

## Design and realization of a Sandbar Breakwater, Lekki, Nigeria

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For the development of the Dangote Refinery, an oil refinery owned by the Dangote Group that is currently under construction in Lekki, Nigeria, a jetty with a RoRo facility needed to be developed for unloading of the project cargo meant for the proposed fertilizer plant and the other industries. For this purpose, we have developed and designed a new breakwater concept based on the dynamics of nature: the Sandbar Breakwater.

### CONCEPT

The Sandbar Breakwater is a unique and innovative concept which follows the Building with Nature philosophy. The concept and design of the Sandbar Breakwater is based on the unique natural coastal system of Nigeria: regular swells arriving at the coast under a relatively constant angle in combination with a uniform steep and sandy coast resulting in a large and unidirectional longshore sediment transport. A conventional rubble mound breakwater would cause a rapid advance of the coastline on the updrift side, ultimately burying the expensive armour rock.

Following the natural characteristics of the environment, the key element of the Sandbar Breakwater concept is a sand body orientated close to its equilibrium and held in place by a groyne structure at the tip of the Sandbar. The Sandbar Breakwater is morphologically dynamic and eventually nature shapes the profile and coastline to a stable equilibrium. It minimizes the use of hard materials and makes optimal use of the abundant sand locally available. This resulted in a significant increase in construction speed, which was vital for the feasibility of the project.

### DESIGN

The Sandbar Breakwater has been designed such that the initial placement of sand was minimized while the natural supply of sand, i.e. due to the alongshore sand drift around 900,000 m<sup>3</sup>/yr, was used to provide the long term stability of the Sandbar body. Extensive morphological numerical modelling has been conducted to optimize the design and construction phasing to ensure the stability of the Sandbar Breakwater and hence safety of the port, while minimizing the costs. The complex geometry of the Sandbar groyne and its connection to the Sandbar body has been detailed in 3D models and was tested on hydraulic stability by means of 3D physical model testing.

Any obstruction of the longshore sediment transport, albeit a conventional breakwater, groyne or a Sandbar breakwater will inherently lead to downdrift erosion and may lead to significant loss of land. The most natural way to mitigate this effect is by restoring the natural sand

balance of the system. Therefore a small-scale Sand Engine (local nourishment) has been implemented in the design to mitigate the coastal retreat downdrift. As erosion continues this Sand Engine requires repetitive nourishment to stabilize the coastline over the coming decades.

### REALIZATION

The Sandbar Breakwater has been successfully realized in the first half of 2018 in less than five months and since September of 2018 the port is in operation. Nature is doing its work: the Sandbar is rapidly reshaping towards its equilibrium as predicted, while ensuring a calm and safe harbour basin.

### FLEXIBILITY

As sand can be easily re-handled and the coastline at the port advances over time, this new concept is flexible and allows for relatively easy future port expansion: the (partly) natural formed Sandbar body may accommodate expansion of the harbour basin. The soft character and the flexibility of the concept makes the Sandbar Breakwater more resilient and adaptable to climate change compared to conventional breakwaters.

### CONCLUDING

The concept of the Sandbar breakwater is innovative and makes optimal use of the dynamics of nature and its materials locally available. This makes the concept not only eco-friendly, but also highly cost effective, flexible and resilient. Hence the Sandbar Breakwater is a perfect example of Building with Nature.



Figure 1 - The Sandbar Breakwater approx. 1 year after completion (March 2019), Lekki Nigeria

### REFERENCES

De Vriend & Van Koningsveld (2012). Building with nature. Ecoshape Building with nature.