The extension of the coal export quay at Richards Bay harbour

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Synopsis
In 1979 it was recognized that additional berthing facilities would be required to serve the envisaged expansion to the coal terminal at Richards Bay. The detailed soil investigations that were immediately embarked upon are described, and details of the planning of the project and the design parameters that were decided upon are given. Problems that were encountered with the disposal of the spoil dredged from the basin extension during construction are discussed, and the method of construction of the new berth described.

Introduction
The need to satisfy the Republic's burgeoning demand for expansion of its harbour facilities was realized on 1 April 1976 when the then Prime Minister, the Hon B J Vorster, officially opened the new port of Richards Bay. At that stage the breakwaters, a facility for harbour craft, two coal export berths each of a nominal length of 350 m, sufficient dredging and a rail link to the site of the coal terminal had been provided by Transport Services. This enabled the Richards Bay Coal Terminal Company to fill the low-lying area behind the berths and construct the coal terminal with its ancillary equipment and so enable the export of coal to commence.

Shortly afterwards in May 1977 the first shipment of sulphur destined for the local phosphoric acid factory was landed at what are now known as the clean bulk berths situated across the harbour from the coal berths. (Fig 1). Subsequently equipment was installed at the clean bulk berth to facilitate the unloading of such bulk commodities as alumina and petroleum coke, and the shipping of phosphoric acid, wood chips and the various minerals extracted from the mining of the coastal dunes to

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In 1958 he worked for Rhodesia Railways as an assistant engineer on maintenance of ways and works and on major relay projects. In 1964 he joined the South African Railways and Harbours Administration, now South African Transport Services.
With Transport Services, Brown was engaged as an assistant engineer on construction work in the Western Transvaal and on new works projects in Durban Harbour. In 1973 he was appointed District Harbour Engineer on maintenance in Durban Harbour. He was transferred to take charge of the Richards Bay construction sub-depot of the Durban Harbour New Works organization in 1974, and subsequently moved back to the Durban Harbour New Works office in 1978 as Senior District Harbour Engineer, where he was appointed Resident Engineer (Harbour Construction) in 1980. In 1982 he was appointed to the post of Inspecting Engineer (Harbour Maintenance) in the Chief Civil Engineer's Office, Johannesburg.

Fig 1: Richards Bay Harbour (1979)
the north of Richards Bay. The first expansion of Richards Bay harbour took place before the completion of the contract for the initial construction, and comprised a 525 m extension of the 850 m long clean bulk berths. The next expansion to take place was the provision of a chemical tanker berth designed to accommodate a range of tanker sizes up to 50 000 DWT. For this purpose a dolphin type berth was built with a depth of water of 14,0 m. This berth facilitated the discharge of a variety of products required by visiting ships for bunkering purposes, the discharge of chemicals in liquid form to the newly established chemical tank farm, and also enabled ships using certain berths which are not provided with bunkering lines to take on bunkers at this berth.

Planning

Early in 1979 it became known to SATS that an increase in the capacity of the existing coal terminal in excess of that which could be handled had resulted from the then two existing berths being given serious consideration by the terminal authority. Transport Services were advised that the terminal authority would be in a position by June 1980 to confirm their decision to proceed with a scheme to enlarge the terminal facility. SATS would undertake the planning and construction of the necessary quaywall extension. The associated basin dredging and the reclamation of the low-lying area required for the coal stockyard.

Because of the lead time required between commencing site investigations and having the necessary information to plan the project and to implement the construction work, immediate action was taken to obtain funds to enable detailed site investigation work to be carried out along the line of the quaywall extension. At that stage the coal terminal authority had indicated their desire to commence exporting 32 million t/a by the beginning of 1983. Further expediting this would be desirable, and it was accordingly decided to widen the existing basin to a width that would enable ships to be turned off the berth. This dimension, for ships of the 300 m length expected of 150 000 DWT ships, was determined at 550 m, and was applied to the basin opposite the new quays as well.

Soils investigation

A contract was awarded on 20 September 1979 for the necessary investigatory work. Borings were carried out in the dredging area on a 150 x 150 m grid with standard penetration tests being undertaken at 1,5 m intervals. The depth of these borings was limited to -25,0 m CD, and where this could not be reached, the depth of refusal on the surface of the cretaceous siltstone underlying the area was recorded. Eight of the boreholes were of 150 mm diameter to permit undisturbed U4 sampling of the cohesive sediments for laboratory testing to be undertaken, and in-situ vane shear test were carried out in the cohesive materials penetrated by 19 of the boreholes.
Along the line of the quaywall, boreholes were sunk at 50 m intervals along the front face, and at 100 m intervals 20 m behind the front face. In addition, six Dutch Cone penetrometers were placed around the head of the breakwater to determine the properties of the sea-bed. A total of 111 of these were placed at a depth of 20 m.

Tenders for project tenders were required to design the structure to accommodate the berthing impact of 250 000 DWT ships approaching at 0.1 m/s, a bollard pull of 150 t with bollards at 20 m centres, wharf crane wheel loads of 25.5 t at 1,327 m centres, shiploader wheel loads of 36 t at 1,227 m centres, standard class one rail loading, vehicular loading type HB (45 units) and a uniformly distributed live load of 40 kPa.

Disposal of spoil

The disposal of the dredged material posed a special problem, as there was no site within the harbour area suitable for the reception of some 8 million m$^3$ of spoil unsuitable for use in reclamation. As it was clear that this work would best be undertaken by cutter-suction dredger, consideration was given to pumping the spoil/water mixture to the adjacent beach which would have involved a pumping distance of approximately 3 km. However, this possibility was ruled out owing to the likely point of discharge of the spoil being some 3 km to the south of the main breakwater — the implication being that this would add to the present maintenance dredging burden caused by the prevailing northerly littoral drift.

This drift presently causes an estimated 800 000 to 1 000 000 m$^3$ of sand to be carried northwards and to accumulate behind the breakwater. Dredgers are constantly engaged on intercepting this sand before it is able to round the head of the breakwater and form a bar across the channel. There is no doubt that the deposition of the 8 million m$^3$ of surplus spoil into the littoral drift would have increased the workload involved in avoiding the formation of the sand bar. In addition the finer fractions of the mixture which stay in suspension in the wave zone would have been carried northwards by the northerly current and been deposited to a greater or lesser degree in the 24 m deep dredged shipping channel at the head of the breakwater which is in only 16 m depth of water.

An alternative and more costly spoil site had to be found, and pumping to the beaches to the north of the harbour entrance was therefore investigated. Two factors had to be considered. Firstly, the northern beaches are the only beaches available to the public of Richards Bay for recreational purposes, and secondly, whilst the littoral drift results in a northerly drift of sand, this represents the net difference between the predominantly northerly drift and a certain amount of southerly drift. In order to determine a discharge point sufficiently far from the north...
breakwater to ensure that the southerly drift component would not result in spoiled material working its way southwards around the north breakwater and into the main shipping channel, the National Research Institute for Oceanology (NRIO) was commissioned to carry out the investigation. It was found from mathematical model analysis that if the discharge point was established at a distance of 5 km along the beach north of the north breakwater, the resulting bulge of spoil so formed at that point would ultimately be flattened by wave and current action to the stage that the southern limit of the flattened bulge would just reach the root of the north breakwater.

While the discharge point on the north beach was receiving attention, it was noted that the beach was severely eroded over a distance of approximately 1,000 m beyond a point 1,8 km north of the breakwater. This was due to the effect of the littoral drift and the harbour entrance works comprising the breakwater and dredged channel having effectively cut off the supply of sand working its way up from the south that had previously crossed the outlet of the Umhlatuzi River. (Prior to the construction of the harbour the presence of the river had caused an imbalance in the sand transport, with the result that the north beach was known to be unstable compared with the beach to the south of the river).

This erosion occurred in spite of remedial steps that had been taken in the knowledge that artificial beach nourishment would be required after the construction of the entrance works. Approximately 900 000 m³ of coarse sand had been pumped onto the north beach in 1977 from dredging works then being undertaken to provide a berth for maintenance dredgers, the berth being provided specifically to enable the dredgers to tie up and provide on-going beach nourishment with a maintenance dredger. The contractor was a South African company with a dredging sub-contractor.

One maintenance dredger commenced this work in 1978, and together with the quantity pumped in 1977, kept the north beach in reasonable condition until 1980 when erosion at 1,8 km point began to show. It was therefore decided that, to alleviate this situation, some 2 million m³ of spoil with a reasonable sand content, obtained from the coal quay extension shipping basin, would be discharged between the 1,8 km and 2,8 km points. In 1981 a second maintenance dredger was stationed at Richards Bay to cope with the littoral drift problem.

Final configuration

Shortly after the return date for tenders (17 October 1980) the decision was taken that two additional berths comprising a quaywall extension of 700 m were to be provided to a depth of -19,0 m CD, with the quays to be so constructed that the berths could be deepened in future to -23,0 m CD. Additional funds were sought to provide for this scheme, and sanction to the amount of R75 285 000 was received in good time to permit the award of the contract.

Main contract

Four tenders were received for the work, three from local construction firms with Dutch, Belgian or Italian dredging sub-contractors, and one from a German construction firm with a Dutch sub-contractor. Three tenderers proposed a caisson type substructure for the quaywall while one proposed a conventional counterfort retaining wall substructure cast in open, de-watered construction pit.

This latter form of construction was the same as that used by the builders of the then existing quays in Richards Bay. Although unusual in concept, it is feasible owing to the fact that the undeveloped bay is on average 1,5 m deep and, as such, the dyking system required to enclose a pit for wall construction is minimal. However, where this system is employed on an extension project to an existing structure, special precautions have to be taken at the interface as the dyke cannot be allowed to encroach on the dredged berth in use.

The adjudication of the tenders was straightforward, and the contract was duly awarded to the lowest tenderer on 22 December 1980 for completion of the first berth and its associated dredging and reclamation work in 24 months. The whole of the works was due for completion in 36 months. The contractor was a South African company with a dredging sub-contractor comprising a joint venture of a Dutch and a Belgian dredging contractor.

The value of the contract was approximately R47 750 000. The
Callason construction in various stages showing (I) base slab being prepared in floating dock, (II) slide being completed, afloat, alongside existing quay-wall, (III) completed callason afloat and ready for placing, (IV) two calasons sunk on line of quaywall extension.

The balance of the sanctioned amount was to cover certain ancillary works such as roadworks and bridges on the approach roads, bunker lines in the quaywall, escalation on the contract (it being a condition of contract that escalation in accordance with the modified Baxter formula be paid on all costs incurred in the Republic — the significant fact being that monies remitted overseas would not be subject to an escalation adjustment since the local indexes would bear no relation to other countries' variations) and to cover the cost of possible fluctuations in the value of the Rand against the currency of foreign tenderers. In this regard, tenderers were required to state at the time of tender the rate of exchange used when converting the foreign currency portion of costs into Rands when tendering, and Transport Services undertook to remit...
increase the area of the coal stockyard so as to cater for future expansion that could be handled through the extra capacity that the two new berths would provide. The additional volume of sand required for this purpose, plus extra required to surcharge an area of stockyard located over a valley of deep, very soft unconsolidated sediments, resulted in the virtual doubling of the quantity to be brought in from the sea and pumped ashore. The original figure of 3 million m$^3$ had to be increased to approximately 6.5 million m$^3$.

**Conclusion**

The first berth and associated dredging were completed within 24 months, enabling the terminal authority to commence the erection of their additional shiploader. Owing to changing priorities in the land reclamation work caused by various factors such as the valley of weak material encountered in the reclamation area which required early filling and surcharging, the reclamation programme did not fully meet the requirements of the terminal authority, but thanks to close liaison between Transport Services, their contractor and the terminal, inconvenience was kept to a minimum.

The remainder of the work, comprising the second berth, its dredging and the additional stockyard area, was completed three months ahead of schedule.

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**Photographs**

Zululand Studios, Empangeni
South African Transport Services

**Contractors**

Main Contractor: Candac Construction (Pty) Ltd, Cape Town
Sub Contractors:

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