NovoCrete®

AUTARK
Energy & Infrastructure Solutions

Jobsite report

Construction of transportation routes and storage sites in the port of Malabo, Equatorial Guinea by using NovoCrete®

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Construction of harbour facilities with NovoCrete®

1. Situation

In Equatorial Guinea, it is planned to enlarge the K5 Oil Centre near the capital city Malabo on the island of Bioko. The expansion of the project area must be carried out by means of a land reclamation measure. For this, ocean sand is to be washed into the area of the dock with hydraulic pumps. The used material is ocean sand of volcanic origin. Due to the loads expected, an NovoCrete® ST stabilisation is planned for the foundation layer. For the dimensioning of the NovoCrete® ST substratum, soil samples of the material to be used were provided for the company GeoConCept GmbH by the company SoilTech. Laboratory examinations are to be carried out on the soil samples delivered, which should clarify whether hardening with the cement additive NovoCrete® ST is possible. In the course of the necessary suitability check, the essential soil-mechanical characteristic values of the NovoCrete® ST soil mixtures were ascertained and a project-specific laboratory examination was carried out on the NovoCrete® ST soil mixtures, on the basis of TP BF-StB part B11.1. The results of the soil-mechanical and construction-material-mechanical laboratory examinations and the requirements resulting from them regarding the execution are the object of the following report.

2. Documents

The suitability test is based on the following documents:

1. Results of the laboratory-technical examinations
2. DIN 18 196 "Earth-moving and foundation work soil classification for structural purposes"
3. DIN 4022 "Naming and description of soil and rock"
4. DIN 18 121 "Water content"
5. DIN 18 123 "Determining of the grain-size distribution"
6. DIN 18 127 "Proctor test"
7. DIN 18 130 "Determining of the permeability value"
8. DIN 18 136 "Determining of the single-axis compressive strength"
9. ZTVE-StB 94 "Additional technical contractual conditions and guidelines for earthworks in road construction"
10. ZTVT-StB 95 "Additional technical contractual conditions and guidelines for substrata in road construction"

Picture 1: *situation at the beginning*

11. TP BF-StB part B 11.1 "Suitability tests in soil hardening with cement" issue 1986
12. data sheet for soil improvement and soil hardening with cement, issue 1984
13. DIN 1048 Sheet 1: test procedures for concrete
14. Guinea Equatorial. Malabo-K5 Oil Centre Jetty Extension, Laboratory Tests on sand for backfill. GEO project no 28965, Report 1, 2006-06-9

3. Geography

The island of Bioko belongs to the national territory of Equatorial Guinea and is located in the Gulf of Guinea. The Gulf of Guinea is the part of the Atlantic Ocean that is bordered by the coasts of West Africa in the North and East. In the Gulf of Guinea, lie the islands of Sao Tome and Principe, which form an independent state, and the islands of Bioko and Annobon, which belong to Equatorial Guinea. These islands were created by a volcanic hot-spot that also brought forth Mount Cameroon on the African mainland. The islands lie in a seismically active zone due to their genesis and the volcanic surroundings.

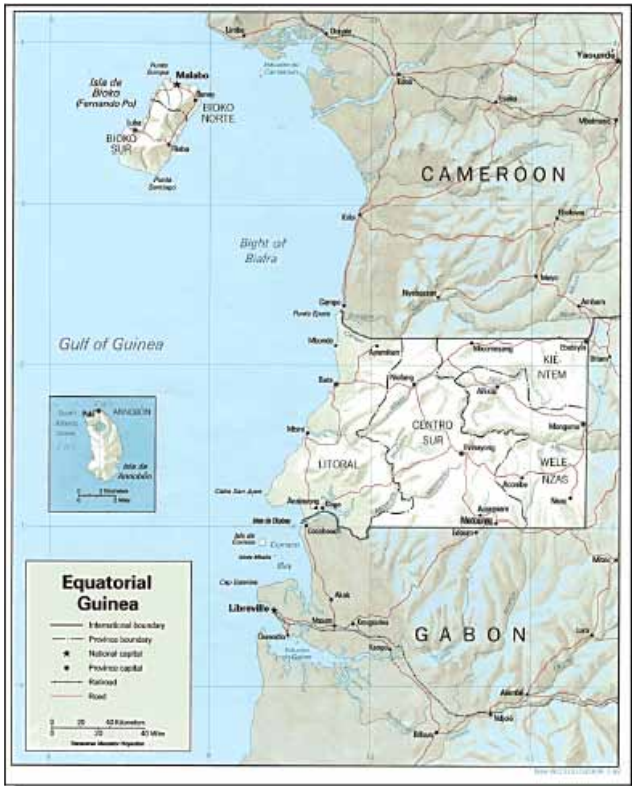

Fig. 1: *geographical map of Equatorial Guinea*

4. Product Description

NovoCrete® ST is a whitish grey powder, which is formed out of alkaline and earth alkaline elements and/or complex mineral compounds. According to the specifications of the manufacturer, NovoCrete® ST promotes the cement hydration processes and counteracts the negative influence of fulvo acid and carboxylic acid. Alterations in the microstructure and the additional formation of minerals in cement hydration lead to an increase of compressive strength and even make possible the stabilisation of soils that are rich in humus. In addition to promoting compressive strength, NovoCrete® ST promotes the immobilisation of environmentally damaging substances. These include heavy metals as well as organic parameters that can be fixed permanently into the newly formed crystal structures.

5. Laboratory Test / Soil Mechanics

The soil sample was brought into the soil mechanics laboratory of GeoConCept GmbH for further processing.

5.1 Grain-size Distribution in accordance with DIN 18 123-4

The grain-size distribution of the soil was ascertained in accordance with DIN 18 123-4 and the natural water content was ascertained in accordance with DIN 18 121.

Sample	Natural water content W_n %	Inhomogeneity value $U=d_{60}/d_{10}$	Bending value	Proportion < 0,063 mm %	Soil classification DIN 18 196
EG 1	10,2	12,8	0,9	8,00	SU

Tab. 1: *Soil classification according to DIN 18 196.*

According to the laboratory tests that were carried out, sample EG 1 is a sand-silt mixture (DIN 18 196: SU) according to DIN 18 196.

5.2 Proctor tests according to DIN 18 127

In order to ascertain the optimum dry density and the optimum water content a Proctor test in accordance with DIN 18 127-P 100 X was carried out on the soil at issue.

Sample	EG 1
Optimum dry density D_{Pr} 100% in g/cm³	2,137
W_{Pr} in %	11,4
Wet density in g/cm³	2,347

Tab. 2: *Results of the Proctor test in accordance with DIN 18 127.*

The optimum water content of the sample EG 1 was determined at 11.4%. With this water content, the Proctor density reached was 2,137 g/cm³. 8.4% NovoCrete® Pr ST (=180kg/m³ binding agent) was then added to the soil. In this process, the water content was increased to approx. 2% above W_{Pr}.

5.3 Testing of compressive strength according to DIN 18 136

The testing of the compression hardness was carried out on cylindrical test specimens with dimensions of H = 120 mm (approx.) / D = 100 mm with a content of 8.4% of NovoCrete® ST. The test samples were produced in accordance with Proctor test DIN 18 127-P 100 X with an optimum water content of approx. 13.5%.

The compression hardness test was carried out on the basis of "TP BF-StB Part B11.1 suitability tests with soil hardening with cement" carried out on test samples aged 7 days, in order to be able to determine the binding agent content necessary for hardening of the soil. The results of the compression hardness test are shown in Table 3.

Sample	NovoCrete ST in %	Diameter in mm	Age-Days	Breaking Load K/N	Compressive strength N/mm³	Correction factor	Compressive strength N/mm³
302 c	8,4 (= 180 kg / m³)	100	7	25,10	3,20	1,25	4,00

6. Soil Stabilisation using NovoCrete®

A quantity of binding agent of approx. 180 kg/m³ NovoCrete® ST is to be regarded as sufficient for the stabilisation and hardening of the sand-silt mixture (DIN 18 196: SU), according to the available laboratory results. Because we currently have no information about the loads occurring, a standard thickness of 0.35m is assumed for the description of the work procedure for the producing of a substratum of NovoCrete® ST. The binding agent is to be mixed in with the soil in the site to a depth of 0.35 in order to produce the necessary load capacity. The work procedure is described in brief in the following:

1. The coarse plane is to be fixed at approx. 2-3 cm under the later fine plane height.

2. The binding agent NovoCrete® ST is to be applied onto the soil to be stabilised, in a mixture ratio of 180kg/m³. With a mixture ratio of 180kg/m³ of NovoCrete® ST and an incorporation depth of 0.35m, about 63kg/m² must be strewn out. The tilling in of the binding agent is to be carried out with a rotary tiller.

3. The soil in the site is sensitive to water and moisture. The first tilling should therefore be carried out without the addition of water and at a depth of a maximum of 0.25m. The addition of water should be carried out via the rotor of the WR® 2500 during the second mixture procedure. The second mixture procedure must be carried out in such a way that a layer thickness of at least 0.35m is ensured.

4. According to the available results, the optimum water content W_{Pr} for the examined soil samples is 11.4%. During the stabilisation phase, the water content is to be increased by approx. 2%, depending on the NovoCrete® ST system.

5. After the homogenisation of the NovoCrete® ST soil mixture, the loosened ground must be evenly distributed by means of a laser-guided grader or tracked grader.

6. The NovoCrete® ST soil mixture can then be dynamically compacted with a smooth roller compacter (weight > 10 to.). During the compaction work, it is to be ensured that a 50% overlapping is kept to in the individual passages.

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7. Afterwards, the fine plane can be produced by means of a laser-guided grader or a tracked grader.

8. The substratum surface is to be compacted once again, statically, with a roller compacter. This compaction work should be carried out with a rubber-wheel roller compacter (weight >12 to.), because a compaction effect will also be achieved in a negative relief due to the rubber tires.

9. In order to prevent evaporation of the water contained in the ground, the compacted surface of the substratum is to be provided with evaporation protection, i.e. the surface is to be made completely wet with a sufficient quantity of water.

When using NovoCrete® ST, one must be aware that not more than 3-4 hours may pass from the first working-in of the binding agent to the producing of the fine plane. The hardening should therefore be carried out in sections. On the basis of empirical values, static deformation modules E_{v2} from 300 to 400 MN/m² are expected after 28 days on the load and frost protection layer thus created.

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