Tunnels & Tunnelling
Experience Record
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INTRODUCTION

Tunnel Engineering Consultants (TEC) is a Joint Venture of Royal HaskoningDHV (RHDHV) and Witteveen+Bos (W+B). TEC combines knowledge, expertise and experience of the mother companies (8000 professionals) within the field of large underground projects.

TEC guarantees continuity and specialized knowledge of tunnel design and construction to solve complicated underground mobility challenges through an integral, innovative and sustainable project approach.

In addition, TEC is able to draw on the considerable expertise of two Dutch engineering consultancy firms and covering the entire range of civil, structural and architectural engineering required for small and large building projects, environmental impact assessment, legal aspects and project management.

This TEC experience record intends to give an impression of the capabilities of Tunnel Engineering Consultants in the field of tunnel related design and tunnel construction related consultancy. It will provide an overview of services that TEC can offer within the preparation and realization of tunnel project.

This document provides a selection of appealing projects in which TEC was and is involved including the position TEC had in the project.
TEC PROFILE

Tunnel Engineering Consultants v.o.f. (TEC) is specialised in consultancy works for underground infrastructure and tunnel projects. TEC is established in 1988 as a Joint Venture between two major engineering consultancy firms:

- Royal HaskoningDHV
- Witteveen+Bos Consulting Engineers b.v.

Profile

TEC’s key expertise is tunnels; in-situ land tunnels, bored as well as Cut&Cover and immersed tube tunnels. The Scope of work comprises tunnel design with construction supervision including the mechanical and electrical tunnel installations. Together with the Dutch Ministry of Transport and Public Works – Tunnel engineering Department (Rijkswaterstaat), TEC developed advanced knowledge in tunnel engineering.

The participating firms employ more than 8000 engineers and specialists and have a total annual turnover of about 748 million EURO (2016). They have subsidiaries and branch offices in countries worldwide.

Royal HaskoningDHV

www.royalhaskoningdhv.com

Royal HaskoningDHV is a leading independent, international project management and engineering consultancy service provider. Specialising in planning and transport, infrastructure, water, maritime, aviation, industry, energy, mining and buildings, each year we contribute to the delivery of some 30,000 projects around the world on behalf of our public and private sector clients.

Our 6,500 staff adds value to our client’s projects by providing a local professional service in more than 35 countries, via our fully integrated international office network. As leaders in sustainability and innovation, we are deeply committed to continuous improvement, business integrity and sustainable development, and work with our clients, stakeholders and communities to enhance society together.

Prior to the merger on 1 July 2012, Royal Haskoning and DHV have successfully delivered millions of world class projects during the past two centuries. With roots established in The Netherlands, the UK and South Africa, our combined experience and longevity spans more than 225 years. Now, as one company, we have the power to make a bigger difference in the world as we rise to the challenges of our 21st century planet, towards a better, brighter future.

Today Royal HaskoningDHV ranks in the top 10 of global, independently owned, non-listed companies and top 40 overall. This makes us the first choice consultancy provider for involvement in major world themes, such as ‘pit-to-port’, food and water scarcity, the development of mega-cities, and sustainable infrastructure and energy resources & supply, such as wave and hydro power. We are also well positioned to contribute to the latest business models, such as Public-Private Partnership.
Witteveen+Bos Consulting Engineers b.v.
www.witteveenbos.com

Witteveen+Bos is a private limited company whose shares are owned entirely by its employees, who are either participants, partners or senior partners. This unique ownership structure ensures above-average commitment, good financial performance and a high profile. It is a structure that appeals to our clients, because it gives them confidence in our commitment. Our net result is paid out entirely as a dividend to our shareholders, so they share in large measure in the company’s result.

The Witteveen+Bos organisation is built around the cells concept that we have shaped in the form of PMCs (product market combinations). Organisationally, the PMCs are clustered into five sectors. The five sectors are: Ports and hydraulic engineering, Spatial development and the environment, Urban development and traffic, Water, and Infrastructure and Construction,

Next to the offices in The Netherlands, Witteveen+Bos also has offices in Belgium, Kazakhstan, Indonesia, Russia and Latvia.

Witteveen+Bos is committed to being a first-rate consultancy and engineering firm. Performing at the very highest level is a precondition for achieving this goal. We think striving for the top is a healthy ambition. A national and international orientation towards products, markets and the labour market is essential to operating being the best in our field of work.

Internationally, Witteveen+Bos has achieved a good position in the following areas:

- preparation, transport and distribution of drinking water
- effluent treatment
- water management
- environmental technology and policy
- ports, dredging, coastal water engineering, river water engineering
- tunnels
SERVICES

TEC provides a full range of consultancy services from feasibility studies, design, tender documents, tender evaluation, design reviews, value engineering, cost analysis, detailed design, and construction supervision to project management for underground engineering, related electrical and mechanical works and traffic engineering. In addition, we are able to draw on the considerable expertise of two Dutch engineering consultancy firms covering the entire range of civil, structural and architectural engineering required for small and large building projects, environmental impact assessment, legal aspects and project management.

Moreover, TEC has at their disposal specific expertise of the Dutch Ministry of Transport and Public works – Tunnel Engineering Department (Rijkswaterstaat), a governmental organisation involved as designer and owner / operator in about 26 road and railway tunnels and their installations in the Netherlands.

Expertise

- Civil
  - immersed tunnels
  - shield tunnels in soft soil
  - cut & cover tunnels
  - pneumatic caissons
- Electro mechanical installations
  - ventilation
  - pumps
  - lighting
  - power supply
  - traffic control
  - operation
- Safety aspects
  - Safety analysis
  - Operational procedures
  - QRA and Scenario Analysis
- Risk assessment & Value Engineering
  - Engineering
OTHER TUNNELS AND RELATED STRUCTURES

General
TEC and its partners have been involved in various other tunnel projects, a selection of which has been provided below. The projects include various jacked and pulled tunnels, pneumatic caissons, NATM tunnels, aqueducts, underpasses and other.

- Amsterdam metro tunnel Damrak, the Netherlands
- South taxiway tunnel, the Netherlands
- Motorway 37 underpass “Erica”, The Netherlands
- Underpass Taxiway Schiphol Airport, The Netherlands
- Aqueduct Grouw, the Netherlands - 1992
- Aqueduct Vliet, the Netherlands - 1996
- Aqueduct Gaag, The Netherlands - 1998
- Aqueduct Alphen, the Netherlands -1998
- Naviduct Krabbergatsluis, the Netherlands
- Aqueduct for Canal through Walcheren, The Netherlands - 2010
- N31 Aquaduct Harlingen, the Netherlands
Amsterdam Metro tunnel at Damrak, The Netherlands

Project
At the “Damrak”, situated near the Amsterdam’s “Centraal (railway) Station”, a part of the North/South metro line will be constructed using the pneumatic caisson method. The project comprises a total of 3 caissons providing a total tunnel length of 150 m. Along this section of the metro tunnel, the rail track will vary in depth between approximately 18 m at the northern end and 22 m at the southern end.

The construction technique selection for this location was highly influenced by the underground condition including the presence of large obstacles, such as the presence of three municipal bridges, the many complex traffic flows of regular traffic made up of cars, bicycles, and pedestrians, as well as traffic generated by trams, busses and sightseeing boats and possible remains from the past (ancient quay walls, sunken ships etc). The selection was also affected by the presence of the main high-water barrier functionality at this part of the alignment. Further evaluation indicated the need for three caissons with different dimensions. The most southern caisson is the largest and includes a movable gate that can be closed in case of a flood in the tunnel section under the river IJ. This caisson also doubles as the starting shaft for the two tunnel boring machines that will realize the 3.8 km long bored tunnel section of the North/South line.

Figure Impression of the pneumatic caisson design and construction
**TEC's scope of work**
The TEC partner Royal Haskoning, through its partnership with Adviesbureau Noord/Zuidlijn V.O.F. (in which the TEC partner Witteveen + Bos also participates) provided the required engineering consultancy services for this project including the structural design, engineering, the preparation of the tender documents, consultancy regarding the contracting strategy, as well as the contract administration and construction supervision.

*Figure Caisson at surface level (top) and excavation below caisson (bottom)*
South taxiway tunnel, The Netherlands

Project
The project concerns the crossing of the south taxiway to the 5th lane on Schiphol with the to be constructed Verlengde Westrandweg (A5). The A5, consisting of 2 roadways with each 2 lanes with a hard shoulder, will for this purpose be constructed with a length of approximately 1100 m in a deep tank-construction. On the south roadway approximately 160 m will be constructed as a closed tunnel. They will reckon with the possibility for a second roadway for satellite traffic in the future.

TEC's scope of work
TEC provided the preliminary and final design for the civil structures as well as for the technical installations.
Motorway 37 underpass “Erica”, The Netherlands

Project
The project concerns a new underpass for 2 lanes of road traffic. The existing national road N37 will be transformed to a highway (2*2 lanes). The existing road will be the future Southern part of the highway. Just north of the existing road, the new road is foreseen. One of the new structures in this road is the KW-13N. This is an underpass, next to the existing structure in the southern road (KW-13Z) near Erica. The local road, the “Ericasestraat”, will cross over the new highway via a fly-over in the middle of the underpass. The underpass will be built in an open trench with drainage. At the intersection with the “Ericasestraat” the excavation will be carried out with sheet piles. At the deepest level the water cellar will be constructed. The crossover is made of pre-cast box-girders founded on the sheet piles.

TEC’s scope of work
TEC provided the civil tender- and detailed design:
- Tender documents and drawings.
- Design calculations.
- Geotechnical and geohydrological calculations and advisory.
- Structural design calculations and drawings.
- Back-office during construction period and review of calculations executed by contractor.
Underpass Taxiway Schiphol Airport, The Netherlands

Project
The project concerns the crossing of the south taxiway to the 5th runway on Schiphol with the Hoofdvaart in the Haarlemmermeer and the roads, which run parallel. These roads are therefore U-shaped concrete structures (open through). The fly-overs for the taxiway and the parallel service road are designed as pre-stressed concrete structure, cast in-situ.

TEC’s scope of work
TEC provided for the preliminary design and final design, detailed design and construction supervision.
**Aqueduct Grouw, the Netherlands - 1992**

**Project**
The Ministry of Public Work in the Netherlands commissioned TEC partner Royal Haskoning to design an aqueduct in Grouw, located in the north of the Netherlands. The tunnel was built to enable the uninterrupted crossing of a highway with a major shipping channel.

The aqueduct is made up of 3 tunnel tubes, 2 tubes for road traffic and one smaller tube for slow traffic. The two traffic tubes are approximately 8 m wide and 4.5 m high and the slow tunnel tube is approximately 3.5 m wide and 3 m high.

After creating a large deep trench on either side of the channel with sheet piling and membranes, the tunnel section was constructed in dry conditions at the location of one of the access ramps. The foundations for the tunnel and the ramps on either side of the channel were built simultaneously, where as the tunnel section was made buoyant; it was floated and lowered into its final location. Although built in-situ, the disruption of traffic for both highway traffic and shipping never exceeded a period of 24 hours.

*Figure: The Aqueduct in operation*

**TEC’s scope of work**
- Detailed design of the tunnel sections, the sub-structures and tunnel foundation.
Aqueduct Vliet, the Netherlands - 1996

Project
The Hague-city is connected with the A4 motorway, by the A14 motorway crossing the navigable canal Vliet. This crossing will be a tunnel part with an aqueduct, both concrete structures. The approaches are open concrete structures. The tunnel is 40 m wide and the length of the structure is more than 500 m. The tunnel is a combined road-tramway tunnel. The structure will be 40 m wide.

The secondary road along the canal crosses the approach by a viaduct. The structures are to be founded on tensile piles because of the high ground water level. The tunnel and the approach will be constructed between sheet piles, the bottom of the trench being watertight covered with an underwater concrete floor. So the groundwater level will not be affected by the works. The ship canal will be temporarily diverted and the tunnel/aqueduct will be constructed in two phases.

Figure: Sketch of the Aqueduct

TEC’s scope of work

- Preliminary design
- Structural computations
- Design drawings
- Design report
- Cost estimates
- Construction schedule including alternative option
Aqueduct Gaag, The Netherlands - 1998

**Project**
The A4 motorway crosses the Gaag River with a 600 angle. The 40 m wide road tunnel is constructed as an aqueduct in the Gaag River. The aqueduct consists of a through shaped pre-stressed concrete structure. The approaches are open concrete structures. The total length is 380 m. The secondary roads along the Gaag River crossing the approaches are constructed as viaducts. The tunnel part and the approaches are founded on tensile piles because of the high groundwater level. The ship canal is temporary diverted and the aqueduct is constructed in phases. The building pits are partly surrounded by steel sheet piles limiting the effects of the temporary lowering of the groundwater level.

*Figure: © Beeldbank Rijkswaterstaat*

**TEC’s scope of work**
- Final design, design report considering alternatives
- Structural computation and design drawings
- Review of tender documents
- Detailed design comprising structural computations and detailed drawings
- Review of contractors design documents
- Design and contract specifications for the electromechanical installations
- Advice upon construction
Aqueduct Alphen, the Netherlands -1998

Project
To improve the infrastructure along the Oude Rijn a new main road between Leiden and Bodegraven will be constructed. Near Alphen aan den Rijn the river Gouwe will be crossed by an aqueduct. The aqueduct consists of an immersed pre-stressed concrete element under the Gouwe, with on both sides an open through construction, at the end changed in a “polder construction”.

Figure: Aqueduct under construction

TEC’s scope of work
TEC has provide detailed design of the Civil and Structural works and site supervision during construction.
Naviduct Krabbersgatsluis, the Netherlands - 2002

Project
In the existing dike between Lelystad and Enkhuizen lies an existing lock named Krabbersgatsluis. This lock crosses the road that is situated on top of the dike by means of a draw-bridge. In the holiday season the junction between the road and waterway is a source of congestion for road traffic because the lock is used for private yachts without having their masts stroked, causing a high frequency of opening of the bridge. For navigation the lock is also an obstacle because the passage capacity is not in proportion with the traffic volume which leads to an extended wait for navigation. To avoid congestion a choice is made for a crossing where the road is led under the waterway. The existing lock will be kept in operation for professional barges only. Because the height of the barges is limited passing the lock will not claim frequent openings of the bridge. The new lock has been constructed on a new artificial island made on the southern side of the dike.

Figure: Rendering of Naviduct

Figure: Naviduct completed (source VBK Groep)

TEC’s scope of work
Civil and structural works:
- Preliminary design
- Final design
- Contact drawings
- Contract
- Pre-qualification of contractors
- Tendering of the project
- Evaluation of the bids
- Assistance on supervision
Aqueduct for Canal through Walcheren, The Netherlands - 2010

Project
The N57 road forms the connection between the Motorway A15 near the city of Brielle and the Motorway A58 near the city of Middelburg and will be upgraded from the existing regional road standard to motorway standards. Since the road now accommodates both normal and slow traffic and crosses several villages, it will be upgraded not only to improve mobility but also to improve road safety and the living conditions along the road, i.e. minimise the nuisance due to the road.

The N57 follows a North-south line across the island of Walcheren and crosses several other roads as well as the “Canal through Walcheren”. For this crossing, an Aqueduct / tunnel will be realised. The total length of the structure, including access ramps will measure some 850 m while the covered part of the aqueduct will have a length of 155 m. The tunnel will accommodate 2 x 2 traffic lanes with an internal size of 9.2 m for each bore. The structure will be partly constructed in-situ and partly as an immersed tunnel.

The project has been realised under a Design & Built contract. For the first phase, TEC partner Royal Haskoning provided the tender design. Following contract award to the consortium, the detailed design was further developed.

The design services also included the horizontal and vertical alignment, the design of the earthworks and the design of all engineering structures.

Figure: The immersion process in progress
Figure: The element in place

TEC’s scope of work
- Tender design
- Detailed design
N31 Aquaduct Harlingen, the Netherlands

Project
The new alignment of the N31 provincial road at Harlingen, Friesland, goes around the city centre of Harlingen and crosses the Harinxma canal, parallel to the old bridge in the existing N31 road. Due to the number of recreational (sailing) vessels passing the existing moveable bridge in the N31 being the cause of usual traffic delay, the new crossing has been designed as an aqueduct under the canal.

The cross section of the aqueduct comprises two motorway tubes with 2 lanes each, with a low internal wall with columns in between. The aqueduct is suited only for motorway traffic.

TEC's scope of work
Civil, structural and marine works:
- Transport and immersion engineering and work preparations of transport configuration, provisions and equipment for float up, transport, immersion, installation and sand flow of the aqueduct element
- Ballast plan, ballast capacity, jacking plan and sand flow calculations
- Geo-hydrological advisory of canal bottom and shore protection
- Construction methods, construction time schedules and transport and immersion time schedules
- Operational management and command of all preparations phases and transport and Immersion operations
- Advisory and provision of working/construction method and guidelines for post-immersion finishing works such as ballast exchange (in co-operation with the client)
- Advisory and supervision upon construction (in co-operation with the client)