



HAECON n.v.
Harbour and Engineering Consultants

PROJECTS MADE BY HAECON
IN THE TRANSPORTATION SECTOR
IN ZEEBRUGGE (Belgium)

121246

January 1983



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**1. Design studies for the extension of the outer-harbour
at Zeebrugge (1976 - 1981)**



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INTRODUCTION

From 1976 to 1981 the engineering office Haecon-Zeebrugge made the design studies for the harbour extension in Zeebrugge

This extension is necessary to ensure access to the new sea-lock which has been under construction since 1971. In May 1976, the Government decided to install an LNG terminal within this extension.

Work began in January 1977 and is effected with a flexible contract which ensures a continuous interaction between the contractors, the study office and the client. Acceptance of the work is estimated for the end of 1985. Ships will be able to have access to the new lock from 1983. The total construction cost estimated is about 1,500,000,000 US \$.

The work involves the construction of outer-port breakwater in the North Sea with a total length of about 11.5 km. This will require 1,800,000 tons of gravel, 11,780,000 tons of stones and 64,000 concrete blocks of 25 tons. The project also requires dredging of about 120,000,000 m³ of which 8,500,000 m³ were used for restoration of the beaches on the Belgian east coast, one of the biggest operations of its kind in the world.

Among the specific problems to be solved, one can mention :

- interaction of the harbour structures on the Scheldt estuary,
- silting of the existing entrance channel to Zeebrugge,
- cross-currents up to four knots at the harbour entrance,
- port safety problems with simultaneous traffic of LNG ships, passenger vessels, container ships and explosives.

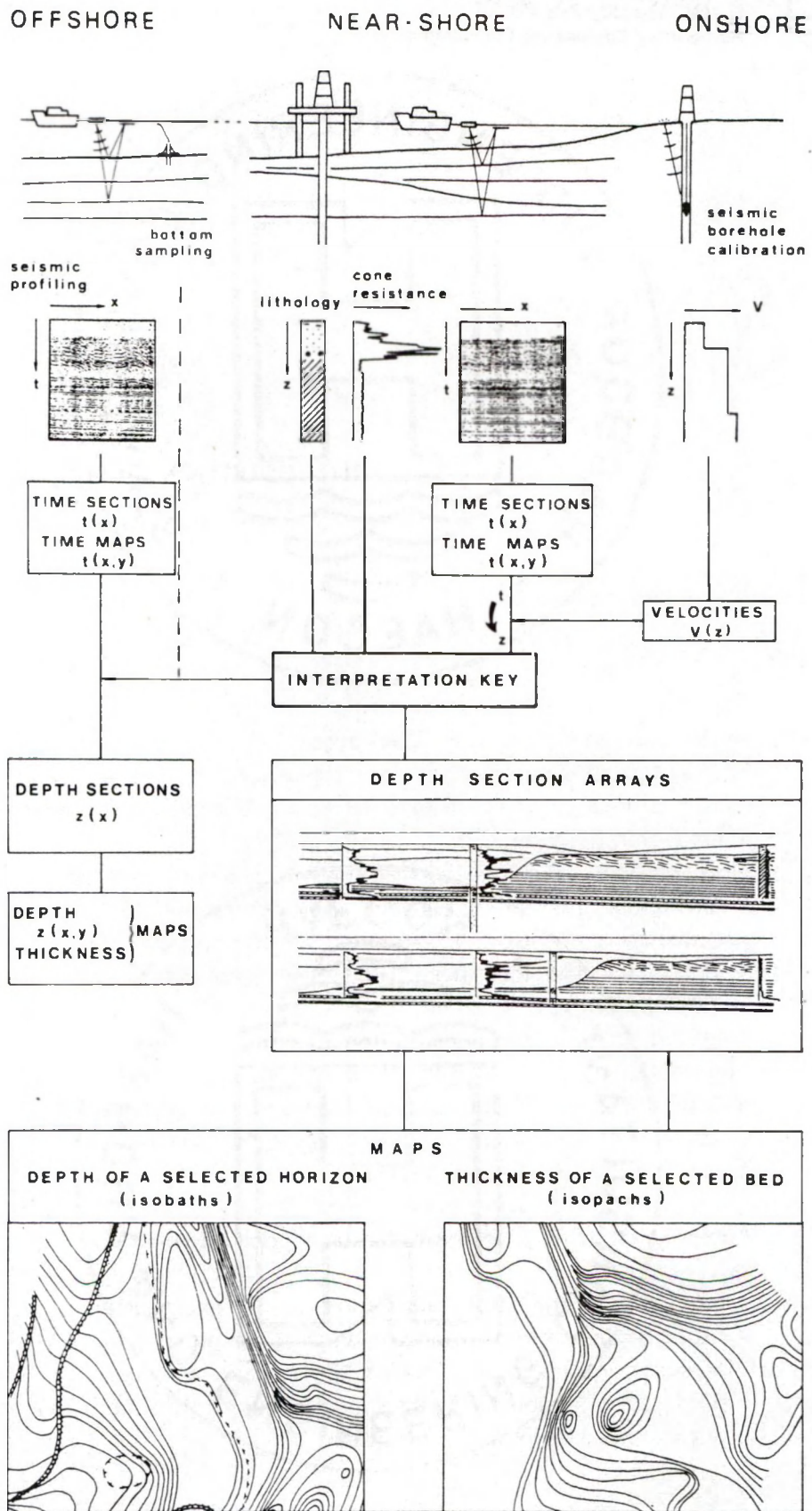


Fig. 8 General scheme of the interpretation flow of the integrated geotechnical and seismic data and presentation mode of the results.



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GEOTECHNICAL SURVEYS

Location : Zeebrugge (Belgium)
Client : Tijdelijke Vereniging Zeebouw - Zeezand
Start of the Study : September 1976
End of the Study : October 1981

Brief description of the project :

The decision to develop the outer harbour of Zeebrugge, which involves the construction of an LNG-terminal and entails the dredging of approach channels and the protection of the east coast, has formed the incentive for an application-oriented seismic survey, integrated into a marine engineering investigation programme.

In its reconnaissance stage, the geotechnical investigation for the outer harbour consisted of the following consecutive phases: seismic profiling (75 km) offshore cone-penetration testing, offshore drilling with associated laboratory testing of disturbed and undisturbed samples (classification tests, stress and deformation tests) backed by parallel onshore cone-penetration testing and drilling. Subsequent detailed investigations involve additional drilling and cone-penetration testing, pressiometer testing, borehole logging and laboratory testing. To interpretate the results of the core penetration tests, the vibrocoreing down to 4 or 5 m was very useful.

Average drilling and geotechnical testing depth amounts to 15 to 30 m below seabed, with a few additional offshore and onshore deep boreholes ranging between 65 and 100 m below seabed or soil level.

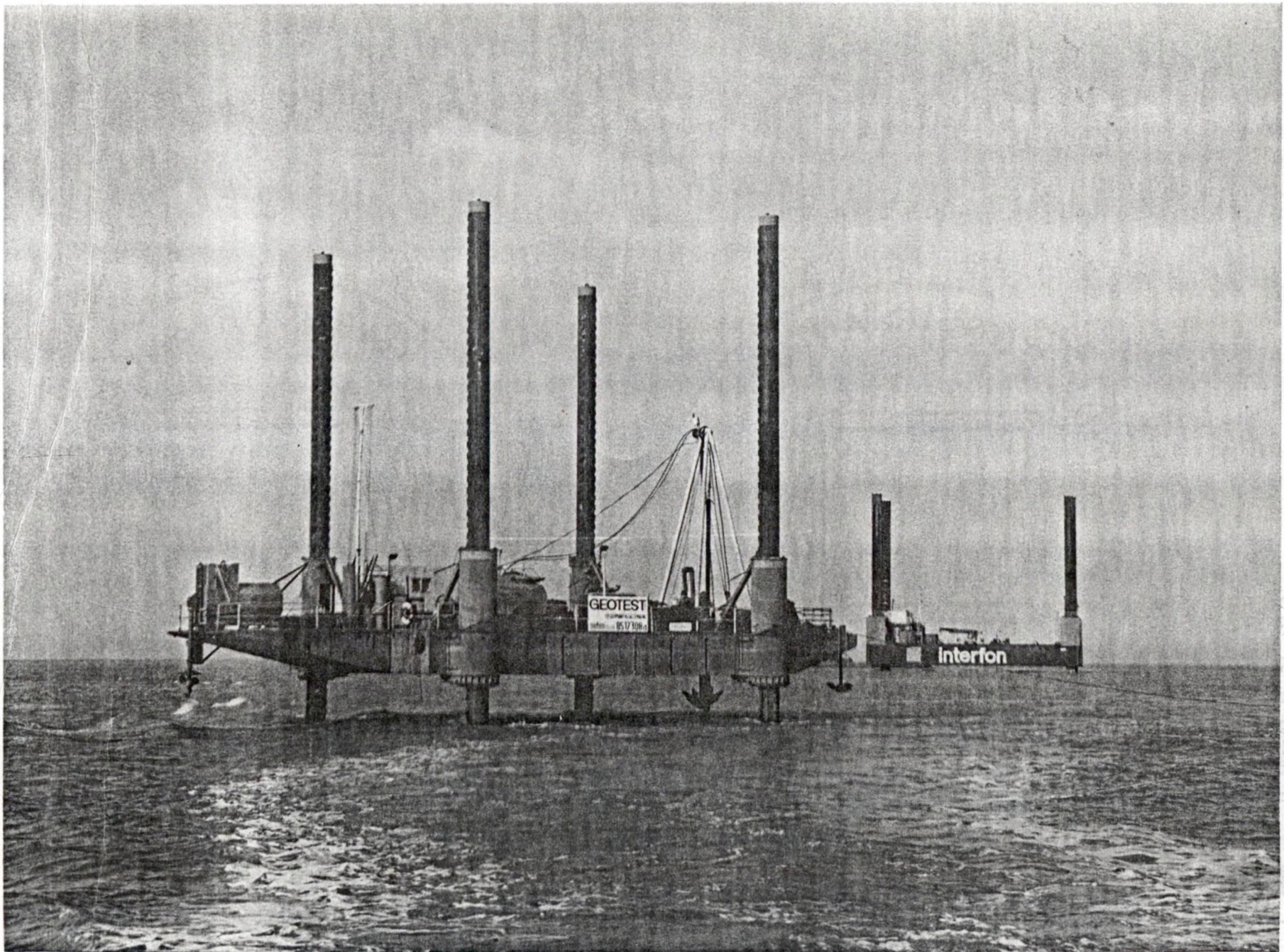
The approach channel area and the eastern near-shore area have been covered by a seismic survey (345 km) and an associated programme of vibrocoreing and offshore drilling. The total number of vibrocores amounts to about 250. Sediment transport investigations involved radioactive tracer studies and bottom sediment density determinations.

The results of the intensive geotechnical survey showed that it was necessary to execute a soil replacement for about 8 km of the breakwaters. The weak top layers (4 to 6 m) are dredged and the trench is filled with coarse sea-sand.

The quality of the dumped sand was controlled :

- in the earlier stage by density measurements (+ laboratory testing) and CPT
- later on by CPT's

(continued ...)



GEOTEST - 1965 - 1966 - 1967 - 1968 - 1969 - 1970 - 1971 - 1972 - 1973 - 1974 - 1975 - 1976 - 1977 - 1978 - 1979 - 1980 - 1981 - 1982 - 1983 - 1984 - 1985 - 1986 - 1987 - 1988 - 1989 - 1990 - 1991 - 1992 - 1993 - 1994 - 1995 - 1996 - 1997 - 1998 - 1999 - 2000 - 2001 - 2002 - 2003 - 2004 - 2005 - 2006 - 2007 - 2008 - 2009 - 2010 - 2011 - 2012 - 2013 - 2014 - 2015 - 2016 - 2017 - 2018 - 2019 - 2020 - 2021 - 2022 - 2023 - 2024 - 2025

INTERFON



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GEOTECHNICAL SURVEYS

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When necessary, the dumped sand is compacted by vibration. After compaction CPT's are executed again.

Seismic work provides the lateral exploration power which point investigations like boreholes lack. On the other hand, borehole data, seabed coring and penetration testing provide the necessary clues for identification of observed seismic events and for raising any ambiguity inherent in the seismic method.

The vertical time dimension of seismic profiles can be converted into depth by suitable borehole control and seismic velocity models, compiled from refraction data and well-shooting.

Services : definition, supervision and interpretation of all tests,

Special technical features :

This comprehensive geotechnical survey for the offshore extension of Zeebrugge harbour illustrates some possibilities and limitations of seismic profiling in Belgian offshore areas and proves a striking example of its successful integration in geotechnical investigations.

Miscellaneous remarks :

This general geotechnical investigation programme was carried out by Haecon-Zeebrugge.

World Bank Symbols : Fields of specialization : K500, K504, K510, K511
Types of services : 1b, 1c, 1e, 1f, 3g, 3k, 4b, 4d,
Level of effort : class 4 (over 200 man-months)



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SURVEY OF SEA BOTTOM-LITHOLOGY

Location : ZEEBRUGGE (Belgium)
Client : Tijdelijke Vereniging Zeebouw-Zeezand.
Start of the study : 1975
End of the study : 1981

Brief description of the project :

The survey of sea bottom-lithology forms part of the design studies for the port extension of Zeebrugge.

About 600 Shipek bottom-samples are taken for the qualitative and quantitative description of the sea-floor.

Samples are sedimentologically described in situ and sent up to the laboratory for analysis of grain-size distribution, organic content and field density.

Continuous lithological surveys are performed using a natural radioactivity gauge.

Vibrocorings up to a depth of 5 m are executed for the lithological depth distributions of loose sediments. The cores are analysed with a gamma-densimetric array to determine the density of the cores without opening them.

Services :

- survey
 - . bottom - sampling
 - . continuous survey of lithology
 - . vibro - coring
- research
 - . analysis of samples
 - . use of the gamma-densimetric array

Special technical features :

- development of a natural radio-activity gauge
- use of gamma-densimetric array.

Miscellaneous remarks : This study was carried out by Haecon - Zeebrugge

World Bank Symbols : Field of specialization : TR-K505
Types of services : 1b, 1i
Level of effort : class 1 (less than 20 man-months)



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MASTER PLAN HARBOUR EXTENSION

Location : ZEEBRUGGE (Belgium)
Client : Tijdelijke Vereniging Zeebouw - Zeezand
Start of the study : 1976
End of the study : 1981

Brief description of the project : At present Zeebrugge is Belgium's major coastal harbour. On a limited area very diversified port users co-exist : containers, a fishing port, a crude oil terminal, a yacht harbour, quays for general cargo (including explosives), as well as a car ferry terminal. A LNG terminal is planned.

The study programme for the extension of the Port of Zeebrugge entrusted to Haecon-Zeebrugge, had, as prime objectives :

1. To assure access to the lock and the deepening of the port with a view to receiving fully laden 125,000 tdw. ships.
2. To determine and prepare the areas for unloading, storage and regasification of the LNG.

Apart from the two objectives mentioned, Haecon-Zeebrugge has also to ascertain that the extension plans are flexible so that future extensions or adaptations of the outer harbour are possible. The way in which the works can contribute to obtaining a better zoning of the port activities has also to be studied.

Whatever the geographical position of a port may be, a rational zoning of the port avoiding dispersion and mixing of different traffic, is an important condition for the proper exploitation of the port. This is why the Haecon-Zeebrugge studies analyse the possibilities of regrouping the energy berths (oil tankers, methane tankers), in one area of the port, the containers in another area, the roll-on/roll-off berths in a third area, and so on. The extension of the port allows a more distinct separation of the traffic and that can only improve efficiency of loading and unloading operations and of safety measures.

On the other hand, taking into account that Zeebrugge is the only Belgian port located off the North Sea, the land which will be gained from the sea has an important port vocation. The design of dykes and entrance channels and the plans for road access must therefore be such, that the creation of a new potential for quick ship handling is not obstructed but, on the contrary, can be realised in an optimum way. With this objective, Haecon has so far elaborated various plans for linking the port with the hinterland, with road and rail plans as well as plans for transport by pipeline. The organization of the general road entrance to the port was the object of a thorough study in 1978-1979. The existing and future port traffic had in no way to be detrimental to tourist activities (excessive noise, site traffic on coast roads etc ...).

World Bank Symbols : Fields of specialization : TR-K101, K102, K201, K405, K514
Types of services : 2c, 5e
Level of effort : class 1 (less than 20 man months)



CENTRAL WORK AREA

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Special technical features :

- automatic weighing system
- As the site finally chosen was partly upon marshland, a detailed geological study has been necessary in order to preclude unacceptable settlements for the incoming wagons.
- The workyard has to be operational 24 hours a day. A special lighting system has to be conceived.
- As the workyard is near a densely populated area, special features have to be provided to decrease noise and dust.

Miscellaneous remarks : The study was carried out by HAECON - Zeebrugge

World Bank Symbols : Fields of specialization : TR-K510, K511
Types of services : 1b, 1c, 1e, 1g, 3k, 4a, 4b, 4g, 5b
Level of effort : class 3 (between 100 and 200 man months)

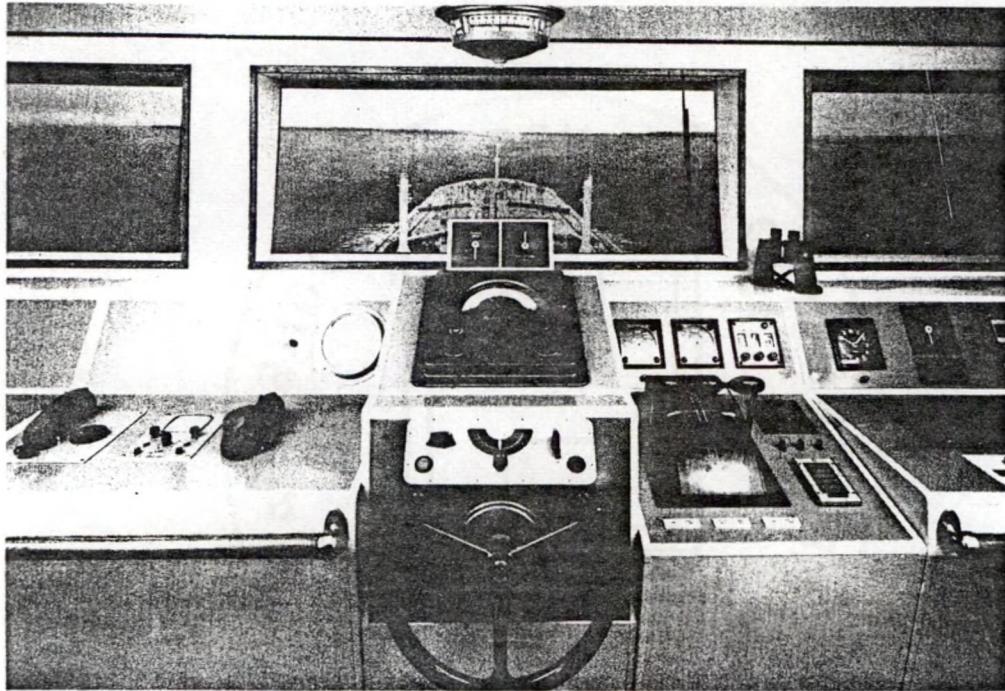


Fig. 26 View from the wheelhouse of the manoeuvring simulator.

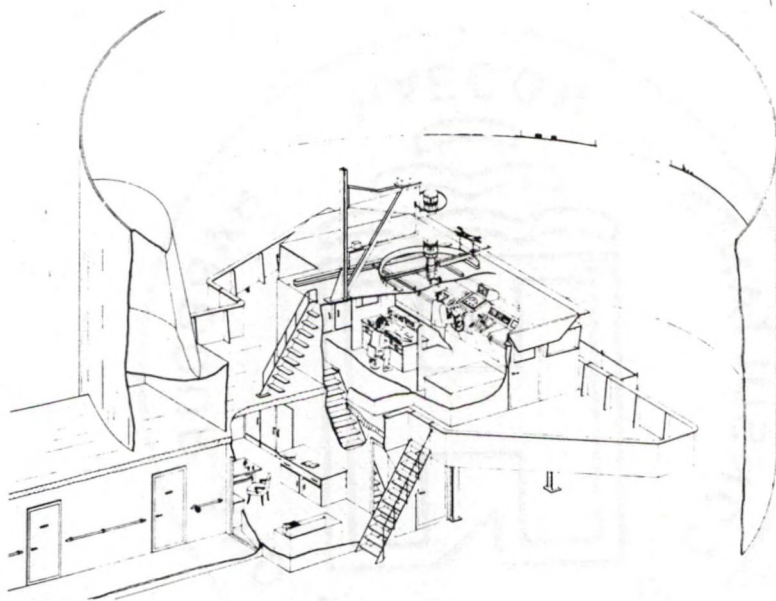


Fig. 25 Sectional perspective drawing of the manoeuvring simulator.



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NAUTICAL STUDIES

Location : Zeebrugge (Belgium)
Client : Tijdelijke Vereniging Zeebouw-Zeezand
Start of the study : 1976
End of the study : 1981

Brief description of the project :

In the design of the port of Zeebrugge, special attention was paid to nautical aspects. The manoeuvring of the ships into the port and their mooring had to be considered with great care.

To this end, experiments on models were effected. Two types of models were used:

1. a physical model for free sailing ships, by which the purely physical aspects of navigation were examined ;
2. a manoeuvring simulator which should show how the pilot interprets the physical configurations, which allows an optimum choice to be made.

The simulator was first of all perfected and tested. A simulation was then effected for different cases ;

- a sensitivity study for three possible extension lengths of the outer harbour.
- a detailed analysis of the final entrance to the port, resulting from the model for free - sailing ships.
- a complementary study of the little-known phenomena in some very particular cases (gate force winds, emergency manoeuvring and special coercions) in the intermediate situations when the breakwaters are still under construction.

In-situ measurements of ship manoeuvres in Zeebrugge gave additional data.

Miscellaneous remarks :

- The data used for these models resulted from hydraulic tests in the laboratory.
- This studies were carried out by Haecon-Zeebrugge.

World Bank Symbols : Field of specialization : TR-K101a K101d,K507,K511,K515,K516,K602,K604
Types of services : 3g, 5e
Level of effort : class 2 (between 20 and 100 man months)



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L.N.G. DOCK

Location : ZEEBRUGGE (Belgium)
Client : Tijdelijke Vereniging Zeebouw-Zeezand
Start of the study : 1976
End of the study : 1981

Brief description of the project :

In May 1976 the Belgian Government appointed Zeebrugge as the Belgian import harbour for the LNG-contract concluded between Sonatrach (Algeria) and Distrigas (Belgium).

In September 1976 HAECON-ZEEBRUGGE was entrusted with the study of implantation and general lay-out of the terminal.

Services :

During the years 1976 - 1978 several alternatives were conceived taking into consideration, execution time, simultaneous construction of both harbour and terminal, safety requirements, navigational demands and the influence of the terminal on port activities.

A detailed soil investigation programme, hydraulic and wave diffraction tests, two- and three dimensional wave tank tests, mathematical calculations and a simulation programme of the LNG-vessel manoeuvres, were part of this study.

As a result of a new decision on the internal LNG-terminal concept (a conventional land-based terminal instead of a semi-prefabricated system), the lay-out study was adjusted and completed with vessel movement calculations, long wave resonance tests.

World Bank Symbols : Fields of specialization : TR-K511,K513
Types of services : 1j, 3g, 3i, 4a, 4c, 4g, 5e, 7a
Level of effort : class 1 (less than 20 man months)



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DREDGING WORKS

Location : Zeebrugge (Belgium)
Client : Tijdelijke Vereniging Zeebouw-Zeezand
Start of the study : 1976
End of the study : 1981

Brief description of the project :

The works for the extension of the outer harbour of Zeebrugge will require, among other operations, the dredging of 120,000,000 m³, in order to ensure access to the port for ships of 125,000 tdw.

Services :

In order to make an optimum choice concerning the access channel linking the port of Zeebrugge to the main shipping-lanes in the North Sea, an inventory of the various possible access routes was established. After an initial rough grading, three channels were chosen and were studied in detail.

The optimum choice results from the analysis of the following elements :

- dredging works for the realization of the channel
- dredging works for the maintenance of the channel
- the qualities and inconveniences of the three routes from a nautical point of view
- the number of wrecks to bring up
- the nature of the material to be dredged
- the possibility of reusing the dredged material for the beach nourishment work on the east coast.

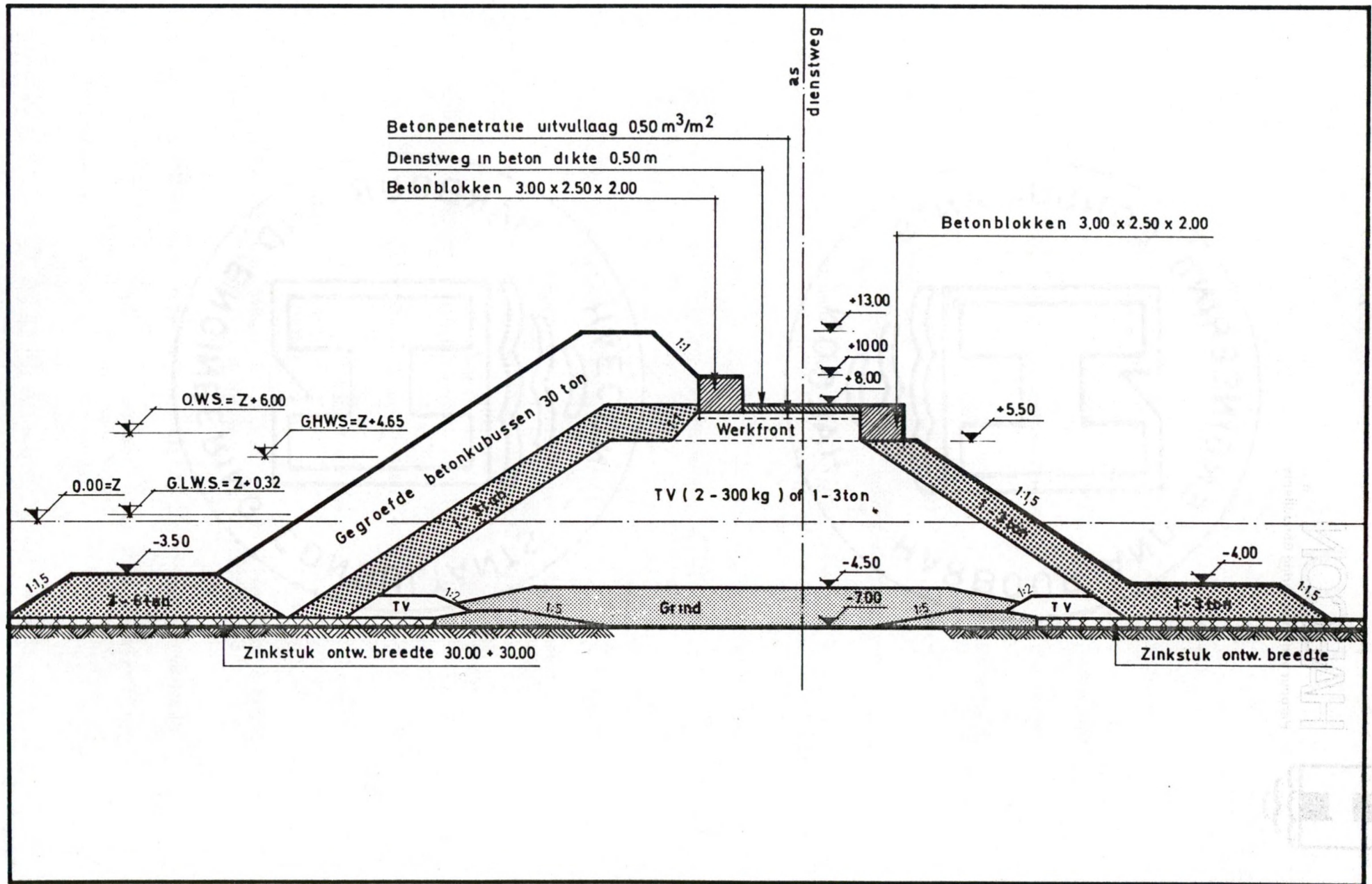
A provisional cross-section was then established, responding to the following requirements :

- traffic in both directions must be possible in the channel
- the channel must be accessible to the design ships
- the norms and safety margins must be respected

Using all these elements as a basis, a comparative study of costs determines the optimum choice of the route and allows the calculation of the cubic volume and the costs of the dredging.

Miscellaneous remarks : The study was carried out by HAECON-ZEEBRUGGE

World Bank Symbols : Fields of specialization : TR-K506
Types of services : 1d, 1e, 4a
Level of effort : class 2 (between 20 and 100 man months)





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BREAKWATER DESIGN : STABILITY ANALYSIS

Location : ZEEBRUGGE (Belgium)
Client : Tijdelijke Vereniging Zeebouw-Zeezand
Start of the study : 1976
End of the study : 1981

Brief description of the project :

To ensure access to the new sea-lock in Zeebrugge, 11,5 km of breakwater have to be constructed in the North Sea.

Within the general framework of the studies carried out by HAECON-ZEEBRUGGE the breakwater design occupies a central position of importance. In this design several stages have to be passed through. The overall stability analysis is one of the most important stages in the design development.

Services :

To begin this stability analysis the material characteristics should be determined. There is a difference between the rubble-mound layers and the soil layers. The characteristics of the soil layers are determined according to test procedures, generally accepted in soil mechanics. The determination of the characteristics of the rubble-mound layers is based on literature and experience.

Several situations have to be regarded :

- normal conditions
 - . overall-stability LLWS
 - . stability analysis during construction phase
- exceptional conditions
 - . exceptional LW without wave action
 - . stability analysis under wave-attack
 - . earthquake

For each situation the required safety coefficient is determined in accordance with the principal, The Ministry of Public Works

The stability analysis under wave-attack demands the determination of the design wave and the knowledge of the pore pressure during wave attack ;

- in the rubble-mound layers,
- in the soil layers.

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BREAKWATER DESIGN : STABILITY ANALYSIS

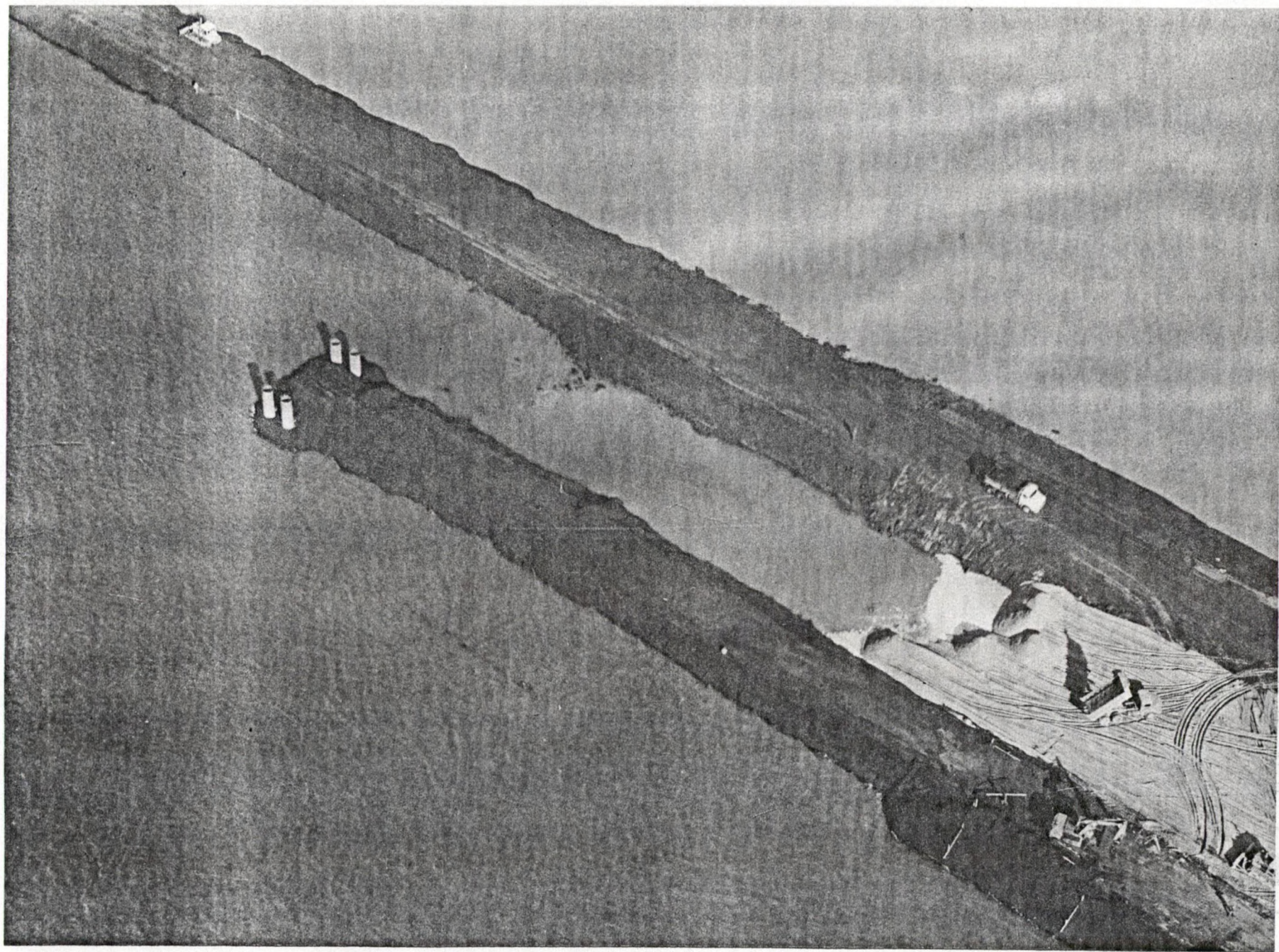
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Special technical problems :

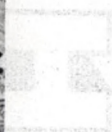
A special aspect of the stability analysis was the study of the liquefaction problem. The average density of natural sand and the dumped sand of the soil replacement have to be specified. The density of these layers should be greater than the control density in order to avoid liquefaction.

As the harbour of Zeebrugge is constructed in a zone with strong tidal currents, erosion of the soil layers along the breakwaters is expected. Special precautions have to be taken to avoid erosion influencing the overall-stability.

World Bank Symbols : Fields of specialization : TR-K510, K511
Types of services : 4a, 4b, 4c, 4d, 4g, 5b, 5e
Level of effort : class 4 (over 200 man months)



PHOTOGRAPH BY THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION





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BREAKWATER DESIGN OF THE PRIMARY ARMOUR

Location : Zeebrugge (Belgium)
Client : Tijdelijke Vereniging Zeebouw-Zeezand
Start of the study : 1976
End of the study : 1981

Brief description of the project :

Breakwaters are necessary to divert current and wave action so that the access to the new 125,000 tdw. sea lock is ensured and loading and unloading vessels is possible in the outer harbour. Breakwaters are thus an essential part of the extension works, and the nautical standards influence their shape and location.

Furthermore, the works should respond to stability requirements, both during the construction and final stages - requirements determined by the local wave climate, the tides and the currents. Finally, one must look for a structure which is as economical as possible, and execution techniques and material characteristics have to be considered.

Services :

Two type of breakwaters were studied and compared on the basis of costs, construction modes, risks and delays. One was a wedge-shaped type, the other was a vertical wall type. These studies proved that the wedge shaped type is preferable to the vertical wall type.

To set up the primary armour of the breakwater, cubic concrete blocks were used. The unit weight of these blocks, the height of the crest, the weight of the rock core component, as well as the height of the access road are determined by means of the following criteria :

- the breakwater must be conceived in such a way that it supports without damages the centennial wave $H_c \cong 6.50$ m
- under these same conditions the breakwater may be overtopped, provided no damage is caused to the construction.
- it has to be possible to use the feeder road for 80 % of the time.

The theoretical cross-section responding to these criteria has been studied in detail in the Central Hydraulic Laboratory in France at Maisons-Alfort, where it has been tested in two-dimensional and three-dimensional scale models.

Miscellaneous remarks : This study was carried by Haecon-Zeebrugge.

World Bank Symbols : Fields of specialization : TR-K510, K511,
Types of services : 1d, 1e, 1f, 1g, 1j, 3k, 4a, 4b, 4c, 4d, 4g,
Level of effort : class 4 (over 200 man-months)



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BEACH PROTECTION

Location : Belgian coast between Zeebrugge and the Dutch frontier

Client : Tijdelijke Vereniging Zeebouw-Zeezand

Start of the study : 1976

End of the study : 1981

Brief description of the project :

For over half a century the east coast of Belgium has been threatened with erosion. In 1976 certain areas of the beach were no more than 25 m wide at low tide, while at high tide the waves were eroding the base of the coastal dyke. Restoration and protection of this section of the coast was indispensable.

The following execution programme in 3 phases was carried out :

1. In a first stage the beaches of the east coast were restored with a supply of about 8,500,000 m³ of sand (one of the largest beach restorations ever realised) which increased the average width from 100 m to 250 m at low tide. The most suitable sand was found 20 km off the shore of Zeebrugge and was brought by dredger in to the port from where the pumping equipment and pipelines assured the distribution of the sand (production of about 200,000 m³/week). The sand supplying plan was determined within the total framework of the port extension.
2. On a parallel with the execution of these works, studies are in progress with a view to determining the long-term methods of protection by trying to diminish the lateral currents. Among other things, the influence of several types and of several implantations of breakwaters along the coast were analyzed with the help of a mathematical model which allows the calculation of the evolution of the coast under the influence of waves and currents (erosion, sand- filling, sedimentation, transport). On the other hand, a total refilling of the Appelzak was also studied, which would require about 7,000,000 m³, a quantity made available by the enormous dredging carried out for the new port and its access channels.
3. In 1976, since the beginning of the studies, a programme for the observation of the coast was put into operation. Numerous site measurements follow the evolution of the beaches over the years and will make it possible to indicate when intervention is necessary.

(Continued...)

BEACH PROTECTION

Page 2

- Services** :
- collecting and interpretation basic data
 - definition and follow-up of laboratory tests
 - definition and follow-up in situ tests
 - design of the beach restoration, supervision of the work

Special technical features :

In order to determine the development of currents, the transport flow, the capacities of transport and the dynamic evolution of the coast, the most modern techniques were put into operation : radioactive and fluorescent tracers, simulation of sediment transport by mathematical model, refraction calculations by computer, hydraulic simulation on physical models with fixed bottom combined with comprehensive measurements on site.

Miscellaneous remarks :

The restoration of the beaches must be studied within the general context of the port extension at Zeebrugge. The future port is going to decrease the increasing tidal currents in the Appenzak from 10 to 20 %, while those of the ebb tide will hardly be influenced .

- World Bank Symbols** :
- Field of specialization : K517
 - Types of services : 1a, 1d, 1e, 1g, 3k, 4a, 4c, 4g, 5b,
 - Level of effort : class 2 (from 20 to 100 man-months)



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YACHT HARBOURS

Locations : Belgian coast between ZEEBRUGGE and the DUTCH FRONTIER.

Client : Tijdelijke Vereniging Zeebouw-Zeezand

Start of the study : 1978

End of the study : 1978

Brief description of the project :

As the existing yacht harbour within the Zeebrugge port boundaries will be incompatible with a large port trading dangerous goods, the transfer of the yacht harbour to a new site outside the port premises is envisaged.

Services : Pre-projects for a yacht-harbour on three sites between Zeebrugge and Knokke
Estimation of building and maintenance costs.
Evaluation of their siting with respect to the regional development plan.

Miscellaneous remarks :

- The location adjacent to the enlarged harbour of Zeebrugge was preferred by the Ministry in view of its sheltered location, reduced costs, inland connections, and expected revitalization of the immediate area.
- This study was carried out by Haecon-Zeebrugge.

World Bank Symbols : Field of specialization : TR-K518,
Types of services : 2c, 3b, 4a,
Level of effort : class 1 (less than 20 man-months)



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SEDIMENT TRANSPORT STUDIES BY MEANS OF RADIOACTIVE TRACERS

Location : ZEEBRUGGE (Belgium)
Client : Tijdelijke Vereniging Zeebouw-Zeezand.
Start of the study : 1977
End of the study : 1979

Brief description of the project:

In 1979 the Ministry of Public Works commissioned HAECON-ZEEBRUGGE with the design of a new outer harbour in Zeebrugge. The studies on sediment transport described on this page form part of those design studies.

To study and perform a quantitative measurement of the sediment transport rate in situ, artificial radio-active tracers are used. After injection in the natural system, they are detected with highly sensitive scintillation-counters, which also give the amount of radioactivity.

These techniques are used both on the sea-bottom (bottom-transport of sand mixed or not mixed with mud) and the dispersion in the seawater (suspension tracer)

These experiments are of application in dredging works, pollution problems of dumping dredged spoil, evaluation of production of winning pits for sand and global sediment migration both quantitatively and qualitatively.

Services :

- survey : detection in the sea of the tracers
- research : dispersion calculations
- engineering : planning of dredging works
- regional development : pollution of mudbanks

World Bank Symbols : Fields of specialization : TR-K505, K506,
Types of services : 1b, 1i,
Level of effort : class 3 (from 100 to 200 man-months)



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SEDIMENT TRANSPORT STUDIES OF SUSPENSION IN SEA

Location : ZEEBRUGGE (Belgium)
Client : Tijdelijke Vereniging Zeebouw - Zeezand
Start of the study : 1975
End of the study : 1981

Brief description of the project :

To evaluate sediment transport in suspension by tidal currents and by waves, some 4000 water-samples were taken at several stations and at different levels. Simultaneous current-intensity measurements, water-depth soundings, wind-intensity and wave-climate registrations are performed. All survey-operations cover the whole tidal cycle.

Calculations are performed on resulting water-discharge and sediment transport. Erosion and sedimentation fluxes are computed. The mean suspension concentration in seawater is calculated for different wave-climates.

This allows calibration of sediment transport formulae, to determine the erosion or sedimentation areas and to evaluate the erosion and sedimentation rates.

Services :

- survey :
 - . water-sampling
 - . echo-sounding
 - . wave/wind registration
 - . water-velocity measurements
- research : suspension - samples - analysis
- computer assistance : calculation of discharges (liquid and solid)

Miscellaneous remarks : This study was carried out by Haecon - Zeebrugge

World Bank Symbols :
Field of Specialization : TR-K505
Types of services : 1i, 1j, 3i, 8e
Level of effort : class 1 (less than 20 man months)



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IN-SITU MEASUREMENT OF THE DENSITY OF LOOSE MUD DEPOSITS

Location : ZEEBRUGGE (Belgium)
Client : Tijdelijke Vereniging Zeebouw-Zeezand.
Start of the study : 1979
End of the study : 1981

Brief description of the project :

The in situ measurements of the density of loose mud deposits form part of the design studies for the Zeebrugge harbour extension.

Backscatter radioactivity gauges are used in the field to measure density profiles in loose mud deposits of the approach-channel and in the inner harbour. Knowledge of these density-profiles found secondary application in the dredging optimization and in the determination of the exact nautical depth.

All these data are used to draw a three-dimensional dredging and navigation chart.

Services :

- survey : hydrographic survey of loose mud deposits in the field ;
- regional development planning ;
- research ;
- engineering : estimation of production of dredgers.

Special technical features :

Assistance with the final development of the radioactive density gauge JTD 3 (ORIS - Saclay).

Miscellaneous remarks : These measurements were made by Haecon-Zeebrugge

World Bank Symbols : Fields of specialization : TR-K505, K506,
Types of services : 1b, 1i, 3g, 4b,
Level of effort : class 3 (between 100 and 200 man-months)



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LAY-OUT OF THE EASTERN OUTER HARBOUR

Location : ZEEBRUGGE (Belgium)
Client : Tijdelijke Vereniging Zeebouw-Zeezand.
Start of the study : 1978
End of the study : 1978

Brief description of the project :

HAECON-ZEEBRUGGE, being in charge of the conception and lay-out of the new outer harbour of Zeebrugge, studied in detail the effects of the implantation of a dangerous goods terminal within the existing port.

To compare its ideas with those of an independent marine safety expert, Lloyd's Register of Shipping was asked in 1978 to give its views on the arrangements incorporated in the design of the harbour and the LNG-terminal.

Being an expert on port and shipping safety matters, Lloyd's Register reviewed HAECON's proposals in the light of existing and foreseeable regulations and current safety thinking.

HAECON's lay-out was approved, provided a number of operational measures are taken when the operation of the terminal will start.

Services :

:

HAECON'S involvement in this safety study may to summarized as follows :

- formulation and discussion of the terms of reference ;
- supervision of the study, supply of all relevant data ;
- translation of the conclusions into the design of the harbour extension.

World Bank Symbols : Fields of specialization : TR-K101, K503, K507, K508, K509, K510, K511,
Types of services : 3k, 5e,
Level of effort : class 1 (less than 20 man-months)

2. **Advisory services by HAECON for the construction of the new
outer-harbour at Zeebrugge (1981-.....)**



HAECON n.v.
Harbour and Engineering Consultants

INTRODUCTION

The extension of the outer harbour of Zeebrugge is necessary to ensure access to the new sea-lock which has been under construction since 1971. In May 1976, the Government decided to install an LNG terminal within this extension.

Work began in January 1977. Acceptance of the work is estimated for the end of 1985. Ships will be able to have access to the new lock from 1983. The total construction cost estimated is about 1,500,000,000 US \$.

The work involves the construction of dykes in the North Sea with a total length of about 11.5 km. This will require 1,800,000 tons of gravel, 11,780,000 tons of stones and 64,000 concrete blocks of 25 tons. The project also requires dredging of about 120,000,000 m³ of which 8,500,000 m³ were used for restoration of the beaches on the Belgian east coast, which is one of the biggest operations of its kind in the world.

Engineering design for this construction project was made by Haecon-Zeebrugge during the years 1976-1981. In July 1981 Haecon was entrusted by the Ministry of Public Works with global supervision and the role of technical adviser.



HAECON n.v.
Harbour and Engineering Consultants

FOLLOW-UP : PHYSICAL AND MATHEMATICAL MODELS

Location : Zeebrugge (Belgium)
Client : Ministry of Public Works
Start of the study : July 1981
End of the study : -

Brief description of the project :

The construction of the new outer harbour in Zeebrugge is a 1,500,000,000 US\$ project. It is evident that the design has been tested on mathematical and physical models and is still continually being tested and improved. Within the general supervision tasks with which HAECON was entrusted in 1981 by the Ministry of Public Works, HAECON is particularly in charge of the follow-up of physical model tests in the hydraulic laboratory of Borgerhout (Belgium) and Maison Alfort (France) and of the mathematical model tests carried out by the University of Liège (Belgium).

HAECON developed also mathematical models of hydraulic and sedimentological phenomena, such as diffraction, refraction, erosion due to tide and wave action, etc.....

World Bank Symbols : Fields of specialization : K500,K504,K510,K511,K512,K513,K516
Types of services : 1d, 1j,3g,4a,5b,5d,5e,8b
Level of effort : class 3 (between 20 and 100 man months)



HAECON n.v.
Harbour and Engineering Consultants

FOLLOW-UP : BEACH EVOLUTION

Location : BETWEEN ZEEBRUGGE AND THE DUTCH FRONTIER
Client : Ministry of Public Works
Start of the study : July 1981
End of the study : -

Brief description of the project :

In the period 1977 - 1979 an important beach nourishment of about 8.5 million m³ of sand was realized on the Belgian East Coast, between the harbour of Zeebrugge and the Belgian Dutch frontier.

Within the framework of the advisory tasks, with which HAECON was commissioned a general beach observation programme is executed.

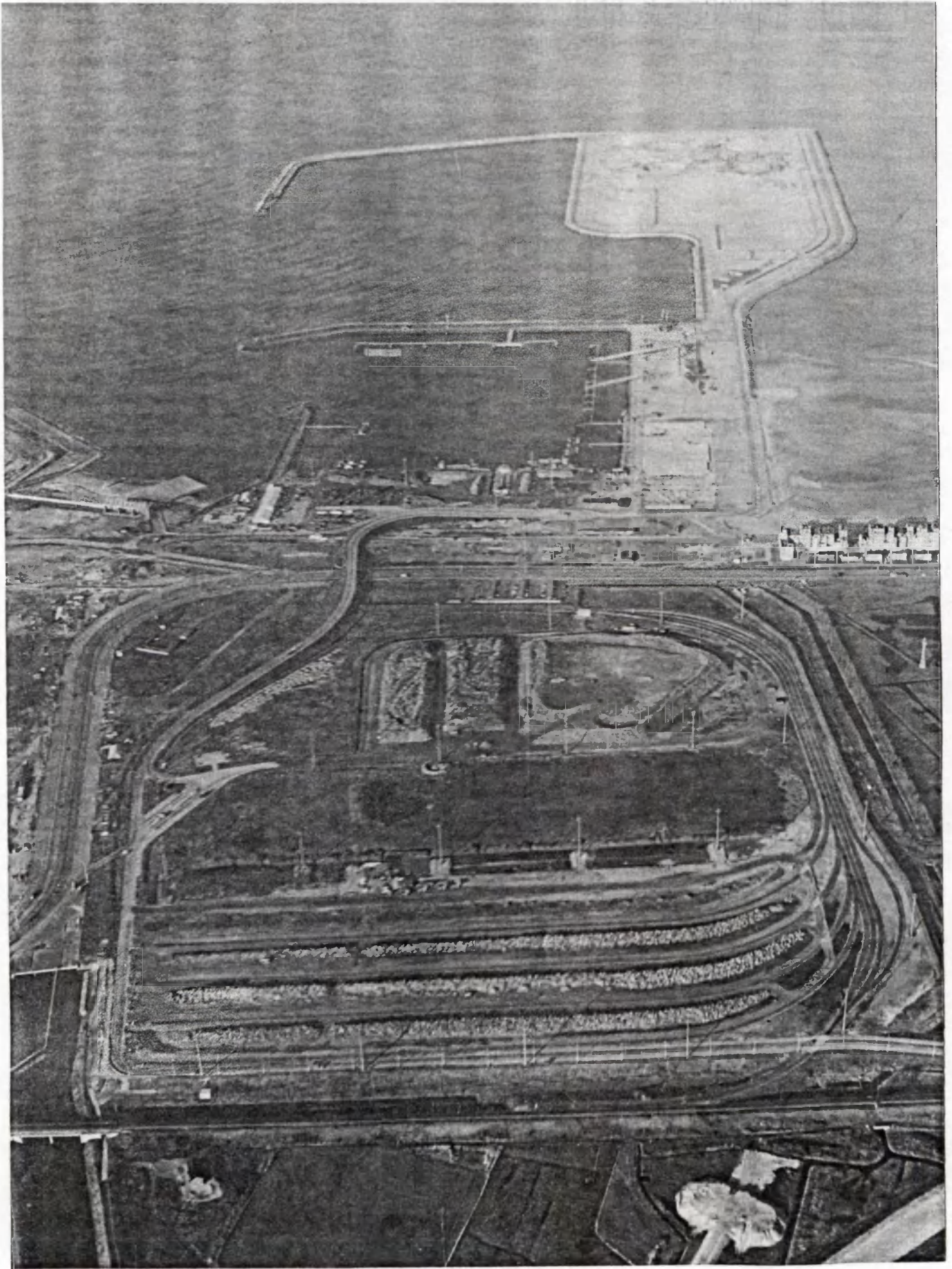
Services :

The programme includes aerial, hydrographic and topographic surveys. The data are compiled by HAECON and stored in a computer database. Through computer processing plans and cross-sections of beach and foreshore are drawn automatically. The variation of different coastal parameters as a function of time are calculated. These calculations enable HAECON to evaluate the coastal state at different time-intervals.

Other in-situ measurements are carried out to study transport mechanisms under different weather conditions and to verify eolean transport rates.

These measurements allow HAECON to calibrate the mathematical coastal models in order to foresee adequate protection measures should beach evolution prove that new protective options should be taken. The studies are still in progress.

World Bank Symbols : Fields of specialization : K517
Types of services : 1a,1d,1e,1g,3k,4a,4b,4g,5b,8b
Level of effort : class 2 (from 20 to 100 man months)





HAECON n.v.
Harbour and Engineering Consultants

SUPERVISION : BREAKWATER DESIGN AND CONSTRUCTION

Location : ZEEBRUGGE (Belgium)

Client : Ministry of Public Works

Start of the study : July 1981

End of the study : -

Brief description of the project :

Since 1976 the new outer harbour of Zeebrugge has been under construction. This includes the setting-out of about 11,5 km of breakwaters in the North Sea. In 1981 the Ministry of Public Works commissioned HAECON with the task of supervising the construction works.

Services :

The job does not merely consist of supervising the realization of existing plans, but also includes the revision of these plans, the follow-up of laboratory tests, the implementation of special measures against sea-bed erosion, the optimisation of the breakwater cross-sections, and the study of execution methods.

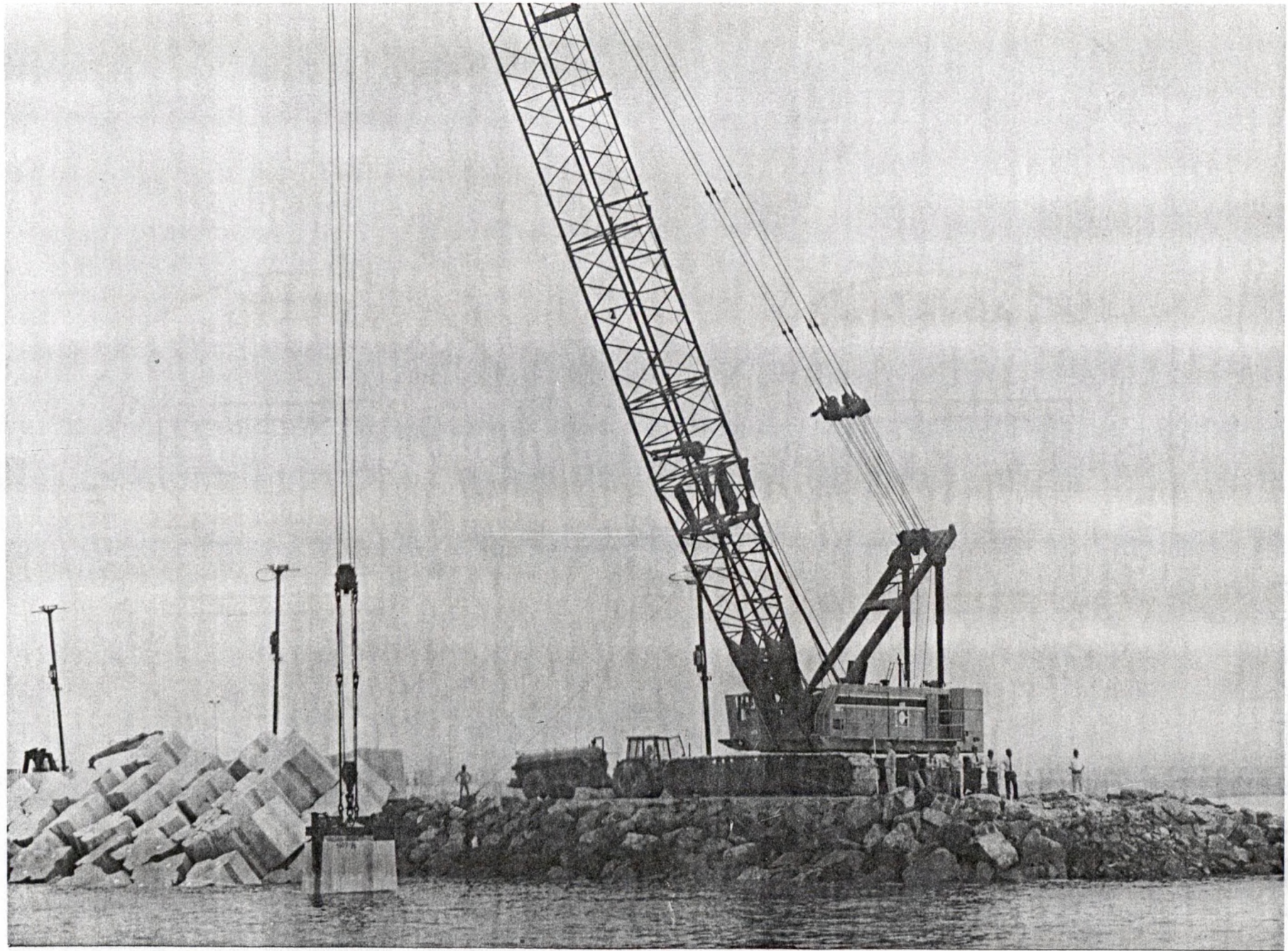
One of the most important items of this supervision is the comparison of the design criteria with the evolution on the site whilst the breakwaters are being constructed.

Miscellaneous remarks :

Some results of HAECON's advisory services can be particularly mentioned :

- a substantial reduction (up to $\approx 10\%$) in construction costs on the breakwater could be obtained through revisions to the cross-section ;
- the follow-up of the foundation works of the breakwater has permitted their successful realization ;
- a substantial reduction in the volume of core protection & filter layers against sea-bed erosion.

World Bank Symbols : Fields of specialization : TR-K510,K511,K516
Types of services: 3g,3h,4a,4b,4d,4f,5b,5e
Level of efforts : class 4 (over 200 man months)





HAECON n.v.
Harbour and Engineering Consultants

OPTIMIZATION OF MAINTENANCE DREDGING

Location : ENTRANCE CHANNELS AT ZEEBRUGGE

Client : Ministry of Public Works

Start of the study : July 1981

End of the study : -

Brief description of the project :

Once the most important port extension works have been completed, the approach channels must be maintained by systematic dredging works. Moreover Zeebrugge has at the moment, one of the highest sediment loadings in the world, more than 60 million tons of mud/year.

During the follow-up of the works, HAECON is investigating the feasibility of upgrading the dredging programme as a whole. This study is, carried out in close association with sedimentological studies which determine numerous criteria.

Services :

- elementary survey of mud parameters (rheology) ;
- transport calculations, direction and quantity (transfer functions) of the sediment-flux ;
- data-processing of echo-soundings to track plots for maintenance dredging.
- forecasting sedimentological tendencies for the coastal zone;
- study of the existing dredging methods and the feasibility of upgrading the dredging programme.

World Bank Symbols : Fields of specialization : TR-K505, K506
Types of services : 1b,1c,1d,1g,5e,7a,7b
Level of effort : class 2 (from 20 to 100 man months)



HAECON n.v.
Harbour and Engineering Consultants

**BASIC RHEOLOGICAL RESEARCH OF MUD
SEDIMENTS IN ESTUARIA AND SEA**

Location : ZEEBRUGGE (Belgium)

Client : Ministry of Public Works

Start of the study : July 1981

End of the study : -

Brief description of the project :

In 1981 the Ministry of Public Works commissioned HAECON with a general advisory role for the new outer harbour under construction in Zeebrugge. The studies described on this page form part of those advisory services.

Bingham plastic behaviour of mud sediments is analysed and applied to erosion.

These properties are analysed in the laboratory and can be calculated from in situ data on the composition and density of the mud.

The studies also investigate the dispersion of dredged spoil dumped at sea.

Services :

- research : laboratory study
- engineering : . stability of mud bottoms
 . erosion of mud bottoms
- computer support : interpretation of analysis, results

World Bank Symbols : Fields of specialization : TR-K506, K505
Types of services : 1b,1j,3i,3k,4b
Level of effort : class 2 (from 20 to 100 man months)



HAECON n.v.
Harbour and Engineering Consultants

MATHEMATICAL DESCRIPTION AND PREDICTION OF SEDIMENT TRANSPORT IN SUSPENSION

Location : ZEEBRUGGE (Belgium)

Client : Ministry of Public Works

Start of the study : 1981

End of the study : 1982

Brief description of the project :

In 1981 the Ministry of Public Works commissioned HAECON with a general advisory role for the new outer harbour under construction at Zeebrugge. The studies on sediment transport described on this page form part of those services.

On the base of data obtained from in situ measurements of water velocity, suspension-concentration, water depth, wave-activity, etc., a model is set up for calibration and prediction of sediment-transport when one of the influencing parameters is changed.

The model is based on the spectral analysis of periodic signals, indicative of most tidal-phenomena .

The model is most useful when civil works tend to set up changes in the bottom morphology or the current pattern of an area.

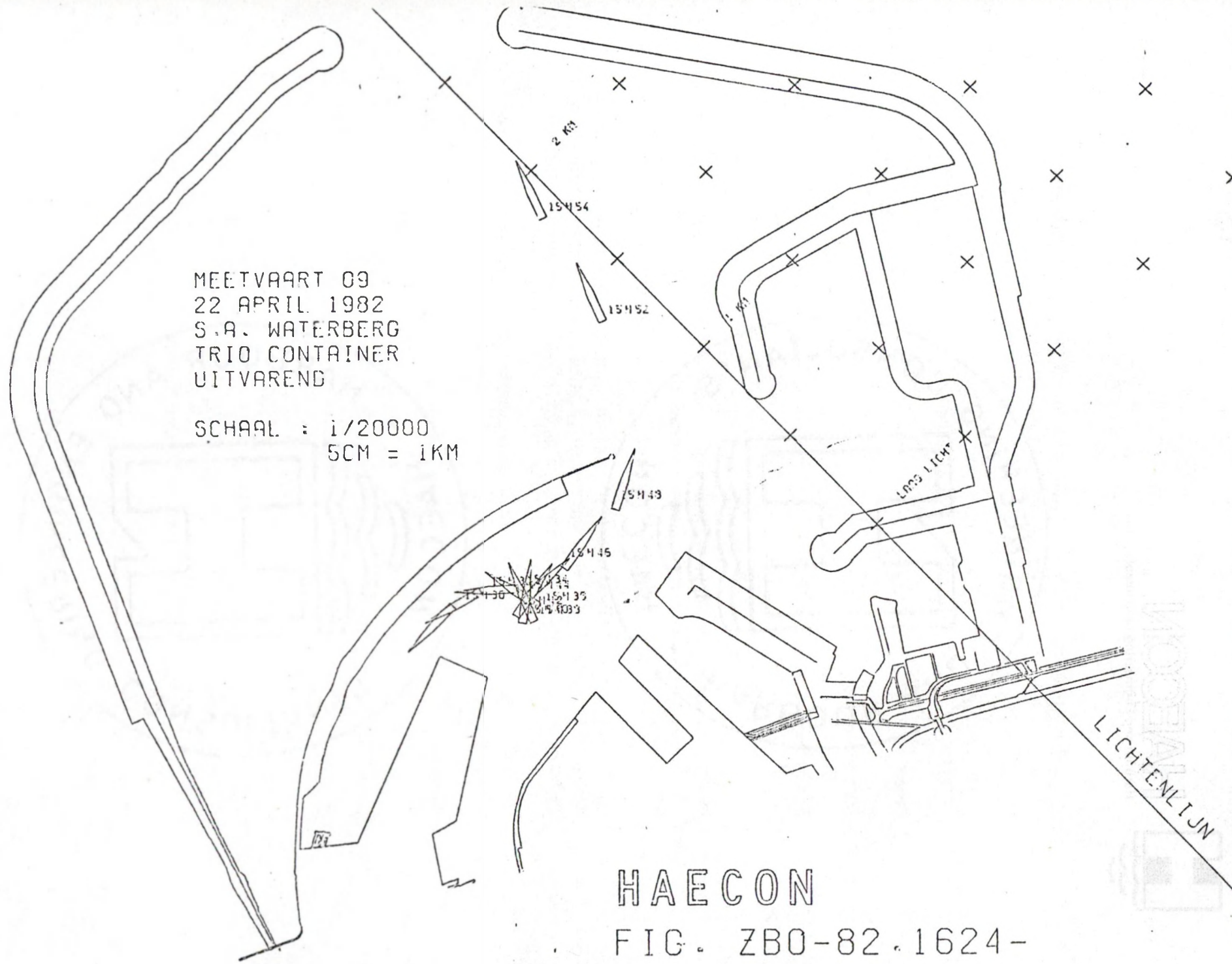
Services :

- computer support
- research
- regional development planning

World Bank Symbols : Fields of specialization : K505
Types of services : 1i,3i,8c
Level of effort : class 1 (less than 20 man months)

MEETVAART 09
22 APRIL 1982
S.A. WATERBERG
TRIO CONTAINER
UITVAREND

SCHAAL : 1/20000
5CM = 1KM



HAECON

FIG. ZBO-82.1624-



HAECON n.v.
Harbour and Engineering Consultants

NAUTICAL STUDIES

Location : Zeebrugge (Belgium)
Client : Ministry of Public Works
Start of the study : July 1981
End of the study : -

Brief description of the project :

In June 1981, the Coastal Service of the Belgian Ministry of Public Works entrusted HAECON with a global programme of marine observation and technical assistance in and around the harbour at Zeebrugge. Amongst these duties, HAECON had to investigate, advise and guarantee the port approaches for the existing and projected shipping.

Services :

1. studies carried-out by the Dutch marine research service, MARIN, at their hydraulic laboratory in Wageningen. A series of trial runs on the ship simulator analyzed the manoeuvres made by LNG-carriers, the VLCC'S, and the trio-container ships during the different stages of encroachment, as defined by the extension of the peripheral breakwaters seaward. HAECON supervised the trial specifications and analyzed the results. HAECON also investigated the existing traffic pattern and incorporated this into its reports.
2. survey runs in-situ recorded on-board in-and outgoing ships by the oceanographic survey office of TVZ2 on behalf of the client. HAECON is responsible for all data processing and technical interpretation of these test-runs.
3. navigational aids for the harbour :
repositioning and/or renewal of navigation buoys and/or light beacons. HAECON works here directly for the client, advising on particular topics, and studying in-depth when requested.

World Bank Symbols : Fields of specialization: TR-K101a, K101d, K507, K511, K515, K602, K604
Types of services : 3g, 5e, 8b
Level of effort: class 2 (from 20 to 100 man months)



HAECON n.v.
Harbour and Engineering Consultants

EVALUATION BEACH PROTECTION PLAN

Location : OOSTENDE
Client : Ministry of Public Works
Start of the study : 1982
End of the study : 1982

Brief description of the project :

At present, during storm conditions, waves frequently overtop the existing sea dyke in Ostend.

Haecon was asked to evaluate a coastal defence plan, proposed by the Belgian Ministry of Public Works.

Services :

First of all Haecon examined if present wave-overtopping of the seadike can be effectively prevented.

Secondly, HAECON is investigating if such coastal defence works might cause additional maintenance dredging of the harbour entrance ; alternative solutions, reducing littoral transport towards the harbour, are being compared.

World Bank Symbols : Fields of specialization: K517
Types of services: 3g,3k,4a,5c
Level of effort : class 1 (less than 20 man months)



HAECON n.v.
Harbour and Engineering Consultants

COMPUTER, PROCESSING PHYSICAL DATA

Location : ZEEBRUGGE (Belgium)

Client : Ministry of Public Works

Start of the study : July 1981

End of the study : -

Brief description of the project :

The collection and storage, processing and interpretation of physical data for the construction works of the new outer harbour in Zeebrugge form part of the global supervision task with which HAECON has been entrusted.

Services :

HAECON writes specifications of the survey methods, processes the recorded data with its specially-developed software, performs the statistical analysis and synthesis of the results, draws comparative plans and diagrams and writes reports, discussing these results with those of the physical data.

Following aspects are treated :

- currents,
- tidal levels,
- waves,
- meteorological data,
- seiches,
- bathymetric data,
- sediment transport,
- sea-bed parameters,
- topographic and hydrographic data of the beaches near Zeebrugge,
- pore water pressure measurements in foundation soils.

The concentrated data is further used in nautical, hydraulic, sedimentological and geotechnical analysis. The design parameters are permanently checked and optimized.

HAECON does the same collecting, processing and interpretation job for data about the construction itself (quantities of used materials,).

World Bank Symbols : Fields of specialization : K500, K504, K510, K511, K512, K513, K516
Types of services : 1a, 1d, 1e, 1f, 1g, 3g, 4a, 4b, 4c, 4d, 4e, 4f, 4g, 5b, 5c, 5d, 5e, 8b
Level of effort : class 4 (over 200 man months)

**3. Miscellaneous projects in the port of Zeebrugge
(1968 -)**



HAECON n.v.
Harbour and Engineering Consultants

INTRODUCTION

Apart from the design of the outer harbour - made by Haecon-Zeebrugge in the years 1976 - 1981 - and the advisory services for the outer harbour construction - with which Haecon was entrusted from July 1981 onwards - Haecon was also in charge of several other projects in Zeebrugge.

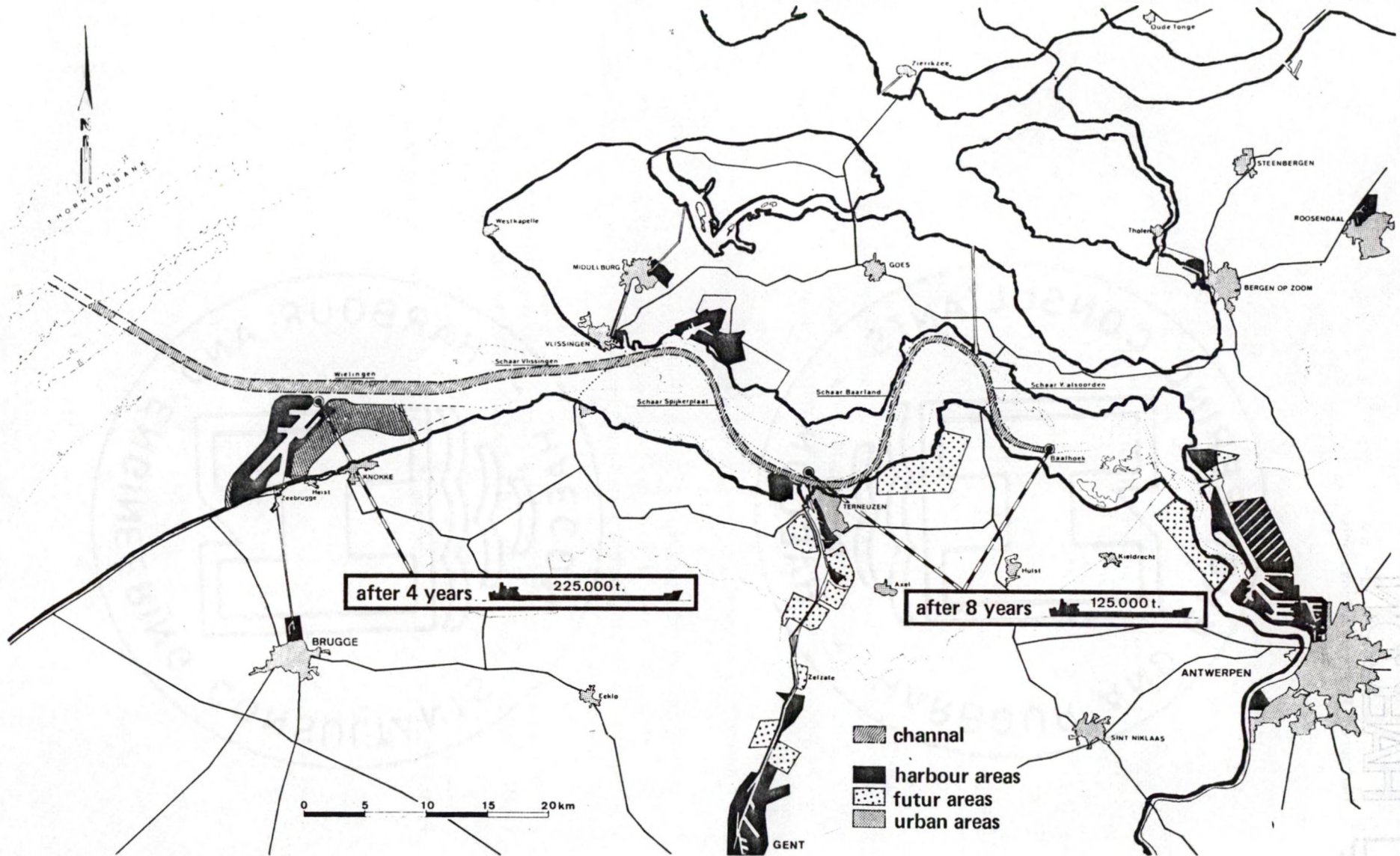
We mention here, in particular, three regional planning studies :

- project Zeestad, requested by the Zeestad-promotors in '68-'69,
- Symarinfra, study requested by the Ministry of Regional Development
- Lay-out Zeebrugge western outer harbour, master plan for the Bruges Harbour Authority (MBZ)

Haecon was also responsible for the pre-design of a new bulk cargo-handling facility (1981), for the design (1980) and installation (1983) of a new harbour approach-aid.

Further details are given of these miscellaneous studies on the following pages.

PROJECT "ZEESTAD" 1968-1969





HAECON n.v.
Harbour and Engineering Consultants

ZEESTAD
(Study for a port in deep water)

Location : Zeebrugge (Belgium)
Client : Zeestad consortium, Ghent (Belgium)
Start of the study : 1968
End of the study : 1969

Brief description of the project :

The idea "Zeestad" originated from a study on the accessibility of the Westerschelde estuary to 125,000 tdw ships. To provide this access enormous quantities would have to be dredged.

Dredging operations are located in three areas :

- a. across the "Vlaamse Banken" towards the deep waters of the North Sea ;
- b. in the estuary;
- c. on the sand bars of the Westerschelde.

Most of the dredging is located in the Westerschelde estuary.

The economic solution of such work depends on the proximity of dumping areas for the dredged sediments. The idea of using dredging for expanding the port of Zeebrugge originated for this reason.

Furthermore, it appeared beneficial to align the dykes so as to safeguard the growth of Zeebrugge, hence directing natural currents to contribute to the maintenance of the dredged channel in the estuary. The backfilling of dredged sand behind the dykes will allow reclamation of large areas from the sea.

Part of the reclaimed territory must be reserved for the port. The rest becomes available for the creation of a residential and recreation area, the location of which should be such that the touristic value of the existing seaside resorts is integrally preserved. To fulfil this requirement the creation of a lagoon between the actual coast and the land reclaimed from the sea is being considered.

However, once it is decided to realize such a costly project, it is worth studying if it is not possible to make the port accessible to ships of 225,000 tdw. Analysis proved such would require only a limited additional cost (for a dredging supplement relatively reduced across the "Vlaamse Banken") and would give considerable benefit.

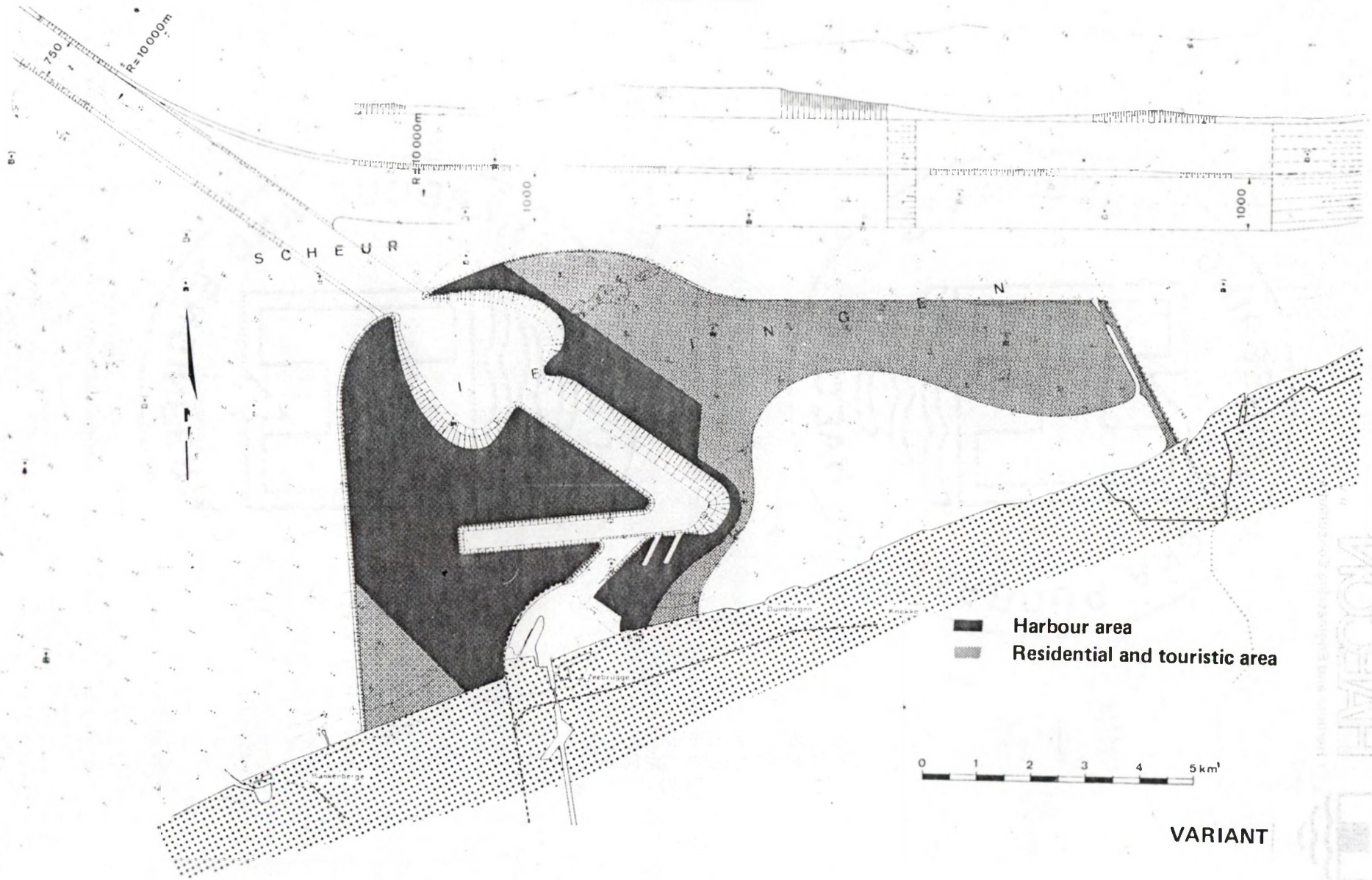
Thus the "Zeestad" project was progressively evolved, as shown on the following pages.

Services- :

Feasibility study carried out by a multi-disciplinary team with the collaboration of engineers, jurists, economists and specialists in matters of town planning and ecology.

(Continued.....)

PROJECT "ZEESTAD"
1968 - 1969



VARIANT

MOCEAH





ZEESTAD

page 2

Special technical features :

The prime advantage of the "Zeestad" project would have been to ensure, in the immediate future as well as in the long term, the expansion of all the Belgian maritime ports.

In fact :

- the accessibility of the Antwerp complex (Baalhoek) would have increased, and during the second five-year period of the operations, it would extend to 125,000 tdw. ships ;
- at the same time Ghent would have been accessible for 125,000 tdw. ships ;
- "Zeestad" would have been able to accept ships up to 225,000 tdw. - this being towards the end of the first five-year stage of the operations.

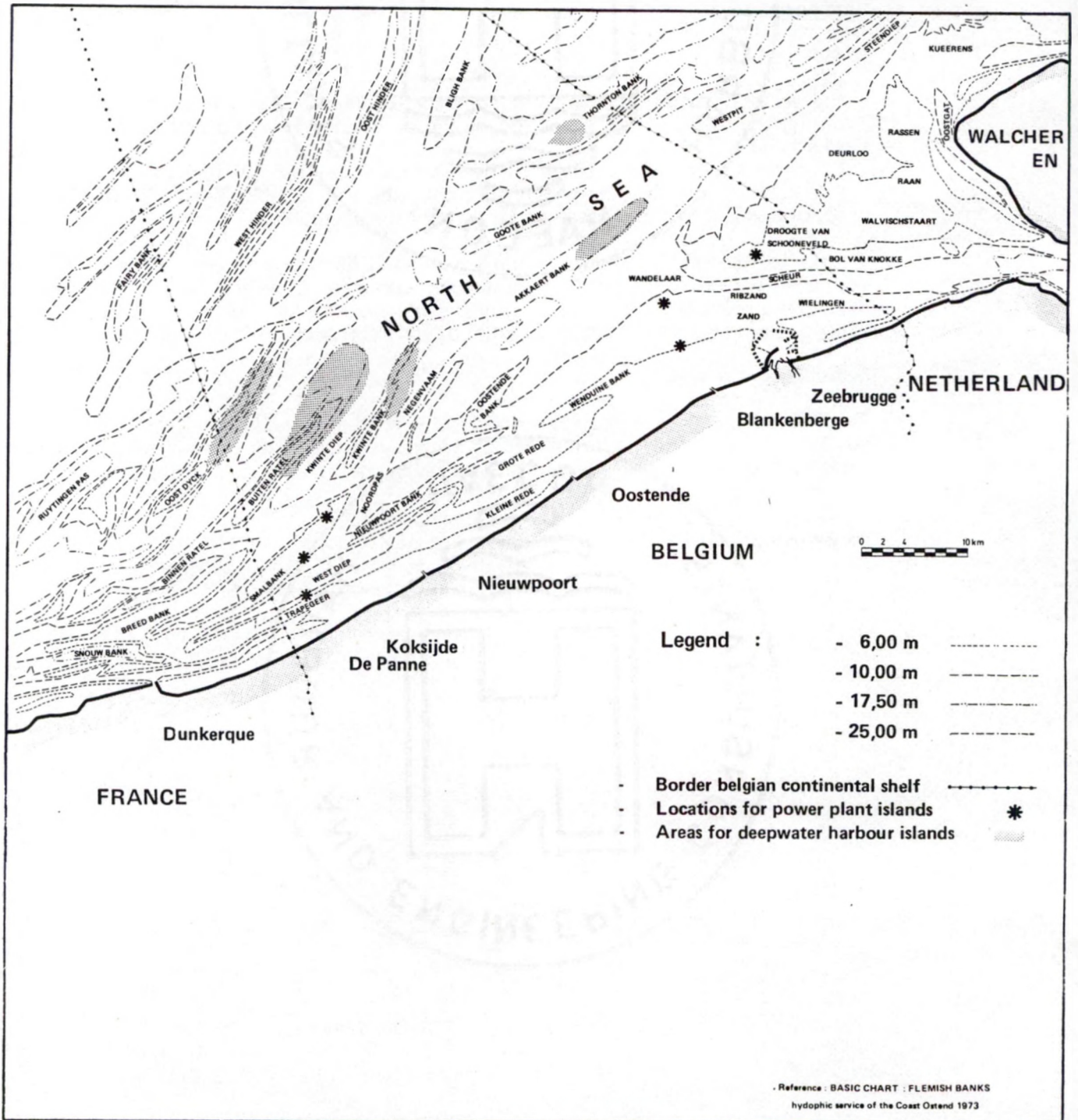
Thanks to "Zeestad", Belgium would have had at its disposal a port in the open sea with easy access, which would have allowed container ships and bulk carriers to be loaded and unloaded extremely quickly (independent of the rise of the rivers and the locks). Zeestad would have made Belgium directly accessible to mammoth tankers.

Miscellaneous remarks :

The " Zeestad " project was not realized in the form presented in the years 1968-1969 but it was at the basis of all discussions, studies and extension plans elaborated since then for the maritime development of the Belgian coast.

World Bank Symbols : Fields of specialization : K504, K506, K511,
Types of services : 3b, 3d, 3g, 3i,
Level of effort : class 2 (from 20 to 100 man-months)

BELGIUM
 OFFSHORE
 SYMARINFRA
 1973-1975





HAECON n.v.
Harbour and Engineering Consultants

SYMARINFRA
Possible infrastructures in the Belgian maritime regions

Location : BELGIAN COAST
Client : Symarinfra / L.L. & N. De Meyer
Start of the study : 1973
End of the study : 1975

Brief description of the project :

Towards the end of 1973 a study syndicate was formed by the Department for industrial promotion (Ministry of Economic Affairs), the National Investment Company (a state holding of the Ministry of Finance) and the company L.L. & N. De Meyer N.V. The object was to study the possible infrastructures in the Belgian maritime regions, from which originated the name of the syndicate: Symarinfra.

Haecon collaborated in this study as technical advisor for L.L. & N. De Meyer N.V. The study was requested by the Secretary of State for Flemish Regional Economy.

As much as for industrialization as for energy supply, maritime regions can play an important role in the national economy. In particular, Symarinfra studied the possibilities of implanting electric power stations (the sea furnishing the necessary cooling water) and a LNG terminal (to receive the liquified natural gas that Belgium intends to import from Algeria, following contracts concluded between the respective governments).

These areas of import and energy production can serve as attraction poles for other industries, notably when using the heat lost through electricity production, and when using the cold of the imported liquid LNG at minus 165° C. On the other hand, the maritime regions are of national importance from a touristic and agronomic point of view. As a result, the ecological impact cannot be neglected when selecting solutions. HAECON concentrated on the possibilities of port extension at Zeebrugge and the technical feasibility of an island off the coast, serving as a basis for an electric power-station ,or for a methane gas terminal.

The technical aspects for the construction of an artificial island were studied. The analysis revealed 4 preferred zones (from a technical point of view) for the location of an island serving as a basis for electric power-stations, and two preferred areas for islands designed for receiving ships with a 30 m. draught. The influence of the island on the currents, on the beaches and on the navigable channels was analyzed. The cost and the time required for construction of the island were studied.

For seven sites selected as possible locations for a nuclear power-station, the legal and ecological aspects were studied. A comparative evaluation was established.

SYMARINFRA

Page 2

With regard to the port of Zeebrugge, the study showed that an extension of the outer harbour was necessary in order to ensure access to the new lock under construction since 1971. A series of preliminary plans were made and tested in the hydraulic laboratory. The tests made it possible to conclude that an extension of the port was technically feasible. The possible activities involved in this extension were studied. The cost of the operation was estimated.

Miscellaneous remarks :

These studies have been achieved within the estimated duration and served as a basis in establishing the governmental policy in relation to the port of Zeebrugge.;

World Bank Symbols : Field of specialization : TR-K510, K511,
Types of services : 3b, 3g, 3i
Level of effort : class 1 (less than 20 man-months)



HAECON n.v.
Harbour and Engineering Consultants

TECHNICAL ASSISTANCE : PORT OPERATIONS

Locations : Port of Zeebrugge

Client : Maatschappij der Brugse Zeevaartinrichtingen, Brugge/Belgium.

Start of the study : 1981

End of the study : -

Brief description of the project :

Technical assistance for the harbour authority. The specific problems to be studied are drawn-up monthly meetings of the harbour authority (Maatschappij der Brugse Zeevaartinrichtingen) and the consultant (Haecon).

Services :

- In 1981 and 1982 a traffic simulation of the port has been set up, in order to gauge the influence of certain safety measures (for the LNG carriers) on the frequency of berth occupation and possible queueing delays for other incoming ships.
- In 1983 an analysis will be made of all functions and duties of the control office for port operations;

World Bank Symbols : Fields of specialization : TR-K101d, K503, K507, K515, K516b, K602
Types of services : 3g, 5e
Level of effort : class 1 (less than 20 man -months)



HAECON n.v.
Harbour and Engineering Consultants

HARBOUR APPROACH AID

Location : ZEEBRUGGE (Belgium)
Client : Ministry of Public Works
Start of the study : 1979
End of the study : 1983

Brief description of the project :

Design and installation of a guiding system for large ships coming in (or leaving) Zeebrugge harbour.

The guiding-system comprises :

- 7 mobile stations which are placed by the pilot on-board ship whilst sailing in or out of port, with 2 mobiles in reserve
- 3 remote stations (Ranging Processors) implanted at 3 key coastal locations
- 1 control station that allows the position, speed, and the drift off-course to be measured
- 1 reference station out at sea

The control station sets, via standard telephone lines, the call-code with the mobile stations, to which the remote stations must also be tuned (Ranging Processors). The latter measure the distance between the mobile stations and each of the 3 remote stations on-land.

These three distances are sent down the telephone line to the control station which defines the position, speed, and the deviation off mid-course in the navigation channel, and the actual course being sailed.

This data is sent to the 3 ranging-processors, which in turn pipe it through to the mobile stations. The course can be then be tracked on the screen display of a mobile station, in other words on-board the incoming ship.

Total value of the works and studies is estimated at some 40 million Belgian Francs.

Miscellaneous remarks :

- Client is the contracting firm TVZ2, a consortium responsible for the harbour extension at Zeebrugge. The owner is the Ministry of Public Works and the operating body will be the Ministry of Transport.
- HAECON assumed leadership and full design, follow-up and supervision of installation. Motorola SA of France were subcontracted for delivery of all electronic equipment.

World Bank Symbols : Fields of specialization : TR-K101b, K503, K515, K516b,
Types of services : 3b, 3g, 5a, 5c, 5d, 8b,
Level of effort : class 3 (from 100 - 200 man-months)



HAECON

n.v.

Harbour and Engineering Consultants **SEABULK TERMINAL**

Location : ZEEBRUGGE (Belgium)
Client : NV Seabulk, Brugge (Belgium)
Start of the study : February 1981
End of the study : July 1981

Brief description of the project :

Bulk cargo terminal in the inner harbour at Zeebrugge. The project foresees a yard throughput of 8 million tons/year after 5 years, made up of steam coals, coking coal, iron ore and phosphates, increasing to 16 million tons year after 15 years. Total investment for the project is valued at around 3.9 thousand million Belgian francs (1981 prices), to be realized in phases over several years.

Services : pre-study

Special technical features :

The stockpiling areas would be spread over some 322.000 m². The ironore stockpiles, 14 to 16 m high, exercise a great load on the pavement structure and the subgrade. Since the ground was characterized by a very variable and weakly-layered structure, this posed serious problems. The detailed geotechnical study investigated various solutions to guarantee the pavement structure. The environmental study served as a basis for an ecological appraisal of possible hazards or hinderance to the local community.

A rolling stock survey was also made of the ship pallets and railway wagons currently used for bulk cargo traffic to and from the port. The future trends in wagon types, and the distribution of arrival and loading patterns/day were also examined.

The latter served to determine the requirements for the loading and off-loading equipment, as well as for forming a basis for a computer simulation, that was used to optimize the number of transit utilities and to set their working capacities.

The technical pre-study investigated several variants for the heavy-duty machinery (cranes, stacker-reclaimers, ...), defined possible automatizations, pre-weighing, and representative sampling. The power supply and distribution over the yard, civil works, and maintenance of all equipment were also foreseen.

Based on this study one could lastly carry-out an economic analysis to finalize the staff quotas needed, the levels of management, the phasing of construction, as well as the investment, start-up and commercialization of the terminal.

Miscellaneous remarks :

The study was carried out by the joint venture HAECON-SECAR.

World Bank Symbols : Fields of specialization: TR-K101a,K101d,K101e,K103,K501,K508,K513, K516b.
Types of services: 3b,3g,3h,3i,4a,4b,4f.
Level of effort: class 2 (between 20 and 100 man-months)



HAECON n.v.
Harbour and Engineering Consultants

TRANSPORTATION SECTOR

STUDIES MADE BY HAECON IN ZEEBRUGGE (Belgium)

Regional planning studies

- 1968 - 1969 : Zeestad
- 1973 - 1975 : Symarinfra

Studies made by HAECON-ZEEBRUGGE (1976 - 1981)

Design studies for the extension of the outer- harbour at Zeebrugge.

- 1976 : Preproject harbour extension
- 1976 - 1981 : Geotechnical surveys
- 1976 - 1981 : Survey of sea-bottom lithology
- 1976 - 1981 : Sediment transport - studies of suspension in sea
- 1976 - 1981 : Master plan harbour extension
- 1976 - 1977 : Central work area
- 1976 - 1977 : Work harbour lay-out.
- 1976 - 1977 : Sandasphalt - breakwaters.
- 1976 - 1981 : Nautical studies
- 1976 - 1981 : LNG-dock
- 1976 - 1981 : Dredging works
- 1976 - 1981 : Breakwater design : stability analysis
- 1976 - 1981 : Breakwater : design of the primary armour
- 1976 - 1981 : Beach protection
- 1976 - 1981 : Yacht harbours
- 1977 - 1979 : Sediment transport studies by means of radio-active tracers
- 1979 - 1981 : In situ measurement of the density of loose mud deposits
- 1979 : Physical properties of mud and sand sediments
- 1979 : Lay-out eastern outer harbour
- 1981 : Western work area..

TRANSPORTATION SECTOR

STUDIES MADE BY HAECON IN ZEEBRUGGE (Belgium)

Advisory services by HAECON for the construction of the new outer-harbour at Zeebrugge (1981 -)

- 1981 - : Computer processing : physical data
- 1981 - : Follow-up : physical and mathematical models
- 1981 - : Follow-up : beach evolution
- 1981 - : Supervision : breakwater design and construction
- 1981 - : Optimization of maintenance dredging
- 1981 - : Basic rheological research of mud sediments in estuaria and sea
- 1981 - : Nautical studies
- 1981 - 1982 : Mathematical description and prediction of sediment transport in suspension
- 1982 : Ostend - evaluation beach protection plan
- 1982 - : Dock for dangerous goods.



HAECON n.v.
Harbour and Engineering Consultants

TRANSPORTATION SECTOR

STUDIES MADE BY HAECON IN ZEEBRUGGE (BELGIUM)

Miscellaneous projects :

- 1979 - 1983 : Harbour approach aid
- 1981 : Seabulk terminal
- 1981 : Technical assistance : port operations
- 1982 - ... : Lay-out Zeebrugge western outer harbour.

WORLD
BANK
SYMBOLS

**WORLD BANK SYMBOLS
TRANSPORTATION SECTOR**

Fields of specialization

TR-K100 : General

TR-K101 : National/regional multimodal transportation planning

TR-K101a : Traffic/Origin - destination surveys

TR-K101b : Information systems

TR-K101d : Transportation models

TR-K101e : Policies and investment programs

TR-K102 : Intermodal transportation technology

TR-K103 : Intermodal freight terminals

TR-K200 : Road transportation facilities

TR-K203 : New structures, reconstruction

TR-K203a : Bridges

TR-K203b : Tunnels

TR-K203c : Interchanges

TR-K203d : Ferry structures

TR-K400 : Rail transportation

TR-K401 : Demand forecasting and investment planning

TR-K407 : Structures

TR-K407b : Tunnels

WORLD BANK SYMBOLS

TRANSPORTATION SECTOR

Fields of specialization

- TR-K500 : Seaports and river ports

- TR-K501 : Demand forecasting and investment planning
- TR-K502 : Financial analysis, costing and tariffs
- TR-K503 : Management and organizational development
- TR-K504 : Harbours, piers, wharves
- TR-K505 : Port maintenance
- TR-K506 : Dredging and reclamation
- TR-K507 : Port operations
- TR-K508 : Warehouses and storage
- TR-K509 : Bulk cargo handling facilities
- TR-K510 : Offshore facilities
- TR-K511 : Deep sea ports
- TR-K512 : Container ports
- TR-K513 : Bulk (wet and dry) ports
- TR-K514 : Cargo handling operations
- TR-K515 : Navigational aids
- TR-K516 : Computer applications
- TR-K516a : Information systems
- TR-K516b : Port operations
- TR-K517 : Beach protection

- TR-K600 : Shipping

- TR-K602 : Management and operations
- TR-K604 : Vessels
- TR-K604a : Tankers, bulk/general cargo vessels, etc.
- TR-K604b : Coastal shipping vessels
- TR-K604c : Inland waterway vessels
- TR-K604d : Ferries
- TR-K605 : Shipbuilding and repairing
- TR-K605a : Shipbuilding
- TR-K605b : Ship maintenance and repairing
- TR-K605c : Shipyards
- TR-K605d : Dry docks
- TR-K605e : Floating docks
- TR-K605g : Marine engineering

WORLD BANK SYMBOLS
TRANSPORTATION SECTOR

TR-K700	:	Inland waterways
TR-K701	:	Demand forecasting and investment planning
TR-K702	:	Management and organizational development
TR-K703	:	River regulation and control
TR-K704	:	Dredging and reclamation
TR-K705	:	Navigation locks and dams
TR-K706	:	Canals
TR-K707	:	Ports
TR-K708	:	Jetties
TR-K709	:	Maintenance
TR-K710	:	Navigational aids
TR-K711	:	Dockyards and vessel repair facilities

Level of effort :

Class 1	:	Fee less than US \$ 100,000 or 20 man months
Class 2	:	Fee from US \$ 100,000 to US \$ 500,000 or from 20 man months to 100 man months
Class 3	:	Fee from US \$ 500,000 to US 1,000,000 or from 100 man months to 200 man months
Class 4	:	Fee over US \$ 1,000,000 or over 200 man months

**WORLD BANK SYMBOLS
TRANSPORTATION SECTOR**

Types of services

- 1a : Aerial surveys, satellite imagery
- 1b : Geological surveys,
- 1c : Geophysical surveys,
- 1e : Hydrological surveys,
- 1g : Topographic surveys,
- 1f : Soil surveys,
- 1i : Oceanography
- 1j : Laboratory tests,
- 2c : Regional development plans
- 3a : Planning studies,
- 3b : Feasibility studies,
- 3c : Market studies
- 3d : Economic studies,
- 3e : Financial studies,
- 3f : Tariff studies
- 3g : Technical studies,
- 3h : Operations studies,
- 3i : Environmental studies
- 3j : Sociological studies,
- 3k : Research design/evaluation,
- 4a : Design-architectural, engineering, industrial etc.
- 4b : Soil mechanics and foundation engineering,
- 4c : Hydraulics studies and engineering,
- 4d : Earthquake engineering,
- 4e : Sabo (landslide protection) engineering,
- 4f : Quantity surveying, cost estimation,
- 4g : Estimation, preparation of contract documents and bid evaluation,
- 5b : Supervision/inspection of construction,
- 5e : Technical assistance and advisory services,
- 7a : Operations and maintenance,
- 7b : Maintenance planning,
- 8b : Information systems and computer processing,
- 8c : Computer technology,
- 9f : Training and technology transfer,

