

## **Construction estimate for a cable-stayed bridge – comparison with the Planning Act**

### **1. Introduction**

The remarks to the Planning Act of April 2009 estimated a cable-stayed bridge to cost EUR 4.4 billion<sup>1</sup>. This was based on a feasibility study prepared by Cowi-Lahmeyer and published by the Danish and German Ministries of Transport in 1999.

The current construction estimate for a cable-stayed bridge is based on a new conceptual design prepared by Cowi-Obermeyer. The new conceptual design has a higher construction estimate since the cost of a bridge solution is now expected to be EUR 5.2 billion. The estimate comprises the costs of the planning phase amounting to EUR 252.5 million which has been granted pursuant to the Planning Act and the supporting appropriation document (aktstykke) of 3 June, 2010. It should be noted that the current construction proposal was prepared prior to the Environmental Impact Assessment.

This document analyses the key reasons for the difference between the two construction estimates<sup>2</sup>.

First, it is important to point out that there is a significant difference between the two bridge projects even if, superficially, there are many similarities.

With regard to the preparations for the current conceptual design, Femern A/S' bridge consultant, Cowi-Obermeyer, has embarked on the design of an entirely new bridge solution inspired by the feasibility study's conceptual design. This is to ensure that the bridge solution will offer the best technical solution based on current construction and civil engineering know-how.

This document, therefore, exclusively focuses on the main differences between the two bridge projects. It does not provide a full overview of all the differences between the two projects. For an overview of some of the major technical differences between the two projects, please refer to the appendix.

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<sup>1</sup>The following is also included in the remarks: "The construction estimates were drawn up prior to the Environmental Impact Assessment. Determining construction estimates for projects of this size carries, of course, some uncertainty. The estimate for a fixed link is based on experiences from the construction of the Storebælt and Øresund fixed links. Experience also shows that the market trends within the building and construction industry can have an impact on costs when it comes to an infrastructure project of this size."

<sup>2</sup>This document is a supplement to the consolidated construction estimate. For a complete explanation of the component elements in the construction estimate, please refer to this note.

Table 1: Construction estimate

<b>2008 prices</b>	<b>Construction estimate 2010*</b>	<b>Planning Act<sup>3</sup></b>	<b>Difference</b>
Construction costs	EUR 3.5 billion	EUR 3.3 billion	EUR 0.2 billion
Other works	EUR 0.2 billion	EUR 0.03 billion	EUR 0.2 billion
Project management, operational preparations etc. .	EUR 0.7 billion	EUR 0.5 billion	EUR 0.2 billion
Reserves	EUR 0.7 billion	EUR 0.6 billion	EUR 0.1 billion
<b>Total gross costs**</b>	<b>EUR 5.2 billion</b>	<b>EUR 4.4 billion</b>	<b>EUR 0.8 billion</b>
Expected EU subsidy	EUR 0.6 - 1.1 billion	EUR 0.5 billion	EUR 0.1 – 0.6 billion
<b>Total net costs**</b>	<b>EUR 4.0 – 4.6 billion</b>	<b>EUR 3.9 billion</b>	<b>EUR 0.2 – 0.7 billion</b>

\* The construction estimate comprises the EUR 252.5 million which has already been granted in accordance with the Planning Act and the supporting appropriation document of 3 June, 2010.

\*\* The total can differ from the individual items after rounding up

## 2. Construction costs

It is estimated that the construction costs of a bridge project will amount to EUR 3.5 billion, which is EUR 0.2 billion more than the assumption in the Planning Act. The increase can be divided into three elements c.f. Table 2: 1) the difference between the projects 2) Harmonisation between the bridge and the tunnel projects and 3) client adjustment

Table 2: Changes to construction costs

<b>2008 prices</b>	
Difference between the projects	EUR -46.8 million
Harmonisation	EUR 120.9 million
Client adjustment	EUR 167.8 million
<b>Total</b>	<b>EUR 241.9 million</b>

The three items are analysed in the following section.

### *Difference between the projects*

Femern A/S' bridge consultant, Cowi-Obermeyer, has prepared a construction estimate for the bridge project which is EUR 46.8 million below the feasibility study's construction estimate. This is due to the number of differences between the two projects, c.f. Box 1

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### **Appendix 1: Changes in the bridge project with larger economic consequences**

#### *Cost increases*

Hinterland infrastructure Fehmarn and Lolland	+ EUR 228.2 mio.
Protection of bridge piers against ship collision	+ EUR 94.0 mio.
Closed steel deck (high level bridge)	+ EUR 13.4 mio.
Windshields	+ EUR 26.8 mio.
Foundation of piles	+ EUR 26.8 mio.

#### *Cost reductions*

Length of the bridge from 18.6 km to 17.6 km	- EUR 134.2 mio.
One navigational span less	- EUR 94.0 mio.
Approach bridges – span 200 m instead of 240 m	- EUR 80.5 mio.
Various adjustments technical installations and railway	- EUR 80.5 mio.
Lower height of bridge at abutment	- EUR 20.1 mio.

*NB The list is not exhaustive. All amounts in 2008 prices.*

The most significant increase relates to the landworks on Lolland and Fehmarn of around EUR 0.2 billion. The increase stems from higher costs for construction sites, earthworks, bridge constructions and roads, etc. This reflects the fact that the current project involves an extra 4 km of motorway and an extra 5 km rail track on Fehmarn and Lolland.

In addition, there are higher costs for protecting the bridge against ship collisions. This is deemed necessary after the latest risk analysis and involves additional costs of around EUR 94.0 million.

Other cost increases include windshields in the order of EUR 26.8 million. The windshields are deemed to be necessary for the comfort of motorists crossing the belt. This should also be seen in the light of the fact that the link, as opposed to the Storebælt and Øresund links, runs North-South and, therefore, will be prone to side winds.

Steel piling foundations on the southern part of the link where soil conditions are challenging have also been included at a cost of around EUR 26.8 million. The need for piling foundations was identified following the geotechnical investigations.

These increases, however, are more than offset by the fact that the differences in the projects also incorporate savings. Among them is a reduction in the length of the bridge, which will be achieved by establishing ramp constructions (peninsulas) off the coast of Fehmarn and Lolland. This will provide savings of around EUR 0.1 billion.

Furthermore, the bridge will only have two navigational passages as studies have revealed that a third passage span would not make any significant contribution to navigational safety. This provides savings of EUR 94.0 million. A solution with shorter spans for the approach bridges (200m compared to 240m) has also been chosen which results in savings of around EUR 80.5 million.

A number of adjustments to the technical installations, including railway engineering installations, have been carried out, resulting in cost reductions of around EUR 80.5 million. The current conceptual design also reaches the coast at a lower level than assumed in the feasibility study, which means savings of around EUR 20.1 million.

#### *Harmonisation between the bridge and tunnel projects*

Femern A/S has examined the two construction estimates for a bridge and a tunnel solution to allow for the two projects to be compared. Accordingly, the same costs for the same services have been applied (salaries, concrete, steel etc.) as have similar assumptions regarding the costs of auxiliary inputs etc. in both construction estimates. In addition, costs relating to the contractor's guarantee deposit have been included. These were not included in the consultants' construction estimate.

This harmonisation has added EUR 129.9 million to the bridge consultants' construction estimate.

#### *Client adjustment*

In respect of the bridge solution estimate, Femern A/S has carried out a client adjustment totaling EUR 0.2 billion. The adjustment derives from the fact that, in Femern A/S' view, the original estimate did not allocate adequate resources for e.g. marine equipment for assembling the bridge elements etc., to comply with the strict timetable for the project. The adjustment is a precautionary measure with a view to ensuring that the necessary means are in place for signing contracts with the contractors based on the current timetable for the construction phase.

#### *Summary*

If account is taken of the increased costs for the landworks of around EUR 0.2 billion compared to the feasibility study, the current construction estimate for a cable-stayed bridge (including harmonisation and a supplement for missing documentation) is in keeping with the construction estimate in the feasibility study and, therefore, in the construction estimate that provided the basis for the Planning Act.

### **3. Other works and reserves**

The Planning Act's construction estimate comprised a total of EUR 0.7 billion for certain other works (EUR 0.03 billion) and reserves (EUR 0.6 billion). It was known that there would be a need for further funds for other works, but these costs were assumed to be covered by reserves and with a few exceptions<sup>4</sup> not specified further.

In connection with the preparation of the current construction estimate, Femern A/S has carried out a detailed assessment of the costs of other works which are in total assessed to EUR 0.2 billion.

A detailed calculation of the need for reserves for client and contractor risks has also been carried out and around 1 per cent of the total gross cost has been allocated as free reserves. This means that there is deemed to be a need for reserves of EUR 0.7 billion.

In the current construction estimate, a total of EUR 1.0 billion has been allocated for other works and reserves, which is EUR 0.3 billion more than estimated in the Planning Act. At a rough estimate, it is estimated that the costs of other works have increased by approx. EUR 94.0 million while the reserves for client risks, contractor risks and free reserves have risen by approx. EUR 0.2 billion.

The higher costs should be seen against the fact that the current construction estimate contains a more detailed assessment of the need for reserves and costs for other works than in the preparations for the Planning Act. The current estimate for reserves and other works has thus become comprehensive and more robust than that for the Planning Act.

#### 4. Project Management, operational preparations, etc.

The final difference is the increase in respect of project management, operational preparations etc. which, at the current time, are expected to amount to EUR 0.7 billion against the Planning Act's EUR 0.5 billion. This constitutes an increase of approx. EUR 0.2 billion due to several factors.

In the first place, the planning phase proved more expensive because of the increased requirements with regard to the environmental investigations. This was dealt with in the supporting appropriation document of 3 June, 2010, which accepted increases of approx. EUR 53.7 million.

Secondly, based on a review of the expected costs relating to the tendering process with a total contract sum of over EUR 4.0 billion, it is estimated that there is an additional need for around EUR 40.3 million extra for this phase above what was anticipated when the Planning Act was approved.

Thirdly, the extended construction period (expected opening in 2020 rather than 2018) etc. has increased expenditure for the client organisation and for external consultancy in the region of EUR 107.4 million.

4) Note: It was assumed that about 26.8 mio. EUR had to be used for a toll station.

Appendix – Technical comparison between the conceptual design and the feasibility study.

	<b>Conceptual design Cowi-Obermeyer, 1/10 2010</b>	<b>Feasibility study 1999</b>
Total length coast-coast		
- Width of road	17,574 m	18,568 m
- Width of railway	22.1 m	24.7 m
- Depth of girder	10.50 m	11.6 m
- max gradient, road	12.9 m	15.0 m
- max. gradient, railway	2.5%	3.5%
- design speed, road	1.25%	1.25%
- design speed, railway	130 km/t	120 km/t
(passenger trains/freight trains)	200/140 km/t	200/120 km/t

Landworks, length from coast line		
- Road: Fehmarn/Lolland	2,300 m / 4,300 m	1,200 m / 1,300 m
- Railway: Fehmarn/Lolland	3,180 m / 5,000 m	1,300 m / 1,450 m
- Ramps: Fehmarn/Lolland	580 m / 450 m	600 m / 400 m
Approach bridges		
- Northerly – length	9,412 m	9,360 m
- Southerly – length	5,748 m	6,000 m
- Span bridge girders	200 m (180 m)	240 m
- Number of bridge piers	74	64
- Number of ship collision prevention piers	4	None
Cable-stayed bridge		
- Total length	2,414 m	3,208 m
- Number of spans	2	3
- Span width	724 m	724 m
- Passage height	66,2 m	65 m
- Pylon height	268.5 m	281 m
- Greatest length of stay	386 m	400 m
Foundation method – basic solution	Direct foundation, piling	Direct foundation, Gravel bed
Height to underside of bridge girder at coast lines		
- at Rødbyhavn	8.0 m	17.4 m
- at Puttgarden	12.0 m	16.2 m
Dredging volumes, m <sup>3</sup>	0.8 million m <sup>3</sup>	>3.0 million m <sup>3</sup>