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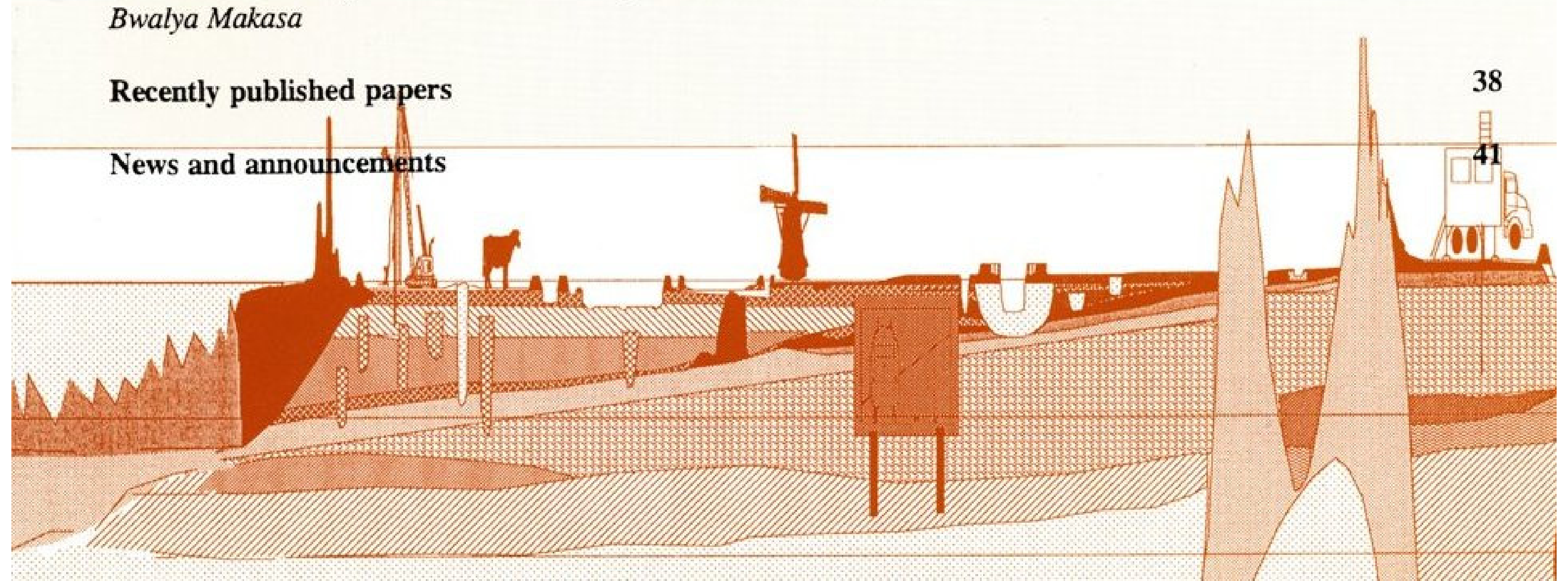
No. 7 Summer 1998





# From the chairman of the Ingeokring

Dear Members,

The previous Newsletters were edited by Alexander van der Wall and Jan-Reinouth Deketh. However, since they left the University in Delft and are not able anymore to do the tedious and time-consuming job of editing the newsletter. I would like to use this opportunity to thank them both for their work in giving the Newsletter its present form and the high quality they maintained. The new editor is ● enol +zmutlu, a Ph.D. student with ITC in Delft. He has enthusiastically taken up the job of editor and I am confident that future Newsletters will remain on the same high standards as we are used to.

Apart from Van der Wall and Deketh also Professor Dieter Genske has left the Engineering Geology Section of the Technical University in Delft. He has found a position as professor with the University of Lausanne in Switzerland. I wish him success in his new surroundings. A committee of the Technical University is working on the profile for a new to be appointed professor in engineering geology. Hopefully the committee will be able to select a good and suitable candidate in due time.

The change of the name of the IAEG to “International Association for Engineering Geology and the Environment” (see the report of the Council meeting of the IAEG elsewhere in this Newsletter) illustrates that environment related to engineering geology is still an important issue in the world. Although in the Netherlands commercial interest is fading.

Environmental impact studies are becoming a standard practice or are required by law for every major civil engineering project. In many of these impact studies it seems that in the Netherlands the emphasis is solely put onto factors which are easily observed at the surface by the general public, such as noise and trees. Geology and the interaction between geology and engineering seem of far lesser interest or are totally forgotten. Many examples can be found such as excessive differential settlement due to housing areas located on alluvial sediments of clay with peat and sand lenses, and road alignments perpendicular instead of parallel to channel structures. And remember the flooding of the housing areas built at locations along the rivers that, as every engineering geologist would have known, are regularly prone to flooding. I do not claim that in all situations these ‘engineering geological hazards’ could have been avoided, however, that is different from totally neglecting them.

Abroad, and in particular in France and the UK, engineering geology is far more incorporated in environmental impact studies. Hazard and risk maps including hazards and risks due to the interaction of geology and engineering are becoming standard and are routinely made for engineering projects. This development can also be expected in the Netherlands and, therefore, it is not a bad idea that the role of engineering geology in environmental studies is more emphasised.

RobertHack

# Geosynthetics and Marketing

*Edwin van der Holst, Vinkenburglaan 67, 2241 WL Wassenaar, the Netherlands,*
*E-mail: mot6vaed@itek.chalmers.se*

During the summer I carried out a summer job for Akzo Nobel Chemicals in Göteborg. My assignment was to assess the potential of the Swedish market for geosynthetics. Akzo Nobel and Huesker (a German company) produce a large variety of geosynthetic products. This article discusses some developments in the market place of geosynthetics.

## INTRODUCTION

First thing I decided to look at were some general trends in the building industry. From some courses and research I carried out, in project management and project finance, I had already an idea what the most important general trends in the building industry are.

### General Trends in Project Development

Throughout the world there is a tendency towards projects that are funded with private capital. Almost all developing and many developed economies face a similar situation:

- Rapidly growing demand for infrastructure projects.
- Insufficient public funds to finance projects.

Liberalisation and privatisation creates the possibility to start independent projects that would traditionally have been financed by the public sector.

The project is often organised as a BOT (Build Operate Transfer). Since these projects have a responsibility to produce yields for the capital borrowed, cost effectiveness and more innovative designs leading to cost savings could have increased attention. An example is for instance the Öresund project, the bridge between Sweden and Denmark, which is funded partly with Japanese pension funds. Another example is a privately financed highway in Finland, which will be build by the Skanska construction group (Sweden's biggest contractor).

Then of course there is the traditional governmental spending on infrastructure, for instance the road authorities. The expenditure on infrastructure by governments depends among others on the political situation in a country.

## GEOSYNTHETICS & MARKET SEGMENTS

After identifying some main trends in the building industry, I started a classification of different segments for the market of geosynthetics. I assessed the market potential of these different segments by interviewing customers, visiting building sites and looking at the previous sales performance. I will give you a short description and some information about the different segments from my classification. Akzo Nobel or Huesker have products in all of these segments.

### Non-Wovens for Road Construction

This market segment is the biggest for the geosynthetics, since the non-wovens are used for the construction of roads. The most important application for non-wovens is separating the different foundation layers of a road. Little development goes on in this area.

### Environmental

The environmental geosynthetics can provide solutions for sealing and capping of pollution, e.g. waste dumps, groundwater protection. There is concern in especially Sweden about the leakage of chemicals that are released after road and rail accidents into groundwater areas. This has led to the sealing of roads, ditches and tunnels to protect vital groundwater reservoirs.

Bentonite mats or plastic foils can be used for preventing pollution to migrate from the source. Bentonite mats contain the well known swelling clay Bentonite, which swells when installed and in contact with water and provides excellent sealing capabilities. The picture shown below shows an installation of bentonite mats for a waste dump.

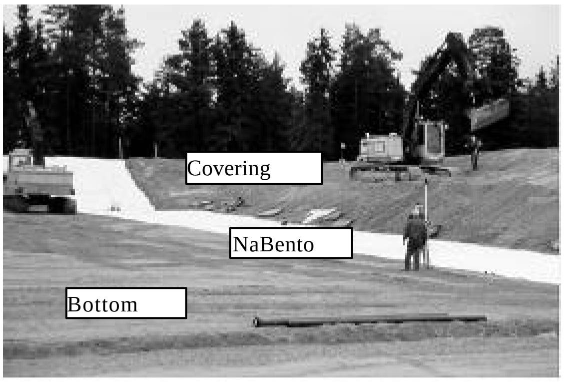


*Figure 1* *Installation of the Bentonite mats in Hovgården, Sweden.*

**Area and Slope Reinforcement**

Area reinforcement is applied on an inhomogeneous or soft underground and prevents uneven settlements. Slope reinforcement is applied to prevent failure of the slope when building embankments. Geogrids or polyester wovens, from high strength yarns are used for reinforcing the slope or area. There is a wide range of applications for geogrids and polyester wovens: reinforced slopes, retaining walls, landslide repairs, noise barriers, earth dams, breakwaters, road, railroad and airfield foundations, unpaved roads, haul roads and reinforcement on top of lime / cement piles.

Geogrids have to compete with traditional methods. For instance when constructing a slope, it can be constructed at a lower angle. If a natural angle of repose is used for the construction of the slope, no reinforcement is necessary. For area reinforcement the geogrid or polyester woven competes with thicker base layers etc.

**Erosion Protection**

Another important application is erosion protection and there is a wide range of products available to cover and protect slopes. In general the geosynthetic products have to compete with the more traditional methods of erosion protection like for instance the covering of slopes with crushed rock. Moreover, land is cheap in Sweden. Slopes do not have to be constructed steep to save square meters of land. Gentle slopes need less protection against erosion and it is easier for vegetation to establish on a gentle slope.

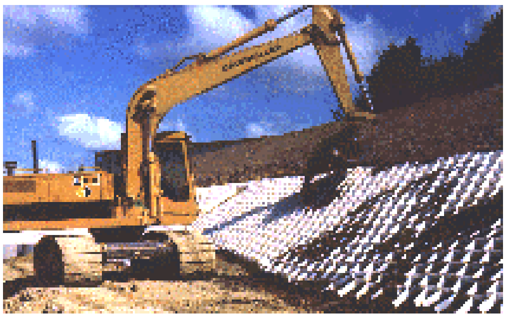


*Figure 2* *Installation of erosion protection (source: www.geosynthetics.nonwovens.akzonobel.com/).*

**Draining**

Synthetic drains can be used in applications like the drainage of tunnels, horizontal drainage, vertical drainage and waste containment. Drainage is applied mostly alongside roads and railways. Drainage of roads and railways is important because the surface of roads must always be as dry as possible for safety of the users and in case of railways it improves the stability of the embankment that the train rides on.

Derailments of trains due to failures of embankments in the past have led to increased attention for synthetic drains. Another application is the draining of tunnel walls.

**Asphalt Reinforcement**

Asphalt reinforcement is used for upgrading existing roads and construction of new roads (especially on a soft underground). The reinforcing grid increases the tensile strength of the asphalt layer, and under load ensures even distribution of horizontal stresses over a wider area.

*Figure 3* *Installation of asphalt reinforcement grids (source: www.huesker.de).*

Competition comes from traditional solutions. The easiest way to reinforce asphalt is to increase the thickness of the layer of asphalt. Although this is an expensive solution it is still applied by the major construction companies, since they are the producers of asphalt paving and are reluctant to come up with more innovative designs. It would be interesting to introduce cost-comparisons between applying thicker asphalt layers and reinforcing grids. Furthermore scientific support and case descriptions of projects would help in educating the customer.

## CONCLUSIONS

More cost effective and innovative designs are needed in the construction industry, with opportunities especially for privately funded projects. Geosynthetics can be used as new solutions to old problems (erosion, settlement, and environmental pollution).

Six market segments were discussed for the application of geosynthetics (road building, environmental, slope and area reinforcement, erosion protection and asphalt reinforcement).

Two main reasons were identified for not applying geosynthetics:

- A lack of knowledge about the application of geosynthetics. The development of geosynthetics in Sweden is more driven by industry than by universities, authorities or consultants.
- Another issue was plain conservatism. People do not have the will to change and apply daring innovative solutions. Traditional methods dominate.

I myself had an interesting work-experience in Sweden and not only got acquainted with the world of geosynthetics, but dealt with management issues at the same time.

For more information:
http://www.geosynthetics.nonwovens.akzonobel.com/,
http://www.huesker.com

# New Geotechnical Journal in the Netherlands

*Martin van Staveren, Tel: 015 2693583, E-mail: sta@delftgeot.nl*

Until recently the Dutch were lacking their own geotechnical journal. Unlike our English and German colleagues for instance, we didn't have our Ground Engineering or Geotechnik. It is therefore a noticeable initiative of the section Geotechnics of the Royal Institute of Engineers (KIvI), to start with the publication of the journal Geotechniek (Geotechnics), just about one year ago. It is written in Dutch and at least for the Dutch, Belgian and may be even South African engineering geologists the journal presents a lot of interesting engineering geology related topics.

**ABOUT THE JOURNAL GEOTECHNIEK**

To date many different topics are presented in Geotechniek. Of course the very actual infrastructural projects are included. Interesting articles explain for example about the geotechnical aspects of the currently bored Heinenoord Tunnel and the high-speed railway link (HSL) between Amsterdam and Belgium, which will cross very soft soil deposits. Furthermore new developments in soil investigation techniques are highlighted, such as the Cone Pressiometer. Existing techniques are critically evaluated, such as inaccuracies during triaxial testing. Case studies provide valuable insight in the day to day geotechnical engineering practice in the Netherlands. Additionally in every journal an interview with a Dutch or Belgian geotechnical "hot shot" is included, besides information about congresses, courses, books, etc. Geotechniek is issued 4 times per year and the costs depend on your address and the type of subscription, as presented in the table below.

| **Your address** | **Type of Subscription** | **Costs in Dfl** | **VAT** |
|---|---|---|---|
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***Table 1*** *Subscription rates*

**GEOTECHNIEK AND THE INGEOKRING**

Geotechniek intends to focus on the wide geotechnical range of soil mechanics, foundation engineering, geohydrology, environmental geotechnics and related fields of interest such as engineering geology. For the near future, the Editorial Board of Geotechniek tries in particular to obtain more engineering geological input. For that reason I became member in the Editorial Board of Geotechniek, on behalf of the Board of the Ingeokring. Our joint purpose is to publish more typical engineering geological topics in Geotechniek. This will hopefully result into more readers of Geotechniek, which will provide the journal a sound basis. On the other hand it will help to obtain an even better understanding of the benefits of engineering geology in the (Dutch) geotechnical branch.

In conclusion, do not hesitate to publish your interesting engineering geological topics in Geotechniek and bring it under attention of many geotechnical engineers!

# Excursion to the Second Heinenoord Tunnel

*Wilbert Enserink, Delft University of Technology, Faculty of Applied Earth Sciences, Section Engineering Geology, P.O. Box 5028, 2600 GA, Delft The Netherlands*

The Second Heinenoord Tunnel is a project located on the banks of the river Oude Maas, south of Rotterdam. The project has been designated as a pilot project, meant to gain valuable expertise and experience in driving through soft ground.

It has been just over two years ago that the Ingeokring organised an excursion to the building site. At that excursion the distinctive parts of the tunnel boring machine (TBM) could be seen. Nowadays the first tunnel tube is ready, so the time seemed ripe for a second Ingeokring excursion to the building site of the Second Heinenoord Tunnel in order to give renewed attention to the results of measurements taken during the boring and their relation to the several model calculations.

After a warm welcome and very nice coffee Mr. Langhout gave a presentation about the experiences gained during construction of the first tube. Two main problems occurred during drilling. The first problem was the inflow of water as a result of a failure in the TBM. Creating a seal, hence avoiding the inflow of water solved this problem. The second main problem was the vertical leakage of bentonite suspension into the river Oude Maas at the face of the TBM. These vertical ‘piping’ features were declared to be weak spots in the soil probably caused by old anchors.

Although the day of the excursion was a famous Friday the 13th, no problems occurred that day…

After this presentation Mr. van der Poel continued about the soil parameter determination for the Heinenoord project. A great deal of soil parameters influences the boring project. The most important being the soil strength and soil stiffness, the unit weight and the type of soil. After measurements had been done and samples were taken conclusions could be drawn about the importance of the soil parameters, for example: The soil stiffness is important for the liner design and highly variable soil types create complicated soft soil conditions for tunnelling.

The final presentation was given by Mr. Feddema who was evaluating the K100 monitoring program and comparing results to the predictions done before the project started. Amongst other it can be concluded that ground settlements due to the support pressure at the face are limited and that there is a strong relationship between ground settlements and the injected grout volume.

The last part of the excursion consisted of a visit guided by Mr. Verveer to the building site at the southern bank of the river Oude Maas. There the final tunnel lining of the first driven tube could be seen together with a great part of the tunnel boring machine standing ready to start with the second tube.

It can be concluded that this day was a very nice day. Not only was the excursion very interesting, the sun was also shining, the temperature was very nice and last but not least the beers in café ‘t Noorden during the Engineering Geology drink tasted very nice. I guess it’s only fair to say that there are also Fridays the 13th who can bring a person luck.

# Asset Information Management

Presentation given by Dalip Sud, Shell at joint meeting of NICE and Ingeokring
*Reported by: Senol Ozmutlu[(1)] and P.M. Maurenbrecher[(2)]*
*(1) International Institute for Aerospace Survey and Earth Sciences (ITC), Centre for Technical Geoscience (CTG), Section Engineering Geology, Delft*
*(2) Delft University of Technology, Faculty of Applied Earth Sciences, Section Engineering Geology, Delft*

The aim of every project or company would be to have an AIM. Not a goal, suggesting entrepreneurship, but to ensure that goals are achieved with efficiency and minimum costs: Asset Information Management. The system is being implemented in many projects and complex installations to ensure their efficient management from maintenance, improving design and performance. The system with Shell is global so that exchange of information is possible between installations. This allows queries to be answered rapidly; for example, information regarding to a malfunctioning compressor can be searched through AIM using similar techniques that are used in databases or Internet navigators. This allows information from various parts of the world on that particular type of compressor to be obtained to see, for example, if the same fault has occurred elsewhere, the type of repairs that have taken place, and the subsequent tests and performance once the compressor went on stream.

**INTRODUCTION**

Though Dalip Sud's background is in Chemical Engineering, the ideas and concepts that were presented at the joint meeting of IngeoKring and the Netherlands Association of the UK Institution of Civil Engineers are certainly "food for thought" for projects and information management within the engineering geology and civil engineering. For a site investigation company, which deals with plant or plant performance, an AIM should be the aim of any geotechnical/ engineering geological asset. Drilling rigs, vehicles, sampling, insitu testing, laboratory testing, design and subsequent initial construction supervision of foundations, dams etc., all are used/ applied to various degree of success in different geological and physical environments.

John Reeves (ICE) introduced the speaker of the joint meeting; Dalip Sud. Originally the topic was advertised as The Global Office/ International Electronic Office, but the new title puts more emphasis on the economical merits of information management as an asset. The new structure within Shell is that new innovative methods are not just implemented within departments and groups but one has to convince these departments and groups that the expense of implementation will reap rewards which will amply offset the costs. Dalip was for 24 years process engineer within Shell graduating originally as chemical engineer and has progressed from refineries to trading and since the last ten years in information business consultancy; more specifically Asset Information management.

Assets directed to physical aspects such as plant, jackets, refineries, factories involving a large amount of engineering input in. It is the highly complex assemblage of detail that makes efficient construction and maintenance of such assets. This necessitates a proper information system at hand which can be shared on the global scale by world-wide operations of Shell.

From 1970s, with the introduction of ARPAnet, which was an experimental network designed to support military research in US army for communication network between a source and a destination computer, until today with widespread INTERNET use the information transfer and message exchange have been improved dramatically. Node to node transfer of information with ARPAnet was upgraded to multi-format extraction and transfer of information on a web like networks, which enables the "Global Office". In spite of recognisable development in browsing and format flexibility, accessing the right information is not that easy.

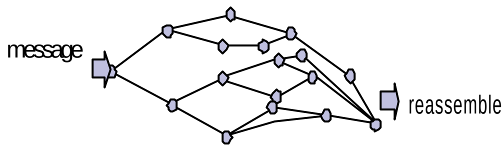



***Figure 1*** *Nodal transfer of information.*

On the other hand, engineering contractor is interested in the cheapest solution. “When I need it I should be able to pick it up” which can be achieved through the “Global Office” by querying good solid information sources. Using present day “search engines” results in too much information or nothing. Too much means that the first ten items are looked at and the rest is ignored. The priority listing of search results is based on a system of “hits” that they get. Hence a better mechanism is needed.

**AIM: Alcohol Induced Metaphors**

The AIM of this global office information Dalip Sud said, let us to believe, was his excuse to take a swing of whisky that is obtained especially for the speaker. “Whisky”: The Chancellor when he presents the budget in the commons (UK) can have drink, which is a whisky.

The present method of information management results in chronic waste. Non-value added activities could cost around 15-25% of design work expenditure. This waste can be saved with efficient information management.

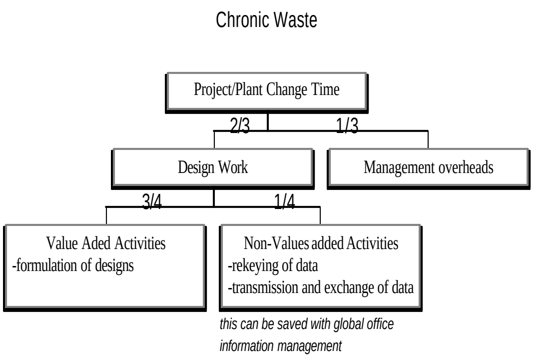
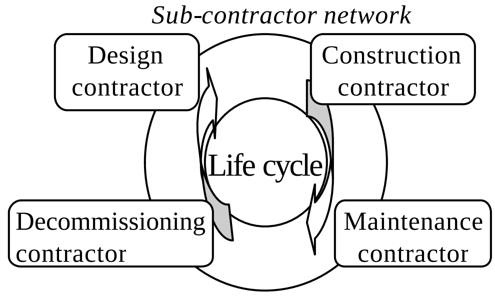



***Figure 2*** *Costs resulting in plant/project execution.*

Asset Information Management (AIM) is the structured approach to the management of engineering data, drawings, procedures, and other information throughout the asset life cycle. It also provides controlled access to the information within and across the organisations.

Managing asset information covers the whole life of a plant. It starts with developing the plant design and continues through its use and update in procurement, fabrication, construction and commissioning. These activities typically involve several organisations. The complete as-built design package is handed over to the operator, who will use it to maintain the plant, and who must keep it up to date when plant changes are made. Experience shows that managing this information using current practices is complex, expensive and error prone.

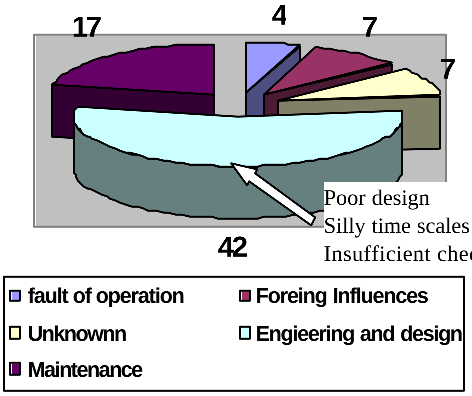
Finding the right information can take time, sometimes half a day or more. As a result, people usually use their own, possibly out of date copies, of vital information introducing errors that may




cause equipment malfunction or serious accidents. The pie chart below illustrates the reasons for various out-of-service conditions.

***Figure 3*** *Life cycle in an AIM.*

For standing business performance, it is vital that the asset information is updated and made available when and where required. This approach

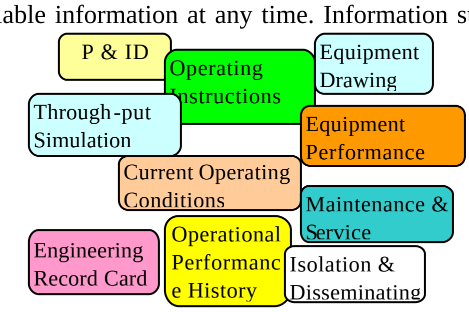



will support the implementation of the best practice, and improve the business processes, at all stages in the life of the plant.

***Figure 4*** *Causes of service faults in a plant.*

**AIMS FEATURES**

At its core AIM is the electronic management of technical data and documents, supported by workflow of other tools within an information management framework. These work together to capture and maintain the relationships between the different types of information about an asset, enabling people and systems to easily access reliable information at any time. Information stored




**The value is in the links: who manages the links?**

at various locations without any links has no value to the user.

***Figure 5*** *User view of asset information.*

AIM is a journey, not an event. It is a series of building blocks implemented gradually in a logical sequence, at a pace that gives people time to understand and learn how to use AIM for business process improvement. Implementations can be spread over several years; each building block yields its own benefits. As more building blocks are added, the accumulative effects greatly exceed the sum of benefits from individual building blocks. Each of these building blocks contain the necessary number of "tags" which are required for effective linking of information sources and thus an effective extraction of information when needed.

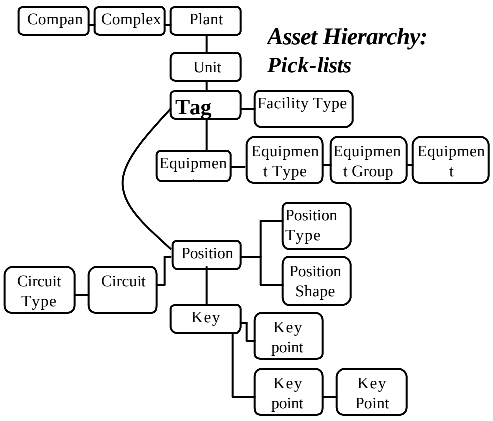



***Figure 6*** *Linking the building blocks in asset hierarchy.*

For example an LNG (Liquefied Natural Gas) plant has up to 40 to 60 different entities That makes about 20 000 tags each tag is an equipment record cards of 200 items of information, giving say information on design pressures and operation pressures as many design values in actual specifications. It is necessary to categorise 1000 keywords into a systematic manner. Often there is a replication in different views/ sheets. Split sheets into databases, then re-assemble (re-construct) relationships.

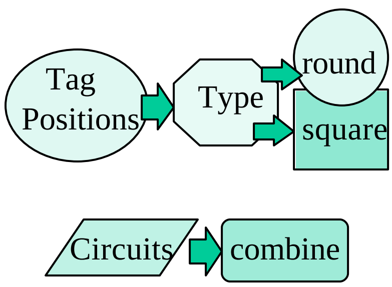



***Figure 7*** *Reconstruction of relationships between the entities.*

AIM supports STEP, the emerging engineering data standard that enables efficient exchange of engineering data between organisations. AIM deliverables support the cost reductions in new projects at a range of 4% of capital expenditure. Improving maintenance management saves direct maintenance costs (by 2 to 5 %) and leads to improved plant availability, thus reducing deferments, which are translatable to increased revenue.

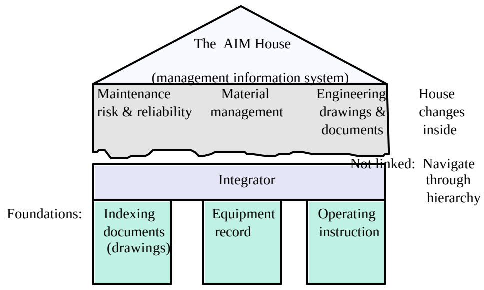



***Figure 8*** *AIM building blocks for an engineering geological asset: the house analogue.*

Many of the existing assets are on paper and have to be transferred to AIM. The basis of the transfer is the ISO standard; AI 221, which Dalip has been instrumental in its set-up.

Information about the changes that were made in assets (not world-wide changes) will have to be kept for the entire life of the facility. The structure of the database is such that you can get back to the information. If this is not so, once the information is archived it would be difficult to retrieve. Whole system can span 30 to 40 years. The biggest problem is closing the system down. The cost for setting up the basis structure is US$100 000, which requires a few weeks. The system is implemented in small bits. There are periods of major shut down during the system upgrades. Though costing $100 000 the system manages assets worth US$100 000 000. Shell Services International's AIM team is actively working with a number of Shell companies including Shell Durban Refinery, Nigeria LNG, NAM, Brunei Shell Petroleum and Shell Expro. The services are offered also for customers outside the Shell Group.

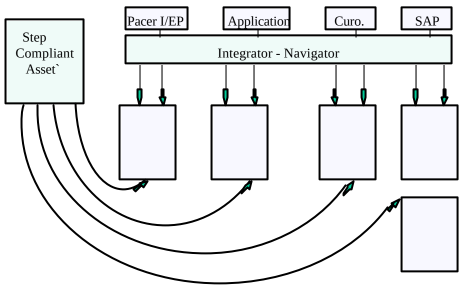



***Figure 9*** *AIM implementation of STEP*

On concluding his talk some of the questions resulted in the following discussion. Chris Parkinson discussed information with regard to CFA (Continuous Flight Auger) piles and how that information would be entered into the AIM.

Dalip Sud emphasised that AIM is a journey and not an event, involving over time a build up of records with regard to a particular item, which would also apply to the CFAs. Presumably: the company that installed them, when they were installed, rate of installation, the test results on its performance, pile dimensions, actual depth, quality of concrete etc. The loading history will not be kept directly but could be determined by the operations taking place in the structure.

For further information about the Asset Information Management, please contact Dalip Sud, via e-mail D.D.Sud@is.shell.com or telephone +31 70 303 4535

# ADVERTISING IN THE NEWSLETTER

*The Newsletter is a journal on engineering geology and related fields. It is distributed twice a year to the 200 members of the Ingeokring and several companies and institutes, active in the field of applied earth sciences.*

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# THESIS ABSTRACTS

This section is aimed at the introduction of M.Sc. (Ir.) level research at the Engineering Geology divisions of the Faculty of Applied Earth Sciences, Delft University of Technology, and that of International Institute for Aerospace Survey and Earth Sciences. We will include abstracts of two randomly selected theses in each volume. Our intention is to give some idea to the geoscience community about the type, and diversity of research undertaken in engineering geology sections of these two institutions.

## A Three Dimensional Production Estimation System: Geotechnical aspects of dredging production estimation in the context of the Øresund Link Tunnel Trench Dredging Project

*M. H. A. Brugman*
*Faculty of Applied Earth Sciences, Section Engineering Geology*

An accurate prediction of dredger performance and, consequently, a reliable estimation of production rates is an important necessity for project planning and budgeting in the dredging industry. In rock dredging, it is often the ability (or inability) of the cutter to dislodge the material, which limits the production rates. It is therefore important to establish relationships between geotechnical characteristics of the rock mass and realisable rates.

The objective of the research done for this thesis is twofold:

1. Design and application of a dredging production estimation system, in a 3D-GIS environment.
2. Evaluation and, if possible, refinement of existing methods and relations used by Ballast Nedam Dredging to estimate production, using the designed system.

A system has been designed, which is able to both make estimations of dredging production rates, and determine actual realised production rates. Loose coupling of the system to a 3DGIS enables production estimation based on a three-dimensional geotechnical model of the subsurface. Calculation of realised production rates is based on real time measurements of several dredging parameters during the dredging process. The system thus enables direct validation of estimated productions in comparison to realised productions during the dredging project, allowing adjustments in the estimations if necessary.

Production relations, used by Ballast Nedam Dredging, have been incorporated in the production-estimation routine of the system. Evaluation of the system and production relations has been achieved by implementing the system, and thus the production relations, in the Oresund Link project. Material dredged during the Oresund Link project consists of limestone formations of Danian age. Main characteristic of the limestone formations is the frequent and regular occurrence of flint with a high strength, as bands of nodules and as relatively thin layers.

Different approaches have been used to estimate production rates and have been tested against realised production rates. The approaches show only marginal differences in results. The main conclusion, which has been drawn from comparisons, is that production rates are underestimated when low production rates are expected.

## Effects of Swelling Clay Minerals on Geotechnical Properties

*C.O. Ndaga*
*International Institute for Aerospace Survey and Earth Sciences, Section Engineering Geology*

Expansive soils have been estimated to cause damages far much exceeding those caused by floods, hurricanes, earthquakes and tornadoes all combined. This damage is mainly directed towards light engineering structures founded on them at shallow depths. This category of structures includes roads, runways and buried utilities. These structures are known to be among the most expensive of the civil engineering structures.

Hence the geotechnical engineer needs to be able to readily identify the soils that could swell and to determine the amount of heave that may occur. There are methods that would help in this respect. However, these methods are normally costly and require expertise interpretation, Simple and less expensive tests are then sorted for that would act as simple indicators of the presence of these expansive soils. Soil plasticity is one of such indicators.

Plasticity of soils, from a geotechnical point of view, is normally determined by the traditional Casagrande and cone penetrometer apparatus. In this research, a third apparatus, the Pfefferkorn plasticity tester has been tried out. This is an apparatus that is heavily relied upon for the determination of plasticity in the ceramic industry, yet is hardly used in the field of geotechnical engineering. In using this apparatus, high correlations have been obtained of results from this apparatus and those of the other two methods. It has even been observed to have some advantages over these traditional methods.

On the basis of swelling pressure results obtained from the oedometer swelling test, a simple method has been established in the course of this research, that would act as a simple indicator of expansive soils based purely on their plasticity values. The relative magnitude of the degree of expansiveness may also be approximately established.

However, it should be understood that because of time element, it is possible that moderately expansive clays with smaller swell potential but with higher permeability may actually swell more in-situ during a single rainy season than the more expansive clays but with lower permeability. This factor makes analytical techniques like x-ray diffraction (XRD) methods indispensable despite their high costs of operation for detection of small quantities of these swelling clay minerals. This is especially necessary when dealing with very sensitive construction works with strict differential uplift or settlement requirements.

# **Amazing Projects:** Channel Tunnel

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In this edition of the Newsletter, we introduce the Channel Tunnel connecting England and France through the English Channel's seafloor. There are many reasons to take this unique transportation system in amazing projects category. We will try to summarise some of the important aspects of Channel Tunnel below. Let's have a closer look at this astonishing engineering feat, which was debated almost 200 years before actually commencing.

## THE CHANNEL TUNNEL IS ONE OF EUROPE'S BIGGEST INFRASTRUCTURE PROJECTS EVER

The Channel Tunnel was a dream for about two centuries. The 50.45km long tunnel has fulfilled this old dream by linking Britain and the rest of Europe. It's not just a tunnel, but a huge infrastructure containing massive machinery and control systems in an underwater tunnel system. The Channel Tunnel was opened for business around mid 1995 and cost in excess of £10bn. It connects England and France 50m below the seabed of the English Channel.

## IT TOOK ALMOST 200 YEARS TO COMPLETE THE CHANNEL PROJECT

Throughought the 19th century engineers were inspired with the idea of a fixed link between France and Great Britain. There were various designs made for tunnels, bridges and even submerged tubes across the Channel. Technological developments and the new means of transportation have given more credit to the proposed Channel projects. However the idea was rejected many times in the British parliament due to fear of invasion by France, defence worries, and economical reasons.

One of the earliest designers is Albert Mathieu Favier, a French engineer. Already in 1802 he has proposed a tunnel for horse-drawn vehicles. The construction of an artificial island in the middle of the Channel would serve as a platform for changing the horses, the tunnels' lighting was to be provided by oil lamps and chimneys would provide ventilation.

Between 1833 and1867 Thom de Gamond worked on various plans for a fixed link. He has researched the geology of the seabed under the Channel by completing a series of hazardous dives, and verified that the chalk rock strata beneath the seabed was a suitable medium for tunnelling

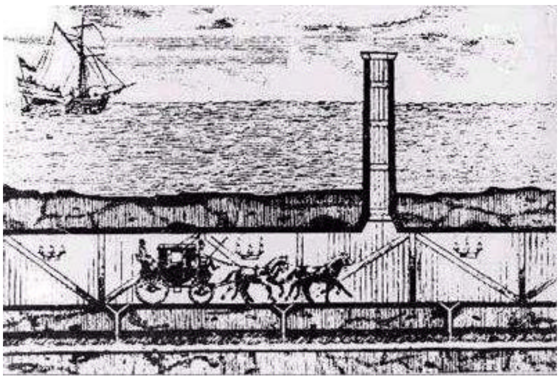


***Figure 1*** *Channel Tunnel design in 1802*

The invention of the tunnel boring machine by Colonel Fred Beaumont and its further development by Arthur English resulted a new era in tunnelling techniques. With a rotating cutting head, a conveyor system for disposal of the waste rock and compressed air systems, this machine was the prototype for all future tunnelling machines. Around 1870 Channel Tunnel companies were formed in France and in England. Tunnel boring operations started on both sides of the Channel with versions of the Beaumont-English machines. After 2000 metres of tunnel were bored at Shakespeare Cliff near Dover and around 1600 metres at Sangatte near Calais, the project was halted by opposition from the British parliament.

Between 1904-1947 a constructive round of relationships started between England and France. With the developments in railway technology, engineers proposed new plans for the Channel Tunnel. A trial tunnel, around 128 meters long was bored, using a machine designed by Douglas Whitaker but this was also halted by political objections. After the Second World War, intergovernmental agencies agreed on the establishment of the feasibility of a Channel Tunnel. Engineering and geological research continued and in 1956 the Channel Tunnel Study group, a French / British consortium, was formed to co-ordinate investigations in all the marine, geological, economic and engineering aspects of a cross-Channel fixed link. In 1974 Work began on both sides of the Channel. A pilot tunnel at Shakespeare Cliff was abandoned after 1400 metres, owing to the British government's withdrawal of support for the project for economic reasons. This section of tunnel would ultimately be used as part of the access shaft for the next Channel Tunnel construction works. After almost 200 years of debate and planning for a fixed-link between France and Great Britain, the governments of both countries signed a treaty in 1986 to permit the building of a Channel Tunnel. On 14th March, Eurotunnel was granted a concession agreement, lasting for 55 years, to construct and operate the Channel Tunnel. Construction commenced on both sides of the Channel by the end of 1987.

***Figure 2*** *One of the earlier TBMs*

**IT CONSISTS OF THREE INTERCONNECTED TUBES EACH 50.45 KM LONG**

Its length is 50.45km of which 38 is under sea. Three concrete tubes each 1.5m thick, plunge into the earth at Coquelles, France and burrow through the chalky basement of the English Channel. They reemerge at Folkstone, behind the white cliffs of Dover. The tunnels are 30 metres apart and were bored in the rock strata under the Channel, at an average depth of 45 metres (50m maximum) below the seabed. The two large tunnels (7.6 metres diameter) each contains a single-track railway line. The smaller service tunnel, for ventilation, maintenance and safety access, (4.8 metres diameter) is located between the two rail tunnels and is equipped with a wire guidance system for specially designed service tunnel vehicles. All three tunnels are connected every 375 metres by a cross-passage which gives access to the service tunnel in case of emergency. The cross-passages are also used for ventilation and maintenance service access. Every 200 metres, the two rail tunnels are linked by piston relief ducts to allow the passage of air through the tunnels, thereby reducing the aerodynamic resistance of the trains passing through at speeds of up to 160km/h. All three tunnels are lined with concrete linings. The rail track consists of continuously welded rail set on rubber pads fixed to individual pairs of concrete blocks. The blocks are cast into a concrete track bed to provide firm, smooth running.

***Figure 3*** *Three interconnected tubes of Channel Tunnel*

**IT TAKES ONLY 20 MINUTES TO COVER THE LENGTH OF TUNNEL UNDER THE SEA**

The Channel Tunnel consists of three tunnels. Trains enter the tunnels at terminals located at Folkestone in the county of Kent in Southeast England and at Calais in the Nord-Pas-de-Calais region of France. The tunnels contain a railway system which takes: shuttle trains between the terminals and through-trains which link with the national rail networks of France and Great Britain. Through two of the tubes rush the broadest trains ever built -- double decker behemoths 4.2m across -- travelling close to 160km/h. Passengers board not on foot, but in automobiles and buses.

**THE TUNNEL WAS CONSTRUCTED BY NEARLY 13,000 ENGINEERS, TECHNICIANS AND WORKERS**

The Channel Tunnel has faced persistent financial problems in its brief history. During the project there have been major cost and time overruns. The total cost of the project is estimated at £4.9 billion in

1987 yet cost more than £10 billion when completed. Opening of the tunnel was seriously delayed several times. Nearly 13,000 engineers, technicians and workers constructed the tunnel

**THE VOLUME OF RUBBLE REMOVED FROM THE TUNNEL IS THREE TIMES GREATER THAN THE CHEPOS PYRAMID IN EGYPT AND INCREASED THE SIZE OF BRITAIN BY 68 FOOTBALL FIELDS (90 ACRES)**

The Channel Tunnel project proposal from Eurotunnel group was accepted not only because of its safety benefits and the favourable technical aspects, but also of the environmental considerations. An extensive programme of environmental monitoring was integrated with the construction projects in both France and Great Britain.

At Shakespeare Cliff, the main construction site in the UK, the construction of the tunnels posed the problem of how to dispose of the 4 million cubic metres of spoil or waste rock in a way which would minimise the environmental impact. It was decided to enlarge the existing platform at the foot of Shakespeare Cliff by putting the spoil into the sea behind a specially constructed sea-wall. This new land has been landscaped and planted with suitable seed-mixes to create a nature conservation area.

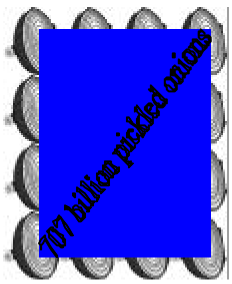

***Figure 4*** *Chepos pyramid and a football field*

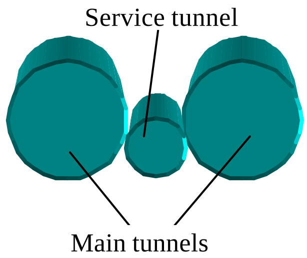
To the east of the Folkestone terminal, the tunnels had to pass through the area of HolywellCoombe, a site of exceptional geological, ecological and archaeological interest. In this valley area, to avoid changes to the natural drainage of the area and to conserve the fen habitat there, the tunnels were constructed in a trench by " cut & cover " method.

At Fond Pignon (France), the site chosen for the disposal of 5.3 million cubic metres of spoil, a new hill has been created from the waste rock. The 3.5 kilometre pipeline was used to pump the spoil to the Fond Pignon site to avoid the need for transportation by lorry. A dam was constructed to contain the wet spoil and this wasteland site has been transformed by landscaping and the planting of vegetation on the new hill.

**22 BILLION JARS CONTAINING ROUGHLY 707 BILLION ONIONS AT A COST OF APPROXIMATELY £18.8BN WILL BE REQUIRED TO COMPLETELY FILL THE TUNNEL AND PREVENT A FRENCH INVASION**

How about the centuries' fear of invasion? The scenario below estimates the required number of pickled onions to fill the tunnel network and cut England off from France in the event of an invasion. The calculation is based on the volumes of the two main tunnels, which are 3.8m in radius and are 50km long, and a service tunnel of 2.4m in radius, which runs parallel to the main tunnels.




*Volume of two main tunnels:*
3.142 * 3.8m * 3.8m * 50000m * 2 = 4577882 m3
*Volume of service tunnel:*
3.142 * 2.4m * 2.4m * 50000m * 1 = 913040 m3

If the volumes of connecting tunnels between the service tunnel and the main tunnels and pressure relief tunnels between the two main tunnels are considered...

3.142 * 1.65m * 1.65m * 20m * 134 = 22925 m3
3.142 * 1.0m * 1.0m * 15m * 202 = 9520 m3
($\pi * r^2$ * length * number of tunnels = volume)

The total volume adds up to 5.523367 million cubic metres. A quick look at the family jar of pickled onions shows that 32 onions occupy 250ml and that 22 billion jars containing a staggering 707 billion onions at a cost of approximately £18.8bn will be required to completely fill the tunnel and prevent a French invasion.

**260,000 HOME REFRIGERATORS WERE REQUIRED FOR THE AIR-CONDITIONING OF THE CHANNEL TUNNEL**

The cooling of tunnels are usually accomplished by circulating air from one end to the other. This technique would not work for the Channel Tunnel case. The high-speed trains running through the Channel's two long, narrow openings would act like pistons in an engine, generating heat that could reach 54.5°C -- too hot for passengers and equipment.

The solution was to use two chiller plants, one at each end of the Channel Tunnel. The plants provide nearly 15,000 tons of refrigeration -- comparable to about 260,000 home refrigerators. It is the world's largest chilled-water system and the world's first air-conditioned tunnel. The complete cooling system -- including design and installation of the chiller plants and chilled-water piping -- cost $200 million, the world's most expensive air-conditioning job.

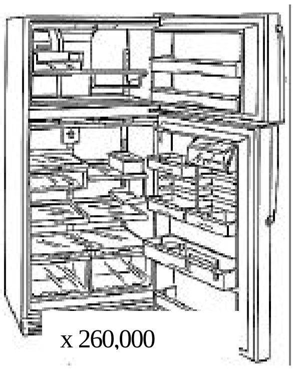



***Figure 5*** *260,000 home refrigerators required for the cooling of Channel Tunnel*

The chiller plants cool and circulate 54 million gallons of water through a 150-mile network of chilled-water pipes. It took three weeks just to fill the system with clean, treated water for initial testing. The 24-inch diameter chilled-water pipes run in closed circuits. Each one goes halfway through a tunnel, makes a U-turn, then heads back to its chiller plant. The pipes serve as huge, natural heat exchangers.

**EUROTUNNEL IS THE COMPANY WHICH OWNS AND OPERATES THE CHANNEL TUNNEL AND ITS RAILWAY SYSTEM**

The Channel Tunnel provides a railway link between the road and rail networks in Great Britain and France. Road vehicles access the terminals from the M20 motorway in Kent or via the autoroutes A16 and A26 in the Nord-Pas-de-Calais. Cars, coaches and lorries are directed into appropriate lanes before arrival at the toll booths. Journey time platform to platform is 35 minutes.

**GEOLOGY & SURVEYING**

Engineering geological investigations were carried out on Shakespeare Cliff in England and on Sangatte in France. The geology of undersea crossovers were characterised as sedimentary rock layers of chalk, chalk marl, and gault clay type down to a depth of 50 meters beneath seabed. The data from geophysical surveys provided information about the geology and helped to determine the alignment and route of the tunnel. To maximise the favourable ground conditions, the tunnels were excavated in the layer of chalk marl except for a 3 kilometres section on the French side.

**CONSTRUCTION WORKS**

In France, the construction of the Channel Tunnel began at Sangatte on the Nord-Pas de Calais coastline at a location just over 3 kilometres away from the French terminal site at Coquelles. A circular access shaft, 70 meters deep and 55 meters in diameter was excavated and lined with concrete. A shed was built to shelter the shaft in the centre of the large construction site which also contained offices and a lining segment manufacturing factory All materials, workers and equipment were lowered down the shaft to the working platform at 47 meters, where the tunnel boring machines could be assembled in dry conditions. From this point, three machines excavated the undersea rail tunnels and service tunnel beneath the seabed towards Kent and two boring machines began the drive underground and inland towards the terminal site. One of these machines was then re-assembled to excavate the second running tunnel, thus using only 5 machines on the French side.

Construction work began on the British side at a platform located at the foot of Shakespeare Cliff. The site, situated between Folkestone and Dover on the Kent coast, was used for the previous tunnel attempt in 1974. The earlier tunnel workings were used as one of the two access shafts to the underground workings. The equipment and material were transported via a rack and pinion railway system to the marshalling area underground. The six TBMs were each assembled in a large cavern area, over 20 metres high and equipped with overhead cranes for lifting the TBM sections, which had first been excavated to accommodate the 8.6 metre diameter machines. From this point under the platform at Shakespeare Cliff, three undersea tunnels were bored towards France and three underground tunnels towards the terminal site at Folkestone. The service tunnel machine on both sides bored in advance of the two running tunnel machines. Probes on the service tunnel machine provided advance warning of difficult ground conditions and the data obtained provided data on alignment and conditions for the larger tunnel drives.

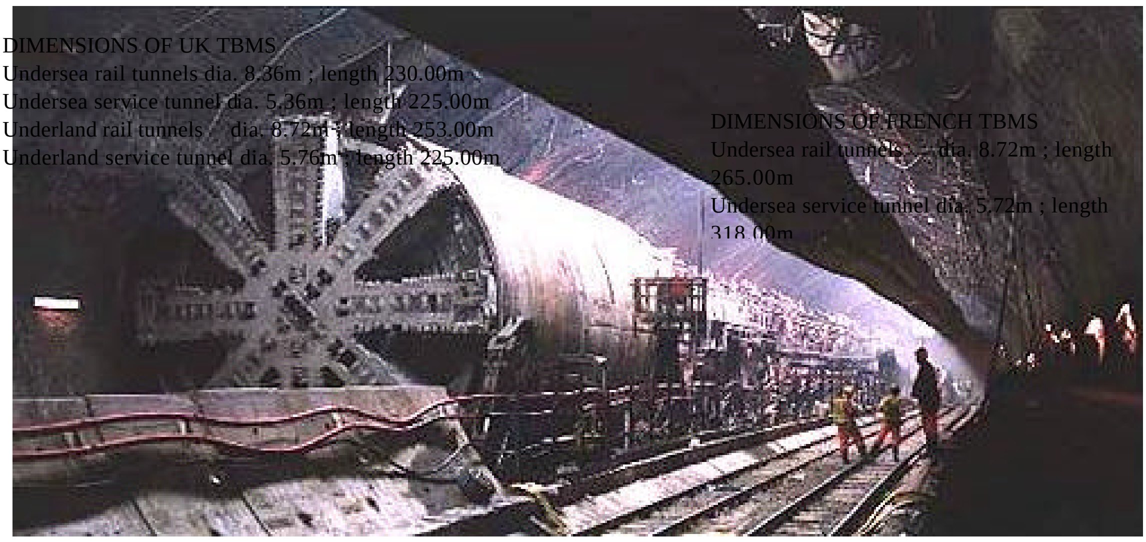
Work on the Folkestone terminal started in 1988 with a major land-fill engineering project in order to provide the level area needed for the railway transport system. Constraints were imposed by the geographical features - the 140 hectare site lies at the foot of the North Downs chalk escarpment and to the south, the long narrow site is bounded by the M20 motorway.

The site chosen for the terminal at Coquelles, near Calais, required a major drainage exercise and millions of tonnes of earth were spread and compacted to lay the foundations for the 480 hectare terminal complex.

***Figure 6*** *Terminal construction sites; Coquelles, France (left), Folkestone, UK (right)*

## 11 TUNNEL BORING MACHINES WERE USED

The tunnel boring machines were specially designed for excavating the chalk marl rock. The ground conditions were expected to be generally favourable in the dry and stable chalk marl, except for the section to be bored in the layer of upper chalk between Sangatte and the terminal site at Coquelles. It was a challenge for those eleven TBMs because the considerable length of tunnel would be driven under the sea, a high advance rate was required in construction programme, and there was a high probability of facing with unexpected ground conditions. The facts below give an indication of the performance of TBMs, and the achievement of all the engineers and workers involved in this remarkable engineering task.



**Number of drives:** ( tunnels excavated ): 12 - 6 undersea, 6 underland

**Number of TBMs:** 11 - 6 undersea, 5 underland (a French machine bored 2 underland tunnels)

**Rate of advance:** - best day - 75.5m ; best week 428m ; best month 1,719.1m (UK TBMS)

**Rate of advance:** - best day - 56m ; best week 292.6m ; best month 1,105.7m (FRENCH TBMS)

**Dates of breakthroughs:** Undersea service tunnel - 1st December 1990, Undersea rail tunnel north – 22 May 1991, Undersea rail tunnel south - 28 June 1991

**Date tunnelling commenced** - 1st December 1987

**Finished tunnel diameter:** Rail tunnels 7.6m, Service tunnel 4.8m

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**CALL FOR CONTRIBUTIONS TO THE NEW SECTION:**

**“Amazing Projects”**

*The contributions to this section should bring to the readers notice the “unusual aspects” of the projects that you take part in or that you have read in a magazine, journal, book or in a newsletter. The “unusual aspects” of the project can include scientific, technical, financial, legal, social etc., extremes. For example, the unusually high or low values measured in an experiment or the very expensive or very cheap contracting of a project, or examples of very bad or very good decision making in an engineering problem etc.*

# In focus:

*J.W. Bierman & W.A.Piek*

Dominique Ngan-Tillard (32) graduated from the Institut de Physique du Globe in Strasbourg, France with a diplome d'ingénieur. With the first ever awarded Richard Molinero scholarship of BP France, she spent a year in the Department of Mineral Resources Engineering at Imperial College, London studying borehole stability. She then continued her interest in research by undertaking a PhD on shear strain localisation in geomaterials at the University of Grenoble, France whilst at the same time working as assistant lecturer on laboratory soil testing methods.

Having finished her PhD, she took up a position as senior site engineer within a subsidiary of Group.

# Utilisation and Improvement of Lateric Gravels in Road Bases

*Bwalya Makasa,*
*International Institute for Aerospace Survey and Earth Sciences (ITC), Section Engineering Geology, Kanaalweg 3, 2628 EB, Delft, the Netherlands*

The most common materials used in the construction and / or rehabilitation of the rural access roads are lateritic soils. This is because: (a) they are the most common naturally-occurring materials, (b) in the tropics weathering is intense, and hence there is lack of good quality crushed aggregate, (c) long haulage distances and the associated high costs involved in the transportation of good quality aggregates, make the utilisation of laterite gravels economically attractive.

Some laterite soils and gravels make good materials for subbase and base construction of roads as they are easy to win and to apply on the road surface. They also have naturally stable gradings with a suitable proportion of clayey materials to act as binder (Ackroyd, 1960). However, in most parts of the tropics there is only a limited choice of sufficiently hard concretionary laterite aggregates to be used in road surface dressing, and often the significant silt and clay contents renders the material moisture sensitive.

The wide spread evidence of the deterioration of laterite roads in Zambia, and probably other developing tropical countries emphasise the need for careful assessment of lateritic gravel to be used for road construction.

## INTRODUCTION

The soil name "laterite" was coined by Buchanan (1807) in India, from a Latin word "later" meaning brick. Soils under this classification are characterised by forming hard, impenetrable and often irreversible pans when dried. However there is confusion in the use of the term, because a variety of materials with many types of compositions and various origins have been called laterites, ranging from iron cappings found on the plateaux of Southern India to the zonal soils of the humid tropics and from the whole weathered profile beneath a laterite of Buchanan's meaning to the iron-rich breccias and slope wash accumulations. Because of this confusion, most workers now prefer to use the definitions based on hardening, such as "ferric" for iron-rich cemented crusts, "alcrete" or bauxite for aluminium-rich cemented crusts, "calcrete" for calcium carbonate-rich crusts, and "silcrete" for silica rich cemented crusts (Fookes, 1997). Other definitions have been based on the ratios of silica ($SiO_2$) to sesquioxides ($Fe_2O_3$, $Al_2O_3$). In laterites the ratios are less than 1.33. Those between 1.33 and 2.0 are indicative of laterite soils, and those greater than 2.0 are indicative of non-lateritic soils (Bell, 1993).

## FIELD PERFORMANCE OF LATERITIC SOILS

The behaviour of laterites in pavement structures have been found to depend on:

1) their particle size characteristics,
2) the nature and strength of gravel particles (pisoliths),
3) the degree to which the soil has been compacted,
4) the traffic volume,
5) climate and,
6) hydrological regime of the engineering site and the topography of the area, (figure 1).

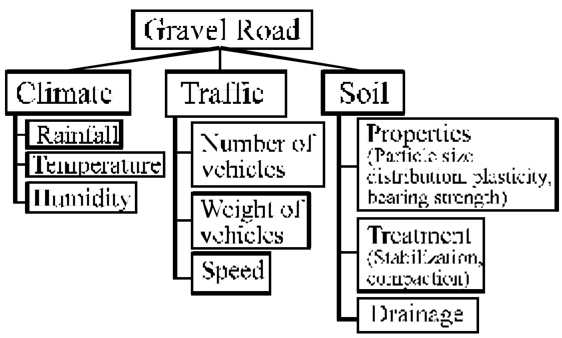


***Figure 1*** *Main factors influencing the performance of gravel roads (after Fooberg, 1963)*

When the grading of lateritic gravel is close to a mechanically stable particle size distribution, the material performs satisfactorily both as unstabilized base and / or subbase in light trafficked gravel roads (Thagessen, 1996). A satisfactory performance of laterite pavements has generally been reported on laterite gravels that posses adequate strength, not over-compacted, and are provided with adequate drainage (figure 2). Weakly indurated gravels have a tendency to break down during compaction and under repeated traffic loading, resulting in the increase of fines. The situation may be worsened by water due to its softening effect on the soil and to the strength reduction it causes. This leads to pavement distress and partially to failure (Arulanandan, 1969). Many laterites contain a proportion of quartz. If the concretionary nodules are comparatively weak, the strength and durability of the coarser fraction become a function of the proportion of quartz.

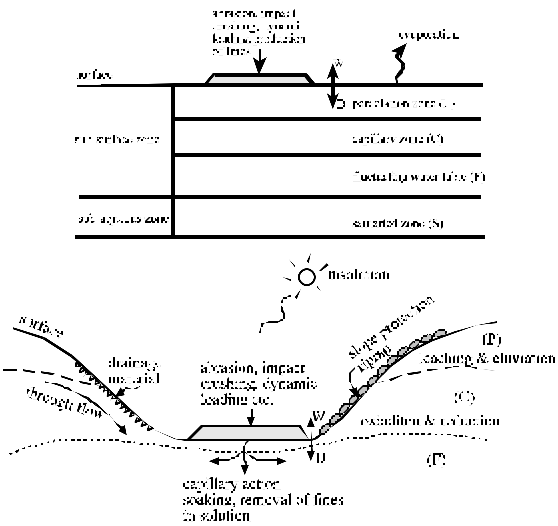


***Figure 2*** *Idealised degradation mechanism in principal hydrological zones (W = wetting, D = drying)*

**Formation of Lateritic Soils**

Laterite soils are formed in hot, wet tropical regions with an annual rainfall between 750mm to 300mm, (usually in areas with a significant dry season) on a variety of different types of rocks with high iron content. The locations on the earth, that characterise these conditions fall between latitudes 350 S and 350 N (figure 3).

Laterization involves physico-chemical alteration of primary rock forming minerals into materials rich in 1:1 lattice clay minerals (kaolinite), and laterite constituents (Fe, Al, Ti, Mn). In the first place Ca, Mg, Na and K are released, leaving behind a siliceous framework for the formation of clay minerals. During prolonged alkaline attack, the siliceous framework consisting of silica tetrahedral and alumina octahedral is disintegrated. Silica, which is soluble at all pH values, will be leached slowly, while as alumina and ferri sesquioxides ($Fe_2O_3$, $Al_2O_3$, and $TiO_2$) remain together with kaoline as the end product of clay weathering. The end result is a "reddish matrix" made from kaolinite, goethite and "fragments of the pisolitic iron crust" (Ibid, 1980).

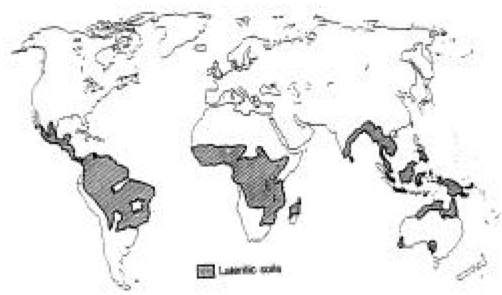

***Figure 3*** *World-wide distribution of laterite soils (after Thaesen, 1996)*

Two aspects of the parent rock affect the formation of laterite. One is the availability of iron and aluminium minerals. These are more readily available in basic rocks. The other is the quartz content of the parent rock. Where quartz is a substantial component of the original rock, it may remain as quartz grains. Laterite profiles occur on flat slopes in the terrain where runoff is limited. On the level ground, where drainage is poor, expansive clays dominate at the expense of laterites.

From the above, three major processes can therefore be identified as follows:

**Decomposition:** physico-chemical breakdown of primary minerals and the release of constituent elements ($SiO_2$, $Al_2O_3$, $Fe_2O_3$, CaO, MgO, $K_2O$, $Na_2O$, etc), which appear in simple ionic forms.

**Laterization:** leaching under appropriate conditions, of combined silica and bases and the relative accumulation or enrichment of oxides and hydroxides of sesquioxides ($Fe_2O_3$, $Al_2O_3$, and $TiO_2$). The soil conditions under which the various elements are rendered soluble and removed through leaching or combination with other substances depend mainly on the pH and Eh of the ground water and the drainage conditions (figure 4), (Pickering, 1962, Loughnan, 1969).

The level to which the second stage is carried depends on the nature and the extent of the chemical weathering of the primary minerals. Under conditions of low chemical and soil-forming activity, the physico-chemical weathering does not continue beyond the clay-forming stage, and tends to produce end products consisting of clay minerals predominantly represented by kaolinite and occasionally by hydrated or hydrous oxides of iron and aluminium (More and Van Barren, 1954).

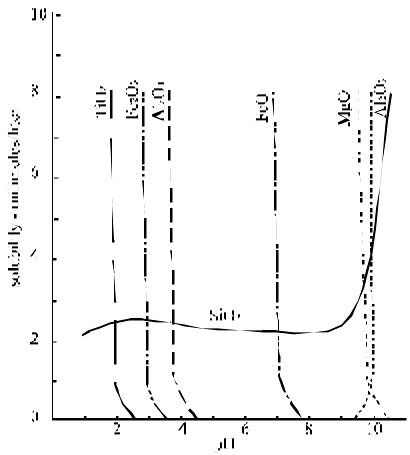

*Figure 4* *Water solubility of some soil and rock minerals as a function of pH.*

**Desiccation:** desiccation or dehydration involves partial or complete dehydration (sometimes involving hardening) of the sesquioxide rich materials and secondary minerals. The dehydration of colloidal hydrated iron oxide involves loss of water and the concentration and crystallisation of the amorphous iron colloids into dense crystals, in the sequence; limonite, goethite with hematite to hematite (Hamilton, 1964).

Dehydration may be caused by climatic changes, upheaval of the land, or may also be induced by human activities, for example by clearing of forests, (figure 5).

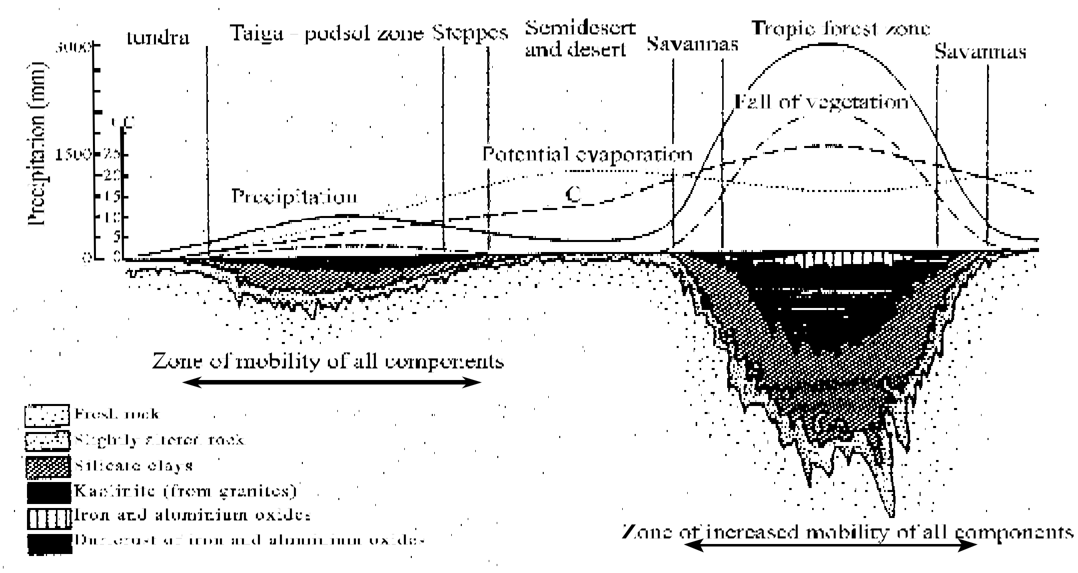


***Figure 5*** *Relationship between climatic factors, vegetation cover and weathering mantle (after Strakhov, 1967).*

**Profiles of Lateritic Soils**

Laterite profiles are generally of three types, those in which the crust is derived from

- the overlaying soil (downward transport / leaching),
- from underlying weathered rock (upward transport), and
- those in which the crust forming material is detrital (that is transported and deposited and / or precipitated).

The laterite profiles that develop in-situ have a number of horizons. The horizons vary in thickness, hardness and colour depending upon the degree of development and preservation of the profile. If laterite soil profiles are dried out, because of the lowering of the water table, the top of the laterite soil may grade into a hard duricrust (figure 6).

Laterites may occur as surface deposits of unhardened clayey soils, gravels, and as hardpans, found as cappings on detached plateau remnants (mesas), but would be in lower parts of the slopes. The hardpans can be subjected to a new cycle of weathering and transportation in which hardpan fragments are redeposited elsewhere as secondary deposits. Rock-like laterite is usually very heavy and abrasive and unsuitable for quarrying and processing to road aggregates. Lateritic gravels stand out as low humps in the terrain. They consist of gravel sized concretionary nodules in a matrix of silt and clay. They may take up an area of several hectares and a thickness of between 1 to 5m.

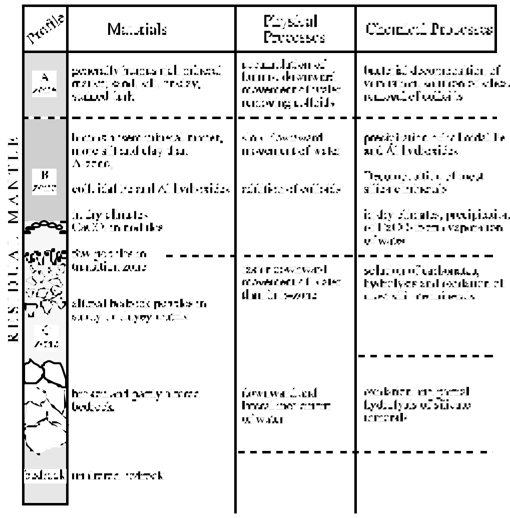


*Figure 6 Generalised composite soil profile and soil forming processes (after Dapples, 1959)*

## FIELD INVESTIGATION OF LATERITIC SOILS

Location and evaluation of suitable borrow and construction materials may be divided into preliminary investigation, and detailed investigation stages. Preliminary investigation should include the identification of soil types from topographical maps, geological maps, soil maps, and aerial photos and examination of road cuts. This preliminary investigation may be coupled with sampling and testing. The information that is obtained should be used in planning and conducting a detailed soil investigation that is necessary for design and construction of the road. The detailed investigation should also be divided into field investigation and laboratory testing on representative samples. The field investigations may include geophysical explorations, test pits and borings, sampling of soil, registration of soil profiles and measurement of ground water levels.

**Soil Survey Maps**
Considerable use can be made of agricultural soil-survey maps, also pedological reports, if interpolated from a geological point of view, can yield useful information to the engineer on the location of lateritic soils.

**Aerial Photographs**
Aerial photographs have been used widely in locating laterite soil deposits (Dowling, 1966; Holden, 1967). Recognisable elements include earth features such as relief, aspects of geology, drainage, vegetation and land use. Recognition of these elements can be used to infer the nature of the superficial soil mantle. Some significant aerial photo keys include (Pearsons, 1970):

- landslides preclude formation of laterites,
- flat hilltops surrounded by thin light-grey lines are positive indications of laterite cap rock,
- recent transported soils are too young to form laterite rocks,
- residual rocks derived from igneous and metamorphosed rocks are likely to be laterized,
- rolling terrain suggests a mature terrain more likely to be laterized,
- lack of surface vegetation in a forested area points to surface laterite rock formation,
- evidence of shifting agriculture point to soils which rapidly laterize on clearing.

**Geological Maps**
Geological information can be used to eliminate a considerable amount of target locations for laterite soil deposits close to a project. The characteristics of the stratification of the soil profile, the thickness of the soil mantle over the bedrock as well as the type of the bedrock can provide useful information on the existence of lateritic soils.

**Geophysical Exploration Techniques**
Geophysical methods; notably electrical resistivity, based on the variation of electrical conductivity or resistivity of the subsurface materials and refraction seismics, based on the fact that the velocity of propagation of a wave in an elastic medium is a function of the modulus of elasticity, the Poisson ratio, and the density of the material, may be used to explore laterites.

**Sounding Methods**
The subsoil exploration with penetrometers provides a means of obtaining an indication not only of stratification, but also of the compactness and/or consistence of soils. A penetrometer is forced into the ground statically or dynamically to measure the side friction, point resistance and /or total resistance. Soundings are considerably faster and cheaper than borings. In areas of erratic conditions, it is advantageous to replace some of the borings with a greater number of soundings.

**Trial Pits and Borings**
The boring or drilling programs may be based on the above mentioned methods. The boring and trial pits are a must in verifying the information that has been provided by the above methods. They will also be required to determine the nature of the material and to provide samples for laboratory analysis. Records of soil profiles or geological conditions along the lines of the road traverses may also yield valuable information in building up landscape units. The form of a given ground

surface is a product of its basic geology and subsequent weathering. Each form is known to be related with it's own soil and terrain. Therefore if a region is divided into areas containing landforms of recognisable type (by using aerial photographs), it should be possible to predict the soil type and drainage conditions at a given site.

## ENGINEERING PROPERTIES OF LATERITIC GRAVELS

Geotechnical characteristics and field performance of lateritic soils, as well as their reaction to different stabilising agents may be interpreted in the light of all or some of the following parameters:

- genesis and pedological factors (parent material, climate, topography, vegetation, period of time in which the weathering processes have operated),
- degree of weathering (decomposition, sesquioxide enrichment and clay-size content, degree of leaching),
- position in the topographic site, and
- depth of soil in the profile (Gidigashu, 1976).

### Particle Size Distribution

Particle size distribution may provide the following information:

1) a basis for identification and classification of soils,
2) the compactibility characteristics,
3) permeability,
4) swellability, and
5) a rough idea of deformation characteristics of the soil mass.

Texturally lateritic soils are very variable and may contain all fraction sizes; boulders, cobbles, gravel, sand, silt, and clay as well as concretionary rocks. Quartzitic gravels, which are formed from the alteration of quartz rich parent rocks, are generally well graded with 20% of silt and clay-size fraction. Concretionary laterites have a higher content of fines ranging between 35% to 40%, (figure 7). Foot slope concretionary laterite gravels are coarse and gap graded (less sand), compared to high level gravels (Gidigasu, 1976).

Pre-testing preparations of lateritic soils for sieve analysis may have the following effects on the size distribution:

1) remoulding and removal of free iron oxide increases the content of fines between 35% to 65% (this will be a function of the dispersing agent),
2) degree of drying and time of mixing of the sample prior to testing influence the degree of dispersion of some laterite soils,
3) cementing effect of sesquioxides which bind the clay and silt size fractions into courser fractions.

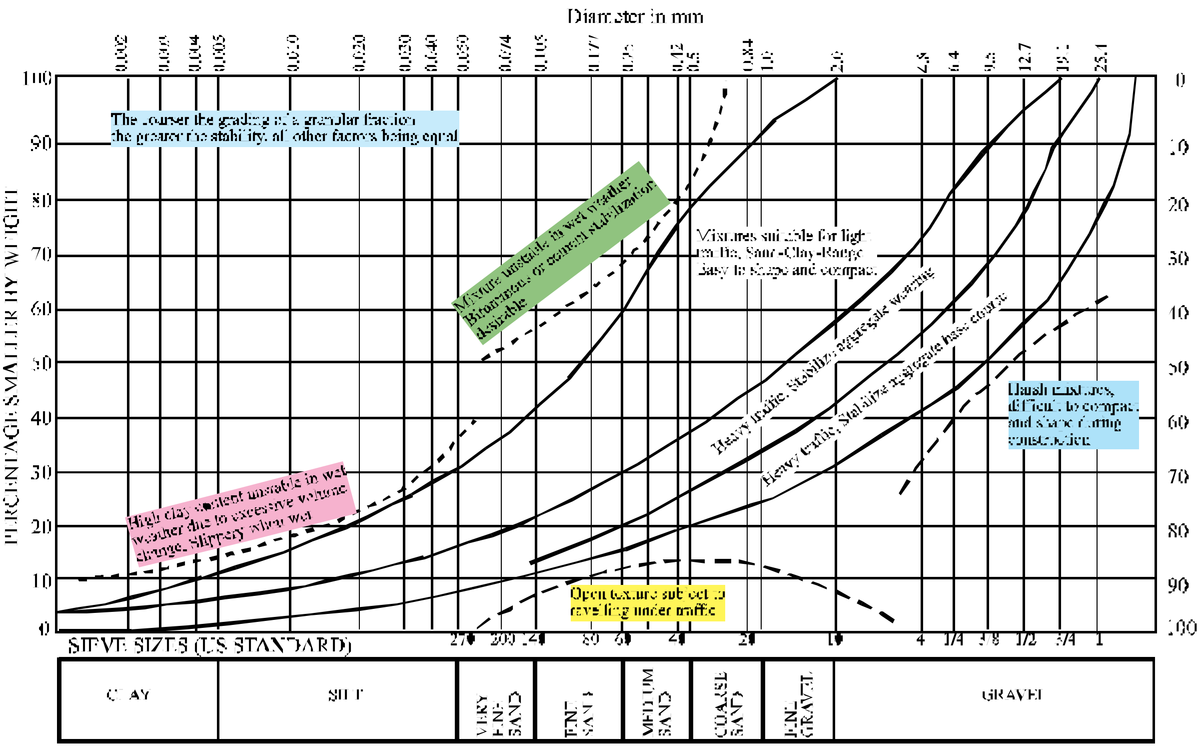


***Figure 7*** *Typical grading of laterite gravels (after Thagessen, 1996)*

**Plasticity Characteristics of Laterite Soils**

The interaction of the soil particles at the microscale level is reflected in the consistence limits or Atterberg limits of the soil at macroscale level. Knowledge of the Atterberg limits may provide the following information: (1) a basis for identification and classification of a given soil, (2) texture, (3) strength and compressibility characteristics, (4) swell potential of the soil or the water holding capacity.

Atterberg limits depend on:

1) the clay content; plasticity increases with increase in clay content (Piaskowski),
2) nature of soil minerals; only minerals with sheet-like or platelike structures exhibit plasticity. This is attributed to the high specific surface areas and hence the increased contact in plate shaped particles,
3) chemical composition of the soil environment; the absorptive capacity of the colloidal surface of cations and water molecules decrease as the ratio of silica to sesquioxides decrease (Baver, 1930),
4) nature of exchangeable cations; this has a considerable influence upon the soil plasticity (Hough, 1959)
5) organic matter; high organic matter increases plasticity, (figure 8).

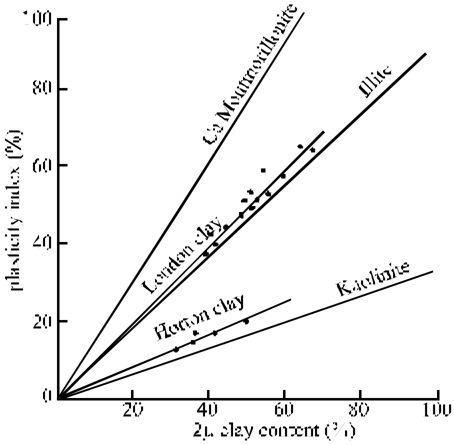


***Figure 8*** *Relationship between the clay content, clay mineralogy and the plasticity index (after Skempton, 1953)*

Plasticity tests may be affected by pre-test preparation, degree of moulding and time of mixing, drying and re-wetting, and irreversible changes in plasticity on drying. Drying drives off adsorbed water which is not completely regained on re-wetting (this is the case in both oven and air-drying) (Fookes, 1997). Distilled water should always be used to minimise the effect of ion exchange on plasticity. Soils which contain hydrated oxides of iron and aluminium may become less plastic on drying. This is partly because dehydration of sesquioxides creates a stronger bond between the particles, which resists penetration by water. The process can not be reversed by re-wetting. The effect is observed during air-drying but is more pronounced on oven drying at higher temperature (Fookes, 1997).

Studies on the relationship between the natural moisture content and the liquid limit and plastic limit have shown that generally the natural moisture content is less than the plastic limit in normal lateritic soils (Vargas, 1953). However, the lateritic soils from high rainfall areas may have moisture contents as high as the liquid limit (Hirashima, 1948).

**Compaction Characteristics**

The compaction characteristics of laterites are determined by their grading characteristics and plasticity of fines. These in turn can be traced to genetic and pedological factors.

The significant characteristic of laterite soils is the influence of the strength of the concretionary coarse particles on compaction. Most laterite soils contain a mixture of quartz and concretionary coarse particles, which may vary from very hard to very soft. The strength of these particles has major implications in terms of field and laboratory compaction results and their subsequent performance in road pavements. Weak coarse fractions breakdown under rolling and traffic loading with a resulting increase in fines of the soil (Ackroyd, 1963). The degree to which the materials break down is related to the content of iron oxide and the degree of dehydration. Higher the iron oxide content and the more the degree of dehydration, the harder the concretionary particles become.

Placement variables (moisture content, amount of compaction, and type of compaction effort) also influence the compaction characteristics. Varying each of these placement variables has an effect on permeability, compressibility, swellability, strength, and stress-strain characteristics (Lambe, 1958). For example soils compacted on the dry side of the optimum moisture content swell more than soils compacted on the wet side because the soil compacted on the dry side has a greater moisture deficiency and a lower degree of saturation (Brand et al., 1969). On the other hand soil compacted on the wetter side of the optimum moisture content will shrink more on drying than a soil compacted on the dry side (Lambe, 1958).

**Compaction Characteristics of Micaceous laterites**

Mica flakes in the soil are usually small and have fine sand and silt sizes. Mica particles have an influence on the compaction properties due to their flaky shapes. For the coarse mica-soil mixtures, a mica particle may simply replace an individual granular particle or fill a void, but as the quantity of mica increases, there is a corresponding increase in void spaces, and therefore a decrease in the dry density of the soil. This effect is due to the following. Individual mica particles are capable of spanning over voids instead of filling them. If the mica flakes are sufficiently numerous to interact, the bridging phenomenon is further augmented. The mica flakes also impart resilience to the soil, which makes it difficult to compact. This is due to the spring nature of the mica flakes, which recover their shape when the bending stress exerted by the impact hammer is removed. Because of this, selection of the type of compaction or compacting effort is important. In this case vibratory compaction is more suitable in micaceous laterites.

Micaceous soils are common in many tropically weathered lateritic soils. The two common species are muscovite and biotite. Muscovites are most abundant in metamorphic rocks, and biotites occur in igneous, metamorphic and sedimentary rocks. Soils formed from the weathering of these rocks will contain mica broken down into smaller sheets. Mica contents of 20% to 30% have been reported (Bulman, 1964).

## IMPROVEMENT OF LATERITIC SOILS

Stabilisation may be defined as any processes by which a soil material is improved and made more stable. The goals of stabilisation are therefore to improve the soil strength, to improve the bearing capacity and durability under adverse moisture and stress condition, and to improve the volume stability of a soil mass.

The tendency for laterite gravels to be gap-graded with depleted sand-fraction, to contain a variable quantity of fines, and to have coarse particles of variable strength which break down, limits their usefulness as pavement materials; especially on roads with heavy traffic and adverse moisture conditions. To improve on the above deficiencies, and consequently to improve on their field performance characteristics, they need to be stabilised.

**Mechanical Stabilisation**

Strength and durability of soils can be improved by mechanical means using compaction without the addition of any foreign matter. Water is added during compaction in order to displace air and facilitate movement of fine-grained particles past one another so as to achieve densification.

**Cement Stabilisation**

Depending on the soil type 3% to 10% of cement by weight of dry soil is mixed with the soil to cause it to harden into a compact mass, which will not soften in the presence of water. Cementation is based on hydration of cement. The major hydration products are a series of calcium silicate hydrates (CHS) and hydrated lime, $Ca(OH)_2$. Reactions of the soil with cement include replacement of $Ca^{++}$, adsorption of $Ca(OH)_2$ by particles and cementation at inter-particle contacts by the CSH gel. When clay-grade minerals are present in excess of about 30% it is more difficult to achieve economic stabilisation by use of cement due to great difficulty in pulverising and mixing (Gillot, 1968).

**Lime Stabilisation**

Lime stabilisation is achieved with calcium oxide (quick lime) or calcium hydroxide (slaked lime). The stabilisation mechanism of lime is similar to that of cement. Lime acquires silica or other pozzolans in the soil to form CSH gel. Cement contains silica initially. Lime reduces plasticity by replacing troublesome cations such as sodium with calcium. At the same time coagulation takes place and the coarser lime particles absorb a good deal of free water resulting in dehydration. Lime treatment of 3% to 8% by weight of dry soil are typical for improvement of plastic and expansive soils (Mitchell, 1982).

**Lime-Fly Ash Stabilisation**

Use of cement and lime may be extended by the addition of pulverised fly ash, PFA (Bell, 1994). The three predominant elements in PFA produced by burning coals are silicon, aluminium, and iron, the oxides of which together account for 75 - 95 % of the material (Sherwood, 1995). Such ashes are known as alumino-silicate fly ash. There is another variety, known as sulpho-calcitic fly ash, which is produced by the combustion of coal with a high limestone and sulphur content. PFA therefore has pozzolanic properties, and can be used with lime to form cementitious gels. It has been reported that mixtures of cement or lime do not give as good results as when lime and cement are used on their own. However, Bell (1994) remarks that, it may be worth making some sacrifices in soil improvement to obtain the saving in cost that the use of PFA brings.

**Bitumen Stabilisation**

In bituminous stabilisation, bitumen materials (in the form of hot, cutbacks and emulsions) or road tars are mixed with soil so as to water proof the particles and/or provide the additional cohesion necessary for stabilisation. The amount of binder normally ranges between 4 and 7%.

**Sand Stabilisation**

Most laterite gravels are gap-graded with a deficiency of sand and silt-size particles. Addition of sand may improve the grading curve with a subsequent improvement in the compaction characteristics of the laterites, reduction in the plasticity of the fines, and swell characteristics (Ashworth, 1970).

**Selection of Stabilisation Method**

The choice of a stabilising method should be based on the following factors:

- genetic characteristics,
- particle-size distribution,
- mineralogical composition of the soil, and
- organic matter, and physical chemical characteristics of the soil.

Studies by Croft and Nettleton (1964) reviewed that surface soils containing active clay minerals, and with acidic reactions are suitable for lime stabilisation. While the lower zones with illite and kaolinite as principle components respond better to cement stabilisation, horizons containing large amounts of montmorillonite with acidic reactions are not suitable for stabilisation.

Felt (1955), on the basis of his investigations concluded that, laterite soils with a relatively low silica - sesquioxide ratio pulverise more readily and react more favourably with cement than do podzolic or chemozem clay soils which have a relatively high silica - sesquioxide ratio.

Tubey (1964) has reported that coarse mica particles have a reducing effect on strength in cement stabilised soils. Laterite soils have high concentrations of sesquioxides ($Fe_2O_3$ and $Al_2O_3$). Because of the sesquioxide content, these soils can be effectively stabilised with small amounts of lime and cement (De Graft - Johnson et al., 1969). This is considered to be due to the reaction of lime with iron and aluminium oxide. However Sherwood (1966) concluded that laterite soils containing high contents of aluminium oxide show a decrease in strength with time when stabilised with cement or lime. This was attributed to the formation of a compound with poor cementing properties. Organic content hinders the development of high strengths in laterite soils.

Croft (1967) has made the following conclusions concerning the influence of clay mineralogy on soil stabilisation. Kaolinitic and illitic soils are more suitable for cement stabilisation than soil containing large amounts of expansive clay minerals. The amount of clay present in a soil determines the quantity of cement required. Heavy clay minerals are difficult to stabilise with cement, and large quantities may be required, even pre-treatment with lime to make it workable may not be very helpful. If the predominant clay mineral is montmorillonite, and if it is present in amounts large enough to control the behaviour of the soil, cement may prove to be very uneconomical and lime should be used.

## CONCLUSIONS

The performance of lateritic gravels in pavement structures is influenced by:

- the nature and strength of the gravel particles,
- the degree to which the soil has been compacted,
- the climate,
- the hydrological regime in which the road is constructed,
- the topography of the area, and
- the traffic volume.

The design, construction and subsequent maintenance of the gravel road should take into account the above factors. Neglecting one or all the above factors has led to the failure of many gravel roads.

Geotechnical properties of lateritic soils are influenced by the degree of weathering, the amount of sesquioxides and degree of desiccation in the soil, the day-size content and the clay mineralogy, the mica content, and the position of the soil in the laterite profile. A critical assessment of the above factors may give a basis to predict the behaviour of a given laterite soil in the field.

The response of a given lateritic soil to stabilisation depends on the grain-size distribution, the clay-size content and the clay mineralogy, the mica and organic content, and the physico-chemical characteristics of the soil regime. Often stabilisation in the field is done without giving particular attention to the above factors, this leads to the failure of the adopted stabilisation methods to achieve the intended purpose.

Laboratory testing procedures designed for plasticity, grain-size analysis, and compactibility characteristics designed from the experience in temperate regions are inadequate for the tropical lateritic soils and may lead to erroneous conclusions.

The use of soil survey maps, geological information, aerial photographs, geophysical tools can aid the engineer to search for good quality laterite gravels close to the project area. But again, the above information and tools are often not adequately exploited leading to poor material selection.

## RECOMMENDATIONS

Based on the preceding study, the following recommendations are made:

To derive maximum benefits from gravel roads, the design and construction should take into consideration, climate, the hydrological regime in which the road is constructed, the quality of the laterite-material, traffic volume, and the strength of the sub-grade. Adequate drainage should be provided to obstruct the increase of moisture in the soil to adverse proportions, the soil should not be over-compacted to levels where fines are increased, the thickness of the road base should be based on the sub-grade strength, and traffic volume projections.

The rural community living alongside the road should be involved in the maintenance of the road under the supervision of technical personnel. Maintenance should involve clearing all the drains before onset of the rains, filling up all depressions with stabilised and / or unstabilized gravel and compacting, clearing of bushes alongside the road to provide good visibility to motorists. In short all the maintenance activities should be scheduled properly.

The selection of the stabilisation method, should be based as much as possible on the compositional elements of the soil (grain-size distribution, clay-content, organic matter, mica content, etc.), type of clay, and the physico-chemical characteristics of the soil regime. The above factors will assist in predicting the performance of a given stabilising admixture well in advance before laboratory testing or actual work is committed, which may result into disastrous results, and a waste of resources.

In order to increase the number of alternatives for the selection of the laterite-soil material, the use of soil survey maps, geological maps, aerial photographs, topographical maps and geophysical tools (notably, electrical resistivity and refraction seismics) should be considered. The use of this information and tools will not only reduce the cost of searching for the laterite soils, but will also give a wide range of potential borrow sites from where laterite soils may be exploited. This will give the possibility of comparing the quality of the laterites from various potential borrow-pits and of selecting of relatively good quality laterite-gravel.

The standards that have been prescribed for soils in temperate regions should be used cautiously in determining the suitability of tropical lateritic soil for use in road bases. Most often the soil properties are changed during sample preparations and lead to the rejection of a lateritic soil which would have otherwise performed satisfactorily in the field. This may also lead to prescribing wrong stabilisation methods on the otherwise good lateritic soil.

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# Book review

## Geosynthetics in civil engineering

*CUR/NGO Report 151, translated by G.P.T.M. van Santvoort, published by A.A. Balkema, Rotterdam, 1995. Hardcover edition. Price: hfl. 75 (ex 6% BTW), p.p.105*

The last decades have shown a sharp increase in the use of geosynthetics in civil engineering. It is therefore not that strange that there is a demand for

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Aveco b.v. - Infrastructure consultants
PO Box 8270
3503 RG Utrecht

*Institute, Japan (1997), pp. 312, ISBN 90-5410-653-0. Price: 150 DM*

# 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.

**Towards the Prediction of rock excavation machine performance**

*Bull. Eng. Geol. Env. (1998) 57:3-15 Springer-Verlag*

Recent rock cutting laboratory experiments and field studies on the performance of rock cutting trenchers has provided a better understanding of the processes and factors affecting tool consumption and excavation rates of rock excavation machines. On the basis of this, a model has been developed to assist in the prediction of trenching rates and tool wear in various geological situations. The paper provides an overview of the set-up and results of both laboratory and field studies. It describes a basic framework model of the processes and mechanisms involved in assessing excavation rates and tool consumption and discusses how the acquired knowledge can be used to assist with predictions for future excavation works. It then considers how this knowledge can be applied by practitioners who have to work with a scarcity or absence of good quality and reliable data.

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**Excavatability evaluation and classification with a knowledge based GIS**

*To be published in the proceedings of the 8th Congress of the International Association of Engineering Geology and the Environment, September 21-25, 1998, Vancouver, Canada*

The development of a Knowledge Based Geographic Information System (KBGIS) for the production of a special purpose engineering geological map is presented. The implemented system prototype, ExpertMapper, uses available engineering geological data, produces the excavatability map of an area, and serves as a geotechnical consultant by giving assistance about the likely excavatability conditions at a certain location and the equipment suitable for excavation works. The development of ExpertMapper includes: the construction of the knowledge base for excavatability classification and mapping purposes, the optimisation of the knowledge base rules, and the loose integration of geographic information system, database management system and output module with expert system shell. The output module produces excavatability maps which delineate the detailed excavatability classes within each geologic unit. The interactive consultancy module provides excavation profile, excavation classes and the proposed excavation method with explanatory text.

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**3D Modelling Aspects of Soft Ground for Tunnelling with TBM**

*Proceedings of GOCAD ENSG Conference 3D Modelling of Natural Objects: A Challenge for the 2000's, June 4-5, 1998, Nancy, France*

We present the development of an Intelligent Decision Support System (IDSS) for soft soil shield tunnelling. The IDSS development involves a heterogeneous integration of 3D modelling, scientific visualisation, and artificial intelligence

technology products for supporting decision-making in tunnelling projects. Modelling and geotechnical characterisation of soil volumes play a critical role in the determination of an applicable Tunnel Boring Machine (TBM) and its performance. The modelling of soil volumes was carried out interactively, using boreholes and Cone Penetration Test (CPT) logs as background information. We have experienced some difficulties in modelling the complex geology of the study area, which is a deltaic setting with discontinuous lenses and inter-fingering layers of sand, clay and peat. In order to overcome these difficulties, some improvements to current three-dimensional geo-information (3D-GIS) techniques are suggested. Geotechnical modelling was based on the site investigation data and the results of laboratory tests on soil samples. Soil property modelling was carried out using knowledge-based approach on rectangular 3D grids. Presently the IDSS prototype allows users to effectively interact with the 3D-GIS, support the analysis and manipulation of geotechnical and mechanical parameters, and provide decision scenario and negotiation routines under varying tunnelling conditions.

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# News and announcements

**REPORT**

**4th International Conference on Case Histories in the Geotechnical Engineering**

*St Louis, USA, March 09-12, 1998*

The Fourth International Conference on Case Histories in Geotechnical Engineering was hosted by University of Missouri-Rolla, Department of Civil Engineering. Over 150 papers from 35 countries were contributed. In addition, 10- State of the Art reports by Jean-Lou Chameau (USA), Prof. W. D. Liam Finn (Canada), Dr. Susumu Iai (Japan), Dr. Suzanne LaCasse(Norway), Dr. R. H. Ledbetter (USA), Dr. Robert Mair (United Kingdom), Prof. Tamotsu Matsui (Japan), R. Kerry Rowe (Canada), Joseph P. Welsh (USA), John H. Schmetrmann (USA), and four Special Lectures and ten General Reports were presented.

The Keynote Lecture was delivered by Prof. Ralph B. Peck. In his lecture Prof. Peck emphasised that by making small, small mistakes, we learn a lot useful information about the behaviour of soils. He cited examples of expansive soils in Texas and permeability of dykes in the Dead Sea, in which what appears to be obvious today was not so obvious in the early years. Dr. Robert Mair presented instructive and exhaustive case of deep tunnelling in London and for the Jubilee lines. Dr. John H. Schmertmann brought out a very interesting point, that is, the piles could be tested up to 15, 000 tons capacity by using the Osterberg Cell. In the absence of this new technique the gravity loading of this order was almost impossible.

There was an exhibition of services and equipment in Geotechnical Engineering by 12 companies. Participants came from 24 countries and the conference was a big success.

The proceedings of the conference are available from the continuing education office at this address:
University of Missouri-Rolla, Department of Continuing Education, 103 ME Annex Building, Rolla, MO 65409, USA, Tel: 573 341 4200, Fax: 573 341 4992, E-mail: suep@shuttle.cc.umr.edu.
Price: $300, Shipping: airmail overseas $20

For further information contact: Prof. Shamsher Prakash, Professor of Civil Engineering, University of Missouri-Rolla, 1870 Miner Circle, Rolla, Missouri 65409-0030, USA, Tel: (573) 341 4489/4461, Fax: (573) 341 6553/4729, E-mail: prakash@novell.civil.umr.edu, http://www.umr.edu/~conted/conf8926.html

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**EUROCK '98**

*Trondheim Norway, August 1998,*

Organised by the ISRM NG NORWAY and the Society of Petroleum Engineers (SPE).

Themes: Rock mechanics in the petroleum engineering. topics: rock properties and rock behaviour, rock stresses, rock mechanics and geophysics in the exploration, drilling and borehole stability, rock mechanics in the well technology, compressible reservoirs, compaction, and surface subsidence, disposal and environmental applications

Correspondence: Prof. Rune M. Holt, Dept of Petroleum Technology and Applied Geophysics, NTH, N-7034 Trondheim, NORWAY. TLP: 47-73-591187, 594982, 591102(fax), or 944472(fax); EM: rune.holt@iku.sintef.no

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**GEOSEA'98**

**Ninth Regional Congress on Geology, Mineral and Energy Resources of Southeast Asia**

*Kuala Lumpur, Malaysia, August 17-19, 1998.*

Organised by Geological Society of Malaysia.

Topics: geology, petroleum geology, economic geology, engineering geology, environmental geology, geoscience education, tectonics, structural geology, geochemistry, geophysics, petrology, stratigraphy, sedimentology, mineralogy, palaeontology.

Milestones: December 1, 1997 - submission of title of paper, February 1, 1998 - submission of extended abstract, June 15, 1998 - submission of full manuscript.

Correspondence: The Organising Secretary, GEOSEA'98 Geological Society of Malaysia c/o Department of Geology, University of Malaya, 50603 Kuala Lumpur, Malaysia
Tel: +(603) 757 7036, Fax: +(603) 756 3900
E-mail: geologi@po.jaring.my

**COASTAL ENVIRONMENT 98**
**Second International Conference on Environmental Problems in Coastal Regions**
*Cancun, Mexico, 8 - 10 September 1998*

Organised by Wessex Institute of Technology, Southampton, UK

Topics: Pollution Management & Decision Analysis, Hazard Mitigation/Risk Analysis, Environmental Impact Assessment & Legislation, Harbours, Ports & Marinas, Littoral Drift, Coastal Erosion, Siltation & Dredging, Oil Slicks & Spills, Acoustic Pollution, Pollutant Transport & Dispersion, Remote Sensing, Wastewater Treatment, Sewage & Chemical Pollution, Atmospheric Pollution & Control, Hydrodynamic & Pollutant Transport Modelling, Water Quality Models, Case Studies

Correspondance: Liz Kerr, Coastal Environment 98, Wessex Institute of Technology, Ashurst Lodge, Ashurst, SO40 7AA, UK, Tel: 44 (0) 1 703 293223, Fax: 44 (0) 1 703 292853, Email: liz@wessex.ac.uk

**HYDROSOFT 98**
**Seventh International Conference on Hydraulic Engineering Software**
*Como, Italy, 16 - 18 September 1998*

Organised by Wessex Institute of Technology and Centro Di Cultura Scientifica “Alessandro Volta”

Topics: HYDRAULIC ENGINEERING: Hydrodynamic Modelling, Dam Breaking, Hydraulic Networks, Open Channel Flow, Transient and Cavitation in Fluid Systems, Hydraulic Software, Wave Propagation, Coastal Dynamics and Estuaries, COMPUTATIONAL ASPECTS: Data Acquisition and Field Instrumentation, Interaction between Experimental and Computer Models, The use of Computers in the Control of Experiments, Expert Systems, Software Maintenance and Support, WATER RESOURCES: Hydrology and Groundwater Flow, Flood and Drought Hazard Assessment, Groundwater and Aquifer Modelling, Aquifer Contamination, Water Pollution, Water Supply, Irrigation

Correspondance: Conference Secretariat, HYDROSOFT 98, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton, SO40 7AA, Tel: 44 (0) 1703 293223, Fax: 44 (0) 1703 292853, Email: liz@wessex.ac.uk

**8th International Congress of the IAEG**
*Vancouver BC, CANADA, 21-25 September 1998*

Organised by the International Association of Engineering Geology (IAEG) and The Canadian Geotechnical Society/La Société Canadienne de Géotechnique.

The International Association of Engineering Geology (IAEG) and The Canadian Geotechnical Society extend a warm invitation to engineering geologists, scientists and engineers from related disciplines and sister societies to attend the 8th Congress of the IAEG in Vancouver, British Columbia, Canada. The Congress will be held 21 - 25 September 1998 at the Hyatt Regency Hotel. In traditional fashion, IAEG meetings of the Executive Committee, Council, Commissions and General Assembly will be held before and during the Congress week.

The Tunnelling Association of Canada (TAC) will hold its 16th Annual Conference concurrently with the Congress and will host the underground construction portion of the Congress.

***The 41st Annual Meeting of the Association of Engineering Geologists (AEG) will be held in Seattle, Washington, USA, 250 km south of Vancouver, during the week following the Congress. Participants can attend the AEG meeting or take part in joint IAEG and AEG field trips.***

Topics: New developments in site investigations, engineering geology and natural hazards, engineering geology and the environment, construction materials, case histories and new developments in surface workings, case histories and new developments in underground excavations, coastal and offshore engineering.

Correspondence: Ms Kim Meidal, Secretariat, 8th Congress IAEG, c/o BC Hydro, 6911 Southpoint Drive, Burnaby, BC V3N 4X8, CANADA.
Tel: 604-5282421, Fax: 5282558,
E-mail: kim.meidal@bchydro.bc.ca, WWW: HTTP://www.bchydro/IAEG/IAEG98.html

**PORTS 98**
**First International Conference on Maritime Engineering and Ports**
*Genoa, Italy, 28 - 30 September 1998*

Organised by Wessex Institute of Technology, Southampton, UK, Italian Association of Ports, Port Authority of Savona, Italy, and University of Genova, Italy

Topics: Port Management, Private and Public Ports, Ship and Port Operators, Multimode Transportation in Ports, Environmental Aspects, Financial and Legal Aspects, Multiuse of Ports including Tourism, Marinas and Ports Issues, Information Systems for Ports and Shipping, Multimedia and other Advanced Training Techniques, Systems of Loading and Unloading, Emerging Technologies in Shipping and Ports, Man Machine Interfaces, Standardisation, Ergonomics in Shipping, Marine Engineering Works, Maintenance Problems, Construction of Ports

Correspondance: Sally Radford, Conference Secretariat, PORTS 98, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton, SO40 7AA, UK, Telephone: 44 (0)1703 293223 Fax: 44 (0)1703 292853, E-Mail: sradford@wessex.ac.uk

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**RISK ANALYSIS 98**
**1st International Conference on Computer Simulation in Risk Analysis and Hazard**
*UIMP, Palau de Pineda, Valencia, Spain, 6-8 October 1998*

Organised by Wessex Institute of Technology, UK, Universitat Jaume I, Spain, Centro de Investigaciones sobre Desertificacion-CIDE, Consejo Superior de Investigaciones Cientificas, University of Valencia, Generalitat Valenciana, and Universidad Internacional Menendez Pelayo

Topics: Simulation of Natural Hazards, Man-made Hazards, Hazard Prevention, Management and Control, Investigation of Adverse Effects, Emergency Response, Estimation of Risks, Data Collection and Analysis, Policy Planning, Social and Economic Issues, Interaction between different Centres, Managing Sustainability, Remediation Studies, Nuclear Waste Disposal, Risk Maps, Remote Sensing, Bio Monitoring, Case Studies, Risk Modelling with Spatial Statistics, Mathematical Modelling of Risk, Data Collection and Structural Analysis, NATURAL HAZARDS: Floods and Droughts, Desertification, Dam Failures, Tsunamis, River and Coastal Erosion, Dust and Sand Storms Dynamics, Meteorology and Climatic Variations, Aeolic Erosion, Earthquake Data Acquisition and Modelling, Engineering Structures and Lifeline Systems Damage, Landslides, Forest Fires, Volcanic Eruptions, Soil Erosion, Biodiversity Lost, Climate Changes, ANTHROPOGENIC HAZARDS: Surface Water Contamination, Coastal and Sea Pollution, Pesticides and other Chemical Dispersion Problems, Air Quality Studies, Radioactive Emissions, Soil and Groundwater Contamination, Work Place Risk, Oil Spills, Remediation of Environmental Damage, Defence Related Problems

Correspondance: Sally Radford, Conference Secretariat, RISK ANALYSIS 98, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton, SO40 7AA, UK, Telephone: 44 (0)1703 293223, Fax: 44 (0)1703 292853, E-Mail: sradford@wessex.ac.uk

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**2nd INTERNATIONAL SYMPOSIUM ON HARD SOILS SOFT ROCKS**
*Napoli, Italy, October 12-14, 1998*

Organised by University of Napoli Federico II
Under the auspices of International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), International Society for Rock Mechanics (ISRM), International Association of Engineering Geology (IAEG), and Associazione Geotecnica Italiana (AGI)

Topics: Investigations, Classification and Testing for Soil Characterisation, Selection of Soil Parameters; Modelling the Soil Behaviour, Tunnelling and Underground Openings, Cuttings and Natural Slopes

Correspondance: MCM Congressi, Rione Sirignano, 5 – 80121 Napoli, Italia, Tel: +39 81 761 10 85 – 66 87 74, Fax: +39 81 66 43 72, E-mail: mcmcongressi@synapsis.it

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**ENVIROSOFT 98**
**Seventh International Conference on Development and Application of Computer Techniques to Environmental Studies**
*Las Vegas, Nevada, USA, 10 - 12 November 1998*

Organised by Wessex Institute of Technology, Southampton, UK, and University of Nevada, Las Vegas, USA

Topics: Pollution: Air, Water, Soil, Noise, Radiation, Mathematical Modelling, Environmental Sciences and Engineering, Chemistry, Physics and Biology, Surface and Groundwater Hydrology, Marine Geotechniques, Oceanography, Ocean Technology, Meteorology and Climatology, Geology and Geophysics, Fluid Dynamics, Satellite Data, Image Processing and Pattern Recognition, Remote Sensing, Databases, Environmental Management and Decision Analysis, Software Performance Optimisation, Software Implementation

Correspondence: Sal Radford, Conference Secretariat, ENVIROSOFT 98, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton, SO40 7AA, UK, Tel: 44 (0) 1703 293223, Fax: 44 (0) 1703 292853, Email: sradford@wessex.ac.uk

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**MARINA 98**
**Fourth International Conference on**
*CapeTown, South Africa,8 - 10 December 1998*

Organised by Wessex Institute of Technology, Southampton, UK.

Topics: Planning and Legal Aspects, Environmental Aspects, Pollution Control and Water Quality, Feasibility Studies and Site Investigation, Wave Modelling and Analysis, Flushing Characteristics and Water Circulation, General Modelling of Marinas and Marina Structures, Hydraulic Aspects of Marine Design, Coastal Considerations, Hydrographic Surveying, Siltation and Dredging, Case Histories.

Correspondance: Liz Kerr, Conference Secretariat, MARINA 98, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton, SO40 7AA, Tel: 44 (0) 1703 293223, Fax: 44 (0) 1703 292853, Email: liz@wessex.ac.uk

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**25 YEARS ENGINEERING GEOLOGY IN THE NETHERLANDS**
*December, 1998*

Organised by Ingeokring

Topics: engineering geology

Correspondence: Martin van Staveren
Delft Geotechnics, e-mail: sta@delftgeot.nl

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**MARINA 99**
**Planning, Design and Operation**
*Lemnos, Greece, 25 - 27 May 1999*

Organised by: Wessex Institute of Technology, Southampton, UK, Marina Management International, UK

Topics: Planning and Legal Aspects, Environmental Aspects, Pollution Control and Water Quality, Feasibility Studies and Site Investigation, Wave Modelling and Analysis, Flushing Characteristics and Water Circulation, General Modelling of Marinas and Marina Structures, Hydraulic Aspects of Marine Design, Coastal Considerations, Hydrographic Surveying, Siltation and Dredging, Case Histories.

Correspondance: Liz Kerr, Conference Secretariat, MARINA 98, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton, SO40 7AA, Tel: 44 (0) 1703 293223, Fax: 44 (0) 1703 292853, Email: liz@wessex.ac.uk

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**ECOSUD 99**
**Second International Conference on Ecosystems and Sustainable Development**
*Lemnos, Greece, 31 May - 2 June 1999*

Organised by: Wessex Institute of Technology, UK and Universitat Jaume I, Spain

Topics: Development Economics, Conservation, Management & Recovery of Endangered & Degraded Areas, Modelling of Natural & Human Ecosystems.

Correspondance: Clare Duggan, Conference Secretariat - ECOSUD 99, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton, SO40 7AA, UK, Email: cduggan@wessex.ac.uk

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**GEOTECHNICAL ENGINEERING FOR TRANSPORTATION INFRASTRUCTURE, XIIth European Conference on Soil Mechanics and Foundation Engineering**
*Amsterdam, the Netherlands, June 7-9, 1999*

Organised by the International Society for Soil Mechanics and Foundation Engineering (ISSMFE) and the Netherlands Society for Soil Mechanics and Foundation Engineering (NSSMFE)

Topics: General aspects of the transportation infrastructure, harbours and waterways, highways and airports, high-speed railways and subways, geotechnical impacts of transportation infrastructure, dealing with uncertainties, crossings over waterways, static and dynamic soil-water-structure interaction, geotechnics related to dredging, foundations on soft ground, maintenance and durability, junctions in transport systems, developments in railway foundations, developments in the design and construction of tunnels

Correspondance: XIIth ECSMFE 1999, c/o Holland Railconsult, Freerk de Boer, P.O. Box 2855, 3500 GW UTRECHT, the Netherlands, Tel: +31 30 2354064, Fax: +31 30 2357229,
E-mail:Va-ct@ns.nl,
http://www.delftgeot.nl/xiiecsmfe.99

**MINETIME 99**
**The 5th World Mining Technology Exhibition**
*Dusseldorf, Germany, June 9-15, 1999*

A forum for presenting the latest products, processes, technologies, and engineering services in the area of mining. This forum is bringing suitable potential business partners together from all over the world.

Correspondance: Petra Hartmann, Petra Wolf, MINETIME Press Office, Tel: 0211 45 60 991, 0211 45 60 544, Fax: 0211 45 60 548, E-mail: HartmannP@tradefair.de

**SECOND INTERNATIONAL CONFERNCE ON EARTHQUAKE GEOTECHNICAL ENGINEERING**
*Lisboa, Portugal, June 21-25, 1999*

Organised by the Portuguese Geotechnical Society (SPG) and National Laboratory of Civil Engineering (LNEC) under the auspices of the International Society for Soil Mechanics and Foundation Engineering, TC4 on Earthquake Geotechnical Engineering.

Topics: Dynamic Characterisation of Soils, Strong Motions, Soil Structure Interaction, Seismic Behaviour of Buried Structures, Liquefaction, Seismic Behaviour of Slopes and Embankments, Seismic Design Criteria and Safety Evaluation, Lessons Learned from Recent Earthquakes.

Milestones: November 30, 1997 - deadline for receipt of abstracts, September 1, 1998 Deadline for receipt of the camera-ready papers.

Correspondence: Pedro S. Seco e Pinto, Chairman for SICEGE, Laboratorio Nacional de Engenharia Civil, Av. do Brasil, 101, 1799 Lisboa Codex, Portugal, Tel: (351) (1) 848 21 31, Telex: 16760 LNEC P, Fax: (351) (1) 847 81 87, E-mail: SICEGE@lnec.pt

# The Netherlands Students Award for Engineering Geology

The Ingeokring, the Netherlands National Group of the International Association for Engineering Geology and the Environment (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.

**We invite the submission of theses produced in the academic year September 1996 - August 1997**

Individuals can send in their own thesis or the thesis of others. Membership of the Ingenieursgeologische Kring is not required. Three complete copies of the thesis (including figures, photographs, annexes) have to be submitted by January 1, 1998 to the secretary of the Ingeokring. The committee which will select the best thesis is composed as follows:

* Dr. H.R.G.K. Hack (chairman, Ingeokring)
* Ir. C.M. Breukink (IWACO)
* Ir. A.H. Nooy van der Kolff (Boskalis Westminster BV)
* Dr. J. Rupke (University of Amsterdam, Dept. of Physical Geography)
* Drs. P.N.W. Verhoef (TU Delft, Dept. of Applied Earth Sciences)

Criteria used for the selection will be:

* Relevance for earth sciences and engineering
* Scientific quality
* Originality of approach
* Quality of presentation

The Award is sponsored by:

* Ingenieursgeologische Kring
* Boskalis Westminster BV
* Fugro Engineers BV
* Ballast Nedam Engineers BV
* IWACO
* Rijks Geologische Dienst
* Geocom Consultants