NovoCrete®

ibs

Jobsite Report

Reconstruction of a Container Terminal in Marburg-Wehrda (D) by using NovoCrete®

ibs GmbH
Neue Weinsteige 33
D-70180 Stuttgart, Germany
Phone: + 49 - (0) 711 - 220 29 290
Fax: + 49 - (0) 711 - 220 29 199
www.novocrete.com
info@novocrete.com

Soil stabilzation with NovoCrete®

1. Situation

The city of Marburg plans to build a container storage area in Marburg-Wehrda. The container storage area is planned to be constructed on a former landfill body in the immediate vicinity of the refuse reloading station in the industrial area of Marburg-Wehrda. The city of Marburg and consultant engineers have planned to reinforce the mixed-grain filling on the surface with the NovoCrete® system in order to stop or minimize the typically occurring subsidence damage. Due to the uneven land level, some parts of the approx. 5,000 m² surrounding area still need to be filled out with mixed-grain earth up to the height of the ultimate precise grade level.

Fig. 1: *Industrial area Marburg-Wehrda was established on a former landfill body. Due to the extremely heterogeneous composition of matter in the landfill body, there is subsidence occurring to different extents. These differences in subsidence are destroying all road and yard surfaces in the industrial area.*

Furthermore, the plan is to produce a barrier layer impervious to water with the NovoCrete® ST base and anti-freeze course in order to secure the landfill body against penetrating rainwater.

2. Product description

NovoCrete® is a whitish-grey powder based on alkaline and alkaline earth elements, or complex mineral compounds. According to the manufacturer's specifications, NovoCrete® promotes the cement hydration process and acts against the negatively influencing fulvic and carboxylic acids.

Changes in the microstructure and the additional new formation of minerals during cement hydration lead to an increase in compressive strength and even allow stabilization of humus-rich earth.

Besides the increase in compressive strength, NovoCrete® promotes the immobilization of environmentally dangerous contaminants. This includes heavy metals as well as organic factors that can be permanently fixated in the newly formed crystal structures.

Fig. 1

3. Technical laboratory test/earth mechanics

The earth sample was taken to the earth mechanics laboratory of GeoConCept GmbH for further processing.

3.1 Grain size distribution according to DIN 18 123-4

At the laboratory, the grain size distribution of the earth in the sample was determined according to DIN 18 123-4 and the natural water content according to DIN 18 121.

Sample	Natural water content W_n %	Coefficient of irregularity U = d60/d10	Coefficient of curvature Cc	Portion < 0.063 mm %	Earth classification DIN 18 196
Mar 1	17.8	—	—	11.65	GU-GT
Mar 2 (Filling)	1.36	37.1	0.2	1.82	GI
Mar 3	8.35	9.4	0.9	1.95	GI

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

According to the laboratory test, the sample *Mar 1* is a gravel-silt or gravel-clay mixture according to DIN 18 196 (DIN 18 196: GU-GT). Earth samples *Mar 2 (Auf)* and *Mar 3* are, according to DIN 18 196, intermittently layered gravel-sand mixtures denoted as GI.

The natural water content W_n for sample *Mar 2 (Auf)* is 1.36 %, while a natural water content W_n of 8.35 % was determined for *Mar 3*. Due to the elevated cohesive portion of 11.65 % (grain size < 0.063 mm), the natural water content of the sample *Mar 1* is 17.8 %.

3.2 Proctor test according to DIN 18 127

To determine the optimum dry density and the optimum water content, a proctor test according to DIN 18 127-P 100 X was carried out on each of the samples *Mar 1*, *Mar 2 (Auf)* and *Mar 3*. The results of the proctor tests are given in Table 2:

Sample	Mar 1	Mar 2 (Auf)	Mar 3
Optimum dry density D_{Pr} 100 % in g/cm³	1.871	2.033	2.184
W_{Pr} in %	13.4	5.7	11.0
Wet density in g/cm³	2.25	2.15	2.39

Tab. 2: *Results of the proctor test according to DIN 18 127.*

The optimal water content of the sample *Mar 1* was determined as 13.4 %, while the corresponding proctor density is 1.871 g/cm².
For the earth samples *Mar 2 (Auf)* and *Mar 3*, the optimal water content W_{Pr} was determined at 5.7 % and 11.0 %. With these water contents, the optimum proctor density D_{Pr} for the respective samples is 2.033 g/cm² and 2.184 g/cm².

3.3 Testing the uniaxial compressive strength according to DIN 18 136

The compressive strength test was carried out on cylindrical specimens measuring H = 120 mm (approx.)/D = 100 mm, with a content of 180 kg/m² of NovoCrete® ST. The test specimens were produced according to the proctor test DIN 18 127-P 100 X with a water content of approx. 16 % (sample Mar 1), approx. 7.7 % (sample Mar 2 (Auf)) and approx. 13 %. In order to determine the necessary binder content, the uniaxial compressive strength test was carried out on specimens aged 7, 14 and 28 days following the "Technical test regulations for earth and rock in road construction" ["Technische Prüfvorschriften für Boden und Fels im Straβenbau"] TP BF-StB Part B 11.1: "Suitability tests for ground stabilization with cement". The results of the compressive strength tests are given in Table 3.

Sample	GeoCrete® ST in kg/m³	Diameter in mm	Age in days	Compressive strength In N / mm²
Mar 1 a	180	100	7	1.48
Mar 2 (Auf) a	180	100	7	1.59
Mar 3 a	180	100	7	1.78
Mar 1 b	180	100	14	4.70
Mar 2 (Auf) b	180	100	14	5.08
Mar 3 b	180	100	14	4.95
Mar 1 c	180	100	28	6.95
Mar 2 (Auf) c	180	100	28	6.95
Mar 3 c	180	100	28	8.05

Tab. 3: *Results of the compressive strength test after 7, 14 and 28 days.*

3.4 Frost classes/freeze test according to TP BF-StB Part B 11.1

According to the specifications of the "Supplementary technical conditions of a contract and guidelines for earthworks in road construction" ["Zusätzliche Technische Vertragsbedingungen und Richtlinien für Erdarbeiten im Straßenbau"] ZTVE-StB 94, the gravel-clay/gravel-silt mixtures (DIN 18 196: GT/GU) are slightly to moderately frost-sensitive earth to be classified as F2 according to the frost-sensitivity classification. The intermittently layered gravel-sand mixture (Din 18 196: GI) is classified at level F1, not frost-sensitive, according to the frost sensitivity classification.

Earth	Frost sensitivity class
GT	F2
GU	F2
GI	F1

Tab. 4: *Frost sensitivity according to ZTVE-StB 94.*

F1 – not frost-sensitive
F2 – slightly to moderately frost-sensitive
F3 – very frost-sensitive

A frost test of the NovoCrete®-earth mixture was carried out on specimens with a binder content of 180 kg/m², aged 28 days, in accordance with the technical test regulations on "suitability tests for ground stabilization with cement". For this, specimens of height H = 120 mm and diameter D = 100 mm were produced in accordance with the proctor test according to DIN 18 127 under optimum water content and in accordance with TP BF-StB Part B 11.1 subject to a frost test with 12 freeze-thaw cycles. The change in length of the specimens due to repeated freeze and thaw stressing was measured.

For this, at temperatures between +20°C and –20°C, the prepared specimens were alternately frozen and then placed on an absorbent surface to thaw and draw out the water, in accordance with TP BF-StB Part B 11.1.

The change in length l of each specimen is the difference between the averages after the first and last frost stressing. It is in relation to the original length of the specimen before the first water draw-off. The related change in length is determined to 0.01 % precision. The results of the frost test are summarized in Table 5:

Samples	Height H1 before 1st water draw-off mm	Height H2 after 1st frost mm	Height H3 after 12th frost mm	Δl (H3–H2) mm	Rel. Δl $\frac{\Delta l}{H1}$
GT – GU	122.7	122.7	122.8	0.1	0.0008
GI	124.2	124.3	124.4	0.1	0.0008

Tab. 5: *Results of the frost test.*

Despite intensive watering, the specimens demonstrated no signs of weathering during the freeze-thaw alternation test. Furthermore, no cross-sectional changes in the specimens were observed. Based on the measurement results obtained, the specimens of the earth samples GU–GT and GI can be designated as resistant against freeze-thaw alternation.

3.5 Determining the coefficient of permeability in accordance with DIN 18 130

To determine the coefficient of permeability in accordance with DIN 18 130, earth samples *Mar 1* and *Mar 2 (Auf)* were stabilized with a NovoCrete® ST content of 180 kg/m². The samples were built into triaxial cells at an age of 28 days and deaerated distilled water was run through them from the bottom up.

The determined coefficients of permeability of the earth samples are given in Table 6:

Sample	GU – GT (Mar 1)	GI (Mar 2 (Auf))
Coefficient of permeability (k_f) in m / sec	6.1×10^{-9}	3.2×10^{-9}

Tab. 6: *Coefficients of permeability in accordance with DIN 18 130.*

According to the present test results, both earth samples have a coefficient of permeability of 10^{-9} m/sec, i.e. the base course stabilized with NovoCrete® ST has a very low permeability independent of the starting earth.

4. Execution

At the beginning of the stabilization measure, the capping layer had to be created with grader 2 cm below the ultimate precise grade level. In the next step, 54 kg/m³ of NovoCrete® were spread out over the surface of the earth layer using a binder sprayer. Next, the applied binder was milled 0.30 m deep into the earth using a WR® 2500 cold recycler. The binder-earth mixture was also watered using the WR® 2500. The water content and the associated water addition varied from 8 % to 16 %, depending on the in-situ earth ground.

After working in the binder, the binder-earth mixture was distributed evenly with a grader and dynamically compacted with a smooth roller compactor. After compaction, the precise grade level was produced using a laser-guided grader. To finish, the base course was statically compacted and watered again. At an age of seven days, a 10 cm thick asphalt layer was applied on top of the NovoCrete® ST base course.

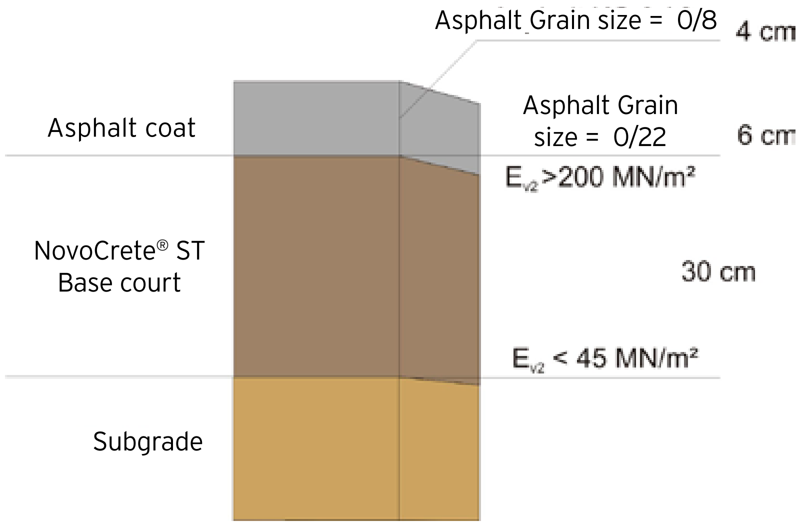


Fig. 1: *Representation of the structure of the NovoCrete® ST base course of the Marburg-Wehrda project.*

Fig. 2: *The special binder NovoCrete® is applied over the base course with a binder sprayer and milled 0.30 m deep into the in-situ earth with a Wirtgen® WR 2500.*

Fig. 3: *A pump truck was used to water the base course.*

Fig. 4: *Directly after watering the base course came another milling step to work the applied water into the base course. After homogenization of the applied water with the binder-ground mixture, the precise grade level was produced with a grader.*

Fig. 5: *Immediately after milling in the binder, the base course was dynamically compacted and production of the precise grade layer commenced.*

Fig. 6: *Depositing a container on the container yard created with NovoCrete® ST.*

5. Quality assurance

Static plate load tests were carried out on the base course produced with NovoCrete® ST in accordance with DIN 18 134 to assure the quality and determine the load bearing capacity.

The results of the tests are given in the figures by side.

GeoConCept GmbH
Am Sportplatz 15
35641 Schöffengrund
Tel.: 06445 - 612 4 3-0

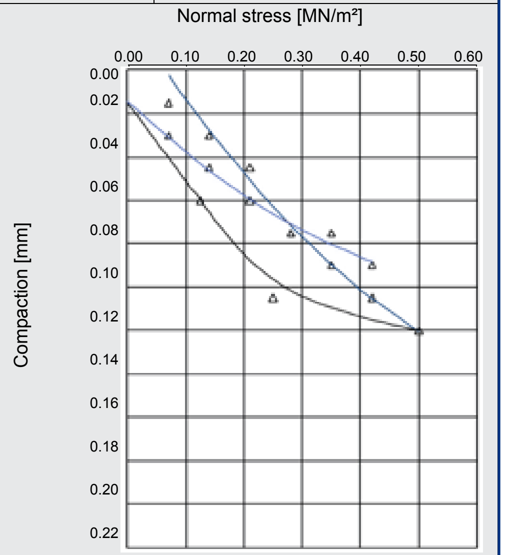
Report AZ 0902 / 998 I
Annex: 1

Plate load test according to DIN 18 134
Marburg-Wehrda
Location 1

Arranged by: Dipl.-Geol P. Hausner Date: 23/09/2002

Test number: 0902 / 998 I
Test point: Location 1
Depth: Precise grade layer
Type of earth: GU
Water content beneath plate: —

Manometer [MN/m²]	Normal stress [MN/m²	Compaction (0.01 * mm)
0.070	0.070	1.5
0.140	0.140	3.0
0.210	0.210	4.5
0.280	0.280	7.5
0.350	0.350	9.0
0.420	0.420	10.5
0.500	0.500	12.0
0.250	0.250	10.5
0.125	0.125	6.0
0.000	0.000	1.5
0.070	0.070	3.0
0.140	0.140	4.5
0.210	0.210	6.0
0.280	0.280	7.5
0.350	0.350	7.5
0.420	0.420	9.0



Weathering: dry
23/09/2002

Previous day:

Test commenced:

Test concluded:

	First cover	Second cover
S_{1max} [MN/m²]	0.500	0.500
a_1 [mm/(MN/m²)]	0.418	0.253
a_2 [mm/(MN²/m⁴)]	−0.251	−0.182
E_v [MN/m²]	769.6	1393.7
E_{v2} / E_{v1} [-]	1.81	

Plate diameter = 30.0 cm
Transformation ratio = 1.500

Comments:

Fig. 7: *Analysis of a static load plate test in accordance with DIN 18 134.*

GeoConCept GmbH
Am Sportplatz 15
35641 Schöffengrund
Tel.: 06445 - 612 4 3-0

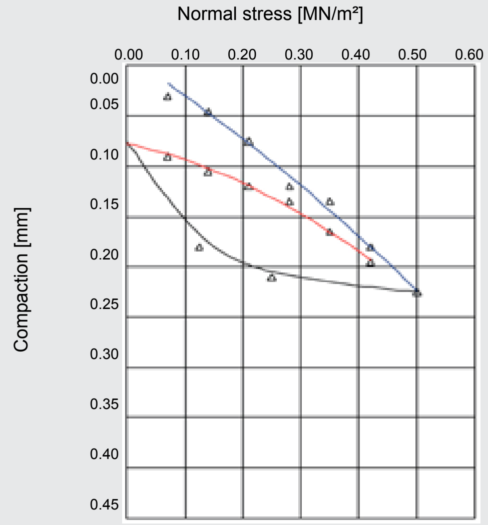
Report AZ 0902 / 998 IV
Annex: 1

Plate load test according to DIN 18 134
Marburg-Wehrda
Location IV

Arranged by: Dipl.-Geol P. Hausner Date: 23/09/2002

Test number: 0902 / 998 IV
Test point: Location IV
Depth: Precise grade layer
Type of earth: GU
Water content beneath plate: —

Manometer [MN/m²]	Normal stress [MN/m²	Compaction (0.01 * mm)
0.070	0.070	3.0
0.140	0.140	4.5
0.210	0.210	7.5
0.280	0.280	12.0
0.350	0.350	13.5
0.420	0.420	18.0
0.500	0.500	22.5
0.250	0.250	21.0
0.125	0.125	18.0
0.000	0.000	7.5
0.070	0.070	9.0
0.140	0.140	10.5
0.210	0.210	12.0
0.280	0.280	13.5
0.350	0.350	16.5
0.420	0.420	19.5



Weathering:

Previous day:

Test commenced:

Test concluded:

	First cover	Second cover
S_{1max} [MN/m²]	0.500	0.500
a_1 [mm/(MN/m²)]	0.378	0.122
a_2 [mm/(MN²/m⁴)]	0.178	0.364
E_v [MN/m²]	481.1	738.57
E_{v2} / E_{v1} [-]	1.54	

Plate diameter = 30.0 cm
Transformation ratio = 1.500

Comments:

Fig. 8: *Analysis of a static load plate test in accordance with DIN 18 134.*