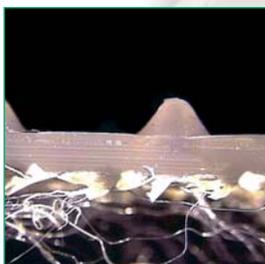




- ✓ Multifunctional sealing applications and low permeability with high swelling sodium bentonite and PE-coating
- ✓ Desiccation barrier
- ✓ Protection against ion exchange
- ✓ Barrier against roots
- ✓ Gas and radon barrier
- ✓ Improves the protection against bentonite erosion at high water pressures and gravelly subsoils
- ✓ Direct coverage with concrete and lime possible
- ✓ Shear resistant overlapping possible with special adhesive strips
- ✓ Cost-saving alternative to compacted clay
- ✓ Robust geosynthetics encapsulate the bentonite sealing core
- ✓ The uniform needle-punching improves multidirectional shear strength and internal friction angle
- ✓ Quick, easy and cost-efficient installation
- ✓  BBA certified waterproofing systems (Bentofix® X2 BFG 5300)
- ✓ ISO 9001 certified and CE marked

Advantages of needle-punched, PE-coated **Bentofix® X** Geosynthetic Clay Liners (GCL)



Bentofix® X

Advantage: Bentofix® with additional surface coating
Bentofix® X-types are 4.85m wide, needle-punched geosynthetic clay liners, comprised of a uniform layer of powder sodium bentonite that is encapsulated between two geotextile layers. The woven fabric of Bentofix® is coated with a low permeability polyethylene (PE) cover to achieve an immediate barrier prior to hydration.



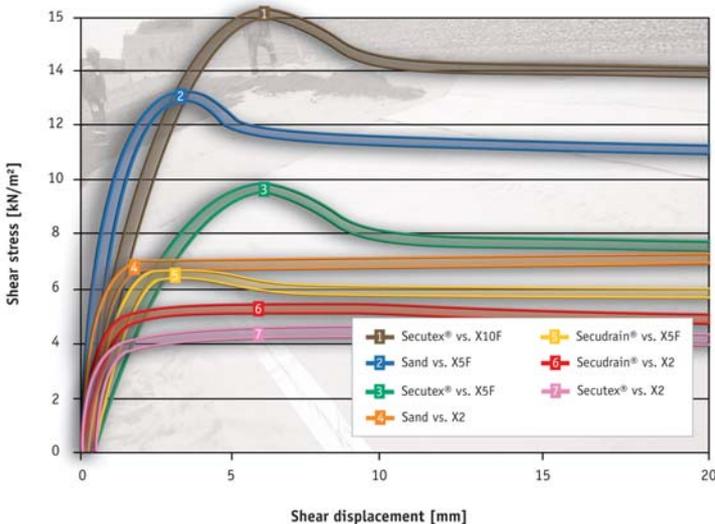
Fig. 1
Schematic of frictional coating being applied to the slit-film woven side of Bentofix®

Bentofix® is used as replacement for conventional compacted clay.

When hydrated with fresh water, the bentonite swells and forms a low permeability gel layer with a hydraulic performance equal to or better than traditional, thick compacted clay liners.

With the additional bonding of a polyethylene coating the so called fibre reinforcement is permanently locked and increases the pull-out resistance as well as the internal shear strength. Polyethylene coated Bentofix® X geosynthetic clay liners are installed where e.g. a prompt barrier against radon gas is needed, a desiccation needs to be avoided permanently, root penetration can occur, bentonite erosion at high water heads and underlying coarse subgrades shall be avoided, a supplementary barrier against critical liquids is required.

Fig. 2
Example of shear stress of Bentofix® X coating against various materials at 20kPa confining stress



Advantage: Shear strength

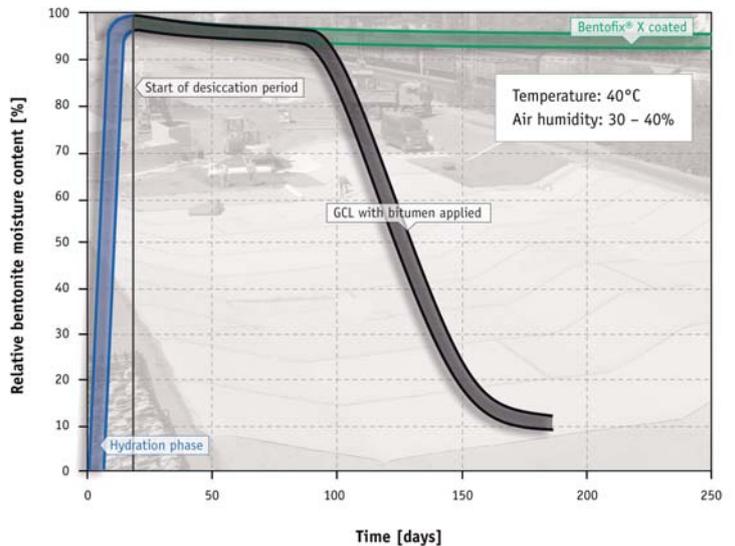
By needle-punching fibres from the cover nonwoven through the layer of sodium bentonite into the carrier geotextile, a completely uniform, reinforced Bentofix® GCL is produced with long-term high shear strength, excellent creep resistance and stability advantages important to any application. This process reduces the pull-out of fibres and increases the internal GCL shear stress, allows the application on steep slopes and assures low permeability without sacrificing slope stability.

The interface friction angle also plays a major role in slope applications. The mechanically bonded nonwoven of Bentofix® provides high interface friction angles. The structure of the polyethylene coating of Bentofix® X geosynthetic clay liners varies according to the thickness of the coating. Therefore the friction angles should be specified project-related. For slope inclinations up to 2.5:1 (h:v) the extruded friction structure of Bentofix® X-types is typically suitable.

Advantage: Better desiccation protection

Bentofix® X-types are coated with a polyethylene layer on the slit-film woven side. Installed with the coating facing up the impermeability but also the performance against desiccation improves.

Fig. 3
Desiccation behaviour of geosynthetic clay liners in a laboratory test



In a test Bentofix® X was placed over a sand layer with the PE-coating faced up. Bentofix® X was saturated for 3 weeks with water through the sand layer under a confining stress of 18kN/m² prior to the desiccation period at a temperature of 40°C and air humidity of 40%. During a period of 250 days the moisture content of the bentonite layer was monitored. The results show that a relative water loss of less than 10% occurred. Therefore it can be stated that Bentofix® X-types do not desiccate under these conditions.

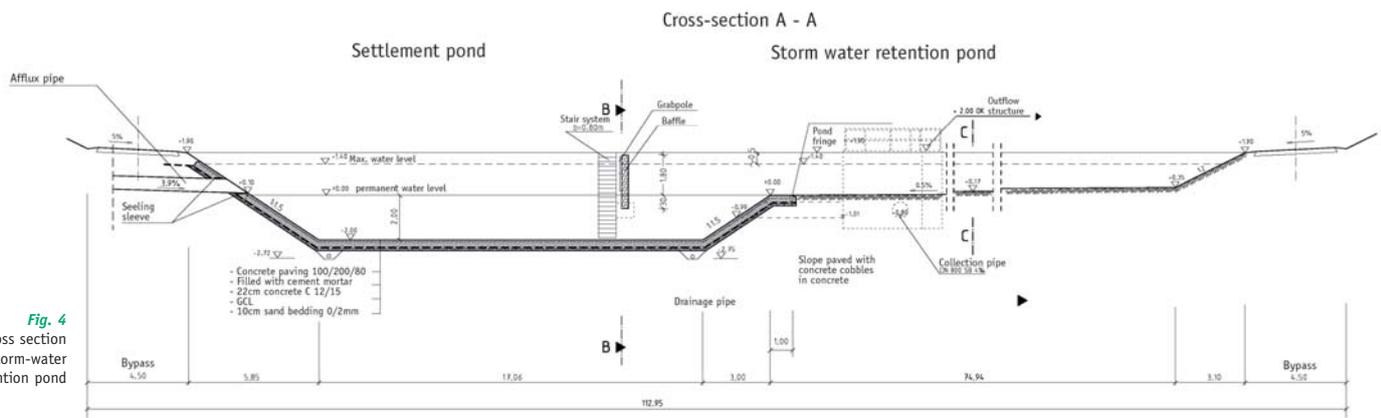


Fig. 4
Typical cross section
for a storm-water
retention pond



Fig. 5
Installed Bentofix®
GCL partly covered
with Secugrid® and
concrete surcharge

POLYETHYLENE COATING SEPARATES CONCRETE AND BENTONITE

Concrete and bentonite are actually quite incompatible: concrete reduces the sealing effect of bentonite and bentonite reduces the strength of concrete. Now NAUE has a solution: Bentofix® X – a polyethylene-coated

bentonite sealing mat, also called a geosynthetic clay liner (GCL). At the A9 Lederhose motorway junction near Triptis, the basin sealing allowed a direct application of concrete onto the bentonite mat.

The A9 is internationally significant. Not only does it connect Berlin and Munich but it continues on to Austria and Italy. The 46.5km extension in Thuringia is the final A9 extension project to be completed of the works that emerged with German reunification in 1990. Of note, this final A9 extension is actually being financed privately as part of a new financing model.

Refinancing according to availability

Via Gateway Thüringen GmbH & Co. KG is the private consortium that is orchestrating the financing, planning, building and operating of the A9 from Lederhose to the Thuringia border. The group's contract is for 20 years. It gets state money for this, but unlike the previous public-private models in which the private management company was paid based upon traffic volume this new scheme is based on roadway "availability." If the route is not accessible or accessible only to a limited extent, the consortium is paid less.

The base sealing system designed into the Lederhose motorway junction is also innovative.

Originally, a Bentofix® BFG 5000 bentonite mat without a coating was planned to be installed underneath the concrete layer and the paving. But because of the historical difficulty of bentonite – concrete designs, NAUE's engineers had some misgivings and produced an alternative, and better, solution: Bentofix® X.

Concrete paving makes cleaning easier

The project team accepted the recommendation and decided to utilize the special coating on Bentofix® X. Subsequently, the construction of the storm water retention pond was implemented in October 2012, with the system containing (from top to bottom):

- Concrete block paving (joints filled with concrete mortar)
- 22cm concrete bedding
- Bentofix® X2 BFG 5300, installed with the coated side facing up (4,300m²)
- Formation

The concrete paving surface plays a very functional role in this design, including for protection. With regular cleaning and potential desludging maintenance needed, the concrete prevents those operations from threatening the integrity of the bentonite mat or its coating. The GCL is engineered as a highly effective liquid barrier only. Hence, actions upon the basin, even for cleaning and desludging, are not appropriate for the GCL and can potentially impair how effective the barrier system can perform over the long-term.

Fig. 6
Cross section of
slope with anchor
trench

Protected by concrete, however, the bentonite mat is ready to provide significant long-term barrier security.

Additional advantages to the use of this coating include: protection against desiccation, increased root protection and resistance to damage from burrowing rodents, a stronger seal (a de facto "double seal"), and even less water permeability than the already exceptional performance of non-coated bentonite mats. Bentofix® X takes the long-term barrier characteristics for which bentonite mats are already renowned and multiplies them.

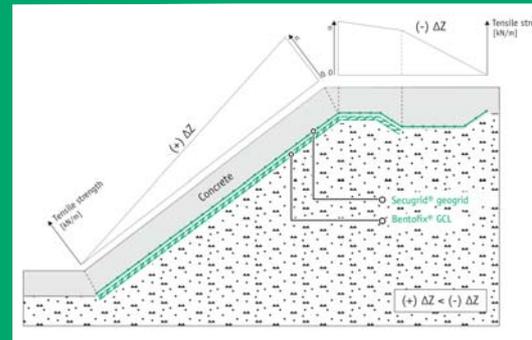


Fig. 7
Bentofix® X
lined storm water
retention pond

For the A9 project, a smooth-surfaced Bentofix® X2 BFG 5300 was installed. An additional Secugrid® 30/30 Q1 geogrid was placed in all sloped areas and back-anchored on the slope crest in a statically dimensioned anchor trench so that the concrete couldn't slip prior to setting. The back-anchoring is only required for the grid, not for the Bentofix®. The GCL is only fitted in the trench, whereas the geogrid is installed through the entire trench cross section.

INSTALLATION



Bentofix®
transportation



Storage on site



Subgrade
preparation



Bentofix®
installation



Bentofix®
overlaps with
butyl tape



Attachment to
a structure



Application of
concrete on
Bentofix® as
surcharge



Cover soil
distribution



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