

CROSSING THE ØRESUND



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The Øresund Bridge in a regional perspective

The Øresund Bridge has created one physically connected region of 3.6 million people with interlinked transport systems for Skåne and Zealand, thus turning Copenhagen and Malmö into a new European metropolis. In turn, this opens up an era of opportunity for people and businesses in the new Øresund Region:

- Commuters between Sweden and Denmark benefit from faster and safer journeys as well as from a common housing and labour market. It is now easier than ever before to live on one side of Øresund while working on the other.
- The choice of leisure activities has exploded. World class cultural events, entertainment, sport and natural experiences are all available within 100 km of the Copenhagen/Malmö conurbation.
- Educational opportunities have expanded dramatically. The many universities and high schools in the region can accommodate 140,000 students, thus constituting one of Europe's largest "educational centres".
- Ever increasing partnerships between universities and high schools have transformed the Øresund Region into one of Europe's leading research centres. Particular scientific strengths lie within the fields the environment, biotechnology, pharmaceutical and medicinal research.
- The region's commercial sector benefits from Northern Europe's strongest domestic market. At the same time, new opportunities for marketing the Øresund Region internationally are constantly emerging. This enhances the Øresund-based companies' profile in export markets and attracts new businesses and jobs to the region.





The Øresund Region.

The Øresund Region comprises Zealand, Lolland – Falster and Bornholm in Denmark and Skåne in Sweden. The region’s two centres, Copenhagen on the Danish side and Malmö-Lund-Trelleborg on the Swedish side, both border Øresund.



ØRESUNDSBRO KONSORTIET

Ownership and operating organisation

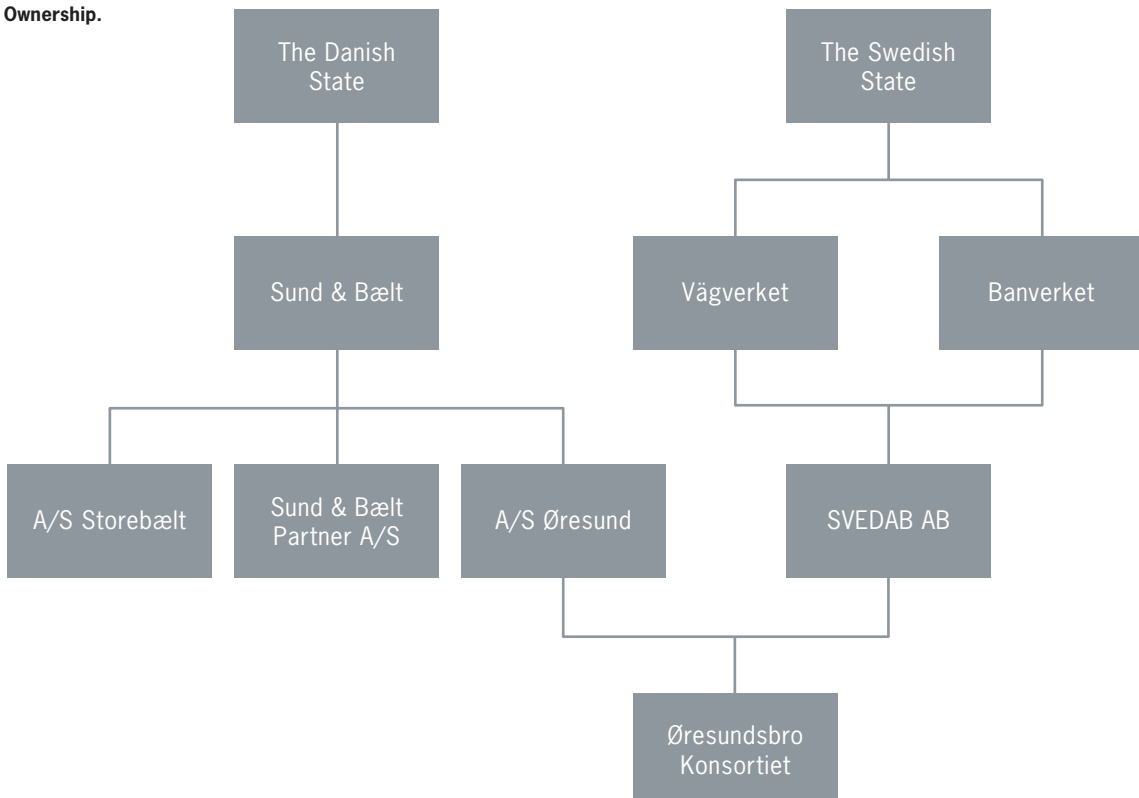
Øresundsbro Konsortiet is a Danish-Swedish company established on the basis of the agreement of March 23, 1991 between the Governments of Denmark and Sweden and ratified by the Danish Folketing and Sweden's Riksdag. Øresundsbro Konsortiet's objective is set out in more detail in the Inter-Government agreement. Its objectives are based on the principle that Øresundsbro Konsortiet is independently responsible for the ownership and operation of the Øresund Bridge.

Øresundsbro Konsortiet is jointly owned by the two companies, A/S Øresund and Svensk-Danska Broförbindelsen SVEDAB AB. The two companies are also responsible for the ownership and operations of the landworks on their respective sides of the Øresund

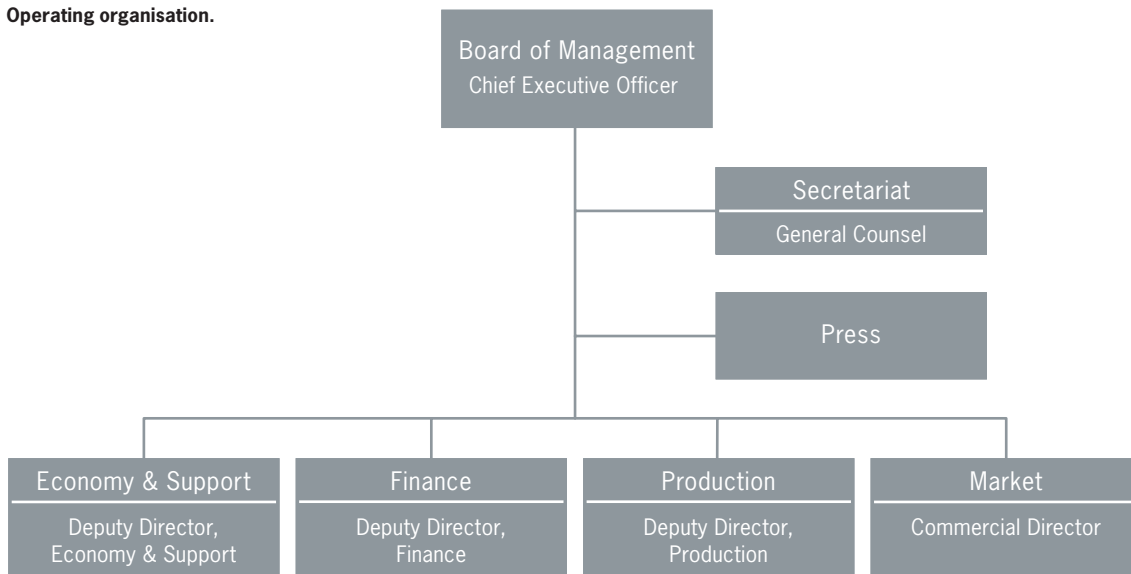
Bridge. The collaboration between the two companies as far as the Øresundsbro Konsortiet is concerned, is laid down in a consortium agreement approved by the two governments. A/S Øresund and Svensk-Danska Broförbindelsen SVEDAB AB are jointly and severally responsible for Øresundsbro Konsortiet's commitments.

Øresundsbro Konsortiet is charged with the commercial, traffic and technical management of the Øresund Bridge between Denmark and Sweden, including marketing, sales, customer and toll services, financial administration, road and rail operations, maintenance, development and administrative functions.

Ownership.



Operating organisation.



Øresundsbro Konsortiet owns, and is responsible for, the operation of the 16km long fixed link between Sweden and Denmark. Its task is to provide a fast, safe and reliable passage at competitive prices.

Øresundsbro Konsortiet manages the rail line while the rail operators are responsible for traffic along the track.

In accordance with the government agreement between Sweden and Denmark, Øresundsbro Konsortiet is empowered to levy fees on the Øresund Bridge's users. Furthermore the Danish National Railways Agency and the Swedish National Rail Administration pay a fixed fee for use of the link's railway section. The revenue from traffic is intended to cover operating costs and interest payments as well as the repayment of construction loans. This applies to both the fixed link and to the landworks on each side of Øresund.



Vision, mission and business concept

Vision

Our vision is to see the Øresund Region emerge as a new European powerhouse – in cultural as well as in economic terms.

Mission

Our mission is to build new bridges – commercially, culturally and psychologically – in the Øresund Region.

Business concept

As the independent owner and operator of the Øresund Bridge, our business concept is rooted in the desire to offer the best possible transport facility – with an equivalent standard of service.

To secure our long-term profitability, everything we do must be in the best interests of our customers. Consequently, we regard all individuals and businesses with transport requirements across Øresund as potential customers and we are committed to meeting the requirements of both private motorists and business customers.

The rail link, too, is an integral part of the Øresund Bridge and our task is to offer the most efficient framework for the rail operators' services.

We occupy a central position in the development of the Øresund Region and we wish to contribute further to the region's development and, thus, to the bridge's profitability.



From vision to reality

The vision of being able to cross Øresund regardless of weather conditions or the sometimes irregular ferry services is not new. For centuries the Strait of Øresund has constituted a barrier to the transportation of people and goods between Denmark and Sweden. Psychologically too, Øresund has also acted as a barrier – to the detriment of trade and personal contact.

With increased industrialisation and the internationalisation of Europe, however, the concept of a fixed link began to take shape. From the early 1900s, several proposals for a fixed link were put forward although a lack of funds and political will meant that the projects did not get beyond the drawing board.

Stable political and economic conditions in both Denmark and Sweden in the latter part of the 1900s, however, created a new basis for an Øresund fixed link. Among the factors were the Nordic countries' growing orientation towards Europe and the subsequent need to bring Scandinavia closer to the European continent.

The fact that the link was built between Copenhagen and Malmö – rather than between Elsinore and Helsingborg – was partly due to a wish to connect the two largest cities in the Øresund Region and partly because a bridge near Copenhagen Airport at Kastrup would benefit air travellers.



July 1, 2000. The Øresund Bridge opens.

History in brief

March 23, 1991

The Danish and Swedish governments sign an agreement for a fixed link across Øresund.

September 16, 1993

Work begins on the Danish landworks which comprise a 9 km motorway and an 18 km railway.

July 17, 1995

Øresundskonsortiet signs a contract with Øresund Tunnel Contractors for the immersed tunnel for the motorway and railway. Øresundskonsortiet signs a contract with Øresund Marine Joint Venture for dredging work and the construction of the artificial island.

August 1995

Work on the coast-coast link commences with dredging of the Øresund seabed.

November 27, 1995

Øresundskonsortiet signs a contract for the construction of the bridge with Sundlink Contractors.

April 1, 1997

The first of the two caissons for the pylons is towed to the bridge alignment from Malmö and immersed in a 17m deep trench in the seabed.

August 8, 1997

The first of the 20 tunnel elements is towed from the tunnel factory at Copenhagen North Harbour to Drogden and immersed in the tunnel trench.

September 27, 1997

The Øresund motorway to Copenhagen Airport opens to traffic.

September 27, 1998

The Øresund Line between Copenhagen Central Station and Copenhagen Airport opens. This completes the Danish landworks for the Øresund Fixed Link.

March 16, 1999

With the casting of the final metres of the tunnel, the first vehicle drives through the tunnel.

August 14, 1999

The final bridge span is placed in position. Denmark and Sweden are connected for the first time.

December 1, 1999

The final section of track between Malmö and Copenhagen is put in place.

June 9 – 12, 2000

The public has access to the Øresund Bridge for the first time. Several hundred thousand people cycle, run or walk across the link during an "Open Day" event.

June 17, 2000

Yttre Ringvägen (The Outer Ring Road) in Malmö and the Swedish landworks are inaugurated.

July 1, 2000

The Øresund Bridge opens.



The first tunnel element is towed from the factory at Copenhagen's North Harbour.



The final bridge span is placed in position.



The Danish Crown Prince and the Swedish Crown Princess meet on the bridge.

ØRESUNDSBRON

Architecture and design



From both sides of Øresund, the Øresund Bridge is a striking spectacle. The 204m high pylons with their harp-shaped stay cables are visible from Falsterbo in the south to Glumslöv in the north on the Swedish side and from Stevns in the south to Rungsted in the north on the Danish side.

By following a curve from Lernacken to Kastrup, the link unites the individual components – the immersed tunnel, the artificial island, the approach bridges and

the high bridge. The experience of crossing the Øresund Bridge is thus enhanced by the architectural impression of cohesion and simplicity with the high bridge as the towering symbol of the entire link.

The Øresund link's overall disposition and general design is rooted in respect for the environment and for simple, rational, Nordic building traditions. The main architect is Georg K.S. Rotne.

The bridge

The bridge consists of two approach bridges, constructed on piers and a high bridge over the Flintrännen navigation channel on the Swedish side. With its 490m long free span, the high bridge is the world's longest cable-stayed bridge for both road and railway.

The high bridge is a simple and strong truss bridge with stylistically consistent pylons. The cables are part of a pure, well-balanced pattern with identical angles towards the pylons and are positioned outside the bridge platform to protect them against collisions. The cables are parallel and symmetrical around the pylon towers which, therefore, receive an evenly distributed load. Under certain light and weather conditions the cables become invisible leaving the pylons as the most prominent part of the link.

The pylons stand out as four monumental towers whose dimensions reduce from sea level and upwards and thus enhance the sense of strength and stability. The inclination on the inner side of the pylons has been adjusted so that the individual tower does not appear to incline inwards.

All visible concrete components – pylon towers, bridge piers, the road, the railway and the bridge abutments are cast in the colour of warm grey. The truss structure carrying road and railway is painted black. All equipment is in galvanised steel. The cable stays are protected by black polyester tubes. At night, the bridge is marked out for shipping and aviation, the towers are floodlit and the road lighting looks like an illuminated pearl chain which delineates the bridge.



The island

The artificial island of Peberholm has been constructed from, sand, clay, stone and lime excavated from the Øresund seabed during the dredging of the channel for the tunnel and bridge piers. On Peberholm, the motorway and railway change course between the bridge, where they run on two levels, and the tunnel where the railway and motorway run parallel on one level.

The contours of the island, with its concave lines and rounded points, reflect several factors. For one, the island must not impede Øresund's water flow and for another, the island must be in harmony with the alignment of the motorway which crosses the island in a slight S-shape curve.

The coastal protection is made from rubble stone from the Swedish west coast and varies from light to dark grey. The biggest stones are placed in the southern, western and eastern sections, as protection against

heavy waves and ice pack. In the northern section towards Saltholm, the stones are considerably smaller.

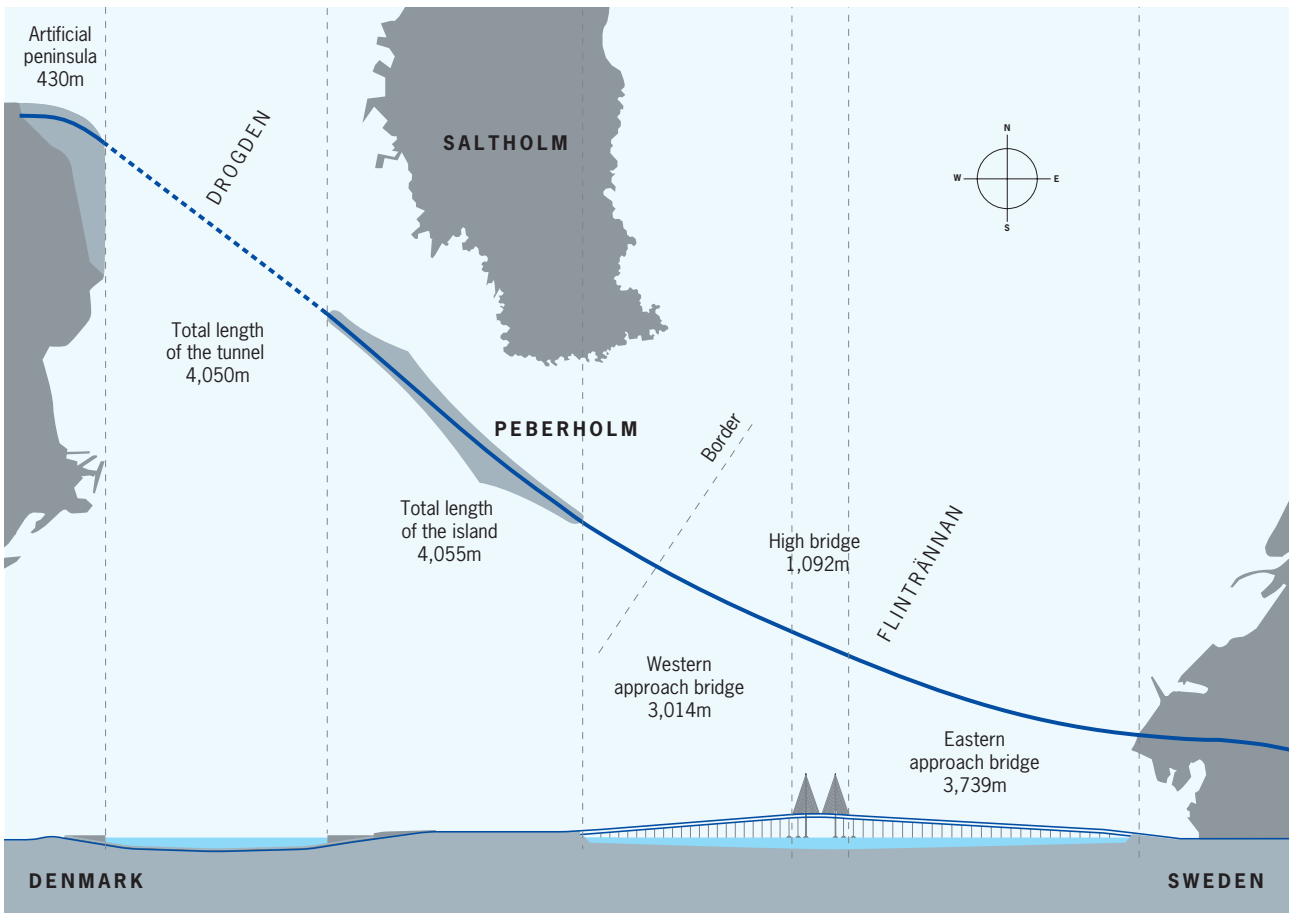
The tunnel

The Øresund Tunnel comprises of immersed tunnel elements beneath the Drogden channel on the Danish side.

Viewed from above, both tunnel entrances point towards each other and clearly mark the tunnel between them. The tunnel has white walls and lighting in two tiers in order to provide motorists with the best possible light conditions.

The entrances to the two motorway tubes have light filters in the roof to allow motorists to adjust to the artificial light in the tunnel. The entrances to the two rail tubes have airshafts in the roof to counter the compressed air effect caused by oncoming trains.





The fixed link across Øresund.

The tunnel

The Øresund Tunnel is 4,050m long and consists of a 3,510m immersed tunnel under Drogden and two portal buildings of 270m each. Together, these make up the western section of the fixed link between Denmark and Sweden. The tunnel was designed as an immersed tunnel with two rail tubes, two motorway tubes and a service and escape corridor. The tunnel was constructed from 20 elements, each measuring 176m x 38.8m x 8.6m and weighing 55,000 tons. This makes them the largest pre-fabricated tunnel elements in the world.

The tunnel elements were placed in a pre-dredged trench on the seabed and covered with a protective stone layer which allows for a free water depth of 10m in the 600m wide Drogden channel. The gradients on the motorway and railway are 2.5% and 1.56% respectively on the railway ramps and 1% in the tunnel.

The motorway tubes have two 3.5m wide lanes without a hard shoulder, but with a one metre wide emergency pavement on a level with the road's asphalt surface.

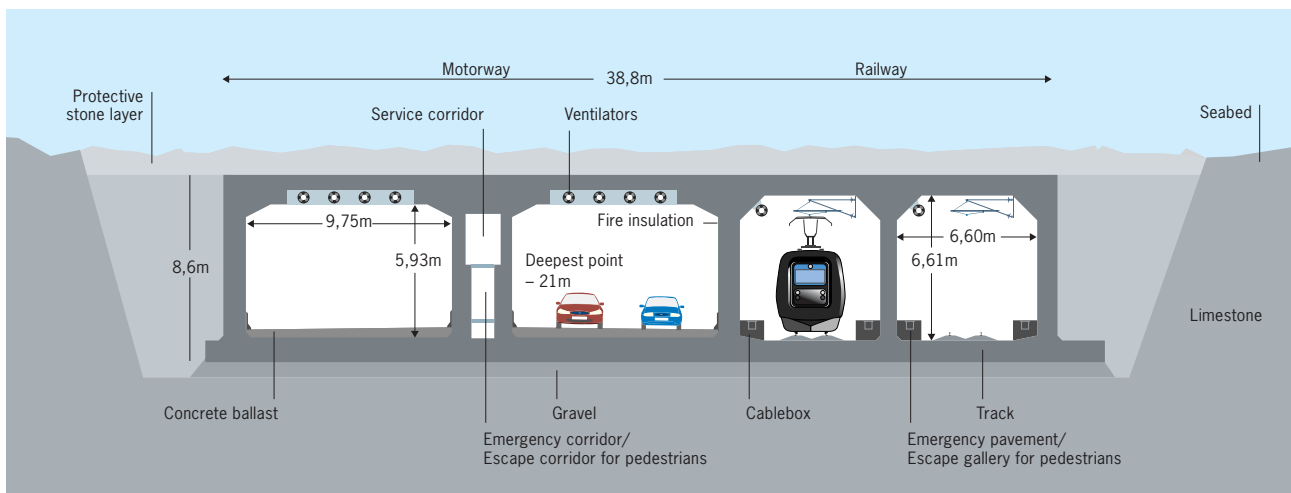
New Jersey safety barriers protect the lower part of the walls, which are clad with washable aluminium panels. Every 88m, there are 1.2m wide emergency doors from the road tunnels to the escape corridor.

The rail tubes have elevated emergency pavements on both sides and emergency doors every 88m. Rescue crews have access from the southern motorway tube to the northern rail tube every 88m.

All tube ceilings, and the top of the walls, are covered with fire insulation (Fendolite) designed to withstand a fire impact of 1,350°C for two hours.

Installations

The motorway tubes have longitudinal light bands on both sides with increased light strength near the tunnel entrances. The light bands can be regulated in accordance with the external level of light. Near the ramps, the motorway is covered by lamella which reduce the black hole effect. Inside the rail tunnels there are light ramps which can be switched on by



Cross section of the tunnel.

the Traffic Controller as required. In both the motorway and the rail tunnels, emergency lighting has been installed in case normal lighting fails.

At every emergency exit in the motorway tubes, panels have been installed, which contain fire valves with pressurised water linked to two 230m³ water reservoirs at the portal buildings. On the opposite wall, in the right lane, there are emergency panels with a fire alarm, an emergency telephone and a 6kg powder extinguisher.

Emergency telephones and fire alarm have also been installed in both rail tubes alongside the emergency doors between the two rail tunnel tubes. Each emergency door and emergency panel is marked by an illuminated sign.

An automatic water mist system has been installed in the technical area between the two motorway tunnels. There are also gas extinguishing systems in the technical room in the portal buildings at Peberholm and Kastrup and at the deepest point of the tunnel.

In the pump sumps in the portal buildings and at the motorway tunnel's deepest point, there are foam extinguisher systems.

Each motorway tube contains 80 ventilators in four groups. Each group comprises 20 ventilators in five rows with four ventilators in each row. In each rail tube, there are 20 ventilators in four groups with five in each group. The main function of the ventilation system is to eliminate smoke and heat in the event of fire and maintain clean air in the tunnel in all situations. Sensors for carbon monoxide, nitrogen dioxide and visibility have been installed at four locations in each motorway tube. The ventilation system is automatically controlled via the SCADA system or from the Traffic Centre at Lernacken.

The road tunnel has an advanced traffic control system which, via cameras installed at 60m intervals, allows the Traffic Centre at Lernacken to monitor the traffic flow and to automatically detect queues and stationary vehicles. Variable information signs allow for speed to be adjusted in the tunnel, for lanes to be blocked and for traffic to be directed to the other lane. At the two ramps, barriers can stop traffic entirely or reroute traffic to the other motorway tube.

There are no loudspeakers in the tunnel, but the Traffic Centre uses three FM channels to communicate with motorists. The radio frequencies, which motorists are advised to tune into during their passage through the tunnel, are indicated on signs before the tunnel.

Under normal circumstances, the maximum speed in the road tunnel is 90km/hour. HGVs are not allowed to overtake in the tunnel. The transport of hazardous freight is only permitted between the hours of 11 pm and 6 am and explosives can only be transported up to 1 ton per wagon or vehicle at a time.



Tunnelentrance on Peberholm.

The artificial island and peninsula

The artificial island of Peberholm is approx. 4 km long and connects the motorway and the tunnel on the Øresund Fixed Link. The name Peberholm is a play on words, salt and pepper, in that the natural neighbouring island towards the north bears the name of Saltholm. Peberholm comprises seabed material dredged from the Øresund seabed.

The island was created to enable traffic to change from the bridge, where rail and road traffic run on two levels, to the tunnel portal at the western end of the island where trains and vehicles drive into the Øresund tunnel side by side in separate tunnel tubes.

The 0.9 km² artificial peninsula at Kastrup, built for the tunnel portal, was also constructed from seabed material. The island and the peninsula are surrounded by a protective wall made from granite shipped from the Swedish west coast.

Peberholm is not only a traffic corridor. From a botanical point of view, the artificial island is a wilderness area where flora and fauna develop almost freely away from human contact.

For the past four years, Lund's Botanical Association has kept a regular inventory of the island's plant life.

So far, botanists have located more than 300 different species which have established themselves to a greater or lesser extent in the lime-filled and very dry soil. Some of these species are very rare in Denmark and/or Sweden, for example the *Sisymbrium supinum* and *Erucastrum gallicum*.

The growth of salix species and trees will also contribute to the overall vegetation on Peberholm over the next few years.

These species are most likely to have derived from seeds in the filling material used for the construction of Peberholm. Others may have been transported here on the clothing of staff, equipment or work units or by birds. Some plants are also dispersed by wind and water or by vehicles and trains running on the link.

Bird life on Peberholm is interesting too. The island is a popular nesting place for some rare and protected species such as tern and avocets. These colonies now cover a large area of the south western part of the island. The reason why these birds have adapted so well is difficult to say, but the area is undisturbed and the birds have chosen their nesting places as far from the traffic as possible.



The artificial island, Peberholm.



Bladder senna on Peberholm.



The artificial peninsula at Kastrop.

The bridge

The bridge between Peberholm and Lernacken, which forms the eastern section of the fixed link between Denmark and Sweden, is divided into three main sections: a 3,014m western approach bridge leading from the artificial island to the high bridge, a 1,092m long high bridge and a 3,739m eastern approach bridge between the high bridge and Lernacken on the Swedish coast. The bridge comprises a cable-stayed bridge with a main span of 490m, two side spans of 160m each and two approach bridges with 141m spans between the piers.

The 7,845m bridge is a combined rail and motorway bridge with a double track railway on the lower deck and a four-lane motorway with a hard shoulder on the upper deck. The bridge is the world's longest cable-stayed bridge for both road and rail traffic.

The cable-stayed bridge is a painted steel truss construction with an upper concrete deck. The steel truss was designed as closed box girder profiles equipped with internal dehumidification systems.

The main span is suspended in four 204m high concrete pylons, via double stay cables (80 in total), which have been designed as single-standing towers with a cross girder under the bridge girder.

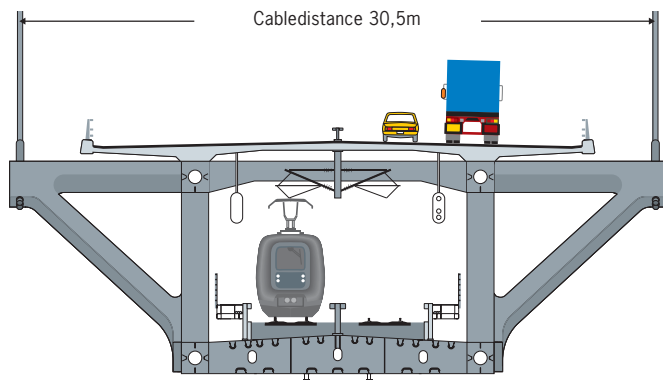
The cable stays comprise of seven, 5mm threads gathered in 68 – 73 strands secured to projecting anchor blocks. To avoid oscillations of the stay cables in high winds, oscillation dampers have been erected.

The majority of shipping passes over the Øresund Tunnel in Drogden, but many vessels also use the 370m wide Flintrännen channel. The pylons and the nearest piers around the pylons are, therefore, equipped with underwater protective islands to safeguard the bridge against collisions. Navigational clearance is 57m.

The bridge piers were cast on land and towed to the alignment as pre-fabricated elements while the pylons were cast in situ in climbing form. The pylons are equipped with staircases and a simple elevator for



Western approach bridge and high bridge.



Cross section of the high bridge.

access to the stay cable anchors, aviation warning lights etc.

Access from the upper to the lower bridge deck is via staircases installed at approx. 700m intervals. These staircases also function as escape routes from the emergency pavements along the railway on the lower deck.

Crash barriers on both sides on the bridge are of a quality that exceeds that of other bridges in Denmark and Sweden. The road surface consists of a 7cm thick asphalt layer.

Installations

Emergency phones are located at all emergency staircases at intervals of approx. 700m in both directions. 12m high pylons at 45m intervals have been installed at the motorway's centre strip on Peberholm and on the bridge. The fences along the escape routes on both sides of the bridge on the railway deck have emergency lighting.

Bridge piers and pylons are equipped with gas extinguishing units and distribution pipes for fire fighting have been installed on the lower deck.

On the bridge and on Peberholm, electronic information signs have been erected at 500m intervals to indicate permitted speeds and changes or closures to lanes due to operational or maintenance work, accidents etc.

On the bridge, electronic information signs have been installed at 1,500m intervals to provide information on weather and wind conditions.

Inspections of the many construction components take place from inspection platforms running on suspended tracks along the bridge.



Eastern approach bridge.



Inspection platform.

The railway

Øresundsbro Konsortiet's double track railway is directly linked to the Danish and Swedish rail networks at Kastrup and Lernacken. The rail line between Copenhagen Airport, Kastrup and Lernacken on the Swedish coast is managed by Øresundsbro Konsortiet. Rail operators can use the link providing they have a declaration of conformity for the Danish section and a rail concession for the Swedish section.

One railway – two systems

A system border has been established on the artificial island of Peberholm, which divides most of the Danish and Swedish rail systems – primarily the interlocking systems and the related ATC system. With regard to the interlocking systems, a special system has been devised for failsafe transfer of information between the Danish and Swedish systems. In connection with the passage of trains across the system border, a so-called mobile Danish/Swedish ATC system shift

component has been developed, which automatically switches the monitoring of trains between the standard Danish mobile ATC system and the standard Swedish mobile ATC system and vice versa.

Track system

The track system totals approx. 34 track kilometres. There are eight points on the Øresundsbro Konsortiet's rail section, of which four are located at Peberholm. These allow for services to and from the main tracks in both directions. The remaining four points are located at Copenhagen Airport Kastrup station at the western tunnel entrance. The track system on the bridge and on Peberholm is a standard system with conventional ballasting. The track in the Øresund tunnel is a so-called Slab-track construction with the rails secured directly in the tunnel construction. The bridge's 14 expansion joints can each absorb the bridge's longitudinal changes of +/- 600mm.



The rail line between Copenhagen and Malmö.

All tracks on the Øresund link's coast-coast section have been constructed for speeds of up to 200 km/hour.

Catenary system

The catenary system is a combined Danish, Swedish and German system. The electrified system is the Danish 25kV/50 Hz system while the mechanical suspension system has been implemented in accordance with German/Swedish standards. The catenary system is supplied from feeder stations in either Kastrup or Lernacken so that one and only one feeder station is in operation at any given time. A neutral section has been established at Lernacken which separates the catenary system on the Øresund line and the Swedish system which uses 15 kV/16 $\frac{2}{3}$ Hz. The catenary system is dimensioned for 250 km/hour with the use of one collector shoe gear and 200 km/hour with the use of up to three collector shoe gears.

Interlocking system

Øresundsbro Konsortiet's railway operates two interlocking systems, one for the Danish section and one for the Swedish section. On the Danish side, i.e. up to the system border at Peberholm's western station border, one interlocking system of type DSB 1990b has been positioned at Copenhagen Airport Kastrup station. Both the station and the line are equipped with the Danish ATC system (ZUB-123) and in direct link with the system border at Peberholm, also with the Swedish ATC system (EBICAB 700). This allows for a smooth transition between the two ATC systems at the system border at the western end of Peberholm. Train detection takes place by normal track isolation in accordance with normal Danish principles, which are detected directly in the interlocking system via a track relay.



The system border which switches automatically between Danish and Swedish interlocking and ATC systems.

From the system transition at Peberholm's western station border and up to Lernacken, a Swedish standard interlocking system of the STLV85 type is in operation.

The interlocking system is owned by Øresundsbro Konsortiet, but is physically located at SVEDAB's interlocking system at Svågertorp station, which is also of the type STLV85. The train control system has been installed in accordance with the guidelines for fixed Swedish ATC systems. The train detection on the Swedish system is through track isolation, which is normal for Sweden.

Remote control and monitoring

Daily traffic management is handled by Banedanmark (Rail Net Denmark) and Banverket (the Swedish National Rail Administration) which are responsible to Øresundsbro Konsortiet.

Operation of the Danish interlocking system is normally handled via the remote control centre at Copenhagen Central Station (RFC). Operation of the Swedish system is handled via remote control from the Train Traffic Management in Malmö (DLC). Traffic management in Sweden and Denmark is, therefore, undertaken by two different remote control systems which do not directly communicate with each other.

The catenary systems remote control function is, like the remote control system for the interlocking system, divided into a Swedish and a Danish control area with the same system border at Peberholm (as for most other rail engineering systems). From Copenhagen Airport Kastrup station to the system border at Peberholm, the catenary system is controlled in the usual Danish way from the remote control centre of power supply in Copenhagen (KC). From Peberholm station to Lernacken station, the catenary system is controlled in the normal Swedish way from the DLC in Malmö.

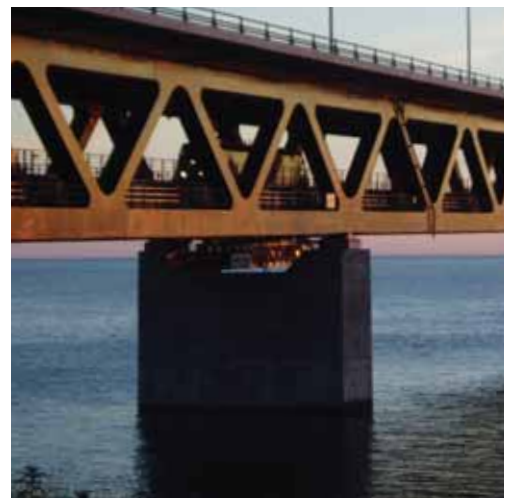


Train coming out of the Øresund Tunnel.

To minimise the risk of trains breaking down on the Øresund Bridge's railway, a detector system has been established on both the Danish and Swedish sides. The system comprises the control of hot wheels and bearings, derailed trains and, exclusively on the Danish side, control of loading gauge (profile control).

Radio system

On both the Danish and Swedish sections, trains must be equipped with train radio. The train radios are used for all traffic safety-related communication between engine drivers and RFC and DLC. Two train radio systems have been installed on the Øresund rail line; a traditional Danish train radio, MSR-3 and the standardised European GSM-R train radio system.



Train on the rail deck.



Lower deck of the bridge carrying the trains.

Toll station



The toll station at Lernacken.

The Øresund Bridge toll station is located at Lernacken outside Malmö in Sweden. The toll station is part of the Link Operation Centre which, besides administrative offices, houses the Øresund Bridge's traffic monitoring centre. The Operation Centre is responsible for the manning of the toll station and surveillance of road traffic and technical systems.

Plaza

The two-lane motorway ends at the toll station's plaza. The toll station has eleven lanes in each direction. Variable information signs above the toll booths show the status of each lane, i.e. BroBizz, automat or manned.

The lanes are manned according to the traffic volume and have a capacity for approx. 200 cars per hour. The manned lanes serve all vehicle types and accept most types of payment. At least one lane is manned 24 hours a day in each direction.

Each lane is separated by so-called quadguards which protect staff and technical installations against collisions. The quadguards are designed to withstand collisions involving even large lorries.

Toll booths

The booths are designed to give staff the best working environment under all weather conditions. The booths are linked to the air-conditioning system which, in addition to temperature regulation, also ensure a constant over pressure in the booths. This means that car exhaust fumes cannot penetrate the booths.

Moreover, the booths are equipped with a post tube conveyor for dispatching change or documentation between the Traffic Centre and the individual booth. The post tube conveyor enables staff to send cash directly to the safe in the administration building.

Each booth is externally equipped with a card automat which the customer can use for payment with a petrol/credit card. The card automat has two levels to accommodate cars, lorries and coaches. Besides the card reader, the automat is equipped with a receipt printer, information display, a service call button and a communication system. The card reader can read both magnetic strips and chip cards.

The classification system

Vehicle classification depends on the length of the vehicle. This is measured by a special measure system which the vehicle passes through. The appropriate toll fee is then determined. Each lane is equipped with two cameras – one which photographs the vehicle from the front to record the registration number and one from above that registers the length of the vehicle. The images are electronic and are used in cases where payment is disputed. At the entry to the lanes, an entry barrier and a light red/green signal, which indicates whether a lane is open or closed, has been installed. In each lane, an exit barrier and a display which provides the customer with information about the vehicle's category and price and whether the payment has been approved has also been installed.



Toll booths.

TECHNOLOGY AND OPERATION

Technical supervision



Traffic Centre at Lernacken.

A number of transverse technical installations on the Øresund Bridge ensure continual supervision, control and regulation of both motorway and rail traffic. Most of these installations are not visible to customers. The installations help to make the journey across the Øresund link safe and comfortable.



SCADA screens.

Traffic and traffic-related weather, physical and technical conditions are monitored round-the-clock from the Traffic Centre at Lernacken through a SCADA system with sub-stations and an internal TV system (CCTV) with monitors.

SCADA

SCADA (Supervisory Control And Data Acquisition) is the brain of the electronic control and supervision system. With SCADA, the traffic controller can control and manage the link, except for the rail traffic, which is controlled and supervised by the regional remote control centres in Denmark and Sweden. In addition to the main SCADA system, there are 25 sub-stations, PES, which act as an interface to the facility's technical systems. The sub-stations gather data from the technical systems and send commands from the operator back to the technical systems. The system handles a total of 18,000 signals.

To enable operators to communicate with the system, three work stations have been established. Together with the two main stations, these work stations are located at the Traffic Centre at Lernacken, at the

Copenhagen Police's Radio Services (HS) and at Tårnby Police.

From the work stations, the operator can control and manage the technical installations and the traffic control systems. Operators can, for instance, activate the ventilators, switch on lighting in the rail tunnel, control traffic signals etc.

CCTV

Road traffic in the Øresund tunnel, on Peberholm, on the bridge and at the toll station is monitored by an internal CCTV (Closed Circuit TeleVision) system as well as other systems. On the bridge, on the island and in the tunnel, detector systems have been built into the cameras to register queues and vehicles which drive in the wrong direction, i.e. against the traffic.

All cameras send images to the Traffic Centre at Lernacken from where the images are distributed to the individual monitoring centres in Denmark and Sweden. There is no CCTV system on the rail line.



CCTV monitors.

Communication and alarm systems

Radio

Aerial systems have been installed for Danish and Swedish train radio and entirely or partially for the emergency services' radios. The radio system is designed with full redundancy. Drivers use the cab-shore radio for communication with the remote control centres.

Site of damage radio is primarily used by the Danish police and Danish emergency services, although the site of damage radio is used on the coast to coast link for communication between the Danish and Swedish units in connection with accidents.

Dark Fibre Link

As part of the Øresund Bridge's redundant communications system, four optical fibre cables have been installed. Each cable contains 96 fibre pairs. Ten fibre pairs are used for the link's own communication requirements while the rest are leased to tele-operators.

COMBAS Ø

A computer-based alarm system for the Øresund Fixed Link (COMBAS Ø) has been installed to ensure

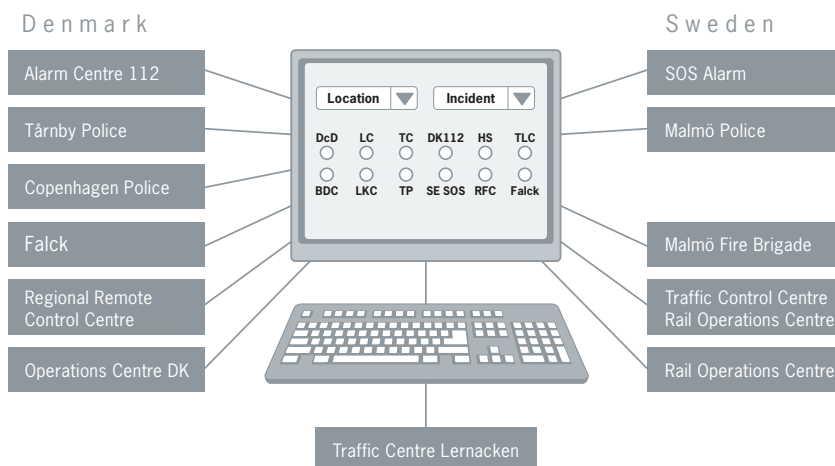
efficient and rapid alarms to relevant parties and immediately accessible action plans. Information on the location of the accident, type of accident and make of vehicle is entered into the system and immediately passed to the emergency services.

Detectors

Automatic fire alarm systems (ABA) have been installed in technical rooms in the portal buildings, the tunnel's service corridor and in the technical hut at Peberholm as well as at bridge piers, pylons and bridge abutments. The ABAs transmit signals to the Alarm Centre 112 in Copenhagen west of the alarm border and to SOS Alarm in Malmö east of the alarm border and to the Traffic Centre at Lernacken.

Power supply

Power is supplied from either Sweden or Denmark with a high degree of supply reliability. For emergency power supply to installations whose functions must not be interrupted even momentarily, a UPS system has been installed. The emergency power supply will take over immediately if the normal power supply fails until rerouting to other normal power supply takes place.



COMBAS Ø Alarm System.

Operation and maintenance

To meet customers' requirements for accessibility and safety, the Øresund Bridge carries out extensive preventive and remedial maintenance, which comprises a wide range of measures from inspections and lubrication to replacement of worn out parts.

The operation and maintenance of the Øresund Bridge's traffic system is carried out by the Production Unit's three line functions:

Road operations

The Traffic Centre at Lernacken is responsible for the operation of the toll station, round-the-clock monitoring of the motorway traffic, alarms from the technical systems and for control of access to the Øresund Bridge's facility.

Facilities

The Facilities Department is responsible for service and maintenance of all technical facilities with the exception of those relating to the railway. The Facilities Department's service group handles the 24 hour technical monitoring in co-operation with the Traffic Centre and assisted by service contractors.

Railway

The Railway Department is responsible for operation and maintenance of the Øresund Bridge's railway, including the safety planning of maintenance activities near the railway in operation.

For each system, an individual with responsibility for the system has been appointed to ensure the optimum function of the system.



Maintenance of the facilities is either preventive or remedial. Preventive maintenance focuses on elements that are crucial for the customers' safety or for the facility's functionality and lifetime. Many of the systems are doubled to prevent faults from impacting on operations.

For safety critical facilities, minimum functionality requirements are in place. If these minimum requirements cannot be complied with on a temporary basis, traffic restrictions and immediate remedial measures come into force.

To deal with sudden faults, which may impact on the safe flow of traffic, staff in the service group are part of a duty rota which is in force every day, 24 hours a day. If there is a need for further skills, specialists will be called in by the service group. In addition, Banedanmark

(Rail Net Denmark) and Banverket (Swedish National Rail Administration) operate a contingency system for the railway.

With faults and errors that do not impact on traffic or affect secondary systems and functions, remedial action will be taken at a later stage.

Work on, or near, the motorway and railway requires detailed planning, also to minimize inconvenience to motorists and train passengers. Planning and coordination of all activities proceed within a maintenance system which generates work sheets for the service group and service contractors. The maintenance system is also used for recording work completed, the causes of faults, time consumption and reports. This is an important element in optimising the workload.



The safety of travellers is crucial, but the safety of staff and service contractors is also important. To live up to the high targets for the working environment, it is vital to train everyone working on the link in all aspects of safety and to ensure that all relevant closures are enforced wherever work is being undertaken near passing traffic.

Working procedures are described in the maintenance manuals and in the Øresund Bridge's quality system, OPUS, which sets out the correct procedures for the provision of information and reporting as well as for the individuals responsible. OPUS also comprises descriptions of when and how barriers should be erected near traffic. Closures on the road link must generally only take place during periods of little traffic and, with regard to the tunnel, mainly at night.



Tunnel maintenance.



Maintenance of the rail track on the bridge.

SAFETY AND ENVIRONMENT

Safety and contingency measures

A huge effort has gone into making the journey across the Øresund link as safe as possible for travellers. Many of the link's safety measures, combined with the Traffic Centre, aim at preventing accidents. For instance, CCTV cameras along the entire road link trigger an alarm should a vehicle stop in the tunnel.

To prevent accidents, there are speed limits in the tunnel and overtaking by HGVs is prohibited. The majority of maintenance work, which causes partial closing of the carriageway, takes place when traffic intensity is low. All road closures are carried out by the Øresund Bridge's own contractor to ensure that the desired closures takes place prior to the work in question.

Like other roads, the Øresund Bridge can become icy during winter. However, warning systems make it possible to warn motorists and to start treating slippery surfaces in good time. Information from the automatic

weather stations also provides warnings about reduced visibility, slippery surfaces and strong winds.

It is important to ensure that a breakdown in the tunnel does not lead to an accident involving other vehicles. Through CCTV cameras, variable speed limit signs, warning signs and lane closures indicated by a red cross and a stop barrier, the traffic controllers at the Traffic Centre can redirect or stop traffic and call for assistance.

Extensive co-operation between the Danish and Swedish emergency services before and after the opening of the Øresund Bridge has resulted in a joint Swedish/Danish contingency plan for the Øresund Bridge. In the event of a serious accident, emergency crews from both countries will arrive at the scene in the minimum of time. In such situations, the Øresund Bridge will be closed to traffic. In respect of minor incidents, the Danish and Swedish emergency crews will cover their respective territories.



Variable signs:



Maximum speed



Change lane



Closed lane

The environment

The Øresund Bridge's general objective is to provide an efficient, safe and accessible traffic facility with minimum impact on the environment. The Øresund Bridge continually monitors and controls environmental impact to ensure compliance with all relevant requirements and conditions in Denmark and Sweden and minimise environmental impact. In 2003, an environmental management system based on the ISO 14001 standard was introduced.

The environmental management system is primarily aimed at the company's operation and maintenance activities. The main objective is to control and minimise environmental impact. Consequently, specific annual environmental targets are set for major environmental impact such as the use of resources (energy, water and consumption materials) and production of waste. Accidents are also recorded.

Targets for other factors that do not directly affect Øresundsbro Konsortiet's own activities may be defined if it is deemed that a viable and active effort will improve the environment. In the spring of 2003, for instance, Øresundsbro Konsortiet erected falcon boxes for peregrine falcons on four bridge piers. The peregrine falcon is regularly observed on the link and the hope is that these birds will begin to breed in the area. In the spring 2004, perches for birds of prey were erected along Peberholm's northern coast.

An annual, public environmental review follows up on the prescribed environmental targets.

Øresundsbro Konsortiet's environmental requirements must be complied with by all suppliers and contractors on the link. The environmental requirements are studied at Øresundsbro Konsortiet's safety courses that everyone working on the link must have passed.



As the Øresund Bridge is located in an environmentally vulnerable environment, Øresundsbro Konsortiet continues to examine the effects of the link and its usage on the surrounding environment.

Rain water from the bridge is continually analysed for a range of tramp material. Air emissions from train and vehicle traffic are assessed annually as is noise at the bridge abutment at Lernacken.

In 2004, a series of investigations into the link's impact on fish will be completed. In 2004 and 2005, investigations into the re-establishment of bottom fauna and flora around the bridge piers and the previously dredged seabed areas along the link will also be undertaken. The results show a density of up to

40,000 common mussels per square metre at the bridge piers. The common mussels provide feed for fish and birds and filtrate the water for algae and thus counteract deoxygenation and contribute to clearer water. In this way, the mussels function much like a purification plant.

Each year, inventories of Peberholm's flora and fauna are taken. Peberholm has no planting or sowing, in order to stimulate the development of a rich and varied flora and fauna.



FACTS AND FIGURES

Tunnel

Total length	4,050m
Immersed tunnel	3,510m
Kastrup portal building	270m
Peberholm portal building	270m
Deepest point below sea level	-21m

Tunnel elements

Number of elements	20
Number of sections per element	8
Length of sections	22m
Length of element	176m
Width	38.8m
Height	8.6m
Weight per element	55,000 tons

Peberholm

Length	4,055m
Width	500m
Area	1.3km ²
Material: 1.6 million tons stone and 6 million m ³ sand and bottom material	

Artificial peninsula at Kastrup

Length	430 meter ud i havet
Area	0.9km ²
Material: broken stone, granite, ramp of moraine clay	

Bridges

Total length	7,845m
Western approach bridge	3,014m
High bridge	1,092m
Eastern approach bridge	3,739m
Pylon height	204m
Main span	490m
Navigational clearance	57m

Stay cables

Cable-stayed arrangement with cables anchored at 20m intervals	
The cables are anchored in the pylons at approx. 12m intervals	
Cable stayed arrangement = 2 x 80 cables	
Each cable comprises 68 – 73 “strands”	
A strand comprises 7 wires which each have a diameter of 5mm	
Total weight of the cables	2,150 tons

Railway

Maximum speed	200 km/hour
Track kilometres	34
Points	8
Expansion joints	14
Signals	38
ATC- balises	160
Danish electrified system	25 kV/50 Hz
Swedish electrified system	15 kV/16 ² / ₃ Hz

Dark Fibre Links

Fibre optics cables	4
One cable = 96 fibre pairs	

Safety

Emergency phones:	
Motorway tunnel	1 pr. 88 meter
Bridge	At all emergency stairs approx. every 700 metres
Ventilators:	
Motorway tube	80
Rail tube	20

Toll station

Lanes	11 in each direction
Capacity	200 cars per hour
Toll booths	10 in each direction

See you again on the Øresund Bridge!



www.oeresundsbron.com



Øresundsbro Konsortiet · Vester Søgade 10 · DK-1601 Copenhagen V · Denmark · Tel. +45 33 41 60 00 · Fax +45 33 41 61 02
Øresundsbro Konsortiet · Kalkbrottsgatan 141 · Box 4278 · SE-203 14 Malmö · Sweden · Tel. +46 (0) 40 676 60 00 · Fax +46 (0) 40 676 65 80
info@oeresundsbron.com · www.oeresundsbron.com