



MARINE AND COASTAL ENGINEERING

COWI

THINK FURTHER

COWI's history in civil engineering dates back to 1930 when the company was founded. Since then, COWI has pushed the boundaries of marine design through our involvement in more than 3,000 marine projects worldwide. These projects range from large and technically challenging LNG terminals, container ports and waterfront developments to cooling water systems, offshore wind farms, flood protection, locks and dams.

Today, we are a world leader in marine and coastal engineering. It is a position we have achieved by diligently pushing the development of new technologies to stretch the limits of what is possible.

We are driven by innovation and by our ambition to work closely with our clients to deliver world-class marine structures. Our services cover the entire life cycle of a marine structure, from the initial ideas to the operation phase, decommissioning or rehabilitation.

With a full set of world-class competencies within marine and coastal engineering combined with local presence and experience, we are ready to take on the most complex projects anywhere in the world – no matter how large or small.

Together, we will take you there.

AIN SUKHNA MARINE OIL TERMINAL - GORGON BARROW ISLAND LNG PLANT - AQABA LNG - SHTOKMAN LNG TERMINA - BATUMI TERMINAL - NEW PIER AND QUAY STOCKHOLM VÄRTAHAMNEN - KAPELLSKÄR - JEBEL ALI T3-Q10 CONTAINER TERMINAL - NEW YORK CITY CRUISE TERMINAL DREDGING - CALETA LA MISION PORT - NORVIKUDDEN CONTAINER AND RO-RO TERMINAL - DEVELOPMENT PLAN FOR KRONBORG CASTLE AND ELSINORE HARBOUR - LUSAIL DEVELOPMENT - MUSEUM OF ISLAMIC ART - AL ZORAH DEVELOPMENT - BEIRUT CENTRAL DISTRICT, MARINE WORKS - CASTING BASIN COSTA AZUL - QATAR - BAHRAIN CAUSEWAY - LONDON ARRAY - WIKINGER OFFSHORE WIND FARM - YANBU 2 POWER PLANT AND WATER PROJECT - RABIGH POWER PLANT NO 2 - NEW ORLEANS FLOOD PROTECTION BARRIER OLMSTED LOCKS AND DAM - UPPER ZAKUM ARTIFICIAL ISLANDS - AL RUWAIS PORT DEVELOPMENT - LNG LTD IMPORT TERMINAL AT MUNDRA - SHOAIBA NEW TANKER TERMINAL - LNG PROJECT, IDKU - RAS LAFFAN MARINE - RUWAIS THIRD NGL TRAIN JETTY - LARGE LIQUID TERMINAL NEW YORK - NORVIKUDDEN - FREDERIKSHAVN - SKAGEN - HVIDE SANDE - IRISH RAIL SEA - ISLAND 2 - PEARL-QATAR - ENERGINET - WIKINGER, TRANSFORMER - RØDSAND 2 - THORNTON BANK - DANTYSK - KÅREHAMN - KRIEGERS FLAK OSS - AIN SUKHNA MARINE OIL TERMINAL - GORGON BARROW ISLAND LNG PLANT - AQABA LNG - SHTOKMAN LNG TERMINA - BATUMI TERMINAL - NEW PIER AND QUAY IN STOCKHOLM VÄRTAHAMNEN - KAPELLSKÄR - JEBEL ALI T3-Q10 CONTAINER TERMINAL - NEW YORK CITY CRUISE TERMINAL DREDGING - CALETA LA MISION PORT - NORVIKUDDEN CONTAINER AND RO-RO TERMINAL - DEVELOPMENT PLAN FOR KRONBORG CASTLE AND ELSINORE HARBOUR - LUSAIL DEVELOPMENT - MUSEUM OF ISLAMIC ART - AL ZORAH DEVELOPMENT - BEIRUT CENTRAL DISTRICT, MARINE WORKS - CASTING BASIN COSTA AZUL - QATAR - BAHRAIN CAUSEWAY - LONDON ARRAY - WIKINGER OFFSHORE WIND FARM - YANBU 2 POWER PLANT AND WATER PROJECT - RABIGH POWER PLANT NO 2 - NEW ORLEANS FLOOD PROTECTION BARRIER OLMSTED LOCKS AND DAM - UPPER ZAKUM ARTIFICIAL ISLANDS - AL RUWAIS PORT DEVELOPMENT - LNG LTD IMPORT TERMINAL AT MUNDRA - SHOAIBA NEW TANKER TERMINAL - LNG PROJECT, IDKU - RAS LAFFAN MARINE - RUWAIS THIRD NGL TRAIN JETTY - LARGE LIQUID TERMINAL NEW YORK - NORVIKUDDEN - FREDERIKSHAVN - SKAGEN - HVIDE SANDE - IRISH RAIL SEA - ISLAND 2 - PEARL-QATAR - ENERGINET - WIKINGER, TRANSFORMER - RØDSAND 2 - THORNTON BANK - DANTYSK - KÅREHAMN - KRIEGERS FLAK OSS - AIN SUKHNA MARINE OIL TERMINAL - GORGON BARROW ISLAND LNG PLANT - AQABA LNG - SHTOKMAN LNG TERMINA - BATUMI TERMINAL - RAS LAFFAN MARINE TERMINALS - RUWAIS THIRD NGL TRAIN JETTY - NEW PIER AND QUAY IN STOCKHOLM VÄRTAHAMNEN - KAPELLSKÄR - JEBEL ALI T3-Q10 CONTAINER TERMINAL - NEW YORK CITY CRUISE TERMINAL

WORLD-CLASS MARINE AND COASTAL ENGINEERING

We create value for our customers through our world-class knowledge and multi-disciplinary approach.

Our references show the breadth and depth of our global experience.





AIN SUKHNA PRODUCT HUB, EGYPT

Arab Petroleum Pipeline Co. has established a fully equipped product hub at their Ain Sukhna complex on the Red Sea Coast in Egypt. The hub includes both onshore and offshore facilities. The onshore facility comprises 61 product storage tanks with a total capacity of 2,125 million m³, and two 50 km long unidirectional pipelines to the city of Suez. The diameter of the individual product storage tanks varies from 21 to 59 m.

The offshore facility comprises a jetty and berths (500-160,000 DWT) including a topside pipeline and other auxiliaries. The hub includes an offshore single point mooring for very large crude carriers (VLCC), connected via a sea pipeline. The offshore facility is intended to accommodate future expansions to handle up to 24 million tonnes per annum of various products.

The entire project development is planned to be completed in five main development phases with a specific phase for LPG tanks and berth.

FACTS

Project period	2012-2013
Client	Arab Petroleum Pipelines Co. (SUMED)

SERVICES

- › Topographic survey at fuel tank site and land pipeline corridor
- › Concept design of marine terminal, tank farm, single bay mooring and land pipeline
- › Plant layout and 3D modelling
- › Front end engineering design (FEED)
- › Preparation of tender documents.



GORGON LNG PLANT, AUSTRALIA

The Chevron-operated Gorgon liquefied natural gas project on Barrow Island will bring on stream a three-train 15 m t/y, exploiting off-shore gas fields off Australia's north west coast.

It is the largest of more than a dozen planned LNG projects in Australia.

Venture partners with Chevron are Exxon Mobil Corp, Royal Dutch Shell Plc, Osaka Gas, Tokyo Gas and Chubu Electric Power. The Saipem-Leighton Consortium (SLC) was awarded the Gorgon LNG jetty and marine structure contact in November 2009 based on a design concept with caissons to be prefabricated off site, towed in and placed onto gravel beds. A connecting trestle is made of steel trusses spanning 70-80 m between caissons. The jetty is located approximately 2 km off shore.

SLC engaged COWI to carry out independent design verification for the marine facility design which included checking more than 2000 documents and performing independent design calculations.

FACTS

Project period	2009-2014
Client	Saipem-Leighton Consortium

SERVICES

- › Independent design verification (IDV)
- › Independent calculations for validation of the structural integrity.



STOCKHOLM NORVIK CONTAINER AND RO-RO TERMINAL, SWEDEN

The Norvikudden project is a modern green-field port development of a 44 hectare site located about 65 km south of Stockholm.

The fully developed port will comprise about 1.4 km of quays accommodating four berths for container carriers with four to five ship-to-shore container cranes and two berths with movable end ramps for ro-ro vessels.

The planned water depth at the quays ranges from 10 to 16.5 m and the port capacity will enable the annual handling of 300,000 TEU and 200,000 ro-ro vehicles.

COWI was selected as the contractor's consultant for the design of all quay structures, revetment, quay equipment, dredging work, scour protection, soil improvement, pavement works, drainage, utilities, mechanical and electrical works and access roads and bridges to the terminal.

FACTS

Project period	2011-2012
Client	NCC-Aarsleff Norvikudden Consortium

SERVICES

- › Numerical modelling of waves, currents and water levels
- › Programming of the geotechnical investigations
- › Design basis for all marine works based on the functional requirements for the container terminal and ro-ro terminal
- › Concept design of all marine works
- › Estimation of main quantities.



NEW FERRY AND CRUISE TERMINAL IN THE PORT OF STOCKHOLM, SWEDEN

The new port facility will consist of three new ferry berths and two upgraded ferry terminals with associated movable steel end ramps and berth equipment.

The design water depth at the new ferry berths will be 11 m. The structural system consists of a prefab concrete deck supported by approximately 1,050 tubular steel piles (diameter 1,000 mm and average length 45 m).

The piled deck consists typically of 8 m by 8 m prefab reinforced concrete deck elements cast together on site. Along the inner edge of the piled deck a double anchored steel sheet pile wall is used to retain the new fill above the existing sea bed.

To support the fill in the existing harbour structure a large prefab reinforced concrete L-wall is used.

Cement-limestone piles and jet grouting are used to improve soil conditions in order to support the new loads behind the retaining walls. Rock armour will protect the existing slopes and the new retaining walls from propeller scour.

COWI is the design consultant for all construction works.

FACTS

Project period	2013-2015
Client	Per Aarsleff A/S

SERVICES

- › Tender and detailed design
- › Geotechnical design
- › Marine structural design
- › Design of pavement, drainage and utilities.



PORT OF SALALAH INSPECTION, SULTANATE OF OMAN

As part of a feasibility study for dredging an additional 2.5 m, COWI carried out an underwater investigation for berth 21-24.

The objective of the investigation was to assess the existing condition of the structure to determine the improvements required to accommodate the additional dredged depth.

COWI mobilized a full surface supplied dive station, an engineer-diver, and a dive supervisor.

Berths 21-24 are constructed as a precast concrete caisson bulkhead that supports a cast-in-place concrete cap. It measures approximately 730 m and is currently dredged to approximately 12 m depth.

FACTS

Project period	2011
Client	Port of Salalah

SERVICES

- › Underwater and above water inspection
- › Feasibility study.

AT ANY GIVEN TIME, WE ARE INVOLVED
IN MORE THAN 200 MARINE PROJECTS
WORLDWIDE

WORLDWIDE REACH

In COWI, we take pride in our achievements. Since our inception, we have been at the forefront of marine engineering, setting the standard for tomorrow's best practices. Together with our clients, we have been involved in more than 3,000 marine projects all over the world – from Argentina to the far corners of Russia.

We can take your marine project further than you imagine. COWI's key marine and coastal engineering offices are shown here. With offices, around the globe, we are never far away. And regardless of the scope of your marine construction or problem, we deliver worldwide.

All other COWI offices are listed on www.cowi.com





KRONBORG CASTLE AND ELSINORE HARBOUR, DENMARK

Cultural Harbour Kronborg is a comprehensive renewal of the area between the town of Elsinore and Kronborg Castle, which is on the UNESCO world heritage list. The area has been developed into a recreational area with a new harbour front with new quay walls, wooden promenades along the quay walls, approximately 12,000 m² of granite paving, lighting, and 1.1 km of benches.

The fortifications around Kronborg have been recreated or restored including the recreation of von Scholten's ravelin, a contemporary architectural interpretation of the original ravelin. Most of the soil was reused in the project to create the new King's Quay and the Ravelin. The project also comprises new access roads and parking for busses and cars.

The multidisciplinary project was developed in close collaboration with the Client and the landscape architect Jeppe Aagaard Andersen. Risk assessment was integrated in the planning phase and the successive cost calculation.

FACTS

Project period	2007-2014
Client	Ministry of the Interior, Elsinore Municipality

SERVICES

- › Overall planning
- › Preparation of tender documents
- › Project management consultant for the implementation of the entire project
- › Environmental and geotechnical investigations
- › Cost estimations and supervision of works.



LUSAIL DEVELOPMENT, QATAR

The waterfront development is located along the shoreline north of Doha. It covers an area of about 21 km² which is approximately the same size as the entire Midtown and Lower Manhattan in New York.

The project has transformed the present shoreline through dredging and reclamation, creating new islands, access channels and beaches. The new development includes low and high rise residential housing for about 200,000 inhabitants.

Further, the development includes business, corporate and mixed use areas as well as quality beaches with top class hotels, two golf courses and an entertainment district.

COWI completed the planning and design activities of the marine and earthworks for the Lusail Development and subsequently designed marinas and beaches. Finally, COWI supervised construction of all marine works.

FACTS

Project period	2004-2014
Client	Qatari Diar / Bechtel Overseas Corporation

SERVICES

- › Master planning
- › Bathymetric and topographic surveys
- › Geotechnical investigations
- › Environmental impact assessment
- › Conceptual and detailed design
- › Preparation of tender documents
- › Assistance in tendering and contracting phase
- › Construction supervision.



LONDON ARRAY OFFSHORE WIND FARM, UK

With 175 monopiles, designed to carry the Siemens 2.6 MW turbines, the London Array offshore wind farm is the world's largest, with a peak rated power of 630 MW in 2013. Monopiles of 4.7 m and 5.7 m diameter have been installed at water depths between 0 m and 25 m. With length up to 85 m, these foundations are amongst the largest ever built.

Its turbines are capable of generating enough energy to power nearly half a million UK homes and reduce harmful CO₂ emissions by over 900,000 tonnes a year.

A consortium of DONG, E.ON and Masdar commissioned Aarsleff | Bilfinger Berger Joint Venture (ABJV) as contractor to undertake fabrication and installation of the steel foundations. To carry out the detailed design of the monopiles, ABJV engaged COWI as lead in a joint venture with IMS Ingenieurgesellschaft mbH, COWI-IMS JV.

The project is one of the first offshore wind projects to use the conical grouted connection. Significant advances were introduced in the geotechnical methodology for calculations of soil-structure interaction.

FACTS

Project period	2009-2013
Client	Aarsleff / Bilfinger Berger Joint Venture

SERVICES

- › Hydraulic load calculations
- › Structural design
- › Geotechnical design
- › Driveability analyses
- › Cathodic protection analysis and design
- › Scour assessment
- › Risk management.

**WIKINGER OFFSHORE WIND FARM,
GERMANY**

The joint venture of COWI and IMS Ingenieurgesellschaft mbH, led by COWI, has been entrusted with the detailed design of the foundations and the basic design of the substation.

COWI was Iberdrola's representative in the preliminary geophysical and geotechnical investigations for the 1st German regulatory system's (BSH) release, and is finishing the detailed geotechnical investigations for the 2nd BSH release.

Before this, COWI carried out the feasibility study of the turbine foundation types, investigating concepts for monopiles, gravity based foundations and jacket foundations for depth variations up to 42 m. Based on our preliminary foundation design, we were awarded the basic design of the jacket foundations equipped with AREVA 5 MW turbine, for the application for the 2nd BSH release. The offshore wind farm is expected to deliver up to 400 MW.

For the offshore substation, COWI's scope of work includes the mechanical and electrical design services in addition to the topside and jackets structure design.

FACTS

Project period	2010-2014
Client	Iberdrola Renovables

SERVICES

- › Structural design of topside and jackets
- › Hydraulic design
- › Geotechnical design
- › Electrical and mechanical design
- › Low voltage design.



Video animation



OUR SERVICES

With our services, we cover the entire project life cycle of a marine project from early ideas to the operational phase and rehabilitation – or decommissioning when the time comes.

We can handle the entire project, or we can step in at any given moment to provide your project with that extra expertise you need. The choice is yours.



DIFFERENT PHASES DIFFERENT SERVICES

Agility and expertise are the key to efficient marine and coastal engineering. We bring both to the table to make sure we provide you with the exact service and expertise your project needs – regardless of where you are in the process.



PROJECT IMPLEMENTATION

We provide policy planning, advice and management consulting in relation to project decision and project implementation.



SITE STUDIES

Understanding the environment in which the project is to be constructed requires knowledge obtained from various sources. The quality of the project depends on the accuracy and details of information obtained through these investigations. This includes met-ocean data gathering and assessment, seismic and tsunami studies, collision/spill risk assessment and mitigation, and navigation simulations.



DESIGN

We handle everything from development of design basis to construction aspects as well as life-cycle design. We have state-of-the-art analysis tools that enable us to deliver competitive designs to tight schedules. With our vast experience we can secure delivery of your project to quality, on time and budget.



FEASIBILITY STUDIES

We have all the competencies to carry out feasibility studies. And we take into account technical, environmental, social and economic aspects to establish the basis for the right decisions.



INDEPENDENT DESIGN CHECK AND VALUE ENGINEERING

We provide assistance to clients of complex marine projects assessing if the project is reliable, safe, durable, constructable and optimal.



CONSTRUCTION ENGINEERING

The right selection and combination of construction methods is of crucial importance to any marine project. We handle erection schemes, logistics, temporary structures as well as the erection engineering itself.



CONSTRUCTION MANAGEMENT

We handle the contract, monitor the progress of the project in all details as well as cost control and take care of risk management. We also handle stakeholders and authorities and perform technical follow-up.



SITE SUPERVISION

We handle all disciplines relating to preconstruction and construction, project completion and subsequent defects liability period and we deliver full project quality documentation.



OPERATION AND MANAGEMENT

Our asset management is based on worldwide practical experience with planning, budgeting and handling of short and long-term operation, maintenance and rehabilitation works, as well as implementation of management concepts.



RE-EVALUATION AND REHABILITATION

We cover all phases and every step of the inspections to ensure that technical evaluations are coherent – from visual inspections to special studies of load capacity and safety of structures.

We design rehabilitation works for existing structures for increased capacity and for replacement of key structural elements.



DECOMMISSIONING

To facilitate the choice between removal options, we carry out quantitative, comparative risk assessments of the various options and we take damaged structures, personnel and environmental risks into account.

**YANBU 2 POWER AND WATER PROJECT,
SAUDI ARABIA**

The power and water utility company Marafiq is developing a new 850 MW (net to the grid) power and water plant for Yanbu 2 Industrial City to meet the increasing demand for power, process and portable water and seawater cooling.

The plant is located on the Red Sea coast of the Kingdom of Saudi Arabia, approximately 280 km north of Jeddah.

Saudi Archirodon Ltd. has been selected as contractor for the marine facilities with COWI as consultant for the detailed design.

The marine facilities consist of a seawater intake facility and associated pumping station and a seawater outfall. Hydraulic modelling was used to develop near shore design conditions for marine structures (extreme waves, currents, water levels).

FACTS

Project period	2011-2014
Client	Saudi Archirodon Ltd.

SERVICES

- › Seawater intake/outfall channel design
- › Hydraulic and coastal engineering
- › Design of dredging and reclamation
- › Design of breakwaters and revetments
- › Pumping station design
- › Architectural and structural design of buildings
- › Infrastructure design (roads and storm water drainage).





RABIGH POWER PLANT NO 2, SAUDI ARABIA

The project is located in Rabigh, on the Red Sea coast, north of Jeddah in the Kingdom of Saudi Arabia. As part of the expansion programme for Rabigh Power Station, an additional four (or six) power generation units of 700 MW capacity each were installed.

Doosan Heavy Industries & Construction (Doosan) was awarded the engineering procurement contract (EPC) by Saudi Electricity Company (SEC) to deliver the Rabigh Power Plant No. 2.

Huta Marine Works Ltd. was sub-contractor to Doosan for the marine works. The marine sub-contract entails a seawater cooling system for the power plant and it covers seawater intake pipes, intake basin surrounded by revetments, pumping station, outfall channel, outfall structure and breakwaters, and shore protection.

COWI provided numerical modelling and design services for the marine subcontract.

FACTS

Project period	2010-2013
Client	Huta Marine Works Ltd.

SERVICES

- › Hydraulic engineering and numerical modelling
- › Management of physical modelling of pumping station, carried out in hydraulic lab, breakwater revetment, and outfall structure
- › Geotechnical engineering
- › Piping engineering for intake glass reinforced pipes
- › Electrical engineering for the cathodic protection of marine works.



OLMSTED LOCKS AND DAM, IL, USA

The Olmsted Dam on the Ohio River is currently under construction 16 miles upstream from the confluence with the Mississippi River. It will consist of an 800-foot-long tainter gate section, a 1,400-foot navigable pass, two boat abutment sections, a fixed weir section, and upstream and downstream scour protection.

COWI provided the detailed design for the new navigation dam and also construction design support of the precast yard including the marine skidway for load-out of the pre-cast shell segments.

The construction design encompassed concrete and steel retaining walls, gantry crane beams, skidway rail including beam and foundation system both above and below water, precast shell cradle, steel frame tremie mat templates, lifting/mating details for the precast shells, mooring anchors and dolphins.

COWI also completed the shell design for the navigable pass precast segments, paving blocks and the lifting frame for the navigable pass segments and supported the design of the tainter gates.

FACTS

Project period	2005-2020
Client	U.S. Army Corps of Engineers, Louisville District

SERVICES

- › Casting yards/launch system
- › Dredging
- › Heavy lift systems
- › Detailed design of all precast and insitu cast concrete elements
- › Foundation design
- › Mooring and berthing
- › Seismic analysis and cost estimation.

NEW ORLEANS FLOOD PROTECTION BARRIER, LA, USA

COWI was responsible for the detailed design of the flood barrier and the monoliths foundations and guide walls, for the main sector gate structure; and a concrete swing barge gate; both of which will be used to regulate navigation, tidal flows, and storm surge into the inner harbour navigation canal (IHNC) in New Orleans.

This \$1.3 billion project is the largest civil works design-build project ever awarded by the United States Army Corps of Engineers. It won the American Society of Civil Engineers' highest design honor in 2014; and is an excellent example of innovative design and of fast-track construction.

The federally funded contract was for construction of a storm surge barrier to keep surges from entering New Orleans' inner harbour navigation canal. Failures of floodwalls overwhelmed by storm surge during Hurricane Katrina in 2005 along the IHNC contributed greatly to the flooding of the city.

The IHNC barrier was completed by mid-2012 near the confluence of the Gulf intracoastal waterway and the Mississippi River Gulf outlet, a natural funnel identified as an area of critical vulnerability.

FACTS

Project period	2008-2012
Client	The U. S. Army Corps of Engineers

SERVICES

- › Numerical modelling
- › Concept and detailed design of the main sector gate monolith, batter pile floodwall, reinforced concrete by-pass barge gate, MRGO berm structure, GIWW approach walls, and scour protection.



OUR TEAMS

Since we designed our first marine project, we have actively participated in the research and development of new techniques, the use of new materials and new technologies in the field of marine structures.

Today, our teams deliver cutting-edge know-how in all aspects of marine and coastal engineering. And we continue to push the boundaries to maximise value for our clients.

DIFFERENT ASSIGNMENTS DIFFERENT COMPETENCIES

Our extensive pool of engineers and experts enable the project manager to set up a team with the right competencies to match your project.



> STRUCTURAL DESIGN > DREDGING DESIGN > COST ESTIMATION > REHABILITATION ENGINEERING > WAVE
MODELLING > HYDRAULIC MODELLING > SOIL STRUCTURE INTERACTION > HYDRODYNAMIC FLOW MODELLING
> CURRENT MODELLING > METEOCEAN STUDIES > SERVICE LIFE DESIGN > LABORATORY TESTING > SEISMIC
ANALYSES > FATIGUE ASSESSMENTS > FINITE ELEMENT ANALYSES > LIFE CYCLE COSTS > SUSTAINABLE
ENGINEERING > MECHANICAL AND ELECTRICAL INSTALLATION DESIGN > OPERATIONAL RISK MANAGEMENT
> CONSTRUCTION RISK MANAGEMENT > NAVIGATION SIMULATION > MASTER PLANNING > STRUCTURAL DYNAMICS
> SHIP COLLISION RISK > UTILITIES > BUILDING DESIGN > MODEL TEST VERIFICATIONS > SHIP IMPACT PROTECTION
> MOORING ANALYSES > HAZID/HAZOP

THE CONSTRUCTION SPECIALIST

Our construction specialist works to secure the balance between design and construction.

THE GEOTECHNICAL EXPERT

Our geotechnical expert specifies the geotechnical site investigations, analyses the results and establishes a geotechnical design basis for the project.

THE PROJECT MANAGER

Our project manager is responsible for managing the contract with the client and for delivering the project on agreed time and budget.

THE STRUCTURAL ENGINEER

Our senior structural engineers are responsible for all basic engineering aspects of the project – drawings and verification, to secure practical buildable structures.

THE SEISMIC EXPERT

Based on information from the site, our seismic expert establishes spectra and time series to be used in the design process.

THE HYDRAULIC AND COASTAL EXPERT

Our hydraulic expert is responsible for determining how the hydrodynamic processes influence the design and functionality of any structure.



AL RUWAIS PORT DEVELOPMENT, QATAR

Al Ruwais Port is located approximately 120 km north of Doha. The project comprises the development of the existing fishing port with new facilities to accommodate dhows, coastal trading vessels and passenger/car ferry traffic importing general cargo including fruit and vegetables, livestock and building materials.

The marine construction work includes dredging, reclamation, concrete block quay walls, fenders, navigation aids, rock revetments, utilities and port furniture, floating pontoons, slipways, fuel storage tanks and dispensers, gantry cranes and block paving.

In addition, there will be service roads and all utilities (sewerage, potable water, surface water drainage, LV, HV and ELV, telecommunication and landscaping including irrigation).

COWI provides post-contract professional general and site supervision and quantity surveying consultancy services for construction.

FACTS

Project period	2010-2014
Client	Public Works Authority (PWA) Ashghal

SERVICES

- › Project management
- › Redesign of marine works
- › Quality assurance program
- › As-built drawing review
- › Record documentation
- › Post contract quantity surveying
- › Site supervision.



GSPC LNG TERMINAL AT MUNDRA, INDIA

The Gujarat State Petroleum Corporation (GSPC) is developing a 5 MTPA (expandable to 20 MTPA) LNG receiving, storage and regasification terminal in Mundra Port in the State of Gujarat, India.

The terminal consists of LNG carrier berthing and unloading, storage tanks, boil-off gas handling, pressurization and vaporization, and connection to the natural gas grid.

The terminal is designed for handling LNG carriers of up to 285,000 m³ capacity.

The marine construction work includes a jetty with an approach trestle of 1.1 km, flare platform, shore protection works, sea water intake and outfall.

COWI provides the preconstruction and construction services including site supervision.

FACTS

Project period	2012-2017
Client	Whesoe Projects Ltd.

SERVICES

- › Front end engineering design (FEED) review
- › Cost estimation
- › Request for proposals
- › Owner's engineering services
- › Site supervision.



OUR EXPERTISE

Every marine project is unique. To meet this challenge, we have world-class engineers and experts working together to seamlessly integrate all aspects of marine engineering – from the marine construction itself to traffic planning, geo mapping and environmental impact assessment.

For every project, from a small coastal protection project to a major LNG terminal, we establish a specific team to ensure that we deliver the perfect solution for you.

DIFFERENT CHALLENGES DIFFERENT EXPERTISE

We combine our expertise and competencies to deliver the optimal solution to your challenge.



SITE INVESTIGATIONS

- › Design basis development
- › Geological, wind and hydraulic investigations
- › Operational risk and safety concepts
- › Metocean conditions



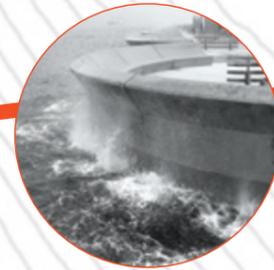
IMPACT ASSESSMENT

- › Environmental impact
- › Hydraulic modelling
- › Social impact
- › Planning impact
- › Cost impact



CONCEPT DEVELOPMENT

- › Marine structures
- › Renderings and animations



DESIGN

- › Marine foundation design
- › Offshore wind turbine foundations
- › Marine terminals
- › Ports
- › Coastal engineering
- › Waterfront developments
- › Man-made islands
- › Breakwaters
- › Electrical and mechanical design of installations



PROCUREMENT

- › Procurement strategies
- › Tender documents
- › Scheduling
- › Contracting



LIFE CYCLE CONSIDERATIONS

- › Operation and emergency planning
- › Inspection and maintenance systems
- › Life cycle cost optimization
- › Sustainability



CONSTRUCTION

- › Construction management
- › Site supervision

THE PEARL-QATAR

The Pearl-Qatar project involved detailed design of the reclamation works for the 400 hectare new island requiring approximately 13.5 million m³ of fill and the associated sea defence structures for the 40 km of new shoreline.

The development included private beaches along most of the perimeter, which adds to the aesthetics and exclusiveness of the development. Various concepts were developed to create a variety of beach environments that are optimised to suit the local conditions and requirements.

Numerical hydrodynamic model studies were carried out to determine the metocean design basis.

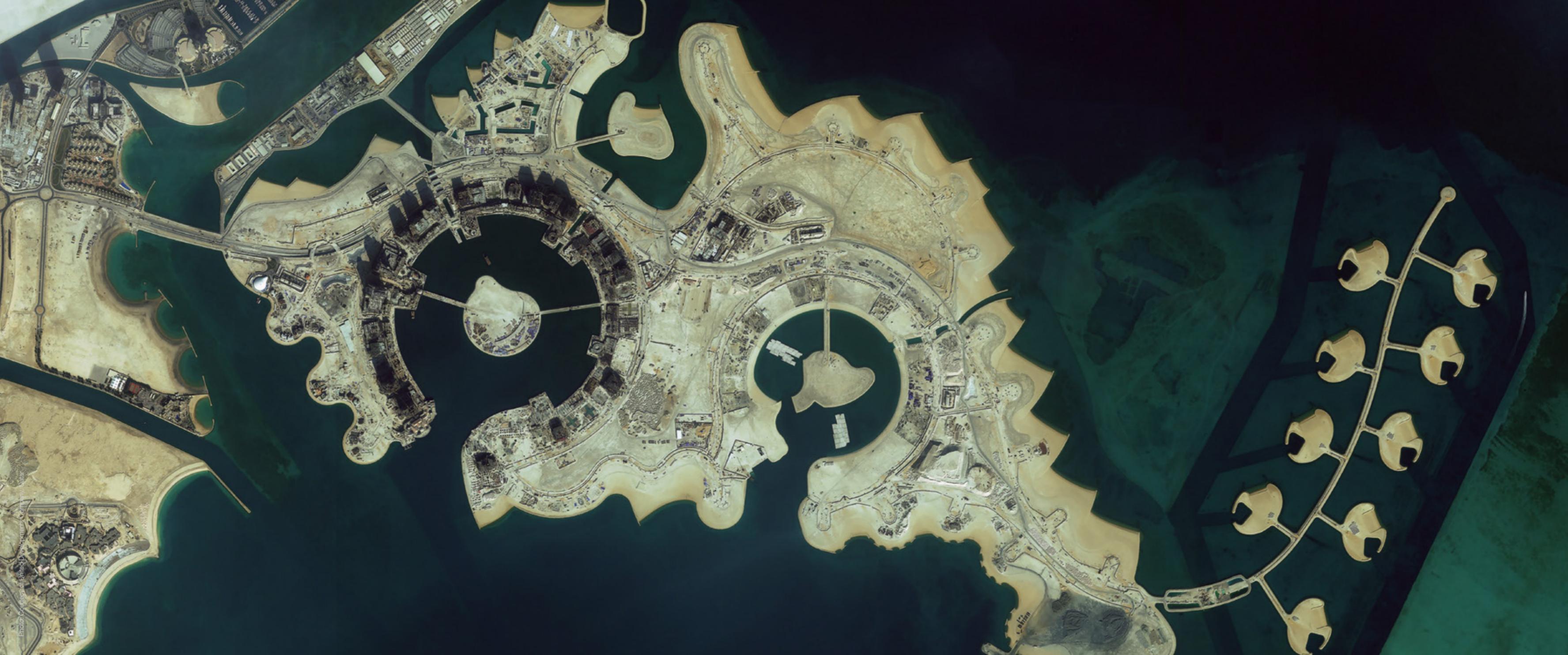
COWI has, in addition to the island design, rendered technical assistance during construction and the design of the marinas.

FACTS

Project period	2003-2008
Client	United Development Company (UDC)

SERVICES

- › Bathymetric survey
- › Design of marinas
- › Design of culverts
- › Design basis
- › Conceptual design
- › Detailed design
- › Preparation of tender and contract documents.



MARINE TERMINALS



RUWAIS SULPHUR EXPANSION, UNITED ARAB EMIRATES

Marine terminal for export of granulated sulphur to handle bulk carriers of 10,000 to 65,000 DWT. The marine terminal is equipped with a quadrant ship loader with a capacity of 1,400 tons/hour and a radius of 58 metres.

Project Period: 2007-2011
Client: Dodsai/Pegasus TSI

SERVICES:

- › Design basis
- › Task management
- › Hydrodynamic modelling
- › Geometric berth layout study
- › Dynamic mooring analysis
- › Concrete and steel pile design
- › Detailed design of marine structures
- › Scoping and supervision of pile testing
- › Preparation of tender documents for the marine works contract, including specifications for marine furniture, gangway and berthing aid system
- › Evaluation of in-coming proposals.



KNPC NORTH AND SOUTH PIER SURVEY, KUWAIT

Terminal for gas import and export of crude oil and refined products, for vessels of up to 300,000 DWT.

Project Period: 2012-2014
Client: Kuwait National Petroleum Company and Integral Services Co. W.L.L. (ISCO)

SERVICES:

- › Sub- and superstructure inspections including underwater inspection of piles
- › Non-destructive testing and gauging with ultrasound equipment
- › Structural calculations of typical sections in North and South Piers
- › Finite element modelling and structural assessments
- › Survey and re-assessment study for the North Pier
- › Re-assessment calculations and rehabilitation strategy study.



PORT OF REDWOOD CITY, CALIFORNIA, USA

Deepwater access for bulk, neo-bulk, and liquid cargos. Existing Wharves 1 and 2, built in the 1930's and 1940's, are used for offloading aggregate, primarily from Panamax vessels. COWI was retained to lead a modernization project for Wharves 1 and 2.

Project Period: 2011-2013
Client: Port of Redwood City

SERVICES:

- › Coordination of site investigations including a geotechnical exploration, hydrographic survey, topographic survey, and hazardous material surveys
- › Marine structural design
- › Production of bridging documents for the design-build team
- › Permitting
- › Review and approval of the design-build teams 75%, 95% and final designs
- › Quality assurance during construction.



SHIP HANDLING PROCEDURES FOR SEMARANG FSRU, INDONESIA

Pertamina Persero intends to build infrastructure for gas importation, storage and distribution centred on the port of Semarang and is now carrying out a number of related feasibility-type studies.

Project period: 2014
Client: PT Pertamina (Persero)

SERVICES:

- › Review, evaluation and recommendation type of mooring arrangement for FSRU
- › Navigation simulation
- › Dynamic mooring analysis
- › Recommendation of standard operation procedures
- › Determination of support vessel fleet number and composition.



SHTOKMAN LNG TERMINAL, RUSSIA

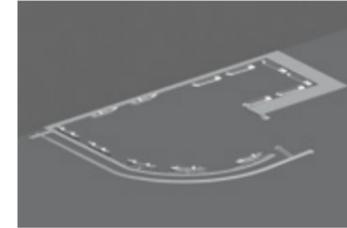
Establishment of a gas condensate facility in the Teriberka Bay on the north coast of the Kola Peninsula.

Project Period: 2009-2012
Client: Shtokman Development AG

SERVICES:

- › Review of pre FEED and FEED study documents
- › Independent assessment of the design basis data and the numerical and physical models applied in the pre-FEED and FEED studies
- › Evaluation of the wave model results
- › Integrated assessment of the completeness and robustness of the FEED studies carried out
- › Comparative assessment of the two proposed locations for the marine facility with respect to safety, operability, product deliverability and constructability.

PORTS AND HARBOURS



MASTER PLAN FOR KAKINADA SEZ PORT, INDIA

All-weather, deep water, multipurpose world-class port for dry bulk cargo such as coal, fertilizer, fertilizer raw materials, food grains and other bulk cargo; containers; liquid bulk cargo like crude oil, POL, bulk chemicals/petrochemicals, edible oils; project and engineering cargo, and other cargo.

Project period: 2012-2013
Client: Kakinada SEZ Pvt Ltd.

SERVICES:

- › Review of previous modelling studies
- › Littoral drift and shoreline modelling
- › Hydrodynamic modeling
- › Cyclone and storm surge modelling
- › Sedimentation modeling
- › Dredge plume dispersion modelling
- › Ship navigation study for optimization of navigational channel and manoeuvring of LNG and bulk carriers.



PLANNING FOR CRUISE SHIP FACILITY, GREENLAND

Updating and clarifying current and future cruise ship operations at the Ilulissat Icefiord in Qaasuitsup Kommunia in northern Greenland.

Project period: 2013
Client: Qaasuitsup Kommunia

SERVICES:

- › Review of current cruise ship traffic to Ilulissat town in terms of opportunities and challenges
- › Meetings and interviews with stakeholder groups to identify local concerns and preferences
- › Field trips by foot and by boat along the wilderness coast north of the Icefiord to identify suitable locations with potential for development of new marine facilities
- › Summary report with proposed next steps.



PORT OF FREDERIKSHAVN, DENMARK

The port expansion comprises 4.5 km of outer breakwaters and dredging of more than 6 million cubic meters from the new port basin to be used as landfill for the new harbour areas. A new 1,000 m long quay is built with 11 m water depth, but designed for future dredging to 14 m water depth. The access channel to the port will be enlarged in order to allow access for Panamax carriers.

Project period: 2012-2016
Client: Frederikshavn Havn A/S

SERVICES:

- › Preparation of master plan
- › Numerical modelling of waves, currents, sediment transport and wave agitation
- › Geotechnical surveys
- › Navigation studies
- › Concept design and budget for works
- › Environmental impact assessment
- › Detailed design and tendering of the expansion in one single lot
- › Supervision of works.



SONAREF REFINERY MARINE TERMINAL, ANGOLA

Two-berth terminal for receiving crude for a new refinery.

Project period: 2013-2014
Client: Odebrecht Angola Projectos e Serviços Lda

SERVICES:

- › Independent design verification (IDV) of design of marine facilities (blockworks, revetments)
- › IDV of reclamation works
- › Hydrographic design conditions
- › Design of shallow water revetments
- › Expert assistance to dynamic compaction trial tests.



BROOKLYN NAVY YARD, NY, USA

Survey of existing conditions to develop a maritime economic study and a recommendation of rehabilitation alternatives.

Project period: 2012-2013
Client: Brooklyn Navy Yard Development

SERVICES:

- › Survey
- › Investigation of Dry Dock 4
- › Investigation of Pier C
- › Environmental permitting
- › Design services to rehabilitate for future improvements.



COASTAL ENGINEERING AND WATERFRONT DEVELOPMENTS



AL FAW BREAKWATER, IRAQ

New port development with 8 km rubble mound breakwater.

Project period: 2012-2013
Client: Archirodon Construction (Overseas) Co. S.A.

SERVICES:

- › Data collection and review
- › Met-ocean and morphological studies including numerical modelling
- › Geotechnical assessment
- › Foundation design including stability and settlement analysis and need for soil improvement
- › Design of breakwater and staging pier.



THE PEARL MARINAS, QATAR

Three large marinas with floating pontoons systems built to the highest international standards. They include the full range of services including a complete maintenance facility for vessels and a large dry storage for 150 boats. The total number of berths is 770 and for boat sizes ranging from 12 metres to yachts of 60 metres in length.

Project period: 2003-2004
Client: United Development Company (UDC)

SERVICES:

- › Basic design of three marinas including super yacht area
- › Marine transport feasibility study
- › M&E design including fuel berths
- › Concept design of the maintenance facility
- › Technical specifications
- › Preparation of tender documents.



ISLAND 2, UNITED ARAB EMIRATES

A mixed-use development that will house a high end boutique resort along with low rise apartment buildings and a marina. A bridge will connect the island to the coast.

Project period: 2013
Client: Meraas Development LLC

SERVICES:

- › Studies and design services for beaches
- › Numerical modelling of wave conditions and flushing
- › Geotechnical assessment report
- › Concept
- › Preliminary and detailed design of marine and coastal protection studies
- › Reclamation works design
- › Preparation of tender documents.



STORM DAMAGE ASSESSMENT AND REPAIR, DENMARK

The storm Bodil in December 2013 coincided with very high water levels in Danish waters and caused much material damage. It gave impetus to many climate adaptation activities.

Project period: 2013-2014
Client: Danish Municipalities

SERVICES:

- › Inspection
- › Surveys
- › Design and permitting of coastal structures following damage by the storm Bodil.



PRE-INVESTIGATIONS AT SIX NEARSHORE WIND FARM SITES, DENMARK

Pre-investigations as part of the process towards the tendering of the operation licenses for offshore wind farms.

Project period: 2013-2014
Client: Energinet.dk

SERVICES:

- › Meteorological and oceanographic studies
- › Background reports to the EIA
- › Met-ocean study report for the concession bidding process
- › Wind resource related report for the concession bidding process.

OFFSHORE WIND TURBINE FOUNDATIONS



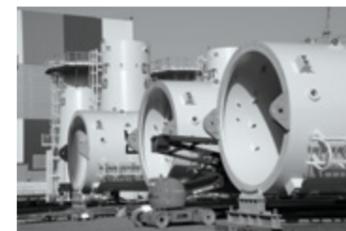
THORNTON BANK OFFSHORE WIND FARM - PHASE 1, BELGIUM

Detailed design of the foundations. In 2003-04 COWI carried out a concept study for alternative foundation solutions, including the innovative conical shell structure, eventually adopted by the project owner.

Total: 30 MW
WTG: REpower 5.0 MW
Water depth: 30 m
Foundation no.: 6
Foundation type: Gravity based
Project period: 2006-2008
Client: Dredging International n.v. Belgium

SERVICES:

- › Structural design of foundations
- › Geotechnical design
- › Numerical and physical hydraulic modelling of installation stages, including dynamic loads and scour
- › Appurtenances design, including boat landing and J-tubes
- › Project follow-up in construction stage.



DANTYSK OFFSHORE WIND FARM, GERMANY

Detailed design of the monopiles with a diameter of almost 6 metres. A grouted cylindrical connection to the transition pieces using shear keys was chosen. The foundations are equipped with internal cabling, steel working platforms and scour protection.

Total: 288 MW
WTG: Siemens 3.6 MW
Water depth: 21-32 m
Foundation no.: 80
Foundation type: Monopile
Project period: 2010-2013
Client: Aarsleff / Bilfinger Berger joint venture

SERVICES:

- › Structural design
- › Geotechnical design
- › Hydraulic calculations.



HORNS REV C, KRIEGERS FLAK A AND B, TRANSFORMER PLATFORMS, DENMARK

Concept and basic design of two transformer platforms for the 600 MW Kriegers Flak offshore wind farms. Furthermore, COWI develops concept and detailed design of Horns Rev C 400 MW transformer platform.

Project period: 2013-2015
Client: Energinet.dk

SERVICES:

- › Design of foundations
- › Basic and detailed design of 2x400 MW and 200 MW platforms including mechanical and electrical design.



FORMOSA 1 OFFSHORE WIND FARM FOUNDATIONS, TAIWAN

An offshore wind farm in East Asia on the western coast of Taiwan, consisting of 36 turbines in total, is planned to be installed in 2018.

Total: 144 MW
Water depth: 15-30 m
Foundations no.: 36
Foundation type: Monopile/Jacket
Project period: 2014-2015
Client: Formosa Wind Power Co.

SERVICES:

- › Front end engineering design and detailed design of foundation for eight positions
- › Front end engineering design of the entire wind farm.



RØDSAND 1 AND 2 GRAVITY BASED FOUNDATIONS, DENMARK

Detailed design of Nysted and Rødsand 2 offshore wind farms located in the Baltic Sea just south of Denmark. 90, 2.3 MW, wind turbines completed the neighbouring 72 wind turbines at Nysted installed in 2002 and 2003.

Total: 368 MW
WTG: SWP 2.3 MW
Foundation type: Gravity based
Water depth: 7.5-15 m
Foundations no.: 162
Project period: 2001/2003-2008/2010
Client: Aarsleff / Bilfinger Berger joint venture

SERVICES:

- › Structural design
- › Geotechnical design
- › Hydraulic calculations and design
- › Project follow-up.



OWF App

COOLING WATER SYSTEMS



QURAYYAH COMBINED CYCLE POWER PLANT, SAUDI ARABIA

A combined cycle power plant located 100 km south of the Port of Dammam. COWI designed the structures for cooling water.

Project period: 2011-2012
Client: Huta Marine Works Ltd.

SERVICES:

- › Wave modelling
- › Hydraulic design and hydraulic modelling
- › Design of intake pipes and intake basin
- › Design of outfall channel and end weir
- › Design of shore protection
- › Geotechnical design
- › Structural design of roads.



GASCO 4TH NGL TRAIN, UNITED ARAB EMIRATES

The seawater cooling system of the 4th NGL train is a once-through cooling water system comprising offshore intakes, manifold, discharge pipes, discharge structure, sealing weir structure and outfall structure.

Project period: 2010-2012
Client: Target Eng. Cons Co.

SERVICES:

- › Marine and coastal design
- › Structural design
- › Geotechnical design
- › Hydraulic studies and design
- › Mechanical design
- › Piping design
- › Electrical and instrumentation systems
- › Smart plant design (3D modelling).



QURAYYAH INDEPENDENT POWER PLANT, SAUDI ARABIA

New gas-fired combined cycle gas turbine power plant of net power capacity 3,927 MW.

Project period: 2012-2013
Client: Hula Marine Works Ltd.

SERVICES:

- › Hydraulic design of intake and outfall pipeline system
- › Design basis including met-ocean verification
- › Geotechnical interpretative report
- › Design of intake risers – velocity cap type structures
- › Design of dredging and reclamation
- › Design of diffuser structures
- › Review of details from manufacturer of glass fibre reinforced pipe for the outfall
- › Review of construction methodology
- › Design of lifting arrangements.



RAS AL-KHAIR, SAUDI ARABIA

The Saline Water Conversion Corporation (SWCC) developed a combined cycle power and desalination plant in Ras Al-Khair formerly known as Ras Az Zawr (RAZ) Power and Desalination Plant.

The plant has a capacity of: 2,400 MW net power output and 1,025 Tm³/d water production.

The Ras Al-Khair power and desalination plant project was divided into two EPC contracts covering power production facilities and desalination plant.

Project period: 2010-2011
Client: Archirodon Ltd.

SERVICES:

- › Seawater intake channel consisting of two approximately 1.4 km long straight breakwaters orientated perpendicularly to the coast
- › Scour protection of outfall structures consisting in eight buried discharge pipes and an outfall structure with diffusers
- › Shoreline protection revetments
- › Design of transition between onshore structures and the eight discharge pipes with the diffuser structure.

LOCKS, DAMS AND BARRIERS



RAS LAFFAN NEW SHIP REPAIR YARD, QATAR

The marine part of the project consists of two graving docks to accommodate QMax and QFlex LNG vessels as well as VLCC's, one floating dock of panamax size, six wet berths with a total length of 2,400 m and a minimum depth of 11 m, a heavy lift berth and extensive lay down and fabrication areas.

Project period: 2006-2011
Client: QP/Nakilat

SERVICES:

- › Optimisation studies
- › Design of finger piers and mass concrete block quay walls for vessel fitting out, including substations
- › Design of load out quay for heavy lifts
- › Design of a lay down and fabrication area
- › Preparation of tender documents
- › Supervision of construction works.



FOLSOM DAM SPILLWAY CA, USA

Design of a new spillway and six new gates to allow release of more water in advance of major storms, taking earlier advantage of the river's capacity.

Project period: 2008-2016
Client: URS Corporation,
USACE - Sacramento District

SERVICES:

- › Structural engineering
- › Geotechnical engineering
- › Coastal engineering
- › Quantities and cost estimating
- › Construction engineering.



CHARLEROI LOCKS AND DAM - LOCK #4, PA, USA

Design of a new river wall and upper guardwall at Charleroi Locks and Dam. COWI designed the upper guardwall. The guardwall consists of six piers and a sheetpile nose cell, which supports seven precast posttensioned concrete box beams, with flow skirts, that form the guard wall.

Project period: 2003-2013
Client: USACE - Pittsburgh District

SERVICES:

- › Detailed design
- › River navigation structures
- › Precast concrete construction
- › Construction sequencing and scheduling
- › Construction engineering.



BRADDOCK DAM LOCK 2, MONONGAHELA RIVER, PA, USA

COWI was retained by the USACE Pittsburgh District to design and assist with construction supervision of the New Braddock Dam. As the Engineer-of-Record for all final structural design drawings, we designed the float-in precast dam segments and developed in-the-wet construction methods and procedures.

The Braddock Dam was constructed using a new and innovative float-in method, a first within the USACE. The application of this innovative in-the-wet approach is a landmark event, and one that could revolutionize the future construction of navigation projects. We successfully completed a major portion of the detailed design following an aggressive seven month schedule.

The challenges presented: developing a cast and launch facility for two, 11,000-ton dam segments; developing a 102 m long precast dam segment

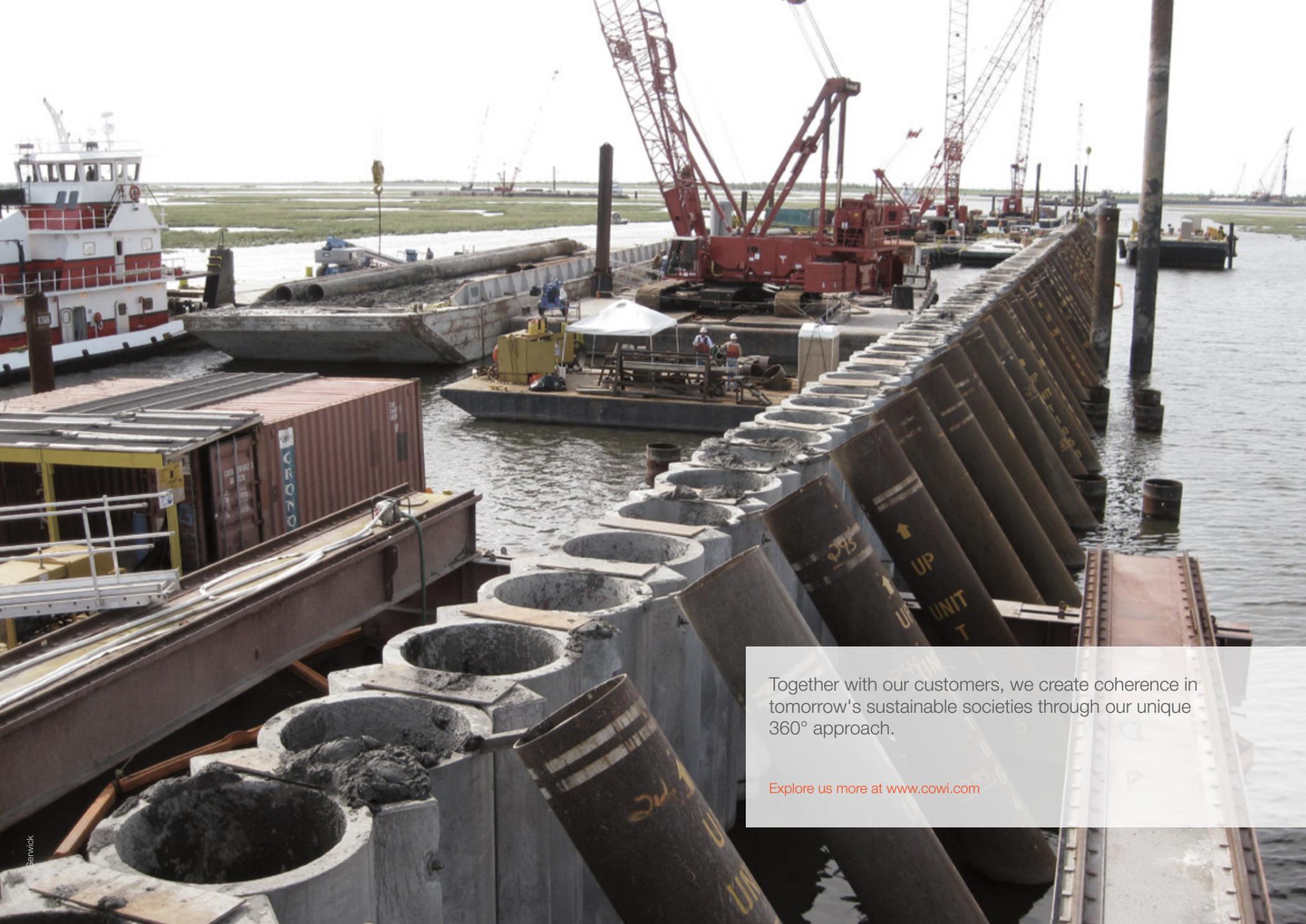
float-in and set-down sequence shell with sufficient strength for launch, transport, and immersion while maintaining a 3.1 m maximum draft; and developing a transport, positioning, immersion, and dam completion plan that would safely accommodate a 500-year flood at any time with 48-hour notice.

Project period: 1997-2008
Client: U.S. Army Corps of Engineers Pittsburgh District

SERVICES:

- › Detailed design
- › River navigation structures
- › Construction sequencing and scheduling
- › Construction means and methods
- › Tremie concrete mix design
- › Construction engineering.





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