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**An engineering geological investigation for the upgrade of Maputo Port,  
Mozambique.**

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Maputo Port is situated on the Maputo River on the western side of Maputo Bay. The regional geology of the area comprises recent unconsolidated alluvial deposits that overlie the Ponta Vermelha Formation (2 Ma to 5 Ma age), which comprises consolidated silty sand that grades into brownish sandstone with depth

An engineering geological study of the entire seafront of the Maputo Harbour was conducted between 2013 and 2014. The investigation consisted of 132 rotary core boreholes and 8 piezo cone penetrometer tests (CPTu). At the current berths, 104 boreholes were drilled in four parallel transects on land and over water, while at the location of future berths, 28 boreholes and piezo cone testing were conducted over water. To aid sample recovery in soft material, continuous down-hole standard penetration tests (SPT) were performed and undisturbed soil samples were retrieved by Shelby tube sampling.

Boreholes drilled at the existing berths showed that the port area is underlain by made ground (granular fill and dump rock) and alluvial sand and clay which overlies the Ponta Vermelha Formation generally from -14 m to -22 m. An isolated zone where the Ponta Vermelha Formation is only encountered at -25 to -35 m was identified in the southern portion.

At the future berth alignment, the investigation showed an increase in thickness of low consistency alluvium towards the north west, and a centrally located zone of very soft material is present from -30 to -35 m. CPTu testing confirmed the results of the borehole drilling, showing the area to be underlain by mixed recent alluvial material overlying (in nearly all cases) a fairly abrupt change to a very dense material.

SPT testing undertaken in the alluvial material typically returned N = 0 in the upper portion of the profile as the equipment tended to sink under its own weight. SPT N values however increased to between 10 and 30 towards the transition of alluvium to the Ponta Vermelha Formation. For the latter, the bulk of the SPT N values showed refusal (i.e. N > 60) although exceptions were noted in some instances where refusal was not encountered in a few boreholes.

Grain size analyses, Atterberg Limits and consolidation tests on soft alluvial clay showed the material to be composed of very soft, highly compressible, highly plastic clay (CH soil type) typically with an average clay content of 54%, liquid limit of > 100 and an average plasticity index (PI) of 59. Similar analysis performed on samples of the Ponta Vermelha Formation classify as silty sand (SM) with a low average PI of 4 and an average sand and clay content of 78% and 9% respectively. Consolidated undrained tri-axial

testing on samples taken from the Ponta Vermelha Formation returned an average friction angle of 41°, which is comparable with a very dense sand or a weathered sandstone.

