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## New Environmental Demands on Major Construction Works

### Exigences nouvelles de l'environnement posées aux grands travaux de génie civil

### Neue Umweltanforderungen an grössere Bauanlagen

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#### SUMMARY



Historically seen, it has been possible to carry out great infrastructure projects among others because of the public admiration for technological and social progress represented by these projects themselves. The consequential costs were considered as negligible.

This is a fact which doesn't exist anymore, and to which I shall return later based on the experiences from the Great Belt project.

Great civil works - it be infrastructure projects: bridges, tunnels, roads, or great industrial installations - always supplicate special interest and today you often see conflicts between these interests which pursue their goals individually.

There are at least 3 interested parties

- The company which stands for the execution of the project. The goal of the company is to ensure 'the shareholder' a reasonable payment of interest of the invested capital.
- The politicians and for instance the environmental organizations and/or the grass root organizations will want a project carried out which is subjected to a number of restrictions, like low fares or no effect on the environment. In reality, many of these goals are incompatible.
- The engineers who have a natural desire, partly to deliver the 'product' ordered by the company, partly to do so technically and scientifically well-founded.

But as I mentioned in the beginning, the interest of these groups has changed from immediate admiration, and we have seen a clear change in the attitude towards the infrastructure projects.

## ENVIRONMENTAL DEMANDS

The great industrial accidents which the world has experienced through the last years ranging from Bhopal in India to Chernobyl in the Sovjetunion and from Seveso in Italy to the latest oil spill in Alaska, have resulted in a focusing on the question of how large an impact our environment can endure. At the same time it has been determined that the environment is vulnerable and that it is already so affected that any new activity must be evaluated in the light of whether the environment is able to endure the impact from a given activity. Construction projects have thus not changed but the evaluation of these has - considering the already affected environment - changed almost dramatically. This has resulted in increasing technological and environmental demands on such projects.

## THE WORLD COMMISSION

The increasing awareness of the environmental problems linked to the level of human enterprise known today is underlined in the report of the World Commission on environment and development. An examination initiated by the United Nations based on the impression of a need for long-term environmental strategies which might secure a sustainable development by the turn of the century.

The work lasted for 4 years and has - since the report was published - had a considerable influence on the strategic plans made by the various countries for the economic and technical development.

Without any doubt the demands from the report of the Commission will have an effect on future major civil works. Therefore the following conclusions must be safeguarded in future civil works.

Environmental and economic goals can and must be made mutually reinforcing. Sustainability requires the enforcement of wider responsibilities for the impacts of policy decisions. Those making such policy decisions must be responsible for the impact of those decisions upon the environmental resource capital of their nations.



They must focus on the sources of environmental damage rather than the symptoms. The ability to anticipate and prevent environmental damage will require that the ecological dimensions of policy be considered at the same time as economy, trade, energy, agricultural, and other dimensions. They must be considered on the same agendas and in the same national and international institutions.

Some major civil works will hardly be able to live up to such an ambitious goal, but it is essential that contractors and designers are aware of their responsibility for the realization of these long-term strategies to be pursued by the political decision makers and organizations of international law.

This results in the fact that considerations for the environment must have an important place in the basis for decisions, in the design phase and in the execution phase.

The demand to the contractor and especially the engineer is therefore to make the environmental criteria operational in connection with the construction project, and they must be prepared to explain the choices made also seen from an environmental point of view. In itself this is not an easy task as it is not always from a scientific starting point possible to produce results at the speed demanded by the human activity. The uncertainty which this leads to may - if not carefully considered - turn out to block the execution of the projects.

In this connection, allow me to mention the uncertainty which is attached to the evaluation of biological and ecological relations in general. With the knowledge we have about these relations the need for accurate knowledge in connection with the execution of civil works cannot be fulfilled, and a possibility for creating a considerable uncertainty about the construction work has been established as far as this might be the aim of interestgroups or politicians.

What does this demand from us as constructors and engineers and from the politicians?

- As technicians we must learn to understand that solutions that seem right from a technical point of view not always are the 'right' ones from a political point of view. Like the politicians we must learn to listen to the grass root groups.
- As constructors we must understand that it is not only economy that counts. Of course we are blamed if our balance is not accurate, but we are also blamed if we do not create an understanding for the things we do with the many debaters who are not interested in numbers and figures.
- And finally the politicians. They must learn to understand that it is not always the latest edition of the morning paper which is telling the truth. Increasingly the press has become accuser, defender, jury and judge. That is a fact about which we - and especially the politicians - must be critical.

There are no easy solutions. In fact, there never is in a pluralistic society, but in order to understand what is going on, we must accept the dilemmas.

In the Great Belt project many of these considerations have played an important role for design and outline of the link, just as - in an early stage - a substantial cooperation with the relevant authorities was established in order to uncover demands from the authorities for the construction work. Besides that the cooperation must ensure a high mutual level of information among the involved parties.

The following important elements must be pointed out:

#### THE CONSTRUCTION ACT

The establishment of the fixed link is based on a construction act passed by the Danish Parliament, Folketinget.



The basis for the organizational set up is Act No. 380 which was passed at the Folketinget in May 1987. This Act stipulated the overall technical framework for the fixed link: configuration, traffic modes (rail and motorway), capacity and other technical issues, as well as the organizational structure which was to be established for the detail planning, design and construction.

The Act specifies, besides these demands for the construction work, an important environmental demand: Out of consideration for the marine environment in the Baltic Sea the water-flow to/from the Baltic Sea must remain unchanged after construction of the link. This is called the zero-solution concept.

In this concept the consideration for the marine environment in the Baltic Sea is made operational as the blocking effect from the various elements in the project is compensated by dredging. It is possible to calculate the blocking effect of the construction and the necessary amount of the compensational dredging by means of a mathematical model.

The consideration for the environment in the far field can thus be obliged, but the completion of the compensational dredging will affect the near field, and therefore it is important to reduce it to a minimum. The choice of working methods is also important.

#### THE ELEMENTS OF THE FIXED LINK

As constructor the company, the Great Belt A/S, - as mentioned above - executes all the duties in connection with the Fixed Link. Therefore the Great Belt A/S has been directly involved in the weighing out of the environmental and economic aspects, which have been the basis of the outline design we know today.

One of the most important dilemmas has been whether the Company should accept higher construction costs by shortening the ramps and therefore pay the environmental regard to occupying the seabed areas and reducing the compensational dredging.

Fig. 1 next page shows the project in January 1988 illustrating schematically the Eastern Channel.

The political discussions and the discussions with the authorities and the green organizations resulted in the project which is now being constructed as it was accepted politically to increase the construction costs if an ramp at Halsskov was not constructed, and if the alignment was carried across Sprogøe instead of constructing an artificial island north of Sprogøe in the middle of the Belt. Out of consideration for among other things the environment, it was decided - at the same time - to build the railway-connection under the Eastern Channel as a bored tunnel instead of an immersed tunnel.

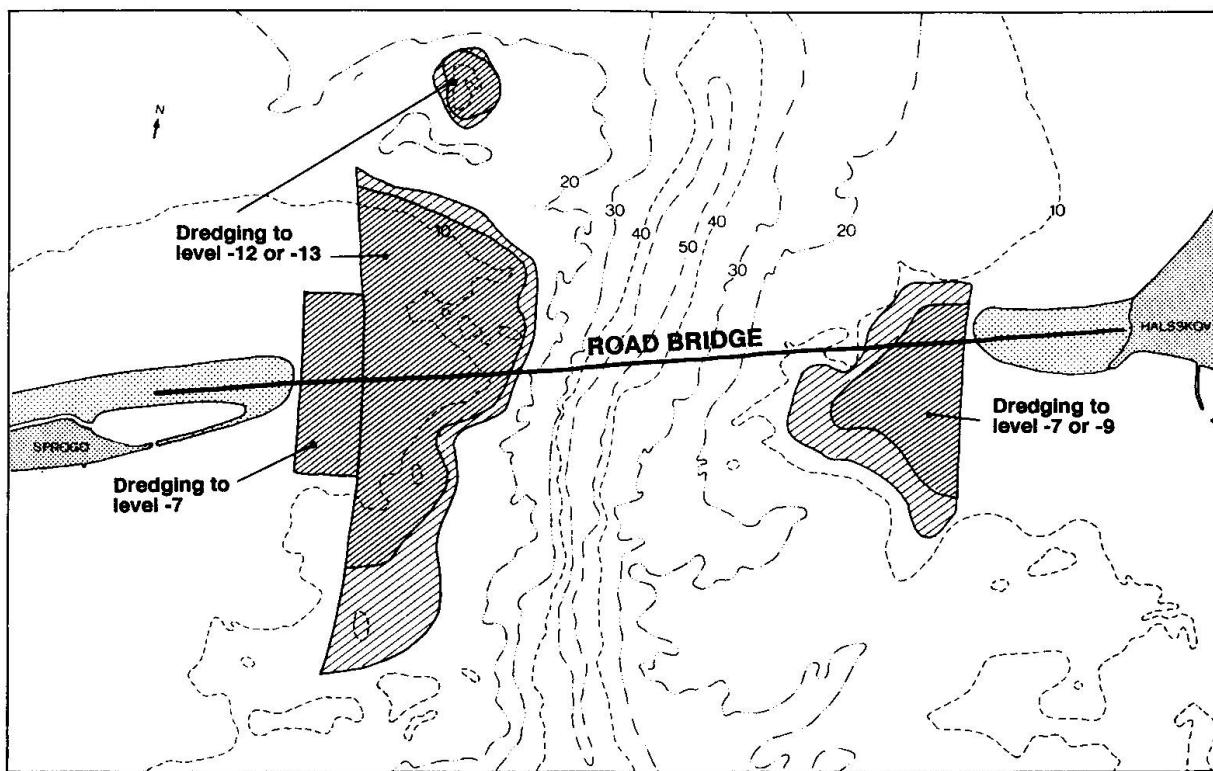


Fig. 1 A calculated example showing the extent of a dredging/excavation possibility for a road bridge and a railway tunnel in the Eastern Channel combined with the Western Bridge in alternative designs.

Seen from the road-users' point of view there will not be any difference in the various alternatives, but we will achieve environmental advantages which to a certain extent are considered more important than the additional costs of the changes in the project.

#### The East Bridge

The most significant singleproject in the Great Belt project is the East Bridge across the Eastern Channel of the Great Belt. Prior to the decision of the outline a large number of examinations were carried out in order to show navigational and environmental circumstances and aspects on international law.

Please allow me to, briefly, describe the navigational and environmental circumstances.

Passage through Danish waters to and from the Baltic Sea takes place by passage through the Great Belt and the Femern Belt or by passage through the Sound.

In certain areas passage through these waters is more difficult because of narrow channels, sharp turns, limited waterdepth and crossing ferrytraffic.

The shiptraffic in the area around the Fixed Link across the Great Belt is dominated by the two crossing maintraffic-streams. A north- and south-bound shiptraffic, annually altogether about 22,000 passages, of which the majority uses the T-route running through the Eastern Channel, and an east- and west-bound ferrytraffic of about 48,000 passages a year. Finally, there is some traffic of the pleasure boats and smaller vessels to the harbours of Nyborg and Korsør.

The Great Belt A/S has gathered all relevant information on shiptraffic in the Great Belt in one shiptraffic-database containing the information necessary to evaluate the safety against collision of the Great Belt bridges.



The relation between vessel size and collision force determines the demands for collision resistance of the piers, and therefore this relation is an important part of the basis for planning.

In the Construction Act of the Fixed Link it is determined that the high level bridge across the Eastern Channel must be constructed with sufficient navigational clearance. An analysis of air draught for large vessels and off-shore vessels in the Eastern Channel resulted in a reduction of the navigational clearance of the main span of the East Bridge from 77 metres to 65 metres, as the analysis showed that traditional vessel types do not have air draughts of more than approx. 60 metres.

Several independent analysis - among others manoeuvring simulations with cable stayed and suspension bridge solutions with spans from 780 metres to 1,800 metres resulted in a determination of the main span of the East Bridge at 1,624 metres.

On the basis of the investigations mentioned above the Danish Maritime Authority recommended that the bridge be constructed with a span of approx. 1,700 metres and that a straightening of the existing channel be conducted so that it is nearly in accordance with the main current.

Out of consideration for the environment and safety of passage submerged reefs to protect the piers are not included in the Great Belt project.

As well the marine authorities as the organizations have advised against the construction of submerged protection reefs because they might result in changed current conditions which especially would influence the safety of passage for smaller vessels and increase the number of groundings resulting in obstructions of the shiptraffic and risks for the environment, say oil spill.

The Great Belt A/S has changed the constructive outline of the two anchor blocks of the East Bridge so that a better water-flow is secured through deposit of excavated material around the anchor blocks. Collisions of the anchor blocks themselves are thus avoided.

## CONCLUSION

Although many more examples from the Great Belt and from other similar projects the abovementioned fully demonstrates the point that major projects cannot be finished without careful examination of the environmental issues. The environmental considerations will also lead to changes in the final design in order to meet these demands, and this will often result in extra costs.

Furthermore it is of importance that the constructor initiates a dialogue with the interested parties at the earliest possible time in order to avoid unnecessary and costly delays in the construction programme. On the basis of such a dialogue and on the basis of awareness of the problems he might be faced with, the engineer has to build in environmental specifications in the design and when choosing equipment and materials for the construction. It is not easy but it will be the start for the civil works to come. So if we want to build them we will have to meet the changing demands of society.

My starting point was partly the World Commission's report and I will finish with this sentence from the same report:

'Yet in the end, sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs. We do not pretend that the process is easy or straightforward. Painful choices have to be made. Thus, in the final analysis, sustainable development must rest on political will.'