FLOATING FUTURE

Luctor, emergo et supernato – I struggle, emerge and float

The Dutch have a rich history of living in river deltas and finding solutions to protect the land from the sea. Climate change brings new challenges and asks for a next step: living on and with the water. A group of researchers and parties from a wide range of disciplines are shaping and testing possibilities for a floating future.

In the Middle Ages, we started to produce more dry land by extracting water from lakes and now a big part of the Dutch population lives beneath sea level. Citizens have much faith in the strong dykes we built, but living on land is becoming more and more dangerous, as the recent disasters in Limburg and Germany have shown. Next year, it will be seventy years since a big part of Zeeland was flooded. The flood museum also pays attention to the floating future in its anniversary exhibition. New solutions have to be found to live with the water. What will our country look like 300 years from now? Two key figures in the Floating Future project tell their story in this article: Olaf Waals, Manager Offshore of MARIN and Rutger de Graaf-van Dinther, co-founder of the Blue Revolution Foundation and Blue21.

As part of the National Research Agenda, the research question of the project team is how to keep the Dutch Delta liveable in the long term and protect the citizens from the sea. The goal of the research is to develop unique knowledge of floating building solutions to contribute to scientific, technical and societal breakthroughs for a sustainable future.

Knowledge development

The biggest challenges in this assignment are efficient use of space and a flexible attitude to climate change. How can we keep our densely populated country livable? More and more people want to live near the sea where the land is low and vulnerable to flooding, not only in the Netherlands, but also in big cities all over the world, like New York, Jakarta and Shanghai. This asks for innovations, new solutions and knowledge development. The knowledge about solutions for living afloat can become an export product for the Netherlands, complementary to the water management knowledge the Dutch are already famous for. New values are being created like new perspectives, new flexible solutions, smart and multiuse applications, experiences with interdisciplinary innovation and so on.

In the Floating Future project, knowledge is being developed in three scientific areas: technology, ecology and governance. The maritime engineering challenges are completely different than the common scope nowadays; a ship is built for a lifetime of 25 years, a floating island has to be designed for a lifetime of over 100 years. More sustainable and robust materials have to be applied and fatigue can be a bigger problem in the long term. Characteristics of materials like concrete and steel are re-evaluated for this purpose. The forces on the structure also form a big challenge, see later on in this article.

Questions that arise in the science of ecology are: What is happen-

Photo: Interconnected pontoons for floating storage.

ing underneath the structures? How does this effect marine life? Experiences with existing big floating structures and recently an expedition underneath the ice of the Antarctic indicate that the lack of sunlight not always causes the ecology to decrease, on the contrary, complete new ecosystems thrive underneath. How can we integrate and live alongside this ecology and maybe harvest from it in a sustainable way?

The third subject is governance, which treats three subjects: policy and management, jurisdiction and economy. Pernille van der Plank of the Utrecht Centre for Water, Oceans and Sustainability Law (UCWOSL) and responsible for the governance subject in this project: 'The most important questions are: How can floating platforms be integrated in spatial planning? How can we guarantee that the floating city forms an inclusive community and is not only a living space for the happy few? Which jurisdiction is applied to the floating platforms? All the existing (building) regulations are based on buildings that are constructed on ground. This means that we have to investigate how new forms of large scale building can be integrated in existing laws. A later question is if it is possible to create a viable form of floating structures that can be applied in port areas.'

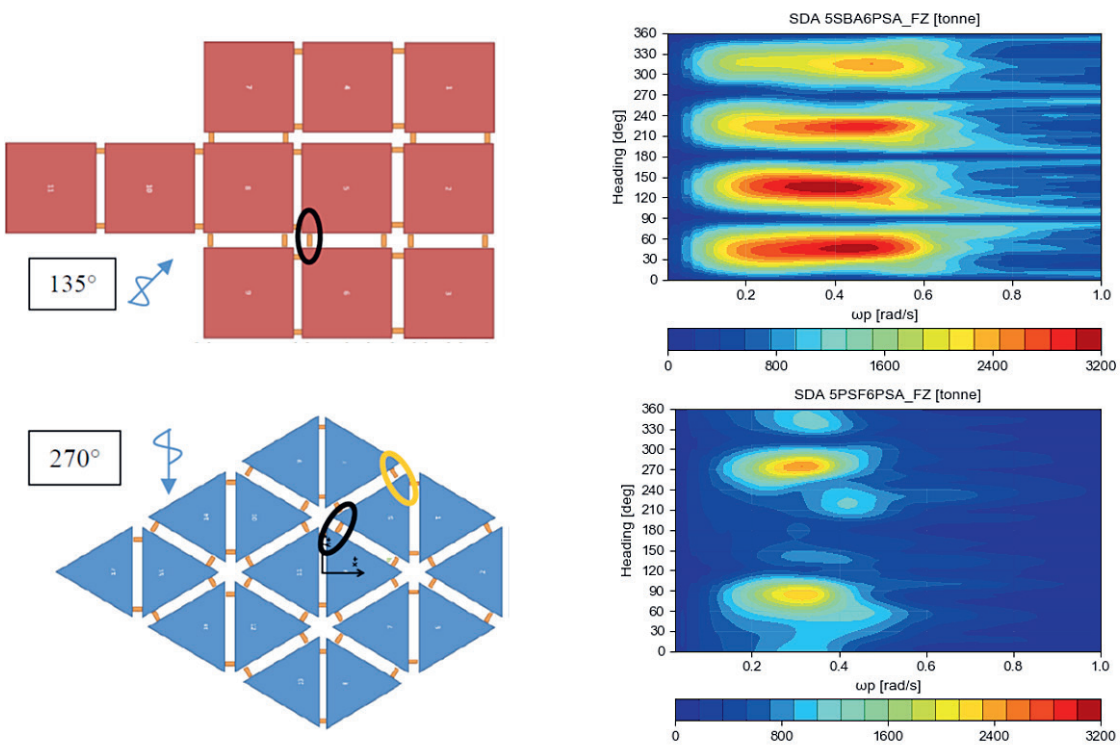
Floating rural development

In the project, the application of floating building will be evaluated for three purposes: floating housing, a floating energy island and floating port solutions.

For floating housing, society has to accept the possibility of living on water. Who wants to live on a floating island in the middle of the ocean? This asks for a tipping point in the way we think about housing. Trust is needed that large scale living on water is safe and comfortable. Therefore, the first applications of living on a floating structure will be in the port of Rotterdam and on inland waterways and lakes such as the IJmeer in Amsterdam. An important subject is movement: Do the people on a floating island feel movement or even get seasick? Tests at the MARIN basins show that you don't want to live at the edges of a floating island in big waves, but in the middle of the island, it could be both safe and comfortable.

The integration of disciplines is actually the real innovation in this project

An application that is less demanding is a floating energy island. On this island, energy can be stored to support old and new infrastructures like wind energy, solar power, hydrogen and storage of fossil fuels. The current energy network on land cannot cope with the increase in sustainable energy. A sustainable fuel terminal can support the energy transition on land and sea in a flexible way. Next to energy storage, other objects can also be stored on the island, which gives a lot of opportunities for flexible port solutions. Storage on barges can easily be moved around the port sites. A much discussed option of floating constructions and infrastructure is to move or expand Schiphol Airport to the sea. This has already



Loads on rectangular and triangular floating platforms.

been tested in Japan and could be a very good alternative to an airport in a densely populated area. For this to happen, it is necessary to convince politicians with practical knowledge and experience. With the appearance of floating solutions, the separation between land and sea will fade away and a synergy between coastal protection and floating building will appear. There are also possibilities for floating islands offshore, but the North Sea is already very crowded. Some have suggested to submerge parts of the land again and make room for floating solutions more inland.

Interdisciplinary knowledge and cooperation

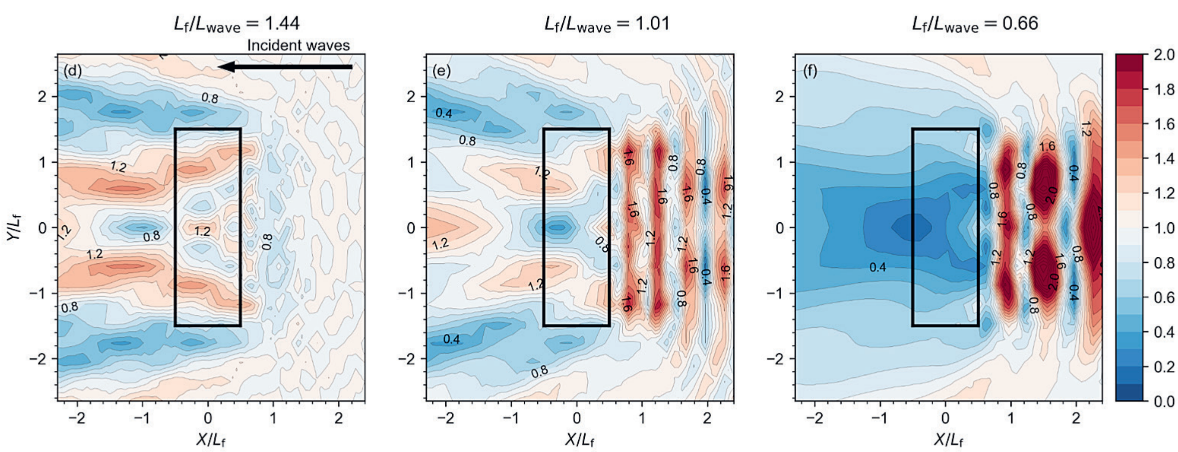
Engineering heroes of the old days like Stevin and Leeghwater had several areas of expertise and had a more integrated view on a subject. Nowadays, the focus is on deep specialisations and knowledge is more fragmented. In this project, the objective is to integrate different fields of expertise again. Multiple disciplines come together and create awareness, an open minded discussion and movement in all parts of the subject. A big group of civil and maritime engineers, architects, ecologists, lawyers and sociologists will investigate all the aspects of floating developments in the coming years. With these actions, a strong connection arises between several existing strong Dutch clusters like the civil, maritime and offshore cluster. The project team is proud of its big community; people from many knowledge institutes, governments, companies and end users work together and are motivated to contribute to this development and learn from each other. These parties all have their own culture and language, so taking time to get to know each other and creating an open mind is very important. The integration of disciplines is actually the real innovation in this project and takes place in an action research process.

Participatory action research

When research is done in close collaboration and with active participation of stakeholders around actual case studies, it is called participatory action research. The "action" in this process can be for instance case studies, pressure cooker meetings, measuring campaigns and participatory design workshops. This approach generates an energetic cooperation process.

The project is in a very early stage of a design process where thinking out of the box is the key. Results of the activities are being shared in open access journals and an online data management platform. Blue21 also developed a maritime engineering and 3D simulation toolkit for floating urban projects: HydroMEC+. Next to this, even civilians can contribute to the research via the Citizens Science Platform ClimateScan.

The study focus areas that have been initiated are: inland (such as rivers, polders and IJmeer); coastal port city (for example the Rijnmond area) and offshore. Applications that are studied are housing, energy and logistics. The next step will be an investment plan and a smooth follow-up in practical application projects.



Calculated transmitted wave field in shallow water conditions for different relative wave lengths.

As technology develops, floating platforms could move further out to sea (by Blue21).

Forces on interconnected floating platforms

William Otto and Joep van der Zande of MARIN have performed tests with different shapes and solutions, their results and thoughts on this subject are shared in the following paragraphs.

When designing a floating platform that consists of interconnected pontoons (see the picture on the first page of this article), it is important to address the degrees of freedom in the system. With rectangular pontoons, we see that the risk of an overdetermined system is larger because the pontoons are restricted on four sides. Especially for diagonal waves (45 degrees, 135 degrees, 225 degrees and 315 degrees), this can result in higher connection loads (red areas in the figure on the second page of this article). This can be avoided if the coupling design allows for more freedom in the local relative motion. When using triangular shapes, the peak loads occur only for two directions and they are much smaller for the same sea state and coupling type.

When floating islands are applied in the North Sea, waves need to be dampened

Floating islands that are able to withstand mild sea states of a few metres of wave height were designed in the Space@Sea project as a first step. When floating islands are applied in harsher environments, such as the offshore North Sea, it is required to partially dampen the waves to reduce the motions of the island modules and the loads on the island and its mooring system. In the HybridEnerseaHub project, which looks at O&M (operations and maintenance) islands for offshore wind, this shelter is provided by an artificial reef with mild slope. The first picture in this article clearly indicates that the waves inside the wave barrier are reduced.

As an alternative, floating breakwaters may be used to attenuate the wave field and provide shelter for the island. A novel “floating beach” concept to enforce energy dissipation of incident waves through wave breaking was recently designed and tested by MARIN. The figure on the previous page (bottom panels) shows the calculated transmitted wave field in shallow water conditions for different relative wave lengths. Up next, MARIN aims to incorporate the floating beach concept into the design of a floating island with the ultimate objective to realise the feasibility of floating mega-islands in harsh environments in deeper waters. Amongst others, the Floating Future project will address this technical challenge.

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