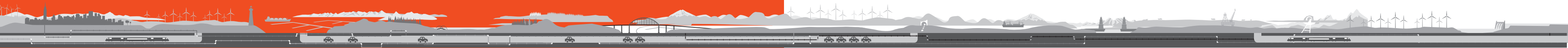


# TUNNELS

A full-page photograph of a tunnel construction site. A worker in a bright orange safety suit and hard hat is positioned on a metal walkway, working on a large, curved concrete structure. In the background, a large, orange, cylindrical pipe or tunnel section extends into the distance. The scene is dimly lit, with a strong light source at the far end of the tunnel creating a bright glow.

COWI

# THINK DEEPER



Urbanisation and the demands of modern society are posing significant challenges for infrastructure in cities across the globe. While much of this development is being built upwards, many features are being driven underground. COWI is a world leader in connecting underground spaces and in driving innovation in congested underground environments.

For over half a century, COWI has been at the forefront of tunnel and underground engineering. Our reputation as world class specialists enables us to contribute to many of the world's most prestigious and challenging tunnel infrastructure projects. With our offices around the globe, we are present in all major markets giving us worldwide reach.

Working closely with clients, we employ knowledge and expertise gained from years of hands-on experience in design and

construction to develop optimal tunnel and underground solutions for even the most complex projects.

Whether you need a total engineering solution or professional advice on a specific problem, we offer a comprehensive set of competencies to tunnel owners and contractors at every phase of a tunnel's lifecycle from early concepts to operations, through to rehabilitation or decommissioning.

We are more than 350 dedicated tunnel and underground engineers and specialists worldwide, who work together to deliver multidisciplinary and seamless solutions focused on safety, function and value, making us the preferred consultants for global tunnel projects. COWI's success in developing metro projects underpins our growth strategy.

COWI. *Your experienced partner in tunnels.*



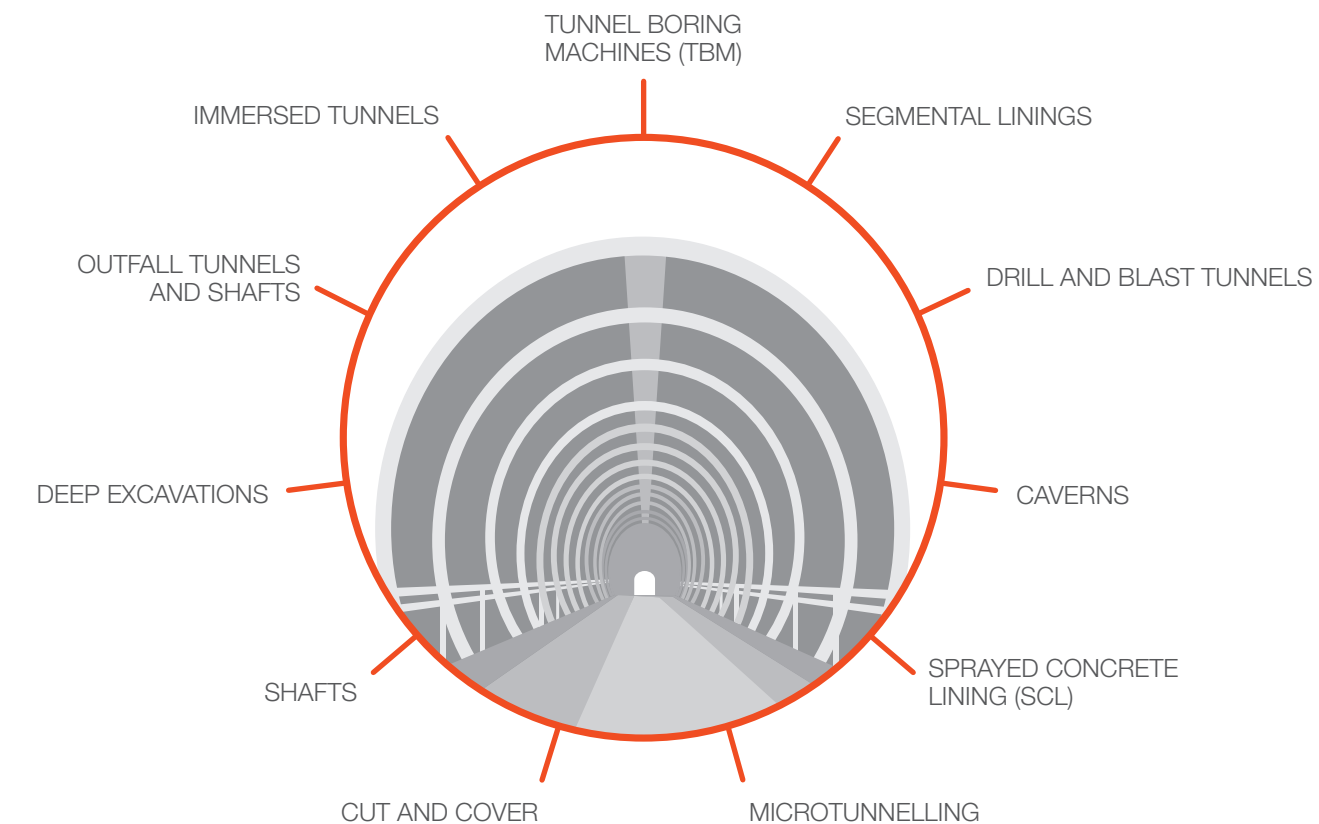
## DIFFERENT CHALLENGES – DIFFERENT EXPERTISE

Our team of international engineers and consultants have the expertise, experience and technical knowledge to help you solve even the most complex tunnel design and construction challenges.

We have done several major metro projects providing the full spectrum of works, including MEP.

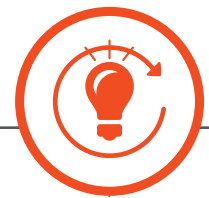
For every project, COWI brings together a world class team with the most appropriate competencies, to ensure the integration of temporary and permanent works design into one seamless solution, and creating value for clients that also benefits society at large.

Our expertise covers all tunnelling technologies:



# DIFFERENT PHASES – DIFFERENT SERVICES

COWI's first tunnel project – the Limfjordstunnel – dates back to 1955. Sixty years on, COWI is internationally renowned for providing full service tunnel design to both tunnel owners and contractors. Our agile teams can handle every aspect in the life cycle of a project, from early concepts to operation phase and rehabilitation and decommissioning. We work closely with clients to identify needs, manage risk, develop solutions and deliver innovative and cost effective designs and advice.



## CONCEPT

- › Feasibility, alignment, EIA, tunnelling methods, reference design and durability assessment
- › Ground investigation, geotechnical studies and geotechnical baseline reports
- › Life Cycle considerations: inspection and maintenance, life cycle cost optimisation and sustainability



## DESIGN

- › Detailed design of tunnels and underground structures: includes civil, structural and geotechnical, mechanical and electrical engineering, and other tunnel-related infrastructure using COWI's wider cross-sector, multi-disciplinary capabilities in rail, highway and utilities
- › Focused studies and advice: settlement prediction, ground treatment and groundwater control
- › Management of all aspects of tunnel projects.



## DESIGN-CONSTRUCT CONTRACTS

- › Consultancy for project owners and concessionaires
- › Detailed design and construction engineering for design and build contractors



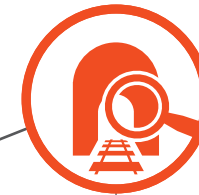
## CONSTRUCTION

- › Tunnelling methodology: advice on suitable methods, TBM design and specification
- › Construction advice: construction management and supervision, temporary works design, integrated temporary and permanent works design, monitoring and instrumentation



## PROCUREMENT

- › Procurement strategies
- › Tender documents
- › Scheduling
- › Contract documentation and management



## TUNNEL OPERATION AND MAINTENANCE

- › Tunnel inspection: includes condition inspection and construction inspection services
- › Refurbishment and decommissioning



## METROS

- › Concept
- › Design
- › Design-construct contracts
- › Construction
- › Procurement
- › Tunnel operation and maintenance



## A MULTIDISCIPLINARY COMPANY

COWI's multidisciplinary approach moves the boundaries and delivers solutions based on our comprehensive understanding of complex projects.

With more than 6,200 employees working in a broad range of professional services, COWI can cover all engineering services across the following business sectors Economics, Management and Planning, Water & Environment, Geographical Information and IT, Railways, Roads and Airports, Building, Industry and Energy, and Bridge, Tunnel, Undergrounds Structures and Marine.

We deliver multidisciplinary services for tunnel and underground engineering projects around the globe. Our services include Planning, Architecture, Civil Works, Mechanical & Electrical, Track & System and Area & Rights

From the hydraulic design of drainage tunnels to holistic Fire, Life & Safety strategies for underground metro stations, COWI integrates a wealth of engineering knowledge when developing our projects.

Life cycle cost, sustainability and mitigation of environmental impacts are fundamental to the way we work. Our project teams are created to match the requirements of a multidisciplinary project and we work collaboratively across disciplines managing the interfaces between all parts of the project to deliver the right solution.

### INTERNATIONAL SPECIALIST IN METRO PROJECTS

We specialise in major metro projects and can provide all services for the entire project life cycle from feasibility study through preliminary and final design, supervision, operation and maintenance.

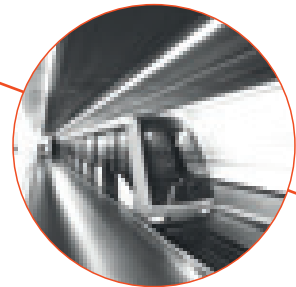
Copenhagen Metro, Cityringen in Denmark is just one example of our multidisciplinary metro projects. This latest phase of the city's metro system involves more than 15 km underground rail, 17 underground stations and 3 emergency and ventilation shafts. Many of the stations are located in the center of Copenhagen very close to existing buildings, often two or three hundred years old, and will go through the Copenhagen limestone as well as in overlying quaternary soil.

For the extensive metro project COWI draws on, among other things, its experience of bored tunnels and Metro installations from the first phase of Copenhagen's Metro and the construction of a four-kilometre long district heating tunnel under the capital. COWI provides Conceptual Design, Owners tender design, Design review and Construction Supervision. The interdisciplinary project utilises employees from virtually all COWI's business units.



# DIFFERENT ASSIGNMENTS – DIFFERENT SECTORS

Every assignment is unique. As a multi-disciplinary consultancy, we bring together teams from across the COWI group to offer a total project solution regardless of the function, purpose or end-use of the underground space. For example, we integrate tunnels and caverns into many types of large infrastructure projects, driving innovation in congested environments. Real engineers with experience in design, assessment and management of tunnels across the entire spectrum of underground infrastructure work to ensure low risk assets, creating an efficient network and security of service.



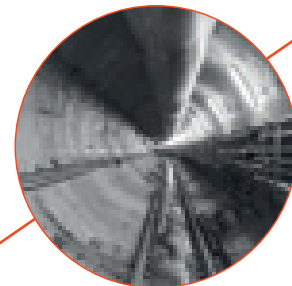
## RAIL – METRO, MRT, HEAVY RAIL

- › Metro, MRT, heavy rail
- › Stand-alone tunnel design
- › Delivery of a whole system
- › Station boxes and platform tunnels
- › MEICA, architecture and environment



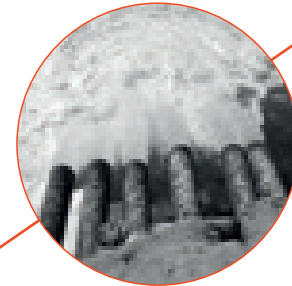
## HIGHWAY

- › Feasibility and option studies
- › Highway tunnel operational safety
- › Integration with highway network
- › Approach ramps and earthworks
- › Refurbishment and maintenance



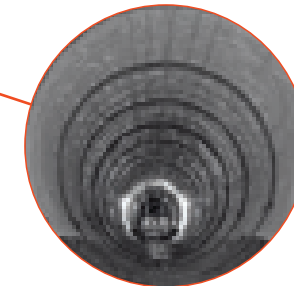
## OTHER TRANSPORTATION

- › Waterways
- › Tramways
- › Airport infrastructure
- › Materials handling
- › Mine-related applications



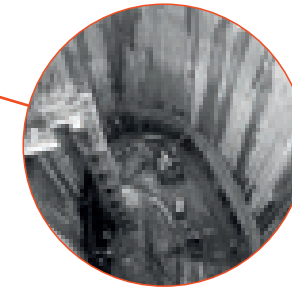
## UTILITIES

- › Process accommodation
- › Product distribution
- › Water and waste water
- › Attenuation and storage
- › District heating



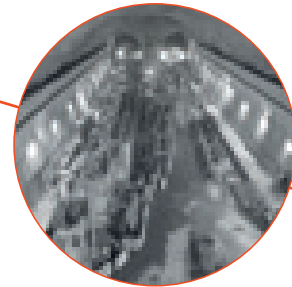
## ENERGY AND POWER

- › Nuclear
- › Generating halls
- › Cooling water intakes and outfalls
- › Hydro-electric installations
- › Gas and electricity



## INDUSTRY

- › Marine and river intakes and outfalls
- › Access and ventilation shafts
- › Storage and attenuation space
- › Conduits and tunnels
- › Space optimisation



## DEVELOPMENT OF CAVERNISATION

- › Underground space for a unique purpose
- › Growth technology across the globe
- › Secure space and deep basements
- › Warehousing, storage and distribution
- › Accommodation of processes and utilities

# GLOBAL TEAMS

## AGILE, ACCESSIBLE AND RESPONSIVE

Our business is engineer-led, characterised by an agile organisation with specialist engineers at all levels who are responsive to client requests.

The first tunnel project dates back to 1955 where we were involved in the Limfjordstunnel. Almost 30 years ago, we made the detailed design on a major railway tunnel which is part of the Great Belt Link and have since been providing full service tunnel design, working with owners to identify needs, manage risk, develop solutions and deliver innovative and cost effective designs and advice. Contributing to technical codes and standards, our methodologies have become benchmarks in the industry, driving forward innovation in congested urban underground spaces.

COWI's integrated tunnel teams have a strong shared culture, engaging in open dialogue

and building professional partnerships to deliver successful projects across the globe. Our work processes and fully integrated IT systems enable our engineers to be agile, accessible and responsive, and to work together on major projects seamlessly across time zones.

Our engineers have broad design and build construction experience combined with deep technical tunnelling and geotechnical expertise. This allows them to add value and reduce risk right from outset, especially at the early scoping stages of major projects, offering practical and pragmatic options for large projects.



# TBM

COWI has built up a significant bank of in-house knowledge within the TBM sector both in urban and non-urban areas in soft soil and in subaqueous environments. Our engineers are internationally recognised for their technical expertise in TBM tunnel design where there is less competent ground, high water pressure environments and drainage challenges.



## CPH DISTRICT HEATING TUNNEL

Copenhagen, Denmark  
Detailed Design for the Owner  
TBM

This 4 km-long heating tunnel was constructed 30 m below central Copenhagen to carry a major system of district heating pipes under Copenhagen Harbour, providing Copenhageners with inexpensive and environmentally-friendly district heating.

Tunnelling in the Copenhagen limestone, designing and constructing three deep shafts in the centre of the city and preventing any significant groundwater lowering or settlement during construction were among the more complex design challenges. COWI solved these by applying steel fibre reinforced concrete for the tunnel lining and by adopting the latest methodologies in durability design to achieve the required 100-year lifetime.

### FACTS

› Year of Completion:	2009
› Owner:	Københavns Energi A/S
› Client:	Københavns Energi A/S
› Contractor:	KFJ-JV MT Højgaard a/s Hochtief

### SERVICES

- › Tender design and tender document preparation
- › Detailed design
- › Construction supervision





## ABU HAMOUR, MUSAIMEER DRAINAGE TUNNEL

Doha, Qatar  
Design-Build  
TBM

The Abu Hamour tunnel is a 10 km, 3.7 m diameter drainage tunnel constructed using two Earth Pressure Balance TBMs and 22 shafts. The project was the first in Doha to use Earth Pressure Balance TBMs, where karstic features present challenging ground conditions. The project also provided a major upgrade of the surface water drainage system in Doha.

In order to meet the requirement of a 100-year lifespan, COWI's engineers came up with the innovative use of steel fibre reinforced concrete for the tunnel and shaft linings and applied the full probabilistic Duracrete methodology, the most up-to-date durability design approach available. This design also produced substantial sustainability benefits for the project by significantly reducing the embodied carbon dioxide of the tunnel and shafts linings.

### FACTS

- |                       |   |
|-----------------------|---|
| › Year of Completion: | 2016 (est)                              |
| › Owner:              | ASHGHAL, Ministry of Public Works Qatar |
| › Client:             | ASHGHAL, Ministry of Public Works Qatar |
| › Contractor:         | Salini Impregilo S.p.A                  |

### SERVICES

- › Durability design
- › Structural design
- › Tender Design
- › Detailed Design
- › Construction Support

# SCL

Sprayed Concrete Lining (SCL) can be used to provide solutions to more complex mined tunnel excavations. For instance, irregular-shaped tunnels such as junctions and cross passages in a metro system; elaborate load transfer systems like the interface between existing piled foundations and new tunnels; tunnels where space, access or ground conditions preclude TBMs.

COWI's specialists have the expertise to design and specify SCL, and we also provide real-time construction supervision on site, working with the contractor to assess and deploy the right solutions that maximise value for our clients and ensure a seamless integration.



## C305 CANARY WHARF SOFT EYE

London, UK  
Design & Construct  
SCL Tunnel

When completed, Canary Wharf will be one of the largest London Crossrail stations. The station box is 256 m long and have 33 m deep concrete reinforced steel tube piles. It has been built in dock water area. Temporary soft eyes were required to allow the TBMs to enter and leave the station box at Canary Wharf, Crossrail.

COWI carried out a review of the ground conditions, together with Lambeth Group, at the soft eye locations, and developed a construction sequence for the works which involved the removal of contiguous piles from the station box structure and the design and installation of sprayed concrete, domed soft eyes.

Our engineers collaborated closely with the construction team to ensure the feasibility of the proposed plans, such as the addition of toolbox items in the final design to help deal with differing ground conditions.

### FACTS

› Year of Completion:	2013
› Owner:	Crossrail
› Client:	Dragados Sisk JV
› Contractor:	Dragados Sisk JV

### SERVICES

- › Review and assessment
- › Design of permanent and temporary works
- › Development of construction sequence



CROSSRAIL CONTRACT  
C300-C410: WESTERN  
RUNNING TUNNELS,  
LONDON, UK

Design & Construct  
Sprayed Concrete Lining Tunnel

Crossrail was one of the largest single infrastructure investments ever undertaken in the UK. The project, a new east-west railway for London and the South East of England, provides high speed and high frequency rail links for up to 72,000 passengers every hour (from 2018), and includes 21 km of new underground railway in twin-bored tunnels.

COWI's subsidiary, Donaldson Associates, was contracted to manage the SCL, scope included review, excavation stability and mining settlement. The team designed toolbox items and temporary works for 72 SCL tunnels, including 57 at Bond Street and Tottenham Court Road stations, cross-overs at Fisher Street and cross passages west of Farringdon. Donaldson Associates was also part of the SCL onsite management team with direct supervision of all tunnel construction

FACTS

› Year of Completion:	2015
› Owner:	Crossrail
› Client:	BAM Ferrovial Kier JV
› Contractor:	BAM Ferrovial Kier JV

SERVICES

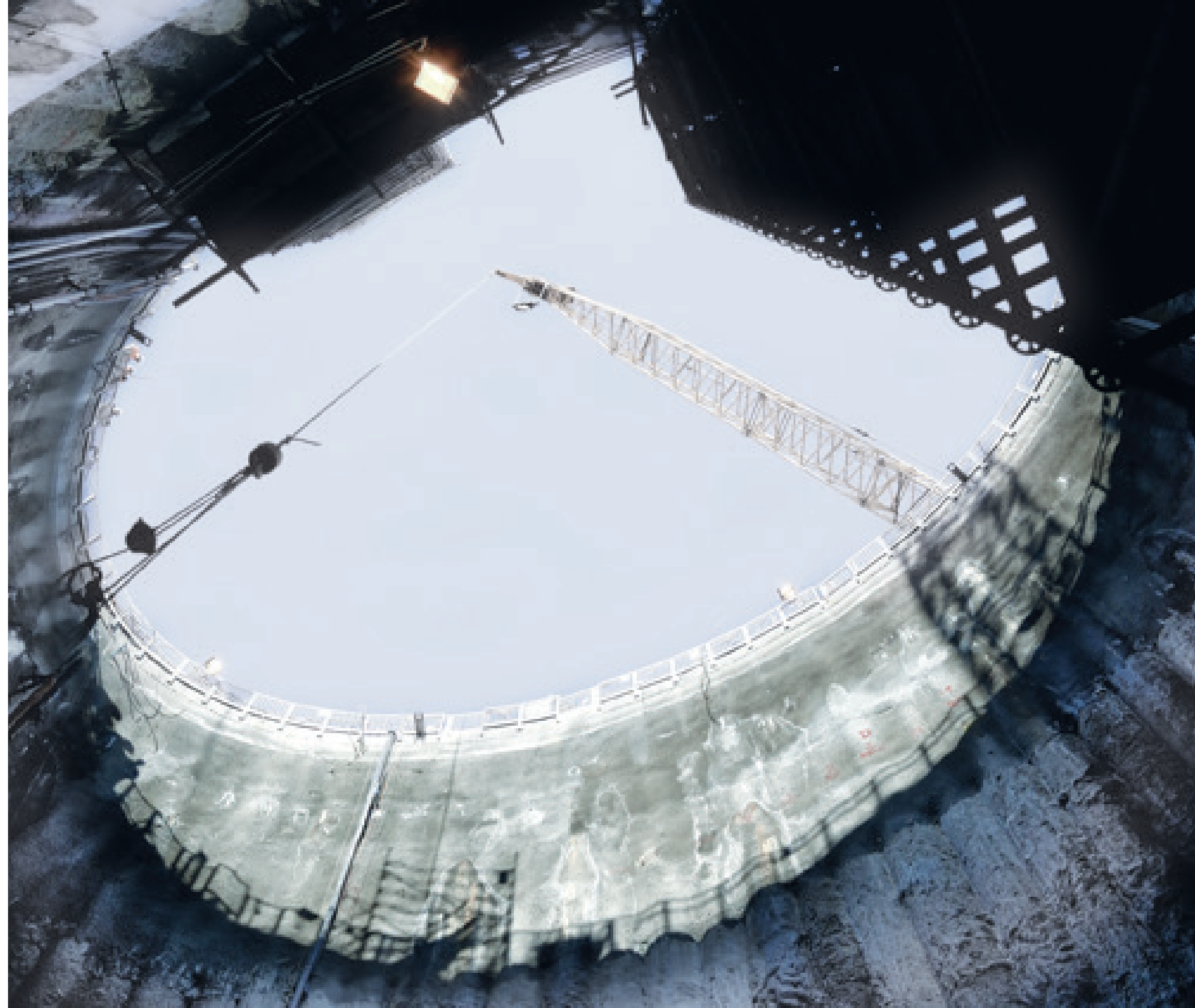
- › Due diligence review of SCL tunnels
- › Design of temporary measures and toolbox items
- › Provision of SCL engineers and superintendents
- › Design of sprayed concrete lining



# DRILL & BLAST

Drill and blast remains a cost effective and optimal solution to hard rock tunnelling in certain situations – where shorter lengths are required, to create caverns, or where the ground conditions warrant it.

Our engineering specialists have years of experience and technical know-how to anticipate the effects of drill and blast, like vibration, and deploy the most appropriate rock support methods for different conditions.



## NYCDEP – CITY WATER TUNNEL #3

Manhattan, New York, USA  
Design-Bid-Build  
Tunnel Boring Machine (TBM) for Tunnel /  
Raise-Bore Technique and Drill & Blast for  
Shafts

City Water Tunnel #3 is the largest capital construction project in New York City history, covering 97 km, at an estimated cost of US\$ 5 billion.

COWI was responsible for construction management of the Manhattan section (stage 2) of the City Water Tunnel #3 project, and for Nine Shafts in Manhattan. The project was to build a 3,7 m diameter, 14,4 km long, 183 m deep tunnel, and nine deep shafts.

To accomplish this, we selected a world class team of top resident engineers and inspectors, technical support staff, project control staff and QA/QC committee to manage the continuous inspection of all contractor operations for this technically challenging, multi-site, mega project.

### FACTS

› Year of Completion:	2013
› Owner:	The City of New York Department of Environmental Protection
› Client:	JENNY, URS Corp-NY, a Joint Venture
› Contractor:	Schiavone Construction

### SERVICES

- › Construction management

# IMMERSED TUNNELS

With many years of experience designing for the distinct technical and practical challenges of immersed tunnels, COWI is a world leader in immersed tunnel technology and has the specialist competencies to devise innovative and cost effective solutions for our clients.

Constructing tunnels beneath wide and deep waterways requires special consideration both in the design and in the execution. Design, water tightness and durability are particularly challenging due to extraordinary conditions such as high water pressure and chemical erosion. Our engineers have the experience to develop unique solutions to overcome these challenges



## BUSAN-GEOJE FIXED LINK, KOREA

### Immersed Tunnels

The Busan–Geoje Fixed Link is an 8,2 km bridge-tunnel connecting Busan to the island of Geoje. The Busan–Geoje Fixed Link is the second deepest concrete segment tunnel in the world, and presented some unique challenges. For instance, the excavation of the tunnel trench took place at 50 m depth, which involved exacting requirements to excavation accuracy.

Challenging foundation requirements combined with high water pressures required the development of an innovative solution for the element joints. Working in partnership with GINA, a gasket manufacturer, COWI’s specialist IMT engineers developed a unique solution to the problem that was successfully employed to overcome these challenges.

### FACTS

- › Year of Completion: 2010
- › Owner: Authorities of South Gyeongsang Province, South Korea
- › Client: Daewoo Engineering & Construction Co. Ltd.
- › Contractor: Daewoo Engineering and Construction Co.

### SERVICES

- › Basic design
- › Detailed design for tunnels
- › Detailed design for mechanical and electrical works
- › Construction engineering
- › Follow-up during construction



## SÖDERSTRÖM IMMERSED TUNNEL

Stockholm, Sweden  
Design-Build  
IMT

The Söderström tunnel is a 340 m long immersed tunnel with dual railway tracks that run beneath central Stockholm. It is part of the Citybanan (The Stockholm City Line) project – 6 km of tunnels linking Södermalm and Ridderholmen.

The main challenge in designing the Söderström tunnel was the soft soil foundations that the tunnel is built on and the connections to the adjacent rock tunnels.

COWI designed a unique immersed tunnel solution, the first sandwich tunnel in Europe, using concrete and a double steel shell, which allowed the tunnel elements to float into the site with a very shallow draft.

### FACTS

- › Year of Completion: 2014
- › Owner: Swedish Transport Administration, Trafikverket
- › Client: JVS Söderströmstunneln HB, E. Pihl & Søn A/G and Züblin AG
- › Contractor: JVS Söderströmstunneln HB, E. Pihl & Søn A/G and Züblin AG

### SERVICES

- › Tender design
- › Basic design
- › Detailed design
- › Construction follow up



# MICROTUNNELLING

A multitude of utility and telecommunications services are essential to modern life and are vying to expand all around us.

COWI has world leading expertise and experience in utilising innovative technical solutions in the development of underground spaces and in particular in the application of microtunnelling techniques to create small channels for utility networks effectively and efficiently.

Increasingly congested urban space, and physical barriers such as highways, railways and watercourses, present significant constraints to the routing and installation of this infrastructure. Microtunnelling is a trenchless technology that can be employed in compact spaces.



## CAT-211, CATSKILL/DELAWARE WATERSHEDS DAMS, TUNNEL & FACILITIES, USA

The reconstruction of Catskill Watershed dams and associated facilities, including the installation of a low level outlet tunnel at Gilboa Dam, ensures a safe and stable water supply to New York City.

The project involved constructing a 2.7m ID pipe with underwater retrieval in the Schoharie Reservoir. Its primary purpose is to facilitate reservoir drawdown during emergencies and to allow partial or full dewatering of the reservoir. COWI helped to delivered a world-class engineering design solution and services during construction.

It is one of the largest microtunnels ever built in the US.

### FACTS

- › Year of Completion: Ongoing
- › Owner: The City of New York, Department of Environmental Protection
- › Client: Gannett Fleming/Hazen and Sawyer, JV
- › Contractor: Southland Construction

### SERVICES

- › Rehabilitation design

# DEEP EXCAVATIONS

For urban mass transit systems, interconnecting underground stations provide an effective means to transport people between different points across the city. To achieve this, complex station boxes are required.

With deep excavations, the right combination of construction methods, strategic planning, and construction sequence will ensure a seamless project implementation that is safe, functional and durable.

COWI provides full service for tunnel and underground construction design and engineering. We have a pool of specialists with the experience and expertise in planning layouts of underground station boxes and in detailed design of temporary and permanent structures for both employers and contractors.



## COPENHAGEN METRO, CITYRINGEN, DENMARK

The new 15,2 km long Cityringen on the Copenhagen Metro will form a circle line around Copenhagen and was based on the station concept for the existing metro. The age and proximity of buildings to the stations as well as the different types of foundation posed special challenges and required COWI to deliver some unique solutions.

Cityringen will have 17 stations and three emergency and ventilation shafts all underground, of which 13 are deep and will require cut-and-cover box structures with deep retaining walls of secant piles or diaphragm walls to support them.

Many of the stations are located in the heart of the city, very close to existing buildings, that are 200 to 300 years old and built on timber frames, and required a design using watertight and rigid retaining walls.

Specific construction methodologies and equipment will be required for different stages of the TBM construction, which will primarily bore through Copenhagen limestone, but will also need to drive through the overlying quaternary soil in the northern part of the tunnel alignment.

### FACTS

› Year of Completion:	2018 (est.)
› Owner:	Metroselskabet I/S
› Client:	Metroselskabet I/S
› Contractor:	CMT, a JV of Salini, Seli and Technimont

### SERVICES

- › Conceptual Design
- › Owners tender design
- › Design review
- › Construction supervision





## DOHA METRO, RED LINE NORTH

Doha, Qatar  
Design-Build  
TBM, Station Boxes/Deep Excavations

The Red Line North is part of the development of Qatar's integrated railway network and will provide seven new stations and 13 km of tunnels for the Doha Metro.

The project presented several significant challenges: the design of large station boxes, the integration of MEP and architectural requirements, and the need for structures with a 100-year design life, suited to the harsh environment of Doha.

Our engineers developed some innovative project solutions including the application of the most advanced durability design approach available (Duracrete) to achieve the required 100-year design life for the steel fibre reinforced concrete for the tunnel linings and the creative use of temporary support systems for the station boxes.

### FACTS

› Year of Completion:	2017 (est)
› Owner:	Qatar Railways Company
› Client:	Qatar Railways Company
› Contractor:	Salini Impregilo, SK, Galfar, Joint Venture

### SERVICES

- › Tender design
- › Detailed design of permanent and temporary works
- › MEP detailed design
- › Architectural detailed design
- › Construction support

# SHAFTS

The interaction of ground and structure is never more apparent than in the design of a shaft. The delicate relationship between the ground and the shaft sinking method is a perfect example of the importance of including temporary and permanent works in the same design and construction process. COWI works closely with contractors and employers to ensure safe, efficient and functional designs, applying our deep technical knowledge and experience of shaft sinkage to manage and mitigate any ground risk.



## OSIS AUGMENTATION RELIEF SEWER (OARS)

Columbus, Ohio, USA  
Design-Bid-Build  
Tunnel Boring Machine (TBM) and Shaft Sinking

The City of Columbus decided to increase the capacity of its sewer system with the OARS project, which consists of six shafts and 23,500 lf of segmental lining tunnel and a completed diameter of 6 m. The tunnel will be excavated in an area of karst rock that has also been classified as “potentially gassy” and required special design considerations.

Our tunnel and shaft design solution included the development of design criteria including groundwater control, evaluation of construction methods, selection of appropriate construction techniques, and design of initial and final tunnel linings.

### FACTS

› Year of Completion:	Ongoing
› Owner:	City of Columbus
› Client:	DLZ Corporation
› Contractor:	Phase I – Kenny Obayashi, JV / Phase II – Trumbull Corporation

### SERVICES

- › Design
- › Construction services



# CAVERNS

COWI has extensive experience of projects involving large span caverns. Increasingly congested urban spaces require ingenuity and lateral thinking to allow efficient movement of people and goods: below ground thinking. The development of underground space also protects the increasingly precious natural environment, such as hydro-electric generation halls. COWI's experience of metro, hydro and other underground space-related development, includes hard and soft ground – drill and blast and SCL.



## HIGH SPEED GUANGZHOU-SHENZHEN-HONG KONG RAIL LINK (XRL)

Ngau Tam Mei to Tai Kong Po Tunnels,  
Hong Kong, China  
Design & Construct  
Caverns

Contract 824 is a 2,6 km long, hard rock tunnel on the Hong Kong section of the new high speed rail link between Hong Kong and Guangzhou in mainland China.

A complex project requiring multidisciplinary competencies, Contract 824 required the design of two deep shafts (one 100 m deep), single track running tunnels (4 km of 7,8 m span, 7,6 m high), two bifurcations and a crossover cavern (22 m, 22 m and 29 m span), plus a pre-excavation grouting system designed to reduce water ingress in fault zones with high water pressure up to 15 bar.

To avoid over-stressing the rock pillar to the adjacent NTV shaft, COWI relocated the crossover cavern while simultaneously reducing the length of ventilation duct tunnel from 300 m to 25 m. This resourceful design solution reduced project costs and added value for our client.

### FACTS

› Year of Completion:	2015
› Owner:	MTR Corporation
› Client:	Kier Kaden Ossa JV
› Contractor:	Kier Kaden Ossa JV

### SERVICES

- › Hard rock tunnel, drill and blast
- › Design of large span crossover cavern
- › Temporary and permanent support design
- › Numerical Modelling
- › Optimization

### AWARD

- › 2015 Ground Engineering Awards:  
International Project of the Year – Finalist

# TUNNEL INSPECTIONS AND REMEDIATION

Tunnel maintenance is vital to the optimal and uninterrupted operation of services provided by the tunnels: security of water supply, regular rail service, continuous power generation.

Minor preventive maintenance and major refurbishment require regular tunnel inspections, effective maintenance strategies and the intelligent design of remedial works.

COWI engineers have vast experience of every tunnelling technology and end use at every project stage. Their know-how, combined with their expertise in monitoring, analysis, remediation methods, programme planning and management means they are trusted by clients to deliver efficient, cost-effective and award-winning plans and designs that minimise the impact on their business.



## LINCOLN & HOLLAND TUNNELS

New York and New Jersey, USA  
Tunnel Refurbishment

The Lincoln and Holland Tunnel systems were built in the 1920s and 1940s to carry vehicular traffic from New Jersey to New York City. The tunnels became a vital link to New York City and remain essential to the economy of the Metropolitan Area.

In addition to performing cyclical condition inspections and design of repairs for Lincoln and Holland Tunnels and ancillary structures since 1997, COWI developed a cutting edge computer-based plotting system for all existing tunnel settlement survey data and for all available sounding data for the river above the tunnels. Using this new technology, the client can review sounding data versus time and tunnel settlement history for each location where survey data is available and allows for input of new data as it is obtained.

### FACTS

- › Year of Completion: Ongoing
- › Owner: The Port Authority of New York & New Jersey
- › Client: The Port Authority of New York & New Jersey

### SERVICES

- › Condition surveys
- › Rehabilitation design



## HOLME RAILWAY TUNNEL RECONSTRUCTION

Burnley, Lancashire, UK  
Design & Construct  
Tunnel Refurbishment

This 250 m-long bored twin track tunnel dates back to 1849 has been deteriorating for many years due to an ancient landslip, that caused the haunches to move inwards by 320 mm and the crown to rise by 180 mm.

When previous stabilisation attempts in the 1980s and 90s failed, COWI was engaged to monitor the tunnel. This led to us designing a major reconstruction strategy for the tunnel that involved permeation grouting, new steel arches with fibre-reinforced sprayed concrete lining, extensive masonry repair and the replacement of concrete trackbed.

Working closely with Network Rail and the contractor, COWI designed a construction methodology and sequence completely integrated with the temporary and permanent works solution to deliver an award-winning tunnel reconstruction scheme which was on programme and well within budget.

### FACTS

› Year of Completion:	2014
› Owner:	Network Rail
› Client:	AMCO
› Contractor:	AMCO

### SERVICES

- › Geotechnical investigation and ground model
- › Temporary support design
- › Build programme to meet blockade lengths

### AWARDS

- › National Rail Award, 2014 Civil Engineering Award of the Year



# DESIGNED BY COWI

EASTSIDE WATER SUPPLY  
RAW WATER INTAKE TUNNEL,  
USA

FACTS

- › Year of Completion: 2012
- › Owner: Monroe County Water Authority (MCWA)
- › Client: O’Brien & Gere Engineers
- › Contractor: Southland Construction

SERVICES

- › Cost estimate
- › Design
- › Geotechnical investigations
- › Resident engineering
- › Construction support

SOUTH ISLAND LINE MTR  
CONTRACT 901,  
HONG KONG

FACTS

- › Year of Completion: 2014
- › Owner: MTR Corporation Ltd, Hong Kong
- › Client: Kier/Laing O’Rourke KAden JV
- › Contractor: Kier/Laing O’Rourke KAden JV

SERVICES

- › Technical advice

MILL CREEK – PEAKS  
BRANCH DRAINAGE RELIEF  
PROJECT, USA

FACTS

- › Year of Completion: 2014
- › Owner: City of Dallas
- › Client: City of Dallas

SERVICES

- › Design
- › Geotechnical evaluation
- › Cost estimate

SHANGHAI CHONGMING  
YANGTZE RIVER TUNNEL  
PROJECT, CHINA

FACTS

- › Year of Completion: 2004
- › Owner: Shanghai Huchong Cross River Investment and Development Co. Ltd
- › Client: Shanghai Huchong Cross River Investment and Development Co. Ltd
- › Contractor: N/A

SERVICES

- › Preliminary design including segmental lining design
- › Durability design
- › Technical advice on tunnelling methods in soft clay conditions, ventilation and fire safety

THOMSON LINE CONTRACT  
226, SINGAPORE

FACTS

- › Year of completion: 2013
- › Owner: Land Transport Authority, Singapore
- › Client: Leighton Contractors (Asia) Ltd
- › Contractor: Leighton Contractors (Asia) Ltd

SERVICES

- › Tender stage design

BAOSHAN-LONGLING  
EXPRESSWAY, CHINA

FACTS

- › Year of completion: 2008
- › Owner: Yunnan Baolong Expressway Co. Ltd and the Asian Development Bank
- › Client: Yunnan Baolong Expressway Co. Ltd and the Asian Development Bank
- › Contractor: N/A

SERVICES

- › Construction management
- › Design review
- › Inspection of construction methods

SILICON VALLEY FORCE MAIN  
ALIGNMENT STUDY,  
USA\*\*

FACTS

- › Year of Completion: Ongoing
- › Owner: Silicon Valley Clean Water (SVCW)
- › Client: Kennedy / Jenks Consultants

SERVICES

- › Conceptual design
- › Final design
- › Geotechnical services
- › Cost estimate

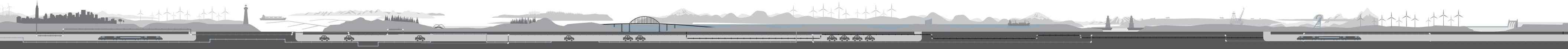
DOWNTOWN LINE 2  
CONTRACT 918-TAN KAH KEE  
STATION, SINGAPORE

FACTS

- › Year of completion: 2013
- › Owner: Land Transport Authority, Singapore
- › Client: Alpine Bau GmbH
- › Contractor: Alpine Bau GmbH

SERVICES

- › Technical advice
- › Assessment of optimal ground treatment and construction techniques for crosspassages during construction phase





TAIWAN HIGH SPEED RAIL PROJECT, TAIWAN

FACTS

- › Year of completion: 2005
- › Owner: Taiwan High Speed Rail Consortium (THSRC)
- › Client: Hyundai-Chung Lin JV, Hochtief-Ballast Nedam-Pan Asia JV.
- › Contractor: Hyundai-Chung Lin JV, Hochtief-Ballast Nedam-Pan Asia JV

SERVICES

- › Independent design check of lots of C240 and C250

TORONTO-YORK SPADINA SUBWAY EXTENSION, CANADA

FACTS

- › Year of Completion: 2013
- › Owner: Toronto Transit Commission
- › Client: Armtec
- › Contractor: South Tunnel: McNally-Kiewit-Aecon Partnership, North Tunnel: OHL FCC, Joint Venture

SERVICES

- › Design

EXPRESS RAIL LINK CONTRACT 822, HONG KONG

FACTS

- › Year of completion: 2013
- › Owner: MTR Corporation Ltd, HK
- › Client: MTR Corporation Ltd, HK

SERVICES

- › Independent review
- › Technical advice

COPENHAGEN AIRPORT AND THE SYDHAVNSGADE TUNNEL, DENMARK

FACTS

- › Year of completion: 1998
- › Owner: A/S Øresundsforbindelsen
- › Client: A/S Øresundsforbindelsen
- › Contractor: N/A

SERVICES

- › Tender documents
- › Detailed design
- › Independent design check
- › Construction management
- › Technical advice
- › Construction site supervision

UNIVERSITY OF NORTH CAROLINA-GREENSBORO RAILROAD PEDESTRIAN AND BIKE UNDERPASS, USA

FACTS

- › Year of Completion: 2013
- › Owner: University of North Carolina-Greensboro
- › Client: Wagner Murray Architects, P.A.
- › Contractor: New Atlantic Contracting

SERVICES

- › Design
- › Construction support

HONG KONG ZHUHAI, MACAO BRIDGE, HONG KONG LINK ROAD TUNNELS, HONG KONG

FACTS

- › Year of completion: 2014
- › Owner: Highways Department HK SAR
- › Client: China State Construction (HK) Ltd
- › Contractor: China State Construction (HK) Ltd

SERVICES

- › Technical advice
- › Design modification of tunnel support
- › Construction supervision

FOURTH VICTORIA HARBOUR IMMERSSED TUNNEL, HONG KONG

FACTS

- › Year of completion: 2009
- › Owner: Kowloon-Canton Railway Corporation
- › Client: Kowloon-Canton Railway Corporation
- › Contractor: N/A

SERVICES

- › Concept design
- › Scheme design
- › Tender design
- › Post tender assistance to the Owner

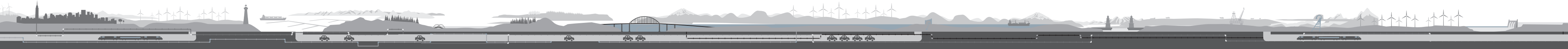
WACHOVIA-FIRST STREET PEDESTRIAN TUNNELS, USA

FACTS

- › Year of Completion: 2008
- › Owner: Wachovia
- › Client: Bradshaw Construction Corporation
- › Contractor: Bradshaw Construction Corporation

SERVICES

- › Design
- › Construction engineering







HARBOUR AREA TREATMENT  
SCHEME STAGE 2 (HATS),  
HONG KONG

FACTS

- › Year of completion: 2013
- › Owner: HK Government Drainage Services Department
- › Client: Chun Wo-CEC JV
- › Contractor: Chun Wo-CEC JV

SERVICES

- › Design of rock mass grouting scheme
- › Construction supervision

HELSINGØR-HELSINGBORG  
TUNNEL, DENMARK-SWEDEN

FACTS

- › Year of completion: 2008-2009
- › Owner: IBU Øresund
- › Client: IBU Øresund
- › Contractor: N/A

SERVICES

- › Feasibility study

CENTRAL ARTERY/I-90 BIRD  
ISLAND FLATS TUNNEL  
SECTION D007A, USA

FACTS

- › Year of Completion: 1996
- › Owner: Massachusetts Highway Department
- › Client: Gannett Fleming
- › Contractor: Modern Continental

SERVICES

- › Design
- › Construction engineering
- › Cost estimate

LIANTANG/HEUNG YUEN WAI  
BOUNDARY CONTROL POINT,  
HONG KONG

FACTS

- › Year of completion: 2013
- › Owner: Hong Kong Government
- › Client: Nishimatsu China State JV
- › Contractor: Nishimatsu China State JV

SERVICES

- › Tender stage design

CONWY ESTUARY TUNNEL,  
WALES

FACTS

- › Year of completion: 1992
- › Owner: The Welsh Office
- › Client: Travers Morgan
- › Contractor: Costain Tarmac JV

SERVICES

- › Tender design
- › Detailed design
- › Construction site supervision

FORT POINT CHANNEL  
CONCRETE IMMERSSED TUBE  
TRANSITWAY TUNNELS, USA

FACTS

- › Year of Completion: 2004
- › Owner: Massachusetts Bay Transportation Authority (MBTA)
- › Client: Massachusetts Bay Transportation Authority (MBTA)
- › Contractor: Modern Continental

SERVICES

- › Final design
- › Construction services

UPPER KOTMALE HYDRO  
ELECTRIC SCHEME,  
SRI LANKA

FACTS

- › Year of completion: 2011
- › Owner: Ceylon Electricity Board
- › Client: Maeda-Nishimatsu JV
- › Contractor: Maeda-Nishimatsu JV

SERVICES

- › Review of ground conditions

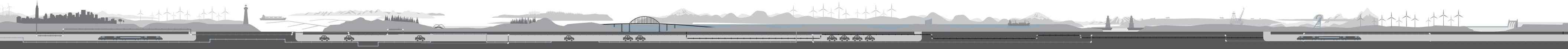
CHENGDU METRO,  
CHINA

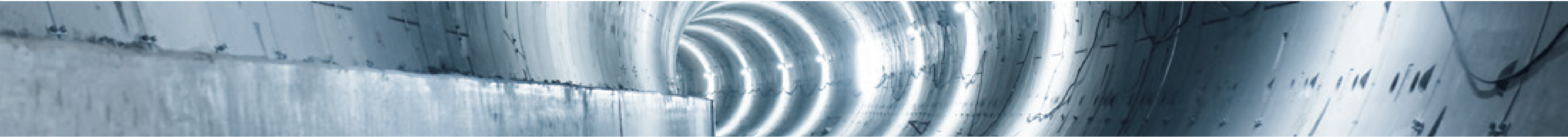
FACTS

- › Year of completion: 2007
- › Owner: Chengdu Leading Group of Metro Construction and Kreditanstalt für Wiederaufbau
- › Client: Chengdu Leading Group of Metro Construction and Kreditanstalt für Wiederaufbau
- › Contractor: N/A

SERVICES

- › Technical advice





NYCDEP WATER TUNNEL  
CONSTRUCTION,  
USA

FACTS

- › Year of Completion: 2011
- › Owner: The City of New York Department of Environmental Protection
- › Client: The City of New York Department of Environmental Protection
- › Contractor: Schiavone Construction

SERVICES

- › Geotechnical investigation
- › Design
- › Construction services

SOUTH ISLAND LINE  
CONTRACT 904,  
HONG KONG

FACTS

- › Year of completion: 2010
- › Owner: MTR Corporation HK
- › Client: Kier-China State JV
- › Contractor: Kier-China State JV

SERVICES

- › Tender stage design

GEORGE MASSEY TUNNEL,  
CANADA

FACTS

- › Year of completion: 2008
- › Owner: Ministry of Transportation and Highways, British Columbia
- › Client: Ministry of Transportation and Highways, British Columbia
- › Contractor: N/A

SERVICES

- › Design of seismic retrofit

WASHINGTON METRO  
SECTION E-5, FORT TOTTEN  
STATION & TUNNELS, USA

FACTS

- › Year of Completion: 1992
- › Owner: Washington Metropolitan Area Transit Authority
- › Client: Sheladia Associates, Inc.
- › Contractor: Mergentine Corporation

SERVICES

- › Geotechnical investigation
- › Design
- › Construction services

SOUTH ISLAND LINE  
CONTRACT 902,  
HONG KONG

FACTS

- › Year of completion: 2010
- › Owner: MTR Corporation
- › Client: Kier Kaden JV
- › Contractor: Kier Kaden JV

SERVICES

- › Tender stage design

IMMERSED TUNNEL FOR THE  
HONG KONG-ZHUHAI-MACAO  
FIXED LINK

FACTS

- › Year of Completion: 2017 (est.)
- › Owner: Project office of Hong Kong-Zhuhai-Macao Bridge
- › Client: Highway Plan and Design Institute
- › Contractor: China Communications Construction Co. (CCCC).

SERVICES

- › Feasibility study
- › Conceptual design
- › Preliminary Design

WORLD TRADE CENTER  
TRANSPORTATION HUB,  
USA

FACTS

- › Year of Completion: 2009
- › Owner: The Port Authority of New York and New Jersey
- › Client: The Port Authority of New York and New Jersey
- › Contractor: Phoenix Constructors

SERVICES

- › Design of various foundation elements and earth support systems

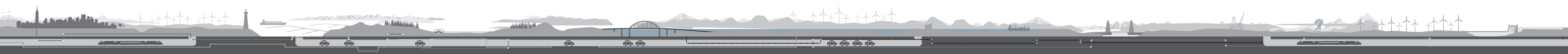
CLYDE TUNNEL,  
GLASGOW, SCOTLAND

FACTS

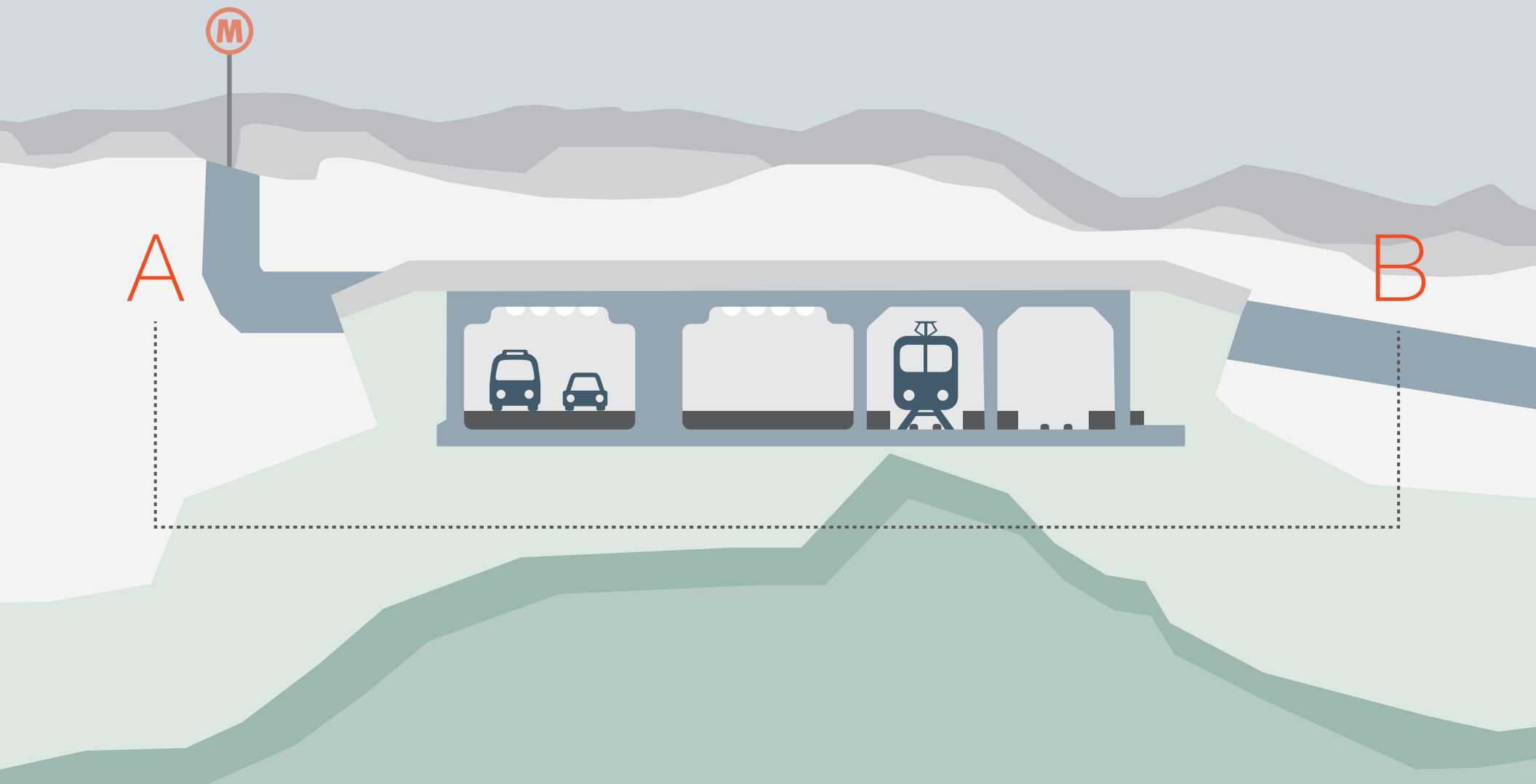
- › Year of completion: 2007
- › Owner: Glasgow City Council
- › Client: Glasgow City Council
- › Contractor: BYZAK

SERVICES

- › Design
- › Design of fire protective lining system



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