From Test to Practice

Inaugural Address of Jentsje van der Meer

UNESCO-IHE
Institute for Water Education

From test to practice

Inaugural Address of J.W. (Jentsje) van der Meer,
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at UNESCO-IHE, Institute for Water Education
in Delft, The Netherlands

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Dear chair, rector of UNESCO-IHE, professor Szöllösi-Nagi,
dear members of the governing board,
colleagues from the academic board,
professors from other universities, professors in the EurOtop author team,
colleagues from UNESCO-IHE, Deltares, Delft University of Technology, Rijkswaterstaat and other institutions and companies,
honoured guests, students, friends and family.
Ladies and gentlemen,

Introduction

Times change. If we place this event about fifteen years back in time, it would have been a farewell speech instead of an inaugural address. The 57-plus arrangement (de 57-plusregeling) was in place and I am in the category of 57-plus. Now one has to work at least till 67 and personally, if health permits, I would like to work a little longer. Anyway, that may be required as politicians seem to change the rules quite often and they show a tendency to increase the retirement age.

From test to practice. Titles of professorial speeches often reflect to some extend the character and/or working attitude of the person. The title shows that I am not a pure academic scientist, nor a pure consultant or designer. From the academic viewpoint, I am very much attracted to research, anxious to explore and try to understand the field of wave-structure-interaction, the field that will be the main topic for this afternoon. I like to develop physical explanations and new relations - if possible, relations useful in design. I like to initiate new developments, preferably in cooperation with my Dutch and foreign colleagues. But I also like to be involved in application, in advising the client in design and construction of coastal structures, or to find out what has happened if something has gone wrong. That is the practice.

Reasons to publish

An academic should publish. Till now there has never been an obligation "from above" for me to publish and write papers for journals. Writing papers during the first sixteen years of my career at Delft Hydraulics, now Deltares, was encouraged, but was not an obligation. You will understand that such an obligation does not exist at Infram, where I worked for ten years, and in my own company. But as half scientist and half consultant I always had, and still have, the drive to publish and present new results in a way that other people are able to use it. This attitude means that my focus was neither specifically on journal papers, which take a lot of your time before they actually get published, nor was it on publishing as much as possible.

A good example of this is what has been published on all our work on the wave overtopping and wave run-up simulators. A picture of the wave overtopping simulator was the attraction on the invitation for this event and we will come back to that later. Eight years of intensive development and construction of machines, testing the strength of real dikes under wave overtopping, learning a lot of these destructive tests and making guidelines. We spent around five million euro on this research and still we did not publish one paper in a journal. But it does not mean that we did not publish at all! The developments, research and results were important enough to spread around the world and since 2006, we always had a number of papers at coastal engineering and coastal structures conferences. The number of these papers in proceedings of conferences amounts to about twenty five. And everybody in the coastal engineering world knows about this topic, and that was our goal to achieve. It was not an academic approach and I understand very well that in my new position at UNESCO-IHE I have to change my attitude. To start with: there is a huge amount of material available on simulator work to be published in journals. It just has to be done.

From test to practice. Publications are the transition from test to practice. The results of research are offered to potential users to be used in practice. And although journal papers have never been my favourite, I have in total over 170 authored or co-authored papers, 24 of them are journal papers and 10 are chapters in books. In those publications are many formulae for design of coastal structures. And to make the step to practice, my experience is that the first application of such a formula is outside the validity range, or not meant for the structure considered. Sometimes, or probably often, the practice is much more complicated than a narrow piece of research. Later, I will come back to practice by giving some lessons learned in my career.

From architect to coastal engineer and professor

Have I always been attracted to coastal engineering? To be honest, the answer is no. Being raised at the borders of the Sneekermeer you would expect differently. But a farmer’s son had to help and work at the farm and there was hardly time for pleasure on the water.

From my childhood on, my focus was on building structures as a few of my great-uncles were carpenters. I got a bachelor’s degree in architecture, but it was clear that I was more a structural engineer than an architect and I went to Delft University for civil engineering, with final specialism concrete engineering. As a “dry” architect or engineer I had the attitude to leave the “wet” lectures out of my study. I never had any lecture from professor Bijker or professor Battjes.

Figure 1 The farm near the Sneekermeer.

Figure 2 Getting grass, handwork and horsepower.

A MSc-diploma in civil engineering means that you should be able to solve any engineering matter at a certain level and a change to another field within the civil engineering should not be problem. With this in mind I made the decision to start my career at Delft Hydraulics, the Voorst Laboratory in the Noordoostpolder. I was testing breakwaters - still structures although of a different kind. Different, unfamiliar loading conditions, different failure mechanisms, and hardly any guidelines for design, compared to structures like buildings, bridges, etc. An interesting field of research. I have never regretted my decision to change.

When do you become a professor? Often after proving that you are becoming an international expert in your world and are now ready for a next step to the highest academic position. This means relatively young, in the middle of your career. A professorial speech should then show that the new professor understands the scientific world he or she has to work in and gives research lines for the next twenty years. She or he has the challenge to improve the world, isn't it? The inaugural address of my colleague professor Bas Jonkman of a little more than one year ago, is a good example of this. It will be different in my case, first of all because officially I have only eight years to go before retirement. Secondly, I have worked for thirty three years in this field and have already influenced the coastal structures and ports community. This speech has not the main objective of showing you how the scientific world would benefit from research lines I think are necessary, although, of course, I will touch on this subject. Thirty three years of experience also means that I can show some interesting learning moments on the way from test to practice. I would like to do this in two ways: first by describing some developments in the coastal structures field in the past thirty years, and then by touching on some simulacra in this field.

Developments in the Field of Coastal Structures

The role of the European Union

The Netherlands, as a small and low-lying country, has always been acknowledged in the world for their knowledge on coastal engineering, flood protection (our many high dikes) and innovative structures like the Eastern Scheldt storm surge barrier. That is still the case, but the attitude and way of working with regard to research has changed since the beginning of the nineties, due to the European Union. Before that time every country had their own national research funds and many research institutes and universities worked on their own with some collaboration. In the United States that is still the case. Our national research funds came directly from the Rijkswaterstaat.

At the end of the eighties, the European Commission decided to make Europe stronger in research. The idea was simple, but was actually very effective. For a research project you were obliged to work together with other universities and institutes in Europe. In return the project was half funded by the European Commission on commercial rates for institutes and marginal costs for universities. By using national research funds as matching you easily got quite nice projects of between one and two million euro and with a limited numbers of partners.

At that time, institutes like Delft Hydraulics and HR Wallingford were competing with each other in the global market and there was no cooperation on research. Of course we knew our competitors at the other institutes, but we did't talk a lot to each other. And now we had to cooperate. I still remember the first meeting where we sat around the table, looking at each other and having in mind that we should not tell everything we knew. That uncomfortable feeling changed within one hour. We realized that we would do pre-competitive research and that colleagues around the table were working exactly on the same topics as you. You had a

Table 1 EU-projects on Coastal Structures

MAST G6S Coastal Structures	MAST-contract 0032_M (JR)	1990-1992
MCS Monolithic (Vertical) Coastal Structures	MAST-contract MAS2 – CT – 0047	1993-1995
Rubble Mound Breakwater Failure Modes	MAST-contract MAS2-CT92-0042	1993-1995
Berm Breakwaters Structures	MAST-contract MAS2-CT94-0087	1994-1997
PROVERBS	MAST-contract MAS3-CT95-0041	1996-1999
OPTICREST	MAST-contract MAS3-CT97-0116	1998-2000
DELOS	Contract n° EVK3-CT-2000-00041	2001-2004
CLASH	Contract n° EVK3-CT-2001-00058	2001-2004

lot to discuss! Since that day the whole coastal engineering community of Europe started to become friends and performed a lot of research together. And cooperating in manageable, good sized research projects advances science quickly. Well within a decade Europe was leading in the coastal engineering science and that has never changed since. The networks created from that time still do their work, even without the European Commission. I think the symposium we had today is a good example of that.

But also the personal cooperation I have with: the University of Edinburgh on wave overtopping; the University of Bologna on reflection and neural networks; the University of Aachen on the projects FlowDike and CornerDike; the University of Ghent on wave overtopping, and Sigurdur Sigurdarson on berm breakwater design - all originate from earlier European funded research. Actually, the topic of research on wave overtopping became so international that it is no longer a national research topic in the Netherlands. Where wave overtopping and required crest height are still the main issue in safety assessments in the Netherlands, we now trust that international collaboration will give us the required input for improved assessment tools. For all other failure modes of dikes we still have or need national funds for research.

One-layer systems for breakwater armour

One of the most significant improvements in breakwater design has been the development of single layer armour systems. The accropode was invented in the beginning of the eighties as a reaction to the failure of a few large breakwaters, like Sines, Arzew and Tripoli. One layer of units instead of two layers. Strong in the middle section of the unit and with many protruding elements for a good interlocking. I had the privilege to test the accropode block for Sogreah, now Artelia, in 1987. It is a very stable block with no damage to a high wave

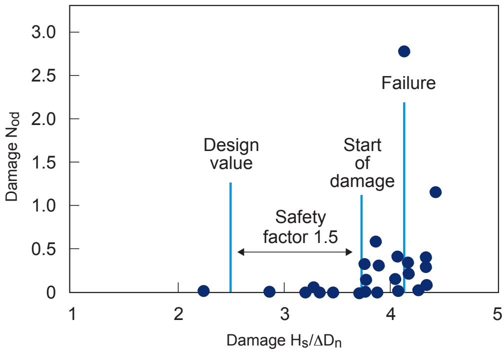

Figure 3 Single layer units as accropode need a proper safety factor for design.

height. But if damage starts for such a high wave height, it fails quite drastically. We call that a brittle failure. For such a failure, it is obliged to use a large safety factor and I have suggested a factor of 1.5 on the nominal diameter. The advantage is then that under design conditions, and even for wave heights exceeding this, no damage is expected. The result is a breakwater without maintenance.

But sometimes practical problems were found. One of the constraints for construction is that the armour layer under construction should have the opportunity to settle during daily wave conditions. This settlement gives better interlocking. But when you are in the Caribbean, like the Dominican Republic, it is always nice weather without waves. Settlement does not occur during construction. And of course then it will occur after the first wave attack by a tropical storm or hurricane. For wave conditions far below design conditions, the settlement results in a gap at the crest wall. In this case, not a big problem as one can take out a few units, rearrange them, add a few more and the problem has been solved. But it would be nice to know this behaviour beforehand, otherwise you may end up with a court case. Which was almost the situation here.

Figure 4 **A gap at the crest appears after the first storm, if settlement has not occurred during construction.**

But there is another problem that may arise with the increasing number of single layer units. All of them have a patent and the patent holder has the attitude to advertise that their unit is more stable than another. More stable means, effectively, that you can design for a smaller unit and save on concrete costs. But actually, you are decreasing the safety factor that is needed for a safe design of a brittle failure mechanism. It was Ole Juul Jensen of COWI who at the Coasts, Marine Structures and Breakwaters 2013, in Edinburgh, stated that this conflict of interest may already have passed the limit, and that we are designing these type of units with a too small safety coefficient (Jensen, 2013). It is a research line I would like to explore a little more here at UNESCO-IHE.

Berm breakwaters

A berm breakwater is a special type of structure, more or less invented by Bill Baird and Kevin Hall in 1983 and 1984. If rock is available, just put it in the water as a berm and the waves will reshape it into a stable, S-shaped profile. When I did my testing for my PhD, I visited Bill Baird in Ottawa in 1984, after the ICCE Houston conference and we discussed the advantages and research topics. I changed my research programme and included dynamically stable structures.

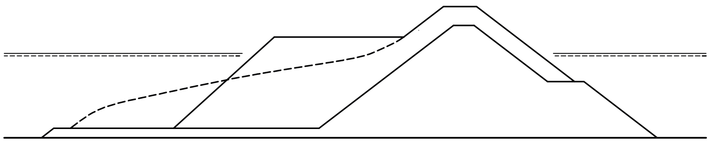

Figure 5 Original idea of the berm breakwater design. Two classes of (small and large) rock and the berm is fully reshaping.

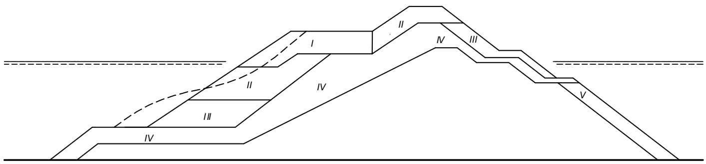

Figure 6 Icelandic type berm breakwater. Four classes of large rock, for example: I = 20-30 t; II = 10-20 t; III = 4-10 t and IV = 1-4 t. The berm is partly reshaping.

But not many of them were built like the original idea. In Iceland, where good rock is available in many places and concrete is expensive, the berm breakwater evolved to a much more stable berm breakwater. Why not use all the rock from a quarry, even the few percentage of rocks that are really big? Why not try to get the big rock by a dedicated blasting? It was Sigurdur Sigurdarson who developed the berm breakwater along these lines and he used rock classes up to 15-35 t, far beyond any limit we have ever used in the Netherlands. But by doing this, the structure may get a large resiliency, without increasing costs. Designing for limited reshaping of the berm means that wave conditions exceeding the design limits just give a little more reshaping, but never a failure. Sigurdarson and I hope to publish a book on design and construction of berm breakwaters in the near future.

CLASH, EurOtop and Artificial Neural Networks

One of the nicest European research projects I have participated in was the "CLASH" project. We did our best to measure wave overtopping in reality – a big challenge. But we also gathered more than ten thousand tests on wave overtopping that had been performed all over the world on all kinds of structures. We screened all those tests and made a homogeneous database. And then we made an artificial neural network as a prediction tool for all kinds of structure. An artificial neural network is a piece of software that has to be trained by data. It looks a little like a black box and it should only be developed if:

- the process is very complex
- there is a large amount of data

If a process is not very complex it is probably possible to describe it with the aid of design formulae. The main challenge was to develop a limited number of parameters that could describe any kind of structure: sloping; vertical; wave walls; berms, and all kind of combinations of these. And we succeeded. By eleven geometrical parameters and four hydraulic parameters the majority of coastal structures can be schematised. And by the cooperation in the project we were able to improve the wave overtopping formulae for more simple structures like slopes, rubble mound structures and vertical walls.

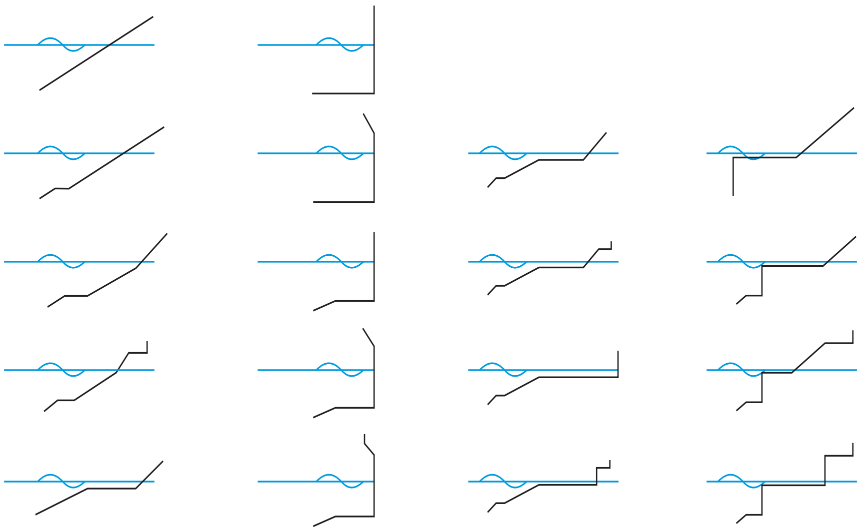

Figure 7 All kind of structure geometries that can be schematised by eleven parameters.

At the end of CLASH we decided to sit together, with the help of national funds, and with seven people we wrote the Assessment Manual on Wave Overtopping, or “EurOtop” for short. Note that the capital is an O and not a T, meaning that we wrote an Overtopping manual, based on European research funds. It was a success from the beginning, partly through the clear guidance on design for overtopping, but also because it was freely available on the internet, together with the neural network prediction tool.

In the past years we have again developed better guidance and today the symposium was on the update of EurOtop. But not only design guidance was developed further. Together with the University of Bologna, we worked on the neural network prediction tools. New databases were gathered for wave transmission and for wave reflection, and new neural networks were built, each with their own set of parameters. In the recent years we have taken the schematisation of the CLASH structure as a basis and we have modified the databases accordingly. Then we trained new neural networks, all based on the same parameters. Dr Barbara Zanuttigh and my final goal, is that we come up with one prediction tool where the designer schematises his or her structure once, and then he or she gets the prediction of wave overtopping discharge, wave transmission and wave reflection all together. If we succeed, this might be a deliverable of the new EurOtop.

Hurricane protection Gulf Coast

Sometimes a nice but small project increases in significance a number of years later. That occurred to me with the design of a hurricane protection around a refinery along the Gulf Coast in Mississippi. The US oil engineers wanted better protection against hurricane flooding as they were only one kilometre from the Gulf, without any flood protection. And

Figure 8 The refinery at the Gulf Coast, Mississippi, that got a hurricane protection in 2000 and survived hurricane Katrina in 2005.

they realised that involving a Dutch engineer would be a benefit for the project. I went there in the year 2000 for one week and advised them about possible dike heights and cross-sections. The coastal consultant finished the designs. In the Netherlands we design for only 1 l/s per m wave overtopping. That was not possible there: the dikes would take too much space that was not available. I decided to design for 50 l/s per m, which gave an acceptable rise, in two hours, of the water reservoirs within the refinery.

Figure 9 Destroyed and flooded houses in the village during Katrina, 2005.

The flood protection was built that same year and remained dry for almost five years. Then hurricane Katrina came in 2005 and flooded New Orleans and destroyed almost everything along the Gulf Coast east of New Orleans. The storm surge at the refinery was around 15 feet, roughly four and a half meters. The village close to the refinery and more inland were about two thirds destroyed. But the refinery was not flooded! It was the first refinery in operation along the Gulf Coast after some repair due to wind damage, not flood damage.

Figure 10 Erosion by waves and trash on the crest.

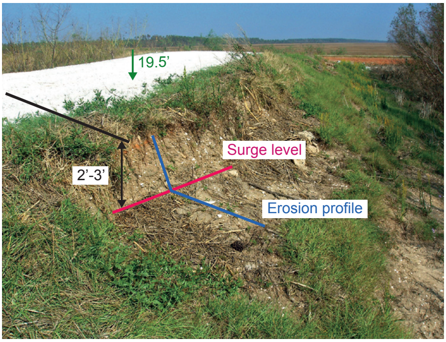

Figure 11 Erosion of the clay at maximum surge level.

But the protections were tested to their limits and maybe even beyond that. And that is a situation we will not often see in the Netherlands with only 1 l/s per m wave overtopping for a probability of occurrence of only once per ten thousand years. So, we learned a lot of this case and I shared the knowledge with the ENW-members. We saw: heavy overtopping without failure; wave impact damage on clay slopes; broken pvc sheet piles due to wave slamming of logs, etc.

Figure 12 Breaking of pvc-sheet piles by hammering logs.

Simulators

Till now in the Netherlands we have designed our dikes according to a given event with a certain probability of exceedance, like a 1 in 4,000- or 10,000 years event. In the near future, and after a preparation time of more than twenty years, we will change to design our dikes for a probability of flooding, taking into account the consequences of such a flooding. It means also that we need to know how strong our dikes are. When will they breach?

The crest level of a dike determines the wave overtopping discharge on the landward slope. Designing for 2% wave run-up or only 1 l/s per m is safe, but when and how will the dike fail? After 1953 we have not really got any experience with wave overtopping. We even lost the feeling of what the number of 1 l/s per m means in reality – what it looks like. That brought me to the idea, in the year 2001, that a wave overtopping simulator would bea good research tool to find out. It took five years before funding was found in the ComCoast project. The wave overtopping simulator was designed and constructed and, in 2007, we tested the dike near Delfzijl. Since 2008 the testing became part of the SBW-project of the Rijkswaterstaat, through Deltares, and as a consortium we have tested dikes every year since then. In total we visited 11 locations in the Netherlands and Belgium and tested 38 cross-sections.

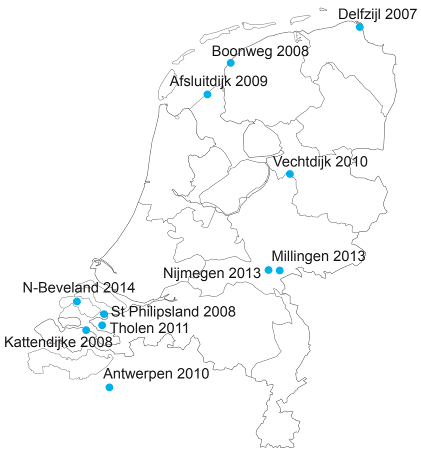

Figure 13 Locations where tests were performed with the simulators from 2007-2014.

The task of a simulator is to simulate a part of a process. This means that one needs to know the process, before it can be simulated. In design practice we often use design parameters like the 2% wave run-up level or a certain overtopping discharge. But with wave run-up, every up-rushing wave is different from another and similarly, for wave overtopping, every overtopping wave volume is different. Actually there was a lack of knowledge, and to some extent there still is, about the processes of wave run-up and wave overtopping. This knowledge was developed in the recent years.

The wave overtopping simulator was a great success and we learned a lot. For example that 1 l/s per m is hardly any overtopping and that it becomes interesting for 10 or 30 l/s per m or more. Also, we learned that a closed grass cover – no small open holes - is quite strong against wave overtopping, and that it will be other aspects like stair cases, trees, transitions, etc that will lead to damage and failure. Our safety assessment rules are still based on the grass cover and not yet really on all the other aspects. We also found that if grass is not maintained well, there is hardly any strength at all. The quality or resistance of a grass cover to wave overtopping is not a sliding scale, but it is good or bad – good resistance, or hardly any resistance. In that respect, daily maintenance of the grass may become more a critical issue in our safety assessments.

After some years we got a lot of experience with a simulator and the logical step was to develop more. The wave impact generator was developed to test river dike slopes against relatively small wave attacks and the most recent development is the wave run-up simulator. Most of our sea and lake dikes have grass above the impact zone, and this is closer to wave attack than wave overtopping. Tests were performed in the spring of this year.

Figure 14 The wave overtopping simulator.

Figure 15 The wave run-up simulator.

Figure 16 The wave impact generator.

All the research has led to methods to assess the strength of grass dikes under wave impacts, run-up and overtopping. The cumulative overload method was developed, which is also able to incorporate objects and transitions. But still it is a struggle to predict the strength of a grass slope beforehand, without using the wave overtopping simulator. We hope that the grass pulling machine may be a helpful tool and research continues in this direction.

Applications come with practical questions. The Afsluitdijk was tested in 2009 and was stable for an overtopping discharge of 75 l/s per m, assuming a wave height of 2 m. Our new safety assessment guidelines allow for good grass covers and an overtopping discharge of only 5 l/s per m. One has to perform a detailed assessment if this allowable discharge is to be increased. The actual design wave height for the new Afsluitdijk is around 4 m, not 2 m. Now what would be a *safe* overtopping discharge for the Afsluitdijk on which to design, and one that would withstand the next round of safety assessment? The answer is confidential for the moment, as the design of the Afsluitdijk is going on right now, but of course it will be quite far away from 75 l/s per m.

Simulacra

What is a simulacrum?

In the first half of this year, discussions were held between members of the ENW (Expertisenetwerk Waterveiligheid) under guidance of Govert Geldof. The subject was flood safety and from everybody's own experience, some critical notes were made about processes in flood safety and how they can be improved. Geldof *et al*. (2014) made a very interesting report for the ENW, called Simulacra in a River delta. Four bottlenecks in and around flood safety (Simulacra in een Rivierendelta. Vier knopen in en rond waterveiligheid). I was struck by the power of simulacra and the negative effects they may have. The following is a more or less free and short translation of parts of the report of Geldof et al. (2014).

A simulacrum is a image that has lost its relationship with reality to a great extent or completely. There is a tension between the modelling, the image and the reality. Simulacra may lead to unhealthy tensions and situations where the dialog has stopped and one only sticks to ones own point of view.

Nobody understands the reality completely and that is why we make images or models of that reality. That is good and even necessary. We also react on those images – they determine what we do. We talk about Simulacra if we go too far and we lose the contact with the real world. It then becomes a copy without an original version. I would like to discuss a few simulacra in the coastal engineering world.

Flood safety approaches

After the flood disaster in 1953 in the South West of the Netherlands, we as Dutch people said: this must never be allowed to happen again. We have raised and strengthened our dikes and flood defences to a level where there is indeed only a very tiny probability of flooding. We believe in flood protection and invest in improving dikes that did not pass the regular safety assessment procedure. We also recognised in the recent years that protection is maybe not the only aspect in a safety approach. We can also look at urban developments and do not design extensions of villages in the deepest part of a polder. And we can look at evacuation, which of course does not really help against flood damage, but can reduce the number of casualties.

And even there we have to realise that evacuation is hardly possible with the super storm arriving, somewhere along the coast of the Netherlands, with unexperienced wind speeds, making evacuation into a very dangerous experience. Evacuation is only an option with extreme high river discharges, without the threat of a large storm. The general idea in the Netherlands is that protection is and will be number one, followed by urban development measures and possible evacuation. That is not a simulacrum, but a fair and realistic approach to deal with mother nature. It would become a simulacrum if we would pay much more attention to the second and third layer than to protection.

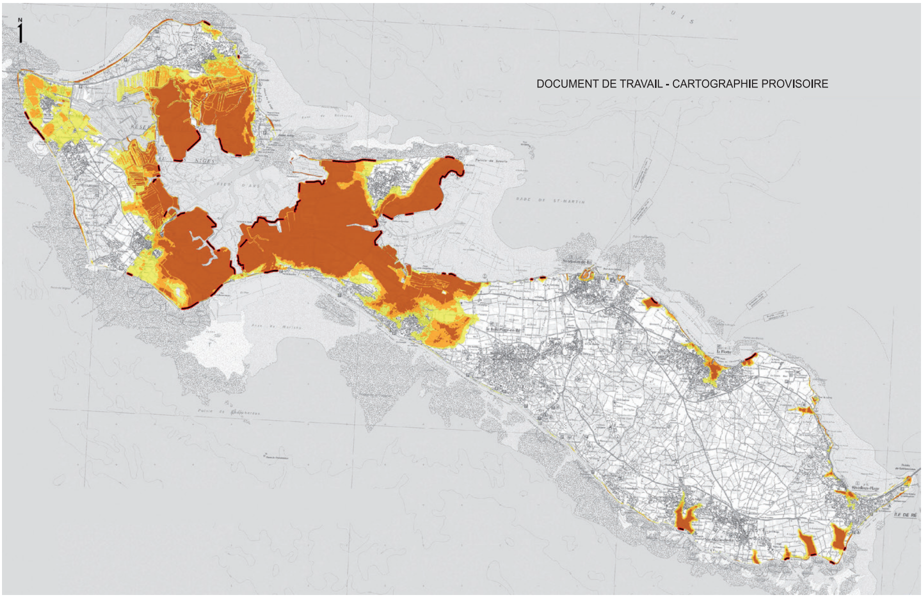

Figure 17 Flood map of Ile de Ré, determining restrictions to urban development.

When we go abroad the image on flood safety may be completely different. In France, the government does not want to be responsible for flood defences. Their simulacrum is: protection by flood defences, by dikes, is not possible, they will *always* breach during a severe event. The government demands by law that flood calculations have to be made for extreme events with many breaches in every protection. The flood map that is the result of those calculations then leads in the decision-making for urban development. In the flood map area, nobody may build a house and perhaps they may not even modify or improve an existing house.

Such an attitude in the Netherlands would mean that almost the whole part of the Netherlands west of Amersfoort would be blocked for any development. In France it leads of course to a lot of frustrations, certainly if communities want and are able to improve dikes and other flood protections to a level where they can withstand a severe event. This simulacrum stops all discussion, and a flood risk project in France has probably more political aspects to solve than engineering aspects. I am involved in such a project in Ile de Ré and you can imagine that I do my utmost to stay away from the political aspects.

The Netherlands must not become a bathtub

Another clear simulacrum is: we cannot keep raising our dikes forever. The Netherlands must not become a bathtub. And this image of the reality is then used to come up with projects like Room for the river (Ruimte voor de rivier) and even room for the sea. I do not say that the Room for the river projects are not good or should not have been performed. I want to talk about the image – the simulacrum of the bathtub.

Everybody has a image of a bathtub in mind. Side walls at similar size as the horizontal dimensions. That is of course not what we want – it would feel like a prison. There are two aspects related to this simulacrum. The first one is: is it true that we cannot raise our

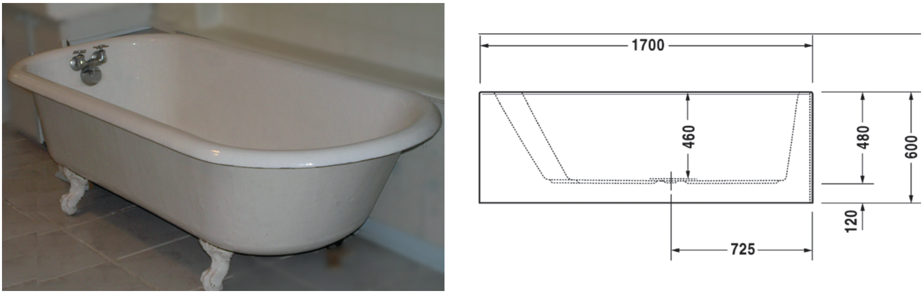

Figure 18 A bathtub: side walls are about one-third of the length.

dikes forever? Technically speaking it would be a challenge to raise all our dikes by, say, fifteen meters and take into account the sea level rise for the next two thousand years. I am convinced that this challenge can be solved. We also have a few thousand years or so to solve it.

The second aspect is the image of the bathtub. We have already several bathtubs in the Netherlands, that are our polders. A picture from the Ketelbrug to the Noordoostpolder shows clearly that the level of the Noordoostpolder is about 4 m lower than the level of the IJsselmeer. Compared to regions where the level of the land is around NAP, the dikes in the Noordoospolder and also Flevoland are 4 m higher, seen from the inside. Who among you realises that when you drive into the polder, you are entering a bathtub? We do not have that experience, simply because it does not even look like a bath tub. The horizontal dimensions are so much larger than the total height of a dike that the picture is not a realistic one. That also becomes clear if we draw a cross-section of the Noordoostpolder at scale, with dikes of 25 m height. The Netherlands is flat, and even with dikes raised 25 m high, it remains flat.

Figure 19 The Noordoostpolder seen from the Ketelbrug. The land is 4 m lower than the water level.

Figure 20 Entering the Flevopolder from the Ketelbrug. Entering a bathtub…

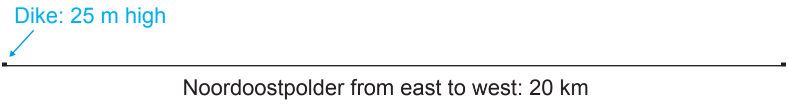

Figure 21 Cross-section of the Noordoostpolder, showing the simulacrum of the bathtub.

Dikes are the only protection against floods

As professor in Coastal Structures and Ports, my view on coastal structures and port structures is a global one. There are many types of structures that have to deal with waves and storm surges: dikes and dunes, like in the Netherlands; rubble mound structures as breakwaters; seawalls; vertical type structures; beaches with boulevards, and many combinations of smooth, rubble mound and vertical structures. The simulacrum in the Netherlands is that a man-made flood protection is a dike.

A dike has a hard but smooth protection against wave attack, preferably a block revetment or asphalt, maybe a berm to reduce the actual dike height and, if possible, a grass upper slope in the run-up zone. For most of the wave conditions in the Netherlands with a wave height more or less around 2 m this is a good and well proven solution. But one should also realise that a dike is very smooth and that energy dissipation by roughness is lacking. Actually, a dike has the property of a slide – the broken wave may freely run-up on the upper slope and cause wave overtopping. As long as the waves are limited, say around 2 m, this is not a problem.

But what if design heights become much larger, say in the order of 4 m? Outwith the Netherlands, the logical and first option would be a rubble mound structure. A rock slope or, if rock is not available or too expensive, concrete armour units. A structure with a steep slope, with armour units sized to cope with the wave attack, and a lot of roughness and permeability to dissipate wave energy and reduce the required crest height of the structure. Roughness and permeability are very effective in reducing wave overtopping and keeping your crest height low.

We have such a situation in the Netherlands right now. The Afsluitdijk has to be improved and designs are being developed. The design wave height is around 4 m, larger than ever-before used in the Netherlands for a dike design. Landscape architects, however, have demanded that the new design for the Afsluitdijk should look like a dike! The old image, the simulacrum, in the head of most Dutch people and also in the head the of the architects, makes a bottleneck here. From a technical point of view, a rubble mound structure is a solid and good solution. It has been applied all around the world, but a lot of Dutch coastal engineers (and architects) are not ready for it, or have difficulties in thinking outside the dike solution.

Figure 22 A rubble mound structure with corelocs. Very efficient in dissipation of wave energy.

Rock slope design formulae as a simulacrum

I come to a serious simulacrum that to some extent affects my functioning in the coastal engineering world. Some of you know that my PhD-work in the eighties has led to two formulae on rock slope stability against wave attack. These so-called Van der Meer formulae describe the stability number as a function of a number of other parameters. I show here one of the two formulae (Eq. 1). Professor d'Angremond in his farewell speech of November 2001 said about this formula, freely translated: "We don't understand it, but do we follow the instructions to apply the formula, and then we get for designers quite good predictions". This was used in comparison with morphological features, which we understand theoretically quite well, but where the tools for good predictions in practice are sometimes lacking.

$$\frac{H_s}{\Delta D_{n50}} = 8.7\, P^{0.18} \left(\frac{S_d}{\sqrt{N_w}}\right)^{0.2} \frac{H_s}{H_{2\%}} \left(\xi_m\right)^{-0.5} \qquad (1)$$

I agree about the feeling that you do not always understand the physical relationships behind an empirical formula. But it does not mean that an empirical formula is lacking physical insight. For instance the formula gives a nice damage curve with a fixed 5th power relation between wave height and damage. It is also quite easy to draw different damage curves and compare them. Another relationship is between wave height and wave period, or breaker parameter. By increase of the wave period, stability decreases in the plunging or breaking wave area. Until the waves become collapsing, often the most dangerous situation in wave-structure-interaction, where a minimum stability is found and the transition to surging or non-breaking waves occurs. Increasing the wave period even more gives an increase in instability, where the increase is limited for an impermeable core and much more for a permeable core. This is logical, as there is simply more energy dissipation in the under layers and core. The structure of the formula is based on empirical data, but also on physical reasoning.

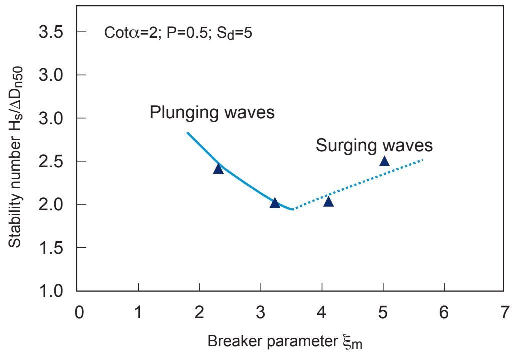

Figure 23 Influence of the wave period on rock slope stability.

That changes when we go the simulacrum. Here (Eq. 2) we see the formula as it has now been presented in the Rock Manual (2007). Note that the coefficient 8.7 has been changed to a coefficient c_{pl}. The simulacrum is that the structure of the formula is taken as a given fact, and that one may change and re-fit the formula on new data. In some cases that may be allowed, if the changes are small and on a specific item, like the influence of the shape of the rock (Latham, 1988). Even then, one should be cautious, as the validation is never on the full range of the original formulae. It is of course not allowed if the whole physics of the process changes. This simulacrum denies that.

$$\frac{H_s}{\Delta D_{n50}} = c_{pl}\, P^{0.18} \left(\frac{S_d}{\sqrt{N_w}}\right)^{0.2} \frac{H_s}{H_{2\%}} \left(\xi_{s-1,0}\right)^{-0.5} \qquad (2)$$

Tests have been performed for very shallow water, where waves break over the foreshore and reduce significantly. Secondly, the wave spectrum changes completely with a tendency to have very long wave periods at the structure. For example the wave height of 4.8 m reduces to 2.5 m, where the wave period increases from 15 s to 65 s! If we have these type of conditions, do we still have the relationship of a fifth power between damage and wave height? It is difficult to validate this, as the wave height at the structure is always depth

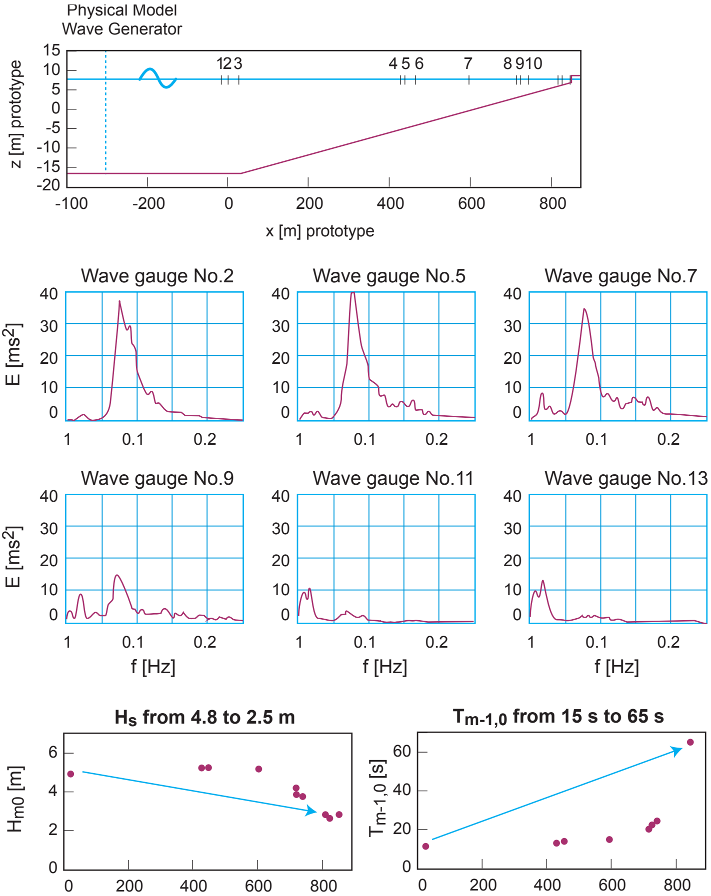

Figure 24 Development of waves over a foreshore, showing very large wave periods (Figure taken from presentation of Verwaest (2012)).

limited and probably similar for the same water level, regardless of the wave height in deep water.

But more worrying is the effect of the wave period. The periods become so long that the breaker parameter is completely out of range of the original formula. Moreover, there are only very long periods, so it is very likely that the influence of the period itself, which is dominant for the original formula, disappears in the new situation. The conclusion is that the damage – wave height relation has probably changed and the wave period influence is completely unknown.

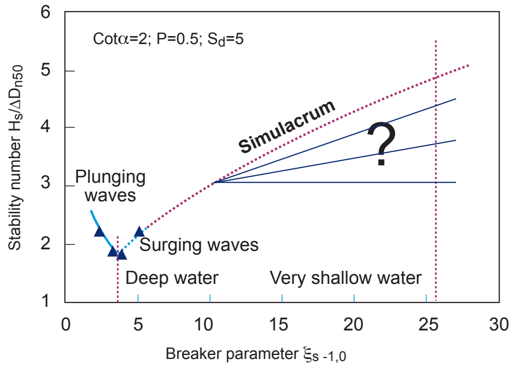

Figure 25 Very shallow water conditions from Figure 24 lead to an unrealistic fit of Equation 2 to the data. The cause is the simulacrum.

But the simulacrum says: just re-fit the formula with a new coefficient. That has led to the "modified Van der Meer formulae for shallow water", equations 5.139 and 5.140 in the Rock Manual (2007). The conclusion is clear: this formula is not based on physical reasoning and is fundamentally wrong due to its being based upon a simulacrum instead of a sound scientific analysis of processes and data. It is time for an errata to the Rock Manual (2007) stating this conclusion, as now many engineers and designers are using a fundamentally wrong formula.

UNESCO-IHE

I have known UNESCO-IHE and the Department of Water Science Engineering for a long time, as I have been guest lecturer in Breakwater Design for more than twenty five years. But a guest lecturer comes for a very short period of time, nowadays for about three weeks in a specific module, gives lectures and an exercise and comes back next year. The guest is not really part of UNESCO-IHE, although I always enjoyed the open and global atmosphere with so many students from all over the world.

I have always worked in research, in combination with consultancy. Tests combined with practice and often from test to practice. Research at a company is different than at a university. First of all, most of the research I did on my own – I had no student to work for me. Secondly, you were always aware that the research would have to be paid for by a client. I went from a non-profit organisation to a consultancy, and finally started my own company. To have your own company gives an extra dimension: you are responsible from a to z; from the first request for proposal to the final invoice. You bear the risks, but may also enjoy the benefits if it goes well. You need a certain attitude, you have to understand needs of clients, be service oriented, but also commercial. This situation will stay for eighty percent of my time. You have me as a new professor, but you have also a businessman in your midst. I see this as a win-win situation.

The position at UNESCO-IHE gives me an extra dimension. The academic freedom in exploring ideas, and MSc or PhD students to assist in working on these ideas. For me it is a pleasant change and challenge from doing research myself to initiating and guiding. Research lines will be of course in my field of interest: understanding and further development of design wave conditions; wave overtopping and structural stability; all important aspects in vulnerable areas with increased sea level rise, and with possibly more intensive wave events. I still have to find my way in initiating academic research projects, but with so many colleagues around me, that will not be a real problem.

I am very glad that Maurits van Schuylenburg has come to take over the port planning issues. Port planning – improving existing ports and developing new ones – is important in many countries that send students to UNESCO-IHE. A research line here is the development and validation of a new harbour simulation model, capable of simulating aggregate traffic simulations in ports.

UNESCO-IHE has no physical model facilities of their own, and I hope to continue working together with Delft University, which often makes its wave flume available to our students. The same I hope to achieve with Deltares in the Netherlands, but also with Ghent University and other laboratories around the world. Possibly we can cooperate in future Hydralab projects.

Often, I see coastal protections or structures as a binding element between risk assessment and vulnerability studies. Without physical flood protections, it is difficult to improve resiliency of coastal and urban societies, although I realise that in many developing countries and countries in transition, flood protection is not often to the level we have in the Netherlands. It will be a pleasure for me to contribute to the work of Professor Chris Zevenbergen on flood resiliency in urban areas, and to the work of Professor Rosh Ranasinghe on risk management in coastal areas and the impact of sea level rise.

Acknowledgements

The first one I like to thank is Krystian Pilarczyk. He showed faith in me in the first years of my career and ever since. Krystian his drive has always been to initiate research and to come with practical guidelines for design, an attitude that is familiar to me. After a literature study in my first years at Delft Hydraulics, he came as Rijkswaterstaat employee with three years of funded research (Eastern Scheldt funds) to fill the knowledge gaps with respect to loose materials: stability of rocks slopes and shingle beaches against wave attack. I was free to set-up and perform this research. It resulted in a pile of Rijkswaterstaat reports with as scientific output my PhD-thesis and finally the stability formulae with my name. Actually, writing my PhD was not more than three months of evening work, it was the scientific summary of five years of finished research. Together with Krystian Pilarczyk I want to thank all colleagues at Rijkswaterstaat for their support and funding of projects.

Colleagues at Deltares, formerly Delft Hydraulics and Delft Geotechnics. I thank you for your collegial cooperation, at the time I worked with you and also after I left you. Specially Mark Klein Breteler, we had many contacts throughout the whole of our career and I am convinced that this will continue. André van Hoven, as project leader of all the Simulation work. We had quite some scientific discussions in our group and I admire the way you have led that. I always had a very nice cooperation with the physical model teams: Leen Tulp, Pieter Pasterkamp and Albert Scheer, to name a few. They always had the intention to improve the model set-up, the performance and the data processing. As a young and starting engineer you had to convince them about your approach and they were always arguing with you. The Friday afternoons in the Delta flume are still a good memory. I trust that my cooperation with Deltares will not only continue, but also will intensify and that we can include students of UNESCO-IHE in some of your research.

I had a wonderful time at Infram. I specially thank Ep van Hijum, who convinced me twice to take the job he offered, once at Delft Hydraulics and later at Infram. Infram is a unique company in the way they are dealing with their employees. They give full faith in their people, including required means and responsibilities and without blocking departmental boundaries. They are always looking for innovation and helping the client in the best way. Even though in near future our offices depart, as you will move to Maarn, I am looking forward to continue our cooperation.

I thank my international colleagues and I am glad that a few can be here today. International cooperation started with EU research and this made many friends all over the world. I like to work in a global setting and cooperation. And UNESCO-IHE is a good place to continue this.

I am grateful for the confidence the Nomination Advisory Committee, led by professor Arthur Mynett and professor Dano Roelvink, has put in me. It is a pleasure for me to work

more on a permanent basis with UNESCO-IHE, although it will be part time.

Professor Ligteringen, dear Han, I am your successor as professor in Port Development, although we changed the name a little to my background. We both had the start of our career at Delft Hydraulics, but then we went a little in different directions. I am glad that you called and informed me that the vacancy for your successor was open. As having my own business I was not aware of and not looking for any vacancy where ever.

Professor Roelvink, dear Dano, we have always worked alongside each other. You in the small material called sand, I more with larger sizes like rock and even concrete units. Numerically modelling the hydraulic and morphological behaviour of nature is your core business, where mine is much more based on physical models like flumes and wave basins. We are quite complementary and it are often these complementary teams that are the best. I enjoy working with you, certainly when you seem to be convinced that XBeach may take over the role of physical models of wave run-up and wave overtopping and related phenomena. We certainly will cooperate on that. I am convinced that XBeach can also help to understand design conditions for structures in very shallow water.

I thank my parents for being raised as a farmer's son. The fantastic playground as a young child, in the middle of nature, but also the requirement to help in working at a farm instead of having a lot of free time, has shaped my attitude to nature as well as work. Moreover, a farmer is an entrepreneur, he has to lead his own business in all aspects. These genes have helped me in my career to start and make a success of my own company.

It thank my brother Gerben for the last eight years of cooperation. I invented the simulators, I told you what they should do. But your experience as a mechanical engineer in designing new machines made it possible that they really were constructed and did the job they were designed for. With you, I want to thank all people that have been involved in the simulator work.

Last but not least, I thank my wife Betsie. Not for the sacrifices she has to bear, not for the long working days I was at the office or abroad and not being available for her or our family. Because these sacrifices do not really exist in our relationship. Being self-employed has some privileges. As my private chauffeur, we are together a lot when I have meetings in Delft, Rotterdam, Ghent or Aachen, or somewhere else in and around the Netherlands. And almost any trip abroad of a week or longer, you join me. I want to thank you for the joy you find in traveling around the world, with me. It makes the working life so much more joyful.

Thank you for your attention.

Ik heb gezegd.

References

D'Angremond, K., 2001. Inspiratie uit Verjaagd Water. Farewell speech, Delft University of Technology.

Baird, W.F. and K.R. Hall, 1984. The design of breakwaters using quarried stones. ASCE, Proc. ICCE, Houston, 2580-2591.

Berm Breakwater Structures, 1994-1997. EU programme MAST-contract MAS2-CT94-0087.

CLASH, 2001-2004. EU-programme Crest level assessment of coastal structures by full-scale monitoring, neural network prediction and hazard analysis on permissible wave overtopping. Contract n° EVK3-CT-2001-00058.

ComCoast. EU-programme. Combined functions in coastal defence zones. Co-financed by the EU-Interreg IIIb North Sea Programme.

CornerDike, 2012. EU-programme Effect of very oblique waves on wave run-up and wave overtopping. Integrated Infrastructure Initiative HYDRALAB-IV. Contract HyIV-DHI-05.

DELOS, 2001-2004. EU-programme Environmental Design of Low-Crested Coastal Defence Structures. Contract n° EVK3-CT-2000-00041.

EurOtop, 2007. European Manual for the Assessment of Wave Overtopping. Eds. Pullen, T. Allsop, N.W.H. Bruce, T., Kortenhaus, A., Schüttrumpf, H. and Van der Meer, J.W. Available from www.overtopping-manual.com

FlowDike, 2009. EU-programme Integrated Infrastructure Initiative HYDRALAB-III Access to major experimental facilities. EC Contract No 022441 (RII3).

Geldof, G.D., A. Cath and F. Timmermans, 2014. Simulacra in een Rivierendelta. Vier knopen in en rond waterveiligheid. "Simulacra in a River Delta. Four bottlenecks in and around flood safety". Report prepared for ENW, Expertise Netwerk Waterveiligheid, The Netherlands.

Hall, K.R., W.F. Baird and C.I. Rauw, 1983. Development of a wave protection scheme for a proposed offshore runway extension. Proc. of Coastal Structures '83, ASCE, 157-170.

Jensen, O.J., 2013. Safety of Breakwater Armour Layers with Special Focus on Monolayer Armour Units (Discussion Based Upon Four Decades Experience of Breakwater Damage). Proc. ICE, Coasts, Marine Structures and Breakwaters 2013, Edinburgh, UK.

Jonkman, S.N., 2013. Het water weet de weg. Inaugural speech, Delft University of Technology.

Latham, J.-P., M.B. Mannion, A.B. Poole, A.P. Bradbury and N.W.H. Allsop,1988. The influence of armourstone shape and rounding on the stability of breakwater armour layers. Report No. 1 Coastal Engineering Research Group, Queen Mary College, University of London, and Hydraulics Research Ltd, Wallingford.

MAST G6S Coastal Structures, 1990-1992. EU-programme MAST-contract 0032_M (JR).

MCS, 1993-1995. EU-programme Monolithic (Vertical) Coastal Structures. MAST-contract MAS2 – CT – 0047.

OPTICREST, 1998-2000. EU-programme The optimisation of crest level design of overtopping coastal structures through prototype monitoring and modelling. MAST-contract MAS3-CT97-0116.

PROVERBS, 1996-1999. EU-programme Probabilistic Design Tools for Vertical Breakwaters. MAST-contract MAS3-CT95-0041.

Rock Manual, 2007. The use of rock in hydraulic engineering. CIRIA, CUR, CETMEF.

Rubble Mound Breakwater Failure Modes, 1993-1995. EU-programme MAST-contract MAS2-CT92-0042.

Van der Meer, J.W., 1987. Stability of rubble mound breakwaters. Stability formula for breakwaters armoured with accropode. Delft Hydraulics Laboratory. Report on basic research, H546.

Van der Meer, J.W., 1988. Rock slopes and gravel beaches under wave attack. PhD-thesis, Delft University of Technology.

Verwaest, T., 2012. Overtopping over constructies – boulevards. Presentation in PAO course Delft: Nieuwe ontwikkelingen in het ontwerp en de uitvoering van kustconstructies. "Overtopping over structures – boulevards".

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