

Delft Cluster Magazine

Our vulnerable delta: a scientific approach



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Delft Cluster is an open network that carries out research into the sustainable organisation of delta areas for the soil, road and hydraulics sectors.

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UNESCO-IHE
Institute for Water Education 



 TU Delft

kiwa 
Partner for progress

 w|delft hydraulics

 GeoDelft

Our vulnerable delta: a scientific approach

More than half the world's population and even more than 80 percent of the world's large cities are concentrated in delta areas. The Netherlands is one such delta area in Europe and, together with other delta areas, is facing urgent social issues.

Our vulnerable delta and its inhabitants are under threat. Climate change, subsidence, rising sea levels, and flooding, are all natural enemies of our low-lying country. Cities are growing and the demand for mobility is increasing. There are growing pressures on spatial planning. We want to live, work and have somewhere to spend our leisure time, yet all these functions must be accessible, of high quality, cause no disruption to ourselves or others, and take account of sustainability.

All these demands and changes lead to problems in the fields of construction above and below ground, water and soil utilisation, water management, and spatial integration. Six renowned Dutch knowledge institutes (GeoDelft, WL|Delft Hydraulics, TU Delft, TNO Built Environment and

Geosciences, Unesco IHE, and KIWA*) have combined their knowledge into a collective research programme known as Delft Cluster. With government support, the objective of Delft Cluster is to find solutions to these issues.

In this edition of Delft Cluster Magazine, we are pleased to present a number of highlights from current findings of this research programme - to share this knowledge with you, to inspire you, and to challenge you to participate.

Yours faithfully,



Mr. Jan Zijlstra
Chairman of the Board of Delft Cluster

* See back of this publication for an introduction to these institutes and an overview of the programme

The Delft Cluster programme

Engineering knowledge is the key to finding ways to tackle and improve all aspects of the problems facing deltas. Investment in developing this knowledge will mean we can help society find effective solutions to today's problems and those of the future. Such solutions can only be developed in conjunction with businesses and regional authorities that implement and use these solutions, and which provide feedback to developers based on their experience.

Would you like to know more?

Visit Delft Cluster at our website: www.delftcluster.nl or contact our programme office on tel. +31 15 26 93 793

Programme design and approach

The Delft Cluster programme comprises six key topics that give a composite picture of the issues facing the sector. These six key topics are:

1. Controlled utilisation of the subsoil.
2. Low-maintenance infrastructure.
3. Decision-making techniques.
4. High tide and flooding risks.
5. Spatial planning with water.
6. Municipal water management.

The Mekong delta project

Building roads in the Mekong delta in Cambodia and Vietnam in a responsible manner is not easy. A variety of aspects must be taken into consideration. On the one hand, roads must be able to withstand the annual floods. On the other hand, they should not act as barriers to the flooding pattern and hence have a negative impact on valuable ecological areas, or create flood-related problems elsewhere in the floodplain.

Delft Cluster Research Project

The objective of the Delft Cluster project is to develop recommendations for (improved) guidelines aimed at planning and designing economically-sound and environmentally-friendly roads in the Mekong floodplains of Cambodia and Vietnam. The project is an integral part of the FMMP Component 2, and a significant collaboration between the Mekong River Commission Flood Management and Mitigation Program (MRC-FMMP), WWF Living Mekong Programme and three Delft Cluster institutes (UNESCO-IHE, W|Delft Hydraulics and GeoDelft). The project will be carried out over a 2.5-year period (from 2006 to mid 2008), and is co-funded by Delft Cluster, MRC-FMMP, and WWF Greater Mekong Programme.

The Mekong floodplain and road development

The floodplain of the Mekong River Basin is amongst the few examples that remain worldwide of a relatively intact and functioning floodplain in a large river basin. It is widely accepted that this is one of the main reasons for the incredibly productive fisheries of the Mekong, as well

as its tremendous biological diversity (MRC State of the Basins report, 2003). The natural conditions and development status of floodplain systems in Vietnam and Cambodia, however, are very different. In Vietnam, it is a highly controlled system with many man-made channels, which is intensively used for irrigated agriculture. Road planning and design are interrelated with flood protection and water management. The floodplains of Cambodia are in a much more natural state, with large areas that are not used intensively. Flood protection and water management are far less intense, although this situation may change rapidly as a result of current demographic and economic development trends.

Although the annual flood cycle of the Mekong provides valuable resources for local inhabitants, it is a fragile process; the balance between nature and human settlements can easily be tipped the wrong way. The most recent examples are two consecutive floods in 2000 and 2001. These two historic events caused severe damage to infrastructure, including roads.





Photo: © Michiel van der Ruyt

In Cambodia, many provincial and local roads are not flood-proof. In the Vietnamese delta, although the road systems are more developed, serious damage still occurs to roads in many areas. One should also understand that roads and road development can themselves have a considerable effect on natural flood patterns. They fragment habitats and interrupt the flow of water, sediments, nutrients and aquatic life, thereby impacting on the beneficial effects normally brought about by the natural flood cycle. This environmental impact is not always sufficiently taken into account when planning road building and construction activities.

The population in the Lower Mekong Basin is expected to rise from about 60 million to 100 million by 2025, leading to an increased demand for roads in the future. Examples of plans are the GMS plans (www.adb.org/GMS/Projects/flagshipc.asp). The question is how to develop infrastructure in a sensitive floodplain ecosystem such as the Mekong delta in a sustainable manner.

Current road development practice

Analysis of current practice in both countries shows that most road engineers only consider floodplain hydraulics in so far as it affects a road's stability and any damage that may result, and whether the road remains passable during a flood. They do not directly consider the effect of the road on the floodplain hydraulics and ecology in a larger area, but only in the immediate vicinity of the road. Environmental aspects are only taken into account during the construction stage of the road. Broader environmental issues, such as the impact on wetlands, are rarely considered.

Improved guidelines

Approximately 60 million people now live in the Mekong Basin, of which 20 million live in the delta area and are largely dependent on fishing and agriculture for their living. This number is expected to increase to 100 million people in the entire basin by 2025. This population increase and the accompanying economic development will

lead to a substantial increase in demand for extra roads in the next 20 years. Delft Cluster is investigating how roads in the delta area can be constructed or adapted to cause minimum interference with natural processes, whilst being able to withstand annual flooding. An important precondition is that construction costs should not be too high, bearing in mind the economic situation of the countries concerned. The ultimate goal of the project is to develop guidelines that can be used to plan and design roads in the area. The project consists of three closely interrelated components - a scientific component, a policy component, and integration with the FMMP.

Scientific work

The scientific component, carried out by three Delft Cluster institutes (UNESCO-IHE, WL|Delft Hydraulics and GeoDelft), adopts a multi-disciplinary research approach, integrating technical and policy analysis to provide recommended guidelines.

UNESCO-IHE and WL|Delft are focusing on the hydraulic and ecological processes in the Mekong river basin. They work with models that show water behaviour during the flood season (flood patterns, flow velocities, water depths), silt transportation, and sedimentation processes. UNESCO-IHE also focuses on the integration of technical and political analyses. GeoDelft is more involved with road construction. The first phase of the research is primarily intended to increase insight into the related processes, and to determine the neutral situation.

Between June 2006 and January 2007, several monitoring surveys were carried out: a post flood monitoring survey to establish the reference situation, flood monitoring consisting of a hydraulic monitoring and damage survey, and the post flood damage survey. All three surveys were conducted in close cooperation with, and partly by, the Mekong River Commission. The surveys will provide information about the flow pattern and



Photo: © Michiel van der Ruyt

inundation characteristics, as well as the damage that has occurred (underlying mechanisms and prevailing conditions). The researchers plan to use the information they collect to link the hydraulic model with features of the damage. Other important points to be considered in addition to road construction are the number of through-flow structures (bridges, culverts) needed to guarantee a relatively undisturbed water flow, the location of these structures, and the measures needed to prevent erosion features. The most favourable orientation of the road in relation to the flow direction will also be taken into consideration.

Policy basis

The collaborating parties recognise that the development of scientific knowledge alone is not sufficient. It is also important to create a political basis for the knowledge that has been developed, and to ensure that this knowledge reaches the relevant parties. The latter is even more important in countries such as Cambodia and Vietnam because a variety of organisations independently carry out road building projects within the framework of development cooperation. This fragmented strategy theoretically supplies a robust road construction framework, but in general, the river basin as a whole and the undesired effects that construction has on other locations are not taken into consideration. The effects are often considerable because the delta area is a closely connected system that is extremely sensitive to local change. WWF and MRC are responsible for the policy component, translating the findings of the scientific component into policy recommendations and ensuring that the key stakeholders are aware of and understand the recommendations. Line agencies and representatives from development banks in Cambodia and Vietnam, led by the respective National Mekong Committees, will discuss the policy and institutional recommendations. The knowledge that is developed will also be publicised and improved continuously by means of practical experience, and imbedded in integrated programmes by the Flood Management and Mitigation Programme Centre of MRC in Phnom Penh. This centre will also ensure that the knowledge is regularly offered to relevant parties in the Mekong Delta.

Wider use

The intended end result of the project - the guidelines - are intended primarily for the Cambodian and Vietnamese public bodies responsible for planning, designing, constructing, and maintaining roads in the Mekong Delta. The results can, in fact, be used more widely. Neighbouring countries such as Laos and Thailand can ascertain how to make use of the research results via the Flood Management and Mitigation Programme Centre. The same is true for financial organisations, such as the World Bank and Asian Development Bank. Furthermore, the project demonstrates what countries in delta areas can achieve with an international plan for river basin management.

Marc Goichot (WWF)

"This project is an example of embedded technical and environmental know-how in social and public issues, and a balanced marriage of technology, social awareness and public management. It shows how cooperation and an integrated approach can lead to the application of technology, with a focus on practical and wide spectrum solutions."



Combined research leads to structured cooperation

WL|Delft Hydraulics has recently been working with the American company Coastal Planning & Engineering (CP&E). The basis for this cooperation was laid during an international conference in 2005, when Delft Cluster researchers Mark van Koningsveld and Dirk Jan Walstra met Lindino Benedet, a researcher at CP&E. Walstra: “It soon became apparent that the models we develop are suitable for solving their problems. We then made arrangements for graduate projects, and everything moved on from there.”

“The collaboration with CP&E from Florida is a wonderful example of how chance contacts can lead to something worthwhile”, says Walstra. “Lindino Benedet and his colleague Tom Campbell, one of CP&E’s directors, both carry out doctoral research with Marcel Stive, a professor in Hydraulic Engineering here in Delft. Stive knew about the work we were doing, was familiar with CP&E’s activities, and came to the conclusion that we could help one another.

That’s why he brought us into contact with Benedet at the conference.”

Sand transport

“We connected straightaway at the first meeting, and started talking about the projects we were working on and the opportunities our models offered for solving concrete problems. It soon became clear that they were extremely



Lindino Benedet

Research assistant

(Coastal Planning & Engineering, Florida)

"I believe that we can also learn a great deal from each other in the future"

interested in the Delft3D model, a 'living model' that we're developing further within Delft Cluster. With the help of this model, we can determine the influence of currents and waves on sand movement. We then agreed that two of our graduates would carry out graduate projects at CP&E to demonstrate the capabilities of Delft3D. We also looked for subjects for graduate projects which are linked to Benedet and Campbell's doctoral studies."

Erosion

Van Koningsveld: "Willem Hartog was the first graduate to travel to Florida for three months. He carried out research into coastal erosion - the subject of Benedet's doctoral research - at the location where one of the first beach replenishment projects had been carried out in America. There was a great deal of erosion at one particular place, and there was no satisfactory explanation for this. To find out the reason, Hartog modelled the coastal zone in a variety of ways using Delft3D, effectively 'turning off' certain aspects of the coast in doing so. Ben de Sonnevile, our second graduate, carried out research into erosion of the Louisiana barrier islands at the mouth of the Mississippi. De Sonnevile used Delft3D to investigate the erosion processes and to analyse which restoration measures were possible."

Enthusiastic

Benedet from CP&E looks back enthusiastically at the two doctoral studies: "In both projects, we could clearly see how the model should be used and what the possibilities are. We were so impressed by the time the projects finished that we bought a license, and now use

the model for many of our projects. At first, we had support from Delft. For example, they showed us how to model specific properties and explained the strong points and limitations of the model. I believe that we can also learn a great deal from each other in the future. And we're not the only ones who are enthusiastic about Delft3D in the United States. We've now given a number of presentations in our country, and it's clear each time that other American parties also see the value of our model."

An attractive combination

Walstra and Van Koningsveld are also extremely satisfied with the CP&E collaboration. "With these two graduate projects, we've laid the foundations for a more structured form of cooperation. WL|Delft Hydraulics has also carried out various commercial projects with CP&E, and it looks as if this will happen more frequently in coming years. In fact, their field knowledge and our scientific support add up to a most attractive combination."

Barrier islands

The Mississippi barrier islands lie in an elongated curve of sandy islands in the southern part of the Mississippi delta. They protect the wetlands and infrastructure that lie behind from the effects of the sea. These islands have experienced severe erosion in recent decades, and almost disappeared completely two years ago due to Hurricane Katrina. Subsidence and the rise in sea level have put this area under even greater pressure. MSc student Ben de Sonnevile studied the erosion processes for his graduate project. "They are correct in understanding that the delta area must be maintained for the sake of safety in the long term. First, I investigated

the processes that occur, and then examined the measures that could be taken to restore the islands. I specifically looked at the so-called soft measures, such as the intelligent replenishment of sand."

De Sonnevile enjoyed his graduate project greatly. "I began by learning about every aspect of the model at WL, and then continued at CP&E in this specific field. I've therefore been able to combine the best of both worlds. I also found CP&E to be a really interesting company, partly because they're active across the whole spectrum, from scientific research to supervising the implementation of projects."

Coastal erosion under the microscope

Willem Hartog worked on the issues surrounding coastal erosion for his graduate study. "Erosion hotspots, places where the coast erodes faster than in the direct vicinity occur in the Delray beach study area on the east coast of Florida. CP &E was unable to explain this erosion. A reef with an opening lies in front of the coast, and they suspected that this was the cause. I began investigating using Delft3D. I first ran the model with the reef opening present, and then without the opening. This seemed to have little impact on the level of erosion.

Further investigation with the model, soon uncovered that old deep sand dredging pits were the cause. These had been created in the past to supply sand for beach replenishment projects."

The strong scientific interest shown by the company surprised Hartog during his time with CP&E: "You don't expect this level of interest in a commercial company. This naturally makes it attractive for WL and the TU to collaborate with CP&E."

High-quality drinking water for everyone

In comparison with other countries, the Netherlands has drinking water of superior quality. This is largely due to the constant research efforts of water supply companies and knowledge institutes, who work together to further improve the quality of treated water. According to Delft Cluster researchers Jan Vreeburg and Dick van der Kooij, the leading position of the Dutch means that the emphasis in the international exchange of knowledge is more on contributing - rather than acquiring - knowledge.

“The Dutch water companies strive for drinking water of impeccable quality”, explains Van der Kooij. “In doing so, they distinguish themselves from their colleagues abroad. Cost is a major issue in many countries, and less attention is given to quality. This approach can lead to consumers buying bottled water rather than drinking water straight from the tap. The costs of drinking water for the consumer are therefore much higher than if they can simply drink tap water. The continuing effort to deliver high quality drinking water is reflected in the Delft Cluster project Q21. The starting point for this project is a thorough investigation of our drinking water concept to pinpoint what we need to adapt to ensure good drinking water in the coming century, and to ensure that consumers carry on drinking water from the tap with confidence.”

Discoloured water, drinking water

The Delft Cluster research has three spearheads, namely particles in the drinking water network, Legionella and the removal of natural organic materials (NOM), and membrane fouling. The first research spearhead is mainly concerned with the issues of discoloured water. Vreeburg: “For a long time, it was thought that this problem was caused by the corrosion of cast iron pipes. We now know that this is not the case. Most of the sediment in the distribution network that can lead to discoloured tap water originates from raw water and the water treatment process. For example, numerous particles are released as soon as sand filters after back-washing are taken into production again. This research shows the importance of looking at the whole system, not just at a particular part.”





Brian Olley

Manager of Customer Services

(Northumbrian Water)

"You sometimes come across an idea that is so blindingly simple that you wonder why it took so long to realise it. These new design rules are so logical that it's hard to understand why it took us so long to embrace them."

Cost savings

Vreeburg continues: "We've not only charted the cause of the problem, but have investigated the solution as well. In the first instance, this calls for careful operation of the treatment plant. It is then important to ensure that any particles still entering the network remain in motion. That means heading towards so-called high-velocity networks, which is a complete departure from the current approach. Research also seems to show that flushing with water is the best technique for cleaning the distribution network, provided that this is done in a well-planned fashion."

Although the research was not carried out in cooperation with international parties, a great deal of interest has been shown from outside the Netherlands. "I've given a number of presentations in recent years, and have also published several articles. This has led to various reactions. For example, we will soon be passing on the concept of high-speed networks to a large water company in the UK (Northumbrian Water), who has about 2.5 million customers. This company is the first authority to be interested in the potential for increased hydraulic network performance with the aim of improving water quality. They eventually came on board because of the cost reductions (approximately 20%) that can be realised with high-velocity networks."

Pure Dutch

Research into Legionella and NOM are a purely Dutch activity, just as research into particles in distribution networks. Van der Kooij: "There is limited interest in these subjects abroad. Many foreign drinking water companies do not consider Legionella research to be one of their tasks, because processes affecting water quality 'after the water meter' are not their responsibility. As a result, there is little stimulus for knowledge institutes to investigate these issues. Fortunately, water supply companies in the Netherlands do consider such water quality problems to be their responsibility. This situation means that we're unable to obtain much knowledge about the Legionella problem in relation to water supply from abroad, but we intend to share our own knowledge. In recent years, a number of articles

have been published in peer review journals, for example about our discovery that Legionella growth in biofilms depends strongly on protozoa and the amount of 'biodegradable' organic material, and details of our research showing that Legionella bacteria in treated water and plumbing systems are often a type that is not dangerous."

Increased authority

Although his colleague Van der Kooij is somewhat sceptical about the possibilities for collaboration with foreign parties, Vreeburg sees ample opportunities: "Although we have a technological advantage in a large number of areas, there is still knowledge to be gained from elsewhere. I personally find it extremely useful to carry out practical research in different situations, for example abroad. Such research can lend extra support to your ideas. Foreign contacts can also lead to new insights that may prove very enlightening. What's more, contact with foreign partners can increase the authority of the Dutch drinking water sector. For example, consider losses caused by leaks in distribution networks. In the Netherlands, they amount to approximately three to five percent. Until recently, this figure was not believed in international circles. We therefore invited international experts to see for themselves that our figures were correct. Having confirmed this at first hand, they're now extremely interested in how we achieve this. In just the same way, we've demonstrated that we're able to provide drinking water of outstanding quality at a relatively low cost. Water that is considerably cheaper than bottled water."

Building at sea, a challenging enterprise

When we need more space or seek to relocate activities that cause disruption on land, we look towards the sea for answers. Just think of the plans for an offshore airport, for instance. According to Professor of Hydraulics Marcel Stive, the ease with which construction at sea is proposed as an option is not proportional to the complexity of land reclamation projects. “There are still many problems to be solved, and Delft Cluster is researching them.”

“Take a mega-project like the Second Maasvlakte”, Stive suggests. “Part of this westward extension of the existing Maasvlakte will be in much deeper water than the original reclamation. This calls for different solutions. For example, the shore profile could go down to the sea bed in steps instead of in gentle inclines. We’re now researching whether geo-tubes – ‘sand sausages’ made of geo-textile – are needed on these steps to prevent the loss of sand. Another difficult problem is the effect on flow patterns when new land is built. Do such interventions lead to coastal erosion further along the coast? Building the Nieuwe Waterweg, the entrance to the Port of Rotterdam, for example, has drastically changed the existing flow of sand along the North Sea coast. We therefore carry out a considerable amount of research into this type of morphological processes.”

Fish larvae

"We're also carrying out research into the problem of suspended matter. Fine grains become suspended during dredging, as well as during dumping. The resulting turbidity has adverse effects on fish larvae. We develop models that predict how much fine material will be suspended. We also carry out research into the composition of the material and into the structure of the particles. The latter is important for predicting whether they will adhere to one another and sink quickly. The issue has become extremely topical in the Netherlands. The most important shortcoming identified by the Council of State in the PKB for the Second Maasvlakte in 2005 was that there was insufficient information about the effect of fine matter on fish larvae in the Wadden Sea. Similar issues arise in other countries. We've carried out research in Singapore, together with the Singapore Public Utilities Board, the Singapore Department of Waterways and Public Works, into the effect of suspended particles in a reclamation project on the fishing grounds of neighbouring Malaysia."

Jet-ski

"We're able to learn an enormous amount from applying our research abroad: Not only from our experience in Singapore, but also from projects we carry out in the United States with the US Geological Survey. The reason is, I think, that knowledge is generally based on the specific situation in your own country. By using your knowledge in different situations, you're forced to thoroughly rethink all its aspects."

Stive continues: "As a result of these collaborative projects, we've also developed new research techniques together. A good example is monitoring equipment mounted on a jet-ski, designed to rapidly map the sea bed. We developed this jet-ski in cooperation with the American Office of Naval Research at Monterey CA. Important advantages of the jet-ski are that it can be deployed quickly, and that it can carry out measurements in shallow waters, in contrast to the ships that are traditionally used for sounding depths."

Piles in the sand

Stive emphasises that construction at sea not only involves land reclamation projects, but wind parks and drilling rigs as well. Tubular steel piles are often used for their foundations. Before installations are placed on them, offshore companies need to ascertain that these piles have sufficient load-bearing capabilities. However, a static test load in the open sea is difficult and costly. The quick pile test - a new testing technique where a pile bears a load for a short period - is far more practical. Delft Cluster has developed know-how and rules that enable the pile test to be applied.

Professor of Foundation Engineering, Frits van Tol: "Knowledge about the behaviour of clay has been extensively researched in quick pile tests, including tests by the University of Sheffield. Dutch piles, however, usually derive their bearing capacity from the sand layer. A PhD student is now carrying out research into the behaviour of piles in sand."

European standards

"At the same time, we are focusing on the application of existing and newly developed knowledge. The sector is in fact calling for regulations when carrying out and interpreting the results from quick pile tests. We initially intended to set up a Dutch report, but we eventually decided to aim higher. One of the participating parties in the research, Shell Global Solutions, would only participate if it would result in publication at a European level. We have meanwhile extended current contacts with international partners, such as Sheffield, and have reached an agreement with them concerning the organisation of a European implementation standard and interpretation guidelines. The universities of Sheffield and Dundee and the BRE in England, the WTCB in Belgium, and even American and Japanese specialists, are now working together to establish these guidelines. We've laid a sound international base for the implementation standard and the guidelines."

Gennaro Esposito

Civil Geotechnical Engineer

(Shell Global Solutions International B.V.)

"The quick pile test could become the most important test method for the offshore industry because of its fast implementation and broad range of application. A major benefit is its suitability for assessing horizontally-loaded piles and groups of piles, as well as high axle-bearing capacities. One requirement is that the speed-dependent effects are understood fully."



Source: Artist impression Maasvlakte 2_2007, Havenbedrijf Rotterdam N.V.



Source: Artist impression Maasvlakte 2_2007, Havenbedrijf Rotterdam N.V.

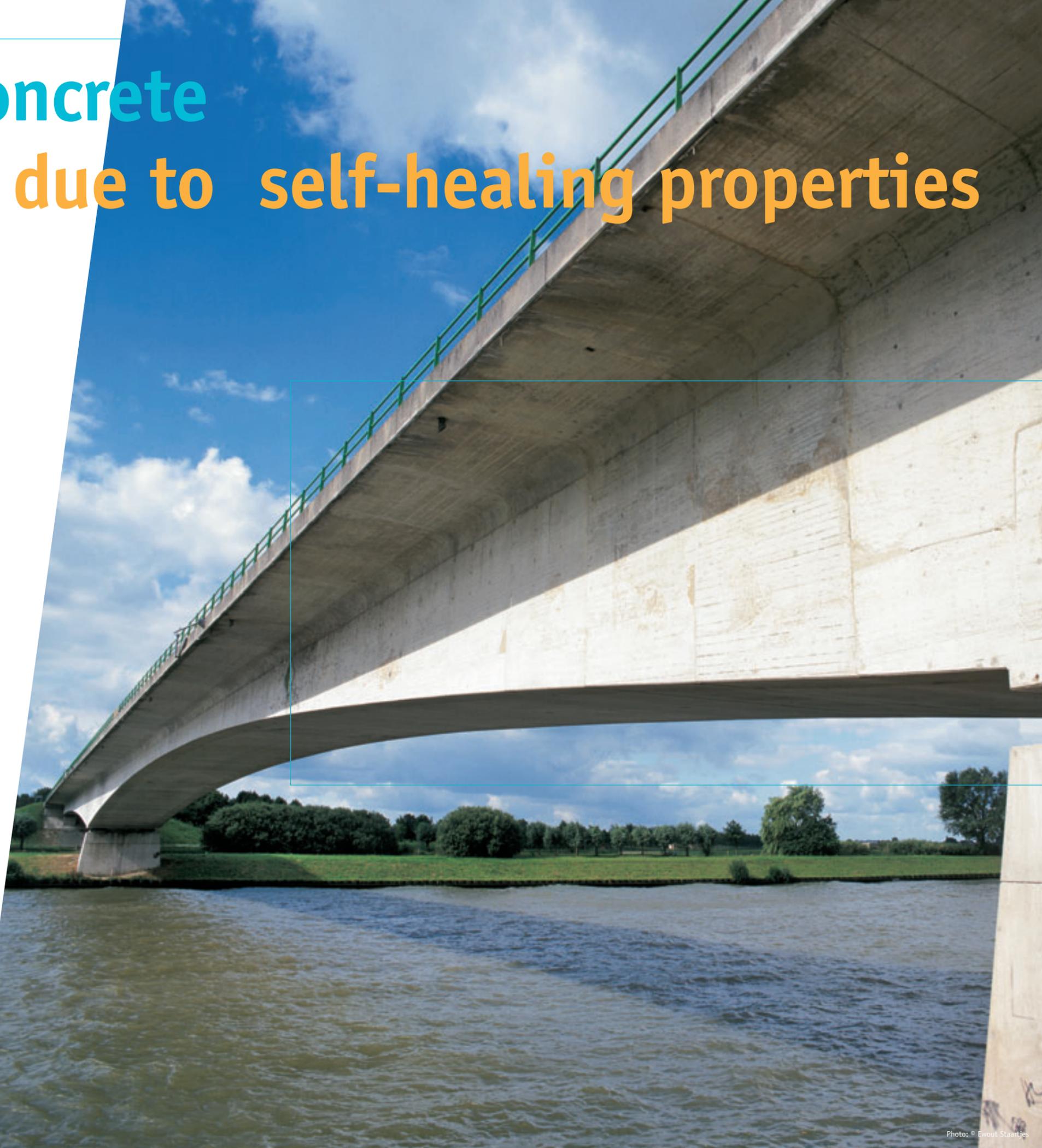
Longer-lasting concrete due to self-healing properties

In recent years, there has been worldwide interest in self-healing materials. An initiative from the Delft Centre for Materials - one of TU Delft's research centres - has led to a national research programme in The Netherlands known as IOP Self Healing Materials. The Microlab in the Design & Construction department is carrying out fundamental research into self-healing concrete as part of this programme. According to Klaas van Breugel, Scientific Director of the Microlab, this research provides interesting interfaces with the more practically-oriented research carried out by Delft Cluster.

Van Breugel knows what he is talking about. He is, in fact, closely involved with Delft Cluster's Durable Management of Concrete Structures research project. "In the Delft Cluster research, part of our focus is on degradation mechanisms and life-span predictions. When studying concrete degradation, you're soon faced with the question of how to slow down and repair damage. The next step towards the self-healing properties of concrete soon follows."

Super cement grains

"The concept of self-healing materials is only a few years old. Interestingly, though, concrete is naturally self-healing to a certain extent. In fact, concrete always comprises grains of cement that have reacted to water



on the exterior, but which still contain unhydrated cement inside. If a small crack develops in the concrete, these grains break open. The dry cement will then react to the penetrating water, causing the crack to partially close. One of the options when developing self-healing concrete is to optimise this mechanism. By adding a type of 'super cement grain', for example, balls of dry cement that open as soon as a crack forms."

Extra safety valve

"There are other options as well", Van Breugel continues. "For example, we're researching the possibility of 'building in' bacteria into concrete. The bacteria we have in mind produce limestone. If cracks form in the concrete and water is able to penetrate, these bacteria would be activated and create limestone. Another option is to add something to the concrete mixture to combat carbonation. Carbonation occurs when CO₂ from the air penetrates the concrete via the pores and reacts with the calcium hydroxide present. The pH decreases as a result of this reaction, the concrete becomes more 'acid', and this can lead to reinforcement corrosion. In my opinion, you must first ensure that your concrete is as dense as possible so that aggressive agents can't penetrate it. In both cases, it would be more sensible to build-in an 'extra safety valve' to guarantee that corrosion cannot occur if your concrete unexpectedly becomes more porous."

Cooperation

"These are obviously not developments that we're carrying out alone. We have good contacts with Professor Victor Li at the University of Michigan, who developed the so-called Engineered Cementitious Composite (EEC). This is a cement product to which small fibres have been added to limit crack formation. Small cracks self-heal more easily than large cracks. EEC is an interesting material, especially for use in concrete repairs. We also have good contacts with Professor Teruo Kishi, Director of the Japanese National Institute of Material Science. This institute is also working on self-healing materials."

Enormous savings

Van Breugel has high expectations from the research being carried out into degradation mechanisms and options for increasing the life span of concrete structures, such as self-healing properties. "Almost 50 percent of expenditure involved with construction in The Netherlands is spent on management, maintenance, and repair. We're talking about a great deal of money. It means that enormous savings can be achieved with even small improvements, such as a small increase in the maintenance-free period or a longer lasting repair technique."

Professor Victor Li

(University of Michigan, USA)

"The ability to control crack width to the micron level (less than the diameter of a human hair) in EEC studied in our laboratory, combined with advanced concepts for the physics and chemistry of cement re-healing processes championed by the Microlab, will accelerate the development of a new generation of "crack-free" concrete. We are delighted to be working with Delft in this effort."



Limiting flood risks

In the 'Safety against flooding' research project, Ir. Bas Jonkman has developed a model to calculate the number of casualties following a large-scale flood. The flood in New Orleans, caused by hurricane Katrina, offered him the unexpected opportunity to test his model. Together with colleagues from the Louisiana State University (LSU), he analysed the events in New Orleans and worked on improving the model.

In The Netherlands, prevention has always been at the top of the agenda when it comes to limiting flood risks. Other opinions have been voiced more recently, however. Wouldn't it be better to use the money we invest in the quality of our dikes more wisely to restrict the consequences of flooding, for example by developing evacuation plans? Delft Cluster researcher Jonkman is very clear in his answer to this question.

"I'm convinced that the emphasis must remain on prevention. Using my casualty model, I've calculated what the consequences would be if sea dikes collapsed in The Hague and at Ter Heijde. If this were to happen, the southern cities of Western Holland would be under water and there would be more than 4,000 casualties. I've also studied how many casualties could be prevented by an evacuation. The number of extra lives that would then be saved is 600. It's clear that evacuation cannot sufficiently limit the consequences of a similar flood, and that it's still necessary to have good dikes."



Casualty functions

Jonkman developed the model used to calculate the number of casualties during his doctoral research at the TU Delft. It consists of various components. One of these components is a model that simulates an evacuation, and shows how many persons would still be in the area when a dike collapses. Another model simulates the course of the flood. How quickly and where will the water go to? Nevertheless, these two models do not give any indication about casualty numbers. So-called mortality functions are needed for this, such as '20 percent of people will not survive in an area where the water is four metres deep.' Jonkman selected these functions by analysing past floods – until, that is, the dikes around New Orleans collapsed in August 2005 as a result of hurricane Katrina.

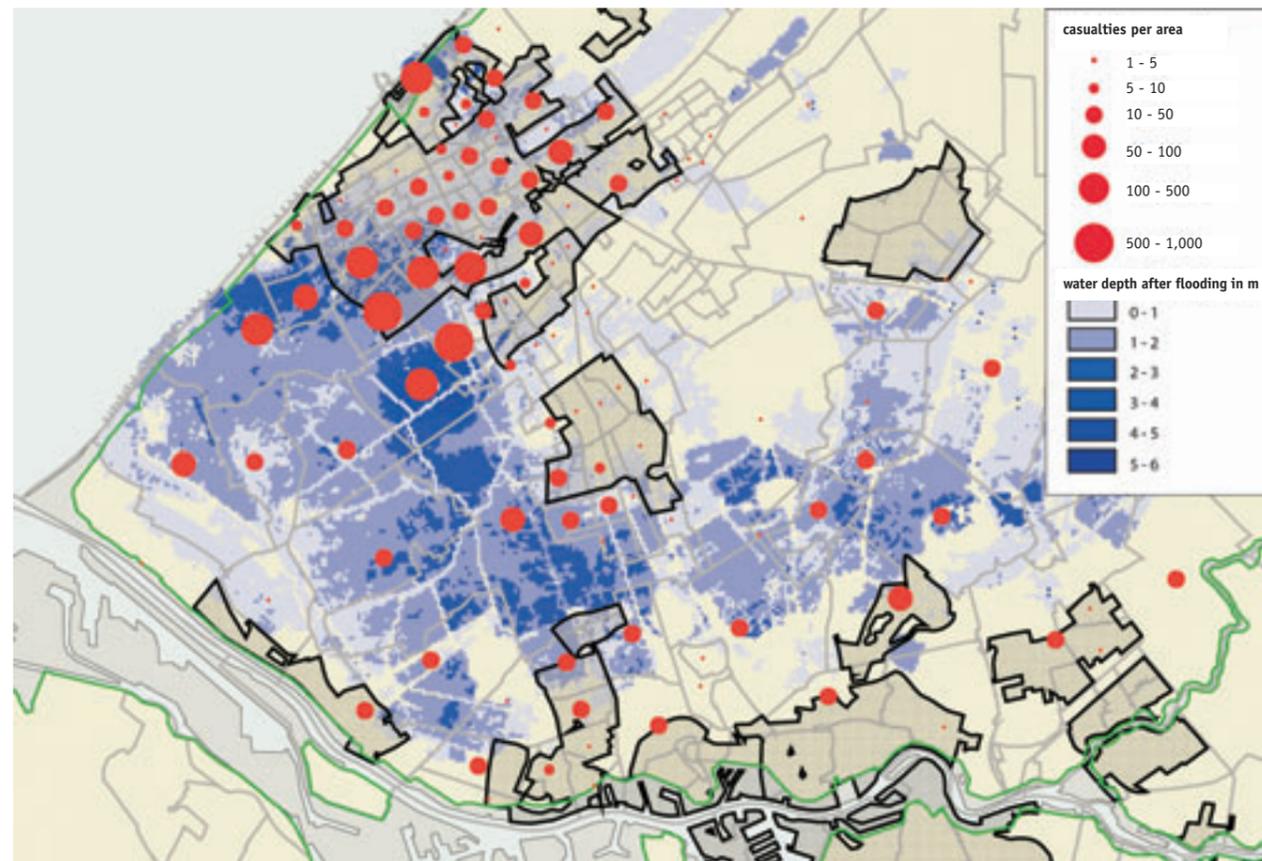
Prediction capability

"Those terrible events offered me the opportunity to calibrate my model. Soon after the disaster, a research colleague at the Louisiana State University with whom I already had contact, asked me to come to the area and gather information. I travelled to the disaster area in February 2006, and gathered data about the locations where the fatalities were recovered. We also used information regarding the flow velocities and depth of water. Using the information in my model, I estimated two thousand casualties. Although this is higher than the 1,100 fatalities already found, the number is in the same order of magnitude. I'm therefore satisfied with the model's prediction capability. An American consultancy firm estimated the number of fatalities to be sixty thousand."

Think safety

"Together with the Louisiana State University, I'm now researching how we can further improve the mortality functions. It appears that the water depth, the rate of rise, and the speed of the current are the most defining factors. In the meantime, we're also working in this field with the Flood Hazard Research Centre at Middlesex University, England. In this respect my research has generated considerable interest. Previously, only economic aspects had been examined during studies into the consequences of flooding. I was one of the few investigating the loss of life that could be caused by floods. This is now also being investigated in England and the United States. For good flood risk management, it is also essential to consider people's safety."

"I don't believe that we should continue pouring energy into the refinement of mortality models. A global indication of the number of casualties is often enough to indicate the problem. It seems more sensible to me to research the whole safety chain and to analyse which measures are possible, what they will cost, and which will contribute to risk reduction."



Source: Delft Integraal

Photo: © Bas Jonkman

Prof Marc Levitan

Director

(LSU Hurricane Center, USA)

"Well before Hurricane Katrina devastated New Orleans and the Gulf Coast in August 2005, we've been collaborating with Jonkman on the development of flood casualty models. The storm emphasised the importance of research into loss of life during disasters. During the first few days after the storm, we used some of Jonkman's models to provide the State of Louisiana with early estimates of the number of fatalities that had probably occurred. Mortality models are also an important tool for planning and assessing different flood protection alternatives for New Orleans, as well as for hurricane and flood disaster operations and emergency management."

Dutch tunnel technology

“Dutch tunnel technology has considerable potential as an export product”, stated Ing. Han Admiraal, Director of the Centre for Underground Construction. According to him, it is time to take the following step, now that The Netherlands has achieved a top position in the field of bored tunnels in soft soil. “If we want to make tunnel technology a successful export product, we must first investigate the most suitable tunnel concept for the delta areas.”

“Twelve years ago, we started construction of the Second Heineoord tunnel, the first bored tunnel in The Netherlands”, says Admiraal. “The standard approach until then was to immerse the tunnel, whereas underground metros and railways were mostly constructed using the so-called open excavation method. Boring in Dutch soils was a revolutionary step, but it’s now become relative child’s play. We’ve widened our knowledge substantially since the Second Heineoord tunnel, and are now amongst the world’s leaders when it comes to boring in soft soils. The fact that we’re now confident enough to construct drilled tunnels in closely built urban areas is partial proof of this.”

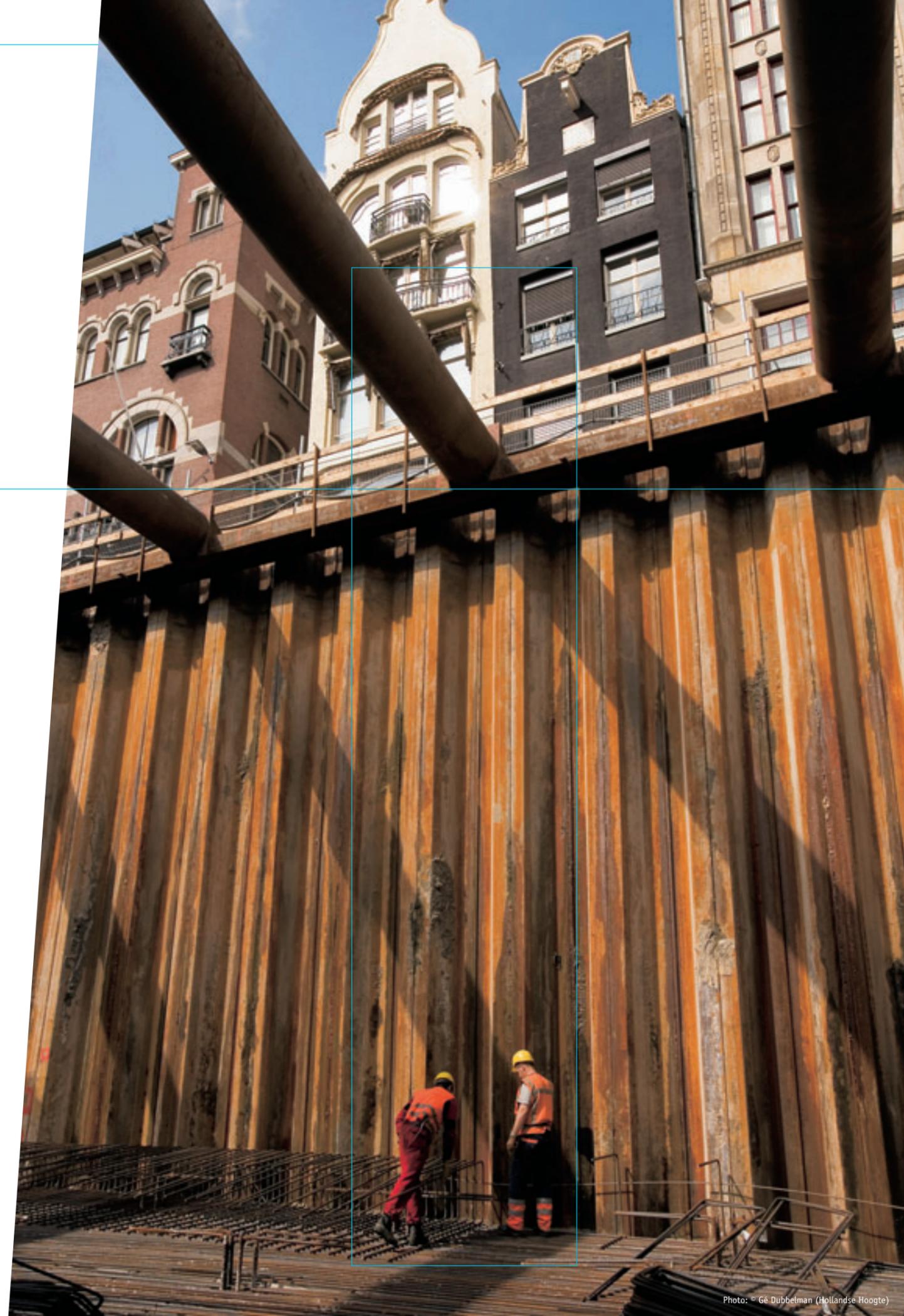
A more clever way

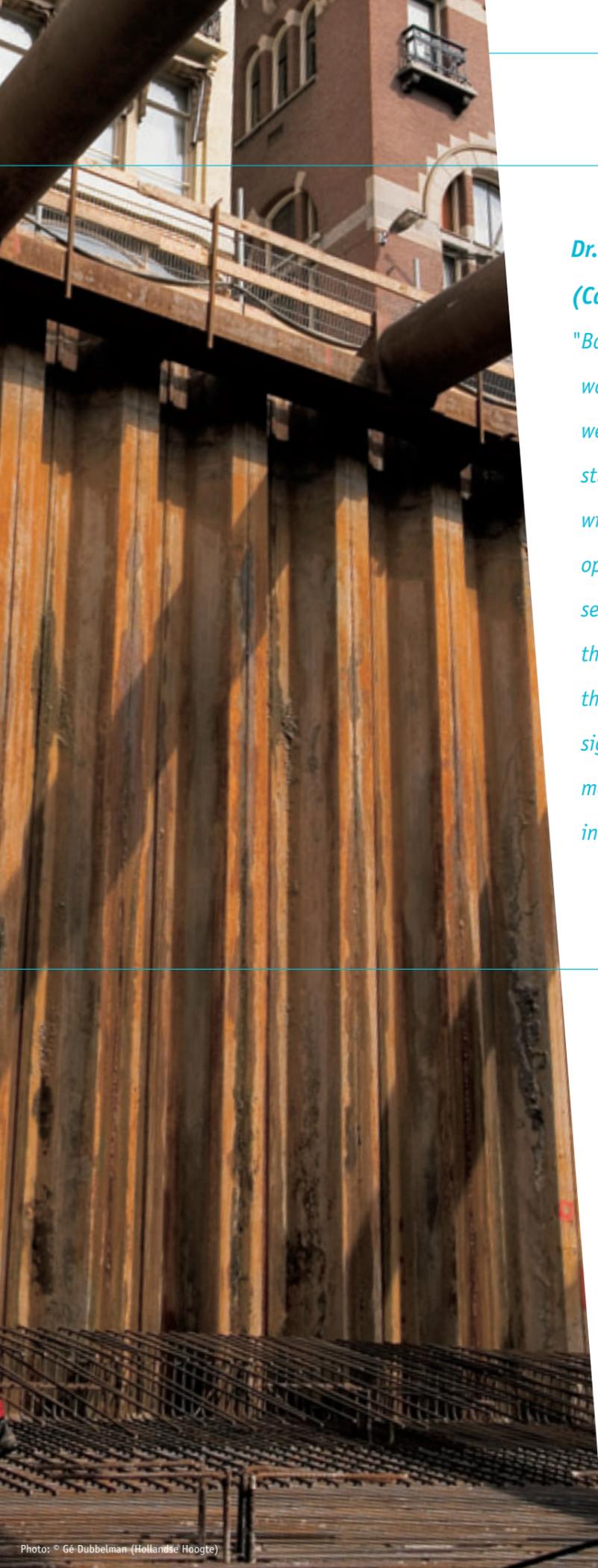
“The only conclusion possible is that we’ve made enormous progress. It’s noticeable, though, that we’ve never asked ourselves if the technique we use to construct bored tunnels is the most suitable. We have an existing technique that has primarily been used for drilling in rocks and stony ground, and that’s been adapted to our

situation, with the typical subsoil of a delta area. It has in fact worked extremely well, and we’ve been able to optimise the technique even further. As a result, bored tunnels are now only slightly more expensive than conventional tunnels. The question remains, however, whether it can be done in a more clever way. To find out, I’m arguing for an integrated research programme into ‘delta tunnels’, enabling us to study design, construction, materials, and use. Naturally, such a study must take stock of what we’ve already learnt from more than ten years experience in constructing bored tunnels. For example, how can existing knowledge be used in an innovative way? The ultimate objective must be development of a delta tunnel that is clearly distinguishable from tunnels in a hard substrate.”

Combined functions

According to Admiraal, a wide variety of themes should be included in an integrated ‘delta tunnelling’ research programme. Admiraal: “Consider, for example, the tunnel shape. Immersed tunnels are rectangular, because this





Dr. K. Soga

(Cambridge University)

"Based on this cooperation, my PhD-student was able to perform more tests at Delft than we could possibly achieve in Cambridge. The student also used 'Cambridge' sand and grout with the GeoDelft test set-up, which gave the opportunity to test the influence of different set-ups. More importantly, we gained access to the test results of Delft Cluster and the ideas that have been developed there. This led to a significant step in understanding the fundamental mechanisms of compensation grouting in sand."

is technically the most efficient shape. Bored tunnels, on the other hand, are round because of advantages in terms of construction and installation techniques. What should be the rule for a delta tunnel: more efficient use of space or a more efficient construction shape?"

Admiraal continues: "Another theme is the construction method (should we keep drilling, or are other promising techniques available?), and the possibility of constructing tunnels at less depth. The current depth of bored tunnels, for example, leads to deep excavations and long entry ramps, which means high costs. A further theme to consider is the material used. Are concrete and steel the most suitable materials if the lifespan of a tunnel is taken into consideration? I think we should also take a serious look at combined functions. In Kuala Lumpur, an innovative tunnel has been built that combines water management and road transport. The drainage capacity is increased during heavy rainfall by temporarily using a section of the tunnel for water drainage that would normally be used for traffic."

Foreign customers

"By looking at tunnels in delta areas in this way, we can convert Dutch tunnel knowledge into a successful export product. The research carried out by the Delft Cluster-COB consortium is a good start. I'm thinking in the first place of the so-called 'Totally Different Tunnel' project, as well as the practical research for the North-South line in Amsterdam. Within the framework of this project, we're carrying out similar research with the University of Cambridge on so-called compensating grouting. This is a ground improvement technique that can be used to increase the bearing capacity of foundation posts in the immediate vicinity of the tunnel tube. For a project such as the North-South line where a metro line will be laid transversely under the historic city centre of Amsterdam, knowledge gained from a similar technique is extremely useful.

I'm convinced that we must pursue the consortium's strategy. To arrive at clever solutions, we must bring together all those parties involved, focus on the development of knowledge, and continue working on practical

projects. What's more, we must continue looking abroad to see what we can learn there, and also ensure that we know the requirements of potential foreign customers."

Delft Cluster and the Netherlands Centre for Underground Construction (COB)

Underground use of space can make an essential contribution to the needs of society. Specific answers and clear choices are needed however, to answer the questions of when, where and how. Once used, space (especially underground space) cannot easily be re-used. The sooner the decision to exploit underground space is made, the better society will be able to use the possibilities offered by underground space in a sustainable way.

Use of underground space is complex, and construction underground means high costs. Extra knowledge is therefore needed to optimise the potential use of underground space, knowledge about technical applications, innovative building concepts, clever cost-reducing construction methods, high flexibility, and sustainability. If we combine such knowledge with a focus on innovation, the Dutch construction sector will be able to expand its expertise and turn underground construction in the Delta area into reality.

Delft Cluster and the Netherlands Centre for Underground Construction (COB) have established a consortium in which we jointly strive to develop a high level of knowledge about underground construction. We also stimulate embedding the results of the projects. The consortium conducts research for almost every large tunnel project in the Netherlands.

Fibre optic measurements

in a Rhine experimental sub basin

Measuring temperatures in a small Luxembourg river with a fibre optic cable does not seem like impressive research at first glance, but nothing could be further from the truth. The measurements will be used to expand fundamental understanding of the relationship between rainfall and river runoff. Using this understanding, it will be possible to accurately predict the amount of water reaching us via rivers, and to predict the consequences of changes in river basins.

The Maisbich in the Luxembourg hills is no more than a small stream, in a river basin measuring approximately one square kilometre. The river flows via the Alzette and the Sür into the Moselle. Outsiders are therefore surprised to learn that Delft Cluster researchers are investigating flood risk in this tiny stream. Having heard an explanation by Scientific Assistant Wim Luxemburg and Professor of Hydrology Huub Savenije, surprise quickly turns into fascination.

Parameter uncertainty

“When precipitation falls on an incline, most often as rain or snow, a great deal happens before the effect is visible in the form of increased river flow”, explains Luxemburg. “If, for example, snow melts on an incline where the ground is frozen, the water mainly flows away over the surface. In other cases, it generally infiltrates the ground. The speed that rainfall subsequently leads

*Professor Jeffrey McDonnell
(Department of Forest Engineering and
Institute for Water and Watersheds,
Oregon State University)*

“Understanding the process of ‘how rainfall becomes runoff’ is vital for safety in low land countries where large rivers cross. New techniques such as fibre optic temperature sensors help provide new insight into river dynamics”



to increased flow depends on a variety of factors, such as the saturation level of the soil or the presence of cracks in the ground. In this research, we are aiming to find out which processes occur and how they work. More insight into these processes will not only mean that we have better understanding of why a certain amount of rainfall can lead to a particular increase in river flow, but that we can also decrease the parameter uncertainty of our models and can make more reliable predictions. Not only for the small river basin of the Maisbich, but also for the Moselle or the Rhine."

Figures from past experience

"It is of course possible to make reasonable statements about the relationship between rainfall and river flow without the models we're now developing. We're convinced, though, that our new models will provide additional value. They not only make it possible to give more accurate and reliable predictions, but the effect that river basin changes have on the relationship between rainfall and runoff can be predicted more accurately. This is not possible with models that only work using figures from past experience.

Measuring seepage with glass fibre

Delft Cluster is the first party that has used the glass fibre optic technique for measuring temperature differences in a river. The technique of measuring temperature with a glass fibre optic cable has existed for approximately a decade. The Water Resources Section of the TU Delft first came into contact with this technique via John Selker from Oregon State University. He used the technique to measure temperature differences above a glacier. There are more applications possible, according to Wim Luxemburg "We're currently holding discussions with a party who wishes to experiment with the glass fibre observation technique in drainage canals, in order to determine potential risk spots where there is water seepage underneath dikes."

Temperature differences

Savenije: "To determine what happens when rain falls, we have laid 1,300 metres of fibre optic cable in the Maisbich. Using this, we can measure even small differences in temperature. This gives us the opportunity to determine where and when the ground water flows into the river and to measure the quantity. At locations where ground water of a different temperature enters a river, it can be seen that the temperature of the river water suddenly changes. By combining these measurements with rainfall data and data about substratum and land use, we can analyse the events between the moment of rainfall and the moment of flow. We not only use temperature measurements as our base, but also work with so-called 'tracers' such as the 'oxygen eighteen' isotope and various other chemicals (for example, from minerals). These tracers are naturally present in water and give us a more accurate indication of the water's origin. Using this information, we can form a better understanding of substrate processes."

Origin

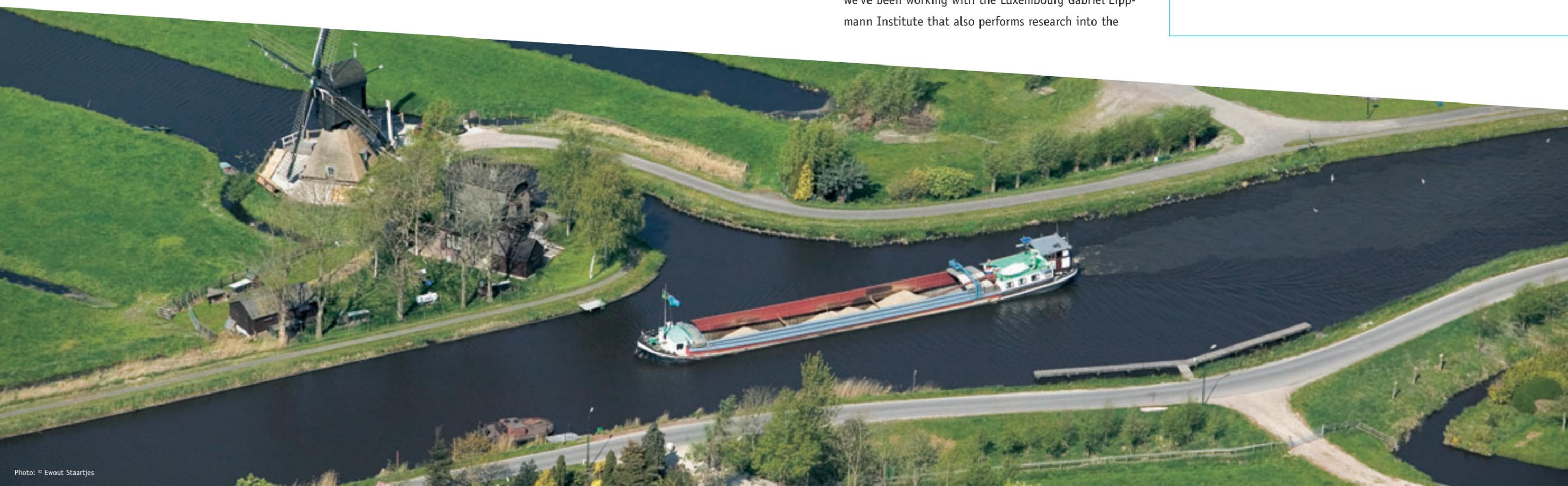
"There are various reasons for carrying out this research in Luxembourg", Savenije explains. "For some time, we've been working with the Luxembourg Gabriel Lippmann Institute that also performs research into the

relationship between rainfall and river drainage in the Luxembourg river basins. The European hills in countries surrounding us, which includes Luxembourg, are also the source of Dutch high-water problems with the Rhine. Which is why I often say that if we understand water in the hills of Luxembourg, this will help us to better understand the Rhine's behaviour."

Dr Laurent Pfister

**Head of the research sub-unit 'Geo-hydro-systems and Land Use Management'
(Centre de Recherche Public - Gabriel Lippmann, Luxembourg)**

"Floods in 1995 and 1997 came as a surprise in Luxembourg. As it's the same water that passes through The Netherlands, we share the concern and research with our colleagues in The Netherlands."



Implementing risk management, that's the trick

Although various risk management methodologies have been developed over the years, they have not been widely applied. Which is why Delft Cluster is now carrying out research into how professionals can be motivated to cope with risks and the accompanying opportunities in a structured way. The researchers are drawing upon international experience to do so.

Martin van Staveren is the leader of Delft Cluster research into risk management. Involved in risk management since 2000, he is the author of the recently published book 'Uncertainty and Ground Conditions, A Risk Management Approach'. "If you look at what's happened in the field of risk management in recent years, you'll notice that considerable energy has been invested in the development of concepts and instruments in particular. Until recently, the emphasis within Delft Cluster was also on these aspects. I'm not convinced, though, that this is the right approach. There are now various concepts, such as MARIUN in the UK and RISMAN and GeoQ in The Netherlands, which are good enough to begin working with risk management. You can of course continue with development, but if you've noticed that risk management is rarely used, I think you should tackle that aspect first."

Public sector

"The present research programme therefore completely concentrates on implementing risk management. We aim at the public sector in the first instance, because the task of the authorities is to use public money as effectively as possible. In their complex role as coordinator

of many parties, municipalities are often faced with unpleasant surprises from problems caused by unexpected events that occur during building projects. Damage caused by unsuccessful building excavations is a clear example."

Van Staveren continues: "Concentrating on the individual professional is an important characteristic of our research. When individuals are asked, they all say that it's important to do something about risk management, but if you then look at their actual behaviour, they always have a reason not to act accordingly. For example, the city councillor doesn't want to be confronted with annoying doom scenarios for their particular project. For this reason, we want to chart the conditions that must be met before professionals in public project organisations actually begin applying risk management."

International experiences

"Our plan is to chart generic impediments on the basis of literature study, our experience so far, and state-of-the-art knowledge from abroad. We can then deduce the conditions necessary for applying risk management. After all, the fact that risk management is not often applied





is not a typically Dutch problem. Implementation abroad has also proved difficult, although the need for risk management is growing. We are therefore interviewing an international peer group consisting of scientists from renowned universities from the United States (MIT and Berkeley), China, and South Africa. We are also involving internationally-operating consultants from the UK to gain insight into practical experience. These scientists and consultants will also be involved in testing our results in a later phase. Obviously, we realise that the manner in which people cope with uncertainties - what risk management is in fact all about- is partly determined by culture. We aim to demonstrate, however, that there are numerous generic knowledge elements that are applicable throughout world, which we can learn about from across each other's borders."

Pilot projects

"We'll then use the generic conditions for applying risk management in a number of pilot projects. We'll tune the conditions in each pilot project as closely as possible to that specific situation. After all, it's about finding the correct balance. What should motivate people in an organisation? What tools should be available to enable them to carry out risk management? And what training is necessary to develop risk awareness, and to ensure that professionals develop the correct skills needed to apply the concepts and instruments? We'll then aim to translate the results of the pilot projects into a set of 'verified and tested rules'. These measures will be scientifically based and tested in practice, and will imbed risk management in project organisations with the aim of visibly improving the process and the end result of civil engineering projects."

Tim Chapman

Director

**(Arup, London, United Kingdom and
Chairman of the JTC4's International
Working Group 3 on Geotechnical
Risk Reduction)**

"For centuries, people have been aware of ground risks, and analogies such as "getting the foundations right" have crept into everyday (English) speech. Yet too often, we struggle to persuade project-funders of the importance of what we do"

Internationalisation

The Delft Cluster Scientific Advisory Board (in Dutch: WAR) monitors the quality of research projects. An important aspect is internationalisation. “Scientists nowadays work in a global environment. It’s only logical that they work with foreign partners, and know where to gain their knowledge and what to do with it”, say Johan Blaauwendraad and Rietje van Dam-Mieras from WAR.

“If you look at those active in Delft Cluster’s research project, you’ll notice that they’re mostly civil engineers”, says Blaauwendraad, who has been the Chairperson of WAR for a year. “When WAR was established natural science at the beginning of the first Delft Cluster research project, a group was purposely chosen from other disciplines. This is reflected in the current WAR. Van Dam-Mieras is a chemist for example, and is now working as a professor of science at the Open University in Maastricht where she is also involved in innovative methods of knowledge transfer. We also have a former chairperson of the Dutch ICT authority Opta among us, as well as a professor of bio-science from Gent, a Canadian professor of hydraulic engineering, several directors of renowned research schools, and a professor from the Dutch agricultural scientific scene in Wageningen. To put it briefly, WAR is a mixed club, and that guarantees a broad viewpoint.”

Advice

“WAR monitors the quality of the total Delft Cluster research package from a distance, without taking the post of scientific director or the board of directors. We do not only look at the scientific quality, but also whether the desired results and the milestones formulated beforehand

have been achieved. I find it fascinating that, in spite of the diversity within WAR, we in fact always arrive at an unambiguous judgement. We then translate that judgement into advice that is subsequently utilised. An important aspect that we judge in every research project is internationalisation. This is the degree of cooperation with foreign partners in the development, dissemination, and utilisation of knowledge,” Van Dam-Mieras explains.

Clear links

Blaauwendraad: “The manner in which substance is given to internationalisation in the various projects varies considerably. Sometimes there is only contact at a scientific level, while there may be more intense cooperation in other Delft Cluster projects. Our starting point is that each project must have an international ‘link’, even when the project is focused on the Dutch situation. Take the Wetlands project. Although this is completely directed at renovation of the Dutch lake area IJsselmeer, you also know that issues being discussed in this project are relevant to other countries. There should therefore be clear international links in such a project. If this isn’t the case, we will pull back on the project.”



Making visible

"For us, internationalisation means contributing knowledge as well as obtaining it", says Van Dam-Mieras. "This isn't always the case in all projects, but we're moving in the right direction. It's sometimes difficult to make this visible, certainly where the acquisition of knowledge is concerned. After all, contact with foreign scientists doesn't always lead to quantifiable results, but usually contributes to higher quality instead. If foreign colleagues have similar experiences, for instance, this can help validate your theory or model."

Structural forms

Van Dam-Mieras continues: "WAR is in favour of the internationalisation of Delft Cluster. Naturally, there is still room for improvement and we would like to see international collaboration take even more structured modes. It would be ideal if more researchers from foreign institutes collaborated with Delft Cluster projects. At the same time, we must remain realistic and recognise that the research structure is not always aimed at internationalisation.

The main objective of a PhD-candidate, for instance, is to become an independent researcher. To do so, they must complete their research within four years. They will consequently attach less importance to internationalisation if it doesn't contribute to reaching their goal within the set time."

Prof Dr Bill Kamphuis

**Queens University Canada and member of
the Scientific Advisory Board
(Delft Cluster [WAR])**

"International exchange of civil engineering people and knowledge in DC projects is a win-win situation. Dutch experience is of high quality but focused, while international experience is normally shallower but broader. A great match! "

"DC uniquely unites Dutch experts in related civil engineering disciplines around specific projects, and encourages them to think internationally."

Delft Cluster Partners



UNESCO-IHE
Institute for Water Education



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UNESCO-IHE Institute for Water Education

UNESCO-IHE is the largest postgraduate water education facility in the world, and the only institution in the UN system authorised to confer accredited MSc degrees and to promote PhDs. The mission of UNESCO-IHE is to contribute to the education and training of professionals, and to build the capacity of sector organisations, knowledge centres and other institutions active in the fields of water, environment, and infrastructure in developing countries and countries in transition.

Since 1957, the Institute has provided postgraduate education to more than 13,400 water professionals from 162 countries. More than 60 PhD candidates have been promoted from the Institute, and numerous research and capacity building projects have been carried out throughout the world. Alumni reach senior

positions in their home countries, and become nationally and internationally recognised experts in their fields of specialty.

UNESCO-IHE centres its education, research and capacity building programmes around five themes: Water Security, Environmental Integrity, Urbanisation, Water Management and Governance, and Information and Communication Systems. Through each of these themes, the Institute focuses its contributions on resolving the major issues and challenges faced by many developing countries, as stated in the Millennium Development Goals and as identified by – among others – the UN Millennium Summit, the World Water Forums, the World Summit on Sustainable Development, and the Commission on Sustainable Development.



WL | delft hydraulics

WL Delft Hydraulics

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WL | Delft Hydraulics is an independent research institute and specialist consultancy located in the Netherlands. For more than 75 years, the Institute has provided clients, at home and abroad, with expert advice and technical assistance on water-related issues. The staff of 350 qualified and committed professionals combine in-depth knowledge of critical details with an across-the-board perspective. Clients include government authorities, multilateral agencies, consulting engineers, contractors and industry.

With a sound understanding of the processes involved and the appropriate facilities, all water systems can be simulated - numerically, experimentally, or by a combination of the two. WL | Delft Hydraulics is well-known for both its experimental facilities and its software, most of which have been developed and validated in-house.

A knowledge centre of international standing has a responsibility to share its expertise: technology transfer is an inherent part of WL | Delft Hydraulics' approach. Related activities are carried out around the world, and include a variety of courses and seminars, and project-based, on-the-job training.

All of the Institute's research and specialist consultancy activities are carried out under a quality system in accordance with International Standard ISO-9001.

WL | Delft Hydraulics, the independent institute for research and specialist consultancy in hydraulic engineering and water management.

For more information: www.wldelft.nl



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A modern university with a rich tradition

Established on 8th January 1842 by King Willem II, TU Delft has a rich tradition reaching back more than 160 years. The university initially focused on civil engineering, but more and more engineering disciplines have gradually appeared on the academic programme. As of today, TU Delft has eight faculties offering 15 BSc and 29 MSc programmes. With approximately 13,000 students and an academic staff of 2,100 (including 200 professors), TU Delft is the largest and most comprehensive university of engineering sciences in the Netherlands.

TU Delft facilities

The eight faculties are given below. Visit the websites for further details and contact information:

- Aerospace Engineering (www.lr.tudelft.nl)
- Applied Sciences (www.tnw.tudelft.nl)
- Architecture (www.bk.tudelft.nl)
- Civil Engineering and Geosciences (www.citg.tudelft.nl)
- Electrical Engineering, Mathematics and Computer Science (www.ewi.tudelft.nl)
- Industrial Design Engineering (www.io.tudelft.nl)
- Mechanical, Maritime and Materials Engineering (www.3me.tudelft.nl)
- Technology, Policy and Management (www.tbm.tudelft.nl)

Excellent research and education standards

TU Delft is a state university that conducts cutting-edge research and provides education to the highest standard. In addition to national accreditation, many of TU Delft's educational programmes have been acknowledged by international organisations such as the American Board of Engineering & Technology (ABET).

TU Delft's research portfolio is clustered around 13 interdisciplinary technological themes, including Computational Science and Engineering, Mechatronics and Microsystems, Nanotechnology, Sustainable Industrial Processes and Water: Water Works, Water Management and Water Quality. Research is conducted within the faculties, research institutes, and research schools. Each year, the University's cumulative research results in an average of 185 PhD dissertations, and over 4,000 publications in scientific journals. Research and education are interrelated. This is most apparent in the MSc programmes, which are research-driven and aim to challenge students to make their own contributions.



Partner for progress

Kiwa Water Research

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Kiwa Water Research is a leading independent and objective international knowledge institute for water and related environmental aspects. Kiwa Water Research is owned by the Dutch water companies, with both bodies maintaining their knowledge infrastructure to meet their technical and scientific knowledge requirements. Kiwa Water Research develops knowledge and makes it accessible, and also provides and helps to implement innovative knowledge, knowledge services, and water technology. In addition to drinking water, the organisation focuses on water systems, industrial water, and waste water. Kiwa Water Research coordinates and conducts research as part of the Joint Research Programme of the Dutch Water Sector (BTO, for the Netherlands, Belgium, the

Dutch Antilles and Aruba) and for a range of other clients.

Kiwa Water Research operates in the international arena. It has a strong position in international networks and the EU, a prerequisite for maintaining Kiwa Water Research's position as an internationally-operating knowledge generator and knowledge broker. As a coordinator and participant, Kiwa Water Research is for instance involved in the Web-based European Knowledge Network on Water (WEKNOW), the Water Supply and Sanitation Technology Platform (WSSTP) and TECHNEAU, a five-year integrated project funded by the European Commission.



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GeoDelft

Founded in 1934, GeoDelft is one of the oldest and most renowned institutes involved with geotechnical engineering in the world. As a Grand Technological Institute (GTI), GeoDelft's role is to obtain, generate and disseminate geotechnical know-how. GeoDelft employs some 220 highly-qualified personnel from a wide range of disciplines, from civil engineering and physics to environmental science and geology.

Partner in risk management

The institute is an international leader in research and consultancy related to the behaviour of soft soils (sand, clay and peat); construction in, on, and using soil, and managing the geo-ecological consequences which arise. Subsoil-related uncertainties and risks repeatedly appear to be the key factors in civil engineering risk management. Control of these uncertainties makes GeoDelft the obvious risk management partner for all parties involved in the civil and environmental construction sector. To facilitate the risk management process, GeoDelft

recently introduced the concept of GeoQ into the geotechnical sector.

One of GeoDelft's key features is the unique combination of routine work, experience-based consultancy, and knowledge development. Integration of these three levels of operational activities is crucial to link practical experience, expert knowledge, and high-tech theoretical knowledge in a mutually-enhancing way.

GeoDelft works in close cooperation with customers and fellow institutes, both at home and abroad, translating new and specialist knowledge into socially relevant practical solutions.

For more information: www.geodelft.com



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TNO Infodesk

The Infodesk can be reached from 08.00 until 17.30 hrs at +31 15 2696969. After office hours, you will be put through to our answering service. If you leave your name and phone number, we will contact you the following working day.

TNO Built Environment and Geosciences

The spatial organisation and use of space in the Netherlands are key elements of the core area of work of TNO Built Environment and Geosciences.

The government and those business sectors whose work in particular directly involves sustainable organisation need knowledge in this area. Topical issues include use of the subsurface, mobility, infrastructure, renewal of inner cities, the formation of a network between cities and the subsequent administrative implications, as well as the development of regions (partly in a European context). Renewable energy and energy efficiency are also themes that play a role in this core area.

Spearheads in TNO's knowledge include: Policy and Planning, Geosciences, Sustainable Transport Systems, Infrastructure and Organisation, Ecology and Buildings, and Building Structures. TNO can contribute to improved policy development and decision-making processes related to the integra-

tion of space, infrastructure, and sustainable development. Moreover, TNO is a partner in projects involved with infrastructure and construction innovation, as well as those related to sustainable innovation and local systems. TNO also contributes to innovative logistical systems and transport and traffic systems. This work involves providing the business sector with logistical solutions in order to achieve savings and optimisation.





Deltares

A new Dutch institute for national and international delta issues

In 2007, the Netherlands will benefit from a new independent institute for applied research and specialist advice. Together with specialist service sections (DWW, RIKZ and RIZA) at the Department of Transport, Public Works and Water Management (Rijkswaterstaat), three of Delft Cluster's six partners (WL|Delft Hydraulics, GeoDelft, and parts of TNO Built Environment and Geosciences) are forming the Deltares Institute. The Deltares Institute will employ 800 people.

The Institute is a unique combination of knowledge and experience in the field of water, soil, and the subsurface. It takes the lead in the development, distribution and application of knowledge for durable design, management, and supervision of vulnerable delta areas.

Deltares works on behalf of the Dutch government, provinces and water boards, for international governments and market parties. As a specialist advisor, Deltares supports Dutch engineering, including construction and dredging companies.

Delta technology

In deltas, water and the subsurface cannot be considered individually. Any interventions related to water and the subsurface will influence one another. Delta management is also becoming increasingly complex. Not only from a technical point of view as we increasingly use areas that are difficult for habitation and construction more intensively, but because fluctuations in water levels are increasing, the ground is subsiding, and sea levels are

rising. This complexity can also be interpreted in social terms: we accept fewer risks.

As a result, we do not simply assess projects on technical criteria, but on economic, social and ecological criteria as well. This calls for an integrated and innovative strategy for delta problems, with the aim of finding better solutions. A strategy that combines scientific and non-scientific disciplines. Deltares calls this strategy 'Delta technology'.

'Enabling Delta Life'

Nowadays, 75% of the world's population lives, works, and spends their leisure time in a delta. Delta areas are characterised by fertile ground and a strategic position adjoining oceans and waterways, as well as by rising sea levels and a subsurface that is constantly becoming weaker. Scarce ground that is needed to provide more space for the world's expanding population. There is therefore a growing worldwide demand for knowledge and expertise to ensure that life in deltas is sustainable.

This intrinsic involvement is expressed in Deltares' mission - 'Enabling Delta Life.'

Combating water

Throughout the centuries, the Dutch have learnt how to deal with water and the subsurface, and how to protect against water in densely-populated delta areas. This experience means that Dutch experts in the field of water management, hydraulic engineering and soft soils are much sought after.

We are constantly searching for sustainable, safe, and affordable solutions. After all, it is these solutions that impact the overall quality of life in deltas.

Background of the participating institutes

WL | Delft Hydraulics is actively involved with water-related issues worldwide, whilst GeoDelft focuses on issues in the field of geo-engineering. The TNO business unit Subsurface and Groundwater carries out innovative work aimed at building neighbourhoods in a sustainable way, infrastructure, and the subsurface. The Department of Transport, Public Works and Water Management (Rijkswaterstaat) is involved with providing flood protection and adequate supplies of clean water for all users. The Rijkswaterstaat has transferred knowledge development for delta issues to Deltares.

For more information: www.deltares.nl

Key areas of Deltares

Building for space

- Construction and soft soils

Living with water

- Water safety and design
- Water management and use
- Healthy water systems
- Hydraulics Engineering

Environmental surroundings

- Subsurface, water and space
- Healthy soil systems and materials

Systems, processes, materials

- Measuring, modelling, predicting, providing information
- Product innovation

Knowledge as power

- Experimental observatories and test sites
- Strengthening the knowledge base

Facilities as power

- Physical laboratory facilities (experimental analyses)
- Software facilities

Colophon

Delft Cluster Magazine is Delft Cluster's international corporate magazine, distributed to Delft Cluster participants, the relevant (sector) parties, governments, foreign information institutes, and educational establishments. Delft Cluster Magazine is free of charge; our intention is to contribute to disseminating information and stimulating a social dialogue about our vulnerable delta.

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Delft Cluster Magazine

Our vulnerable delta: a scientific approach

