



**PROJECT REPORTS**  
**Bentofix® X (PE coated GCL)**



*Water gardens on Reden's old mining area are sealed with Bentofix® X*

## Bentonite Sealing Mat Wakes Sleeping Beauty

Waterfalls, sea roses, steel sculptures, a stream made seemingly of drifting fog – the water gardens at Landsweiler-Reden, Germany astonish visitors. Though miners once toiled there in bleak conditions, the site is now a place characterized by geothermal energy, tourism, extraordinary views, and recreation. The fantastic water gardens are a main attraction, and they have been made possible by an efficient sealing system of Bentofix® X2 BFG 5300 Geosynthetic Clay Liner (GCL). Approximately 25,000m<sup>2</sup> of GCLs have been installed.

The site of the water gardens is in the state of Saarland, a historical mining region. That legacy has left behind many industrial areas and other sites in need of care. In Reden, an organization known as the "Industrial Culture Saar" has executed some fascinating redevelopment projects - most notably, the water gardens.



**Figure 1**  
Taping of  
Bentofix®  
overlaps

The site was opened in 2012, an event that sought to "wake Sleeping Beauty." The impact was immediate. Spectators were awed by how dramatically the landscape had changed. Indeed, the organizers had sought to use this site as a way to stimulate interest in other developments. All along, they had planned for this crowning water garden zone to be integrated into the larger region's remediation and redevelopment of old mining operations. And for more than 10 years, as site by site was evaluated for its potential, they had dreamed of waking Sleeping Beauty here.

The site's redevelopment used all available possibilities, with a major driving force to turn the necessities of the work into opportunities. For example, the water needed to be pumped out of the underground mines. This water was warm, so it was converted to a source of energy production. It was also used to create the "Fog Stream." And since the site's existing brownfields needed to be capped regardless, the redevelopment team used this as an opportunity to create rainwater and storm water retention ponds.

## The Necessity of a Secure Sealing System

The water gardens involve five connected ponds that branch out and incorporate different water levels. To have this elaborate, aesthetically-driven design over a sensitive site required a secure, long-term barrier system. It was a perfect application for the recently developed and introduced GCL Bentofix® X2 BFG 5300. To act as a long-term barrier against many kinds of hazardous and chemical liquids - common on mining remediation sites - these Bentofix® GCLs have been engineered with an additional polyethylene (PE) coating. Bentofix® GCLs - also known as geosynthetic clay barriers (GBR-C) - are needle-punched, reinforced composites that combine two durable geotextile outer layers and a uniform core of high-swelling powder sodium bentonite clay.



**Figure 2**  
Bentofix® X sealed  
section and cover  
soil placement

This construction forms a shear-resistant hydraulic barrier with self-sealing and re-healing characteristics. Additionally, the Bentofix® X series is coated with a durable and uniform polyethylene (PE) coating on the woven side, creating an additional low permeability barrier prior to hydration. It combines the benefits of bentonite and a PE coating in one multifunctional barrier system.

## Constructing a Critical Subgrade Seal

The subgrade throughout Reden's old mining area and its railway network is very permeable. It is characterized by a mixture of old crushed rock from track beds, unknown fill material, contaminated soils and coarse grain soils.

In redeveloping the site and making the water gardens possible, the initial planning phase looked at using a 500mm-thick compacted clay as a seal. However, this sealing system would not have worked with the many known and anticipated penetrations and connections to structures, such as concrete stairs, pipes, foundations, old and new walls, etc. With Bentofix® X, the concerns were resolved. Batten strips secured the Bentofix® panels to structures and appurtenances to ensure firm seals throughout the system.

To ensure that the PE coated GCL was not damaged during installation, a needle-punched Secutex® R 404 nonwoven was placed under and over the GCL. Since the subgrade material was expected to be very coarse in several places, the designers wanted to ensure that the bottom geotextile of Bentofix® would not be damaged. For this reason, Secutex® was laid under the Bentofix® GCL. Secutex® on top of Bentofix® protects the PE coating from being damaged during the cover soil placement process, as well as during the service life against any loads occurring from above.

The smart design and careful construction works ensured that the Bentofix®-based barrier system began its service life in optimal condition. And with the geotechnical and environmental protection issues taken care of, the awe-inspiring surface aesthetics were able to be developed.

Overall, 25,000m<sup>2</sup> of Bentofix® X2 BFG 5300 and twice that amount of Secutex® R 404 were installed according to the following cross-section (from top to bottom):

- Pond beds with different types of vegetation
- Nonwoven protection geotextile, Secutex® R 404
- GCL, Bentofix® X2 BFG 5300
- Nonwoven protection geotextile, Secutex® R 404
- Leveling material for subgrade (aggregate 0/16mm)
- Subgrade

#### Guarding against subsoil lifting

### Bentofix® secures Weinmann and Schanz's new logistics center in Balingen

**Businesses often select locations based upon infrastructure advantages. Logistics centers, in particular, play an important role. This was the case for Weinmann & Schanz in Balingen, located in the Swabian Alps, Germany. The site choice had a number of difficult problems, but Bentofix® solved them.**

Rock layers are complex. Although it may sound trivial, they can torpedo construction in Balingen in Upper Swabia. When planning the construction of a new logistics center, engineers discovered a Lias rock layer in the new structure's intended foundation site. This rock increases its volume by dehydration, which increases pressure on the foundation and can potential damage the entire structure. After intensive discussion, a special solution was found utilizing GCL. A geosynthetic clay liner (GCL) can ensure a constant moisture level with the ground and is very economical to install.



Figure 3  
Insulation placed directly over the coating side of Bentofix® X

In Balingen, this innovative geosynthetic solution involved the encapsulation of the rock layers that were at risk of drying out. The sealing product used was NAUE Bentofix® X2 BFG 5300, a polyethylen (PE) coated GCL that's characterised by extremely low permeability.

The installed GCL over the subgrade and under the concrete foundation minimizes, if not even prevents an evaporation processes in the sealed zone. The potential threat of structural damage to the foundation due the potential risk of volume increase of the Lias rock during dehydration was mitigated.



Figure 4  
Preparation for the concrete pouring over Bentofix® and insulation

Bentofix® provided numerous welcomed benefits. One of them was that the installed GCL qualified as an smooth and flat surface for the installed insulation under the concrete slab. Additional security was derived from the multi-functionality of the GCL's composite structure. The high-swelling bentonite component of GCL acts as a "self-sealing" barrier, in the event that the robust polymer coating is accidentally damaged.

And the polymer coating ensures that the bentonite and the surrounding soil layer remain hydrated with a more or less constant moisture content.

Overall, the 24,000m<sup>2</sup> warehouse and logistics center in Balingen was made possible with Bentofix® X2 BFG 5300. Construction took place over a short period (March-October) and provided an economical, high-quality solution. The site is has been given permanent protection against a dangerous drying out of the rock below. Valuable property has been made more so with Bentofix®.

**Fuel Depot Protection: Always 100% Secure**  
**Bentofix® X protects against drying out**

Airport fuel depots are enormous and, needless to say, they must meet stringent safety standards. Among other things, flood control basins are required for heavy rainfall. The Leipzig/Halle airport, however, encountered the following problem: How can security be guaranteed if the bentonite seal is exposed to drying conditions? The new Bentofix® X is the solution: Thanks to a novel coating, the geosynthetic clay liner (GCL) provides protection from drying out even in dry conditions and is immediately fully functional when heavy rain occurs.



**Figure 5**  
Installation and overlapping of Bentofix® X GCL rolls

The Leipzig/Halle airport is in the process of establishing itself as a significant air freight hub. It is run by "AeroLogic", a cargo airline founded in 2009 and a joint venture of DHL and Lufthansa Cargo. AeroLogic utilises Leipzig/Halle as a base airport and primarily offers flights to destinations in Asia. Since the airport's beginnings as a freight hub, its freight volume has grown from 442,000 tonnes to 760,355 tonnes (in 2011). As a result, Leipzig/Halle now ranks second after Frankfurt/Main. The airport currently employs more than 5,500 people. Due to the recent growth, the fuel deposit had to be expanded. All of the kerosene, which the cargo planes use on their flights to 33 different countries, is provided by the Total refinery in Leuna, Germany, and is delivered twice per week. The fuel deposit holds 11 million litres of kerosene.

**Dry conditions threaten seal tightness**

To protect the new fuel containment structures after heavy rainfall, flood control basins had to be built.

They protect the fuel zone from flooding and feature geosynthetic clay liners for security. The sodium bentonite core of the GCL swells when hydrated to form an exceptional barrier to liquids, essentially creating an impermeable barrier. However, the flood control basins at Leipzig/Halle airport only serve as short-term, temporary basins. They dry out on a regular basis. This raised a concern as to whether the bentonite in the GCL might desiccate during prolonged dry spells and create permeable channels in the clay.

Generally, this potential problem is circumvented by means of a 60cm cover layer on top of the GCL. At this site, however, only 30cm of cover was possible. The bentonite core, even protected by its carrier and cover layer geotextiles, would not be guaranteed to remain in a permanently swelled state. The installation of Bentofix® X2 NSP 4900 offered a strong solution: the GCL the client wanted originally but without any site desiccation questions. This innovative GCL from NAUE has further advanced the 25-year history of Bentofix® GCLs. It contains the high-swelling powder sodium bentonite core and scrimreinforced, needlepunched nonwoven geotextile encapsulation that Bentofix® is renowned for; as well as the new Bentofix® X line polyolefin polymeric coating.



**Figure 6**  
Cover soil placement over installed Bentofix® GCL

Adhered to the outer side of one of the geotextiles, this special coating protects the bentonite from drying out in difficult project environments, increases gas barrier performance, extends GCL service life, prevents ion exchange, mitigates root penetration threats, and more. Approximately 3,500m<sup>2</sup> of NAUE Bentofix® X2 NSP 4900 was installed. It was placed with the coated side up (standard installation).



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