

## **The preferred technical solution for the EIA process – the recommendation of Femern A/S**

### **1. Introduction**

Femern A/S has conducted comprehensive preparation work in regard to both preparing detailed conceptual designs for an immersed tunnel and a cable-stayed bridge and in regard to conducting an extensive investigation programme covering environmental, geotechnical and navigation factors, etc.

All investigations have not been finally concluded, but the work is now so advanced that it is possible to present a recommendation to which technical solution, according to the company's opinion, should be the basis for the authority processing.

This brief summarises the company's assessment of the most important factual conditions influencing the choice of technical solution. In-depth background notes on the individual points have been prepared, which are forwarded as appendices to the recommendation.

It must be emphasised that the recommendation remains provisional pending the Environmental Impact Assessment (EIA). Thus, this only concerns a recommendation of which solution should underlie the authority processing. The final decision on which solution is to be built will be made pursuant to a specially enacted construction act in Denmark and subject to approval by the German authorities. Reference is made to the brief on authority processing, see appendix 1, for a review of the approval process in Germany and Denmark.

### **2. Environment**

One of the key parameters for the choice of technical solution is the environmental impact of the projects.

As is apparent from the brief on environmental factors, see appendix 2, both a cable-stayed bridge and an immersed tunnel will involve environmental impacts in the Fehmarnbelt. The preliminary conclusion is that a bridge would have slightly more significant permanent environmental impacts than an immersed tunnel. However, the environmental impacts of a bridge are such in nature that a bridge would not be precluded as the solution from a purely *environmental* perspective.

On the other hand, the difference in environmental impact between the two solutions might preclude a bridge owing to the requirements of environmental legislation. This is because a number of the environmental impacts of a fixed link would affect Natura 2000 areas and in such instances EU legislation prescribes that the least intrusive solution must be selected, which based on the conducted environment screening in this instance, would be an immersed tunnel.

This does not mean that approval of a bridge project can be excluded, but it would involve a greater risk of appeal cases and a higher risk that the appeal cases will have a negative outcome in comparison to a tunnel project.

### **3. Navigational safety**

The Fehmarnbelt is a heavily trafficked stretch of water with 47,000 vessel transits per annum (2006), including many tank vessels. At the same time, the expectation is that shipping traffic will increase significantly up to 2030 (approx. 90,000 vessel transits).

In the interests of navigational safety, a tunnel clearly poses fewer risks than a bridge.

However, risk analyses show that navigational safety (i.e. safety seen from the vessels' perspective) will be improved if the bridge is designed with two navigational spans of at least 724 m each and with the introduction of a Vessel Traffic Service (VTS) system covering a range from the south end of the Great Belt to the Cadet Channel compared to a situation with no bridge and continued ferry crossings.

The collision risk assessed by the bridge consultant shows that a collision with the bridge construction will occur about every third year. Only in rare cases will the bridge be damaged, which would mean a disruption to traffic or give rise to significant repair costs.

The probability of vessel collisions against the bridge leading to a long-term (three-month) disruption is however slight, being once every 500 years.

A bridge will always entail a risk that collisions between vessels and the bridge could cause an environmental accident, e.g. in the form of an oil spill, toxic spill, etc. The risk of this is, however, assessed as being relatively small and at the same level as the current risk of vessel-vessel collisions, running aground, etc.

As is apparent from the brief on navigational safety, see appendix 3, based on a utility view the company concludes that in the event of selection of a cable-stayed bridge, the basis should be in a bridge with two passage spans of 724 m each.

The maritime authorities have not yet made a decision on the results of the risk analyses, navigation simulations, etc.

#### **4. Safety and emergency preparedness**

It is crucial that a future Fehmarnbelt Fixed Link lives up to a high safety level and that effective emergency preparedness is in place should an accident happen.

The two existing projects live up to the requirement for a high safety level, given that both the tunnel and bridge solutions have a higher safety level (measured by the risk of fatalities) than standard motorway or railway systems.

Safety and emergency preparedness is explained in detail in the briefs, safety in the Fehmarnbelt tunnel, see appendix 4, and safety for the Fehmarnbelt bridge, see appendix 5.

#### **5. Technical risks**

The company's technical assessment is that a cable-stayed bridge with two passage spans of 724 m each would present a greater technical challenge than an immersed tunnel.

A bridge solution would entail the two largest spans ever built on a cable-stayed bridge for both road and rail traffic and they would both be more than 200 m longer than the span on the Øresund Bridge. Equally, construction would take place in a channel where the weather conditions are often harsh and where the vessel intensity is high. Not insignificant risks are estimated for the construction phase, for cost overruns, delays and occupational injuries.

An immersed tunnel would also present a technical challenge because of, among other things, the often harsh weather conditions and the high vessel intensity in the Fehmarnbelt. An immersed tunnel, however, does not involve similar technical "breakthrough" activities since it fundamentally concerns executing the same operation as with the construction of the Øresund link's immersed tunnel (the Drogden tunnel), just many more times and in somewhat deeper water (up to 30 m). Thus, the increased length will not mean an increase of risks to the same degree as is the case with an increase of the bridge span. For a review of the project's technical risks, see the brief on technical risks, appendix 6.

#### **6. Time schedule**

The company's technical consultants conclude that the two projects could be built in approx. 5½ years (bridge) and 6 years (tunnel). However, the company's opinion is that the consultants' conclusion is based on overly optimistic assumptions concerning mobilisation periods, establishment of production sites, authority approvals, weather conditions, etc., which is why it has been established in the construction estimates that a bridge would take 6 years to build, while an immersed tunnel would take 6½ years. Since both time schedules are still regarded as being tight, the longest construction time of 6½ years has been included in the submitted, revised time schedule for the Fehmarnbelt project coast-to-coast, see appendix 7.

## **7. Financial factors**

Assessment of the overall finances of the two projects must necessarily include both the overall construction costs, construction time as well as operation and maintenance costs.

As is apparent from the consolidated construction estimate for the two projects, see appendix 8, a bridge project is estimated to cost 5.2 billion EUR in total, while the tunnel project's overall construction estimate amounts to 5.1 billion EUR.

The operation and maintenance costs for the two projects are calculated on the basis of experience from Øresund. The estimates, which are naturally subject to some uncertainty, show that the costs are somewhat higher for a tunnel than for a bridge.

When the above construction estimate and operation and maintenance costs estimate are taken into account, and on the assumption that the total construction time for the two projects will be 6 years (bridge) and 6½ years (tunnel) respectively, the repayment time for the two projects will be essentially the same, all told.

With conservative assumptions of TEN support and real interest rate, the coast-to-coast link and the Danish land-based facility will be repaid after 36 years for a tunnel and 34 years for a bridge.

This means that, from an overall financial perspective, there is no difference between bridge and tunnel.

## **8. Conclusion**

Based on the above review of the most significant expert criteria for the selection of technical solution, the company concludes that overall, an immersed tunnel would entail the

least risks in the construction phase and in the operating phase. In this connection, special importance has been attached to the two projects' technical, execution risks and consequences for navigational safety as well as the higher risk that a bridge would run into environmental legal problems.

The recommendation was approved by Femern A/S' board at the board meeting held on 23 November 2010.