IMDC

International Marine and Dredging Consultants (IMDC) is an engineering and consultancy company specialized in a vast range of water related projects. Our highly qualified staff offers advice based on recent research results of leading universities and research institutes and hands-on experience acquired throughout the years.

In this product sheet, a number of our competences and services related to immersed tunnels are highlighted.

More information can be found on our website: www.imdc.be

Immersed Tunnels

Immersed tunnels consist of very large pre-cast concrete or concrete-filled steel tunnel elements fabricated in drydocks and then installed at the riverbed or seabed.

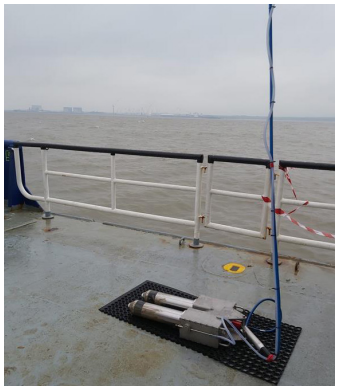
At IMDC, we have been involved in multiple immersed tunnel projects since 2014, in a variety of soil and hydrodynamic conditions. While the structural design of the tunnel elements can be tackled by IMDC's mother company Tractebel, IMDC's particular expertise is exceptionally valuable when focusing on installation and environmental aspects.

Services

Based on our experience, IMDC stresses the value of assessing construction, installation and maintenance aspects in a very early project stage and to take these also into account in a thorough risk assessment. While risks are inherent to every project, many of them can be avoided when complex operations like over-water transportation and immersion of tunnel elements are planned well ahead. With this in mind, IMDC has developed a number of services that are focused on the de-risking of tunnel immersion projects:

Monitoring

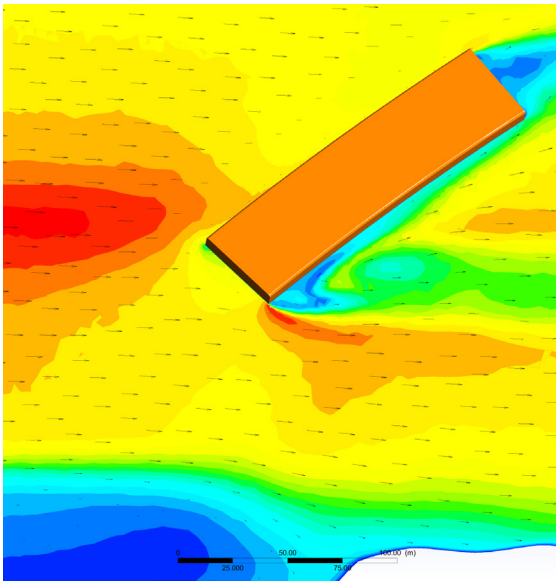
IMDC disposes of a large team of monitoring experts and owns a comprehensive range of high-tech equipment capable of measuring hydrodynamics (waves, water levels, currents) and sediment transport (incl. turbidity), water and bed densities and a series of water quality parameters (salinity, dissolved oxygen, …). These resources allow IMDC to support clients with site characterization campaigns and baseline surveys before start of the works as well as on-site real-time monitoring during the works :



- Hydrodynamic conditions along the trajectory of transportation of the tunnel elements (ocean, river, estuary) and at the tunnel installation location > The results of these campaigns can be used to calibrate a hydrodynamic model or forecasting application (see lower) and check conditions at the time of execution.
- Environmental conditions at the tunnel installation location (e.g. turbidity, dissolved oxygen, etc…) > baseline survey as input for EIA and permitting process.
- Water density and salinity at the tunnel installation location > IMDC has experience with the impact of density variations during the immersion operation .
- Sampling of (surface) sediments and in situ mud density measurements > Characterization of sediments and mud is necessary to assess the risk of sedimentation of the tunnel trench prior to immersion.

Hydro-dynamic and environmental modelling

IMDC is specialized in preparing realistic 3D models to predict (tidal) water levels, currents, waves, sedimentation and density variations in the vicinity of the tunnel installation location. The output of these detailed models can be used for the design of the immersion systems and dredging works, but also to prepare workability criteria for the installation. Finally, these models can be coupled to forecasting tools (see lower) to provide support on GO-NOGO decisions in the days before scheduled installation.



CFD Modeling

When it comes to a detailed planning and preparation of the tunnel installation activities, IMDC has a large experience in applying Computational Fluid Dynamics (CFD) modelling e.g. for immersed tunnels in Belgium, the Netherlands, Denmark and Germany. This type of advanced models is particularly suitable for studying the following phenomena:

- Current loads
- Passing vessel loads
- Vortex induced motions
- Immersion in fluid mud (effects when positioning tunnel elements on gravel bed foundation)
- Immersion complicated by density stratification

The output of these CFD simulations are very detailed 3D flow patterns as well as pressure distribution over the tunnel element walls. These loads can be directly integrated in a dynamic mooring analysis assessment to design all the mooring and hoisting systems.

Operational forecasting

A safe and controlled installation of immersed tunnel elements requires a decent understanding of the meteorological and hydrodynamic conditions that might occur and impact the operation at the crucial moment of positioning and immersion of the tunnel elements.

IMDC can predict the expected waves, currents, water levels and wind for the coming days. Based on this outcome, a workability prediction is derived and reliable go or no-go decisions can be taken (see figure on the right).

Geotechnical and hydraulic expertise

IMDC can also support in the detailed design of the surrounding infrastructure and protection :

- Soil improvement methods where necessary
- A stable gravel bed foundation
- A stable underwater slope for the trench
- Protection on top of the tunnel elements (against falling and dragging anchors and hydraulic loads caused by propellor jets and waves and currents from passing ships)

Tunnel elements manufacturing site @Zeebrugge

On-site follow-up during installation

Bringing all this relevant practical experience together, IMDC is the perfect partner to involve for on-site supervision of the most crucial activities.
During the installation itself, the forecasted values for currents, discharges, water salinity and density are continuously compared with the real-time in-situ measurements to keep control on the boundary conditions at any time. Meanwhile the actual operational parameters (observed forces, movement of the tunnel element, …) are also monitored and compared with the design values originating from IMDC's CFD models to ensure that every step is executed safely within the operational design limits. This way IMDC can carefully guard the proper conduct of the operation and advise on the spot on appropriate corrective actions if necessary.

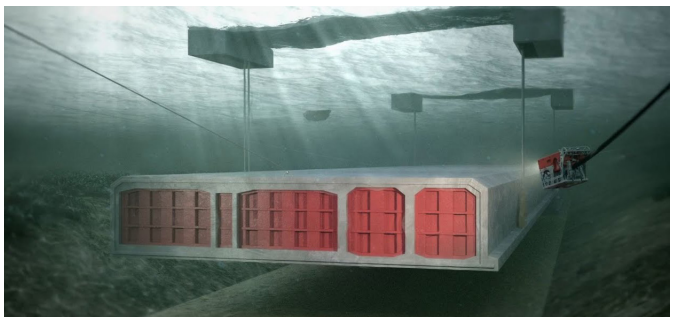
Nautical expertise

For transportation, the same nautical infrastructure is used as for existing shipping traffic, which makes it a high-risk operation.

IMDC has the necessary nautical expertise to assess and optimize possible transport routes over water and determine the tug requirements. By combining this expertise with our experience in CFD modelling and the development of forecasting tools (cfr. other paragraphs), IMDC possesses the right skills and competences to evaluate the risks and design loads.

Support during EIA and permitting process

Prior to any tunnel construction work, an EIA (Environmental Impact Assessment) is usually needed, and based on this, a permit application procedure is started. IMDC can assist with specifying or executing the required baseline studies (cfr. paragraphs on modelling and monitoring above) for this EIA, assessing the impact of the works on the marine or estuarine environment and the recommendation of mitigating measures. IMDC can also take the lead in the application of the environmental permits on behalf of the Client. Often, within such a permit, an Environmental Monitoring and/or Management Plan (EMP) is requested by the competent authorities. The exact specifications for such an EMP can be provided by either the permitting authorities themselves or proposals are expected from the Client (Project Owner) or the bidders (Contractors) during tendering. IMDC can support all parties in setting up the relevant, adequate and feasible (read: realistic and cost-effective) monitoring and/or management plan.



Femern Belt, Credit: Femern A/S

Key references

Fehmarnbelt Tunnel

Country: Germany - Denmark
Year: 2014-2025
Client: Femern Link Contractors

General engineering services related to dredging, environment, navigation, hydraulic design for the Fehmarnbelt tunnel during the tender phase and execution phase. For the TDR (Tunnel Dredging and Reclamation) contract, IMDC assisted the Client in estimating the sedimentation during and after the capital and during maintenance dredging works of the tunnel trench and the working harbour (Lolland). IMDC reviewed and assisted in writing the environmental spill monitoring management plan. For the TUN/TUS contracts, scour protection calculations and design was performed specifically on propeller jets and ship's manoeuvres, falling and dragging anchor calculations, gravel bed stability. Regarding navigation, IMDC designed the temporary working harbour lay-out and issued specifications and guidelines for navigation during the works. Regarding immersion of tunnel elements in possibly a silt layer, IMDC performed CFD simulations of the interaction of moving tunnel elements, silt and background flow. This was to investigate whether the silt was going to be blown away by the tunnel element and whether the gravel bed would remain stable during this operation.

Sustainable Development Goals

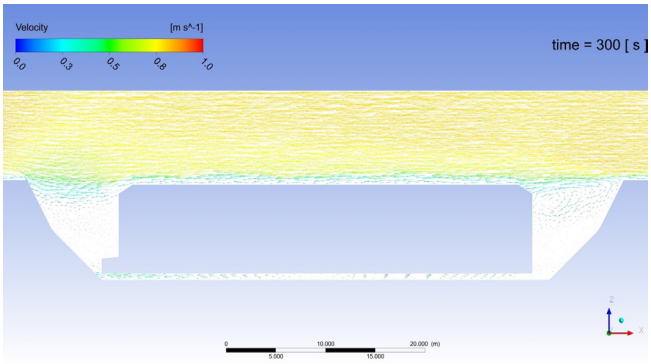
Maasdelta Tunnel, Credits: Rijkswaterstaat

Maasdelta Tunnel (a.k.a. the Blankenburg connection)

Country: Netherlands
Year: 2017-2023
Client: Dredging international NV

IMDC supported the Combination BAAK, during tendering for and execution of the DBFM contract for the Maasdelta tunnel in the Rotterdam Port area. IMDC applied a detailed numerical model (Telemac) of the Rotterdam Port area, in order to compute the complex 3-dimensional pattern of currents, salinity distribution and sediment transport for various construction phases. In addition, a CFD model was applied to assess the current loads on the floating tunnel elements. IMDC assisted the immersion captain during the immersion with assessments of real-time workability data. Furthermore, IMDC performed flow monitoring prior to and during immersion operations.

Sustainable Development Goals



Femern Belt

Oosterweel Tunnel (a.k.a. Scheldt Tunnel)

Country: Belgium
Year: 2019-2025
Client: TM COTU

IMDC provided assistance to the winning combination of contractors.
A large range of services was performed on different aspects throughout the different project phases (tender, design, work preparation and execution):

- In situ flow measurements (ADCP) and detailed flow modelling using TELEMAC 3D to gain insight in the local flow phenomena and to derive design conditions for design of the immersed tunnel and the immersion equipment.
- detailed CFD modelling to simulate the loads on tunnel elements due to tidal currents and passing ships. These models were also used to model turbulent flows around the tunnel element and in the tunnel trench in preparation for diving and other marine operations.
- sedimentation and erosion modelling for the trench and assessment of environmental impact, based on sediment plume simulations and compensation measures.
- managing and delivering specific flow fields for transport simulations, metocean analysis and the preparation of the transport procedure with local pilots (assuring a safe transportation of the tunnel elements from the construction site towards the immersion location)
- setting up a detailed and validated operational forecast model, predicting the water level, salinity and flow conditions on multiple locations on the immersion site, to be used to plan and carefully prepare the immersion operation, delineation of the GoNoGo criteria and for follow-up during the immersion.
- follow-up and monitoring of all measured, predicted and modelled parameters (flow, salinity and sedimentation) to advice the operational lead accordingly during the transport and immersion operations themselves.

Sustainable Development Goals

Scan for more info on Water Modelling & Monitoring @IMDC