Exercise Port d'Ehoala (Madagascar)
Course year 2009

QIT Madagascar Minerals (QMM) mineral sands mining project, in the Fort Dauphin region of south-eastern Madagascar, is the largest investment in the island's history (US$660 million). Rio Tinto owns 80% of QMM through its subsidiary QIT; the Madagascar Government owns the other 20%. Production of ilmenite (titanium dioxide) from the mine is expected in late 2008. This project will be the catalyst for broader economic development of the country, while also providing environmental conservation opportunities. Additional information on the project may be found at http://www.riotintomadagascar.com.
A key component of the project is a port to facilitate loading of ilmenite sand onto bulk carriers for export. Initial studies, dating back to the late 1980s, considered alternative sites for the port, as well as various port concepts.
QMM, in cooperation with the Madagascar Government and the World Bank, developed a legal and fiscal framework for the project that includes a sheltered, multi-user, deep-water port facility. The US$145 million port will meet QMM's requirements (initial ilmenite production of 750,000 tonnes/year, with potential expansion to two million tonnes/year), but will also provide facilities for the import/export of other commodities by third party users. Over time, it is expected that the port will make an important contribution to the Consideration of numerous factors led to the selection of Pointe Ehoala, at the south end of Fausse Baie des Galions, as the site of the new port. The site location is presented below.
For further details is referred to Google Earth.

Location

The key features of the project include the following:

- 600 m long breakwater extending into 15 m water depth;
- Multiuse quay, including 275 m long primary berth for bulk carriers up to 60,000 DWT and 150 m long secondary berth for third party users;
- 783,000 m^3 of dredging for harbour basin and entrance channel;
- 34.5 hectares of land reclamation;
- Groyne to limit sedimentation in the dredged area;
- Landside port facilities (cargo handling and storage) and infrastructure.

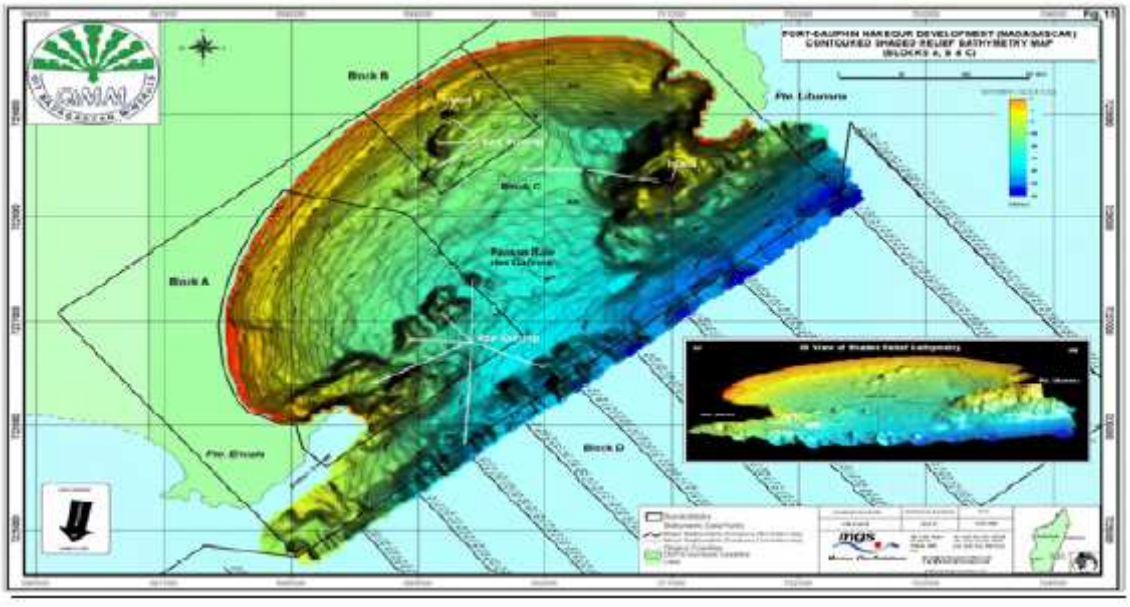
Port layout

As shown in the figure, the project site is located at the south end of Fausse Baie des Galions, a large bay anchored by Cape Ranavalona to the southwest and Cape Antsirabé to the northeast (where the town of Fort Dauphin is located). The shoreline within the bay consists of wide, sandy beaches backed by large sand dunes. The beaches become relatively narrow as one approaches the project site, with scattered rock outcrops along the shoreline at the site. The Ehoala headland (and adjacent shallow rock shelf and small islands) is a dominant feature at the project site, extending towards the NE off the Cape.

Extensive site investigations were undertaken in 2003-04, including topographic, beach and hydrographic surveys, and geophysical investigations.

Unfortunately, it was not possible to collect geotechnical information (i.e. boreholes), as the mobilization cost to get a jackup barge to the site was in excess of US$1 million. The geophysical information was verified to the extent possible using diver inspections, underwater test pits and land-based cores.

However, the subsurface conditions represented a key uncertainty during the design process, particularly for the quay structure and dredging.

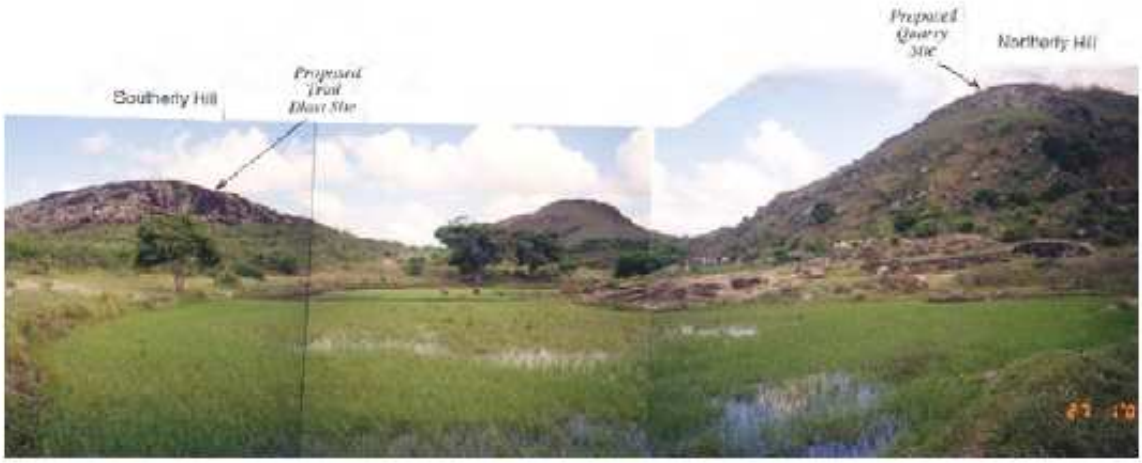


Depth contours

The figure above illustrates the bathymetry within Fausse Baie des Galions. Key features of interest include the shallow shelf feature adjacent to the Ehoala headland, as well as a series of shoals (reef outcrops) scattered around the bay and beyond. Interpretation of the geophysical data indicated a complex, layered geology at the port site. The shallow shelf feature was determined to be a combination of aeolianite and beach rock overlying sand with cemented layers, while the adjacent area (to the north) was determined to be loose sediments.

Detailed layout

The identification of a suitable source of quarried stone (for coastal structures) and aggregates (for roadways and concrete) was a key task. Initial reconnaissance around the project area identified a number of potential quarry sites. Preliminary evaluations identified the "North-South-West hill complex", located approximately 10 km from the port site, as the most likely source for this project.



Potential Quarry area

You don't have to consider the quality of the subsoil. You may assume that everywhere is course sand with sufficient bearing capacity present. For this exercise the different groups will design a cross section with a given type of armour.

Boundary conditions
For an overview of internet sources of information is referred to the Knowledge Centre Water: http://www.library.tudelft.nl/civiel/information_resources/water/index.htm). Under the heading "data" information on data sources is available

For detailed information regarding the bed topography is referred to the digital nautical map, available in the TU-Delft map room (in the library of the temporary building of Architecture, Julianalaan). Also you may use the printed nautical charts available in the TU map-room

Tidal information is available from various sources, for example the admiralty tide tables (library) or the website of the UK hydrographic office (only one week) or the French hydrographic office. You may also find tide info via Mobile Geographics: www.mobilegeographics.com:81

For waves you should use two sources:

- The Global Wave Statistics (available in the citg library, ask the librarian)
- The Argoss database (www.waveclimate.com)

For the Argoss database a password is required. For this exercise no password is available, however, all relevant data for this site have been downloaded and can be accessed via Blackboard.
For the transformation of waves from deep to shallow water you may SwanOne.

For the calculation of the armour units you may use Breakwat. In Cress you will also find a routine for application of the Goda method for vertical wall breakwaters. Breakwat can be accessed via the student network Start ➔ Programs ➔ Delftchess ➔ Breakwat3.1

Your assignment is to design the cross section of Reach 2

On Friday every group will:

1. Give an oral presentation, explaining the cross sectional profile of the both sections of the breakwater, including the choices made. The total duration of the presentation should be maximum 10 minutes, followed by 10 minutes of questions by other groups.
2. All groups present will comment on the presentations of other groups.
3. You have to hand in a drawing with a design of a cross-sectional profiles of the breakwater. On the drawing the contractor has to be able to find sufficient information regarding:
   - weight of armour units
   - slopes
   - crest height
   - toe
   - sub-layers
4. Additional information plus explanation of the choices has to be presented in a short report. The total size of the report-text should be less than 5 pages (figures are additional to the 5 pages).

The design lifetime for the port is 50 years.

Armour	cross section I
Natural Stone	1
Core Loc	2
Dolos	3
X-bloc	4
Berm breakwater	5

Make calculations with a classical approach, see if you can use PIANC guidelines, and see if it is possible (and useful) to make a full probabilistic approach.

Presentations are on Friday 15 May 2009 in room 3.270 (this is in the TA-wing of the building, on the North side). We start at 9: 00. At that moment you also have to hand in your report.

Groups:

1	Siem Troost 1379631 siem_troost@hotmail.com	Kees Willem Pruis 1383280 casepruis@hotmail.com
2	Richard van Liere 1332813 C.A.M.vanLiere@student.tudelft.nl	Lennert Lievense 1275143 L.Lievense@student.tudelft.nl
3	Trinh Dieu Huong 1550136 TrinhDieuHuong@yahoo.com	Serene Tay Hui Xin 1550268 serene_00@hotmail.com
4	Vaia Tsimopoulou 1345567 vanatsimop@gmail.com	Anestis Lioutas 1542273 a_lioutas@yahoo.com
5	Adil El Hamdi 1241044 adil_eh@hotmail.com	A,B,M.K. Mozahedy 1550284 A.B.M.K.Mozahedy@student.tudelft.nl