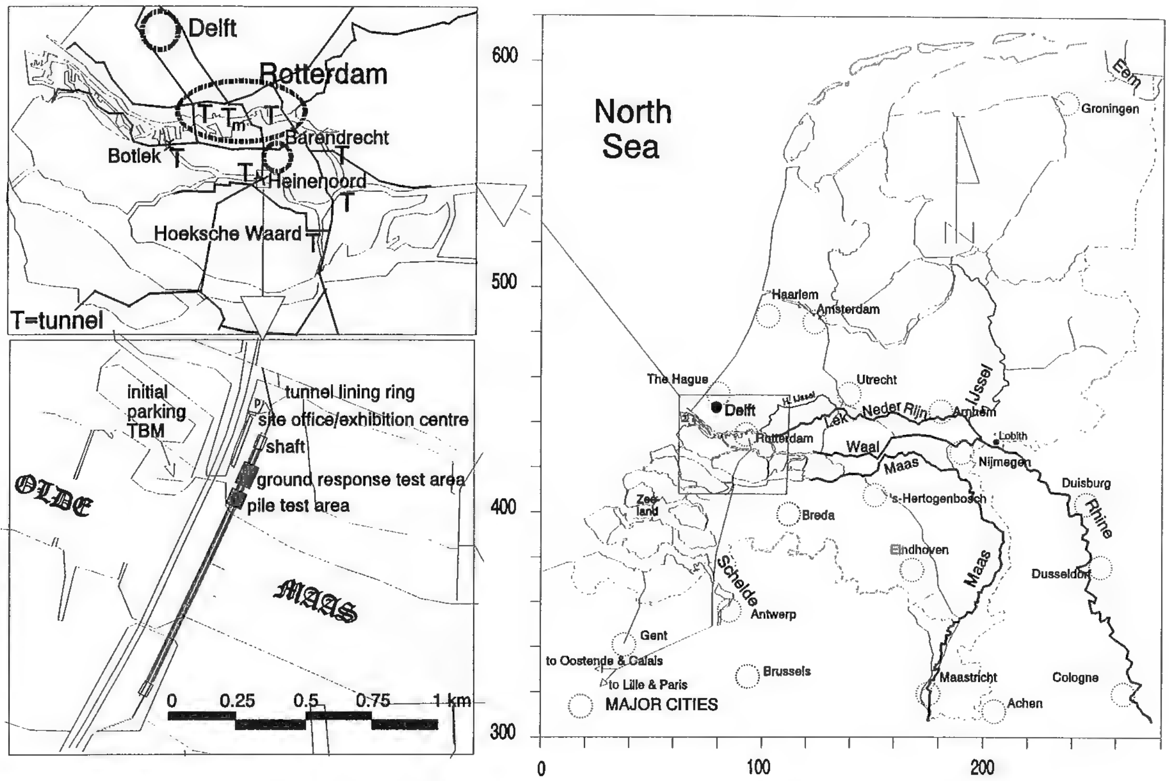


Figure 1 Location and plan of the Heinenoord tunnels including tunnel location around Rotterdam.

variations thereof) the choice of a bored tunnel was made on the basis of developing expertise on soft ground bored tunnels.

The organisations that are involved as clients, financiers, consultants, contractors and researchers are more numerous than such projects usually entail: Rijkswaterstaat (Public Works Department) is the client and the project is supervised by the Rijkswaterstaat section Bouwdienst (Construction).

Four contractors have formed a construction consortium called Tunnelcombinatie Heinenoord (TCH) consisting of Ballast Nedam Beton en Waterbouw BV, Van Hattum en Blankevoort BV, Hollandse Beton en Waterbouw BV and Wayss und Freytag AG. The research is carried out on the auspices of COB (Centrum Ondergronds Bouwen). COB finances and coordinates the research; the research is done essentially by

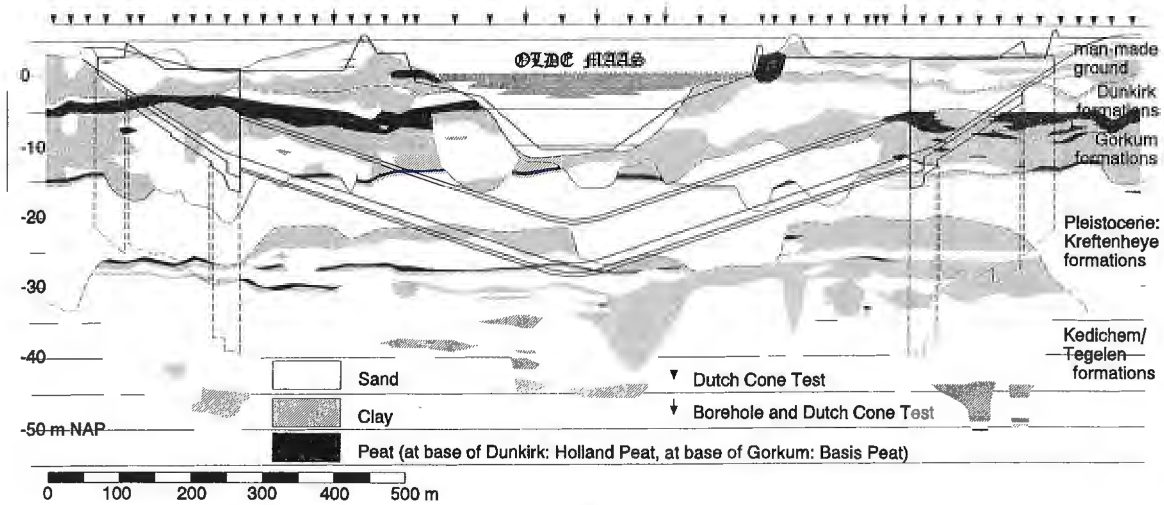


Figure 2 Geological profile and outline of second Heinenoord tunnel (note: anchor pile depths outlined beneath tunnel shaft and ramps).

Grondmechanica Delft, Holland Railconsult, Gemeentewerken Rotterdam, TNO-Bouw (Building and Construction Research) and Fugro Geotechnical Engineers. The actual tunnel bore machine, a slurry shield, has been constructed by Herrenknecht GmbH.

The ground the shield goes through is 80% sand and 20% clay and peat (see figure 2). In this material piles have been placed; they are to represent the Amsterdam foundations for the North- South metro-line tunnel bore project. In another test area, between the pile area and the tunnel portal, careful measurements are made of settlements, soil deformations and changes in insitu earth and pore-water pressures (figure 3). Actual piles that form an integral part of the structure are used to counter the buoyancy of the tunnel approach ramps and the access shaft floor.

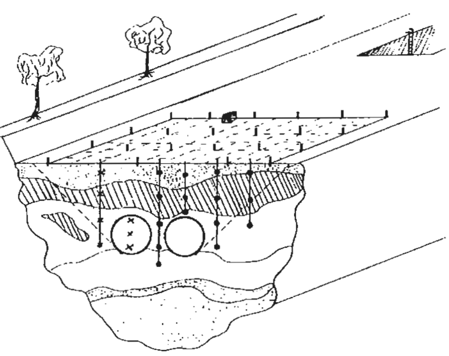


Figure 3 concept lay-out of the test area, in-situ earth and porewater pressure and subsidence marks on the surface.

Such projects increasingly become a social-communication exercise despite the Heinenoord tunnel being located in a rural location causing very little disruption. Communication skills probably ensure the success or failure of a project rather than a good design! This involves the rural inhabitants around the Heinenoord Tunnel in discussions, readily available readable literature, even use, these days of Internet (http://www.bouwweb.nl/CUR).

The second Heinenoord Tunnel is to solve the extensive queue formation during rush hours. This will be done by transferring the slow, local traffic into the new tunnel; essentially pedestrians, cyclists and farm traffic. The slow traffic does not need a large diameter tunnel and hence a relatively small 8m diameter tunnel could be built. Two extra lanes would then become available in the existing Heinenoord tunnel.

The tunnel carries nearly all the traffic from the province of Zeeland into the province of South and North Holland (for Rotterdam, The Hague and Amsterdam). Increasingly traffic syphoned off at Antwerp will also be directed through this tunnel as an alternative faster route from western Belgium (i.e. traffic coming from Paris, Gent, Brugge, Oostende and Calais) to Rotterdam.

Martiene concluded that besides the novelty of using boring techniques, other innovations are the great care taken to make the tunnel precinct feel safe for its users especially pedestrians and cyclists. This is achieved through use of glass partitions to keep people visible and let in as much light as well as the use of video cameras which are monitored by the tunnel operator.

Inevitably on concluding her talk questions were made on technical aspects, of which the subject matter would be covered by subsequent speakers. i.e. The TBM consists of a slurry shield type which consists of a front cutter chamber using bentonite to support the predominantly sandy face and to transport the excavated soil hydraulically to filtration screens at the surface to separate the soil from the bentonite (see figure 4). A scale model is shown of the TBM in the exhibition centre. The present phase of the work consists of the imminent building in and assembly of the TBM in the north shaft. Cost of the project is *f*250m out of which *f*150 is for the contractor and *f*40 for Herrenknecht TBM.

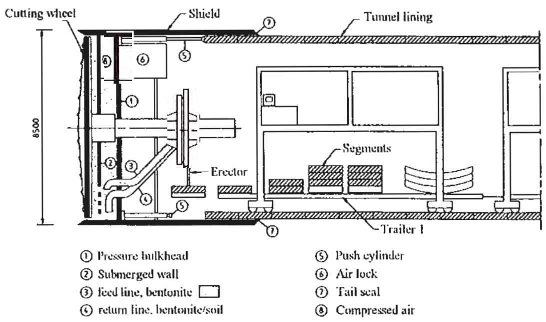


Figure 4 schematic section of a slurry shield Tunnel Boring Machine.

THE EXHIBITION AND SITE VISIT

A coffee break with a visit to the adjoining exhibition room was next on the programme. Several video shows with themes relating to underground space were already being studied by the non-Dutch speaking visitors (the videos can be listened to in Dutch and English). One video, whose theme has to do with strategic perspective in the use and requirements of underground space for the next 20 to 30 years, features Prof. H.P.S. van Lohuizen, member of Ingeokring and past member of the IngeoKring committee. He had taken many initiatives to establish underground space development in the Netherlands which resulted amongst others in the chair of underground construction, occupied by Prof. E. Horvat. He also features in the videos, as well as some AIOs of Policy Analysis and Systems Engineering (TU Delft), who participated in the excursion.

The exhibition was followed by a visit to the pile - tunnel interaction test site and the temporary parking site for the TBM modules. Initially a short stop was made for a photo opportunity in the tunnel lining ring guarding the wooden barracks which house the exhibition centre and the site offices of the tunnel staff (see also figure 8). Each cylindrical ring varies slightly in length along its perimeter. The alignment of the tunnel is made by rotating each cylinder with respect to the previous cylinder. The amount of rotation (up to a maximum limit) will give the required alignment. The steering of the TBM will depend on alignment requirements as well as any divergence the TBM makes (due to settlement or buoyancy lift). Rings alternate as well in the set of elements from which they are assembled to make sure that the joints are staggered from one ring to the next to increase both tunnel lining rigidity and strength. Special bolts are used to properly secure the lining against the previous lining and an estimated 6 m^3 grout is injected through precast nozzle ducts to minimize subsidence resulting from relaxation of the earth as the shield moves forward to allow the ground to relax against the lining.

The aspects of the site are sketched in figure 1. The pile test area shows a cross beam superstructure used to both load the piles to their equivalent working loads and use to measure displacements. The piles, precast concrete and wooden driven piles reflect those commonly found in Amsterdam were already installed. Instrumentation was still in progress for the piles (carried out by Prof. A.F. van Weele's company IFCO) as was the installation of inclinometers and settlement gauges in the tunnel-soil displacement test area. The visit must have been the only opportunity to inspect at close quarters the various modules making up the TBM. Parts were lying under tarpaulin. The shield and rotary-cutter chamber were facing in such a way that they appeared to be set up to drill vertically downwards (figure 5).

WHY ARE RAILWAYS INVOLVED AT HEINENOORD?

The exhibition and site visit interlude was

***Figure 5** Part of the TBM appears to be set up to drill vertically downwards.*

followed by the second presentation by Ing. Eric Kwast of Holland Railconsult. Readers must be asking why Railconsult? The tunnels at Heinenoord are not for railways but the participation of Railconsult on this project is in anticipation of the Netherlands Railways proposed bored-tunnel at Botlek further downstream so that performance and ground and pile response to tunnelling is of interest to them. The piles reflect those of Amsterdam: this is in anticipation of a bored tunnel for the proposed North-South metro line for Amsterdam. In fact some of the sand was removed at the pile test area and replaced with peat to correspond to Amsterdam soil conditions. This was despite the fact that substantial peat deposits exist at the southern landfall. Eric works for two days a week on this project and is funded by COB (Centrum Ondergronds Bouwen). Hence the type of information he is interested in is the bore-front efficiency based on horizontal and vertical ground deformations, soil and pore water pressure changes, forces on the tunnel lining, and the magnitude and persistence of vibrations that may develop.

The type of instrumentation within the TBM should measure bentonite pressure, density of the bentonite, feeding and removal pressures, wear of cutter heads, rotation speeds, hydraulic jack forces, forward speed & flow rates of bentonite (figure 6). The tunnel lining is also instrumented to measure the ground forces and transfer of hydraulic jack forces. Expected settlement is of the order of 2 to 4 cm over a two year period.

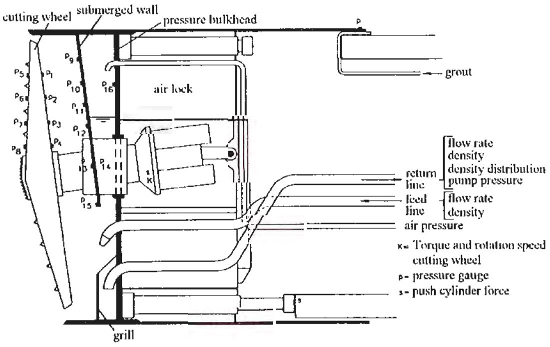


Figure 6 *Schematic overview of the total instrumention in the TBM.*

ROTARY BORING AND ROTARY MODEL TESTING?

Ir. Joost van der Schrier concluded the days presentation (he also introduced the days programme for those travelling in by coach). Joost now works at Haskoning but presented results from work he had done with his former employers, Delft Geotechnics. There he had carried out centrifuge model tests to investigate tunnel-pile interaction. Joost has discussed much of his work in a previous publication "Overview of engineering geology in the Netherlands" a symposium organised by the DIG (students chapter engineering geology at Delft, Schrier et al, 1993). Joost put the question: model testing, why? Though a great deal can be simulated by finite element methods (see proceedings meeting "Geotechnische aspecten en rekentechnieken boortunnels", KIvI 1995) model testing can be regarded as a preliminary stage to the real scale situation in order not only to have a comparison with numerical models but helps develop techniques to be used for instrumentation. The centrifuge model also can investigate more complex situations such as what happens if collapse of the tunnel face occurs. A more comprehensive report on centrifuge testing is that compiled by CUR (Civil Engineering Centre for carrying out research and guidelines) CUR-CIE C-89 "influence of bore-tunnels on pile foundations" (summary given in KIvI, 1995). In the summary Joost (he wrote it) says the research results show that when the pile foundations are less than 2 m from the tunnel casing they are substantially influenced by settlement. From 2 m to 6 m the influence is variable and depends on the size of the volume decrease resulting from the tunnel operation. Over 13 m distance the influence of the tunnel does not affect the pile. We will soon see if this is so!

The IngeoKring visit started and ended with Joost van Schrier who played several functions: organised and arranged the meeting, acted as guide on the bus from Delft to Heinenoord, gave the introductions, collected the dues from the visitors as IngeoKring treasurer and, finally, gave a presentation. Robert Hack, the chairman of the IngeoKring thanked Joost for these efforts and, of course all the other speakers and guides who made this (inaugural?) visit a very worthwhile occasion, the more so, judging by the large number of visitors who attended.

A SUBSEQUENT VISIT:

Only four days later a second visit was payed, this time under the auspices of the Netherlands Association of Members of the Institution of Civil Engineers. This latter visit could have been combined with the earlier but because there too a substantial interest was shown by its members and associates (KIvI Afdeling Bouw and Waterbouw) and that there were different speakers, the two meeting were thus kept separate. (There have been successful combined meetings in the past!). The slightly earlier time of the NL ICE meeting meant that the exhibition centre was still shut in less favourable weather conditions than for the IngeoKring visit. The doors soon opened and, having savoured the fresh air longer than anticipated, meant that for the early arrivals the coffee tasted all the better.

INFRASTRUCTURE AND LOGISTICS OF THE HEINENOORD TUNNEL

The meeting was opened by Ing. Freek Wermer of the Bouwdienst, Rijkswaterstaat. He gave the general history leading up the present project outlining especially the design options. The Heinenoord tunnel connects Rotterdam with the Island of Hoeksewaard. Congestion in the tunnel is often the result of slow (agricultural, cyclists and pedestrians) and rapid traffic using the same facility. The tunnel arrangements over the years is shown in figure 7.

The time table is follows:
1989 Start investigating design variants.
1990 Submission proposals by contractors including alternative designs (all sunken tunnel versions); prices exceed funds.
1992 Combination High Speed Railway considered, but procedures to incorporate rail traffic could not be resolved.
1994 Government funding underground space and bored tunnels created impulse to restart Heinenoord second tunnel.
1995 project started.
1995 December completion North Shaft.
1996 November-1997 January Install Herrenknecht TBM (in progress during second visit) End January the Minister of Public Works will switch on .
1997 Bore from North to South (10m daily, 24hrs each day for five days each week; weekends for maintenance TBM).
1998 January to 1999 February for completion of works.
1999 June Project to be realised: handover date.

The Government made funding available for two trial projects: the Heinenoord and Botlek (see situation map figure 1). As both tunnels were as good as agreed to, they could start immediately, any financial holdups were removed as funding for bored tunnels became available. The Heinenoord location was also suited because it is in open country: minimum disturbance could be caused due to subsidence and plenty of space for setting up trials.

Design studies had to take into consideration:
- Restrictions from the groundwater company which did not allow dewatering.
- Economic support of users; to what extent is the tunnel economically viable.

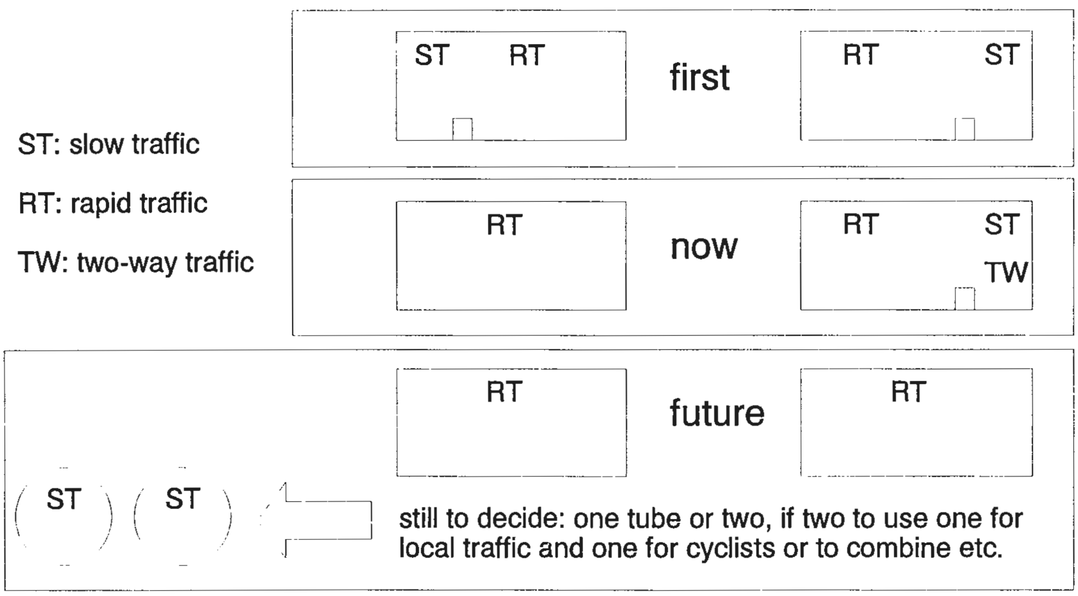


Figure 7 *Traffic configuration through first and second Heinenoord tunnels at various stages of use and development*

- Risk analysis especially with respect to geotechnical conditions.
- Requirements of users' organizations (The Netherlands Cycle Bond, the local agricultural association, environment preservation groups.
- Information exchanges with municipalities in which the tunnel location occurs within their boundaries
- Drainage authorities (waterschappen and other departments of the State Public Works Authority- the Rijkswaterstaat) responsible for flood defences and navigation: the risk of dyke subsidence was minimized by choosing two 8.5 m diameter tunnels instead of one 11.5 m tunnel.

In the latter consideration a deeper tunnel was required for the 11.5 m which made it less attractive for the cyclists and pedestrians as well as requiring even longer ramps for the agricultural traffic, resulting in no saving in costs over two 8.3 diameter tunnels.

Discussions with the users organizations resulted in the use of one tunnel for the cyclists and pedestrians and the other for the farm traffic. This would not only increase safety but also offer a greater sense of security, reduce fumes, and save expense in having to "decorate" both tunnel linings to give them a pleasing impression to the users.

The design was based on a set of calculation rules set out in the COB-project K 100 document and COB Commission L500) (Bakker and Leendertse, 1996; van der Put et al, 1996).

Essentially the design is based on input parameters expected values resulting in a parametric-type analysis rather than making use of factors of safety. The intention is on conclusion of the project to publish the design criteria and methods in a bored tunnel design handbook. The design is also subjected to scrutiny by architects to check that hidden nooks or crannies offering hiding places for malevolent undesirables. Use is made of lots of glass such as for the lift shaft and the lift cage wall and door panels. On completion a TV monitoring system will be installed for safety and security.

Following the design the contract and specification were compiled in which the main incentive to complete the work in advance is to offer a bonus which becomes less as the contract time limit is reached.

The tunnel is 2350 m long of which 950 m is bored. The shaft is 35 m and 165 m length is for the access ramp. Internal and outer diameters are 7.6 m and 8.3 m respectively of which the tunnel lining is 35 m thick . The base of the tunnel is at -11.5 m NAP (New Amsterdam Level: about 0.5 m less than present average sea level) at the entrance and -26.5 m at he deepest-mid stream point. The gradient of the tunnel is 1:30 and the access ramps are 1:15. A mat filtercloth overlain with ballast overburden is used over the tunnel route on the river bed to add and maintain a counter-buoyancy weight.

The scheme is designated a "Practice (Test) Project". By this is meant a project that will add valuable experience and knowledge by trying out new technologies. This thus implies that alternative cheaper schemes such as immersed tube tunnels would not have to be implemented based on EU open tendering regulations as the objective of the scheme is broader than just establishing an underground thoroughfare. The cost of the scheme (exclusive VAT) is ƒ150m which is made up of the following items:

ƒ23m for groundworks and piling
ƒ8m concreting
ƒ61m Basic components TBM
ƒ13m Assembly and installation TBM
ƒ13m Utility (technical equipment) installations
ƒ32m for contingencies and smaller items

Freek completed his presentation by giving more details of the time-table and fielded some questions from the audience in which following extra subject matter was addressed:

There were no cross-connections between the tubes though this would add to safety. However, the separation of traffic and low risks involved in the type of traffic give such a low chance of calamities, that it is considered unnecessary. Although, in a Practice Project perspective it would have been interesting to include these in the design. A more horizontal tunnel would have been more ideal so that cyclists and pedestrians can see the tunnel exits: this would have meant even deeper shafts and longer ramps.

To prevent cyclists using the tractor tunnel special deterrent paving is used. Ventilation is provided in the cyclists' tunnel.

The Maas tunnel (location see T_m on insert map figure 1) is the first tunnel in the Netherlands also has pedestrian and cyclist facilities. Because of increasing criminality in Rotterdam the facilities were hardly being used. The tunnel operators now employ 72 tunnel monitors to stop junkies and other undesirables from loitering and maintaining discipline which has resulted in a resurgence in the use of the tunnel facility. The Heinenoord tunnel is in a rural setting so that there is less chance of criminal occupation. The TV facilities

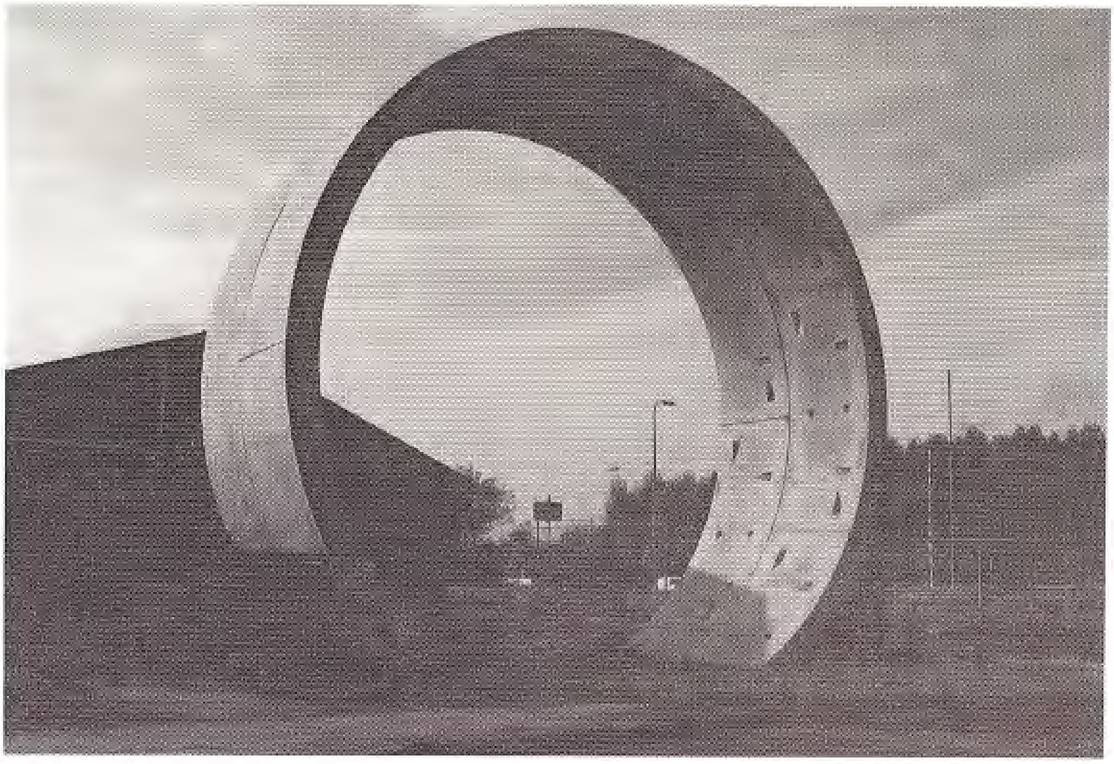


Figure 8 *Two rings of tunnel lining segments guard the exhibition centre*

are there to deter undesirables and give the user a sense of security.

THE DESIGN OF A LOOSE GROUND TBM AND THE TUNNEL THAT FOLLOWS

The second presentation was given by Arjan van der Put also employed at the Bouwdienst of the Rijkswaterstaat in which he outlined the design criteria used to design the TBM and the tunnel.

The site investigation geotechnical parameters governed the TBM design: a geotechnical profile was obtained from boreholes and CPT at 25m (over land) and at 50m (over water) spacing (see figure 2). From the CPTs and the boreholes through laboratory tests the soil stiffness and densities, amongst others, were determined.

Tunnel design requirements and methods:
- diameter tunnel
- thickness of tunnel lining
- minimum soil cover (taken at about equal to the tunnel diameter),
- TBM departure and arrival into north and south shafts respectively required constructing a double sheet pile wall and infilling the space between with a sand cement mixture weak enough for the TBM to cope with. The outer sheet piles are removed once the cross-over mix has set. A hole is cut through the inner sheet piles to allow the TBM to depart.
- Hydraulic jacks require sufficient reaction force on the tunnel lining segments. This demands a close tolerance so that the lining segment rings fit snugly to ensure a proper transfer of the jacking forces. Use is made of rubber strips, almost cellular in structure, to ensure they can deform to form a water tight fit. The ring ends have spacers to take up the first load when the jacks are applied so that gradually the complete ring face come into contact to take up the full jacking load and so prevent cracks forming due to stress concentrations.
- the amount of segments in the ring or mantle should be get to a minimum to ensure maximum stiffness, minimum handling operations and size and weight that can be easily handled in transportation and installation in confined space. Seven elements were found to be optimum, the key closure wedge element being kept near the apex to facilitate the ring assembly (see also figure 8).
- The elements rings perimeter edges are not parallel (see earlier explanation for steering the TBM). Arjan suggested cut a remainder cardboard of a toilet roll at an angle, by twisting the toilet roll it starts to make a bend.
- Strukton constructs the elements using 32 molds of which 16 different elements are cast.

- A conveyor system/assembly plant system is used for the manufacture of the tunnel elements. The elements are stored at the factory of which a smaller buffer is stored on site.
- For the structural calculations to determine the force and stress distributions a model was used consisting of discreet spring supports at the ring liner edges representing the elastic support of the surrounding ground. The calculations determine the deformation that could occur and the stresses applied on the lining. The elastic or bedding constants of the springs are based on the depth of the tunnel. (see further van der Put et al. 1996).
- Other loading scenarios were modelled, such as the sinking of a fully loaded ship over the tunnel.

THE CHOICE OF TBM

Two types of machine are used to bore in soils: the Earth Pressure Balance shield and the Slurry Shield or Hydroshield. In the EPB the soil, usually cohesive is gradually removed after being loosened by the cutting wheel by an Archimedes screw and then on to a conveyor belt for disposal. In sands Arjan suggested the concept of a "heap of marbles". Such a heap would soon collapse as marbles, in all probability, will start rolling. This may be also the case with sands at the tunnel face so that the excavation chamber may fill rapidly through this phenomena. Hence the use of slurry, usually a bentonite/water suspension, will support the loose sands. As the sand is scraped by the rotating cutter arms and mixed with the bentonite the rich sand-bentonite mixture sinks to the base of the excavation chamber where it is hydraulically displaced into the exit valve at the base of the TBM face by bentonite slurry entering through a nozzle higher up (see figure 4 for details). The sand-bentonite mixture is separated in the separation plant at the surface, which allows much of the bentonite to be recycled.

Following the excavation chamber are the hydraulic jacks to push the TBM forward, of which each jack can exert up to 300 kN. The tunnel lining erector plant follows the jacks. Three trailers are towed by the shield to supply all the material and power. The first trailer contains hydraulic pumps, the pilot's cabin and the canteen. The second trailer has the bentonite pumps and power unit. The third trailer contains the extension pipes for the bentonite supply.

The alignment is continuously monitored and through a computer programme the next ten elements for the lining ring are chosen to make sure the tunnel remains or steered back on course. Further monitoring automatically adjusts any loss in pressure at the tunnel face. Pressure is determined and maintained through an air cushion

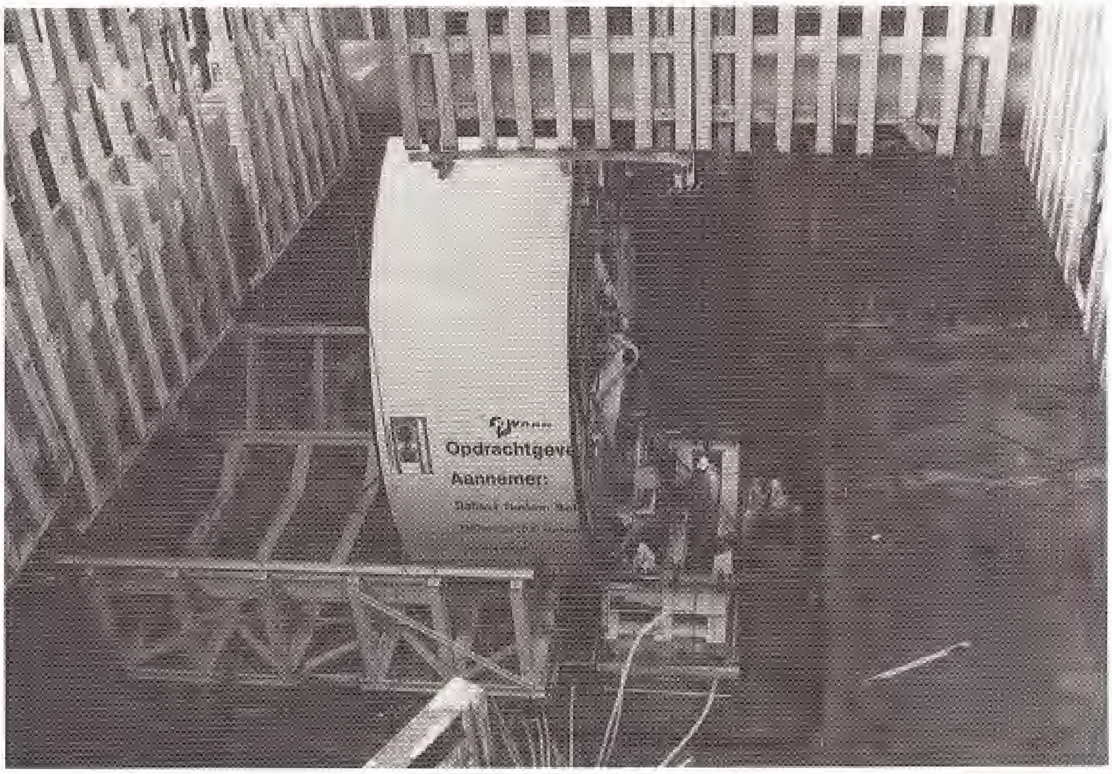


Figure 9 Part of the TBM set up in the s‹art pit

situated behind the submerged wall of the TBM excavation chamber.

With this wealth of information on tunnel and TBM design Arjan completed his talk though he too had to field one or two questions on prevention of settlement: To fill the space left by the advancing shield and the newly place lining grout is injected through six ducts along the periphery of the lining rings. Should subsequent settlement occur Arjan suggested that overburden ballast would have to be removed to increase the buoyancy of the tunnel to force it to rise.

Safety consists of a sprinkler system for fire. Almost all items have double components so that failure will mean a back-up exists to allow work to continue.

The speakers were both thanked for their inaugural presentations and much appreciated by the guests who came to witness this occasion. To bring their own presentation exertions back into balance, after all we humans are all fluid pressure balance machines, they were rewarded with a further token of appreciation: a good bottle of claret.

A SECOND SITE-WALK-ABOUT

The talks were followed by a site visit which pursued a different course to the previous visit. The first stop was the shaft pit where activity centred around a large crane in the process of lowering the TBM components. The two legs of the crane closest to the pit are founded on specially installed piles to minimise the pressures on the walls. The first section of the shield had been lowered into the pit (figure 9). A spray of sparks signalled that workmen were busy with their oxy-acetylene burners cutting the departure portal in the sheet piles for the TBM.

Behind the shaft pit complex a fenced area represented the test area for determining earth pressures and displacements through insitu instrumentation. Fugro Geotechnical drilling equipment was on site for making boreholes to instal inclinometers and settlement gauges. Behind the fenced area was the test area for the piles which had been visited a few days earlier by the IngeoKring group.

The full day visit (as it turned out to be adding the two separate mornings together) was hereby concluded. A bibliographic list is attached giving more technical back-up to the general report on the site visits.

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Research visit to the Disaster Prevention Research Institute (DPRI), Kyoto

Ir. A. den Outer, Delft University of Technology, Faculty of Applied Earth Sciences, PO box 5028, 2600 GA Delft.

Liquefaction has played a role during the 1992 Roermond earthquake. In order to estimate the significance of liquefaction in relation to damage to structures in the Netherlands, more knowledge is necessary to establish the liquefaction potential for Dutch soils. A research visit to the DPRI in Kyoto, Japan, has improved the knowledge on the way individual parameters influence the final liquefaction potential. Centrifuge testing has been carried out, measuring movement, accelerations, porewater and soil pressures, to study the effect liquefaction on failure of gravity quay walls in the Kobe Harbour during the 1995 Hyogoken-Nanbu earthquake. During the preparation of the scale models it became clear which parameters could easily be controlled. The research continued after the research visit and updates of the result are still supporting the understanding of liquefaction for application in the Netherlands.

INTRODUCTION

During the 1992 Roermond earthquake in the Netherlands proof has been found that subsurface liquefaction has taken place. Sand vents have been observed as linear features in the field (Nieuwenhuis 1994, Davenport et al 1994), as a result from overpressure in the liquefying layer and upward movement of the liquefied sand through a approx. 2 m. thick firm clay layer.

A follow-up study of this phenomena took place from late 1995 till June 1996. A detailed study on the liquefaction potential of the layers present in the subsurface of the research area (Manzano 1996) (Herkenbosch, near Roermond) showed that the predicted liquefaction potential of those layers, that proved to have liquefied, was too low. This resulted in the conclusion that either the foreign empirical formula's used in the study do not apply for this area or the estimated a_{max}, given in the literature and derived from attenuation models and intensity estimates, was underestimated.

The discrepancy between the calculations and observations shows that determining the significance of liquefaction in the Netherlands, which is a main cause of damage during earthquakes, is not an easy task and needs further investigation. Due to the lack of information on seismicity, soil properties and measurements of soil behaviour during earthquakes, it is nearly impossible to derive new empirical liquefaction potential formulae for the Dutch environment.

To be able to adjust existing formulae to the Dutch situation a proper understanding of the liquefaction phenomena has to be obtained. Especially the individual contribution of each parameter in the final liquefaction potential assessment is important. If the significance of the parameter is high than this parameter has to be measured with a high accuracy and vice versa. In laboratory experiments additional data on the behaviour of soils during dynamic loading cycles might be obtained. However, a proper empirical relation can only be established if the significant parameters can be controlled with high accuracy.

During the research visit to the DPRI this particular knowledge, controlling the parameters during experiments, has been improved as a result of actually participating in carrying out a series of dynamic centrifuge experiments.

DISASTER PREVENTION RESEARCH INSTITUTE (DPRI)

The frequent occurrence of natural disasters in Japan has forced the them to establish a well organised platform for research in the field of natural hazard investigation and mitigation. Communication during the recent annual meeting of the Engineering Geological Group of the Geological Society in Coventry (Maund et al 1996) showed that in Europe such a platform is just developing, and even then for large parts focusing on applications abroad. The Disaster Prevention Research Institute is only one of many government organisations capable of executing long term research programs, as well as responding to sudden disastrous events.

Within the institute, which is closely co-operates with Kyoto University, quite a number of chairs and research sections have been defined for 5 fields (Adachi 1995): (1) Structural Engineering, (2) Hydraulics, (3) Soil Mechanics, (4) Planning and Transportation Engineering, (5) Environmental and Sanitary Engineering. These fields cover very well the science related to the numerous types of natural hazards known to Japan: Hurricanes, storm surges, flooding by the sea or rivers, landslides and rock fall and not the least earthquakes.

The department of Geomechanics is part of the field of Soil Mechanics and focuses in general on slope failure mechanisms and prevention, the evaluation of ground improvement techniques, geotechnical management and utilisation of waste, engineering properties of seabed deposits, deformation analysis of marine clay (major soil type in the off-shore Kobe area) foundations and the development and application of the RI cone penetrometer (determination of natural water content and wet density). The second research area studies not only the possibilities of ground improvement for civil engineering works, but the changes in ground conditions as a result of weathering or acid rain as well. Durability of improved soil below road-alignments is investigated on laboratory and field scale.

During and after major disasters like the Hyogoken-Nanbu earthquake, research has been focussed towards supporting a quick response to the disaster and preventing future damage from similar disasters. In the case of the department of Geomechanics the soil improvement theme was applied to the study of the behaviour of quay walls in the Kobe harbour, during and after the earthquake. The effect of soil properties, e.g. liquefaction potential, on the behaviour of the dam are quantified and used to improve dam design, other than just over-dimensioning.

HYOGOKEN-NANBU EARTHQUAKE

The most recent disastrous event in Japan was undoubtedly the Hyogoken-Nanbu earthquake of January 17th 1995, in the Kobe area. Over 5000 people were killed during that event and tens of thousands of people lost their houses. The event had a Richter magnitude of 7.2, which released 30 times more energy than the maximum expected earthquake for the Roer-Valley-Graben ($M_L = 6.25$ (Rosenhauer & Ahorner 1994)), and a comparable focal depth of 14 km (JGS 1996). The observed epicentral intensity was VI-VII on the Japanese Meteorological Agency scale (JMA), which is comparable to IX on the European Macroseismic Scale (EMS) (Grünthal 1993). The maximum expected epicentral intensity for the Roer-Graben-Valley is EMS VIII (de Crook 1996), resulting in epicentral accelerations about 3 times less than those in Kobe harbour.

During the 1995 Hyogoken-Nanbu earthquake all of the 186 quay walls in Kobe harbour were damaged. In a short period 82 of the quay walls have been repaired, sometimes only using temporary measures. In total 88 quay walls could not be repaired, which resulted in a major impact on the serviceability of the Kobe harbour. The prospect of total rehabilitation to the situation before the Kobe earthquake is 2 years (Kimura 1996). The productivity growth of the Kobe harbour area has been delayed permanently.

Loss of serviceability of the quay walls and the related economical damage has been the main reason for a large investigation of the behaviour of the quay walls during the earthquake and the influence of liquefaction on the changes in soil pressures on the quay wall.

DYNAMIC CENTRIFUGE TESTING

For centrifuge testing in general, scaling laws apply for a physical properties of the soil and porefluid, as well as the dimensions of the model. In table 1.1 the scale factors for the main parameters are expressed as function of N-times the gravitational acceleration (Kita 1994).

***Table I** Scale factors in relation to centrifugal acceleration.*

Parameter	Scale Factor
Centrifugal Acceleration (times g)	R
Length	1/R
Density	1
Porosity	1
Stress and Strength	1
Strain	1
Strain Rate	R
Displacement	1/R
Velocity	1
Acceleration	R
Time period of vibration	1/R
Permeability	1
Viscosity	R

In liquefaction analysis especially the properties and behaviour of the soil/fluid-matrix should be

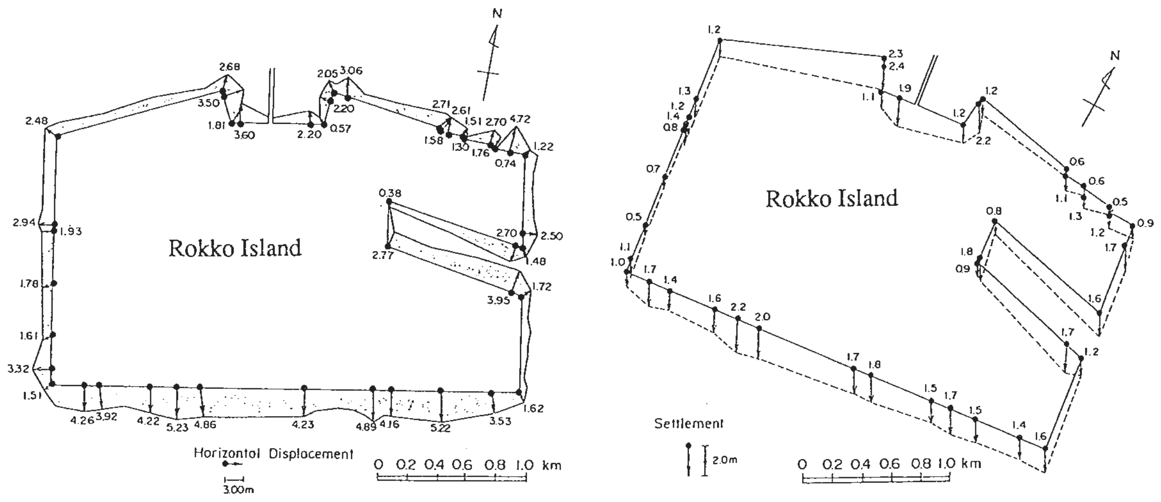

Figure 1 Horizontal and vertical movement of quaywalls on Rokko Island (after Inagaki et al 1996)..

comparable to the behaviour under 1*g* conditions. Specifications for the fluid have been defined by Delft Geotechnics (Allard and Schenkelveld 1994), considering the scale factor for density and viscosity, the mechanical properties and the handling and use of fluids. Specially designed silicon oil is often used as a substitute of water in centrifuge modelling.

The centrifuge tests have been used extensively for static loading or rapid loading conditions for a long time, but only for just over ten years dynamic centrifuge tests have successfully been carried out (Lambe & Whitman 1985), be it with limited frequencies and yet without comparison with the original behaviour of the model in the ordinary gravitational field.

The dynamic centrifuge tests make it necessary to define more boundary conditions in order to have a comparable behaviour of the scaled model and the ordinary model. The scaling of the soil model should not affect the frequency response of the soil and the fluid. But also the effect of the laminar-box in which the model is contained should be considered, as well as the monitoring equipment that should have a sufficiently short response time to be able to record all changes in the model. Preliminary studies (Kita 1994) showed that the mechanical behaviour of the soil/fluid-system is similar to the ordinary model. However, for high frequencies the effect of the laminar-box becomes significant. The pressure measurement devices should be 100% saturated to prevent extreme damping of the pressure changes and therefore incorrect registration of the pressure values.

Dynamic centrifuge testing at the DPRI has been developed in such a way that this type of testing is now very common for many applications using complicated models and tests, even with miniature CPT-equipment.

GRAVITY QUAY WALL FAILURE

As indicated before the extend of damage to conventionally designed quay walls in the Kobe harbour was 100% to all conventional quay walls. Only a few specially designed high-seismicity quay walls, an improved version of the Dutch caisson quay wall, stayed in service during the earthquake and hence were used to transport

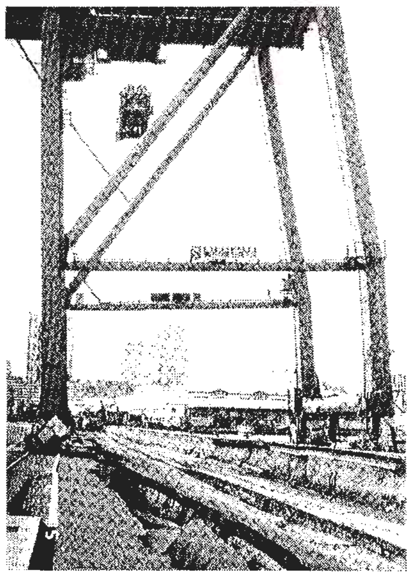

Figure 2 Destruction of service area due to failure of quay wall.

emergency equipment into the area.

The failure of the other quay walls, both gravity and caisson, was related to liquefaction behind and below the quay walls. As shown in figure 1, the horizontal movements were large (over 3m at Rokko island), as were the settlements (up to 2.5m at Rokko Island). Due to these horizontal movements towards the sea and additional settlement as a result of liquefaction below the service area, the service area behind the quay walls subsided and became unusable, see figure 2. A drawing of the quay walls, see figure 3, shows the typical effects observed in the harbour area: A combination of horizontal shift and settlement, resulting in forward rotation of the quay wall.

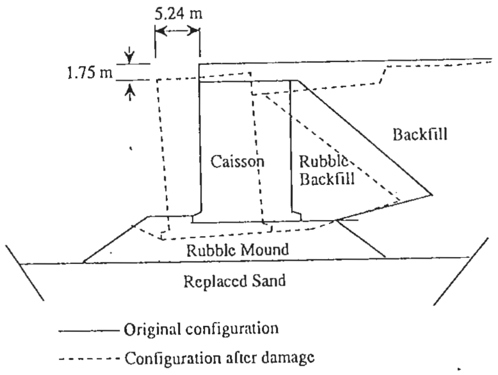

Figure 3 Typical effects of failure on quay walls.

MODEL PREPARATION AND TESTING

To quantify the influence of liquefaction on the failure of the quay wall tests have been proposed to model the motions of the Kobe earthquake and monitor the soil stresses and porewater pressures in the soil and on the quay wall. Simultaneously the displacement of the quay wall is measured to identify changes in displacement velocity for those instances that liquefaction takes place behind or below the quay wall (Matsuda 1996).

During a 1-g test (normal gravity acceleration) the behaviour of the quay wall at a reduced real scale has been investigated. The results showed that the observed failure types during the earthquake, horizontal and vertical displacement and rotation of the quay wall, were confirmed in the laboratory tests.

An additional series of tests have been developed to test the behaviour of the quay wall under real time and size conditions. Such a simulation can only be done using an increased gravity field and downscaled model properties, tuned in such a way that the behaviour of the model is similar to the real time and size model. This type of testing is done with a shake-table mounted centrifuge tester.

The test series carried out during the research visit consisted of two quay wall types; the original and improved gravity quay wall version. The models are carefully prepared over a period of 5 days each, to be able to generate models with known and constant soil properties in all dimensions. Measurements are taken within the soil and at the contact between the soil and quay wall, see figure 4. The acceleration, soil stresses

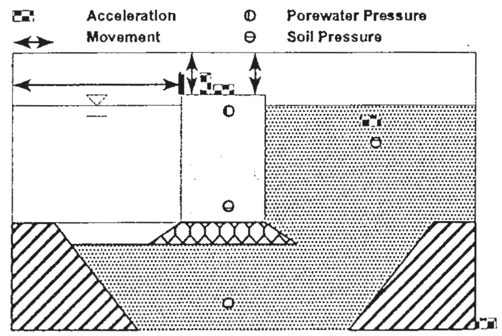

Figure 4 Arrangement of monitoring devices within centrifuge model.

and porewater pressures are measured at the indicated positions in the model. The first model has been tested under a 30g gravity field, while the second has been tested with 50g gravity (which is the model design acceleration). The initial input motion is a simple sine motion, which will be changed in future tests into the original earthquake motion, to keep the response of the model simple.

RESULTS TESTING

During the 30g test no liquefaction has occurred at any location in the model. The porewater pressures stayed below the total soil pressure at any time. Some movement of the quay wall has been observed but could not be properly monitored due to technical problems. A manual measurement after the test showed that approximately half a centimetre horizontal movement had taken place. Settlement of the quay wall was not observed but settlement of the backfill was about 5-10% over the height of the quay wall.

The 30g test was carried out at a lower gravity field than the design gravity as it served as a test to find technical problems in the monitoring devices. Qualitatively the test results are useful, but they will not be used quantitatively in future calculations.

The 50g test showed liquefaction in the middle sensor in the backfill, see figure 5a, clearly showing that the ratio of excess porewater pressure (E.P.P.) over initial vertical effective stress (I.V.E.S.) becomes larger than 1. At the locations higher than this the shear stresses developed in the field have been sufficient to cause liquefaction at least at the level of the highest porewater pressure device on the quay wall, see figure 5b. For the lower points the shear strength of the soil was to high to be liquefied and the rubble mount may have its influence too, see figure 5c. Due to the fact that the previous test was carried out at a lower gravity field the influence of the geometry of the improved model could not be assessed.

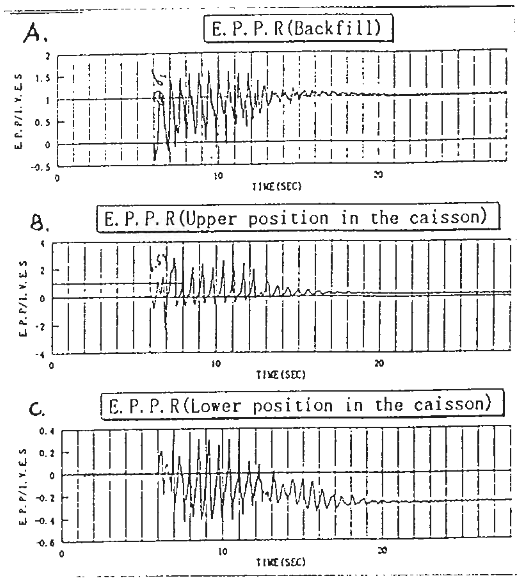

Figure 5 Pore water pressure measurements during centrifuge testing.

When considering the response of the model in time it is also clear that once liquefaction takes place the E.P.P./I.V.E.S (stress ratio) stays at approx. one, which is explained by a slow dissipation of the excess porewater pressure. Furthermore, at the lower position in the quay wall the porewater pressure is lower at the end of the test than at the beginning, which is at this moment not explained. It is also clear that the response at the end of the test is less extreme than at the beginning, which may be well explained by the compaction of the soil during the test, given the opportunity for the porewater pressure to dissipate.

Discussion laboratory results

A number of results and problems in the approach should be shortly discussed:

- During sample preparation it became clear that some basic factors like soil density, relative density etc. could not be decided by the investigator, but had to be determined after sample preparation and testing. It is therefor difficult to do a parameter study using these properties as variables.
- The first two tests, in a larger series to be carried out, showed that the response of the model is at least qualitatively similar to the response observed during the earthquake.
- Liquefaction has been proven to occur at a number of depths in the backfill, but not at the bottom of the quay wall. The displacement of the quay wall has not been monitored accurately enough to quantify the contribution of liquefaction to the amount or rate of displacement.
- The number of test and the limitations of the amount of measurements that could be taken during the test make it at this time of reporting impossible to come forward with a solid discussion on the effects observed, other than the explanation of effects given earlier. Specially quantification of the effects will take more tests.

In general the preliminary tests showed no contradictions with the general understanding of the mechanism of liquefaction, but some details on the way the porewater pressures develop and dissipate still have to be studied. Also the observations of liquefying weathered gravely material during the earthquake need more attention, since some of these materials are used for improving the sand used as backfill material.

EVALUATION RESEARCH VISIT

When it is necessary to adjust existing empirical liquefaction methods, before application of the models in the Dutch environment, more understanding of liquefaction is needed. During the research visit it became clear that, in that respect, testing and observing the liquefaction phenomena, even in models, is a great advantage above trying to understand the more simple empirical approaches. The opportunity to record all significant changes in the model improves the understanding of the process of liquefaction rather than establishing only the point of liquefaction or if liquefaction has occurred or not.

It would be a great advantage if the liquefaction phenomena could be studied in a similar way in the Netherlands, using for example the centrifuge of Delft Geotechnics. Because this might become very costly, it is important to find multiple interesting parties to contribute to the research. However, since the effects of liquefaction have been observed in the Netherlands and might have serious consequences on civil engineering structures like (critical) buildings, dikes and slopes, interested parties should already exist and need only to be organised.

ACKNOWLEDGEMENTS

This opportunity to visit Japan, the DPRI, learning more about liquefaction and dynamic centrifuge testing, as well as experiencing two 4 Richter scale magnitude earthquakes has been made possible by Prof. Kamon (DPRI), Prof. Genske (TU Delft) and the NWO/NISSAN-fellowship programme.

Those people who want to experience an earthquake, but do not have the money to go there and the patience to wait for one or those people that want to go to Japan prepared, should follow the advice of my colleague Michiel Maurenbrecher. Visit the Geological Museum, London, where you can experience an ongoing earthquake in a small Japanese supermarket from 9 till 5 (its even free after 4 o'clock) at 10 minute intervals. Unfortunately you can not buy anything, but you can drink a dry 'vodka-martini'; shaken not stirred, at the pub down the road to get over the giddiness one feels for the remainder of the museum visit.

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Book review

Schadstoffausbreitung in Geklufteten Medien - Alternativen

Dieter D. Genske (1996), Verlag Sven von Loga, Köln, pp. 150. ISBN3-87361-251-8. Price: 55 DM

The spread and the subsequent distribution of contaminants in the underground is one of the crucial aspects in the field of risk assessment and remediation of contaminated sites. Transport phenomena also are a factor in discussion about (underground) storage of contaminated residues. Hence, this review of different transport phenomena of pollutants in joints of water-bearing beds tackles a most current and important field in engineering geology.

As an introduction to the subject components of mass transport are defined and described. Keywords in that context are convection, hydrodynamic diffusion (molecular diffusion, dispersion), adsorption, retardation, degree of saturation, matrix diffusion, rate of decomposition and decay. Being aware of the process' complexity a critical distance towards simplifications and idealisations is maintained. For that reason factors like multiphase flow are touched considering dispersion processes of different phases, too.

Physical and mathematical transport models for pollutants are introduced, their applicability for pore-water flow is discussed in light of possible suitability for jointed media. Most of the models mentioned confine themselves to the case of absolute saturation of the pore-water or joint-water zones. Other ones, however, are only applicable for the joint-water free zone, where migration of pollutants only is caused by gravity. The contrast between classical models like analytical solutions, numerical models and alternatives such as percolation theory and fractal approaches is examined. As a counterweight to the traditionally dominating numerical methods stochastic methods hold an eminent place in the considerations.

A different important contribution to the discussion of transport phenomena in fractured media is the interpretation of migration paths as linear channels that are apt to transport pollutants within a short time period over long distances. Next to this qualitative discussion, the dilemma of conducting quantitative investigations with a general validity is shown.

Because pollutant transport phenomena in fractured rock is not well researched yet, both physical and analytical models as well as numerical models still can be improved. By means of the partly controversial debate of alternatives and new tendencies in this research field this book gives on the one hand a good introduction in the subject to students and on the other hand it may stimulate a discussion about forthcoming developments among experts.

The book is published by the Verlag Sven von Loga, geoscientific/geotechnical literature, with more than 4000 publications up to 1995. Books are published in German and English. So far "Schadstoffausbreitung in geklufteten Medien - Alternativen" is only published in the German language. The book is published as a paperback and it's price of 55 DM (about 61fl.) lies in the normal range of technical literature. The explanations are illustrated by a lot of high quality figures. Furthermore the book contains a quite extensive bibliography.

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Faculty of Applied Earth Science
Section Engineering Geology

NIEUWE & RECENTE A.A.BALKEMA TITELS:

Support of underground excavations in hard rock 90 5410 186 5
1995, 28 cm, 232 pp., Hfl.95 / $45.00 / £35 - Student edn., 90 5410 187 3, Hfl.45 / $19.50 / £16
A comprehensive volume dealing with the design of rockbolts, dowels, cable bolts and shotcrete for underground excavations in hard rock. Many practical examples are given and extensive use is made of user-friendly software developed specifically for this application (available separate). Topics include rock mass classification systems, shear strength of discontinuities, analysis of structurally controlled failures, in situ and included stresses, estimating rock mass strength, support design for overstressed rock and discussions on different types of underground support. Authors: E.Hoek, P.K.Kaiser & W.F.Bawden.

Open pit mine planning and design 90 5410 173 3
1995, 25 cm, 864 pp., 2 vols, Hfl.245 / $125.00 / £90 - Student edn.,90 5410 183 0, 2 vols, Hfl.125 / $65.00 / £46
The book is divided into two parts. Part 1 consists of six chapters in which the basic planning & design principles are presented: Mine planning; Mine revenues & costs; Orebody description; Geometrical considerations; Pit limits; Production planning. Much of the actual calculation involved in the design of an open pit mine is done by computer. Two professional computer programs CSMine & VarioC have been specifically developed with the university undergraduate learning environment in mind. These programs, their related tutorials & user manuals, together with a data set for the CSMine Property, are subject of part 2 of this book. Six chapters involved are: Introduction; CSMine property description; CSMine tutorial; CSMine user's manual; VarioC tutorial & user's guide; VarioC reference manual. Authors: W.Hustrulid & M.Kuchta.

Brittle failure of rock materials – *Tests results and constitutive models* 90 5410 602 6
1995, 25 cm, 456 pp., Hfl. 195 / $115.00 / £74
Comprises different basic aspects of brittle failure for rocks. Classical & contemporary models are considered theoretically as well as failure patterns under different loading schemes. Terminology; Strength theories; Contemporary models about brittle fracture; Laborational methods for determining some mechanical properties of rocks; Mohr strength envelopes; Experimental investigation of brittle behaviour; Size effect; Concluding remarks and references. Author: G.E.Andreev.

Fractals in rock mechanics (Geomechanics research series 1) 90 5410 133 4
1993, 25 cm, 464 pp., Hfl. 150 / $85.00 / £55
Important developments in the progress of the theory of rock mechanics during recent years are based on fractals and damage mechanics. The book is concerned with these developments, as related to fractal descriptions of fragmentations, damage, and fracture in rocks, rock bursts, joint roughness, rock porosity and permeability, rock grain growth, rock and soil particles, shear slips, fluid flow through jointed rocks, faults, earthquake clustering, etc. A simple account of the basic concepts, methods of fractal geometry & their applications to rock mechanics, geology & seismology. Discussion of damage mechanics of rocks & its application to mining engineering. Author: Heping Xie (M.A.Kwasniewski, Editor-in-Chief).

Rock mechanics in salt mining 90 5410 113 X
1994, 25 cm, 544 pp., Hfl.175 / $99.00 / £65 - Student edn., 90 5410 103 2, Hfl.95 / $55.00 / £6
5 chapters consider general geology, folding & faulting structures compilation of salt & form of salt bodies with the simplifications. 3 chapters deal with the exploration & opening of salt deposits with the aspect of design of safe & stable mine structures, and risk of water inflow into the mine. 3 chapters analyse deformation & failure of the salt due to elasto-plastic, creep & outbursts loading conditions. 5 chapters discuss strata mechanics & control for different mining systems of flat, inclined & massive salt bodies, as well as solution mining & excavation for storage.Last chapter presents the stability analyses to the mine structures in regard to salt mining subsidence. Author: M.L.Jeremic.

Grouting of rock and soil 90 5410 634 4
1996 (May), 25 cm, 288 pp., Hfl.175 / $99.00 / £65
Grouting is a proven but complex method to seal and to stabilize substrata. This book deals – on the present state of the art – with the design and execution of grouting works in all kinds of rock and soil, including jet grouting. The theoretical background is shown so as easy to understand it. Design principles are discussed whereby different approaches, exercised in different parts of the world, are compared to each other and evaluated. The work performance including the necessary machinery and accessories is explained with the aid of many examples from practice. Considerations are made of conventional and advanced methods of tendering and contracting. The book reflects the author's more than 30 year experience in design and execution of grouting work in rock and soil. The readers are invited to participate in prestigeous tasks in many countries of the world and to follow up the approach to solve them. Author: Christian Kutzner.

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Report on the ingeokring excursion to the railway tunnel project at Zaventem airport

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Experiences from the excursion to the construction site of the railway tunnel at Zaventem airport in October 1996 are reported. The maintenance of the air service, safety considerations and existing structures demanded both, a sophisticated logistical management and site specific and partly uncommon tunnel construction methods. An explanation about the site's geology and its geotechnical properties is given. The tunnel can be divided in four parts of construction design:
Part A: Cut and cover,
Part B: Tunnel undercutting beneath a sub-terrain roof plate,
Part C: Longitudinal and transversal pipe jacking,
Part D: Jet grouting at the intersection part of the old and new station.

INTRODUCTION

On 10 October 1996, about 30 Ingeokring members accompanied by ITC-students[1] visited the construction site of the railway tunnel at Zaventem Airport, located in the NE of Brussels. The Group was invited by the Belgische Comité van Ingenieursgeologen.

In course of the airport's reorganisation and extension a more than 40 years old feeder line from the rail connection Brussels-Leuven to the airport has to be substituted by a modern and more efficient one. Not least, the modernisation is to be seen in light of the realisation of the European high speed train network. This would integrate the airport in a rail network with links to London, Paris, Amsterdam and Cologne. Last but not least, the integration would contribute to the competitiveness of the whole region and to the airport itself. Nowadays the airport has 10 million passengers per year. The extension of the airport is projected for 20 million customers. So far the

Figure 1 View of the Tunnel in part A.

station is planned as a terminus that leaves the option for a future north connection to Amsterdam. The total operation should be completed in 1998. The N.M.B.S. (Belgische Spoorwegen) heads the project whereas the technical realisation is conducted by the Flemish Transport Company (Centrale diensten de lijn).

The route of the new switch line has to pass the airfield in a tunnel and ends in a sub-terrain terminus under the existing airport buildings. This, of course provokes some logistical problems, because a regular air service had to be maintained as good as possible. The engineering geological background and the four different parts of construction of the tunnel will be described in the following chapters.

THE GEOLOGY

A transgression in the late Eocene created an opening from the North Sea Basin via the 'Strait of Lâon' towards the Basin of Paris in the south (map1). This depression was about 25 km in width and stretches NNS-SSW. By the time some deeper erosion channels in the 'Strait of Lâon' were filled up with sediments, with the so called *Brussels Sands*. These longitudinal sand bodies with transversal bars were deposited in a shallow marine environment (-50m) under tidal influence. Differential erosion of the sand bodies modelled the recent morphology of elongated ridges. The usually fine grained sediments have a high content of organic material (Donselaar, 1990).

A site investigation, repectively CPTs' proved the sand to be mostly slightly cemented. Lenses of sandstone concretions were encountered. The geology at the construction site at Zaventem Airport is made up of fine to medium grained *Brussels Sands*. At that very location the sands are abundant in marine fossils. An exposure showed an undulating paleo-relief of the Eocene that was covered by an approximately 2 m thick Loess-layer which was deposited in peri-glacial times and is smoothening the surface relief.

At the site a groundwater dewatering system has been installed. So far nothing is known about settlement caused by this drainage.

THE TUNNEL

The tunnel has a length of approximately 1 km and will have 2 tracks, respectively 3 tracks in the station. As mentioned above, the underground passage has to cross the scope of the airfield and ends in a terminus under the existing airport building (map 2).

Not only the maintenance of the air service with regulations for security distances and other safety norms caused restrictions for the construction process. The old train station had to be tunnelled without disturbance of the train traffic. In the scope of the old station one had to deal with special height restrictions for the new tunnel. Along the tunnel's span different construction sections have been determined and the layout was tailored to meet the necessities of a continuous air service. One part of the tunnel has been realised by the 'cut and cover method' (Part A). Another method can be described by 'undercutting beneath a sub-terrain roof plate'(Part B). In contrast, a tunnel boring machine (CBC Boorschild) has been used in a combination of longitudinal and transversal pipe jacking to create an in-situ roof plate for the tunnel under the airport building (Part C). Part D of the tunnel (station) is located at the intersection of the old and new station. Here, an approach based on jet grouting and underpinning of existing foundations was chosen. However, disregarding the 'cut and cover method', the tunnelling methods are very site specific due to the special circumstances. The methods and the different layouts will be successively discussed under the titles such as indicated in map 2.

TRENCH CUTTING AND COVER METHOD (PART A)

About 600m of the tunnel construction has been accomplished by means of the 'cut and cover method'. An exemplary sectional view of the tunnel in the scope of Part A1 can be seen in figure 1 and 2.

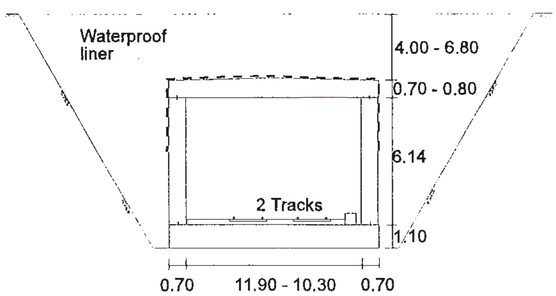

Figure 2 *Trench cut and cover method (all measures in metre).*

The construction began with the excavation of soil in a wide trench up to a depth between 12m and

15m. At this level the tunnel's reinforced ground plate had to be built. Both excavation sides are sloping 60°. On the left and right side of the ground plate the formworks of the side walls were located and after placing the reinforcement the concrete walls were casted in place. Subsequently the roof plate was constructed and sealed with a waterproof liner. The back-filling of the ground and the modelling of the surface completed this part of the tunnel (Figure 1). Only the implementation of the railway installation has still to be carried out.

This economical 'cut and cover method' only could be applied in these areas of the airport where any impact on the air service could be exculded. Hence, in the other sections the tunnelling method had to be more complicated and expensive, since maintenance of air traffic and safety considerations had first priority.

UNDERCUT BENEATH A SUB-TERRAIN TUNNEL ROOF PLATE (PART B)

By means of this method a 400m tunnel has been constructed under a runway (B1) and below the airfield (B2). The principle of this method is illustrated in figure 3. This chapter focuses exemplary on a description of the tunnel part B1.

After removing the runway's pavement the ground was excavated until a level of 3m below surface. This level made up the bottom plane of the roof plate to be constructed.

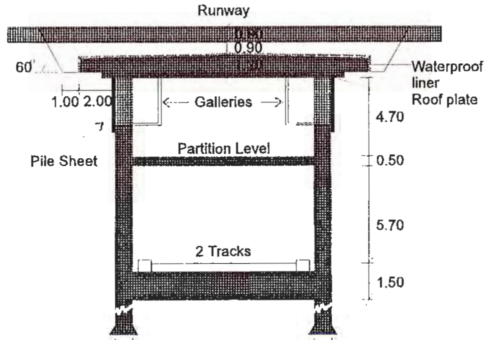

***Figure 3** Undercutting beneath a Sub-terrain Roof Plate (all measures in metre).*

Before the plate's completion concrete pile sheets had to be driven into the ground up to a depth of 0.5m under the bottom of the later galleries. Consequently, the resulting retaining walls have been about 3.0m in total. The roof plate has a slight saddleback-shape with an inclination of 2%. It was sealed with a waterproof liner and was finally protected with lean concrete. Afterwards the roof plate was covered again and within a total time period of 1 month the runway was in use again.

The construction period for the airfield tunnel was 3 months. One hundred and twenty workers have been working during that period on the construction site.

Beneath the runway under the roof plate two galleries were excavated (figure 4). During that process the stability of the sand was advantageous. From these galleries the excavation of trench-segments with a width of about 1.2m and a length of 1.5m was conducted up to the final depth of 14m. The excavations were done manually.

***Figure 4** Undercutting beneath a Sub-terrain Roof Plate at Section B1 (looking S to N); Two Galleries are in use (Photo: centrale studiedienst de lijn).*

After reinforcement and concreting a new segment was excavated. As soon as the side walls have been created the gap between top of the wall and roof plate could be filled. This step was decisive, because at this point the connection of roof and wall had to be established. This was achieved by means of anchors. After removing the retaining walls of the galleries the remaining the ground material was excavated. Because of the total excavation depth of 14m stability considerations forced to the construction of a partition roof that support the tunnel walls. The resulting upper tunnel level will serve as emergency exit when the tunnel will be in use. Beneath the partition plate the excavation continued until the required depth was reached and subsequently the bottom plate was established. The bottom plate and the wall are connected by means of anchors that were placed into the walls.

For these tunnel sections the designed tolerance of settlement is 30mm. So far, after its completion a maximum of 20mm of settlement has been observed. The final step will be the installations of the rails.

LONGITUDINAL AND TRANSVERSAL PIPE JACKING (PART C)

At this part of the tunnel project circumstances became more complex. The underground passage is directed S to N and had to tunnel the existing airport building including the old train station. The construction works neither should affect the stability of these buildings nor their regular operations. The principle of the tunnel construction in Part C of the sections is depicted in figure 6.

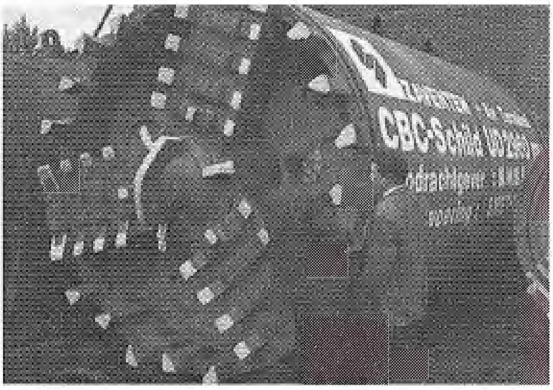

***Figure 5** Tunnel Boring Machine, CSC Schild (Photo: centrale studiedienst de lijn).*

The construction of the tunnel started in an excavation pit at the Land-Airside. A Tunnel Boring Machine (TBM) was lowered and driven from this pit (map 2, figure 5). The TBM pressed a steel pipe (Ø2.96m) longitudinally, that is in direction of the later railway tunnel (S-N) into the underground below the airport building.

After a level surface has been realised this pipe served as base for pipe jacking of the transversal pipes. The transversal pipes are compounded out of steel elements with a diameter of 2.10m. The remaining soil in the pipes was excavated manually and the pipes were connected with each other every metre by bolted connections. The distance between these pipes is about 0.10-0.20m. Thereafter these pipes were reinforced (reinforcement rods 20mm and 40mm) and filled with concrete in two phases (figure 7). To avoid an inhomogeneous filling first low pressure was applied and in a second step the concrete was pressed into the pipe by high pressure. A tube guaranteed the discharge of remaining air and the filling process was monitored with sensors. Figure 8 shows the longitudinal pipe with the concrete fillings of the transversal ones.

By means of the inter-connection of the transversal pipes a massive roof for the later railway tunnel was created. The roof has an overburden of 9m. In a next step the floor of the longitudinal pipe was opened to be able to excavate a trench for the later left side wall of the tunnel. The establishment of the galleries was the following step. From here the remaining distance of up to 0.20m between the pipes was filled up with concrete to virtually complete the roof. The columns in the central part of the later station and the right tunnel wall were excavated from the galleries, too. The approach of excavation was the same as described in the previous chapter. In October 1996 this is the status quo of construction at this part of the tunnel.

Hereafter the central columns will be connected

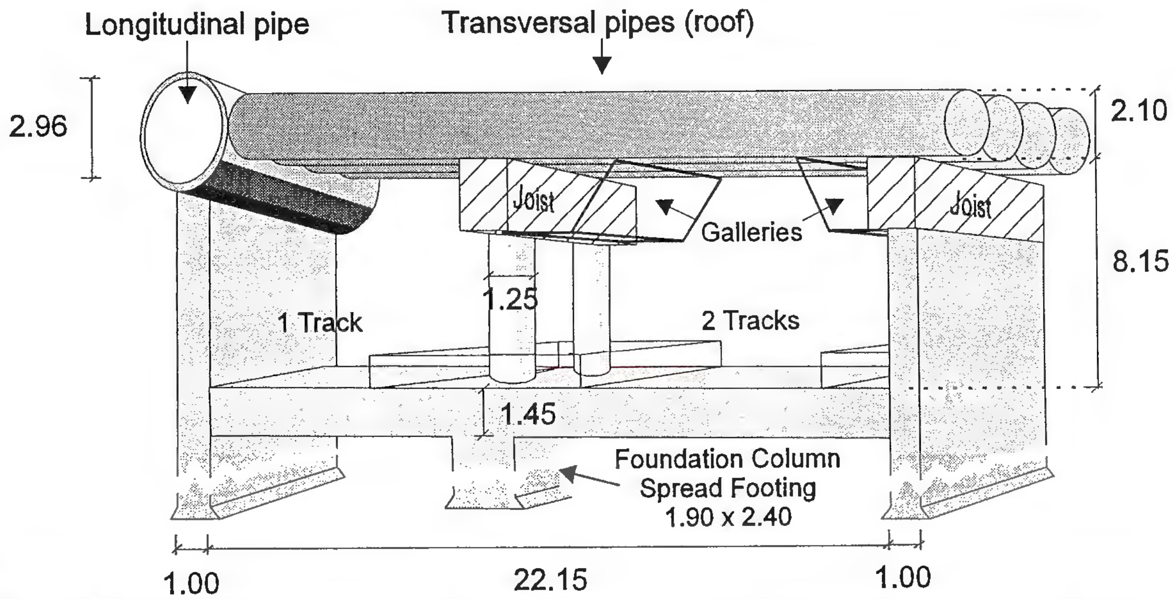

***Figure 6** Schematic view of the longitudinal and transversal pipes in the tunnel section C (all measures in metre).*

***Figure** 7 Transversal pipe (∅ 1.90m) with reinforcement and filling tube for concrete (centre).*

by longitudinal roof joists. The right tunnel wall's roof joist is about to be constructed, too. When the joists will be finished a first excavation in the upper part of the tunnel will be performed. Again, this work will be carried out manually with an expected progress of 10m/day. During a second phase the excavation shall reach the base of the future bottom plate at a depth of 20m below the

***Figure** 8 View along the longitudinal pipe with concrete filled transversal pipes at the right side.*

surface. As the last step of the construction the tunnel roof especially in-between the pipes have to be definitely water tightened. At that time the tunnel will have reached the stage where rails, platforms, electrical installation (e.g. trolley wires), etc., can be established.

JET GROUTING AT INTERSECTION OF THE OLD AND NEW STATION (PART D)

The old railway station stretches in E-W direction and is encountered at the foundation level. Hence, at this location the intersection with the N-S stretching new station resulted in height restrictions. However, a conflict with the existing pile foundations of the old station had to be solved. Before the ground could be excavated the pile foundations were underpinned by means of jet grouting. By this method new columns could be created in-situ beneath the existing ones. These column extensions only had temporary character, because they did not fit in the design of the new station. Once established the ground masses were digged out around the old columns and new foundations for the new station and for the existing buildings could be built. After connecting old and new structures the grouted piles have been removed and a new ceiling was built. In October 1996 this part of the station was finished and waiting to be connected with the other part of the tunnel.

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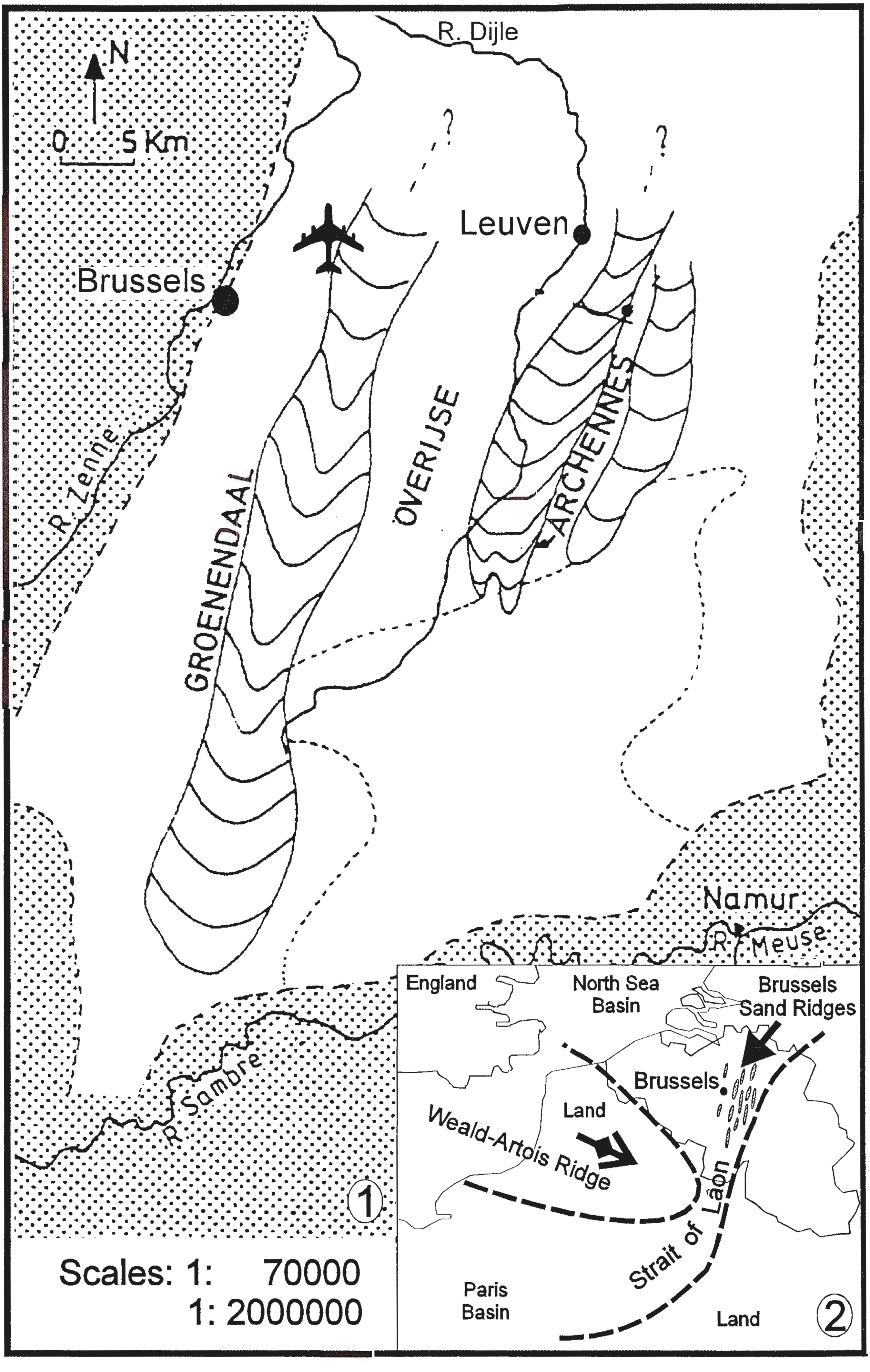
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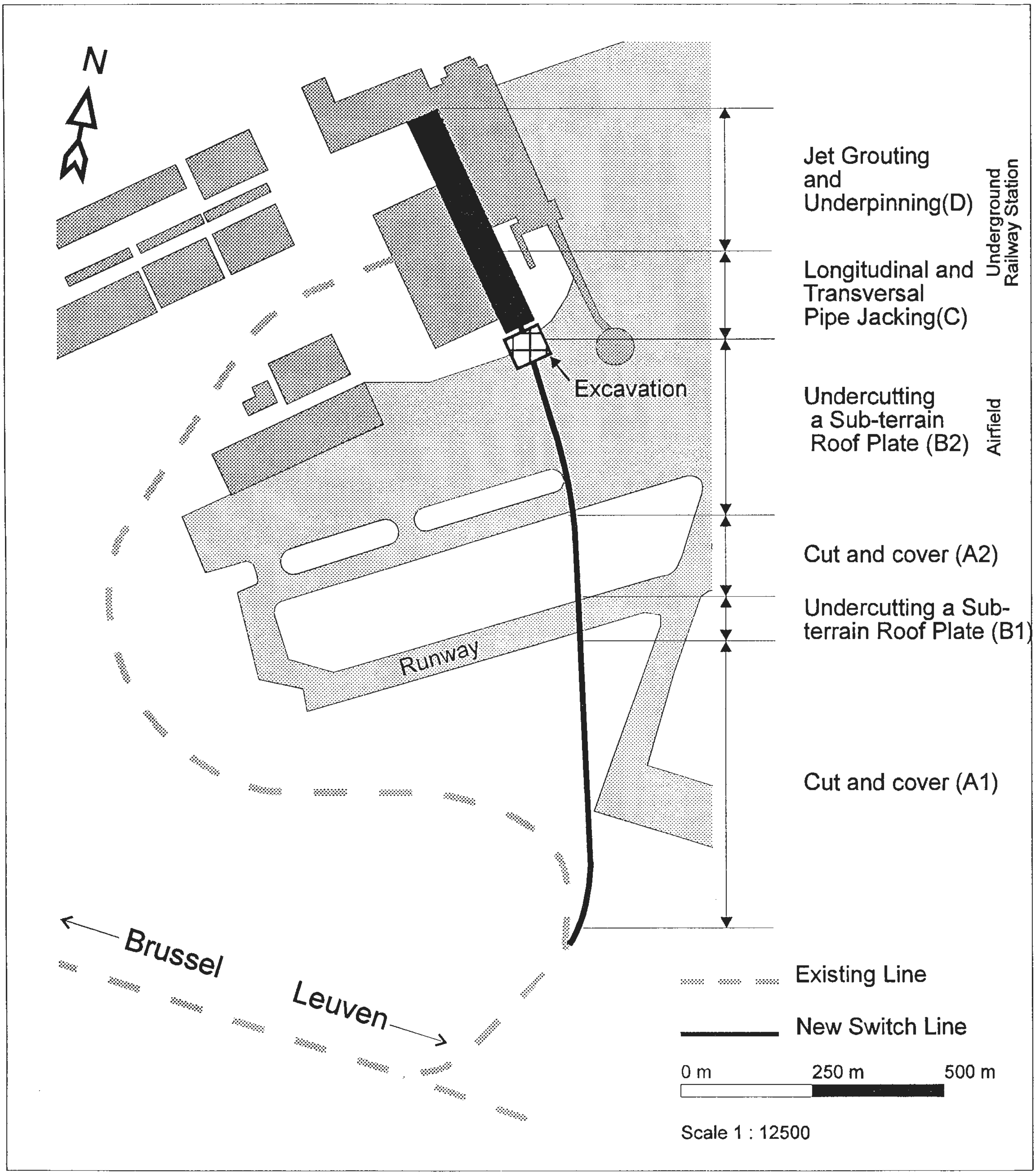

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Jet Grouting and Underpinning(D)
Underground Railway Station
Longitudinal and Transversal Pipe Jacking(C)
Excavation
Undercutting a Sub-terrain Roof Plate (B2)
Airfield
Cut and cover (A2)
Undercutting a Sub-terrain Roof Plate (B1)
Runway
Cut and cover (A1)
Brussel
Leuven
Existing Line
New Switch Line
0 m
250 m
500 m
Scale 1 : 12500

Book review

Mining environment

Bharat B. Dhar, D.N. Thakur(editors), 1996 A.A. Balkema, Rotterdam/Brookfield. pp.408, ISBN 9054107154, Price Hfl 125.

'Mining environment' contains selected papers from the First World Mining Environment Congress, held in New Delhi, India on 11-14 December 1995. The objective of this congress was to provide a stimulus of ideas, strategies and initiatives for the implementation of environmental aspects of mining in its most general meaning.

The themes covered by the congress are ordered in the proceedings as follows: I. Environmental problems & issues, II. Environmental practices, including a case study, III. Environmental policy and legislation, IV. Socio-economic dimensions, health and its impact, V. Sustainable development vis-a-vis environmental management, VI. Environmental training and education, VII. Future strategies. The proceedings also contain abstracts of poster session papers.

One of the first major assemblies on environmental issues in a global perspective was the Stockholm Conference of 1972. Since then, there have been several of such meetings. The concern for the environment is furthermore stressed by the establishment of, for example, the Mining and Environment Research Network (MERN), and initiatives in this field by UNEP and UNCTAD.

All countries (and companies) agree on the importance of safeguarding the environment. However, each has its own ideas, priorities and implementations to address these problems. This diversity is related to the fact that different problems are faced, but also to the fact that the political structure is not the same everywhere.

It is the belief of the organising committee, as expressed in the preface, that, rather than unifying the approach to environmental issues, the congress should give new ideas and stimuli for each individual reader to address their problems. Conform this belief, the proceedings give an extensive range of different views on environmental issues. For example, several articles give different approaches for similar problems.

The articles, presented in 'Ming Environment', are generally easy and pleasant to read. It is striking though that the majority of the articles comes from outside Western Europe (many from India to be exact). This means that the reader may miss information on the current practice in Western Europe. Another point to note is that quite a few articles originate from the organising institute itself. Although, in a way, this can be expected it raises some questions about the 'global' perspective of the conference.

Overall, I did find the book very interesting. The proceedings give some very interesting views on the problem of safeguarding our environment, especially in the developing countries. The subject is furthermore highly relevant in a time where the economical profitability of mining operations comes ever more under pressure. I also appreciated the consequent lay-out kept throughout the book. It is rare that in proceedings, all articles are actually printed in the same type face.

To conclude, this book may not be the best choice if area-specific information is needed, but it does give a very good introduction into the field of environment & mining practice, both with regard to technical and political /economical aspects.

Ir. A.R.G. van de Wall
Delft University of Technology
Faculty of Applied Earth Sciences
Section Engineering Geology

News and announcements

International symposium on rock support: Applied solutions for underground constructions
Lillehammer, Norway, June 22-25 1997

Organised by the Norwegian Group for Rock Mechanics, Norwegian Tunnelling Society, Norwegian Society of Chartered Engineers, Norwegian Concrete Association and the International Society for Rock Mechanics (ISRM).

Themes: Theory, projects for public use, sewage and water, nuclear waste, mining and temporary excavations.

Correspondence: Norwegian Group for Rock Mechanics, P.O.Box 2312 Solli, N-0201 Oslo, Norway.

14th international conference on soil mechanics & foundation engineering
Hamburg, Germany, September 6-12, 1997

Organised by the International society for soil mechanics and foundation engineering (ISSMFE).

Themes: Soil testing and ground property characterisation, recent development in foundation techniques, retaining structures and excavated slopes, underground works in urban environment, soil improvement and reinforcement, waste disposal and contaminated sites.

Correspondence: XIV. ICSMFE 97, Deutsche Gesellschaft für Geotechnik e.V., Hohenzollernstr. 52, D-45128 Essen, Germany, tel: 201-782723, 201-770821, fax: 201-782743.

NYROCKS '97, 36th U.S. rock mechanics symposium
New York, USA, June 29 - July 2, 1997

Organised by the Henry Krumb School of Mines, Columbia University in the City of New York and the American Rock Mechanics association under the sponsorship of the U.S. National Committee for Rock Mechanics and the International Society for Rock Mechanics (ISRM).

Themes: Excavation and ground control: blasting and fragmentation, TBM performance enhance-ment, micro-tunneling, advanced drilling methods, deep drilling and wellbore stability, deep mine and surface mine design; Slope Stability Site Character-ization: laboratory and field investigation, scale and rate effects, in situ stresses, near surface geo-physics, constitutive models and rock classification systems, probabilistic methods, forensic enginee-ring; Fracture and Fracture Phenomenon: friction and stability, dynamics and seismicity, fracturing and fracture networks, fractals, micromechanical approaches, damage mechanics; Coupled Processes and Fluid Flow: fractured and porous media, petro-leum reservoir engineering, nuclear waste reposi-tory studies, hydraulic fracturing in oil and gas production, site remediation technology; Other Topics of Interest: history of urban tunneling, large caverns and underground storage facilities, sealing and mine land remediation, foundation on rocks, risk assessment methodology, large dams and hydro projects, rock instrumentation.

Correspondence: Prof. Kunsoo Kim, Henry Krumb School of Mines, 812 Seeley W. Mudd Building, Columbia University, New York, NY 10027, USA, tel: 212 8548337, fax: 212 8548632, e-mail: kk21@columbia.edu, World Wide Web: http://www.columbia.edu/~kk21

Geo-engineering of hazardous and radioactive waste disposal, 3rd European engineering geology conference and 33rd engineering group annual conference.
Newcastle upon Tyne, England, September 10-14, 1997

Organised by the Geological Society Engineering group and the University of Newcastle upon Tyne.

Themes: Site selection and evaluation methodology for hazardous and radioactive waste disposal, site identification and selection, site preparation techniques and geo-engineering, site investigation methods and technology, case histories and lessons for the future, remedial methods and engineering, the role of geoscience in national waste disposal policy and planning, radioactive waste disposal research and development, geoscience research and investigation programmes, site investigation techniques and technology, radioactive waste disposal planning, policy and the earth sciences, site performance and safety case evaluation.

Correspondence: George M Reeves, EEG '97, Geological Society Engineering Group, Geotechnical Group, Drummond Building, Dept of Civil Engineering, Newcastle University, Newcastle upon Tyne, NE1 7RU, England. tel: 0191 2227121 Fax: 0191 2226613.

The 1997 annual conference of the International Association for Mathematical Geology, IAMG '97
Barcelona, Spain, September 22-27, 1997

Organised by the International Association for Mathematical Geology (IAMG)

Themes: Statistical analysis of compositional data in the earth sciences, different views of the Darss Sill data set, compositional data in petrophysics, environmental geology, numerical methods in the earth sciences (26th Geochautauqua), seismology, volcanism and geodynamical settings, developments in computer software for the geosciences, neural networks, fractals and other concepts in fashion, marine geology, geostatistics, modelling subsurface flow. engineering geology.

Correspondence: IAMG'97 - Conference Secretariat, CIMNE - International Center for Numerical Methods in Engineering, Campus Nord UPC (Edifici C1), E-08034 Barcelona, Spain, tel: +34 34016037, fax: +34 34016517, e-mail: iamg97@ma3.upc.es, http://www.iam.org./iamg97.html

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7th international conference underground space: indoor cities of tomorrow
Montréal, Canada, September 29 - October 3, 1997

Organised by the University of Montréal and the city of Montréal.

Themes: underground planning: challenges and issues, underground architecture, engineering and technological innovation, aspects of durability and viability, integration of the arts, archeological heritage, orientation and safety in enclosed environments, environmental dimensions, integration of surrounding context, tourist attractions, aspects of urban analysis, subsoil rights, economic potential of subsoil, segregation of transportation modes.

Correspondence: 7th International Conference Underground Space: Indoor Cities of Tomorrow, Organizing Committee, 303, Notre-Dame St. E., 5th floor, Montréal (Québec), Canada H2Y 3Y8.

Sardinia '97: Sixth International Landfill Symposium.
S. Margherita di Pula (Cagliari), Sardinia, Italy, October 13-17, 1997

Organised by the University of Cagliari, Technical University of Denmark, Technical University of Hamburg-Harburg, CISA - Environmental Sanitary Centre, Cagliari.

Themes: waste management and landfilling strategies, waste characterisation, waste pre-treatment, processes and emissions, design & construction, operational problems, special waste landfilling, administrative and financial aspects, environmental law and landfill regulations, aftercare, technology advances & developments, public concern, quality and risk assessment, economical aspects, old landfill, barrier performance, environmental impacts and monitoring, case studies, experiences and future perspective, education.

Correspondence: Ms. Anne Farmer, CISA - Environmental Sanitary Centre, Via Marengo 34, 09123 Cagliari, Italy. tel: +39 70 271652, fax: +39 70 271371, e-mail: cossur@vaxca3.unica.it

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MJFR-3, 3rd international conference on mechanics of jointed and faulted rock: 3D-Modelling, time dependence and complex interaction
Vienna, Austria, April 6-9, 1998

Organised by the Institute of Mechanics, Technical University Vienna, sponsored by the Österreichische Gesellschaft für Geomechanik (ISRM NG Austria).

Themes: geology and structural geology, dynamics of jointed and faulted rock, physical modelling and testing, constitutive modelling, numerical modelling, seismicity and tectonics, instrumentation, hydraulics, applications.

Correspondence: Dr. H.P. Rossmanith, Institute of Mechanics, Technical University Vienna, Wiedner Hauptstr. 8-10/325, A-1040 Vienna, Austria, tel: 43/1/588015514, fax: 43/1/5875863.

Fourth international conference on case histories in geotechnical engineering
St. Louis, Missouri, USA, March 8-15, 1998

Organised by the University of Missouri-Rolla.

Themes: Case histories of foundations, case histories of slopes, dams and embankments, case histories of geotechnical earthquake engineering, case histories of engineering vibrations, case histories of retaining structures deep excavations, case histories of geological, rock and mining engineering including underground structures and excavations, case histories of soil improvement, grouting, geosynthetics, dynamic compaction, vibroflotation, blasting and other methods including geo economics, case histories of forensic engineering "where things went wrong", case histories of new solutions to traditional geotechnical problems, case histories of geotechnical and hydrological management and remediation of solid, hazardous and low-level radioactive wastes, including liner cover systems, case histories of non-destructive evaluation of drilled shafts, auger cast piles and driven piles. A special session on geotechnical engineering in the 21st century will also be conducted.

Correspondence: Shamsher Prakash, 308 Civil Engineering, University of Missouri-Rolla, Rolla, Missouri 65409-0030, USA, tel: (573) 341-4489, fax: (573) 341-4729, e-mail: prakash@novell.civil.umr.edu, http://www.umr.edu/~conted/

World Tunnel Congress '98, Tunnels and Metropolises 24th ITA Annual Meeting
Sao Paulo, Brazil, April 25-30, 1998

Organised by the Brazilian tunnelling committee (CBT), the Brazilian society for soil mechanics (ABMS) and the international tunnelling association (ITA).

Themes: Planning and project management, design criteria, geotechnical and structural aspects, infiltration, maintenance and rehabilitation, mechanized tunnelling, urban constraints on underground works.

Correspondence: Argimiro Alvarez Ferreira, IPT-DEC (ABMS/CBT), Caixa Postal 7141, 01064-970 São Paulo, SP, Brazil, tel: 55 11 2687325, fax: 55 11 2837464, e-mail: abms@mandic.com.br.

8th International congress of the International Association of Engineering Geology IAEG
Vancouver B.C., Canada, September 21-25, 1998

ISRM 9th International congress on rock mechanics
Paris, France, September, 1999

Academia

On thursday October 31, Robert Hack was awarded a PhD in engineering geology at Delft University of Technology. His dissertation "Slope Stability Probability Classification SSPC" describes a rock slope classification scheme developed during four years of research in Falset (Spain). By classifying rock mass parameters in one or more exposures a reference rock mass can be determined. Using the SSPC a slope stability assessment of existing or any new slopes in the reference rock mass can be made, with allowance for the influence of excavation method and future weathering. The large quantity of data used in this research allows for the development of a classification system based on probabilities.

Dr. Th.E. Wong, former head of the scientific laboratory department of the Geological Survey of the Netherlands, is appointed as Professor in the field of "sedimentary geology of the Dutch subsurface" at the faculty of Earth Sciences, Utrecht University. This new special chair is founded and sponsored for five years by the Geological Survey of the Netherlands.

Excursion to South-Africa

Students of the Engineering Geology Group Delft of Delft University of Technology are planning an excursion to South-Africa. The idea is to visit companies and projects for a period of 14 days in september 1997. The excursion will focus on the following issues: Infrastructure and housing, construction, underground disposal/waste disposal, underground construction, energy/dams, harbour construction technics/dredging-operations and geology.

All those who are interested in this excursion are invited to the presentation about the project on friday, 13 December at 19.00 h. at the Faculty of Applied Earth Sciences (formerly known as the Faculty of Mining and Petroleum Engineering), Mijnbouwstraat 120, Delft.

The 'South African Tour Committee':
S. Sonneveldt - president
E.W. Enserink - thesaurier
A.M. van Noort
J.E. Cools
F.E. Roes

Recently published papers

Most members of the Ingeokring are working in the field of Engineering Geology and related fields of expertise. By virtue of the interdisciplinary character of Engineering Geology the topics of work and study of the members of the Ingeokring range widely, and as a result their work is published in journals and proceedings of different nature. Because of this, not all publications come to the attention of the different members. To ease the access to the publications of different Ingeokring members, the authors of recently published papers are given the opportunity to present a short abstract (15 lines) of their publication, in the Newsletter. In addition the authors should give a name and address, to which persons that are interested can respond to for more information.

Slope stability probability classification SSPC

PhD Thesis, ITC, The Netherlands, publication number 43, ISBN 90 6164 125 X, 258 pp. 1996

The need to include discontinuity properties in slope stability analyses and the poor results of existing rock mass classification systems applied to slope stability has led to the development of a rock Slope Stability Probability Classification (SSPC) system. The system has been developed during four years of research in Falset, province Tarragona, Spain.

The rock slope classification scheme, which has been developed, classifies rock mass parameters in one or more exposures. These are compensated for weathering and excavation disturbance in the exposures and parameters important for the mechanical behaviour of a slope for an imaginary unweathered and undisturbed 'reference' rock mass are calculated. The slope stability assessment thence allows assessment of the stability of the existing or any new slope in the reference rock mass, with allowance for the influence of excavation method and future weathering. The large quantity of data allowed for the development of a classification system based on probabilities. This resulted in a classification system based on a probability approach: the 'Slope Stability Probability Classification' (SSPC).

Dr. H.R.G.K. Hack

International Institute for Aerospace Survey and Earth Sciences (ITC), Kanaalweg 3, 2628 EB Delft, The Netherlands
Tel:015 - 2569358, Fax:015 - 2623961

Knowledge-based fuzzy model for performance prediction of a rock cutting trencher

IJAR J. of Approximate reasoning Autumn 1996

A knowledge-based fuzzy model for performance prediction of a rock cutting trencher has been developed. A trencher is a machine that uses a rotating cutting chain equipped with bits to excavate trenches in rock and soil. The performance of a trencher, and consequently the cost of a specific excavation project, is determined by its production rate and by the bit consumption (due to wear and breakage). Both these factors depend on the properties of excavated rock material and on the trencher characteristics.

Mathematical modelling of the trencher performance is difficult, since the interaction between the machine tool and the environment are dynamic, uncertain and complex. The number of available measurements is too small to use statistical methods. Hence, an approach based on expert knowledge was applied to developed a rule-based fuzzy model.

The use of fuzzy logic allows for smooth interfacing of the qualitative information involved in the rule base to the numerical input data. The developed model uses six input variables (rock strength, spacing of three joint(discontinuity) sets in the rock mass, joint orientation and trench dimensions) to predict the production rate and bit consumption in terms of qualitative linguistic variables. Numerical predictions are obtained by using a modified fuzzy-mean defuzzification which allows for straightforward adaptation of the consequent membership functions in order to fine-tune the model performance to the data. The expert knowledge is coded as if-then rules, hierarchically organized in four rule bases. The model was validated both qualitatively using dependency analysis and quantitatively using the available data. The results obtained so far are satisfactory.

M.H. den Hartog[1], R.Babuska[2], H.J.R. Deketh[1], M. Alvarez Grima[1], P.N.W. Verhoef[1], H.B. Verbruggen[2].

[1] Faculty of Applied Earth Sciences, Engineering Geology, PO Box 5028,2600 GA, Delft
[2] Faculty of Electronic, Department of Electrical Engineering, Control Laboratory, Delft University of Technology

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Performance of rock cutting trenchers at different sites
Proceedings of the second North American Rock Mechanics Symposium (NARMS), June 1996, Montreal Canada, p. 669-675

This paper compares the in-situ observations on the performance of T-850 trenchers at eleven different sites. Different damage and excavation processes are described and related to trencher and geology characteristics.

The observations on rock cutting trenchers yielded a better understanding of the factors which control the damage and excavation processes during rock cutting trenching. This better understanding can aid to optimize trencher performance (low bit consumption and high excavation rate). Alternative approaches in trench excavation with T-850 trenchers are recommended. Moreover with the insight acquired in this study unexpected difficulties and downtime during a trenching job can be reduced through better anticipation on the encountered rock and a better prediction of trencher performance in advance of a trenching job.

Deketh, H.J.R., M.Giezen, M.Alvarez Grima & M.H. den Hartog

Delft University of Technology,Faculty of Applied Earth Sciences, PO Box 5028, 2600 GA Delft.

Uncertainty handling of mechanical rock excavation process with fuzzy logic
Third International Workshop "Informatics and Geosciences" Havana, November 21-24 1996

This paper presents the application of fuzzy logic for uncertainty handling of bit consumption and production rate predictions for T-850 rock cutting trenchers. The data and knowledge used to formulate and build the fuzzy model have been gathered during in-situ observations of the trenchers at different sites. These observations include a day of trencher performance monitoring, a thorough rock (mass) description and rock sampling. In a laboratory, mechanical testing of the rock samples and thin section analysis has been carried out.

At this stage of the research, the unconfined compressive strength, joint spacing (determining the rock block size), joint orientation, and the feed of the individual bits seem to determine the excavation and bit consumption processes in practice. The results obtained thus far with the developed fuzzy knowledge based model to describe these processes are very promising. The model has been validated both qualitatively using dependency analysis and quantitatively using the gathered data.

M. Alvarez Grima[1], M. H. den Hartog[1], H.J.R. Deketh[1], P.N.W. Verhoef[1] and R. Babuska[2].

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(2) Faculty of Electronic, Department of Electrical Engineering
Delft University of Technology.

Variaties in gesteente eigenschappen
Proceedings Wegbouwkundige Werkdagen, 4-5 june 1996

To (engineering) geologists it is well-known that rock is a heterogeneous material. However, technicians often regard rock, especially if it comes from crushed rock quarries, as a homogeneous material. This heterogeneity can have its consequences for the behaviour of the construction the rock is applied in. It is therefore important to know the quality and the variation in quality of the aggregate. These two aspects can already be established in the quarry. The advantage is that in the quarry the rock is present in ordered in zones that can relatively easy be investigated and quantified.

Ir. J.K. Haasnoot & Ir. A.R.G. van de Wall

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GIS application for mining & rehabilitation planning
Brachflächen recycling (Recycling derelict land, no 2-3, 1995

Underground coal mining in the Upper-Silesian coal basin has created important environmental problems, varying from subsidence to ground water pollution.
In this study, maps are made with the help of a geographic information system (GIS), which can assist in the development of rehabilitation and "environmental friendly" mining planning. The study has been carried out for a small scale pilot study area in the Karviná district in the Czech republic.

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Geoinformation systems for mine-planning purposes
Proceedings of the Int. Conf. on the occasion of the 50th anniversary of the TU of Ostrava, Czech republic, September 1995

A centre that provides geoinformation services can be of great help in optimising environmental friendly mining. Data derived from the centre can be entered in a geographic information system (GIS) which acts as a tool in decision making concerning future mining activities. With proper knowledge of the impact on the environment caused by mining activities, mining companies can adjust their planning in order to minimise the damage to the environment.
The information for the article is derived from a MSc thesis study, carried out by the authors on a test area in the Karviná district in the Czech republic.

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Tel: 015 - 2748847, Fax: 015 - 2623961

Verhitting van aggregaten in asfaltinstallaties
Proceedings Wegbouwkundige Werkdagen, 4-5 june 1996

Heating of aggregates during the production of asphalt mixes may influence the properties of these aggregates. In this article we discuss the possible influences of drying and heating. Crushing tests and Micro Deval Abrasion tests have been performed on aggregates that are presently used in asphalt mixes.
The aggregates were tested both before and after heating in an asphalt mix plant. The results of these investigations can be used to determine if a heat resistance standard is necessary and, if so, what such a standard should comprise. At present the CEN is elaborating this.

dr. Rutger L. Krans[1], ir. Alexander R.G. van de Wall[2] en Jan L.M. Voskuilen[1]
[1]Road & Hydraulic Engineering Division (DWW),Public Works and Watermanagement (RWS), PO Box 5044, 2600 GA Delft
[2]Delft University of Technology, Faculty Applied Earth Sciences, PO Box 5028, 2600 GA Delft
e-mail: R.L.Krans@dww.rws.minVenW.nl
A.R.G.vandeWall@MP.TUDelft.nl

Zandstralen en de natuurlijke opruwing van wegdekken
Proceedings Wegbouwkundige Werkdagen, 4-5 june 1996

Two factors are involved in the polishing of road surfaces: the resistance against polishing of the road aggregate and the regeneration of the surface roughness under the influence of the natural environment. This articles discusses the ongoing research by the Road and Hydraulic Engineering Division of the Directorate-General for Public Works and Water Management in cooperation with the Faculty of Mining and Petroleum Engineering of the Delft University of Technology into the phenomenon of polishing and texture regeneration. During this research the possibilities of using sandblasting for the interpretation of the regeneration of road surfaces, under the influence of the natural environment, are evaluated. For the research ZOAB samples have been used of which several have also been applied in highway test sections.

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e-mail: R.L.Krans@dww.rws.minVenW.nl
A.R.G.vandeWall@MP.TUDelft.nl

Interpretation of Chirp acoustic profile in a trial survey of the contaminated lake bed deposits of the Ketelmeer, the Netherlands. (Technical Note) *Proceedings 2nd meeting Environmental and Engineering Geophysics, Nantes-France 2-5 September 1996.*

Recent experience is presented from a case study on an inland lake using the continuously variable frequency signal produced by the Chirp sonar from 5 kHz to 20 kHz. This method allows high resolution differentiation of reflectors delineating properties of aquatic sediment profiles. The trials did reveal reflectors which show the boundary of the contaminated IJsselmeer formation with that of the underlying Zuiderzee formation. The reflector corresponding to this boundary, though, would end abruptly, probably as a result of screening caused by trapped gas underneath a thin weakly cemented crust-like layer near the surface of the IJsselmeer formation. Use of GIS techniques produces results which are comparable to an early sampling survey. (The short technical note in the proceedings will be published as more extensive paper in the European Journal of Environmental and Engineering Geophysics.)

P.M.M. Maurenbrecher, B.T.A.J. Degen and J. Keasberry

Info: P.M.M. Maurenbrecher, Delft University of Technology, Faculty Applied Earth Sciences, PO Box 5028, 2600 GA Delft.

Research overview into contaminated groundwater flow at Engineering Geology and Reservoir Engineering
Preprints Proceedings of 32nd Annual Conference of the Engineering Group of the Geological Society, University of Portsmouth, "Contaminated Land and Groundwater-Future Directions (Editors D.N. Lerner and N. Walton) p207-214.

A number of studies have been done at the Faculty of Mining and Petroleum Engineering, TU Delft in connection with dispersal of contamination through groundwater flow. Two recent studies have been made. The initial study examines a case history of contamination from heating oil tanks leakage dispersal due to ground water flow by use of two computer programmes MOC and AQUA a finite difference and finite element flow dispersal models respectively in an urban setting (de Groot, 1992). The second study is more theoretical investigation into three phase flow (water/oil and air) and the influence on dispersal of oil contamination (Nguyen, 1993). Early research work anticipated the recent resurgence in interest in the environment by the professor in petroleum engineering Prof. D.N. Dietz (1984) who modelled the effects of dispersal from spillage from an overturned oil tanker. Despite this early work most initiatives in research have taken place elsewhere: TNO-IGG (Institute for Geophysics and Geosciences) and at the Geo-Hydrology section of the Civil Engineering Faculty. Recent developments have resulted in a renewed research programme at the Faculty of Mining and Petroleum Engineering. This paper restricts itself to contributions made by the faculty.

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Flächenrecycling in Europa
Geowissenschaften 14 (5), 196-202, Ernst & Sohn, Berlin

This article gives - in a nutshell - an introduction into the problem of land remediation and recycling in Europe. Based on a short outline of the historical background the status quo of land recycling is discussed and the amount of land left by industry is quantified. Tools and techniques to carry out site investigation, risk assessment, and feasibility studies are explained in brief. The article concludes with future trends in European land recycling policies. (A similar paper stressing different points is presented at the 2nd International Congress on Environmental Geotechnics, 05-08.11.1996, Osaka, Japan).

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The Achenbach Case History - Recycling Land in a European Coal Mining District
Proceedings International Symposium Recent Major Case Histories in Environmental Geotechnics, Presses de l'école national des ponts et chausseés, Paris, France, 215-226, 1996.

The former coal mine Minister Achenbach is one of the major high profile remediation cases in the German Ruhr District. It is in many respects typical for land recycling projects in the European industrial belts: the contamination of the ground is diverse and severe, the ground is disturbed by many generations of different industries, the financing model of the remediation is complex, and the project management demands a high level of flexibility from all parties involved.

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Brachflèchenrecycling Jahrbuch
VGE Verlag, Essen, 1997

Ein Jahrbuch mit Informationen, Fachbeitragen und Profilen zur Re-Urbanisierung von kontaminierten Standorten. Schwerpunkt 1997: Schweiz.

Ed. D.D. [1]Genske, W [2]Beimann,

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Land recycling - tools of visualisation
6th Spanish Congress and International Conference on Environmental Geology and Land-use Planning Natural hazards, Landuse Planning and Environment, Volume I, Granada 1996, ISBN (of complete volume) 84-89683-01-8, pp, 245-264

Site investigation and remediation of derelict and contaminated sites is highly complex subjects. The revitalisation comprises ecological, economic, political and town planning aspects and thus needs a special approach to process and harmonise information relevant for the remediation to achieve cost-effectiveness. An introduction to the three basic steps of site investigation is given followed by the description of visualisation tools. The application of geophysics as a non-destructive survey method is also included. Geophysics allows a three dimensional insight into the subsurface. Visualisation tools will be illustrated by examples from practice. For each method drawbacks and advantages are considered. The paper is based on experiences gained in major remediation projects, some of which were funded by the European Fund for Regional Development EFRE.

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The significance of rock ductility for mechanical rock cutting
2nd North American Rock Mechanics Symposium (NARMS'96), June 19-21, Montréal, Canada, in: M.Aubertin et al (eds.) Rock Mechanics, Tools and Techniques. Proceedings 2nd North American Rock Mechanics Conference, Montreal, June 1996: 1, 709-716. Balkema Rotterdam.

From triaxial rock testing experiments it is known that a transition from brittle to ductile failure occurs at increased confining pressure σ_3. Rock cutting tests have shown that very high confining pressures can exist near the tip of rock cutting tools, with values above the brittle-ductile transition stresses known from triaxial tests. Despite the physical conditions of ambient room temperature and pressure normally present when cutting at shallow depth, near the cutting tool stress fields may occur in the ductile field of rock failure. The intensity of the stress field around the tool relates to the size and extent of the zone of crushed rock commonly present around cutting tools. In many rock types during rock cutting near the cutting tip ductile failure takes place, while further away from the tip brittle fracture occurs. Some weak rock types exhibit gross ductile failure during mechanical rock cutting, which has several disadvantages. Apart from a lower production rate, in some cases very high temperatures may arise at the cutting tip. The temperatures may be above the plasticity limit of the cutting tool material, resulting in extreme rates of wear. These observations suggest the importance to establish at what stress levels a rock is likely to fail in a ductile manner.

Results from two different test methods used to

determine the brittle-ductile transition are compared, the triaxial cell and a newly developed compression cell. Several rock types have been tested, on which previously cutting tests have been carried out. The brittle-ductile transition stresses were established using the classical triaxial test method. The specially designed rock compression cell was developed to determine the transition pressure of weak rocks in one test run. In this cell the growth of bifurcating fractures is prevented. The brittle-ductile transition stress value determined with this new method is compared with the triaxial test results.
The type of rock engineering data to be gathered during site investigations that prepare for mechanical rock cutting projects are discussed. Apart from unconfined strength tests and petrographic examination (to assess abrasiveness), information on the likeliness of ductile failure behaviour is needed. The significance of simple rock index numbers, such as the ratio of Unconfined Compressive Strength and Brazilian Tensile Strength, *UCS/BTS* (ductility number), and the Hoek-Brown *m*-value, in assessing the ductility of rocks is examined and compared with the results of the new compression cell.

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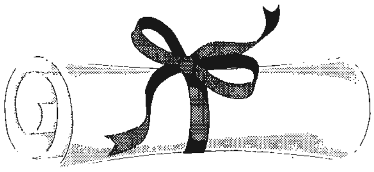
The Netherlands Students Award for Engineering Geology



The Ingenieursgeologische Kring, the Netherlands National Group of the International Association of Engineering Geology (IAEG) has established a prize for the best ir., drs. or MSc thesis in the field of Engineering Geology submitted to a Netherlands institute of higher education. The prize consists of a sum of NLG 1,000 and a certificate, to be handed out at the annual meeting of the Ingeokring in the spring of 1998. The thesis must be a contribution to the application of earth scientific knowledge to the solution of problems in civil engineering, mining engineering or environmental engineering.

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[1] ITC - International Training Centre, respectively International Institute for Aerospace Survey and Earth Science

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