PORT AND MARINE ENGINEERING

CONSULTANCY SERVICES
FROM IDEA TO REALITY

WWW.RAMBOLL.COM
A PORT CONTAINS ALL COMPONENTS OF A CITY. THE PLANNING AND DESIGN OF PORT COMPLEXES THEREFORE REQUIRES A VAST NUMBER OF INTERRELATED SERVICES. RAMBOLL PROVIDES ALL NECESSARY SERVICES AND WILL ASSIST CLIENTS THROUGH ALL PHASES OF A PROJECT.
Ramboll can provide you with professional and independent consultancy services in all areas of port, coastal and marine engineering. Our competent and dedicated staff has comprehensive experience from national as well as international projects.

We undertake both major and minor projects and assist clients throughout all phases of a project from the earliest planning and pre-feasibility studies to master-plan studies, design, and tendering. Further, our services include assistance during construction, operation and maintenance.

It is our policy to work with local companies and hire local manpower. We benefit greatly from their in-depth local knowledge and are hereby able to adapt projects to local conditions and economies. Through such joint ventures important know-how and technology is also transferred to our local partners.

Ramboll is a major international engineering, design and consultancy company founded in Denmark in 1945 by two young Danish engineers, B.J. Rambøll and J.G. Hannemann. Today, we employ close to 9,000 experts and have a significant presence in northern Europe, India, Russia and the Middle East. With more than 180 offices in 24 countries, we emphasise local expertise combined with a global knowledge base. Our multidisciplinary activities range from sustainable energy to structural engineering.
Hambantota, Sri Lanka. Following the finalization of the detailed feasibility study and port master planning, the first phase of the port development was initiated, comprising a service, liquid bulk and multipurpose terminal. Construction works corresponding to costs of approximately 450 million USD, were financed by the Chinese government and carried out by Chinese contractors.

Based on the construction of consistent development scenarios, we prepare feasibility studies and can provide expert consultancy in port master planning.

The feasibility study typically includes technical investigations, traffic analyses, financial analyses and environmental impact analyses. Further, Ramboll will also assist with conceptual and preliminary designs, authority management and development policy.

Financial and economic evaluations are typically based on the set up of traffic forecasts. Ramboll is uniquely qualified to identify and analyse port cargo-potentials and to subsequently prepare the reliable viability analysis.

In-depth technical, environmental and economic issues must be evaluated when greenfield seaport projects are considered. Ramboll can assist port authorities, municipalities, and other decision-makers with preparing a basis for decision-making. We have vast experience within project management of large projects through all phases from pre-investigations and planning to design and project implementation in the field.

Feasibility studies typically form the basis for investor decision-making. Ramboll is well qualified to prepare feasibility studies that fulfil the specific requirements of development banks. Based on our feasibility studies, we have helped clients get financing for their projects, notably from the World Bank (WB) and Asian Development Bank (ADB).

Feasibility studies often comprise traffic forecasts, technical investigations, port planning activities, environmental and socio-economic assessments – and viability assessments.
Among others, Ramboll has assisted Sri Lanka Ports Authorities (SLPA) with planning the development of a new major greenfield seaport at Hambantota, situated on the south coast of Sri Lanka. Hambantota Port is expected to relieve Colombo Port and is intended to support the growing demand for servicing large vessels.

The new seaport will have a water depth of 23 metres, and the complete reserved port area is 15 square kilometres. The seaport will contain a wide variety of terminals, including a dry bulk terminal, liquid bulk terminal, break bulk terminal, Ro-Ro terminal for vehicles and a Container transhipment terminal. The harbour basins are located inside an existing natural lagoon and the entrance channel will be protected by the construction of two breakwaters that will be 500-1500 metres long.

Ramboll has carried out detailed feasibility studies including: Site identification, analysis of land use pattern and constraints, coastal surveys, geotechnical and geophysical field investigations, mathematical modelling and evaluation of coastal processes, traffic forecasts, environmental assessments (IEE and EIA), socio-economic assessments, port planning, conceptual design and costing of primary port and marine structures, economic and financial viability assessments, commercial and financial project structuring, master planning and phasing of the project. Ramboll worked with local Sri Lankan firms, including Lanka Hydraulic Institute.
The Port of Copenhagen, Denmark, wishes to develop a new cruise terminal in order to accommodate the increasing number of large Voyager Class cruise vessels that call every year. It will be developed in the North Harbour along the existing approach channel, Kronløbet. The project comprises the development of a 900 metres new quay and quay area, Ro-Ro facilities, connection roads, terminal buildings and adjustments to the existing approach channel.

The planned position of the new terminal, close to the existing approach channel to the port, implied need for an evaluation of wave interaction between cruise vessels moored at the new cruise terminal and passing ships.
When port authorities consider expanding and upgrading port facilities to accommodate new or larger vessels, a number of facilities may need to be reconfigured such as, for example, berths, land storage areas, mooring systems, and scour protection. The first step, however, is evaluating and analysing the facilities. Ramboll will assist port authorities with all necessary evaluations and analyses. The need to keep up operations during expansion and upgrades are duly considered in all our studies.

In our evaluation of the manoeuvring conditions at project sites, we include real-time ship simulations—preferably carried out by local captains. In the design of mooring arrangements and quays, the dynamics of moored ships, which are influenced by wind, waves, currents and passing ships, are analysed using numerical mooring models.

The crucial analysis of wave climate in coastal regions, wave agitation and sediment processes in ports, coastal development and particle dispersion in oceans, rivers and estuaries, are carried out using the internationally recognized MIKE 21/3 and LITPACK models, developed by DHI. The models are used by our highly qualified staff, who are experts in ports, hydrodynamics and coastal morphology.
Ports are on a continuous basis being developed in response to changing cargo traffic patterns and climate. Ramboll has been involved in many new port projects around the world and can assist port authorities and municipalities with all design-aspects of such projects from planning and conceptual design through detailed design and supervision.

Ramboll has experience within all types of marine works from small marinas to large ports. Ramboll’s expertise includes the following:

- Large cargo ports, such as general cargo ports, container ports, dry bulk ports, liquid bulk ports, oil terminals and LNG terminals
- Fishing ports
- Small harbours, such as marinas
- Ferry ports
- Dry docks and floating docks
- Fairways, dredging, land reclamation, stabilization of sediments
- Breakwaters
- Coastal protection, such as groins, revetments, beach nourishment etc.

Port structures are optimized based on evaluations of local conditions, including soil and hydraulics. Ramboll is able to assist with optimizations of all port structures from breakwaters, pavements, moorings, scour protection, ramps, and installations. In most cases we carry out port rebuilds, while the existing port is running. In fact, we have assisted a large number of ports around the world with solutions that facilitated rebuilds with minimal interruptions of port operations.
Port of Helsinki in Finland has opened a new cargo port at Vuosaari. As Finland’s new main port, it offers efficient transport with frequent shipping services to Central European ports as well as direct connections to the entire Finnish main road and railway network. The new location of the main port eases the traffic of downtown Helsinki significantly, as heavy traffic is transferred to Vuosaari. It is estimated that the harbour road will be used by approximately 10,000 vehicles a day. At the same time former port areas Jätkäsaari and Sompasaari in Helsinki centre will be released for housing and business premises. While being a unique project both in size and scale in the history of Finnish port engineering, Vuosaari harbour is also one of the few entirely new port constructions in the world. The harbour centre comprises a gate area, closed harbour area, adjacent Harbour Business Park and Meriportti Business Park.

The huge six-year project with a total cost of 682.1 million Euros employed about 100 engineers from Ramboll. Our experts were involved in a large number of planning tasks for traffic and land structure engineering as well as environmental impact assessments and ground surveys. Ramboll also carried out the design of the new RoRo / RoPax ferry terminal in Vuosaari harbour for Finnlines’ German traffic ferries, comprising three ferry berths, two designated tier ramps and cargo areas. Ramboll conducted preliminary and detailed design for the following structures: Berths, mooring systems, bunkering systems, adjustable lower ramp, adjustable multipurpose upper ramp, concrete bridge to the upper ramp, steel structures incl. FEM modelling and semi automated mooring systems.
Port of Göteborg, Sweden - modernization and extension of container port in Skandia Harbour.

The port is a major hub for overseas container traffic. The port has invested in new Super-Post Panamax cranes for the ship to shore handling, and a new terminal master plan with new handling equipment has been prepared to meet the demands up to year 2012, including replacement of the present system with straddle carriers with rubber tired gantries (RTG) or rail mounted gantries (RMG).

The study covered the entire Skandia Harbour, including a rail terminal, truck traffic areas, empty storage, reefer blocks, storage blocks with beams and/or rails for gantries, geotechnical stability analysis, paving and drainage, power system and lighting. The services also included calculation of investment costs and elaboration of an environmental impact assessment for the various alternatives - diesel powered RTG cranes or electrical powered RMG cranes.

At an early stage, 600 m berths were deepened from 12.0 to 14.2 m depth to be able to serve post-panamax container vessels. The project was carried out in stages to allow full operation of the terminal. Ramboll provided the planning and design of dredging, fairways, new berths, port areas, logistic studies, repairs and maintenance, utility systems including electrical power, drainage, water/ sewage, etc. Ramboll was the sole consultant for all phases, from feasibility studies to advisory services during the construction phase.
UPGRADING PORT FACILITIES
- MEETING NEW DEMANDS

Ports are important links in the transportation chain, and efforts to upgrade facilities and increase cargo capacity are continuously being made in response to increasing demands. The new generation of ships are larger and carry more cargo, thus calling for a vast number of rebuilds.

Receiving new vessels requires re-evaluations of water depths, berth lengths, land storage areas, mooring conditions and facilities, ship manoeuvring conditions and existing operations. Deepening of berths for larger vessels typically requires rebuilding and reinforcement of existing quay structures. In this context it is often necessary to carry out environmental assessments of the procedures for handling contaminated soil or sediment.

Landside operations are also continuously changing and may call for port upgrades. The introduction of larger and heavier truck loads or cranes will require investigations and most often require reinforcements of the existing pavements and foundations.

Within the ferry terminal segment, ramp systems with higher capacity are continuously being developed, and automatic mooring and bunkering systems implemented. Furthermore, new regulations such as the ISPS and environmental stipulations influence operations and infrastructure.

Rebuilding and upgrading of port facilities are typically carried out in stages to allow ongoing operations and execution of port activities.

TOP RIGHT
The Ro-Ro and container terminals in the Port of Göteborg were originally built on a reclaimed area consisting of a mix of soils and construction material from damaged buildings. Increased traffic and higher axle loads have necessitated large maintenance costs for surfacing as well as for water and sewage systems. Ramboll has participated in the real time monitoring of different designs and work methods, which have led to new standard designs of terrace and paving for different traffic situations, including the handling of the 90 t special SECU box for transport of paper rolls to the continent.

BOTTOM LEFT
The Port of Göteborg, Sweden, decided to upgrade the container terminal to accommodate super-post panamax vessels. This also required improvements of two fairways; one fairway was straightened and deepened to 20 m, and one fairway to 13 m. Ramboll elaborated the Environmental Impact Assessment, cost estimates and tender documents. The project involved dredging and disposal of 12 million cubic metres of silt, and blasting of 400,000 cubic metres of hard rock. Part of the blasted rock was used to build “lobster hotels” on the bottom, which has increased the number of lobsters in the area considerably.
Ramboll can assist port authorities and municipalities with rehabilitation services within the following areas:

- Inspections and evaluations of existing structures
- Possible technical pre-investigations for further and in-depth examination of the deterioration, in order to optimize rehabilitation efforts
- Setting up suggestions for possible rehabilitation works and repair strategies, adjusting the strategies to the economic possibilities
- Suggestions for future maintenance efforts, in order to minimize future maintenance and repair costs
- Design and supervision of rehabilitation works

The expected life span of port structures and facilities is typically 50 years. Advanced corrosion of steel structures (sheet pile walls and steel piles) and deterioration of concrete and wooden structures (piles, beams, piers and quay structures) are common after 40-50 years and pose a serious threat to the load carrying capacity.

However, the life span of existing structures can be prolonged at reasonable rates, if rehabilitation works are initiated in time. If not, rehabilitation may become both extensive and expensive, often requiring the replacement of entire structures.

In connection with the increase of the crane capacity on Levantikaj in Port of Copenhagen (Denmark), crane rails were extended and reinforced. The total length of crane rails on pile foundation was approximately 450 metres. Ramboll has carried out geotechnical field investigations, assessment of load carrying capacity, preparation of detailed design for extension and reinforcement of crane rails and contract management and supervision during construction works.
Rehabilitation of wharves in Malindi Port, Zanzibar (Tanzania).

The existing wharves in Malindi Port were reconstructed and upgraded to facilitate container handling and storage in the port. The following elements/areas are reconstructed: North Wharf, length 114 m, design depth 8.3 m – and West Wharf, length 276 m, design depth 11.8 m.

Due to late and surprisingly unfavourable results from the supplementary geotechnical investigations, complete detailed designs were carried out for two different solutions: replacement of the reinforced free spanning concrete superstructure, utilizing the existing foundation piles – or complete replacement of the existing structure with a retaining-wall type structure of steel-sheet piles.

Ramboll carried out design control for both design projects. Each detailed design comprised elaboration of design basis, structural calculations and drawings.
The Port of Skagen is situated downtown Skagen on the northern tip of Denmark. The town is a main tourist attraction and has important nature reserves. The Port of Skagen has been extended with 20 hectares. Ramboll has carried out an EIA, including assessment of possible changes in the sedimentation pattern along the coast. We also studied impacts from noise, traffic and visual effects. Further, Ramboll carried out an Environmental Screening for recovery of 900,000 m³ sand from the sea as fill for the expansion project.
ENVIRONMENTAL STUDIES
- MINIMIZING ENVIRONMENTAL IMPACT

Today environmental considerations are integrated into the decision process of most construction projects in coastal zones.

An environmental impact study, usually in form of an environmental impact assessment (EIA), is therefore often called for.

Projects which require an EIA include:

- Establishment of a new port
- Extension of an existing port
- Recovery of building materials (i.e. sand) from the maritime environment
- Disposal of contaminated sediments

Environmental impact studies typically consider the following areas:

- Impact on nearby protected natural resorts and animal habitat areas
- Impact from dispersion of sediments during construction
- Changes of existing hydraulic flow and possible sedimentation/erosion
- Noise, emissions and smell
- Future traffic
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Handbjerg Marina is situated in Limfjorden, Denmark, near a number of protected natural habitat areas, and is designed to contain 400 pleasure crafts. Ramboll has carried out an Environmental Screening and an Environmental Impact Assessment with special focus on the impact the marina will have on nearby colonies of seals and otters. Changes in hydraulic flow, sedimentation pattern and traffic were assessed, and illustrations showing the visual impact were produced.

Controlled treatment of TBT-contaminated dredged sediments.

Ramboll has been involved in the development of a new environmentally friendly process stabilisation method for the treatment of contaminated sediments. The method is now utilised, in for example Pansio Harbour in Port of Turku, Finland.

Ramboll has been involved in a large number of coal port developments and extensions around the world. Besides planning and design, Ramboll has carried out a large number of Environmental Impact Assessments, seeking to minimize impacts on the environment.
Coastal protection and shoreline management has received increasing attention during recent years. New developments of coastal zones and more extreme variability in the oceanographic and meteorological conditions impact existing assets and set new demands. Ramboll carries out planning and design of coastal protection solutions, provides expert consultancy for shoreline management, and prepares coastal protection strategies.

Design criteria are evaluated based on statistical analyses of extreme weather events (wind, water level, current and waves). Complex problems are evaluated based on in-situ investigations and numerical modelling, using state-of-the-art models.

All marine works must be tailored to local conditions. To ensure that each project is optimized accordingly Ramboll undertakes site investigations, prepares analyses of data and collects samples, including hydrographical, meteorological, oceanographic, geotechnical surveys and hydraulic model studies.

The internationally recognized MIKE 21/3 and LITPACK models developed by DHI are utilized to analyse the hydrodynamic climate of coastal regions, wave agitation in ports as well as sediment processes, coastal development and particle dispersion in oceans, rivers and estuaries. The models are used by an experienced staff with expertise within ports, hydrodynamics and coastal morphology.

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SHORELINE MANAGEMENT
- SAFEGUARDING ASSETS AND MEETING NEW DEMANDS

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Manoeuvring problems for the ferries in Port of Hirtshals in Denmark have suggested that a new breakwater was required. Ramboll has carried out wave analyses, preinvestigations and the design of the new breakwater.
Implementation of SMART Ports in Port of Hamina and Port of Naantali, Finland.

Maintaining two of the largest ports in Finland has become easier and more structured. The two ports have ordered software licenses for Ramboll’s Port Maintenance Management System “SMART Ports”.

The Port of Naantali is the third largest port in Finland, with an overall traffic of 8.5 million tonnes of cargo annually (2007) and more than 2,000 vessels/year, covering liquid bulk, dry bulk, containers and trailer cargo. The total quay length is more than 1,300 m. The port has focused heavily on rehabilitation of quay structures and maintenance during the past years, and now with the SMART system it will be systemized even further. The Port of Hamina is the fifth largest port in Finland, with an overall traffic of 5.4 million tonnes of cargo annually (2007) and more than 1,450 vessels/year, covering liquid bulk, dry bulk, general cargo and containers. The total quay length is more than 3,000 m and the storage area is more than 470,000 m².

Ramboll has assisted the ports during implementation and training of the staff in the ports.
MAINTENANCE MANAGEMENT - IMPROVING OPERABILITY

Maintenance management of ports is highly complex, requiring the integration of several disciplines and services. In fact, maintaining a port is comparable to maintaining an entire city. Ports have a similar multitude of different structures and facilities, notably quay structures, piers, breakwaters, paved areas, buildings, loading and unloading facilities, movable equipment.

It is, however, possible to simplify, optimize and keep maintenance procedures within budget by systematizing the procedures and introducing known and tested methods from other fields such as maintenance of bridges and roads. This approach will also allow forecasting of future costs, increase safety and minimize the risk of unexpected break-downs. The result is a vastly improved port operation.

By prioritizing activities, appropriate actions may be taken in time. In other words, rehabilitation efforts will not be taken too early or too late. So, while expenses may initially increase slightly for the planned maintenance services, ports will in the long run save money by avoiding potentially costly mistakes such as heavy repair on structures overdue for rehabilitation.

To support the growing demand for efficient maintenance management of ports and similar infrastructure facilities, Ramboll has developed a program called SMART Ports – a web-based IT-system featuring systematic and well documented maintenance management procedures, long-term budgeting and easy access to large and complex amounts of data. SMART Ports is based on state-of-the-art principles within operation and maintenance. It provides a user-friendly interface supporting all levels of maintenance management.

HOW RAMBOLL CAN HELP PORT AUTHORITIES

Ramboll processes knowledge within most of the fields which is required for port maintenance management, e.g.:

- Systematic registration methods
- NDT (non-destructive tests) and Destructive test methods
- Determining conditions and damage reasons
- Estimating life span and deterioration rate of materials and structures
- Evaluating environmental influence
- Setting up optimal repair strategies and solutions
- Financial evaluations
- Working out projects and supervising rehabilitation works

FROM LEFT
Registration of facilities in SMART Ports
Inspection and condition evaluation of structures
Well represented in the Nordic countries, Ramboll has carried out a large number of port planning and design projects in Denmark, Sweden, Norway, Finland, Faroe Islands, Iceland and Greenland.

Ramboll has been involved in complex planning and design of structures for dry docks or spectacular buildings along the harbor front in e.g. Copenhagen, Oslo, Reykjavik and Skagen.

From top left: Bodø, Norway (Port Planning & Design) – Runavik, Faroe Islands (Port Master Planning) – Stigsnaes, Denmark (Feasibility Studies) – Harstad, Norway (Port Planning) – Qeqertarsuag, Greenland (Port Planning & Design) – Hammerfest, Norway (Port and infrastructure Planning & Design) – Oslo, Norway (Port and infrastructure Planning & Design) – Skagen, Denmark (Design of Dry Dock)
Ramboll has carried out a large number of projects in Finland and the Baltic countries, covering planning, environmental management, design and supervision services.

L&T Ramboll has carried out planning and design services in many large scale port projects in India and neighboring countries.

From top left: Hamina, Finland (Port Planning & Design) – Naantali, Finland (Design) – Kokkola, Finland (Planning and Design of dredging works) – Peipsi Lake, Mustvee/Omedu, Estonia (Planning of fairways and harbors) – Aalborg Havnebad, Denmark (Planning & Design) – Vizhinjam, India (Planning & Design) – Copenhagen, Denmark (Planning & Design of new beach) – Estonia Archipelago, Estonia (Rehabilitation of Archipelago area)
Ramboll possesses expert know-how within planning and design of marine works for immersed tunnels and related structures.

Ramboll can offer special services such as geophysical and geotechnical investigations, risk analyses, planning and design of LNG facilities, planning and environmental management in connection with dredging and fairway projects, maintenance management, pavement management etc.

From top left: Hambantota, Sri Lanka (Geophysical field investigation and bathymetry) – Øresund, Denmark (Risk analyses of navigational safety) – Sethusamudram Channel, India/Sri Lanka (Planning & Design) – Fehmarn Belt Fixed Link, Germany/Denmark (Design of marine works) – LNG facilities, Finland/Estonia (Planning & Design) – Finland (Fairway design) – APM Terminals (Pavement Management)
SELECTED REFERENCES

Sweden  Göteborg, Halmstad, Helsingborg, Malmö, Trelleborg, Landskrona, Varberg, Ystad, Karlskrona, Stockholm, Norrköping, Oxelösund, Kalmar, Gavle, Gotland
Norway  Oslo, Drammen, Sandefjord, Fredrikstad, Bergen, Tromsø, Narvik, Bodo, Hammerfest, Alta, Kirkenes, Vardø, North Cape

Egypt  Suez
Sri Lanka  Colombo, Hambantota
Bangladesh
India  Gangavaram, Kakinada, Mithi, Voll乾, Chennai, Ennore Port, Cuddalore, Vizhinjam, Machilipatnam, Haldia (Kolkata), Sethusamudram Ship Canal
China
Lebanon  Beirut
Egypt
UAE
Saudi Arabia

Spain  La Coruña, Ferrol, Carboneras, Alcudia
UK

Ireland

Ecuador
Nicaragua
Honduras
Dominican Republic
Haiti

Denmark  Copenhagen, Aarhus, Aalborg, Esbjerg, Hirtshals, Skagen, Thyboron, Grenå, Ebeltoft, Randers, Vejle, Køge, Kalundborg, Ranne
Faroe Islands  Torshavn, Runavik, Svinoy
Iceland  Reykjavik
Greenland  Nuuk

Estonia  Tallinn
Latvia  Riga, Ventspils
Lithuania  Kaunas, Klaipeda
Azerbaijan  Baku

Mozambique  Beira
Tanzania  Zanzibar, Dar Es Salaam
Côte d’Ivoire  Abidjan
Benin  Cotonou
Morocco  Casablanca, Dakhla
Libya
Algeria

Russia  St. Petersburg, Murmansk, Arkhangelsk
Finland  Kemi, Kotka, Petäjävesi, Rovaniemi, Rauma, Uusikaupunki, Naantali, Turku, Hanko, Tamminen, Helsinki, Kotka, Hamina
Estonia  Tallinn
Latvia  Riga, Ventspils
Lithuania  Klaipeda
Azerbaijan  Baku

Spain  La Coruña, Ferrol, Carboneras, Alcudia
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Nicaragua
Honduras
Dominican Republic
Haiti

Denmark  Copenhagen, Aarhus, Aalborg, Esbjerg, Hirtshals, Skagen, Thyboron, Grenå, Ebeltoft, Randers, Vejle, Køge, Kalundborg, Ranne
Faroe Islands  Torshavn, Runavik, Svinoy
Iceland  Reykjavik
Greenland  Nuuk

Estonia  Tallinn
Latvia  Riga, Ventspils
Lithuania  Klaipeda
Azerbaijan  Baku

Mozambique  Beira
Tanzania  Zanzibar, Dar Es Salaam
Côte d’Ivoire  Abidjan
Benin  Cotonou
Morocco  Casablanca, Dakhla
Libya
Algeria

Russia  St. Petersburg, Murmansk, Arkhangelsk
Finland  Kemi, Kotka, Petäjävesi, Rovaniemi, Rauma, Uusikaupunki, Naantali, Turku, Hanko, Tamminen, Helsinki, Kotka, Hamina
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Cover image: APM terminals

• International recognised world-leading consultancy
• 100 specialists working with port and marine projects
• 20 ongoing and more than 100 completed port and marine projects in more than 35 countries around the world