Capability Statement
Open Excavation and Cut and Cover Tunnels
Delta Marine Consultants
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Delta Marine Consultants (DMC) was founded in 1978 for the purpose of providing consultancy, project management and engineering design services to clients on a worldwide basis. The company has expertise in the fields of urban infrastructure, large-scale transport infrastructure, ports and harbour development and coastal engineering. DMC holds strong links with the construction industry through its parent company, the Royal BAM Group. This contributes to the ability to provide solutions to practical problems and to blend innovation with reliability in design.

DMC has been rebranded into ‘BAM Infraconsult’ and is working under that name in the home market. DMC is still used as a trade name for international projects and referred to as such in this Design Capability Statement.

DMC has well over 300 employees working in the various offices worldwide. The head office is in Gouda (the Netherlands) and apart from several other offices in the Netherlands, local offices are also located in Singapore, Dubai, Jakarta and Perth. DMC has been or is active in a great number of other countries on project basis, often together with BAM contracting companies.

DMC and Open Excavation Tunnels

DMC has a long tradition in designing open excavation tunnels, starting well before it was formally founded as an independent design company. Our engineers have been closely involved in many projects worldwide for more than half a century. Building on these decades of experience, DMC has developed in-depth understanding and knowledge of these structures, keeping up with the latest developments in the field.

DMC’s long tradition in Open Excavation tunnel design originates from two main types of tunnel construction:
- Approaches to bored (TBM) or immersed tunnel river crossings
- Land-based tunnels

Both types have certain design and construction aspects in common, but also some differentiating aspects that need to be integrated in the design. Typically, open excavation approaches for bored tunnels have very specific interfaces with the bored tunnel process (interface with TBM), where approaches for immersed tunnels need to have dedicated provisions for the immersion process. Land based tunnels are often located in very densely populated and built-up areas which requires special attention and care for existing infrastructure and nearby buildings/constructions. In other words, each type has specific characteristics and requirements that need to be integrated in the design.

DMC is used to teaming up with construction companies for both Construct-only and Design-and-Construct contracts. Working closely together with our sister companies such as BAM Civiel and BAM International, who are experts in infrastructural construction, we can ensure our designs are not only feasible, but also constructible and cost-effective. Our engineers are trained to understand the consequence of each design choice from a construction point of view. Having worked for owner-clients, DMC engineers are used to keeping an eye on the functionality, quality and maintainability of the end product.
**Client Orientated Approach**

The often demanding projects related to infrastructure development require a genuine understanding of the clients’ needs and strategies to support and facilitate decisions making on the most economic approach in view of capital investments and life cycle costs. DMC, through its close involvement in construction projects of its sister companies, is regularly encouraged to develop the safest and most cost effective solutions. In that technical details are transferred to straight-forward solutions, striving to reduce construction risks to a minimum. Due to the wide experience and the interdisciplinary approach by DMC, valuable input can be provided from concept stage to construction design.

Design quality monitoring is carried out at various levels and includes expert panel meetings in particular for extremely multifaceted projects and/or innovative designs.

 DM staff is familiar with the relevant international standards and guidelines, including the oil and gas industry and related classification societies. Lead engineers actively participate in national and international work groups of engineering associations.

Regular advanced training is provided in-house, supplemented by external seminars to increase knowledge and expertise focussing on new standards and latest scientific developments.

**Open Excavation Tunnels, What We Offer**

With its broad knowledge and detailed expertise of open excavation tunnels, DMC is able to cover the whole project life cycle. Conceptual designs, feasibility studies or detailed designs: DMC can do it all. Working for a contractor or for the owner of the tunnel: DMC has done it before. Permanent tunnel design, temporary works design: DMC has proven skills.

With our specialists, project managers and engineers we can facilitate the full design scope or provide any combination of services.

**Civil Design and Geotechnical Engineering**

Our departments for Civil design, Maritime structures and Geotechnical Engineering can design to any code or standard. Our experience includes FEED services, consultancy, detailed design and design review. Potential interfaces with Tunnel Boring Machines or Immersed tunnel construction are an integral part of design. DMC has extensive experience working in this multidisciplinary field.

Advanced structural and geotechnical analysis is used to ensure structural strength, stability and durability of the new structures and evaluate the effects on adjacent structures or infrastructure.
Roads Design, Rail Design, Technical Installations Design

By involving our Roads Design, Rail Design and Technical Installations departments, we are able to make an integrated tunnel design, managing the interfaces between disciplines to ensure an optimal and cost-effective design, while in parallel reducing client risk.

Concrete Technology

Our Concrete Technology department provides tailor-made concrete mixes, ensuring structural performance, durability and watertightness. Special mixes can be developed and tested in our “in-house” concrete laboratory. In-house developed software is used to model heat and strength development during concrete curing/hardening and to design cooling systems for the purpose of monitoring and controlling early age cracking. We are, in fact, one of the pioneers in concrete cooling and watertight concrete technology.

For a large number of bored tunnels our Concrete Technology department has prepared the design for TBM start/arrival shafts using custom designed Low Strength Mortar mixes. This patented concept, pioneered by DMC, has proven to have significant benefits with regard to quality, risk reduction and cost.
Steel and Mechanical Engineering
Our Steel and Mechanical Engineering department is specialised in the design of various types of temporary works and equipment. We also provide support in the co-ordination of third-party equipment designers, the procurement process and supervision during fabrication.

Drafting and Visualisation
Our drafting department makes construction models, drawings, visualisations and animations in the 2D, 3D, 4D environment or higher. As one of the early users of this technology, BIM is used intensively for clash detection and constructability assessments of complex parts of the project. The models can subsequently be used to provide the survey teams with 3D information and each location of the structure. The 3D models can be linked to the construction and cost estimations. Our Jakarta office is specialised in 3D reinforcement drawings from which bar bending schedules can be extracted.
Our models can be upgraded to full architectural visualisations which can be of great value for presentation purposes, is to be instrumental in the communication with stakeholders.

Project Support
Our department for Tender strategy offers a wide range of services aimed at providing winning tender strategies, plans and documentation. During construction, our Infra management department minimises traffic congestion through optimisation of construction sequences. The interest and perception of stakeholders is managed by our Stakeholders communications department. The RAMS/Risk and Systems engineering departments manage risks, interfaces and requirements. Our Relatics system analyses, allocates and manages projects requirements to control the process of compliance throughout the design and construction process.

Integrated Approach
An integrated approach is one of the key factors to successfully design, construct, operate and maintain a tunnel. More so than with other civil structures, all aspects are inter-related. The design requirements of all MEP-installations need to be integrated with the civil works design from the start. Interfaces with construction equipment such as a TBM needs to be considered from early design.

Having all relevant design disciplines in-house, DMC is able to manage the full design scope, including the co-ordination of services by external specialists. Our experience is that the best way to control the interfaces between design, construction and all other disciplines is to have the design team embedded in the project team. DMC has been part of integrated teams for decades. All disciplines are integrated into the design while the design is integrated with the construction operations.
International Experience

DMC has been involved in projects on all continents; regions include North and South America, Africa, Asia, Middle East, Australia and Europe. DMC maintains a steadily growing overseas office strategically located in Singapore, which efficiently cooperates with DMC branches in the Netherlands as well as servicing clients in the region independently. In 2013 a new DMC branch was opened in Jakarta to serve the increasing number of large projects in the area. Most recent branch openings are in Perth, Australia and Dubai, U.A.E.

All DMC offices work closely together and facilitate the formation of international project teams to best suit specific project demands. DMC arranges for frequent exchange of staff throughout the organization for training purposes, to learn and benefit from each others work methods and to familiarize with colleagues and cultures.

We liaise with skilled partners to complement our expertise and use local knowledge as required to maximise the benefits for our clients.

DMC has been involved in tunnel projects in The Netherlands, Germany, United Kingdom, USA, Ireland, Greece, Norway, Denmark, China, Turkey, Belgium, Sweden and Brazil.

Tools and Software

The engineers and their skills form the basis of DMC’s capabilities. The most reliable modelling and analysis software packages are at their disposal to enable a rapid and thorough analysis of various design aspects.

The geotechnical department makes use of PLAXIS (both 2D and 3D) to analyse deformation and stability of the foundation and soil structures. Specific tools are at the disposal of the geotechnical engineers for the design, calculation and code checking of pile foundations, slope stability, cofferdams, settlements etc.

The structural departments mainly use STAAD.Pro and Scia Engineer to analyse and design the structures. Code checking of reinforced concrete is done with Idea. For complex details ANSYS or Atena is used to investigate load transfer, stresses and strains using plate or volumetric finite elements, taking into account non-linearly changing properties during crack development.

DMC has several software suites available for 3D modelling of roads, civil works and equipment. Some examples are MX, Civil 3D, ADT, Revit/Autocad, Navisworks and Viz.

The concrete technology department makes FEM models in FeC3S for concrete curing control. This is essential in tunnel construction to ensure water tightness. We have our own concrete laboratory where special purpose concrete mixes can be tested.

For requirement compliance and interface management we make use of Relatics.
Key Projects

Our Open Excavation / cut & cover tunnel track record is significant. Sometimes we are part of the contractor’s joint venture; sometimes we are involved as a consultant. Key examples of our involvement in these projects are given below.

**High Speed Rail Tunnel (HSL3), Rotterdam, the Netherlands**
Client: Dutch ministry for Infrastructure and the Environment
Period of services: 2000-2005

The construction of the High Speed Rail link from Amsterdam to Rotterdam required the construction of a cut and cover tunnel in the northern built-up area of Rotterdam near the Rotterdam-the Hague Airport. The tunnel was constructed using various techniques, including temporary sheet piling construction pits, but also the application of permanent reinforced concrete slurry walls.

DMC performed the tender design for this D&C project, and provided full design services during the construction stage (Basic Design, Detailed Design, Site Engineering and As-Built).

**Rail Tunnel Best, the Netherlands**
Client: Dutch Railroad Authorities
Period of services: 1998-2001

Den Bosch – Eindhoven railroad crossed the centre of the city of Best for many years, causing significant hindrance to the local community. To mitigate this the Dutch railroad authorities commissioned the construction of a 1.1km long cut and cover tunnel. The first phase of tunnel construction had to take place directly adjacent to the fully operational existing railroad. After delivery of the first phase all railroad traffic was transferred to the new tunnel after which the old railroad was decommissioned and the second half of the tunnel could be completed. DMC provided Basic and Detailed Design services for this project.
Sluiskil Tunnel, Sluiskil, the Netherlands
Client: Province Zeeland
Period of services: 2009-2014

The existing movable bridge over the canal between Gent and Terneuzen caused significant delays for road traffic near the city of Sluiskil. The Client commissioned the construction of a bored tunnel underneath the canal, connecting to two open excavation approaches on both banks of the canal. After having provided the tender design, DMC was appointed for a wide range of design services during the construction stage (Basic Design, Detailed Design, Site Engineering).

This project successfully featured one of DMC’s own innovations: For the transfer of the TBM to and from the start/reception shafts the in-house developed Low Strength Mortar transfer blocks were used.
Mini Metro Copenhagen
In 1995 DMC was involved in the civil part of tender design for first two stages (M1 & M2) of the Mini Metro in Copenhagen. The design was prepared for a consortium where also BAM construction companies where involved.

The system consists of a 20.4 km long track with in total 22 stations, of which 10 km as bored tunnel type and 9 stations where underground. The metro system runs in the city of Copenhagen with a connection to the Kastrup Airport and the new area of Orestad. The metro system must be designed for Driverless trains and the station platforms must have platform screen doors. The deep stations were designed as open stations with daylight on the platforms and construction was planned in deep open cofferdams. Outside the tunnel part the system has to be built on embankments and viaducts.

A4 Motorway, Leiden, the Netherlands
Client: Dutch ministry for Infrastructure and the Environment
Period of services: 2006-2014

Upgrading of the A4 motorway near the Oude Rijn river included the replacement of the movable bridge by an aqueduct and replacing the old motorway embankment by half open approach sections on both banks of the river, creating a 1.4 km long semi-open tunnel section leading to a large reduction of traffic noise emissions. The section was constructed using various open excavation techniques, and featured very stringent requirements with regard to deformations of the adjacent, fully operational motorway and movable bridge.

DMC performed the tender design for this D&C project, and provided full design services during the construction stage, Basic Design, Detailed Design, Site Engineering and As-Built.
The construction of the Botlek rail tunnel is part of a major upgrade of the railroad network connecting the port of Rotterdam to the hinterland. The actual crossing of the Botlek canal was constructed using an EPB TBM, the approaches were constructed in a traditional cut & cover method. The approaches were constructed in very close vicinity of existing railroads and sensitive utility lines, requiring specific attention for the designers.

DMC provided engineering services for the cut & cover approaches during Basic- and Detailed Design.

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