THE ARCTIC CHALLENGE

Marine engineering services for oil and gas development projects in arctic areas.
A GLOBAL PRESENCE
Over the last 40 years, Multiconsult has developed a unique expertise in several competence areas for the Oil and Gas Clients:

- Marine Subsea Foundation Engineering, with a world class reputation in Marine Geotechnics
- Marine Concrete Structures Engineering, with a world class reputation on gravity based and floating concrete structures using in-house software design tools
- Multidiscipline consulting and engineering in the Civil, Infrastructure and Marine area for oil and gas onshore facilities, as well as coastal/marine projects at shore and offshore
- Specialised competence in the area of noise and vibrations, mechanical, high voltage electrical, fire and HSE in compliance with the demanding NORSOK requirements
- Long experience with engineering and project management of complex and challenging integrated projects, using project execution models to develop and keep track of design and construction

During the last couple of decades, the company has developed special expertise in cold climate and marine engineering; defining the physical cold climate environment, setting up design premises for fixed and floating facilities offshore and coastal facilities at/onshore, developing arctic operations premises and management.

Photo: (Statoil) Helge Hansen, Harald Pettersen, Øyvind Hagen
There has been a growing interest in the global Oil and Gas market towards explorations and development of resources in arctic areas and ice covered waters. During the last 25 years, Multiconsult has specialized in technology and engineering subjects related to planning, design, construction and operation of onshore and marine/offshore infrastructure and installations in cold climate.

The basis for this expertise is a broad experience with projects in the Arctic area of Northern Norway, including the extreme cold climate on Svalbard as well as onshore and offshore infrastructure and platforms in the Arctic seas. This experience is combined with a strategic involvement in research and development projects, both in-house and in cooperation with other major research organizations like the Norwegian University of Science and Technology (NTNU), the University Courses on Spitsbergen (UNIS), and Sintef.

The coast of Norway is characterized by a complex bathymetry with islands, reefs, subsea cliffs and steep shore slopes. This represents challenges in assessment of wave state and wave propagation, as well as impact of waves on structures. The Barents Sea presents a transition zone to ice covered areas in the European Arctic. The Eastern part is characterised by yearly presence of first year sea ice, occasionally multi-year ice and icebergs. The western part of the Barents sea is ice free and poses Arctic challenges such as sea spray icing in combination with severe wind and waves. Further east and north, the Kara Sea and Arctic Ocean present challenges related to extreme cold climate and the presence of severe ice conditions, with multi-year ice and icebergs.

Multiconsult has extensive experience in coastal and offshore infrastructure, in particular Arctic engineering and design for cold climate. Our experience ranges from assessing the design of physical environments, planning and logistics, onshore infrastructure, harbours and sea front structures, fixed and floating structures near shore and offshore, and infrastructure design in ice covered waters.
Research and development are key factors in the planning and construction of structures along the northern coasts and seas. This applies in particular for Arctic projects involving operations and actions from sea ice and icebergs.

With the increased focus on field development in remote Arctic areas, new onshore terminals are required to handle seaborn transport. Logistics and operations in cold remote areas poses challenges to all parts of such developments. Bigger ships requires larger maneovring space, which motivates terminals to be built in increasingly remote locations.

With regards to drilling, production and offloading, field development solutions must be operable all year. Experience with development and export of hydrocarbons from Arctic areas is sparse, found mainly in the Beaufort Sea. However, the proprietary solutions used here are often unsuitable in other areas, and new solutions are therefore needed.

The need for research and development is apparent in areas where fixed and floating structures interact with complex wave regimes in shallow waters, sea spray with atmospheric icing, cold precipitation and snow drift in general.

Infrastructure in extremely cold areas involves the presence of permafrost, which challenges the coastal infrastructure and subsea structures. In particular, the dynamic shore zone will challenge the infrastructure with shore erosion and instability, as well as subsea impact from drifting sea ice (ridges, stamuchas).
Multiconsult has been participating in several Joint Industry Projects related to marine and cold climate technology. These are executed using experienced personnel with research background from universities (PhD’s). The projects have covered several topics:

- Ice gouging and ice impact on subsea facilities (pipelines, templates)
- Shallow water waves and wave action on fixed and floating structures
- Offloading and production of hydrocarbons in ice infested water
- Ice actions on fixed and floating structures, including model testing in ice
- Numerical simulations of how fixed and floating structures interact with drifting ice
- Sea spray icing on offshore structures

Part of the basis for cold climate engineering is experience with field work and field observations. Our key personnel have experience with field work in arctic conditions, including several expeditions with ice breaking vessels: Lance, KV-Svalbard and Oden.

There has been a substantial cooperation between Multiconsult, the University Centre on Svalbard (UNIS) and the Norwegian University of Science and Technology (NTNU). Multiconsult is an industry partner in the strategic cold climate research project SAMCoT at NTNU’s centre for research based innovations (SFI). This project is organised in several research packages, with focus on field work and full scale data collection, constitutive modelling of ice and permafrost, ice management, ice actions on structures, coastal processes and shore erosion.
ARCTIC ENGINEERING

ARCTIC MARINE TECHNOLOGY

• Structures in ice-covered waters
• Numerical modelling of ice actions
• Hydrodynamic analyses
• Mooring design and response of moored structures
• Ice interaction with marine slender structures
• Field work/simulation/analysis of metocean data
• Coastal engineering
• Cold climate engineering and winterisation
• Research and development

STRUCTURES IN ICE

Geo fixed, i.e. fixed or floating structures, makes a step change compared to shipping in ice. While ships operation in ice represents valuable experience, the faces limited motion energy and stress related to geo fixed structures. And, as opposed to fixed structures, ships can adjust routing and speed in heavy ice in order to limit exposure.

Multiconsult has experience in the design of structures in ice, ranging from fixed sea front structure and jetties to fixed and floating offshore structures. The nature of ice is complex, from the forming of ice in early season to melting, partly melting and refreezing the next season resulting in old ice. The ice drift is highly dynamic, with ice features that will pose large threats to any structure. When ice is present, it will therefore govern the design.

Assessment of ice interaction with structures can be performed with code design. While this can be sufficient in many cases, especially in early design and studies, the use of advanced Finite Element Methods (FEM) is a good option with reliable results representing design load actions.

Multiconsult has experience with FEM software like LS-Dyna and Abacus, and our experts have published a number of articles on the topic.
PHYSICAL ENVIRONMENT SPECIFICATION AND DESIGN DATA

The Arctic represents large remote areas in a complex environment. The physical climate data suitable for engineering design is limited, but we have found an increasing number of parameters and physical phenomena correlating in various ways:

- Sea spray icing: wind, waves, sea temperature, atmospheric temperature
- Cold precipitation and snow drift: dependent on precipitation, snow morphology, temperature, wind
- Ice drift: wind, current, ice presence, ice features and location

For realistic representations of the environment, correlations and other statistical properties must be considered. Multiconsult has developed new and sophisticated methods to this end, and combining these with the engineering process we get dependable assessments of the safety and reliability of the design as an integrated system.

SNOW AND ICING

Snow and snow drift represent challenges to structures onshore and offshore. Snow drift will increase actions on structures in general, on specific equipment, escape ways and operations. To address these issues, methods involving flow pattern (CFD) and air transport are needed.

Sea spray icing pose risks to seafront and offshore structures in arctic waters. Extensive work based on semi-empirical formulas has been done to assess sea spray icing on smaller vessels. However, these methods will largely overestimate icing risk on larger structures, and methods involving CFD are needed to establish a comprehensive design basis for sea spray icing.
MODEL TESTING

To investigate the response of structures in ice, model testing will in most cases be the best solution. However, the limitations are numerous and model testing consumes a lot of time and resources. Multiconsult is experienced in supervising ice model testing, and our experts have published a number of articles on the subject.

SIMULATION OF ICE LOADS

Multiconsult has developed a proprietary ice load simulation software, modelling how fixed and floating structures interact with ice. The model represents a fully coupled moored structure in variable ice drift, exposed to level ice and ridges. The software comprises non-linear simulations, with ice/structure interaction (i.e. surcharge effects). The load formulation is compliant with the ISO 19906 standard.
CONCRETE STRUCTURES

Concrete geobased structures are attractive solutions for shallow waters exposed to ice. They are robust, with proven technology and capability to withstand actions from ice forces many times higher than wave forces. There are a number of platforms installed in Arctic conditions, designed for heavy ice conditions.

Design life and durability are major issues for concrete facing direct exposure to ice, with abrasion from dynamic ice drift particularly challenging. Multiconsult has core expertise on these issues, with extensive research and analyses on the effects of ice scoring and concentrated ice loads on the concrete face.

SOIL INTERACTION AND PERMAFROST

The design of landfall and seabed structures in shallow waters are governed by ice drift and seabed scouring, as is the burial depth of pipelines. Numerical modeling of ice interaction is feasible, but involves advanced FEM methods. Furthermore, numerical modeling must include soil conditions, back-fill materials, pipelines, type of ice features, bathymetry and sea bottom topography.

Permafrost will be present in extreme Arctic locations. Permafrost in shorelines and offshore is dynamic, and poses challenges to the design of offshore structures in shallow waters and landfalls. Multiconsult is an industry partner in the strategic research program (SFI) at NTNU that focuses on shore erosion and shore dynamics with permafrost/shoreline interaction.
ABOUT MULTICONSULT

Multiconsult is a leading consulting engineering company in Norway and Scandinavia. We offer multi-disciplinary consulting, design, engineering, project monitoring, verification, inspection and supervision. With more than 105 years of experience, we continue to create history together with our customers, focusing on expertise and the right balance of skills among our 1500 employees.

Both our staff and our customers are encouraged to see opportunities where others see problems. This way, we aim to break the barriers that other people are tempted to.

Multiconsult has 30 offices in Norway and overseas. Our head office is in Oslo, but all of our expertise is available through all of our offices. Multiconsult offers design and consulting services for all project phases. Multiconsult’s international business continues to grow. We are working on projects in Africa, Asia, South America, Canada and various parts of Europe.

Multiconsult’s business areas:
- Buildings and Properties
- Industry
- Oil and Gas
- Transportation and Infrastructure
- Energy
- Environment and Natural Resources