

**Fehmarnbelt Fixed Link**

**Bridge Design**

**Scope of Services**

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## **1. Introduction**

### ***1.1 The Overall Context***

This document describes the services to be provided by the Consultant responsible for the Bridge Design.

A complete list of major consultancy contracts for the entire fixed link across the Fehmarnbelt is given in appendix A.

Subject to the uncertainties mentioned below, the Bridge Design services are expected to comprise the following stages:

1. Conceptual Design.
2. Plan Approval Design.
3. Tender Design.
4. Enquiry Documents and tender period.
5. Tender Evaluation.
6. Review of Basic and Detailed Design. (The Basic and Detailed Design is assumed to be made by the Contractors designer)
7. Monitoring and Supervision of construction works.
8. Detailed design. (May replace activity no. 6).

The Ministers of Transport of Denmark and Germany have agreed that a cable stayed bridge should be considered as the preferred technical solution and an immersed tunnel should be considered as the preferred alternative solution for future investigations.

Nevertheless, the suspension bridge solution is a bridge solution which is included in the navigational studies and the choice between the cable stayed bridge and the suspension bridge solutions will await the results of the navigational studies and the conclusion/recommendation from the maritime authorities.

Therefore the stages Conceptual Design, Plan Approval Design and the Tender Design shall include both a cable stayed bridge and a suspension bridge.

A final decision to build the bridge or the immersed tunnel can not be expected before completion of the authority plan approval process. Therefore the need for the activities no 4 to 8 can not be defined before the final decision has been made.

Should the Client decide to take over the responsibility for the Detailed Design, the activity no 8 will replace activity no 6. Activity no 6 will then be made by a third party appointed by the Client.

A decision to build the Fehmarnbelt fixed link has not yet been completed through the Danish and German legislative processes and an unconditional right to discontinue the services at any time is therefore reserved.

This document describes in general terms the expected services and specifies certain requirements to be fulfilled by the Consultant.

Each assignment, to be developed by the Consultant, will be subject to a specific requisition from the Client and the content of this document is neither meant to establish the extent of services nor to exhaustively describe the requirements attributable to each task.

At the time of signing of the contract, the services to be provided are consequently not yet defined in all detail.

The Client requires independent, innovative and creative developments of concepts, ideas and methods from the Consultant with the overall purpose of establishing state-of-the-art technical solutions for the project.

The services described in Section 2 are foreseen to be performed in the period 2009 – 2018, or a possible extended period until completion of the construction contracts for the link.

## **2. Scope of Services**

### **2.1 Organisational Aspects**

Appendix B presents a provisional set up of the Client's organisation.

In order to establish a close and efficient co-operation between the Client and the Consultant, certain requirements on the organisation of the Consultant are listed in Appendix B.

### **2.2 Conceptual Design**

The Feasibility studies completed in 1999 will form the basis for the Consultant's investigations and development of an extended number of state-of-the-art solutions within the scope of the Conceptual Design services.

The Conceptual Design services shall include everything necessary for:

- performing state-of-the-art investigations in order to identify critical technical problems;
- the development of solutions which are sound and robust with respect to the construction as well as the operation and maintenance of the bridge for a period of 120 years;
- presenting a number of alternative solutions for a cable stayed bridge and a suspension bridge with cost estimates and technical and aesthetical evaluation.

The Client's expectations with respect to the level of detailing in the Conceptual Design services are given in Appendix C.

### **2.3 Plan Approval Design**

The activities mentioned under the Conceptual Design phase will be continued and among the presented alternative design layouts of the bridge design, a preferred design layout for a cable stayed bridge as well as a preferred design layout for a suspension bridge as chosen by the Client shall be developed further.

The bridge design shall be detailed to such a degree that it can form the basis for the authority plan approval process. It is foreseen that the applications to the authorities shall include a design where the following matters are fixed:

- Alignment.
- Main dimensions of substructure and superstructure.
- Architectural layouts.
- Interfaces to the Danish and German hinterland infrastructure.
- Construction methods.
- Quantities.

A detailed planning for the Plan Approval Design services will await the authorities' detailed requirements.

Preparation of an environmental evaluation of the proposed solutions and alternatives is assumed to be done by other consultants.

### **2.4 Tender Design**

During this stage it is expected that results of the navigational studies, performed by another consultant, are available and that the maritime authorities have made their conclusions/recommendations regarding the navigational conditions in the Fehmarnbelt. Nevertheless it is expected that this stage also will include both a cable stayed bridge solution and a suspension bridge solution.

The bridge design shall be detailed to such a degree that it can form the basis for the bridge construction procurement procedures.

The Client's expectations with respect to the level of detailing in the Tender Design services are given in Appendix D.

### **2.5 Enquiry Documents and Tender period**

The services in this phase can only be described in detail after the Client has decided upon procurement strategy, number of construction contracts etc.

The services shall include:

- Completion of technical documents such as Design Requirements, Project Application Document, Reference Conditions and Construction Requirements.
- Completion of Definition Drawings and an Illustrative Design (from Tender Design phase).
- Preparation of Special Conditions.
- Preparation of additions and amendments to the enquiry documents
- Review of and commenting on enquiry documents prepared by others.

### **2.6 Tender Evaluation**

The services shall include:

- Evaluation of the technical aspects of the tenders.

### **2.7 Review of Basic and Detailed Design**

It is assumed that the responsibility for the actual development of the Basic and Detailed Design shall rest with the contractors in charge of the construction work.

The review process with respect to the Basic and Detailed Design will be specified after award of contracts for the construction work.

### **2.8 Monitoring and Supervision of Construction Works**

The services will be specified after award of contracts for the construction work.

### **2.9 Detailed Design**

The services will be specified in case the Client should decide to assume the responsibility for the Detailed Design.

## **3. Activity & Time Programme**

The following milestones shall be the basis for the planning of the design work:

Award of contract	1 April 2009
Conceptual Design completed	1 April 2010
Plan Approval Design completed	1 February 2011
Tender Design start	1 February 2011
Tender Design completed	1 April 2012

The geotechnical investigations are expected to be performed according to the following overall time schedule unless the design process or the authority plan approval process requires a replanning of the activities:

Geophysical surveys	2008
Boring Campaign	2009 – 2010
Advanced Laboratory Tests	2009 – 2010
Large Scale Tests	2010 – 2011

The navigational studies are expected to continue until the end of 2010.

The plan approval process is planned to start not later than first quarter 2011.

The activity and time programme is further illustrated in Appendix E.

All activities and milestones are to be considered provisional and thus subject to possible revised planning.

## **Appendix A: Contract Overview for Consultancy Services**

The technical consultancy services for the Fehmarnbelt Fixed Link are divided into a number of areas, each subject to a separate procurement process.

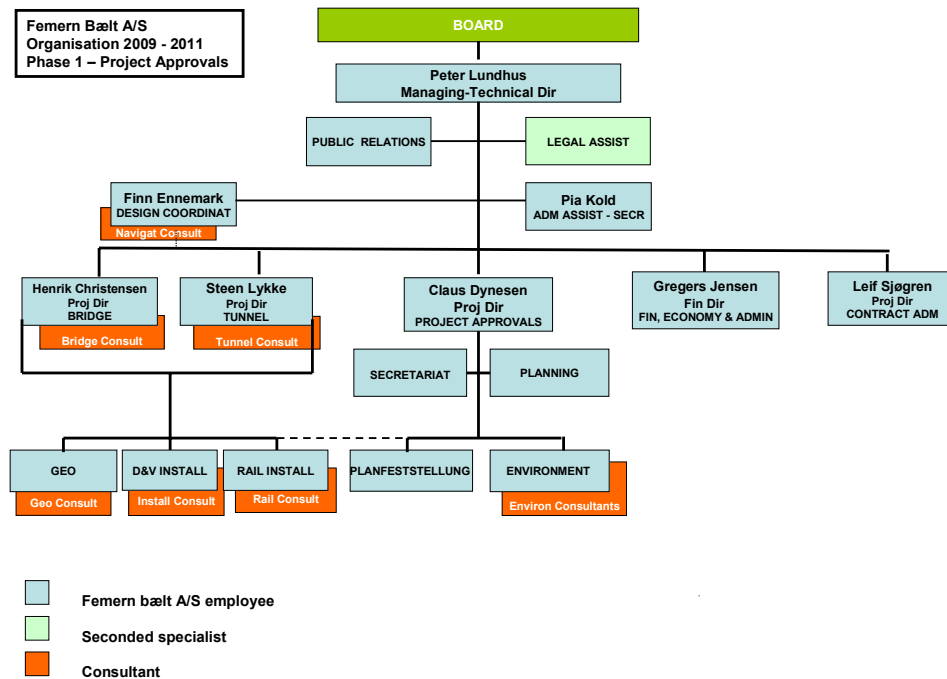
The main areas are:

1. Navigational Studies
2. Geotechnical Investigations
  - 2.1. Geotechnical consultancy services
  - 2.2. Boring campaign
  - 2.3. Laboratory tests
  - 2.4. Large scale site tests
3. Environmental Investigations
  - 3.1. Birds
  - 3.2. Fish and Fishery
  - 3.3. Marine mammals
  - 3.4. Marine biology
  - 3.5. Hydrographic services
  - 3.6. Ramp and approach areas, Denmark
  - 3.7. Ramp and approach areas, Germany
  - 3.8. Archaeological investigations
4. Bridge Design
5. Tunnel Design
6. Installations
  - 6.1. Railway installations
  - 6.2. SCADA
  - 6.3. Traffic control system
  - 6.4. Communication system
  - 6.5. Power supply
  - 6.6. Terminal area
  - 6.7. Toll station
  - 6.8. Other minor contracts
7. Heavy Lift Vessel

## Appendix B: Organisational Aspects

### The Client's organisation

The Client's organisation is illustrated in the figure below.



### The Consultant's Organisation

The following Key Individuals shall work full time on the project during the entire design period:

- Project Manager
- Client Liaison Officer
- Lead Engineers

The Client Liaison Officer shall work permanently at the Client's offices in Vester Søgade except for necessary visits to the design office not extending beyond 30 hours per month. The Client Liaison Officer shall have the authority to make binding agreements with the Client.

The Client Liaison Officer shall be able to discuss technical details in the Consultant's reports/drawings and to properly record and convey the Client's verbal comments thereon to the Consultant's organisation.

The Client Liaison Officer shall have access to all drawings and reports prepared by the Consultant from the moment they are available in a nearly complete first draft. The Client Liaison Officer may show such drafts to the Client in order to get a second opinion or an instruction on any point of doubt. Similarly, the Client may request to see such drafts, which request the Client Liaison Officer shall obey to without any delay. Comments from the Client to such drafts will normally be verbal, which the Client Liaison Officer shall record and convey to the relevant designer and get his reply back to the Client. Such reply shall normally be in writing.

In this interactive process it is the responsibility of the Client Liaison Officer to identify matters of principle importance for attaining the defined requirements and draw such matters to the attention of the Client.

In case the Client or the Client Liaison Officer finds that there are serious differences of opinion, the Client Liaison Officer shall request the designer and his Lead Engineer or the Project Manager to come to a meeting with the Client as rapidly as possible.

The Client Liaison Officer may have to be supported by a suitable staff, maximum three persons, also located at the Client's office.

The holidays of the Project Manager must not coincide with the holidays of the Client Liaison Officer. During the holidays of the Client Liaison Officer the Project Manager shall be located in Copenhagen and available for meetings with the Client on ½ day notice.

The following Key Individuals shall be available (with maximum 1 week notice outside properly announced holidays) on an ad hoc basis during the design period:

- Geotechnical Expert
- Risk Analysis Expert
- Design Basis Expert
- Dynamic Analysis Expert
- Alignment Expert
- Wind Tunnel Expert
- Cost Estimate Expert
- Construction Planning Expert
- Corrosion Protection Expert
- Concrete Expert
- Steel Expert
- Cable Expert
- Waterproofing and Pavement Expert
- Substructure Design Expert
- Superstructure Design Expert
- Aesthetical Expert

In general, the mentioned experts shall be responsible for the functional and or specific technical requirements within their domain. However, the Material and Construction Requirements for concrete will be produced by a group of concrete experts selected and chaired by the Client. The Consultant's Concrete Expert shall normally participate in all meetings in this group and other meetings when requested by the Client.

## Appendix C: Conceptual Design

The services shall include but not be limited to:

- Preparation of a Design Basis, which describes the requirements, such as geometrical requirements, loads, etc., which the bridge design shall comply with.
- Preparation of Geotechnical Baseline Reports, based on the Consultant's evaluation of factual geotechnical information, reported in Geotechnical Data Reports, provided by the Client's geotechnical consultant. The Consultant shall review and comment a program (developed by the Client's geotechnical consultant) for all necessary geotechnical investigations including boring campaign, laboratory tests and large scale site tests.
- Preparation of alternative design layouts for the comparison and evaluation of possible alternative technical solutions to the project and for the comparison and evaluation of solutions to a number of critical aspects.
- Preparation of review studies and/or work shops where specialists on a number of specific aspects from consulting companies, contractors and institutes are invited to participate in seminars in order to involve possible relevant experience and in order to get a second opinion of proposed solutions to specific problems and design layouts, all for the benefit of the project.
- Preparation of a technical evaluation of proposed solutions and alternatives.
- Preparation of an aesthetical evaluation of proposed solutions and alternatives.
- Preparation of estimates for the construction costs including probabilistic analysis of such costs.
- Preparation of a description of possible construction methods.
- Preparation of necessary information required for an Environmental Impact Assessment prepared by other consultants.
- Coordination of the interfaces to the design of bridge installations and equipment. (Appendix A item 6)
- Coordination of the interfaces to the design of the German and Danish hinterland infrastructure.
- Coordination of the interfaces to the environmental investigations.
- Coordination of the interfaces to the Heavy Lift Vessel design.
- Coordination of interfaces to the Navigational Studies.
- Coordination of interfaces/evaluation basis to the Tunnel Design.

Furthermore, the Conceptual Design phase shall identify and solve critical aspects which have a considerable impact on the cost estimates, whereas critical issues with minor cost implications shall be postponed to a later design stage. As a guideline the following critical issues are considered to have a considerable impact on the costing:

- One typical node in upper and lower deck
- Design of cable stays and anchorages/ main cables and cable saddles
- Design of anchor piers/ anchor blocks
- Design of pylons

- Foundation design for various ship impact forces.
- Mitigating precautions against long term settlements.
- Design of pier protective works.
- Layout of arrangement for M&E installations.

The analyses carried out in the Conceptual Design phase shall be sufficiently accurate and complete to determine all main quantities.

Drawings shall include:

- Horizontal and vertical alignment
- Elevation and plan
- Cross sections in approach and navigation spans
- Elevation, plan and cross section of typical piers and their foundations
- Elevation, plan and cross section of pylon and foundation
- Bearing and expansion joint layout plan
- Layout plan and sections of ship impact protection works.
- M&E installations

The alignment drawings are needed for the cost estimate, but minor changes may be introduced in the subsequent design phase.

## Appendix D: Tender Design

The services shall include but not be limited to:

- Detailed investigations of aspects identified under the Conceptual Design stage and not completed under the Plan Approval stage.
- Preparation of a Project Application Document, PAD, based on applicable Eurocodes, which shall be the codes and standards for the Fehmarnbelt bridge.
- Preparation of Design and Construction Requirements.
- Preparation of Reference Conditions for the project describing hydrological, meteorological and geotechnical conditions for the project all based on data provided by other consultants.
- Preparation of estimates for the operation and maintenance costs.
- Preparation of a Operational Risk Analysis.
- Preparation of a time schedule for the constructions works.
- Preparation of an Illustrative Design.
- Preparation of Definition Drawings

The following detailed investigations are proposed to be carried out in the Tender Design phase:

- Wind tunnel testing; section model in a static and dynamic rig.
- Design of truss nodes not mentioned above including hot spot fatigue verification.
- Definition of comfort criteria for trains.
- Investigation of dynamic behaviour including fulfilment of comfort criteria.
- Investigation of passive damper arrangement against cable vibrations.
- Investigations of railings and wind shields.
- Detailed interpretation of the results of geotechnical investigations.
- Determination of allowable cable types (cable stays and main cables and hangers).
- Investigations on corrosion protection, waterproofing and pavement.
- Determination of allowable types of bearings and expansion joints.

In the Tender Design phase the Consultant shall present Definition Drawings showing all visible dimensions of abutments, piers, pylons and superstructure. Furthermore, an Illustrative Design showing a possible and acceptable design of the bridge conforming to the Definition Drawings and the Design and Construction Requirements shall be presented. The Illustrative Design shall be based on a construction method proposed by the Consultant and agreed by the Client. The Illustrative Design shall at least show:

- Concrete dimensions of foundations, piers, pylons and superstructure.
- Main prestressing and reinforcement of these members.
- Dimensions of cable stays or main cables / hangers.
- Pier protection works.
- Typical truss nodes with stiffening plates, manholes, etc.

- Guard rails, wind screens and similar visible appurtenances.
- Bearings and expansion joints.

The Illustrative Design drawings shall be used to update the cost estimate for the bridge presented in the Conceptual Design phase and to provide potential Contractors with a clear indication of the Client's expectations to the Basic Design.

Appendix E: Design Schedule

