Port and Waterway Engineering, Project Development

Kertih marine facilities

Client: Ethylene Malaysia SDN. BHD.
Main contractor: Penta-Ocean / Muhibbah J.V.
Sub-contractor: Zinkcon Marine Malaysia SDN. BHD.
Location: Kertih, Kemamam, Terengamu Darul Iman, Malaysia
Period: August 1993 - November 1995

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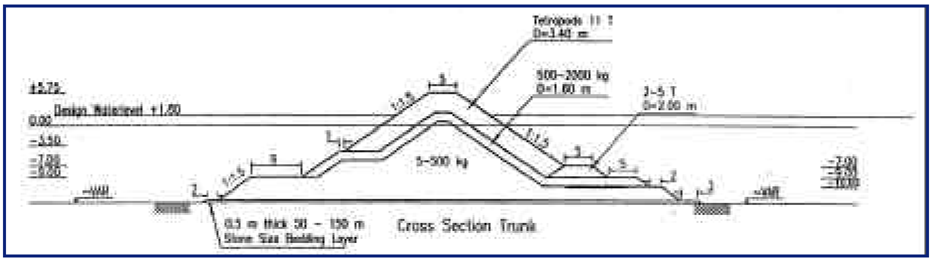
Introduction

Ethylene Malaysia planned to build an ethylene production plant near the village of Kertih, on the East Coast of mainland Malaysia, 100 km north of Kuantan.

A concrete jetty was to be constructed, protected against waves by a large longshore breakwater, in order to allow the import and export of related products.
4 rock groynes in conjunction with a revetment were also proposed, so as to control any erosion problems caused by the main works. The works were known as the Kertih Marine Works.
The "design and construct" fixed price contract was awarded to Penta-Ocean/ Muhibbah JV on August 11, 1993.

Boskalis Westminster was requested by Penta-Ocean to act as their subcontractor for the breakwater, groynes and revetment on the bases of an EPC (Engineering, Procurement and Construction) contract. Hydronamic was requested for the design work during the tender stage as well as during the execution.

Above: Final crosssection trunk;
Under:Actual construction.



Pretender hydraulic design

The design specifications given by the Client were:

- Minor damage <5% (Hudson criterion); Hs = 4.70 m, Tp = 11 sec.;
- Design wave height for moderate damage (5 to 10%); Hs = 5.20 m, Tp = 11.5 sec.

The allowable overtopping requirement was 0.5 cum/m^1/sec for the design wave of Hs = 4.70 m and a design waterlevel of MLSD (approximately MSL) + 1.80 m.

After a thorough investigation it was decided to apply tetrapods as primary armour.
On the bases of the criteria as given, the tender design included:

- A crest height of MLSD + 5.75 m, resulting in a lower overtopping rate than required;
- Primary armour layer of 10 tonne tetrapods, on the trunk at a 1:1.5 slope and on the head at a 1:3 slope.

Location map.

2D tests were performed after submission of the tender documents to verify the correctness of the preliminary design.

Pretender geo-technical design

The foundation profile consisted of a thin top layer of silty sand overlying a 4 to 6 m thick soft clay layer.
A very strong geotextile (600 kN/m^1) was proposed in order to maintain the structural integrity of the cross section and to add some additional strength. A finite element calculation model, Plaxis, was used for the stability calcultions. Plaxis is based on the Mohr-Coulomb theory and includes a Cam-Clay model. Staged construction was taken into account. The extra stability required against failure was achieved, after extensive and comprehensive design work, by widening the berms.

Design stage

Design activities

The preparation for the final design commenced immediately after award. This phase including:

- Aditional soil investigation programme;
- Geophysical survey to detect paleochannels etc.;
- Selection of hydraulic laboratory for physical 3D-model tests of breakwater and groynes;
- Performance of lab testing at Delft Hydraulics (breakwater) and Danish Hydraulic Institute (groynes);
- Hydraulic design work;
- Geo-technical design work.

Geo-technical design of the breakwater

Additional Boreholes were proposed in order to obtain more accurate information, particularly in those areas that had not been covered by the client's drilling programme. It was also decided to perform a geophysical investigation, as the distance between the boreholes was still such that discontinuities could be missed. The geometrical analysis was done using the geo-statistical programme BluePack. It was apparent from the geophysical investigation that the thickness of the soft clay lay was more than expected in some places. These investigations and the soil mechanical testing were performed under close supervision of Hydronamic.

A probabilistic design philosophy was adopted in order to get a good understanding of the sensitivity of certain parameters and the combination of parameters.
The new calculations were also done with the computer model Plaxis.
Settlements were calculated using the M-Series of the Delft Geotechnics.

Three cases were taken into account:

- A characteristic case; based on average soil parameters;
- A worst case; based on 95% probability values of the soil parameters;
- An ultimate case; based on correlated 95% values.

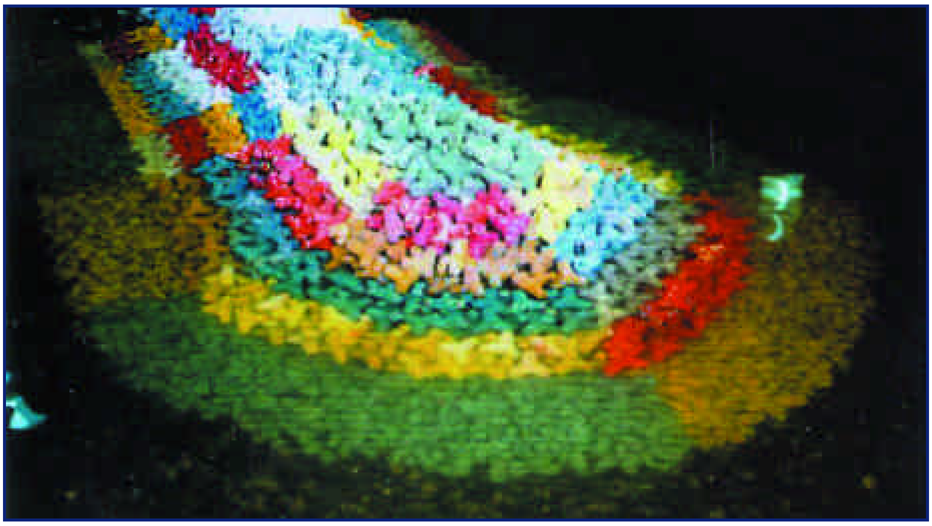
The criteria taken into consideration included:

- The maximum strain rate;
- The maximum displacement;
- The maximum forces in the geotextile.

Safety margins were determined by the so called c-Phi reduction. Though for the worst case in a probabilistic approach, there is no need for any safety margin.

Longitudinal geological profile

A great number of calculations was made prior to the field work for sensitivity analyses. Critical items appeared to be, as expected, the thickness and the strength of the clay layer. After the data from the fieldwork became available some specific calculations were made.



Test of the head.

Hydraulic design of the breakwater

Tests were performed in a 3D-test basin at Delft Hydraulics.
A snake type wave generator, capable of directing wave energy in all directions, was installed in the tank. In this way short crested waves were created which are more natural.
Each series of tests consisted of 6 steps of 6 hours prototype duration. The last step involved a waveheight of Hs = 6.00 m.

Test sections included the head, the transition between head and trunk and the bend in the trunk .
Modifications to the head and the weight of the tetrapods were made during testing in respect of the following aspects:

- Weight versus gradient of slope;
- The density of placement. The average density of placement was 90% of the theoretical placement;
- The wide berms caused waves to break directly on the slope.

Eventually 20 tonnes tetrapods were proposed on a 1:2 slope and a density of average 23.7 kN/m^3.
The shape of the head was changed to a real roundhead.
The weight of the tetrapods for the trunk was slightly increased to 11 ton due to the effect of the bend.
The total number of broken and displaced tetrapods have been calculated by the computer programme "rocking".

The damage calculated in this way was within the required limits.
The total quantities of rock and concrete required were within the quantities used for the tender.

Overtopping

Measurements of overtopping and wave transmission were also made. The results of the overtopping rates were slightly more than that of the 2 D tests.

Design of groynes

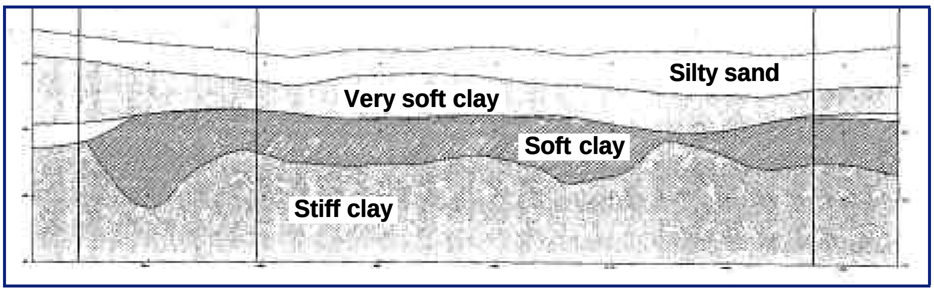
Wave tank tests on groynes have been performed in the Danish Hydraulic Institute. Some minor changes were made to the design of the client.

Site engineering

During the construction many detailed engineering questions items were investigated such as a.o:

- The design of the workharbour;
- Detailed tetrapod design and specifications;
- The placement grid of the tetrapods;
- Detailed work drawings;
- Alternative solutions when the construction time was shorter than the required consolidation time;
- Analyses of damage during storms;
- Monitoring of settlement;
- Support by obtaining temporary and permanent completion certificates.

Longitudinal geotechnical profile.



Settlement.