COWI A/S

COWI, founded in 1930, is a privately owned company and completely independent of any manufacturer, supplier or contractor. The COWI Foundation is the majority shareholder and supports research and development in the various fields of consultancy activities.

COWI is a leading northern European consulting group. We provide state-of-the-art services within the fields of engineering, environmental science and economics with due consideration for the environment and society. COWI is a leader within its fields because COWI's 4,800 employees are leaders within theirs. COWI's staff includes engineers, planners, sociologists, biologists, agronomists, economists and other academic specialists. The net capital and annual turnover are at present EUR 79 and 376 million, respectively. More than 50% of the turnover comes from international projects.

The skills represented in the COWI Group are complementary to a very large extent, and hence we can create synergy between the versatile bouquet of disciplines required in complex projects and offer total solutions to our clients considering all constraints and options in a balanced way.

Transportation

COWI has more than 75 years of experience in transportation covering all phases of infrastructure projects from initial planning and feasibility studies to maintenance management and training. Roads, railways and airports with more than 3000 bridges of all types and sizes have been constructed according to COWI's designs.

Bridge engineering

COWI is an international market leader in bridge engineering. Highly professional staff with broad international experience have reached this position through a continuous commitment to work of the highest professional standards and a constant search for efficient and innovative solutions.

COWI is proud to present its capabilities and achievements in bridge engineering. We have endeavoured to present COWI's comprehensive services within bridge engineering in this brochure. Please, do not hesitate to contact us for further information.

The 33 multidisciplinary consultancy services provided by COWI are based on the three Es: Engineering, Environmental Science and Economics

- Development assistance
- Urban and regional development
- Environmental and social due diligence
- Geographical information systems and IT
- Mapping
- Energy planning and systems
- Environmental policy and regulation
- Natural resources management
- Environmental protection
- Health, safety and environment
- Municipal and hazardous waste
- Water and wastewater
- Production and process plants
- Oil and gas
- Coastal engineering
- Bridges
- Tunnels
- Ports and marine structures
- Roads
- Airports
- Railways and metros
- Telecommunications
- Residential buildings
- Educational buildings
- Hospitals and health buildings
- Cultural and sports buildings
- Industrial buildings
- Commercial buildings
- Welfare economics and services
- Public administration
- Social development and HRD
- Transport planning and management
- Cadastre and land administration

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Bridge engineering

**Working with bridges**
COWI does not only design and supervise the construction of mega or major bridges. Also bridges with relatively moderate spans carrying and/or crossing roads, railway or waterways constitute a core activity within COWI. In cooperation with other parties involved in infrastructure design, COWI has designed and supervised the construction of several hundred bridges in many countries over the past decades. COWI provides services in the design of roads and railways and environmental and financial consultancy. These services combined with external assistance from architects and contractors result in a synergetic development of appreciated bridge projects.

**Services**
COWI’s services cover the whole project life cycle from the early conceptual ideas, through design and supervision to the operation phase, rehabilitation or decommissioning.

COWI works for public clients, concessionaires and contractors (BOT and design-build projects). COWI advocates a close dialogue in order to optimise the design and the construction.

**Expertise**
We participate actively in the research and the development of materials, new technology and methods of analysis in order to develop our core competencies. This knowledge is used to develop innovative concepts in design such as the use of carbon fibre reinforced polymer cables, selective use of stainless reinforcement steel, more environmental sustainable concrete, “green” concrete, etc. Our in-house integrated bridge design and analysis system, IBDAS, based on 3D parametric modelling, enables COWI to make state-of-the-art structural analyses and documentation.

**Quality management**
COWI’s business unit Bridge, Tunnel and Marine Structures is ISO 9001 certified. All design activities in COWI are performed according to a project quality plan tailored to meet the special project requirements.

**Market areas**
COWI is an international market leader in the design of bridges, and we provide our services from offices in Denmark, Norway, Oman, Qatar, Bahrain, Abu Dhabi, Latvia, Lithuania, Poland, Hungary, Uganda, Tanzania, Zambia, Mozambique, Korea, China, and from our subsidiaries in Canada and United States.

**Bridge projects**
- Highway bridges
- Railway bridges
- Pedestrian bridges
- Urban bridges
- Moveable bridges
- Signature bridges
- Jetties

**Services**
- Concept studies and value engineering
- Preliminary and detailed design
- Design check
- Construction engineering
- Tendering and procurement
- Construction management
- Contract administration and site supervision
- Operation and maintenance
- Re-assessment and rehabilitation

**Expertise**
- Tailormade high quality bridge engineering
- IBDAS – integrated design
- Numerical analyses
- Structural and corrosion monitoring
- Construction engineering
- Prefabrication and erection
- Construction materials
- Service life design
- Durability strategies
- Concrete technology
- Corrosion assessment
Urban bridges are often incorporated into an exiting context, which for urban bridges often implies restrictions to the design and planning. This could be the architectural nature of the surroundings and it is very often the case that urban bridges has to be erected with very tight restrictions in relation to existing traffic, which has a significant impact on planning and design.

Due to this fact the users get in close contact with the structure which means that the requirements to such bridges are consequently often stricter in respect of aesthetical appearance and detailing of finishes. In short the detailing shall look as if it was for indoor use while the service life requirements are obviously for outdoor in harsh environment due e.g. desalination. As these urban bridges often link urban areas together in respect of transportation of people, these bridges often serve as structures which carries pipelines as water and sewage pipelines and other utilities.

A subject often neglected in traditional bridge design is the railing. The railing on many urban bridges is the most visually exposed structural element. The railing is often more visually dominant than the load bearing element itself. In these situations COWI are experienced in the use of glass as load bearing safety elements, use of stainless steel wires, exotic wood and high strength stainless steel.

Aesthetics
COWI has an extensive tradition for collaboration with recognized architects when designing bridges – in particular for urban bridges – in order to make the bridges fit into the existing environment. COWI has participated in a large number of competitions together with architects and the teams have won a significant number of prizes.

Lightness and transparency
Urban bridges are located in confined spaces and should be light, transparent and elegant structures to avoid an intrusive appearance.

Landmarks
Bridges may be required to exhibit landmark qualities and are designed with unique, characteristic shapes. For this reason they may become points of attraction for the citizens of and visitors to the city.

Functional sculptures
The bridges naturally have a primary technical function, but if the structural elements exhibit simple geometric shaping the final result may have the supplementary quality that the bridge becomes a sculpture and thereby adds quality to the appearance of the city.
References

- Åbuen bridge, Copenhagen, Denmark
- Roskilde pedestrian bridge, Denmark
- Munksjön Bridge, Sweden
- Pedestrian bridge, Naestved, Denmark
- Pedestrian bridge, Copenhagen Airport
- Railway station bridges, Copenhagen, Denmark
- Lusail bridges, Qatar
Moveable bridges

In COWI, a group of staff has specialised knowledge of the design and the rehabilitation of moveable bridges: swing, bascule and lift bridges. A special niche within movable bridges is design of landing aprons at ferry terminals.

**Clients’ requirements**
Ship traffic and ship collision analyses are performed internally and applied as a firm basis for specifications of functional and design requirements for the bridges – including protection structures.

**Aesthetics**
COWI has strong relations to leading bridge architects and a proven ability to develop designs for moveable bridges of a high aesthetic standard.

**Multidisciplinary design approach**
The structural specialists provide designs that comply with the clients’ requirements and expectations by applying a multidisciplinary approach, where dedicated mechanical and electrical engineers provide the functional specifications and designs for the systems that make the bridges moveable. Such a design comprises all mechanical / electrical systems supplemented with the necessary monitoring and control systems for the lifting gear and the road, rail and shipping traffic.

Structural monitoring systems are often included in order to facilitate a systematic surveillance of the structures and the collection of data for inspection and maintenance planning.

**Structural analyses**
All kinematics and dynamic aspects of the designs will be designed by in-house developed software, including, for example, wind buffeting analyses, wave climate and load effect analyses.

**Inspection and maintenance**
The continuous involvement in planning, inspection, maintenance and repair works on existing moveable bridges is the basis for broad and specialised experience with COWI’s staff available to our clients.

The detailed experience with the actual operation and performance of moveable bridges is also utilised in the design, where operation and maintenance aspects are carefully integrated in the designs based on service life design and life cycle cost analyses.

**Repair and strengthening**
COWI has prepared repair and strengthening designs for bascule bridges with dense traffic. The removal of entire bridge parts, rehabilitation and strengthening at difficult accessible area and reinstallation were carried out by using a cost efficient approach, which, at the same time, had few negative implications on the traffic.

References
- Bryggebroen, Denmark
- Knippelsbro, Denmark
- Langebro, Denmark
- Aalborg, Denmark
- Korsør, Denmark
- Stege, Denmark
- Grenå ferries, Denmark
- Pir Brua, Norway
- Fredrikstad, Norway
- Frednes, Norway
- Malmö, Sweden
- Marieholm, Sweden
- Södertälje, Sweden
- Trollhättan, Sweden
- Varberg ferries, Sweden
- Ratasolta, Finland
- Ventspils, Latvia
- Klaipeda, Lithuania
- Limerick, Ireland
- Marsa Arabia, The Pearl, Qatar
Illustration: Dissing+Weitling Architects', impressions, Pir Brua bascule bridge, Norway
Pir Brua bascule bridge  
Trondheim, Norway

In a design competition in 2006, the winning project is a bridge with a bascule span of 20 m and four approach spans, each of maximum 30 m and a total bridge length of 135 m. The width of the carriageway is 15 m and the bridge is equipped with two 4 m sidewalks on either side.

The bascule span is an orthotropic steel deck supported on two longitudinal girders and cross beams, spacing 3.5 m. The approach spans are designed with a composite deck structure which interacts together with the two longitudinal steel girders and cross beams like the cross beams of the bascule span.

A counterweight is omitted in the bascule span for aesthetic reasons and to obtain substantial savings on the immersed foundations. In the absence of the counterweight, each cylinder of the opening mechanism has a capacity of 4500 kN to overcome the governing dead load from the bascule span, most adverse in the opening phase. The pairs of V-shaped struts distribute the load from the superstructure to elastomeric bearings on coned concrete piers.

The bridge is founded on circular, 50 m long driven steel piles. The load is merely resisted by skin friction as the underlying lime stone is located too deep to be penetrated. The structure and the navigation opening are protected against ship impacts by measures derived from a risk analysis. Four concrete disks are cast on top of steel piles to protect the navigation span against ship impacts. The disks are connected internally with a hollow steel beam under the bridge.

Aesthetics
Dissing+Weitling were the architects of the project, and participated with an aesthetical vision. The signature of the bridge is two fins at the bascule span reaching upwards and corresponding visually with the struts at the supports of the approach spans reaching downwards. The fins have a structural and aesthetic function by distributing the moment forces from the opening device to the span, and by announcing the opening span and its position.

Costs
Total construction cost for the bridge structure is estimated to be EUR 15 million.

Services
- Detailed design
- Technical assistance during construction

Project period
2006 - 2009

Client
The Road Directorate (Statens Vegvesen), Norway
Railway bridges and stations

Through the years, COWI has undertaken numerous projects with the design and the supervision of railway bridges. Such projects include steel girder decks, concrete decks and orthotropic steel decks.

Clients’ requirements
One of the commonest and most challenging requirements of railway bridge design and, in particular, the installation is the very little time during which existing railway lines can be closed. In most cases, closure is limited to a few weeks or to limited time slots during nights.

Fast installation
COWI has designed many bridges which are installed in their final position in the allowed, limited time period. The design may vary but a common method is to use prefabricated steel decks assembled either adjacent to the final position and moved laterally onto the new permanent substructure or mounted directly in the permanent position. Another commonly used method, applicable for smaller size spans, is the construction of the entire bridge, sub- and superstructures, and rolling or pushing the bridge on rollers or air cushion pads into its permanent position.

As a completely different approach COWI has designed and undertaken the supervision of bridge elements, integral types, which are installed by thrust and excavation through the embankment carrying an existing railway line. This approach requires temporary track bridges while the installation takes place but it is advantageous as the railway is not interrupted for more than a few hours.

Multidisciplinary design approach
In the occurrence of integrated design, railway alignment and vertical reference lines can be adopted directly into the bridge design tool IBDAS facilitating a parametric design of the structures.

Structural analyses
All structural design disciplines are covered within the competencies of COWI’s employees.

Inspection and maintenance
COWI is continuously involved in planning, inspection, maintenance and repair works on existing bridges and stations.

Repair and strengthening
Subsequent to the experience gained from inspection and the capability of performing structural analyses COWI often can provide ingenious solutions, adding life span and load bearing capacity and hence value for the owner.

References
- Widening M3, Denmark
- Oresund Landworks, Denmark
- Allerod, Denmark
- Hellerup Station, Denmark
- Vigerslev Allé, Denmark
- Replacement of bridge superstructures, Denmark
- Allébron, Sweden
- Trollhättan, Sweden
- Botniabanan, Sweden
- Taiwan high-speed rail, Taiwan
- Rasolta, Finland
- Sopot, Poland
Flintholm Station, Denmark

A railway line for passenger traffic was constructed in Copenhagen. A new major station, Flintholm Station, was constructed on this line, at a central junction between 2 main railway lines and the Copenhagen Metro. Flintholm is thus the third largest railway station in Denmark.

**Bridge structures**
A number of large bridge structures were constructed as part of Flintholm Station:

- 2 railway bridges for the Metro, each 119 m long
- 2 railway bridges for the main railway line, length 102 m each
- A platform bridge for the Metro, 45 m long
- A platform bridge for the main railway line, 36 m long
- A footway bridge, 40 m long.

In addition, a number of miscellaneous structures were designed, e.g. retaining walls, platforms on embankments and ground level, visual barriers, etc. The demolition of 4 existing concrete bridges was also included in the project.

**Prefabration**
The 4 railway bridges were designed as steel structures and prefabricated elements were extensively used, as the erection conditions were very restricted due to existing railway lines and roads in operation.

The cross-section of the bridges was designed as a trough structure with 2 main girders as the primary structural elements. This concept was selected due to a very limited headroom clearance.

The substructures were designed as circular single concrete columns with steel structures on top to obtain the desired aesthetical appearance and to occupy a minimum of space in the station area.

The erection of the railway bridges was carried out with full span elements using heavy duty mobile crane equipment. The escape route footway sections were mounted separately afterwards.

The platform bridges were designed as steel/concrete composite structures, with permanent formwork used for concrete casting. The platform bridges were erected similarly using large mobile cranes.

Elevator towers were integrated in the platform structures serving as substructures for the platforms.

The footway bridge was - as the other structures - designed in steel to provide optimum erection conditions and to comply with requirements regarding the period of installation. The bridge was erected in its entire 40 m length in one operation.

**Complicated construction**
The construction conditions for the railway bridges and the platform for the two main railway lines were extremely complicated.

During the entire construction period the railway traffic was required to be maintained except for a few hours during nights and a very limited number of weekend closings. In addition, the existing road crossing below the bridges should be kept in full operation at all times.

Despite these requirements, the construction was completed successfully with the existing road and railway traffic maintained as planned without adverse incidents of importance.
New Ellebjerg Station is the latest station on the commuter railway line in Copenhagen. The station is an end station on the orbital railway line and serves intense traffic.

The station is located in a point of intersection with cargo trains and commuter trains serving southern suburbs of Copenhagen.

During construction it was mandatory that disruption of commuting and cargo trains only could be allowed in very limited periods of time. Experience gained from similar projects had a great impact on the design and the construction methods and sequence.

Prefabrication of large and smaller construction members was planned for and mounted during traffic disruption over night. Hence steel was the natural choice of material and with altogether around 1000 tons of steel is comprised in the structural structures in the station.

The platforms are 180 metres in length. The load carrying structures are concealed in hot dip galvanized steel plates which resembles the shape of the commuter trains which reflects the aesthetical vision. The appearance of the platforms and trains are intended to be futuristic in the way the fixed elements and the moving objects merges.

The concealed load carrying bridges are closed box girders with a concrete deck. The closed girder concept is necessary to provide sufficient torsion capacity. The 200 mm concrete deck on the platforms is selected to provide a solid base for a granite tile surfacing.

Embankments are retained by means of steel sheet piles cladded with white concrete. The sheet piles were very advantageous in terms swift installation. The piles were driven to the bearing strata of limestone and through this the load bearing capacity and the possibility of retaining traffic was enhanced.

**Services**
- Design
- Supervision
- Technical follow up during construction

**Project period**
2002 - 2005

**Client**
Banedanmark
High-speed rail project, Taiwan

The high-speed rail system connecting Taipei and Zuoying is 345 km long and was inaugurated in 2006.

Procurement model
The Taiwan high-speed rail project under the BOT (Build-Operate-Transfer) model was constructed and is operated privately, and it will be returned to the government upon expiry of the concession period. The construction of the Taiwan high-speed rail represents one of the most challenging and largest projects in the world with regard to private sector investment in public construction.

Topography
The topography is generally hilly, and elevation ranges from 35 to 140 meters above sea level. The alignment crosses flat alluvial plains and creeks.

Lot C240
The lot includes the construction of the 3 km long Miaoli tunnel, a number of other short tunnels, 8,000 m of high embankment works and approximately 5000 m of viaducts comprising 18 viaducts/bridges with lengths from 120 m to 1,010 m. Most of the foundations are based on pile foundations with bored piles up to 30 m. The substructures consist of single hollow pier shafts up to 30 m high. The superstructures mainly consist of post-tensioned cast in-situ concrete box girders with span lengths of up to 45 m. The superstructures are constructed mainly by using MSS (Movable Scaffolding System) and FSM (Full Stacking Method).

Lot C250
The lot includes the construction of the branch line to Wujih Depot. The works include approximately 35,900 m of viaduct and bridge structures, with more than 1500 bridge spans together with short sections of cut and cover tunnel and earthworks. The earthworks include embankments required at the location of the Tun Tzu Chiao active fault, which crosses the alignment.

More than 95% of the civil works consist of bridges or viaducts:
- Long-span steel girder bridges with span lengths up to 150 m
- Composite box girders with very eccentric loaded substructures
- Pre-cast, pre-stressed I-beams, up to 60 m span lengths simply supported or continuous
- Triple span continuous concrete box girder post-tensioned with span lengths up to 65 m constructed using MSS (Movable Scaffolding System), FSM (Full Stacking Method) or FCC (Free Cantilever Construction)
- Pre-cast, pre-stressed box girders constructed span by span, simply supported with span lengths of 25 m to 35 m
- In situ post-tensioned, simply supported box girders up to 40 m span lengths

Services
- Checking design of permanent works
- Checking design and construction of major temporary works
- Checking changes in design of permanent works
- Verification of geotechnical conditions on site during construction
- Analytical check including independent calculations

Project period
2000 - 2006

Client
- Lot C240: Hyundai - Chung Lin JV
- Lot C250: Hochtief AG - Ballast Nedam - Pan Asia JV

Concessionaire
Taiwan high-speed rail cooperation

Function
Contractor’s independent checking engineer

Cost
The total construction investment needed was approximately USD 15 billion
Highway bridges

COWI has designed and supervised a large number of highway bridges, either as solitary structures or, often, as more complicated bridges in interchanges.

Overpasses
Depending on the country, authority traditions and the type of road, etc. the most used construction material is concrete. In some locations, composite or even sheer structural steel and timber have been used.

Road carrying bridges are predominantly designed and constructed as in-situ cast, post-tensioned box girder or slab bridges, alternatively as composite bridges with prefabricated beams and an in-situ cast roadway slab. Main spans range from a few metres to more than 80 m, and the overall length could exceed several hundred metres for particular viaducts or interchange bridges.

Underpasses
Road carrying underpasses are frequently designed as in-situ cast concrete integral bridges, e.g. frames with inclined or vertical walls. Inclined walls alleviate the impression of being in a confined space in the underpass.

Design tools
Bridges are designed and analysed by using an Integrated Bridge Design and Analysis System, IBDAS, featured elsewhere in this brochure.
Prototype models

As parametric modelling is utilised, a range of generic prototype models are available for different bridge types. The models can be used for similar bridges with only minor geometric differences. This enables COWI to prepare series of bridge designs at a high pace at competitive prices – and maintain a high quality because of the consistent project basis provided via the IBDAS design tool.

Accumulation of experience

Best practices attained through construction supervision are mapped and included in the design models to ensure optimal feedback constantly.
Motorring 3, Denmark

The widening of the major traffic link Motorring 3 west of Copenhagen from a dual 2 lane to a dual 3 lane motorway is Denmark’s most complicated project of its nature to date. The number of daily vehicles exceeds 100,000. The length of the stretch is approximately 16 km. A large number of interchanges are included in the project.

Comprised in the works are approximately 40 bridges, which are constructed either as new bridges, full replacements or widened due to the widening of the carriageways. 35 of the bridges carry road traffic, one bridge carries the main railway out of Copenhagen and the remaining are pedestrian bridges. The bridges, which are being widened, are also provided with new waterproofing and surfacing during the execution of the works. Moreover, about 18 km of typically 4 m high noise barriers and 11 km retaining walls are designed and constructed.

One of the main merits of the design has been the integrated road and bridge designs made possible by the interface between the road design tool InRoads and the bridge design tool IBDAS, see elsewhere in this brochure.

The bridge designs imply great variety in terms of logistic and technical challenges. Most bridges are constructed in reinforced or post-tensioned concrete. Some bridges are constructed by using precast, pre-tensioned concrete girders.

- Partial and sectional demolition of existing bridges and subsequent sectional construction of new bridges have been implemented in three locations.
- In seven locations the superstructures are constructed in a super-elevated position to facilitate the normal headroom clearance, during construction and subsequently lowered to the permanent level sitting on the abutments and piers.
- One bridge has been pushed under four existing and fully operational railway tracks by means of the thrust-excavation method.
- Four bridges have been constructed as composite bridges with prefabricated beams and an in-situ cast roadway slab.
- A large number of sidewise widening of slab bridges to accommodate for additional lanes has been performed.
**Services**
- Environmental impact assessment
- Preliminary design
- Detailed design
- Construction management
- Construction supervision
- Design and design check, temporary structures
- Operation and maintenance manuals

Integrated design involving other departments of COWI
- Traffic management
- Road design
- Pavement design
- Relocation of utilities
- Expropriation of land and properties
- Environmental management

**Costs**
The grand total construction costs for the widening is in the order of EUR 375 million, of which bridges and noise barriers amount to EUR 80 million.
Replacement of Sitra bridges

The causeway and bridges between Sitra and Manama in Bahrain are one of the most important traffic links in the country’s road network. The dual two-lane roads and the at-grade junctions cannot cope with the present, heavy morning and afternoon rush hour traffic loads, which exceed 6,000 vehicles per hour.

Replacement needs

The Ministry of Works and Housing in Bahrain has concluded that the existing marine bridges built in the 1970’s have reached the end of their service life, as concrete deterioration has reached an extent where the bridges can no longer feasibly be repaired. At the same time, the causeway is to be widened to increase traffic capacity.

Project components

The project comprises a realignment of the causeway, a widening of the embankments and carriageways to accommodate dual four-lanes, two new marine bridges on the causeway – 200 and 400 m long - a three-tiered grade-separated interchange at the Umm Al Hassam junction at the northern end, a grade-separated interchange at Nabih Saleh at the middle, and a grade-separated interchange on Sitra island at the southern end of the causeway.

Constructability and traffic management

Constructability aspects and traffic management are critical issues as traffic must be maintained throughout the construction period, and services and utilities must not be interrupted except in the wintertime.

Environmental impact

The impact on the environment has been assessed through extensive numerical modelling with special emphasis on the Tubli Bay to the east of the causeway, and mitigating measures to improve the flushing of the bay have been investigated.

Service life design

The new structures will be predominantly post-tensioned concrete. According to the client’s terms of reference, the structures must be designed and constructed for a service life of 120 years – a demanding task in the extremely hostile marine environment. These requirements were met through extensive use of stainless steel reinforcement in the most exposed parts of the concrete structures.

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Cost

The grand total construction cost for the causeway is in the order of EUR 175 million.
Pedestrian bridges

In urban areas with dense traffic and with complex infrastructure grade separation of pedestrians and bicyclists from other traffic often becomes imperative. Tunnels and bridges resolve this need. This can naturally be accomplished in many different ways spanning from resolving the basic demand to striving for establishing landmark features.

Architects and bridge engineers are frequently pushing the limits of structural engineering. In some occasions this is a way to achieve the ultimate or tailor made in aesthetics. In other cases the keep it simple approach is much more appropriate.

The scale of this type of bridge design does indeed in some cases call for using other materials than the most traditional concrete and steel. COWI can provide experience with wooden bridges and fibre composites.

References
- Widening M3, Denmark
- Bryggebreen, Denmark
- Åbuen Bridge, Denmark
- Flintholm Station, Denmark
- Pir Brua, Norway
- Gota Channel, Sweden
- Muscat Airport, Oman
- Albertslund Bridge
Signature bridges

Sand dunes
The form of the Sheikh Zayed Bridge in Abu Dhabi — designed by the renowned architect Zaha Hadid — is inspired by the sand dunes in desert areas in the Gulf region. Due to its similarity with dunes — and also due to its unusual shape — it has become a landmark in the local environment and a signature bridge for the Emirate of Abu Dhabi.

The complex shape makes the structural design and construction very challenging. COWI performed the independent design check of the bridge structures.

Ring bridges
Lusail City development north of Doha, comprises, among others, two signature bridges connecting the main land areas with new artificial islands, separated by channels. The location is unique as the bridges are visible from dense city areas on either side of the water.

The signature ring bridges were designed by Dissing+Weitling with a circular shaped structural element carrying the cables supporting the bridge girder. The elegant shape is very simple in form and could be perceived as a logo for the new city development.

Though simple in appearance and shape the structural system is complex both to design and to construct. COWI designed the bridge structures, prepared the tender documents and carried out the supervision.

Gateway to the city, Åbuen Bridge
An elegant and light structure that provides convenient facilities for pedestrians and bicyclists when crossing a busy road entrance to Copenhagen and, at the same time, the bridge appears as a gateway to the city. COWI performed conceptual designed and won the architectural competition together with Dissing+Weitling.
Jetties

Export Terminal
Idku is located on the Mediterranean coast 50 km east of Alexandria. An export terminal for LNG was needed due to the finding of sizeable gas fields.

The terminal caters for 140,000 m³ LNG vessels. It consists of a construction harbour and a 2.4 km long access trestle, which extends into the berth for gas tankers.

Facilities
The mooring and turning area is protected by an 850 m long breakwater. The mooring and turning area is dredged and so is a long approach channel.

The substructure consists of driven steel piles and pile caps and it supports a composite superstructure in spans of 40 m. The loading, mooring and berthing platforms are all steel supported structures.

Site conditions
The site is very exposed with an off-shore significant wave height of 11 m. However, this height is reduced to approx. 6.8 m at the breakwater by wave breaking and energy dissipation as the water depth is 12 to 13 m.

The breakwater is located in an area with up to 15 m of soft clay. The combination of the large breakwater in a zone subject to seismic activity and the severe wave climate resulted in a need for replacement of the soft clay with sand.

Design focus
COWI’s design services for this project included all studies and design tasks including mooring analyses, numerical and physical model studies performed in a sub-consultant’s hydraulic laboratory. Focus in all the studies and design services were on optimising the design with respect to minimising quantities and, at the same time, making construction as easy as possible for the contractor.

Services
- Assessment of geotechnical investigations
- Hydrographical analyses
- Breakwater design
- Dynamic mooring analyses
- Design of access channel and navigational lights
- Vessel downtime assessment
- Structural design of jetty structure
- Seismic analyses
- Building design
- Electrical and Mechanical design

Project period
2002 - 2004

Client
Archirodon Construction/Bechtel International

Ruwais third NGL train jetty project, Abu Dhabi, UAE
Multidisciplinary projects

Design tools
A main advantage of design anchored in COWI is the facilitation of an integrated road and bridge design enabled by the interface between the road design tool InRoads and the bridge design tools IBDAS, see elsewhere in this brochure.

The exchange of data between these two design tools ensures maximum consistency in the geometrical layout. InRoads generate output data for horizontal and vertical alignments as well as cross-section data. These data is read automatically by IBDAS precluding erroneous manual data transfer. Another main advantage is the implementation of geometrical changes which is acknowledged to occur. Interface checks between road and bridge designs are considerably eased with the integrated design method.

Items comprised in multidisciplinary projects
Major infrastructure projects excluding major traffic links such as major bridges or tunnels, comprise various design and construction aspects.

As a leading consultant, COWI has the capacity to provide services for environmental impact assessment, surveying, land acquisition, inventory of adjacent facilities, conceptual, preliminary and detailed design of roads, railways and bridges, retaining walls, noise barriers, stormwater drainage, road lighting, road and bridge furniture, road marking, etc.

Traffic planning, simulation and management, relocation of utilities, value engineering during all phases of the design, construction engineering and planning of phasing of the works are also an integrated part of the combined design and supervision package offered by COWI.

The preparation of tender dossiers including prime documents, specifications and bill of quantities are included. Contract management and supervision of all trades on site are provided by COWI.

COWI has vast experience in many different fields. For this reason we can staff multidisciplinary projects with in-house people. This is an advantage for project owners as it facilitates conforming, economical and timely completions of projects.
Developing countries

**Roads and bridges**
Infrastructure projects in developing countries often encompasses a wide range of disciplines and services ranging from economic and social studies to hard core engineering disciplines.

In the early stages of project implementation the task is to identify and formulate the project. It would often include traffic studies, hydrological studies, sketch designs, and preliminary cost estimates. This will be basis for feasibility studies, environmental and social impact studies, preliminary design and more accurate cost estimation.

Once the owner has decided to execute the project, the task is to carry out field investigations, design, tender documents, tendering, tender evaluation, contract negotiations and in case of design and build also design check.

In the execution phase construction supervision will be required including follow up during the defects liability period, and the owner will have to organize how to operate and maintain the new or rehabilitated roads and bridges after completion of construction.

COWI possess the required expertise in all these disciplines via in-house employed economists, sociologists and engineers. It is important that the projects are carried out in close consideration of local conditions and environment. Therefore COWI provides its services through locally established daughter companies near the client. This allows us to let locally employed professionals provide the services in close liaison with the client, and at the same time draw from the resource pool of specialists from elsewhere in COWI from inside or outside the region.

**Services**
- Feasibility studies
- Environmental impact assessment (EIA)
- Social impact assessment (SIA)
- Traffic studies
- Hydrological studies
- Geotechnical investigations
- Topographic and bathymetric surveys
- Road and bridge design
- Procurement
- Tendering
- Tender evaluation
- Design check
- Construction supervision
- Maintenance
- Labour intensive methods
- Institutional capacity building and training of staff
- Quality management

Unity Bridge
Limpopo Bridge, Mozambique
IBDAS, Integrated Bridge Design and Analysis System

Advanced bridge design calls for highly specialised analysis tools to meet today’s requirements of high quality, detailing level, efficiency and competitiveness.

COWI’s in-house developed IBDAS program is a state-of-the-art FEM program and CAE tool, which has been developed to be optimal with regard to design and analyses of new and existing bridges and to the analysis of construction sequences.

IBDAS is a fully integrated system, which is based on three-dimensional parametric modelling of the bridge geometry. The information retrieved from the geometric model is utilised as basis for the finite element modelling, the drawing preparation and the production of structural documentation. This ensures a coherent and fully consistent project basis, documentation and working drawings.

An important feature is the integrated data transfer from the road design tool InRoads to IBDAS. Through this interface horizontal and vertical alignments are imported as well as cross-sections for the over- and underpassing roads.

Important features
IBDAS has facilities for (selected examples but not limited to)
- linear static analysis
- geometric non-linear analysis
- plastic analysis
- dynamic wind analysis using Davenport’s buffeting theory
- time history dynamic analysis
- seismic response spectrum analysis
- multi-support seismic response spectrum analysis including varying support conditions, coherence etc.
- train-structure interaction analysis including comfort analyses
- buckling and stability analyses
- float stability analyses for caissons
- probabilistic reliability analysis
- pile foundation analysis

Load combination
Bridge live loads and other loads can be modelled and maximum load effects automatically be determined based on simple as well as complex load combinations.

Verification
Design verification can be performed for truss, beam and shell elements for various design
codes and, at present, the following have been incorporated:
- Eurocodes
- BS 5400
- AASHTO
- Danish, Swedish and Norwegian
- German
- CEB-FiP Model Code

**Construction sequences**
IBDAS is capable of modelling the exact sequence of construction including, but not limited, to activities such as:
- casting of structural parts
- erection or removal of structural parts
- stressing/slackening of tendons
- changes in support conditions during erection
- temporary loads applied and relieved

Associated time indications enable IBDAS to keep track of and determine time dependent phenomena such as creep, shrinkage and relaxation.
Construction engineering / interim works

The development of optimal construction methods is of vital importance for economical and timely completion of bridge projects.

**Erection techniques**

Depending on the constraints of each project location and the time available for the construction process the methods used have an important influence on the success of the project.

In recent years a great number of roadway bridges have been constructed in elevated position on elevated falsework and subsequently lowered to final position over trafficked roads. Use of partly prefabricated elements in superstructures is used if appropriate.

Of more specialized character has been installation of two 3,600 ton superstructures installed by sideways movement on air cushion pads. The translocation straddled over 40 metres and the duration was about one hour.

Another frequently used methodology is installation of bridge structures under railway tracks in full service. COWI has designed a number of bridges which have been constructed immediately beneath temporary track carrying bridges and excavation under those temporary bridges is carried out after installation of the bridges. A sophisticated methodology is thrust and excavation through an embankment carrying an existing railway line in the event that an underpassing road or railway shall be installed.

Installation of bridges designed to accommodate for incremental launching or by sequential construction span by span in either concrete or steel superstructures has been developed in the design tool IBDAS.

**Logistics**

The logistics of construction sequences can be an important issue during construction of bridges. COWI has used solutions developed in close corporation with the Contractor in order to utilize available equipment and to simplify construction methodology.

Considering construction methods in the design is usually a key to minimize risks and to facilitate construction methods fitting to Contractors equipment and knowledge.

**Temporary structures**

Construction of bridges calls for interim structures to support the bridge elements during the erection stages and often custom made erection equipment for the installation of bridge components. COWI provides detailed design and design check of a variety of temporary structures.
Operation and management

Major public assets as roads and bridges need efficient management, administration and operation in order to utilise resources in an economic and technical optimal manner.

Over a period of more than 20 years COWI has developed an asset management approach based on practical experience from planning, budgeting and handling of both short- and long-term operation and maintenance and rehabilitation works.

**Concept**

Operation management normally comprises:
- Administration with a description of organisational responsibility for operation and maintenance and relations to external parties
- An inventory with a systematic filing system for all inventory data
- Management tools including systems developed to fulfill the need for information to the:
  - public
  - management
  - bodies engaged in the operation and the maintenance
  - managing of tasks including time, economy, quality, safety and environmental matters
- Traffic and technical operation consultancy in preparing procedures and instructions for the daily operation

COWI has extensive experience in designing maintenance works to be carried out during traffic flow in urban environments and traffic near the capacity limit. New and innovative solutions are required to maintain the structures.

- Inspection and maintenance activities aim to maintain the structures by preventive maintenance with a minimum of corrective maintenance. The daily maintenance comprises principal and special inspections, preventive and corrective maintenance and monitoring
- Equipment and materials including advise on necessary maintenance equipment and tools with instructions about use and servicing

COWI has been involved in designing equipment for inspection of bridge girders, main cables and pylons.

**Maintenance management systems**

Efficient computerised systems are needed in order to support the management concept and to optimise the use of allocated funds amongst all the components of infrastructure elements.

COWI has more than 20 years of experience in implementing both management concepts and computer tools e.g. in Singapore, China, Thailand, Spain, Denmark and Uruguay.
Inspection and maintenance
Continuous involvement in planning, inspection, maintenance and repair works on existing bridges is the basis for broad and specialised experience with COWI’s staff that is available to our clients.

The detailed experience with actual operation and performance of bridges is also utilised in the design where operation and maintenance aspects are carefully integrated in the designs based upon service life design and life cycle cost analyses.

Repair and strengthening
COWI has prepared repair and strengthening designs for bascule bridges with dense traffic. Removal of entire bridge parts, rehabilitation and strengthening at remote sites and reinstallation enabled a cost-efficient approach which, at the same time, had the least negative implications for traffic.
Integrated life cycle design and assessment

Integrated life cycle design is a complex approach implementing all relevant and significant requirements into one single design process.

This approach integrates material, component, and structure design and considers selected relevant criterions from a wide range of criterions sorted in three basic groups: environmental, economical and social expressed by corresponding technical quality criteria.

Life cycle assessment

The assessment methods and models in the integrated life cycle design process can include the entire life cycle of a concrete element and/or of a whole concrete structure. The evaluation of environmental impacts of concrete products or the entire structure within the entire service life can be done using LCA (Life Cycle Assessment) methodology i.e. specified in International Standard ISO 14040.

Durability strategy – optimal solution technical and economical

COWI uses a methodology aimed at combining structural and durability related design in order to obtain the technical and economic optimum durability strategy in relation to a specified service life.

This methodology lists critical and limiting parameters for the structural design as well as for the durability design. A number of strategies are established, each with a specific combination of durability related parameters against reinforcement corrosion.

Durability improving measures

- Higher/denser concrete cover quality
- Increased concrete cover thickness
- Increased amount of reinforcement to reduce crack width.
- Application of surface coating/membrane
- Application of surface impregnation or corrosion inhibitors
- Use of stainless steel reinforcement
- Use of non-metallic reinforcement, e.g. carbon fibre reinforcement
- Application of cathodic protection at time of construction or at time of corrosion initiation
- Use of fibre reinforcement or prestressing to minimise crack formation and reduce crack width
- Use of sacrificial reinforcement layer outside the structural reinforcement
**Life cycle costs**
Based on an evaluation covering all relevant durability strategies two or three strategies are selected where the life cycle costs are priced. The selection of the relevant strategies is made in close co-operation with the owner.

The life cycle costs in the different phases of the life cycle are priced, being construction, operation, maintenance and repairs.

A principal figure showing life cycle costs over an entire of a life cycle for two different durability strategies are shown below.

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**Service life design**
The nominal end of service life for a given structure is to be specified. This can be based on corrosion initiation with specified probability, first sign of cracking, reduction of steel bars cross section, spalling of a certain percentage or other.

COWI have the tools in-house to design for durability using the so-called Duracrete methodology, where the ingress rate of aggressive substances are modelled using probabilistic methods taking the uncertainties on the decisive parameters in the ingress models into consideration.

The methodology has been developed with COWI as scientific lead partner in the European research project DuraCrete.
COWI has the expertise within the field of corrosion. We evaluate the corrosion risk, monitor and control the corrosion, including:

- Condition survey
- Design and installation of corrosion protection
- Supervision, operation and maintenance.

Where construction of sheet piles, steel piles and concrete members are placed in an aggressive environment we evaluate the corrosion risk and evaluate the design in relation to the given environment.

**Corrosion monitoring**

As opposed to conventional visual inspection, durability monitoring will provide the operator with detailed information about the current deterioration state of the structure. The monitoring techniques will ensure detection of the critical initial stages of deterioration and unacceptable rates of deterioration will be detected at early stages.

COWI provides the following services in relation to corrosion monitoring:

- Evaluation on where and to which extent monitoring should be conducted
- Conceptual and detailed design of a corrosion monitoring system including design of remote monitoring system allowing for access to data from remote placed server.
- Systems to monitor for general corrosion, localized corrosion and stray current corrosion
- Supervision
- Monitoring and evaluation of corrosion risk at all time
- Updating of service life performance based on data from the monitoring system.

**Cathodic protection**

We have in-house expertise

- to evaluate whether cathodic protection is a feasible technical solution
- to perform conceptual and detailed design of a cathodic protection system tailor making the solution to match the structure to be protected
- supervise the installation works
- monitor and evaluate the performance of the systems.

COWI is a member of NACE, National association of corrosion engineers, and are certified within the Cathodic protection area.
Condition assessment

Inspection
In connection with as-built verifications, operation and maintenance, inspections and condition assessments of concrete and steel structures we carry out all steps of the investigations - right from the visual inspection to special investigations where we evaluate the load carrying capacity and the safety of structures.

Re-evaluation, in many cases, justifies the continued use of a bridge and ensures the owner a significant increase in return of investment.

COWI have been deeply involved in the project Sustainable bridges, “Assessment for Future Traffic Demands and Longer Lives” funded by the European Commission.

The main objectives of the project were:
• Increase the transport capacity of existing bridges by allowing axle loads up to 33 tonnes for cargo traffic with moderate speeds
• Increase the capacity for passenger traffic with low axle loads by increasing the maximum speeds to up to 350 km/hour
• Increase the residual lifetime of existing bridges with up to 25 %
• Enhance strengthening and repair systems

Testing
ISO9001 certified laboratory
We have our own materials laboratory including a wide range of testing equipment for site measurements and in-lab, measurements.

Thermography recorded photo of abutment wall where changes in temperature indicate areas of delamination
Repair

Reliability based re-evaluation

During the lifetime of a bridge the use may change, e.g. the loads acting on the bridge may increase, or the bridge may be subject to deterioration, e.g. corrosion, which influences the ability to fulfill its purpose with sufficient safety. Re-evaluation, in many cases, justifies the continued use of the bridge and thus ensures the owner a significant increase in return of investment.

Competences

COWI designs the durability of concrete structures based on fixed service life requirements, the environment and our knowledge of deterioration mechanisms and the rate with which the deterioration takes place.

Reliability-based re-evaluation.

For deteriorated major bridges COWI has experience in re-evaluation based on a rehabilitation design basis uniquely developed for the considered bridge.

Selected competencies related to re-evaluation

- Deterioration modeling
- Testing of materials and structural testing of bridge structure
- Service lifetime assessment
- Inspection using state-of-the-art inspection techniques
- Optimal plans for inspection, maintenance and repair needs
- Structural reliability
- Calibration of bridge specific loads
- Calibration of safety factors
- Reliability updating based on inspection or test results
- Advanced numerical analysis
- Development of national guideline for probability based assessment of bridges
- Chloride-induced corrosion

Petrographic investigation of concrete

Corrosion rate measurement on reinforcement
Construction management and supervision

Site supervision
The experience of construction management and site supervision on behalf of the employer on a worldwide basis is accumulated in COWI including disciplines such as:

Preconstruction tasks
- Reviewing the detailed programme of the works, proposed by the contractor
- Technical project review
- Review of performance security, insurance policies, work and payment plans
- Review of the contractor’s quality, environmental, health and safety plan
- Review of the contractor’s method statements, work procedures and control plans
- Safety issues.

Tasks during construction
- Liaison with the designer in technical matters as appropriate
- Site instructions to the contractor including the preparation of further plans, drawings, designs and schedules
- Examination and approval of detailed drawings submitted by the contractor
- Arrangements for inspection and testing during manufacture and installation
- Supervision of acceptance tests on site
- Participation in site meetings and preparation of minutes
- Issue of progress reports to the employer
- Recording non-conformances
- Suspension of works as appropriate and at the instruction of the employer
- In the event of arbitration, if requested by the Employer, make available existing information in his possession, which the employer may require to present an effective legal action
- Taking over parts of the works.

Quantity surveying
- Receiving and assessing contractor’s schedule defining the percentage value of cost incurred against each item of the works
- Advising the employer on estimated cost implications of project modifications
- Valuing and processing variation orders to the contract
- Preparation of financial status reports
- Measurement of works performed.

Tasks at project completion
- Checking and providing the employer with as-built documentation
- Obtaining from the contractor records and operation manuals
- The contractor’s application for taking over
- Tests on completion as appropriate or specified in the contract documents
- Taking over certificate.

Tasks after project completion
- Reviewing statement on completion submitted by the contractor
- Completion of payment certificate
- Defects notification period and supervising making good defects
- Performance certificate.

Documentation
Upon completion of the construction works, the construction management and site supervision deliver comprehensive documentation of the content and quality of the project.
Noise barriers

Noise emission is a major environmental problem for many inhabitants close to major roads, highways and railways – primarily due to increasing traffic volumes, but also due to increasing congestion in urban areas.

The installation of noise barriers is one measure to reduce the noise, and COWI has vast experience with many different types of noise barriers.

Solid structures
Noise barriers can be shaped as different walls with very visible structural elements, and they reflect the noise or include noise absorbing materials. Barriers made of wood, aluminium and steel are common and can be shaped in many ways, but also masonry barriers are seen occasionally. Due to the solid appearance of these barriers they may have an intrusive visual character.

Transparent barriers
As opposed to the massive structures transparent barriers are increasingly used. These types have the advantage that the visual intrusion and shadow effects can be reduced significantly.
**Green walls**
Noise barriers can also be established using soil and brick work – sometimes supplemented by small concrete blocks, geotextile and steel mesh components to obtain a wall-like shape. Trees, bushes and/or sprawling plants can cover the barriers so that the noise barrier will fit better into the surroundings and be less visible.

**Services**
- Mapping of areas with noise
- Evaluation of noise barrier effects
- Minimising land acquisition
- Land-owner agreements
- Assistance with EIA approval
- Optimisation of barrier design
- Noise barrier design
- Tendering and contracting
- Supervision
- Operation and maintenance
Construction materials

**Fibre composites and stainless steel**

Herning pedestrian bridge pushed the limits of the state-of-the-art regarding the application of fibre-reinforced polymers. This project was the result of a research and development project initiated by the Danish Road Directorate.

The cable-stayed bridge has a central steel pylon and two 40 m side spans with a width of 4 m. All 16 cable-stays are made of carbon-fibre reinforced polymer (CFRP) cables, as are six non-bonded post-tensioning cables in the bridge deck.

The reinforcement in half of the bridge deck consists of CFRP bars and stirrups. The reinforcement in the other half of the bridge deck is a combination of stainless steel and carbon reinforcement steel.

The cross-section is over-reinforced and the compression zones are confined by means of stirrups. The result is a flexural failure governed by ductile concrete crushing due to the high ultimate compression strain of confined concrete.

**Stainless structural steel**

For the Stonecutters Bridge in Hong Kong the pylon tops have been designed with a stainless steel surface in order to minimise future maintenance on the outside of the pylons and also for aesthetic reasons. The repainting of ordinary carbon steel would involve extensive works above the bridge deck and it would be both costly, difficult and cause restrictions on traffic during repair works.

**Sustainable concrete**

A Danish research project called “Green Concrete” had the objective to create new knowledge about environmentally friendly types of concrete and to develop technological solutions aimed at promoting the use of this type of concrete. The project developed the following strategies:

- Cements that require less energy under production using e.g. 18% renewable fuels instead of coal
- Reduction in CO\textsuperscript{2} emissions by using large amounts of fly ash (> 20%)
- Bridge decks without surface protection (asphalt or waterproofing membrane)
- Selective use of stainless steel and carbon reinforcement to relax requirements to concrete

The strategies help to reduce the impact on the environment throughout the service life of construction.

The suggested strategies were tested in a motorway bridge (2002) built by the Danish Road Directorate. The bridge stands as tangible proof of the applicability of environmentally friendly concrete.
Wooden bridges meet the intention of using sustainable materials in bridge building.

Structural protection
The principle of structural protection has to be applied when chemicals cannot be applied to the wood for protection against rot, bacteria and fungi.

Critical elements, elements that are difficult to replace and severely exposed elements, are made of very durable woods such as eg. oak and azobé.

Less exposed elements can be made of more inexpensive wood types with a natural resistance against decay when exposed to the environment, eg. Douglas Pine and larch. Shielding elements may be made from thuja, which contains natural compounds making it resistant to rot and decay.

The structural detailing should, furthermore, be made to remove water from the structure and avoid soaking of the wooden structural elements.

Skjern River suspension bridge
The suspension bridge for pedestrians across the Skjern River in Denmark has a main span of 55 m extending from bank to bank and with towers 8 m high. The towers are made of solid oak wood, cross- beams in Douglas Pine and deck and railings in larch. Only the cables, clamps and fittings are made of steel.

The wooden elements will obtain a natural patina over time and combined with the elegant structural shape the bridge has become an “integrated” part of the flat landscape around the bridge site. The bridge was completed in 2003.

Remmevej wooden bridge
The bridge has an overall length of 54 m divided into a main span of 26 m and two side spans of 14 m each. The total width is 13 m and the bridge carries two traffic lanes and an eco-passage for the wildlife fauna in the region. The bridge is designed for full traffic load according to the Danish codes, i.e. Eurocode, and with an expected service life of 50 years.

The bridge is constructed of 4 longitudinal sections, each built up as multiple T-shaped laminated wooden beams with flanges constituting the deck. The deck is designed as a mega-plywood construction in order to compensate for the anisotropic properties of wood. Full length sections were delivered by special transport, and the low weight allowed a mobile crane to lift the elements to their final position.

The sections were prepared for a bolted connection reducing the assembly time to a mere 4 days, allowing the overlaying waterproofing and surfacing to be applied quickly onto the unprotected deck.

The edge beams of azobé (Lophira procera) came from environmentally sustainable forestry. The principle of structural protection has been used, and no chemicals have been applied to the wood.

The bridge across Remmevej was opened to traffic in 2001.
Skjern River suspension bridge, Denmark
Ravelins bridge, Denmark
Remmevej wooden bridge, Denmark

Photo: Christian Alsing
COWI acknowledges the increasing global consensus of the importance of fast interventions and innovative solutions within the Climate Change agenda and the expected demands of a low carbon economy.

We focus our business development towards being a leading consultant developing future Climate Change mitigation measures and adaption solutions in sectors and regions where we have a strong foothold.

COWI’s strategy on Climate Change communicates the ambition to encourage involvement, creativity and innovation of our organisation inviting our clients worldwide to co-operate with relevant members of our global company network.

COWI's 3E profile - engineering, environment and economics - provides a strong platform for multidisciplinary, balanced mitigation and cost effective adaptation solutions to Climate Change in many sectors.

COWI’s Climate Change agenda
COWI contributes actively to reduce and document our global climate effects for our activities in mitigation as well as adaptation:

• COWI will actively evaluate potentials for and contribute to optimal climate solutions in partnership with our clients
• COWI will reduce its in-house and on-project climate effects through carbon-conscious policies and potential carbon offsetting in respect of the efficiency needs of our clients and our organisation
• COWI will in partnership with our employees promote voluntary participation in our climate initiative and provide tools for improved individual climate behaviour.

COWI participated in the International Scientific Congress on Climate Change in Copenhagen, Denmark March 2009 planned by Copenhagen University and the International Alliance of Research Universities (IARU). In this connection COWI has published interviews, features, background and news items about the congress and its issues.