Flanders Hydraulics Research

Expertise in movement

Flanders
State of the Art

DEPARTMENT
MOBILITY &
PUBLIC WORKS

Flanders Hydraulics Research

Who are we?

For more than 80 years, Flanders Hydraulics Research (FHR) has been a centre of expertise for research and advice on hydraulic, nautical, sediment-related and hydrological topics. As a scientific institute and technical support service, we are a division of the department of Mobility & Public Works of the Government of Flanders. Flanders Hydraulics Research supports the preparation and execution of the policy of the Government of Flanders by providing comprehensive, scientifically sound knowledge, knowledge products and advice on water systems.

Besides activities on behalf of the policy domain Mobility & Public Works, Flanders Hydraulics Research develops activities for other entities within the Government of Flanders, for other domestic and foreign government services and for the private sector. Research projects for third parties are facilitated by Flanders Hydraulics Public Agency.

OUR VISION

Flanders Hydraulics Research aims to provide knowledge, knowledge products and advice on water systems in an integrated, scientifically sound and high-quality manner. In this manner, we aim to support the policy of the Government of Flanders.

OUR OBJECTIVES

These are the strategic objectives of Flanders Hydraulics Research:

1. We support the Government of Flanders in its efforts to:
   - improve the safety of navigation;
   - effectively and efficiently address flooding and water shortages, improve flood safety and focus on the management of water quantity;
   - develop safe, efficient and effective water-related infrastructure;
   - develop sustainable coastal and waterway management;
   - contribute to the waterway, coastal and port policy, as part of economic development, but while also taking into account the environmental impact.
2. We commit to the long-term objectives of the policy and the customers.
3. We form strategic alliances to improve our services and strengthen our position.
4. We develop specific scientific instruments and strive for applicable, high-quality and economically justifiable innovation.

OUR APPROACH

Together with our approximately 100 employees - who have a wide range of specialised knowledge - Flanders Hydraulics Research is committed to an interdisciplinary approach. We thoroughly analyse topics and issues before presenting methods and solutions. Each is scientifically substantiated and addresses the needs and expectations of the customer.

We follow new developments closely and gather new knowledge to use in our projects through studies, research and development. We have specific expertise that allows us to support the Government of Flanders and to advise in the areas of water management and policy, hydraulic engineering, nautics, sediment management, morphology, hydraulics and hydrology.

We also stimulate the market to develop and disseminate innovative products, applications and technologies. We undertake structural partnerships within our national and international network to test, consolidate and further develop new knowledge.

To ensure better service for our customers, we pay special attention to the planning and management of all our projects. At each stage, we strive for clear communication and optimal interaction with the customers. Within this context, we apply our ISO 9001 certified quality system.

OUR INSTRUMENTS & EQUIPMENT

Every research topic deserves a high-quality answer. Flanders Hydraulics Research can rely on a wide range of instruments and equipment for this. For a good understanding of the problem and development of solutions we can rely on:

- physical (scale) models;
- ship manoeuvring simulators;
- numerical models and supporting IT infrastructure;
- a measurement network for continuous monitoring of hydrological and physical parameters on and along navigable waterways;
- instruments for measurement campaigns;
- the sedimentological laboratory;
- our own documentation centre for literature research and desktop studies.

What do we do?

The activities of Flanders Hydraulics Research can be divided into five groups:

- study & advice;
- research & development;
- operational services;
- knowledge & information management;
- management & maintenance of research tools.

STUDY & ADVICE

The first core activity of Flanders Hydraulics Research is to provide scientific and technical support in the field of hydraulic engineering by conducting research and providing advice. In practice, this is achieved through desktop studies, by designing and building scale models, conducting scale model tests and performing numerical calculations, measurement campaigns and sample analyses. To ensure efficient performance and reliable results, we always aim for the most appropriate combination of research tools that are available.

RESEARCH & DEVELOPMENT

Flanders Hydraulics Research is committed to the development of dynamic and state-of-the-art research tools and specific expertise. Our research and development projects deliver technological innovations and specific knowledge that we can apply in our study and consultancy assignments. This allows us to continuously improve our services and products with a focus on effectiveness, efficiency and quality.

OPERATIONAL SERVICES

The Hydrological Information Centre (HIC) is part of Flanders Hydraulics Research and is responsible for the ongoing operational services for policy makers and managers of Flemish waterways and for the public. It provides specific products and services such as high- and low-water reports, real-time water levels and river flows, and forecasts of discharges and water levels (from the next few hours up to 10 days in the future). The HIC also organises helicopter flights during floods to identify the affected areas. Sediment and water samples from continuous measurements or measurement campaigns are analysed in the sediment laboratory of Flanders Hydraulics Research.

Furthermore, Flanders Hydraulics Research includes ship manoeuvring simulators which are also made available to masters, pilots and skippers for education and training.

KNOWLEDGE & INFORMATION MANAGEMENT

A large proportion of the output from Flanders Hydraulics Research is also available to the general public via the websites www.waterbouwkundiglaboratorium.be and www.waterinfo.be and the library system. Together with Ghent University, we established the knowledge centre 'Manoeuvring in shallow and confined water', with an international anchor via the website www.shallowwater.be.

We use the latest technologies to personalise the available information and to tailor the content and format to the needs and desires of the audience.

We archive the files of each project and keep the results ready for any future questions. To allow tracing and reuse of the information in future projects, we work with a system of internal version management for numerical models, databases, reports, plans and manuals.

MANAGEMENT & MAINTENANCE OF RESEARCH TOOLS

Every day we ensure a professional service in the form of reports, opinions, predictions, etc. To make this possible, enthusiastic employees are permanently working behind the scenes to manage and maintain the instruments and infrastructure.

We strive to keep all components of the research and monitoring instruments operational and functional in accordance with state-of-the-art technology. That is why we pay close attention to the management and development of these. The physical models and equipment require a coordinated use of expertise gained in Flanders Hydraulics Research. This ensures tests perfectly aligned with the wishes and needs of our customers.

We also provide real-time communication through our measurement networks in the field, the operation of the ship manoeuvring simulators and the use of numerical models. This is made possible by our own server farm, computing infrastructure, cloud services and collaboration with universities. Our IT team plays a key role and works closely with researchers and technicians to ensure optimal operation.

> We ensure scientific and technical support through professional service in the form of measurements, reports, advice, predictions, ...

Expertise and research areas

Flanders Hydraulics Research has expertise in four research domains that are strongly connected with each other:

- harbours & waterways;
- water management;
- hydraulics & sediment;
- hydraulic structures.

HARBOURS & WATERWAYS

Flanders Hydraulics Research promotes safe and efficient ship navigation to the Flemish ports and on inland waterways. Using state-of-the-art technology, we provide a scientific basis for the criteria applied to determine whether vessels may or may not be allowed on trajectories to Flemish ports and on inland waterways. We study the manoeuvring behaviour of ships, including those based on research using scale models in our own towing tank. We also work together with pilots to test the feasibility of manoeuvres as a function of current, wind, speed, tugboat assistance, etc. on our ship simulators.

Accessibility

We have a specialised team that investigates the accessibility of ports and waterways. They study the relationship between the configuration of ports and channels, local hydro- and sediment dynamics and the ship's behaviour while sailing to the ports and on inland waterways.

To improve the accessibility to Flemish and international ports and waterways, we propose solutions, often in international partnerships. These are based on measurement data, simulations and numerical and physical models that allow us to determine flow fields, sediment dynamics and ship behaviour in shallow and confined water.

Our studies influence the design of ports and lock entrances and are an important source of information in terms of the feasibility of ship manoeuvres in ports and waterways. In addition, we investigate and assess the accessibility of existing infrastructure and dimension external resources such as tugboat assistance, fendering and navigational aids. We also advise on optimisation strategies for maintenance dredging of ports and waterways. Finally, we determine the focus areas for procedures at critical ship movements.

Simulators

Our ship simulators provide a detailed analysis of all available information. Furthermore, we determine accessibility limits based on external factors such as wind, currents, presence of banks or structures or the interaction with other ships.

Accessibility is examined by our simulators in real-time or fast-time (computer-controlled). To conduct real-time simulations of the seagoing vessel, we have 'full mission' bridge simulators, the SIM 360+ and SIM 225, including tugboat simulations, which can also be coupled together. They are used for seagoing and inland simulations. We also work with the Lara simulator specifically for inland simulations.

Numerical models and software

We use numerical models of ports and waterways to calculate flow fields and

expected dredging issues for actual or fictitious scenarios.

The ProToel (Probabilistisch Toelatingsbeleid) software was developed to predict the admission policy for the Flemish ports and the access channels from the North Sea to the terminals. ProToel allows tidal port calculations to be carried out through both probabilistic criteria (on the basis of a maximum accepted risk of touching bottom) as well as deterministic criteria (on the basis of a fixed minimum keel clearance). Additionally, we analyse ship movements based on Automatic Identification System (AIS) registrations to obtain an overall picture of the traffic on the waterways.

Manoeuvres

Ships are getting bigger and bigger. They operate in waterways whose dimensions have not increased at the same rate. This means that ships have relatively less space to sail in. As a result, their room to manoeuvre is decreasing and their manoeuvrability is more difficult. Flanders Hydraulics Research focuses on sailing in precisely these difficult circumstances.

We conduct experimental research on the behaviour of ships in shallow and confined water. We carefully examine the manoeuvrability characteristics above a solid or nautical bottom. Flanders Hydraulics Research identifies the forces that are important for ship manoeuvring simulations including:

- the influence of the proximity of a bank or a quay on the hydrodynamic forces acting on the hull and on the operation of the propulsion, rudder and bow thrusters;
- forces that occur when approaching, entering and leaving locks;
- interaction with other (moored, encountered, overtaken) ships.

In addition, we perform studies on squat effects (steady vertical motions) and the behaviour of vessels in shallow water under the influence of waves.

Scale models

We conduct various tests as scale model studies in our towing tank:

- Computerised Planar Motion Mechanism (CPMM) trials or forced tests to predict ship behaviour in open and calm water as well as in waves;
- forced interaction tests between ships or ships and structures (ship-to-ship, ship-to-shore, ship-to-bottom, lock effects, etc.);
- free-sailing tests in which the ship is controlled by an autopilot navigating a trajectory in the towing tank using a steering device (propeller and rudder).

Calculations & measurements

The calculations of ship hydrodynamics in shallow and confined water are performed using numerical models, including CFD calculations. To obtain acceptable computation times in this complex domain, part of our internal computational cluster is dedicated exclusively to this research. We also carry out measurements on ships and inland vessels as validation for our models.

> We conduct experimental research on the behaviour of ships in shallow and confined water.

WATER MANAGEMENT

One of the main research activities of Flanders Hydraulics Research is to understand, explain and simulate the water discharge in rivers and canals, taking into account all the features of the waterway. Our focus is on the management of surface water, but in collaboration with other partners, we are also committed to a comprehensive approach, including rainwater and groundwater.

Flanders Hydraulics Research's expertise extends from flood models to water availability studies. Scenario analyses of the current or future state often play a central role in these, especially in terms of calculations and analysis.

We support Flemish policy makers and managers of navigable waterways and the coastal zone. Our knowledge is used to develop (local and international) water regulations in the field, to make strategic plans and to improve the operational management.

Floods

Flanders Hydraulics Research develops a wide range of activities in the field of floods. These include the operational tasks of the Hydrological Information Centre (HIC) as well as measurement campaigns during high-water situations or helicopter flights to quickly assess the situation.

Moreover, Flanders Hydraulics Research has invested in flooding studies for quite some time, mainly through numerical models. We start with a detailed representation of the current state of the river, its structures (and their management), dykes, etc. to quantify the rise of the water level and storms in the tidal area. This allows us to clearly identify the extent of floods, water depths, current velocities, etc.

We provide an updated model of all navigable waterways in Flanders and the coastal zone to quickly respond to new advice and research topics. In this manner, we can modify the boundary parameters to study e.g. the effects of climate change. Or we can study the effects of an intervention prior to the implementation by adjusting the model.

The increasing processing power of computers allows us to develop models that include a continuously growing area. We can therefore study the combined effects of storms and high river discharges, and their relationship.

Not all floods result in the same consequences. Certain areas, such as flood control areas (FCA) or controlled reduced tide (CRT) areas), are even constructed with the aim to allow them to flood more or less regularly. That is the reason we develop our flood maps using hydraulic models combined with damage models to determine the economic, environmental and social risks.

Water availability

In Flanders, a large number of people live within a limited area. Our water availability is also low compared to most other European countries. It is therefore an important exercise to achieve an optimal allocation of the available water including many complex parameters.

Water availability and water allocation models provide spatial and temporal insight into the amount of water available for the various economic sectors, households and the environment.

These highly relevant models allow us to provide insight into the impact of socio-economic developments and decisions on water availability and assess the impact of climate change.

Policy support

As technical experts, we provide support to policy makers and managers of navigable waterways and the coastal zone.

Flanders Hydraulics Research is represented in work groups for water management and policies in Flanders, Belgium and internationally. Our focus is on the international river basin districts of the Scheldt and the Meuse, however we also help develop an integrated water policy for other river basins within and outside of Europe.

For large projects, such as the Sigma Plan or the Integrated Coastal Safety Plan, we provide technical support during the entire process: from development of the vision and the initial ideas to the final plan and the implementation in the field. As an independent knowledge centre, we support scenarios for individual measures and measure programmes with figures.

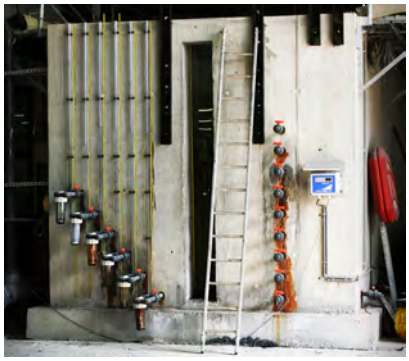
The European Flood Directive (2007/60/EC) and the Decree on Integrated Water Policy are important references. Every six years, Flanders Hydraulics Research creates a full set of maps for all navigable waterways and in doing so goes beyond what is strictly required for European reporting. We want to not only comply with the rules, but offer policy makers and managers the best possible insight into the studied water system.

HYDRAULICS & SEDIMENT

Hydrodynamic research by Flanders Hydraulics Research focuses on coasts and estuaries. We study the tides, tidal currents, waves and saltwater intrusion using field measurements, physical model tests and numerical simulations.

Research into cohesive sediment (sludge) should provide more insight into the sediment transport, sediment consolidation and turbidity in view of dredging. At the same time, knowledge of the rheology (nautical bottom) is important for determining the manoeuvrability of ships and the boundary conditions for safe access to ports.

For shipping interest, we conduct research into the safety against flooding and natural sediment and morphodynamics of large-scale structures such as sandbanks off



the coast and systems of trenches, barriers and plates in estuaries. In morphodynamic studies, we examine beach dynamics and coastal erosion in detail. This involves both the transverse transport (foreshore - beach - dune) as well as longitudinal transport. This knowledge is important to achieve the most suitable coastal defence and safety.

Hydrodynamics

Our hydrodynamic research focuses on the tides, tidal currents, waves and saltwater intrusion from coasts and estuaries. We mainly study the hydrodynamics of the North Sea and the Scheldt estuary, but other areas are also investigated to expand our knowledge of processes. We utilise field measurements, physical model tests and numerical simulations.

To balance the computing time and level of detail, a flexible numerical modelling tool is required to both understand the entire system as well as make detailed conclusions about specific locations. In addition to using commercial and open source software, Flanders Hydraulics Research also develops proprietary tools and schematisations tailored to the coastal and Scheldt research.

To address concerns regarding saltwater intrusion, a 2D representation is often insufficient. For this, Flanders Hydraulics Research uses complex 3D models that, for instance, can demonstrate the water column variation.

Cohesive sediment

Research into cohesive sediment (silt) provides Flanders Hydraulics Research with better understanding of sediment transport, sediment consolidation and turbidity.

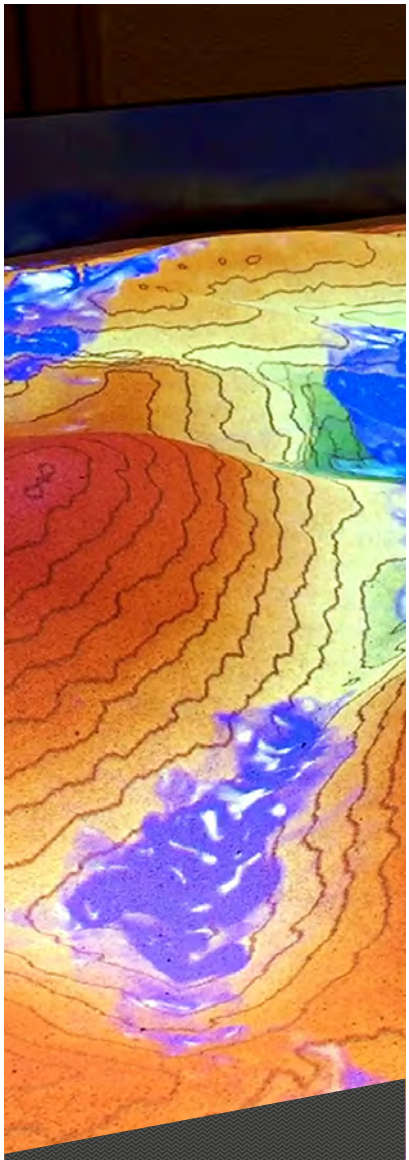
The characteristics and movement of sediment volumes that we identify are not only used for dredging. Knowledge of the rheology (nautical bottom) is also important for determining the manoeuvrability and boundary conditions which provide ships safe access to the ports. Research into cohesive sediment by Flanders Hydraulics Research also has significant economic importance.

To gain insight in the possibility of a regime shift towards a hyperturbid state in the Schelde estuary, the behaviour of cohesive sediment transport (mud) is compared with other European estuaries. Together with our partners, we conduct research on tipping points for sediment transport in the estuary to ensure a sustainable, safe and accessible estuary.

Morphodynamics

In morphodynamic studies of the coast, Flanders Hydraulics Research investigates both longitudinal transport and transverse transport. Transverse transport studies focus on foreshore, beach and dune erosion caused by storms. With this knowledge, we support coastal safety and help create sustainable coastal defences.

The morphological evolution of sandbanks near the coast and channels and sandbars in estuaries are also among our expertise. Our knowledge about the morphology of estuaries is important to guarantee the accessibility of the ports, to propose sustainable flood protection and to maintain the naturalness of the estuary. Therefore, understanding the long-term evolution of the estuary and the coastal zone is crucial.



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HYDRAULIC STRUCTURES

Flanders Hydraulics Research examines the behaviour of hydraulic structures and their interaction with the environment. They are affected by e.g. current, ship waves, wind waves and water pressure. The expertise we gain in this area of research is aligned closely with our goal to constantly pursue safe, smooth and smart mobility. Furthermore, we want to help create an infrastructure that is integrated and managed effectively for society and the economy.

For water-retaining structures such as sea and river dykes, we investigate the effect of the erosive action of hydraulic forces on the stability of the dyke or components thereof and determine the impact of the potential failure of the dyke.

When new locks are designed or existing weir lock complexes are renovated, we provide advice and/or a hydraulic study. In this manner, we also contribute directly to the movement of fish through weir lock complexes using fish passes. We also perform hydraulic studies for other hydraulic structures such as dams, inlet and outlet structures and culverts.

Flood defences

Flanders Hydraulics Research specialises in policy-supporting advice and (preliminary) design, monitoring and evaluation of flood defence structures. We have specific expertise in banks, retaining walls, river dykes and sea dykes and carry out research in breach sensitivity, failure rates, failure mechanisms and breach growth.

For coastal protection structures such as sea dykes and dunes, groynes, breakwaters and storm walls, we investigate the interaction of waves, currents and sediment movements. We do this using in situ measurements, scale model tests and advanced numerical models for wave and current forces which give us insight into tides, wave impact, wave run-up and wave overtopping.

We also carry out dimensioning of the revetment of river dykes, sea dykes, overflow dykes and ring dykes for flood control areas. First we analyse or measure the erosive action of hydraulic forces acting on the dykes and then we determine the need, type of revetment and dimensions.

Locks

Levelling system design

Flanders Hydraulics Research specialises in studies for levelling systems in locks. Using a desktop design, we estimate the required flow section for the levelling system. We then draw the geometry and examine whether there is any air entrainment or cavitation.

With the help of various specialised software packages (including our own developed programme vul_sluis), we simulate the filling and emptying of the entire lock chamber and identify the forces that occur on vessels in the lock chamber. We can also build a scale model of the lock chamber or simulate the flow in the lock chamber with CFD modelling. Similarly, the local flow pattern of specific components of the levelling system can be simulated and analysed.

> We also carry out dimensioning of the revetment of river dykes, sea dykes, overflow dykes and ring dykes for flood control areas.

We perform field measurements in existing or new locks to increase the ships' comfort during filling or emptying of the lock chamber and to optimise the operation of the lock system. We therefore measure:

- the variation in the time of the rising speed of the water;
- the slope of the water level in the lock chamber;
- the opening speed of valves or gates;
- any hydraulic losses of the lock chamber levelling system;
- waves in the outer port or canal reaches caused by the locks.

Bottom protection design

We also design the bottom protection in the outer ports of the lock or alongside the quay walls. For this, we first determine the hydraulic forces on the bottom using a desktop study or numerical modelling. Based on this result, we propose the type of bottom protection required as well as the dimensions. The hydraulic forces on gates (e.g. by waves) can also be determined.

Fish passes

To resolve issues with fish migration, Flanders Hydraulics Research conducts research for the hydraulic design of fish passes. This often happens in close cooperation with the Research Institute for Nature and Forest (INBO), which plays an advisory role on ecological aspects and criteria. Through desktop studies, we determine the most appropriate fish pass type (e.g. V-shaped basin stairs or vertical-slot passages) and the best spatial and hydraulic integration.

In the event of more complex design or research topics, e.g. creating an optimal attraction flow or implementing in more complex spatial and/or hydraulic situations, we conduct studies with scale models and numerical models (e.g. CFD modelling).

Flanders Hydraulics Research not only provides advice and research on the design of new fish passes, but also evaluates the hydraulic performance of existing fish passes. We perform field measurements for this including water levels, discharges, current velocities and current patterns.

Other hydraulic structures

Flanders Hydraulics Research specialises in studies on all types of water-bearing structures such as inlet and outlet structures, drainage culverts, dams, sluices, supply and discharge to pumping stations and turbines, etc.
We use desktop studies to determine the necessary flow section, to estimate the hydraulic losses, to design the stilling basin and to control the air entrainment at the inlet of the structure.

To simulate the discharge, current velocity and pressure in the pipes, we use specialised software packages. Based on a scale model study or CFD modelling, we can determine the design of the stilling basin or the flow pattern (into or out of these constructions) in greater detail as well as the hydraulic loss of the structures.

We identify the current velocities at the bottom using numerical models or scale models to determine the need, type and dimensions of the bottom protection next to the structures.

We also conduct field measurements to gain more insight into the hydraulic operation of these structures. We determine the discharge through the structures and the water level upstream and downstream of the constructions. The current velocity into or out of the structure can also be measured as well as the position of gates or valves.

We use desktop studies to determine the necessary flow section, to estimate the hydraulic losses, to design the stilling basin and to control the air entrainment at the inlet of the structure.

Operational services

The operational measurement network of the Hydrological Information Centre (HIC) includes real-time monitoring of water levels, discharges and precipitation at approximately 200 Flemish locations. By developing predictions, the HIC supports the daily water management in navigable Flemish waterways.

DEVELOPMENT OF FORECASTING & WARNING SYSTEMS

The HIC uses accurate forecast models provided by the latest measurement information from its own measurement network, but also utilises similar measurements and predictions from Wallonia, Brussels, France and the Netherlands in addition to meteorological forecasts. Several times per day, the water levels and discharges are predicted for the next 48 hours.

Continuous monitoring ensures the operation of the measurement network and the availability of the measurements and predictions. When significant rainfall or high water levels occur in tidal areas with an increased risk of flooding, constant monitoring of the water system is provided. A permanent team of experts is also in direct contact with all the relevant agencies. This team is responsible for preparing flood messages and communicating them with the crisis centres.

To improve access to the predictions, flood messages and all other HIC products by professional agencies and the public, the HIC has developed the website www.waterinfo.be together with the Flemish water managers.

All real-time measurements and predictions from all agencies, including interpretations of the current and expected situation, will be made available on this site.

SEDIMENTOLOGICAL RESEARCH

We not only monitor the water levels and discharges on the Flemish waterways, we also study the sediment transport and other physical parameters. We continuously collect water samples at fixed measurement locations or during regular measurement trips which we analyse at our own sedimentological laboratory. The measuring devices used in the field are also calibrated here.

Interest in sediment has steadily increased in the past decade because of the importance for planning dredging works, safeguarding access to ports, the discharge behaviour of rivers and the risk of flooding. Contaminants also easily attach to sediment particles and are carried by the river flow. Based on the unique composition, shape or colour of the particles, we can create a sediment classification. Even when sediment is carried off, we can still trace the origin of the particles.

For an overview of the analyses that we perform and the parameters that we measure, please refer to our 'Measurement techniques & instruments'.

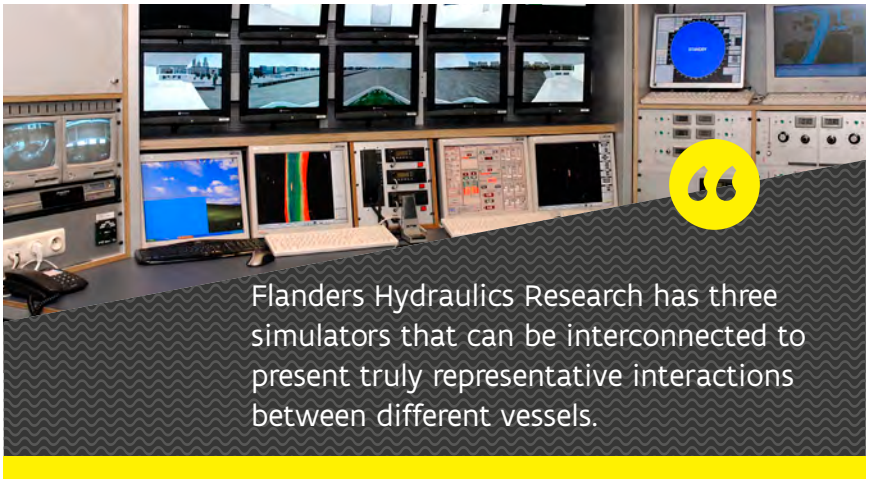
SHIP MANOEUVRING SIMULATORS

A ship manoeuvring simulator is a physical ship's bridge with a projected virtual environment. It is designed to teach or to test manoeuvres on waterways or ports with every possible ship type and under various conditions (such as weather or tide).

Flanders Hydraulics Research has three simulators that can be interconnected to present truly representative interactions between different vessels.

The SIM 360+ and SIM 225 simulators allow operation with various types of ships, including seagoing vessels, coasters and tugboats. The Lara simulator is a ship manoeuvring simulator specifically for inland vessels.

Our simulators have been developed from the need to study and conduct research on navigability, accessibility and manoeuvring behaviour. They are also a useful up-to-date tool for the education and training of masters, pilots and skippers.



Knowledge & information management

The Open FHR Archive is an online service accessible to experts and the public. They can freely consult a wide range of digital brochures, own publication series and research results via the website www.water-bouwkundiglaboratorium.be ('Open FHR Archive').

OPEN FHR ARCHIVE

In this manner, Flanders Hydraulics Research aims to stimulate the visibility, dissemination and use of its research results and promote scientific communication to the greatest extent possible.

Government agencies, scientific institutes and consultancy firms can obtain FHR studies digitally through the usage agreement form. Flanders Hydraulics Research also makes data, documentation and infrastructure available for the media and other interested bodies.

NETWORKING & COOPERATION

Flanders Hydraulics Research participates in a great number of knowledge networks and enters into cooperation agreements with domestic and foreign partners to collaborate on thematic knowledge development.

Within the framework of international projects and based on the request or subject, we enter into partnerships with domestic and foreign knowledge institutes (such as universities and research institutes) and managers as well as with private parties.

A number of these partnerships are long-term and formalised in cooperation agreements with partners that have complementary expertise to allow us to always offer customers the best possible service. Within these agreements, we always respect the rules in force as part of the Government of Flanders such as the law on public procurement or public access.

Coastal research or the knowledge network on 'dykes' are excellent examples of the collaboration with universities as well as other specialised (government) services.

Knowledge centre 'manoeuvring in shallow and confined water'

The knowledge centre 'Manoeuvring in shallow and confined water' was established in 2008. It aims to gather, expand and promote scientific knowledge and practical experience on the behaviour of ships in shallow and confined water. As such, it provides support for the admission policy and the development of ship waterways to the Flemish ports and inland waterways.

The objectives of the knowledge centre are:
- efficient documentation management;
- accurate data management;
- complementary international cooperation.

The knowledge centre will be further developed in cooperation with Ghent University, section Maritime Technology, and disseminate its knowledge globally through the English website www.shallowwater.be. It is also responsible for the organisation of the international MASHCON conferences.

Instruments and equipment

Flanders Hydraulics Research has significant expertise and tools available for both measurements in the laboratory as well as measurement campaigns in the field.

In addition to continuous monitoring of the operational services provided by the HIC, we perform measurement campaigns for various types of research topics and projects for customers. As a result, we can utilise the most optimal combination of sensors for every type of measurement.

MEASUREMENT TECHNIQUES & INSTRUMENTS

An overview of the main types of measurements that we can perform follows. Depending on the project requirements and in consultation with the customer, we determine the most appropriate combination of measurement techniques, frequency, duration and sensors. Flanders Hydraulics Research is not committed to a specific manufacturer or supplier for the purchase of measuring instruments. Furthermore, we personally develop specific instruments that are not available on the market.

Measurements in situ

For in situ measurement campaigns, Flanders Hydraulics Research possesses the expertise necessary to carry out the entire process: from exploration of the measurement locations, organisation and preparation of the campaign, through the mobilisation, implementation and demobilisation, to the delivery of data (including a factual data report). We use an extensive set of high-tech measuring equipment, including:

- equipment to measure the flow rate and direction: various types of Acoustic Doppler Current Profilers (ADCP), Acoustic Doppler Velocimeters (ADV) and electromagnetic velocitymeters;
- instruments to measure the water level and wave run-up (acoustic and pressure);
- turbidity, pressure, conductivity, oxygen and temperature sensors;
- various equipment for sampling water and other materials;
- RTK-GPS for height and position determination;
- measuring frames to place on the sea/river bed;
- positioning system for ship motions;
- angle sensors and rotational speed indicators;
- high-definition cameras.

Flanders Hydraulics Research also provides advice on specialised measurements carried out in situ to identify silt layers and properties. We guide customers in using the right geophysical measuring devices and correctly evaluating the data obtained. These include the following equipment:

- acoustic bathymetric equipment (single-beam and multi-beam);
- in situ density profiling equipment;
- rheological equipment.

Measurements on physical models

To perform measurements on scale models and other equipment at Flanders Hydraulics Research, we determine the most appropriate instrument choice and method. This is based on the parameters to be measured and the available measurement space on the model. The possible measuring instruments include:

- electromagnetic and acoustic velocimeters and discharge meters;
- pressure sensors for static or dynamic pressure;

- wave gauges;
- laser position meters;
- total station and electronic levelling equipment;
- angle sensors and rotational speed indicators;
- force sensors;
- water level gauges;
- calibration devices for control and measurement signals and strain gauges;
- vision systems including Particle Tracking Velocimetry measurements;
- custom-made measuring instruments for specific applications.

Laboratory analyses

We most frequently perform the following analyses in our sedimentological laboratory:
- grain size distribution;
- determination of rheological characteristics;
- density determination;
- determination of lime and organic content, sediment concentration, salinity and Cl content.

We have devices to determine the dry matter content, the loss on ignition and the sintering of samples. For an automated determination we use a PrepAsh, for a manual analysis we use a drying oven and a muffle furnace. With the automatic filtration machine that was developed in-house, we can determine said contents on water samples. Furthermore the sedimentological laboratory has an ion chromatograph and equipment for lyophilisation and making digital microphotographs with a light microscope and a scanning electron microscope. The latter is also equipped with an energy-dispersive X-ray spectroscope for elemental analysis of samples.

In the sedimentological laboratory we conduct innovative project-based research and laboratory analyses, including light and electron microscopy using EDX and the option to include digital micrographs.

NUMERICAL MODELLING

We use a variety of commercial software, open source solutions and proprietary programmes and tools for our numerical modelling. Flanders Hydraulics Research has the proper in-house expertise to select the most appropriate tool from the existing portfolio of models for every application. We continuously maintain and extend the portfolio.

We are familiar with numerous software packages for a wide variety of applications. The most important are listed below.

Hydrological models

Flanders Hydraulics Research uses hydrological models to calculate the run-off from a river basin to the waterway. We use these to define the boundary conditions to be used in hydraulic models and water balance models.

Most hydrological models, especially operational models, from Flanders Hydraulics Research are conceptual reservoir models. For research assignments, we make comparisons between conceptual models (NAM, PDM, etc.), mixed conceptual physics-based models (e.g. WetSpa) and highly detailed, physics-based and fully distributed models (e.g. MIKE SHE).

Hydrodynamic models

Flanders Hydraulics Research mainly uses 1D hydrodynamic models to calculate water levels and discharges in rivers and their floodplains as a function of time. We use models such as MIKE11 which we maintain and update to reflect the actual situation as closely as possible.

In terms of 2D and 3D hydrodynamic models, a range of applications is possible. Flanders Hydraulics Research uses these models for the coastal zone, the river deltas and for specific issues such as saltwater intrusion in ports. These software packages also include modules to simulate sediment transport.

Depending on the functionalities required for the job and the partners, we apply programmes such as TELEMAC, Delft3D and MIKE21. We work on new developments for several of these software packages by writing new code for specific applications or modules, or by extensively testing new functionalities.

We use hydrodynamic models in both studies, advice and research as well as for our operational forecast models. Typical study topics are scenario analyses to support water management, planning and policy development. In addition to water movement, these software packages also contain morphology modules.

For the operational forecast models, Flanders Hydraulics Research connects its hydrological and hydrodynamic models to the WISKI database via web services. This database continuously stores information on rainfall, discharges, water levels and sediment quantities based on field measurements. This allows us to make forecasts at least 4 times per day for the next 48 hours for all navigable waterways in Flanders.

NEVLA model

The NEVLA model, short for 'NEderlands-VLAams' [Dutch-Flemish], is a hydrodynamic model developed in the SIMONA software. It encompasses the Belgian coastal zone, the Western Scheldt, the Sea Scheldt and the Durme, Rupel, Nete, Dijle and Zenne tributaries. All these rivers are included in the model up to their tidal boundary. SIMONA stands for 'SImulatie MOdellen voor de NAtte waterstaat' [Simulation models for wet water management] and the instruments which the Dutch government (Rijkswaterstaat) uses for its water management tasks. By creating and maintaining the NEVLA schematisation in this software, the model can easily be used in an international (Flemish-Dutch) context.

The model is maintained by Flanders Hydraulics Research in 3D and 2D versions. The 3D version is mainly used for salinity and sediment (sand and silt) transport calculations. The 2D version performs computations more quickly and provides operational predictions.

Water balance models

We rely on water balance models (such as MIKE Basin) for studies on water availability and water allocation. We utilise them, for example, in scenario analyses of changing climatic conditions or changing water demand.

Wave models

Numerical modelling of waves is a way to study the behaviour of coastal defences. Flanders Hydraulics Research mainly uses SWASH, DualSPHysics and XBeach. We are also actively involved in the further development of DualSPHysics. The XBeach package is also used for coastal morphological studies.

Sediment transport and morphological models

Knowledge of sediment dynamics and morphodynamics in the waterways, estuary and coastal zone is described in mathematical models. Knowledge gaps are addressed through targeted research and measurement campaigns to improve the weaknesses in the models in a step-by-step, structural manner. Basic models for the entire scope are kept up-to-date by modifying geometry and boundary conditions of executed works and evolutions on the field.

Various types of mathematical modelling can be utilised depending on the application. For the shorter time scales, process models driven by hydrodynamic models are the most appropriate. For longer time scales, models with an idealised process description or idealised geometry are also developed. In addition, empirical modelling driven by sediment-related or morphological data is applied.

Shipping traffic analysis

Flanders Hydraulics Research has a specific tool to analyse maritime and inland shipping traffic.

AIS data analysis tool
Flanders Hydraulics Research developed a tool to analyse Automatic Identification System (AIS) data in a flexible and effective way. AIS data contains information that can be used, for example, in the analysis of shipping traffic for operational purposes or for specific manoeuvres at specific locations.

Because data volumes are often very large, the AIS data analysis tool allows filtering of the data on vessel dimensions, on geographical restrictions or on voyage characteristics. To visualise the data, the AIS data analysis tool includes export options in various formats which are compatible with GIS viewers.

Computational fluid dynamics

Computational Fluid Dynamics (CFD) is used to study currents in liquids and gases (such as water and air) in a numerical manner using computers.

The Navier-Stokes equations are solved in discrete form which allows us to simulate detailed flow patterns. CFD is used to determine the hydrodynamic forces on ships and to simulate the flow through or in the vicinity of hydraulic structures.

FINE™/Marine
The FINE™/Marine software package developed by NUMECA calculates the turbulent air-water flow around a vessel based on the Reynolds Averaged Navier-Stokes (RANS) equations. Flanders Hydraulics Research focuses its research on simulating experimental results obtained through research conducted in the towing tank (e.g. ship-bank interaction, ship-to-ship interaction and the behaviour of ships in waves). At the same time, in case Flanders Hydraulics Research has no appropriate experimental facilities available, we use this software to provide the necessary inputs (e.g. wind coefficients of ships) for ship manoeuvring models.

OpenFOAM
OpenFOAM is a free, open source CFD software developed by the OpenFOAM Foundation. The package includes multiple solvers to simulate specific flow problems. Flanders Hydraulics Research uses OpenFOAM mainly for the modelling of local flow processes through or near hydraulic structures.

Flanders Hydraulics Research uses hydrological models to calculate the run-off from a river basin to the waterway.

Hydrostatics of vessels

Flanders Hydraulics Research can utilise a wide range of software for hydrostatic calculations of vessels, each with its own features and capabilities.

DELFTship
DELFTship Pro is a complete design package for applications in the maritime sector. It allows us to enter every possible hull shape and offers great flexibility. Because of its visual approach, it can be used for nearly any floating object.

Rhino and Orca3D
This programme calculates the hydrostatics and stability of a vessel and can manage a wide range of input and output files.

Hydrodynamics of vessels

We also have various research capabilities for the study of the hydrodynamics of vessels.

ROPES
ROPES is a project that studies the effect of passing vessels on the movement of moored vessels. The size of vessels is constantly increasing and new terminals are being continuously developed along waterways and port access routes. It is therefore especially important for the planning and development of the operational activities in the port to properly identify the impact.

ProToel
Flanders Hydraulics Research developed the ProToel software together with Ghent University's department of Maritime Technology. It is a user-friendly application that determines the tidal windows of marginal ships sailing to Flemish ports based on both probabilistic criteria (maximum probability of touching bottom) as well as deterministic criteria (minimum keel clearances, maximum current velocity, etc.).

A user can simulate the desired voyage in the ProToel GUI by selecting the vessel, cargo condition, the route with the corresponding sailing speeds and the desired date(s) of departure. At each waypoint in the voyage, ProToel requests the predicted hydro-meteorological data (tide, current and directional wave climate) from a web service which Flanders Hydraulics Research hosts. For long-term calculations, it is possible to define astronomical hydro-meteorological data in the local database.

ProToel calculates the vertical motions of the vessel resulting from waves (dynamic vertical movement) and squat (stationary vertical movement) using a database of ship movement characteristics (obtained from model tests and numerical calculations).

Filling & emptying locks

Flanders Hydraulics Research uses programmes that describe the lock filling and emptying process in schematic form. They calculate the variation of the water level in the lock chamber, the variation of the discharge through openings in gates or culverts and the variation of longitudinal forces on the ship in the lock chamber (transverse forces cannot be calculated), all as a function of time.

LOCKFILL
The LOCKFILL programme is provided free of charge by the independent research institute Deltares. The calculation method is based on scale model research, desk studies and previously developed calculation programmes. LOCKFILL was commissioned by Rijkswaterstaat and developed by Deltares in the period 1989-1993. This programme allows the filling and emptying of a lock through openings in the lock gates to be simulated and the longitudinal forces on the vessel in the lock chamber to be calculated. To a limited extent, it is also possible to study levelling systems with short culverts and a stilling basin in LOCKFILL.

vul_sluis
Vul_sluis is a (Matlab) programme developed by Flanders Hydraulics Research and based on the available literature for the LOCKFILL programme. It was validated using measurement data from literature and additional measurement data from Flanders Hydraulics Research. This programme also makes it possible to simulate the filling and emptying of a lock through openings in the lock gates and calculate the longitudinal forces on the vessel in the lock chamber.

During the development of the vul_sluis programme, only the levelling through openings in the lock gates was taken into account. Levelling systems with short culverts and the longitudinal component of the force on the vessel as a result of differences in density are hereby not considered.

Impact of floods

In addition to determining physical parameters such as water levels and rising rates in flooded areas, Flanders Hydraulics Research also calculates the impact of floods by estimating damage and casualties. We do this to compare the risk before and after an intervention or, for example, to calculate the effects of climate scenarios.

LATIS
To calculate the impact of floods, Flanders Hydraulics Research developed a specific GIS tool in cooperation with Ghent University called LATIS. LATIS is used to determine flood damage and risks. The tool calculates both the economic risk (in euro/year) as well as the risk of casualties (in victims/year). This flood risk is the product of the probability of flooding and the damage caused by the flood. The damage caused by a particular flood is determined by the water depth and the maximum damage, which in turn depends on the type of land use and socio-economic context.

LATIS uses a very detailed land use map specified to plot level. The exact location of (residential and industrial) buildings, roads and other structures is identified. Based on this land use information and socio-economic data, it is possible to establish a potential damage map. This is combined with several flood maps for various repeating periods to create a single risk map. With the aid of damage functions, the actual damage is calculated based on the water depth as well as the current speed and the rate of the rising water.

LATIS plays an important role in meeting the requirements of the European Flood Directive (Directive 2007/60/EC). The package is built using Microsoft.NET with the aid of the Idrisi API (raster-GIS, Clark Labs). The user interface and the algorithm of the model are implemented in C#.Net.

SHIP MANOEUVRING SIMULATORS

The ship manoeuvring simulator is an instrument to test designed waterways in a virtual environment. Flanders Hydraulics Research has three simulators: SIM 360+, SIM 225 and Lara.
SIM 360+ and SIM 225 allow sailing simulations with various types of ships such as seagoing vessels, coasters and tugboats. Lara is a ship manoeuvring simulator specifically for inland vessels.

In a simulator, ship manoeuvres are simulated as follows:
- motions of the ship can be observed by the instruments on the navigation bridge and through the windows (exterior visuals);
- the navigator observes how the ship behaves;
- the navigator uses adaptive commands (rudder, telegraph, tugboat assistance) to steer the ship;
- the forces on the ship are calculated (mathematical ship manoeuvring model);
- the speed and new position of the ship are determined and displayed on the instruments and through the exterior visuals.

Objective

The simulators are used for research and manoeuvre training.

When used for research, the experienced navigators are provided a manoeuvring task. Afterwards, a statistical analysis of the manoeuvres takes place. This allows the condition to be evaluated and, for example, to estimate the safe navigation path width. We conduct various types of simulation research to:
- design ports and waterways;
- optimise nautical procedures;
- determine the limits for safe traffic (risk analysis).

Manoeuvring training for pilots and navigators entails practising specific manoeuvres.

SIM 360+

Characteristics Ship's bridge:
- navigation equipment for steering various types of vessels (seagoing, coastal shipping and Voith-Schneider tugboats);
- automatic radar plot device (ARPA radar);
- quadrophonic sound system;
- VHF radio;
- Electronic Chart Display Information System (ECDIS).

Exterior visuals:
- computer-generated perspective image of the surroundings projected on a cylindrical screen;
- field of view: 360° horizontally and 35° vertically;
- fog, mist, twilight and night vision.

Instructor's room:
- operator console to select, develop, start and stop voyages;
- control of target vessels;
- set atmospheric conditions and the time of the day;
- opening and closing of bridges and lock gates;
- operate traffic lights;
- operating console for 4 tugboats (classic, Voith-Schneider, Z-Peller).

Mathematical manoeuvring model:
- calculation of hydrodynamic forces, shallow water effects, restricted water effects;
- propulsion;
- aerodynamic forces;
- contact forces and interaction with encountering and overtaking target vessels.

SIM 225

Characteristics
The SIM 225 ship manoeuvring simulator is nearly identical to the SIM 360+, except for the exterior visuals. The image of the outside world is projected on a cylindrical screen with an image field of 225° horizontally and 35° vertically. It is possible to change the viewing direction so that the ship can be visualised from bow to stern.

Lara

Characteristics Wheelhouse:
- autopilot for the rudder control;
- telegraph;
- dual bow thruster control;
- Electronic Chart Display Information System (ECDIS);
- radar;
- adjustable camera view;
- wheelhouse height adjustment;
- indicators of course, rudder angle, rate of turn and numerous others.

Exterior visuals:
- computer-generated perspective image of the surroundings displayed on seven 52" LCD monitors with full HD resolution;
- 210° field of view;
- fog, mist, twilight and night vision.

Instructor's room:
- operator console to select, develop, start and stop voyages;
- control of target vessels;
- set atmospheric conditions and the time of the day;
- opening and closing of bridges and lock gates;
- operation of traffic lights.

Mathematical manoeuvring model:
- calculation of hydrodynamic forces, shallow water effects, restricted water effects;
- propulsion;
- aerodynamic forces;
- contact forces and interaction with encountering and overtaking target vessels.

Custom models

In addition to the permanent models described below, Flanders Hydraulics Research also designs custom models for specific studies of a particular area. In the multi-purpose indoor space of our test halls, approximately 5,000 m² is available to design custom scale models in consultation with the customer. The existing infrastructure (e.g. overhead cranes) and available tools allow us to study and test a wide range of hydraulic, sediment-related and nautical structures.

ZEEBRUGGE MODEL (CUSTOM)

Currently, approximately 2,000 m² of our halls is occupied by a specially designed scale model of the port of Zeebrugge for long-term trials.

In recent years, the Government of Flanders has invested heavily in dredging to deepen the access for large vessels to the port of Zeebrugge. This currently enables ships with a draft of 15.5 to 16.0 m to reach the port. However, the navigation window, which is the access time in and out of the port, of such vessels and LNG carriers is limited to approximately 4 to 6 hours per day. This is because of the large cross flow at the port mouth and difficulties associated with dredging the sludge layer in the outer port. Furthermore, the port of Zeebrugge faces the issue of siltation in which the silt present on the seabed flows inwards during the twice daily flood stage.

Problems with tidal flow

The current along the Flemish coast is generally parallel to the coastline. During the flood stage, water from the Strait of Calais flows along the Flemish coast towards the Western Scheldt and during ebb stage flows away from the Western Scheldt in the opposite direction. Near the port of Zeebrugge, the flow parallel to the coast concentrates in front of the port mouth, creating a strong cross flow in the fairway. During the period around the high tide, this current is so strong that large ships can not safely enter or leave the port. This is a significant limitation for the port of Zeebrugge since at that moment, the water depth is the greatest and provides the best access for the largest ships.

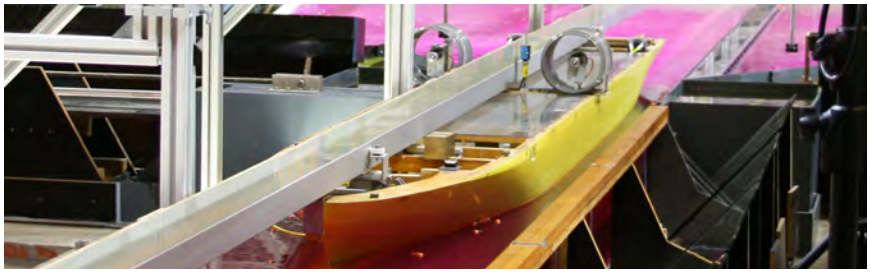
Modelling

Flanders Hydraulics Research is studying this issue using three different research tools: detailed numerical models, ship simulators and a large scale model. The cross flow at the port mouth and in the fairway are studied in detail, for both the current situation and potential modified layouts.

The large scale model and accompanying steering software were designed completely in-house. The model includes a 15 km coastline (from Blankenberge to Knokke) and extends 10 km into the sea, past the 'Scheur' fairway. The scale model simulates a complete spring tide, including the correct variation in the changing water level and current throughout the entire tidal cycle. The current velocities and flow patterns are measured and analysed in detail.

Features of the scale model of Zeebrugge:
- horizontal scale: 1/300;
- vertical scale: 1/100;
- velocity scale: 1/10;
- time scale: 1/30;
- discharge scale: 1/300,000;
- tidal cycle: 25 minutes (= 12.5 hours in reality);
- amplitude at mean spring tide: 4.3 cm (= 4.3 m in reality).

In the multi-purpose indoor space of our test halls, approximately 5,000 m² is available to design custom scale models in consultation with the customer.



Lock model

The nautical lock model allows us to study a vessel both entering and leaving a lock chamber. The ship model sails along a guide rail which forces a straight trajectory while the lateral forces at the front and rear of the ship model are measured. The guide rail can impose a well-defined drift angle or eccentricity on the vessel in relation to the axis of the lock chamber. The ship model enters or leaves the lock chamber under its own power and is controlled by the ship's propeller. We can also simulate longitudinal tugboat assistance by using aeroplane propellers mounted on the deck.

The lock chamber is fitted with a lock gate which can be opened at a specified speed. This allows the lock chamber to be filled with water of a different density compared to the approach zone (e.g. salt water-fresh water) to study the density exchanges during the tests. When the water in the lock chamber is dyed, an advanced camera system can visualise the currents.

Characteristics (basic configuration)

Approach channel:
- length: 38.00 m;
- width: 3.50 m;
- maximum water level: 0.32 m.

Lock chamber:
- length: 6.10 m;
- width: 0.69 m;
- removable bottom to create a threshold.

In addition to the basic configuration, the following changes are possible:
- shorten and narrow the lock chamber;
- install a second lock chamber for lock-lock tests;
- apply a bank profile in the approach zone and guide walls for the lock chamber;
- schedule lock culvert outlets, with accompanying filling and emptying laws.

Wave flumes

The test halls at Flanders Hydraulics Research include two wave flumes to test the resilience of hydraulic structures.

We can digitally generate both regular (monochromatic) and irregular (spectral) wave patterns. The control software allows the generation of standard wave spectra (JONSWAP, Pierson-Moskowitz) as well as user-defined spectra (e.g. measured in situ).

Large wave flume

Use:
We can conduct various types of research using 2D scale models:
- stability of beaches;
- stability of dykes and breakwaters;
- comparative research between various types of top layer elements;
- porosity of armourstone layers;
- water pressure and wave force on structures;
- wave run-up and wave overtopping on dykes;
- wave propagation over a specific bottom profile;
- etc.

Dimensions:
- length: 70.00 m;
- width: 4.00 m;
- height: 1.40 m.

The large wave flume is fitted with a piston type wave generator. The stroke length wave maker is 60 cm allowing for a wave height of 65 cm to be generated at a water depth of 90 cm.
The dimensions of the large wave flume allow research to be conducted on scale models with conventional scale factors between 1/25 and 1/40.

Small wave flume

Use:
The small wave flume allows research on:
- flow over (movable) bottoms;
- interaction between waves and current;
- water pressure and wave force on structures;
- wave run-up and wave overtopping on dykes;
- etc.

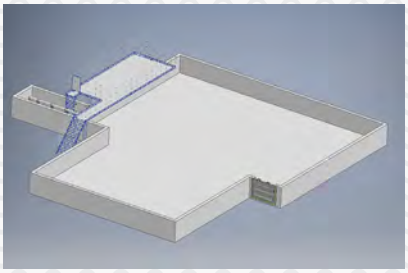
Dimensions:
- length: 31.70 m;
- width: 0.70 m;
- height: 0.86 m.

The middle portion of the flume is fitted with 20 metre long glass walls.
The small wave flume is fitted with a piston type wave generator. The stroke length of the baffle is 30 cm allowing for a wave height of 40 cm to be generated at a water depth of 60 cm.
The height of water in the flume can be varied in accordance with a given tide. A pump with a maximum flow rate of 175 l/s can generate currents in the channel in the direction of the wave propagation as well as in the opposite direction. The maximum current velocity is 0.3 m/s.
Due to the dimensions of the small wave flume, the conventional scale factors for scale models in this flume are between 1/40 and 1/70.

Wave tank

Use:
Flanders Hydraulics Research uses the wave tank to test various approaches and extensions and choose the best solution for a specific port. Furthermore, we can perform wave studies for coastal safety. 3D scale models can be built in the wave tank to conduct the following research:
- 3D stability of breakwaters and breakwater heads;
- wave run-up and wave overtopping on (sea) dykes and quay walls;
- wave intrusion in harbours;
- water pressure and wave force on structures.

In 2016, Flanders Hydraulics Research took a major step forward in terms of realistic modelling of waves on scale models. We built a completely new wave tank in accordance with the current international standard including a multi-directional wave paddle. This allows us to generate both long-crested oblique waves and short-



crested waves (from various directions simultaneously). Similarly, active wave absorption is applied so that reflected waves in the wave tank are not reflected again by the wave paddle.

Dimensions:
- length: 19.70 m;
- width: 17.40 m;
- height: 1.20 m.

Current flumes

Use:
The current flume is used to conduct research on topics such as current patterns, head losses and such in locks, fish passes, flood control areas (FCA), reduced tidal areas (RTA), etc.

Large current flume

Dimensions:
- length: 56.20 m;
- width: 2.40 m;
- height: 1.45 m.

The maximum discharge in this channel is 400 l/s and the maximum water depth is 1.30 m. At the downstream end, the water level can be adjusted using a tilting weir.

Small current flume

Dimensions:
- length: 34.80 m;
- width: 0.56 m;
- height: 0.76 m.

This flume is fitted with 20 m long glass walls and can be used as an inclined flume by adjusting the movable bottom.

It is fitted with a carriage and can be used to calibrate measuring devices.

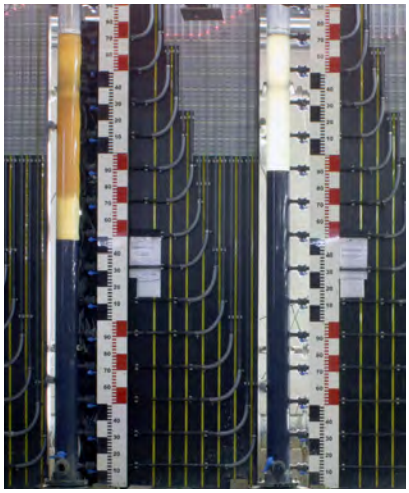
Multifunctional test basin

Use:
This test basin can be used to conduct research on:
- locks (design of filling and emptying systems and hawser forces);
- controlled flooding areas with reduced tide (design of inlet and outlet structures and submersible dykes);
- testing confluences (e.g. the attraction flow of a fish pass at a weir lock complex);
- etc.

Dimensions:
- length: 19.00 m;
- width: 9.80 m;
- height: 1.60 m.

The test basin is divided into two sections:
Tank A: zone available for models of 18.00 m x 4.90 m. This tank can be used as a current flume with a maximum discharge of 400 l/s. Downstream, the water level can be adjusted using a tilting weir (height: 0.56 m). The maximum water level is 1.20 m.

Tank B: zone available for models of 16.5 m x 4.00 m. This basin is mainly used for research on locks. A constant water level can be imposed both upstream as well as downstream using spillways. The maximum discharge is 200 l/s. This tank can also be adapted and used as a current flume. The maximum water level is 1.20 m.



Sediment test tank & consolidation columns

The sediment test tank is a multi-purpose concrete tank which allows research to be conducted on various aspects of silt bottoms. Built with various compartments, the tank allows sludge with different properties to be created and used. The sludge may or may not be applied in several silt layers to mimic the most realistic situation.

It is also possible to test the sludge created against various sludge treatment techniques (water injection, aeration, etc.).

The following research activities can be carried out in this tank:

- development of new measurement techniques to determine the navigability of sludge;
- development of new dredging technique(s) by adjusting the sludge structure (water injection, aeration, etc.);
- calibration and evaluation of measuring instruments in situ;
- research on consolidation behaviour of treated sludge;

- research on the connection between the required pump characteristics and rheological characteristics of sludge;
- research on the generation of density currents.

All these research topics are part of the greater goal of optimising and minimising dredging activities in our ports and rivers.

Towing tank

Model tests are required to investigate the behaviour of vessels in confined waters. Flanders Hydraulics Research therefore built a 'towing tank for manoeuvres in shallow water' in 1992-1993 in cooperation with Ghent University.

The ship model is attached to the towing carriage through force gauges. The towing carriage forces the ship to sail a specific trajectory which creates forces on the ship model. A mathematical model of the forces acting on the ship is developed.

The mathematical model is used to simulate the manoeuvring behaviour of the ship in the ship manoeuvring simulator.

Use:

- captive manoeuvring tests (the ship model is forced to move in the horizontal plane);
- free-sailing manoeuvring tests;
- captive sea keeping tests (waves);
- manoeuvring in confined waters (including bank effects);
- influence of ship-ship interaction.

Characteristics:

- overall length: 88.00 m (67.00 m for testing);
- width: 7.00 m;
- maximum water depth: 0.50 m;
- length of the ship models: approximately 4 m (scale 1:50 to 1:85);
- the towing carriage moves along the length of the tank (24 hours a day, 7 days a week);
- the Planar Motion Mechanism allows lateral movement up to 5.50 m and rotation through 355°;
- the wave generator produces regular and irregular waves to study the vertical motion of the ship;
- auxiliary carriage for a second ship model (can only move along a straight trajectory).

FUTURE INFRASTRUCTURE

In September 2016, the Government of Flanders decided to build a new research facility in Ostend with a towing tank and a wave basin (Coastal & Ocean Basin, COB). By 2020, these facilities shall be fully operational.

The new towing tank will have a total length of 174 m (of which 136 m useful length for testing), a width of 20 m and a maximum water depth of 1 m. In addition to this water level, waves with an amplitude up to 20 cm can be generated. The ship model designed for use in this towing tank has an overall maximum length of 8 m and a width of 1.5 m.

In contrast to the current towing tank, the new towing tank will have observation windows and an observation tunnel to easily visualise the flow next to and beneath the ship model. The fully automatic towing carriage will offer the same features as the current towing tank and additional functionalities are still being considered.

The COB is a cooperation between the Universities of Ghent and Leuven and Flanders Hydraulics Research. In this 30 x 30 m^2 wave basin, scale models may be subjected to waves as well as currents and wind. Various wave paddles will allow a multi-directional wave climate to be created in combination with maximum currents of 0.4 m/s. Wind loads up to a maximum speed of 70 km/h can also be applied. The basin can be utilised in a wide range of fields and markets such as wave and tidal power, offshore engineering, coastal engineering or wave/current-vegetation interactions.

In September 2016, the Government of Flanders decided to build a new research facility in Ostend with a towing tank and a wave basin.

Government of Flanders
Department of Mobility & Public Works

Flanders Hydraulics Research
Berchemlei 115
2140 Antwerp
Belgium
Tel. +32 3 224 60 35
Fax +32 3 224 60 36

www.waterbouwkundiglaboratorium.be

waterbouwkundiglaboratorium@vlaanderen.be

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