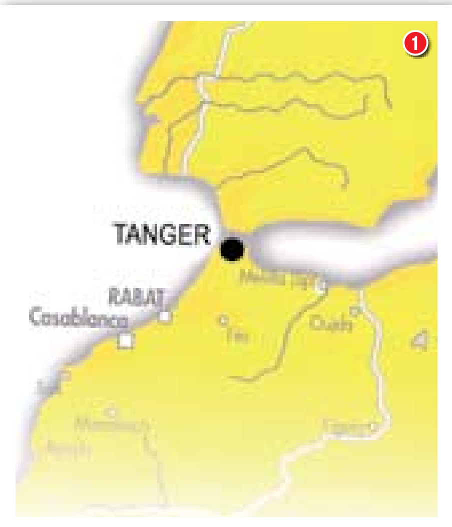
Massive concrete

requirements of new Med harbour

FORTY CONCRETE CAISSONS, each with a mass of nearly 8 000 t, form the main sea wall of the multi-million-rand new Tangier Med Port which is destined to become the biggest harbour on the African continent.

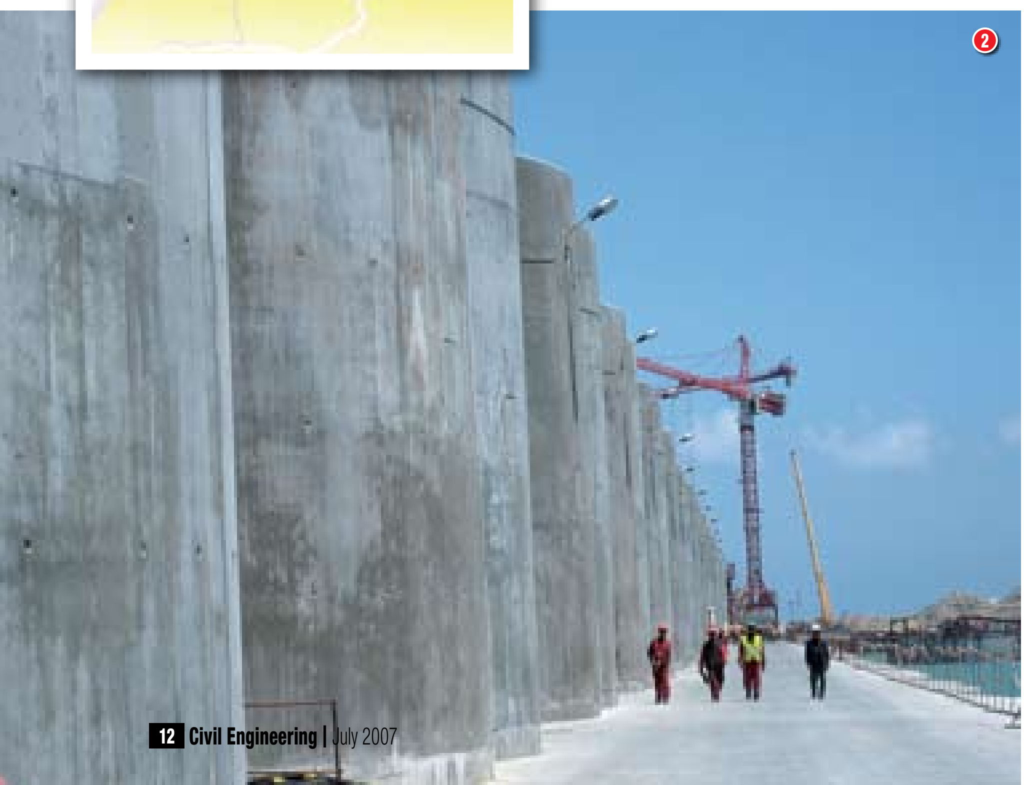
Situated in the Strait of Gibraltar across the ocean from Algesiras in Spain, the first container terminal of Tangier Med is scheduled for opening this year, with the second expected to launch operations in mid-2008. The first terminal covers 40 ha and has an 800 linear metres quay; the second covers 39 ha with an 812 linear metres quay.

The new port, which replaces the old harbour 35 km away in downtown Tangier, is a mere 15 km across the sea from the Spanish coastline. It is expected to become a key port and hub in the Mediterranean region for the shipment of containers between America and Europe and between the Middle East and Asia. The multi-purpose port has five terminals reserved for containers, cereals, passenger services, the import and export of merchandise, and oil shipment.



The construction of the Tangier deep-water port calls for the erection of a 964 m long sloped dyke with embankments and Accropodes (interlocking concrete blocks similar to the South African-designed dolosse) in the hollow part of the dyke, a series of concrete caissons and a 1 612 linear metre long quay.

The major project in building the new port is the construction of the sea wall that protects the harbour from the open sea. The French firm Bouygues TP (in association with Saipem and Bymaro) won the contract by proposing the use of caissons and Accropodes because the resultant caisson footprint would be substantially smaller than that of an embankment. The space gained made it possible to increase the dock area by 18 ha and brings the total land reclaimed from the sea to 142 ha. The Bouygues tender furthermore reduced the materials required for filling to 7 million tonnes, compared to 21 million tonnes that would have been required without the caissons.



The sea wall was built in two stages:

- The first section was built in shallow water, with an embankment reinforced by 7 500 Accropode concrete units
- The second section used 40 prefabricated reinforced concrete caissons for areas where the water is over 20 m deep

The 964 m long, 37 m high sloped dyke was installed to form the first part of the main sea wall. After building up the mound and positioning the protective boulders, 7 500 Accropode concrete units in three sizes (from 4 m^3 to 16 m^3) were installed by divers for additional protection. The heaviest of the Accropodes weighed 40 t, the lightest 10 t.

A total of 72 000 m^3 of concrete was required for the production of the Accropodes. Prefabricated on site at an average of 30 per day, the blocks were stored on site before being positioned on the sea wall. Despite their lack of steel reinforcement, the Accropode units are expected to withstand sulphate and chloride attack from the seawater because of the special concrete mix formulated for their production. The inclusion of a special super-plasticiser, Chrysofluid Optima 175, adds vital concrete cohesion, water reduction and extended workability time to the production of the Accropodes.

A total of 115 800 m^3 of concrete is required for the production of the 40 caissons. Each caisson weighs 7 900 t, has a surface area equivalent to two tennis courts, and the height of a ten-storey building (length 28 m, width 28 m, and height 35 m).

The caissons are made in three stages, at a rate of one per week. The initial stage takes place on land on a special pre-fabrication site where the first 9 m are fabricated. After two days maturing, the caisson is then transferred to water and the next 15 m are cast in the docks. Finally, the caisson is towed to its final resting place at the end of the dyke and filled with sand to resist swells and currents between tides. Once positioned in the ocean, the last 11 m are fabricated. The top walls have an 'open-work' design to cope with the impact of ocean swells.

The specifications for the caisson construction provides for:

- An operating life of 100 years
- Sea-spray resistance, as well as resistance to salt deposits
- CPJ55R cement with fly ash and silica fumes
- Concrete workability retention of 90 minutes
- 8 cm concrete coverage of the reinforcement steel

It is also essential that the concrete is crack-free.

The Bouygues research laboratory in France took nearly a year to develop the concrete formula which met specifications such as a water/cement ratio of 0,33; the development of the special cement in collaboration with Lafarge; and the use of four aggregate sizes to obtain the correct particle size distribution in the concrete.

The high-density concrete – which almost has a self-levelling consistency – has to meet the following criteria:

- Slump – 220 plus/minus 20 mm
- Workable time – 1,5 hours
- Compressive strength at 28 days – 90 MPa
- Compressive strength at 90 days – 130 MPa

The use of Chrysofluid Optima 175 superplasticiser is guaranteeing the necessary 1,5 hours workability retention to ensure good cohesion between each layer of concrete (the sliding form advances at a rate of 20 cm per hour) and also provides sufficient rigidity to enable the form to be lifted after four hours. Chryso is also supplying the admixture, Chrysotard CHR, for the Tangier Med harbour project. Chrysotard CHR is a setting retarder that slows down the hydration of cement.

The old Tangier harbour will in future be used for tourism and other non-export applications.

Figure 1 *Tangier Med Port location*
Figure 2 *Tangier caissons*
Figure 3 *Dolosse at the new development*

PROFESSIONAL TEAM

- **Owners and project managers** Agence Spéciale Tanger-Medéterranée (ASTM)
- **Contractors** SRPTM, comprising Bouygues Travaux Public, Bouygues Morocco, and Saipem
- **Concrete suppliers** SRPTM