

# Carbofol®

Carbofol® HDPE geomembranes with BF/TF surface structure



Technical Note

## What is a geomembrane with a structured surface?

A structured or textured geomembrane is a polymeric geosynthetic barrier (GBR-P) with an artificially roughened or patterned surface. This surface structure can take the form of regular raised or embossed patterns, dimples, studs (as for Naue Carbofol®) or irregularly sprayed/co-extruded HDPE matter (a common method for cheaper production). All these types of textural features are intentionally added to the geomembrane during manufacturing, and they serve several specific purposes in various engineering and environmental applications.

## What is the reason behind it?

Geomembranes with surface structure are often used in applications where increased friction is required to achieve stability against slip-page on or below the geomembrane. The textured surface creates a higher coefficient of friction between the geomembrane and the adjacent materials (e.g., soil, rock, or other geosynthetic materials). This improved friction can ensure stability against sliding, especially on steep slopes.

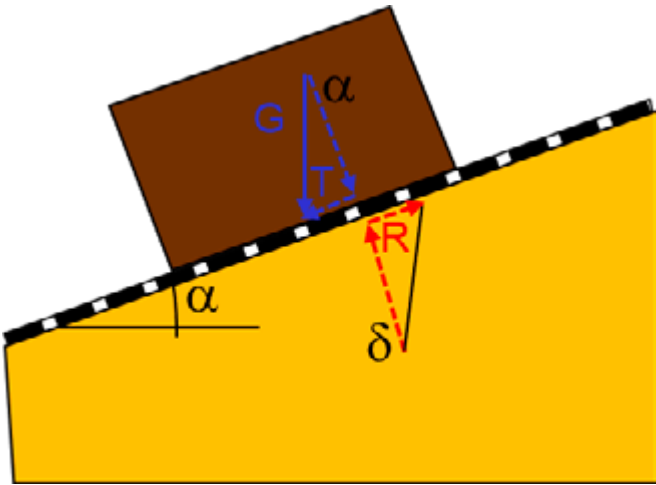


Figure 1: Stability against sliding of lining systems – mechanical principle

The ultimate cause for surface structures is to achieve an increased interface shear strength, which is predominately defined by the contact friction angle  $\delta$ , but also by the adhesion  $\alpha$ . Simplified, it is to be achieved that the frictional resistance  $R$  (which is defined as the slope-normal portion of the load multiplied with  $\tan \delta$ ) exceeds the slope-parallel driving force  $T$  to prevent a sliding failure in the shear interfaces of a sealing system under the load of the covering soils, waste or mining residues. In that respect, a higher angle of friction  $\delta$  allows for a higher slope inclination  $\alpha$  or represents a higher safety when  $\alpha$  is constant.

That said, it is of high interest for all parties in a lining project to choose products with

1. exceptional high frictional characteristics to allow for optimum safety.
2. homogeneous distribution of the structure elements that create the friction.
3. identical stabilisation and thus long-term oxidation resistance of the structure elements and the geomembrane sheet itself.
4. high abrasion resistance of the structure elements.

Naue is proud to say that our Carbofol® BF/TF fulfils all these requirements in an outstanding manner. The method of applying Carbofol® BF/TF structure with moulded rollers that shape the dimples directly into the HDPE melt of the geomembrane as it leaves the die differentiates from other methods such as spraying or co-extruding a secondary HDPE melt onto the original membrane.

When visually comparing the geomembrane structure types embossed (A), co-extruded (B) and sprayed (C) as thin sections under a microscope, it becomes visually clear that the embossed structure is rooting from the original geomembrane sheet while the others are applied subsequently.

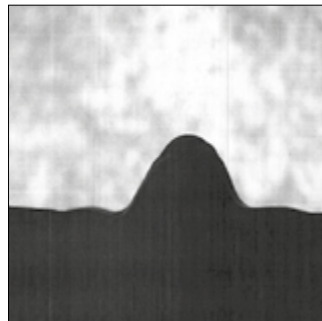


Figure 2: Visual comparison of embossed structure (A, left), co-extruded structure (B, middle) and sprayed structure (C, right)

Other significant differences between the structure types include:

	Embossed structure	Co-extruded structure	Sprayed structure
Uniformity	Always identical pattern, homogeneous shear properties	Structure orientation randomised by process, inhomogeneous shear properties	Structure orientation randomised by process, inhomogeneous shear properties
Thickness of original membrane and asperity height	Easy to assess, original sheet and asperity height can be measured	Difficult to assess, as all surface of the original sheet is covered by co-extrudate.	Easy to assess, original sheet and asperity height can be measured
Abrasion resistance	Excellent – dimples cannot be removed even with high shear loads	Varying – while some portion of the structure can be removed with few efforts, lower sections of the co-extrudate stick well	Low – certain structure particles can be peeled off by fingernail
Material homogeneity	Identical raw material and extruder for geomembrane and structure	Different extruder and potentially different raw material for structure	Different extruder and potentially different raw material for structure

### What are the advantages for Naue customers?

Not only did Naue develop the BF/TF structure to optimise the shear strength of our Carbofol® geomembranes towards the typical friction partners. We also have the equipment and know-how to test and evaluate shear strength between different geosynthetic components or towards soil in our own laboratory in large-frame shear tests.

We are eager to provide assistance on questions of shear resistance and structure durability from our long experience in shear testing, manufacturing and improvement of our products.

Our aspiration to manufacture the best possible geomembrane surface structure is advantageous for all projects – for example, in mining or landfilling – where

1. **optimum use of space** is of essence to achieve sufficient safety even in challenging/steep conditions.
2. **high safety** is of essence due to the environmental sensitivity of the project.
3. **fast installation** is of essence, as no grinding of the structure is required before welding.

