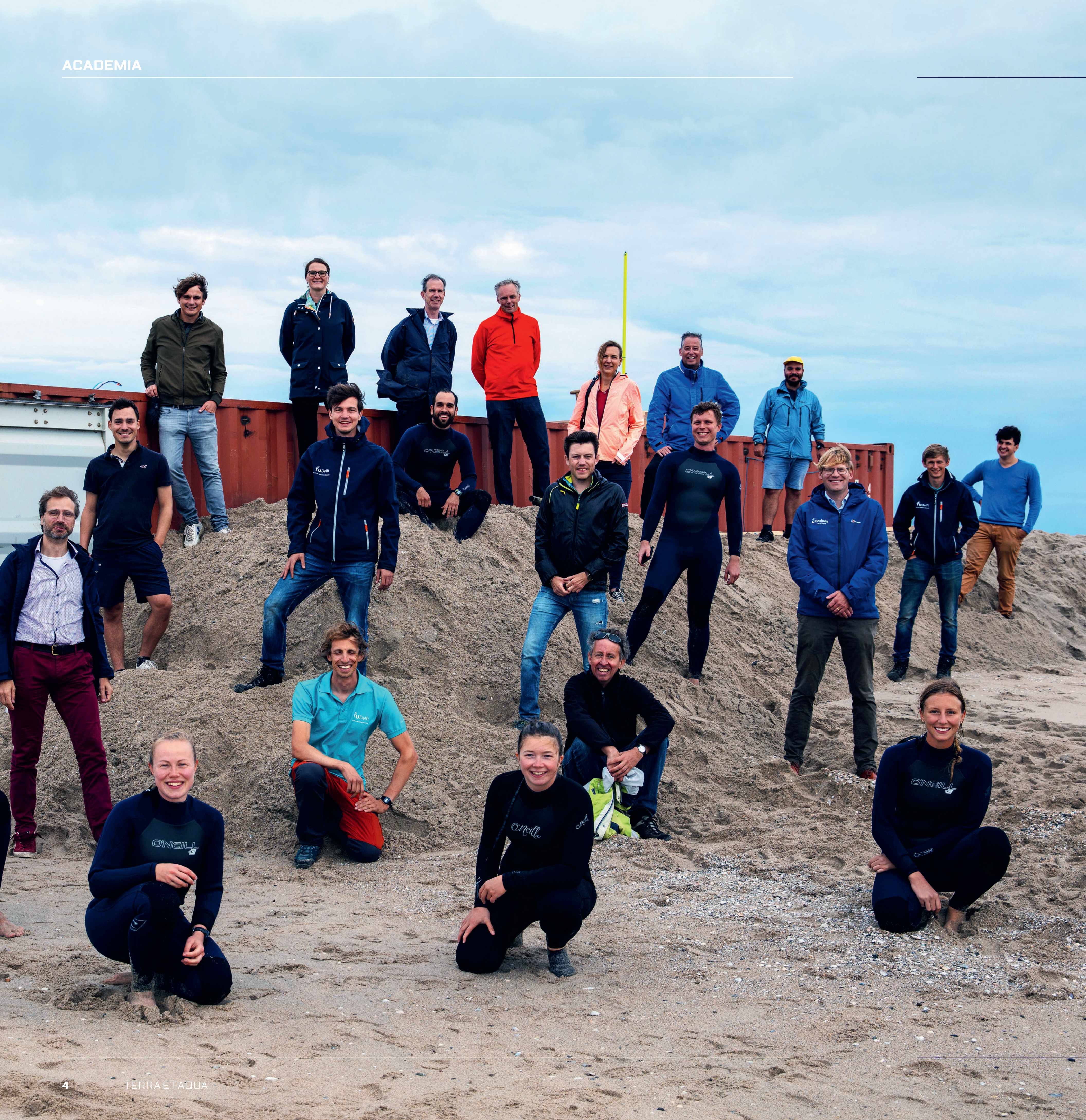

SHAPING THE ENGINEERS OF TOMORROW

During his distinguished career as professor of Coastal Engineering at Delft University of Technology (TU Delft), Kees d'Angremond served as head of Hydraulic and Offshore Engineering, chair of the department of Hydraulic and Geotechnical Engineering, and dean of the faculty of Civil Engineering from 1989 to 2001. Now professor emeritus, he still works as an advisor and independent consultant. We invited Kees to a conversation with Stefan Aarninkhof, professor of Coastal Engineering and chair of the department of Hydraulic Engineering at TU Delft, to talk about their careers in the dredging industry and the role of academia in the industry today.

The path into academia

Kees graduated as a civil engineer from Delft University of Technology in 1963. He worked in the lab of Delft Hydraulics (now Deltares) for two years before being assigned to a project in India, even though as he admits he was far too junior to do the job. Upon his return, he become head of Delft Hydraulics' wind-wave flume where all the breakwaters are investigated.

Around 1970, Eco Bijker, who was the deputy head of the Delft Hydraulics' laboratory, was appointed as the first professor in coastal engineering at Delft University of Technology (TU Delft). Eco was also lecturer at the IHE Delft Institute for Water Education (IHE Delft) at the international course in Hydraulic Engineering for engineers from developing countries. However, there were people from all over the world – from Australia, the USA, Canada, India, Latin America and Africa. Eco had no extra time and so he asked Kees to take over lectures at IHE Delft on breakwater design. There Kees met students from all over the world and expanded his network immensely.

In those early days, the way the Netherlands facilitated these students was insufficient. Adequate housing was not provided and most students didn't have extra money for what was already at that time expensive student rooms, or they were living in less than ideal conditions, for example, five students to one room. Since Kees knew that the conditions were so poor, once a year he invited the whole class of 30 students to dinner at his home and his wife mobilised their children to help with all the cooking. These gatherings allowed him to experience the cultural differences between the many students, knowledge that would serve him well throughout his career. Many of his professional contacts in his working life were actually once his students and also became friends for life.

Kees benefitted tremendously from these early student contacts. In later years, they would meet each other at various conferences such as PIANC. Within the COPEDEC (Conference on Coastal and Port Engineering in Developing Countries) society, there were numerous students who joined those yearly gatherings. Kees fondly recalls, "Often at a conference, people would come up to me and say 'Kees, do you remember I played hockey in your garden with your kids and that we almost broke a window?'"

Key projects: The Delta Plan

Indirectly Kees also benefitted from early events in the 20th century. The IJssel Lake project with the closure of the Zuiderzee (Southern Sea) and the development of different polders, the repair of the dykes in Walcheren after the destruction in the Second World War, and then the devastating floods of 1953 after which everything came together in the form of the Delta Plan.
His professional generation had the good fortune that they grew up with the Delta project, which was really designed as one project; starting with the smallest items and ending up with the closure of the Eastern Schelt. "That was the way it was designed," Kees explains. "The engineers involved in the design wanted to learn during the construction and a great deal of experience was gained as a result.

The IJssel Lake project initiated the founding of Delft Hydraulics in 1927 and facilitated the design of the Afsluitdijk – a major dam and causeway in the Netherlands that closed off the Zuiderzee (a shallow bay of the North Sea), with all the tidal consequences. At the time, it was a major enabler for hydraulic research and formed a strong network for cooperation. As was the Netherlands Centre for Coastal Research (NCK), which over the last 30 years has been a key network for scientific collaboration between different universities, Deltares and the government. Stefan explains, "This is in fact where research on the interaction between hydraulics, morphology and ecology was born with a few pioneers in the field who started developing new research lines. It's actually where the basis for Building with the Nature comes from. Together of course with the many initiatives taken by Ronald Waterman, who promoted the implementation of Building with Nature solutions on real-world projects in The Netherlands as well many other locations worldwide."

FIGURE 1
Closing a gate of the Eastern Scheldt Storm Surge Barrier.

There was a sense of urgency and cooperation was key to making the Eastern Scheldt Storm Surge Barrier a success.

It's true to say Kees found it a marvellous time in his career. "It was a period when all the barriers and the borders between contractors, government and consultants completely disappeared. There was a sense of urgency and cooperation was key to making the Eastern Scheldt Storm Surge Barrier a success." It's a point that Stefan shares regards the major challenge the world is facing today. "We need that same spirit and sense of urgency when it comes to climate adaptation," he concurs. "Only together can we face this challenge and deal with the future risks."

Introduction into the dredging industry

After the flood disaster in 1953, the Dutch government set about implementing the Delta Plan to safeguard the province of Zeeland from another flood. At that time, ir. P.Ph. Jansen, the director of the Delta Services at the Department of Waterways and Public Works (*Rijkswaterstaat*), was afraid that the capacity of the dredgers was not sufficient to cope with the volumes involved with the closure of the Eastern Scheldt. Because at that time, it was still the plan to close the Eastern Scheldt completely.

Jansen realised that a production of 1,000 m^3 of sand per hour was a hell of a quantity for a dredger. However, he was of the opinion that the capacity was insufficient to handle the job at hand and he urged the larger companies to take part in a joint research project.
This research had to be done by an independent institute and the task came to Delft Hydraulics. Kees was selected to negotiate the project management and Jansen selected companies that had research capacity and which would really contribute to the research. Jansen wanted only those companies that could incorporate the results of research in their own companies. In the end, there were six companies of which IHC was one. At a certain point, however, the dredging companies rejected IHC as part of this research consortium. Contractors had invested heavily in the research that could bring them a competitive advantage and they wanted to keep that knowledge in the Netherlands, not export it to foreign contractors as IHC was doing. *Rijkswaterstaat*, one of the paying partners, along with the other partners then agreed to 100% secrecy concerning the research results. And there was another rule – that it should be only pre-competitive research.

It was a tremendous pleasure for Kees to work not only as a project manager on behalf of Delft Hydraulics, but also as secretary of the steering committee that consisted of all the board members of the large dredging companies. He facilitated the negotiations between the group of contractors and Delta Hydraulics and in this way, completely from the research side, Kees entered the world of dredging.

A couple of years after the India project, a second project in Burma came along and Delft Hydraulics asked him again. For a second time Kees agreed. Every two months, he would leave his family in Rangoon and travel from Burma back to Delft for a week to hold a meeting with the technical management of the dredging companies to keep the research project running. In that period, Age Hoekstra, the successor to Eco Bijker at Delft Hydraulics, had joined Adriaan Volker Dredging company and asked Kees to come work for Volker. At a certain moment, Age visited Kees in Rangoon to persuade him and impressed by this enthusiasm, Kees signed a contract with Adriaan Volker. And so Kees' career in the dredging industry began.

Career similarities

Stefan's introduction to the dredging industry was somewhat similar to Kees. In fact, there are many similarities in how both their careers evolved. Stefan had completed a PhD thesis at Delft University of Technology on the video imaging of coastal zones and had been at Delft Hydraulics for 9 years when he became involved in a large-scale research project for the industry-sponsored foundation for dredging-related strategic research , Stichting Speurwerk Baggertechniek (SSB). Then in 2005, the dredging industry was looking for a project manager to lead a series of large-scale field experiments on dredging-induced turbidity, as part of the SSB-TASS programme. People, such as Cees van Rhee, Wim Rosenbrand and Wouter Dirks were heavily involved in this research. At the time, the generation of dredging plumes was one of the major uncertainties on dredging projects, as an increase in turbidity levels is associated with increased light attenuation in the water column and possible smothering of sensitive ecosystems.

To avoid negative impacts, dredging projects often came with strong environmental restrictions, however the scientific basis for these restrictions was not always very strong. First because dredging-induced turbidity plumes were hard to predict and second because limited understanding of the actual impact to sensitive ecosystems at the time. The TASS programme delivered a series of large-scale field experiments around dredging activities in Bremerhafen (Germany), Rotterdam (The Netherlands) and in Western Australia. Moreover, a model was developed (together with HR Wallingford, UK) to enable improved assessment of dredging-induced turbidity both near the dredging works as well as the far-field plume dispersion.
The programme had major impact in the field, not least because all outcomes were shared with the dredging, research and consultant community via conferences, training courses and in literature.

We need that same spirit and sense of urgency when it comes to climate adaptation.

After a year in this role of project manager, Stefan made the move to Boskalis to join their in-house engineering department Hydronamic. One of the major projects he was involved in was the Khalifa Port and Coastal Zone project (UAE), a large-scale port development scheme in a sensitive environment at the Abu Dhabi coastline.
The work involved, amongst others, the set-up of an extensive 24/7 environmental monitoring programme and a system for operational plume predictions for different phases of the construction works.
An excellent example of a project where all state-of-the-art knowledge on turbidity monitoring, model simulations and adaptive planning came together.

Along with these valuable lessons from practice, the EcoShape Building with Nature programme was established as a strategic sector initiative to develop and implement novel approaches for marine infrastructure

FIGURE 2
Researchers from various universities and knowledge institutes have been closely following the development of the Sand Motor, off the coast near The Hague, since its construction in 2011.

design, based on the principles of Building with Nature. "This development was very close to my heart," explains Stefan, "as it foresaw truly multidisciplinary cooperation based on full-scale pilot experiments in the field. I was therefore very keen to be involved." An opportunity that later transpired when Stefan was first appointed as manager of the case Holland Coast (centred on the famous Sand Motor experiment) and afterwards as programme manager of the overall programme.

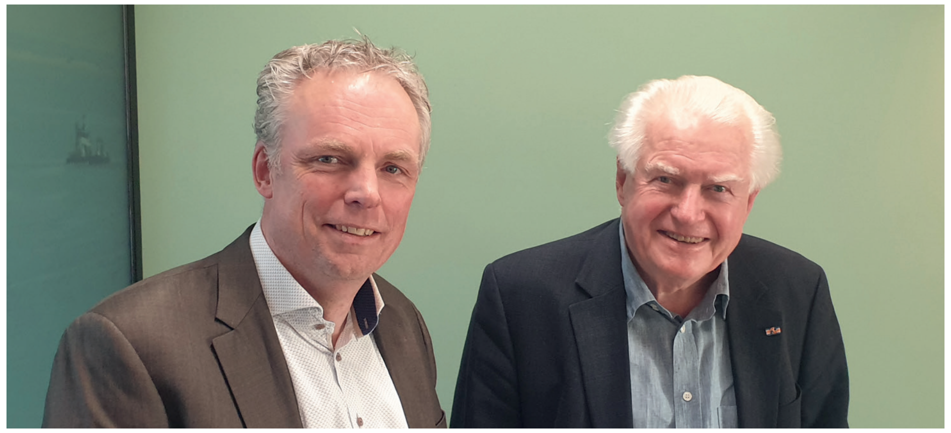

FIGURE 3
Stefan Aarninkhof (left) and Kees d'Angremond.

Knowledge of the industry

Starting in the industry, Kees had 12 years' experience in hydraulic research and research management but no real practical hands-on experience in the dredging world. He knew the science behind the practice but nothing about the reality of dredging. Therefore, he started in the engineering department of Adriaan Volker. The company that still exists today as AVECO (Adriaan Volker Engineering Consultants).

The first project Kees worked on was a study on an issue he found very alarming – the pollution of dredged material. NGOs were claiming that dredgers were spoiling the environment. Whereas the industry said, "We are not spoiling the environment, we're just handling the material that is contaminated by others." The image of the dredging industry was not very positive in those early days. "There was even a visual hindrance in that all the dredgers of the time were grey," Kees explains. "And there were two shades – Volker grey and Boskalis grey. We used to joke that when you walked through Sliedrecht you could tell who worked for which company purely by the colour of the shed in their back garden."

It is fair to say the reason for dredging's less than positive image was due to lack of knowledge – not knowing what dredging was really about and what the real impact was on the environment. Stefan agrees it played a major role; "The industry didn't know, the public didn't know and the government didn't know; environmental limits were simply copied from one site to another. We simply didn't have better knowledge back then. This has certainly changed over time as a result of the Foundation for Research on Dredging Technique (*Stichting Speurwerk Baggertechniek* (SSB)), a strategic research platform of the Dutch dredging industry." It is about understanding what was happening. "In those days," Kees elaborates, "when a budget estimate for works had to be made, the project engineer would simply take a clay sample and would chew on it and say, well this is difficult clay. And on that basis the price was determined!"

> You're not simply preparing students for scientific work. You're preparing engineers for a life in the real world.

According to Stefan, the SSB research was also an enabler for scale increase. The big projects in Singapore and Hong Kong would never have been possible without the work of SSB. It goes even further back. All the ports in the Middle East where rock dredging was taking place would also not have been possible without the fundamental research on rock cutting and cutter suction dredgers. In the beginning, dredging companies were very secretive about sharing their research and developments in vessel design and production innovations. This too has changed. Companies realised that closing themselves off from the rest of the world was not wise. If you want to stay a frontrunner in competition, you have to develop your knowledge and technological standards. The moment you stop developing, your competitors will take over.

Early research days

In the mid-70s, Kees was involved in all kinds of research projects. Volker worked with the municipality of Rotterdam carrying out research around the city. Many areas had been reclaimed with contaminated dredged material from the port of Rotterdam and were in fact polluted. Together with the port of Rotterdam, Volker did a joint study with the United States Corps of Engineers (USACE) to find a solution to the problem. First, they had to establish how dangerous the chemicals attached to the silt particles were. Did they enter into foods that were grown in urban gardens in the reclaimed areas? And how thick would you need to cover the polluted soil to eliminate those dangers. Through that project, Kees came to know many colleagues in the US and the Corps. The fact that he is still a member of ASCE-COPRI indicates the importance of that time in his career. Looking at the dredging process today in the port of Rotterdam, it no longer has to do with contaminated sediments. Due to all kind of measures, the water quality has improved tremendously and all the sediment that settles in our estuaries is no longer polluted, which is a great victory.

As already mentioned, research on specific equipment was necessary. There was no specialised equipment at that time, it had to be invented and developed especially concerning the reduction of turbidity. An example is the development of a diffuser to reduce the turbidity when discharging material in a deep pit. For the same purpose, many companies changed the design of the overflow of the trailing suction hopper dredgers so that the turbidity remained close to the bottom.

The attention was not restricted to the disposal of material, it was also attempted to reduce the spill of material at the actual digging location like the cutter of a CSD, the bucket of a BLD and the draghead of a TSHD. The research of the dredging industry together with supply chain partners and research institutes has resulted in several very effective measures such as the green valve system for trailing suction hoppers, which reduces turbidity caused by overflow during the dredging process. The knowledge collected by environmental monitoring was evident in decisions on dredging around coral reefs. And the development of predictive models and simulation tools contributed to knowledge-based decisions.

A more formal approach to training

30 years ago, dredging was considered perhaps more an art than a science. Later came the realisation that a more formal approach to training than practical experience was desirable. When Kees was appointed professor at Delft University of Technology, the only education in the field of dredging was in the faculty of mechanical engineering and core of that course was the construction of dredging equipment. It was not aimed at working with dredgers. Whilst some of the professors tried to introduce the subject, there was hardly a civil engineering student who studied dredging.

Kees was not happy with what the students were taught. When he took over the lectures of Eco Bijker on maintenance of coastlines, Kees saw his chance and started lecturing on the role of dredging. He taught students the theoretical background, how the production process works, as well as how you cost estimate a project and all the factors involved.

"I taught students how a trailing suction hopper dredger works and what impacts the dredging process. I explained how to calculate the cost of a project taking into account the production cycle time, mobilisation, installation and dismantling costs, etc. And most important, factoring in the risk as there are many uncertainties that come into play. What is the risk for the contractor and for the employer? And last but not least, calculating the profit margin. All of which gives you the price to the client." In a later stage, Kees got support from the industry through the *Dutch Association of Dredging Contractors* that made a dedicated part-time teaching role possible.

"We give exactly that same class today," says Stefan. "It's the starting point that provides students with the basic scenario, whereby you can only optimise based on the requirement to maximise production rates. And then we build out with additional requirements, including environmental requirements. If one of the requirements is to take care of a coral reef, located two kilometres from the site, then you have a simple model to estimate how the suspended sediment concentration decreases with increasing distance from the dredging activities. Then additional requirements come into play such as limited emissions allowed, which becomes increasingly important. There are, of course also functional requirements. If you have both good and poor quality sediment, but you need good quality sediment at the location where you're going to construct a port for instance, this also needs to be considered." It's interesting to hear how both professors taught the same class. Today, students receive lectures on both dredging equipment, taught by the Mechanical Engineering department headed up by Cees van Rhee, as well as the more civil engineering elements that Stefan teaches together with Mark van Koningsveld, as part of the Hydraulic Engineering track at the faculty of Civil Engineering and Geosciences.

Teaching the commercial aspects of the industry

According to Kees, it is a responsibility of the university that students are taught the commercial aspects of the dredging industry. He explains, "You're not simply preparing students for scientific work. You're preparing engineers for a life in the real world. Whether it's working for the government, a company, as a contractor or a consultant, students have to realise it's part of their education. You have to realise that everything costs money otherwise you cannot be a proper engineer."

In broadening the conversation, Stefan explains, "This is one element where we want to educate students. At the end of the day, you want to apply your technical knowledge and expertise in a real-world context. And the commercial consideration is one element of that context. You want to employ an engineer who knows how to apply their knowledge to the benefit of something bigger. The environmental aspect is another element. As an engineer, you also need to be able to communicate to an ecologist for instance and to be aware of the impact of dredging activities to the outside world. You don't need to become an ecologist, but you need to be able to interface with people in this and other specialties."

> You have to teach students how to look at a project from so many different perspectives and the local culture is one of them.

Transition from theoretical to practical knowledge

Students today are extremely enthusiastic when they have the opportunity to deploy their technological expertise to the benefit of real-world projects; designing and building interventions to the benefit of society, protecting against flooding for example, and creating opportunities for nature. That's a big driver nowadays according to Stefan. "Off course, there are still those who really go for the big equipment and big projects but the majority of students have a much more altruistic attitude."

From that perspective, the dredging industry has really transformed, starting from the strong core that it has. At the end of the day, dredging companies have successfully built all kinds of complex projects at challenging locations across the world. "When dredgers come in," continues Stefan, "it generally means that there is nothing there. Only a beach and an ocean and there you go. That's still the case, but at the same time, the industry wants to work in a responsible way. That's where high-end dredging companies nowadays are making a difference. And that's something students in particular want to be associated with." Students get the whole story by being shown the entire picture of what the dredging industry looks like and entails. "These links between the industry and all universities, not only Delft University of Technology, are so very important," says Stefan. According to Kees, it goes deep into the philosophy about the role of a university. "You want to employ an engineer who has had an academic education,

FIGURE 4
Kees d'Angremond (front row centre) and Stefan Aarninkhof (directly above) on a field study trip to Chek Lap Kok, Hong Kong (1994).

but you still expect that they also have the practical experience and know how to carry out the job at hand."

A good engineer has an international orientation

Engineers today have to have a broad skill set in that they have to deal with the ecological considerations involved in a project, as well as legal, social and sustainability issues. This is one point Kees is very adamant about. "You have to teach students how to look at a challenge or a project from so many different perspectives and the local culture is one of them. I think you can compare engineers to doctors in the same way they have to have a completely applied medical education, which is aimed at not only advancing science, but also being able to do your job in the correct manner with patients from different cultures, with different habits and attitudes."

> Field trips give students an invaluable insight into what's expected of them in the industry.

From Stefan's perspective, it's not only dredging engineers that need this orientation, but engineers in general. "If you look at people in the Ministry of Infrastructure and Water Management for instance they also have a diversified background and not only an engineering one. The way Delft University of Technology teaches students makes it distinctive. They are not only focussed on educating engineers and helping them to understand the basics and all the theory, but at the same time students are being taught how to effectively operate in this broader community and to be aware of the impacts of engineering interventions."

In today's landscape, Kees sees this as a major challenge for universities. "On the one hand civil engineers need in depth theoretical knowledge and on the other a wide variety of capabilities to keep costs in hand and make a broad, integral evaluation of project effects. The challenge is how to educate such engineers. While universities seemed to have a bias towards the valuation of academic skills, that situation is changing, as Stefan explains: "Over the last few years, the appreciation of engineering and design has been growing again at university. Engineering and designs skills are increasingly recognised as key competences of engineers, along with scientific skills and personal leadership to solve complex problems across the world." In line with this, universities and researchers are no longer evaluated solely on the basis of an indicator such as the number of publications, but on a broader range of qualities and impacts – either in fundamental science, or benefits for society.

The university aims to bring those people together and create an open atmosphere where people from industry, from the outside world, can collaborate. Stefan elaborates, "As an educational institute, Delft University of Technology can say something is important but it's much more convincing if the industry or the government says it's the right way forward and gives it an agenda or a perspective to which the university can contribute."

Is practical experience an essential element in academia?

For Stefan, it's a question of balance. "Of course, it has its advantages as you bring hands-on expertise, which comes from having knowledge and experience in the industry. But scientists are also needed. And what about a feeling for policy and good people managers, they are also indispensable. It's all about having a balance. That's something that should be valued." Universities are made up of a group of extremely bright individuals, each with unique skills and talents. Academics by nature are quite competitive, as they need to develop their research profile and win projects and research grants. "However, as far as teamwork goes, they can probably learn from dredging industry, where teamwork is common practice and a prerequisite for successful projects."

"That's something we're trying to develop again, more multidisciplinary projects," Stefan adds. "It is not only important to have all the disciplines on board but they have to collaborate, which is of utmost importance. You need the right people, both in terms of disciplines, but also attitudes." It's something Stefan's department is working on and he takes responsibility of. "It comes down to leadership. Where do you see yourself individually or as a group? How can you develop initiatives with the industry and make it happen? That's the long-term agenda, and for the industry I think that it's important."

The importance of field studies

One of the benefits of Stefan's role is seeing students get inspired. For instance, during study tours to major projects abroad. The student association for Hydraulic Engineering (*Waterbouwdispuut*) is very active in organising such trips and in 2019 travelled to Brazil. Back in 1994, as a student, Stefan was personally involved in the organisation of the tour to Taiwan, Hong Kong and China, together with Tim Helbo, Ronald Roosjen and Janet Kroes. One of the highlights was the visit to the famous Chek Lap Kok airport that was under construction (Figure 4). Kees joined this tour as a supervisor, spending nearly three weeks with the students, sharing his vast experience of working in the Far East. This trip, along with so many others, provide an incredible experience. They not only give students a unique opportunity to get an inside view of international marine infrastructure projects but also invaluable insight into what's expected of them in the industry. "As a contractor, no matter how scientific you are or how many doctoral degrees you have, you have to get your hands dirty to gain credibility within an organisation," explains Stefan. "It's an important characteristic of the industry. As a young employee or as a mid-term career employee, you need to be open to that."

It's one of the reasons why Stefan is keen to maintain the course on field experiments, under the supervision of Matthieu de Schipper. For example, students get to carry out field experiments in the near shore zone where the waves are breaking and you can see the sediments being transported. As Stefan explains, "The course is co-funded by the Dutch Association of Dredging Contractors (*Vereniging van Waterbouwers*), as they find it important to be able to hire students and young engineers who are experienced with the forces of nature."

> No matter how many doctoral degrees you have, you have to get your hands dirty to gain credibility within an organisation.

Real-time monitoring data can also play a role in building up a good and open working relationship with the client. Such data are usually collected as part of large-scale construction projects, for instance, to verify if environmental limit levels are being met. By sharing such data with the client (or even making it publicly available), the contractor gains confidence in the work methods applied and the management of its dredging

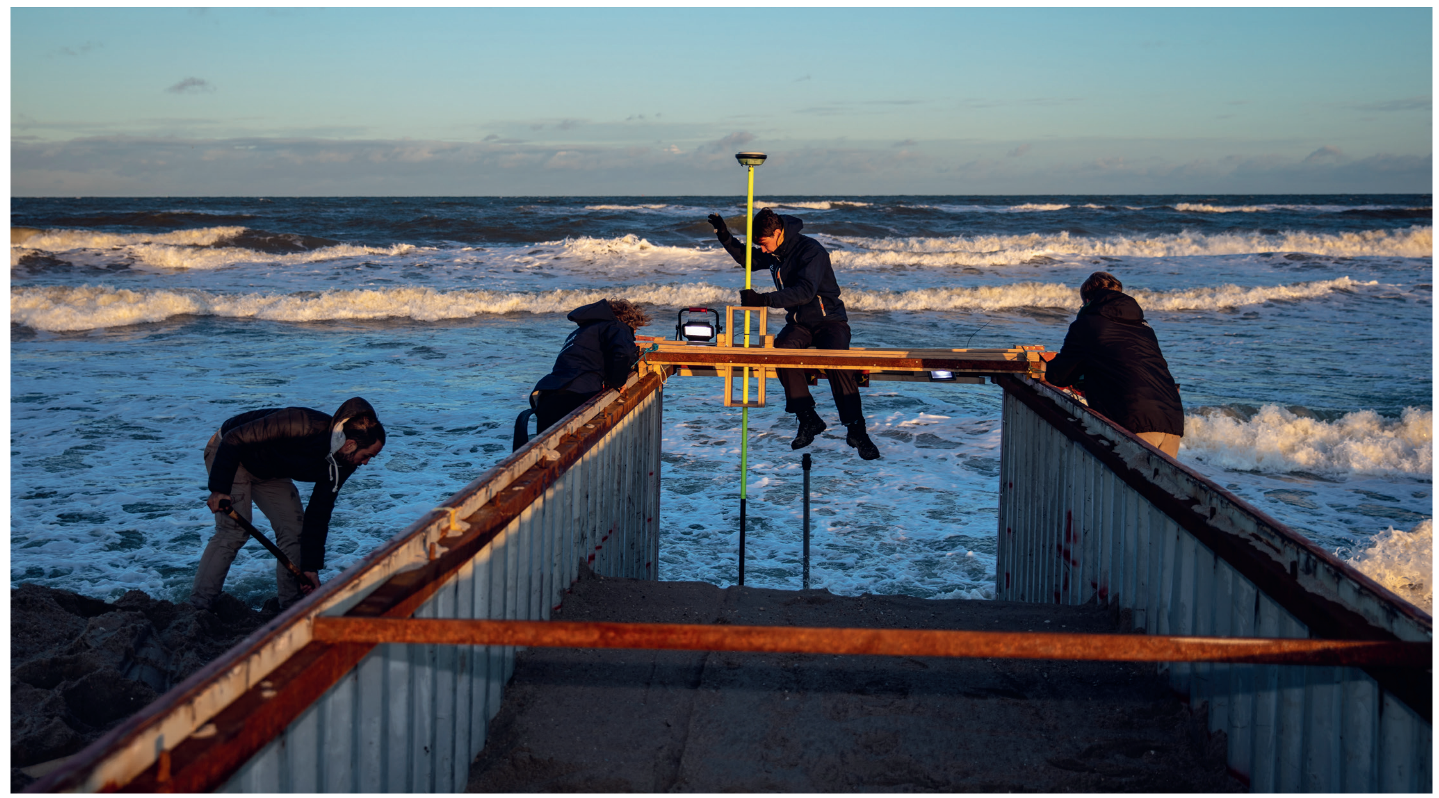

FIGURE 5
Students from Delft University of Technology battling the forces of nature during a prototype dune erosion experiment in a container at the Sand Motor (2020).

FIGURE 6

Kees d'Angremond advising on the reclamation methods in Pulau Tekong, Singapore.

operations. A sharp contrast to the days when a contractor would sit on the data to keep the competitive edge for the next project. Stefan confirms, "Of course, it took time to move away from that initial mindset but I think the dredging industry has matured in that sense. How companies communicate to the public has seen a big turnaround. Open communication proved to be a key enabler for the completion of the Port Phillip Bay channel deepening project in Melbourne; sharing of data to inform both stakeholders and the public resulted in turning it into a successful project."

Can academia play a role in sustainable infrastructure?

Dredging companies today have to convince clients and consultants that complex projects should be done in a sustainable way. You need to get all your stakeholders on board from the very beginning, carry out ecosystems services assessment, establish what is the impact your project has on all this and inventorise all the externalities to see how sustainable a project really is. "This is where science and knowledge development is an excellent starting point," comments Stefan. "You have to start building these relationships because knowledge development in itself offers no commercial interest. However, it helps in building trust, not only amongst the companies you work with, but also research institutes, ecologists and NGOs."

Today, NGOs are getting involved at the beginning of a project and seeing the benefits of working that way rather than simply opposing development proposals. The Marker Wadden project is an excellent example of a cooperation between the industry, *Rijkswaterstaat*, *Natuurmonumenten* (Association of Nature Monuments), as well as universities involved nowadays.

There are many more examples – the Sand Motor is a prime example, where the World Nature Fund was involved upfront in order to help initiate and develop the project.

What's inspirational about the DELTA21 idea is building something at the seaward side of our country to solve a problem inland.

The need for a new Delta department

Today, sustainability is top of mind for all industries. For dredging companies that means the acceptance of working sustainably too. Even in the time of the Eastern Schelt closure there was a concern of the environmental impacts. When the Delta law was signed in parliament, the plan was that the Eastern Scheldt would be closed. Then due to pressure from NGOs and the local population, that decision was turned around. The main concern was the deterioration of the water quality in a stagnant Eastern Scheldt and the complete loss of the mussel and oyster culture near Yerseke. Work had already begun on closing the estuary, so the whole plan had to be changed and instead a Storm Surge Barrier needed to be designed and constructed. It was a massive undertaking. "The whole Delta Plan was aimed at learning towards the more difficult parts of the project," explains Kees. "Then all of a sudden the whole process of learning was changed because we had to build a completely different structure. The whole civil engineering world of the Netherlands was mobilised and was then working on one project for about 10 years and together we solved the issue. We need this same spirit to face the challenges of sea level rise today."

"I totally agree," adds Stefan. "Half of the Dutch and Belgian population live in flood-prone areas and it's a very real concern. When we have 10-metre sea level rise, which is possible in the far future, then people may consider moving further inland to the east. But in the meantime, we cannot sit still and do nothing. There are a lot of opportunities to mitigate the risk to ensure safe living in the low-lying parts of the country. Then there will be the need for hydraulic engineering along with the companies to build the solutions in both a good and sustainable way." According to Kees, we should start making engineering solutions. A new Delta department with dedicated engineers who are not only talking, but are really examining what are the consequences of certain measures. And it should not be limited to the Netherlands. The cooperation with other institutes, such as the US Army Corps of Engineers should be sought.

There is a great need for qualitative assessments, because the question is based far too much on "narratives". As Stefan explains, "At the very least, we should start making an assessment of what is known and what is happening in different scenarios, because the longevity of these large infrastructure interventions is not infinite – you design something to last for 50 or 100 years. Then you can use that assessment for a basis of decision making." One of the plans that is on the table is the DELTA21 idea; a future-proof solution for the south-western Delta, providing a solution for flood protection, energy storage and nature restoration. "What's inspirational about this idea is building something at the seaward side of our country to solve a problem inland. There's a lot of inspiration in this way of thinking. It's all about coming up with solutions and quantifying them, and not going by the 'narratives' or gut feelings. And that's where engineering comes into play." A sentiment fully embraced by Kees; "It needs to not only be dreamed about but it also needs to be calculated."

Greatest achievements

After a moment of contemplation, Kees smiles and says, "I'm most proud of the number of students I've taught during my time as a professor and that they all found their career path." He was a professor for 12 years so approx. 50 students per year, that's 600 graduates in total. "Most of them landed where they should and that's an achievement." He is also proud of his role in the early dredging research programme that he helped start and later his role in Singapore. After his retirement, he was invited by the Singapore Government to help them in a court case with Malaysia, concerning environmental problems. Together with colleagues, he supervised research studies by different labs and evaluated the results. They then made a proposal to the two countries and their recommendation was adopted by the negotiating politicians to settle the court case out of court.

For Stefan, his greatest achievement comes from his role in EcoShape and that he was able to make a difference, not only in the programme itself but also in the change of mindset that it invoked. As he explains, "An important element in the EcoShape network is spanning bridges – beyond the interest of individual parties or persons – to make sure that people come together and start collaborating. Also to develop mutual trust and at the end of the day to create better solutions. Marker Wadden is a nice example of that, but also the Hondsbossche and Pettemer Sea Dunes and the Prins Hendrikzanddijk project are great examples. By coincidence they are all in the Netherlands, but there are many around the world."

I'm most proud of the number of students I've taught during my time as a professor.

The research initiated in Indonesia is a prime example. "It's just incredible to think of all these dredging companies together with academics and NGOs working together on improving coastal protection in the poorest regions. The business case is still under development but at the end of the day, it's a crucial project for local communities. These are the examples that appeal nowadays to students; engineers who want to bring their sound engineering knowledge into practice in this new environment. It therefore helps greatly if they have seen the hydraulic world from different sides."

Plans for the future

For Kees, his sights are set on the coming few years. As a consequence of his role in the court case in Singapore, he was asked by the Singapore government to assist them in designing some of their land reclamation works. After many years of discussion, designing and debating, it was decided to build a polder in Pulau Tekong, Singapore. A project that he still supervises and one that he's very proud of.

Stefan has many plans for the future, including educating new generations of hydraulic engineers and promoting the concept of Building with Nature as a means to develop climate-resilient solutions. Nature-based solutions can offer excellent opportunities to deal with the uncertainties of climate change. The challenge is to demonstrate that they work, also in tropical environments such as Singapore. "It would be great," he says, "if a joint public-private innovation programme could be initiated that aims to gain experience with these solutions from living lab experiments, that translates this new knowledge into design guidance for future projects and establishes an education centre to raise the engineers of the future.