Boskalis
Dredging & Marine Experts

PROJECT SHEET

PORT EXPANSION PROJECT, RAS LAFFAN, QATAR
EPIC FOR DREDGING, LAND RECLAMATION AND BREAKWATER CONSTRUCTION/ DESIGN AND ENGINEERING

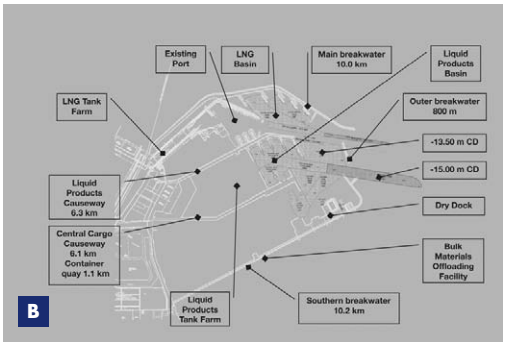
INTRODUCTION

The Ras Laffan Port Expansion project is one of the largest maritime engineering projects in the world. In addition to the dredging of approximately 24 million m^3 of rock and 29 million m^3 of reclamation material, the project required the design and construction of an astonishing 21 km of rubble mound breakwaters and 42 km of rock protection works, involving 40 million tons of rock and 250 thousand concrete elements. This was the largest breakwater construction project in history, and it proved to be an enormous challenge in terms of design and site engineering.

The Boskalis in-house engineering department Hydronamic mobilized no fewer than 13 experts to support the design team in France and the project site organization in Qatar in various fields of expertise. Throughout the work, Hydronamic engineers provided the necessary site engineering, supported by experts from the head office in Papendrecht.

FEATURES

Client	Qatar Petroleum (QP)
Location	Ras Laffan, Qatar and Grenoble, France
Period	2005 / 2009
Contractor	Boskalis Westminster Middle East Ltd and Jan de Nul Dredging Ltd (joint venture)



A Location map
B Main characteristics of the Ras Laffan Project
C Construction of a 3D physical model
D Satellite image of the project
E Constructing the largest LNG harbor in the world

BREAKWATER AND REVETMENT DESIGN

Due to the sheer size of the project and the resulting amount of design work, a dedicated team of experts was mobilized to Grenoble (France). Here, the design of the structures was developed together with 'Sogreah', an internationally recognized consultant specialized in marine, hydraulic and civil works design. The design team of the Joint Venture, which mainly consisted of Hydronamic marine, coastal and civil engineering specialists took a leading role in the management, organization, planning and review of the design process. Design comprised the following stages:

- Establishment of design input conditions (basis for design) Offshore and inshore wave conditions were established using state-of-the-art numerical wave modeling techniques.
- Preparation of desk studies Using recognized modeling techniques for the preliminary design of the typical sections and layouts to be tested by

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physical models.

- Physical model studies Both 2D and 3D physical model studies were performed to optimize the preliminary design and verify it against the design criteria and boundary conditions.
- Development of the final design Combining the results of the desk studies and physical model studies. Detailed hydraulic, structural and geo-technical verifications were carried out for each section.
- Preparation of the construction drawings Using the final design as input, including all the structural and construction details necessary for operations.

In total, fourteen 2D model studies, five 3D model studies, twenty-four final design reports (on different sections), more than four hundred construction drawings and numerous supporting investigations and documents were produced within approximately two years.

QUAY WALLS, SERVICES AND NAVIGATION AIDS DESIGN

The design works of the project were not limited to breakwaters and revetments, but also included detailed engineering of concrete block gravity quay walls, navigational aids, mass concrete slabs and crown walls and several other civil structures. Hydronamic engineers also coordinated and supervised all the engineering activities for these works.

SITE ENGINEERING

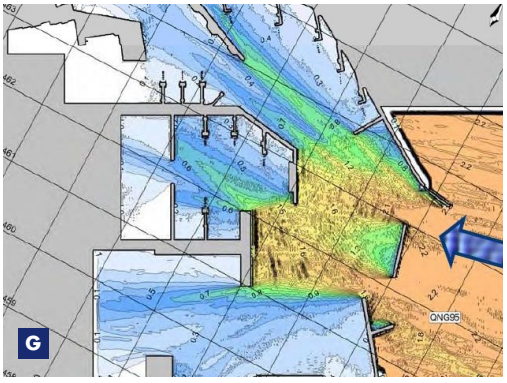
Hydronamic engineers were employed in various departments of the organization in order to assist the operations. In addition to involvement in the management of the planning & engineering department, they took a leading role in the development and tracking of the project construction schedule, one of the most important tools for the verification and quantification of the progress of the work. They helped with the preparation of management summaries and took a prominent position in discussions with the client about technical issues. To verify compliance with contractual requirements, all materials used in the construction of the breakwaters and reclamation had to be tested. A dedicated site laboratory was set up for performing both in-situ and laboratory tests. Hydronamic engineers developed and managed this laboratory, as well as supervising the compaction and density verification of the reclamation materials. They also translated the construction drawings prepared by the design team into detailed work method statements and state-of-the-art quality control procedures for the efficient verification of the quality of the delivered work. Furthermore, they helped during the development of advanced surveying techniques for the rapid under water placement of large amounts of concrete elements.

EXPERT ASSISTANCE

During the course of the project, a series of specific engineering problems were encountered. Senior Hydronamic experts (mainly in the fields of marine breakwater design, environmental permits and geotechnology) helped the project management, both from the main office and on site, with rapid troubleshooting, allowing the work to continue with minimal interruption.

CONCLUSIONS

The Ras Laffan Port Expansion Project proved to be a challenging design task that the Boskalis in-house engineering department Hydronamic concluded successfully in time and to the client's satisfaction. With on-site experts in all areas of the work, the knowledge that has been gained through this project will generate an ongoing benefits for Hydronamic and Boskalis during future Design & Construct works all over the world.



F Testing of a 2D physical model
G Wave modeling inside port
H In-situ testing
I Compaction works in progress

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