CONCRETE
SikaGrout®-3500 WP
SECURE GROUT CONNECTIONS FOR OFFSHORE WIND TURBINES
OPTIMUM WORKING

One of the essential requirements for high performance grouts in offshore turbine connections is the consistent production and workability of the Grout under the difficult offshore conditions. SikaGrout WP-3500 meets all of these demanding requirements, even in extreme temperatures.

SIKAGROUT®-3500 WP UNDER TEST CONDITIONS

In co-operation with specialist manufactures of offshore grouted joints, the excellent characteristics of SikaGrout-3500 WP was proven in a large-scale test.

- low pumping pressure
- very high grouting output
- outstanding flow properties
- annular gaps filled free from voids
- optimal load transfer

Advantages of SikaGrout®-3500 WP – Overview

- outstanding flow properties
- extremely long workability (≥ 4 h between 3 °C and 30 °C)
- annular gaps can be fully filled, free from voids, even under water
- self-compacting
- good consistence stability without sedimentation

slump flow acc. DIN EN 12350-8

![Graph showing slump flow results for different temperatures](graph.png)
STRONG AND DURABLE

In monopile foundations the weight of the total wind power plant must be transmitted through the grouted connection into the foundations. SikaGrout-3500 WP is designed specifically to accommodate these high loads with its Class C100/115 compressive strength, which also allows a cost effective structural steel design.

The high consistence stability of SikaGrout-3500 WP without sedimentation ensures a homogenous hardened concrete structure. This ensures the uniformly high load bearing capacity within the grouted joints to accommodate safe and secure load transfer.

**EFFECTIVE AND FAST – SIKAGROUT®-3500 WP**

Offshore labour and equipment is obviously expensive. The viability of a wind farm can therefore even be dependent on the length of the construction period and on the question: “How many days in the year do the wave height and ambient temperatures allow grouting work to take place.

The faster the strength development of the grout, the more offshore working days are possible, because shorter fair-weather windows can also be used and at lower temperatures grouting can continue.

SikaGrout-3500 WP is characterized by a rapid strength development even at low temperatures. As a result adequate resistance to wave exposure and frost is achieved very early on and almost year-round grouting is possible. This can considerably shorten the overall construction time and thus significantly reduce costs.
TOUGH UNDER SEVERE CONDITIONS

Grouted joints between monopiles and transition pieces are exposed to considerable dynamic load.

In addition to the static compressive strength of the grouting material, it is above all its fatigue strength that is of critical importance. The DNV standard DNV-OS-C502 contains a model for fatigue dimensioning of concrete and grout under water. Therefore the fatigue strength of SikaGrout-3500 WP was determined at the University of Hanover, both in air and under water.

Results:
- The number of stress cycles before failure of SikaGrout-3500 WP were significantly above the Wöhler stress curve from DNV-OS-C502 (red line in the chart). The Wöhler stress curve can therefore also be used for the dimensioning of grouted joints with SikaGrout-3500 WP.
- The so-called fatigue factor $c_5$ can be applied with a value of 1.0. Thus 25% higher fatigue strengths can be applied in comparison with the standard assumption.

Fatigue Test under water

![Fatigue Test Graph](chart)

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A HIGH QUALITY SOLUTION

Sika products are renowned for the highest quality standards. Quality Assurance according to ISO 9001 and ISO 14001 together with internal and external monitoring in accordance with all relevant DIN and EN standards ensure this high product quality and performance.

SikaGrout-3500 WP is certified and externally monitored by the QDB to German high performance grout standards. Expert assessments from the University of Hanover and the University of Kassel also confirm the suitability of SikaGrout-3500 WP for use in offshore wind turbines.

OPTIMUM PERFORMANCE of SikaGrout®-3500 WP:

<table>
<thead>
<tr>
<th>material characteristic</th>
<th>test standard</th>
<th>specific value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static E-modulus</td>
<td>DIN 1048-5</td>
<td>43 GPa</td>
</tr>
<tr>
<td>Dynamic E-modulus</td>
<td>–</td>
<td>43 GPa</td>
</tr>
<tr>
<td>Poisson’s ratio</td>
<td>–</td>
<td>0.15</td>
</tr>
<tr>
<td>Flexural strength</td>
<td>DIN EN 196-1</td>
<td>13 MPa</td>
</tr>
<tr>
<td>Indirect splitting tensile strength</td>
<td>DIN EN 12390-6</td>
<td>7 MPa</td>
</tr>
<tr>
<td>Frost and de-icing salt</td>
<td>BAW-guideline</td>
<td>weathering 77 g/m²</td>
</tr>
<tr>
<td>ASR-resistance</td>
<td>German alkali guidelines</td>
<td>elongation &lt; 0.1 mm/m</td>
</tr>
</tbody>
</table>
SAFELY AND SECURELY ANCHORED IN ANY WIND AND WEATHER

The replacement of fossil fuels and nuclear power by the use of renewable energies is one of the greatest challenges of the present. Offshore wind energy is and has great potential to be an increasingly important part of this.

Depending on the depth of the sea different types of foundation structures are used. The foundations and the Wind turbines are joined by grouted connections. Inside these connections the annulus gap between the Monopiles / Piles and the Sleeves / Transition Pieces is filled with a special cementitious grout. This grouted connection has to safely and securely transfer all of the static and dynamic loads from the wind turbine above into the foundation structure in the seabed.

TYPICAL WIND TURBINE FOUNDATION STRUCTURES
Due to their ideal positioning and locations, wind turbines are subjected to many different stresses and exposures including extreme temperature fluctuations, high UV and high moisture – offshore installations especially have to be protected against the aggressive salts in marine atmospheres. Sika provides complete protection for wind turbines with a wide range of specialist products, such as:

**SIKACOR® AND SIKA® PERMACOR®**
The long-term corrosion protection products and coordinated systems designed to protect steel surfaces in all of these different and specific aggressive environments.

**SIKAFLEX® SEALANTS AND ADHESIVES**
Nacelles and blades are subject to constant wind and water exposure and attack. Sikaflex sealants and adhesives provide permanent elastic sealing solutions to ensure watertightness in and around ducts, joints and mounting flaps.

**SIKA® VISCOCRETE®, SIKALASTIC® AND SIKAGARD®**
High performance concretes and mortars are produced with Sika ViscoCrete technology for high strengths, impermeability and durability. Additional protection against mechanical and aggressive environmental attack can be provided by Sikalastic® and Sikagard® protective coating systems.

You can learn more about the entire Sika program at www.sika.de or download our brochure: “Reliable protection for gentle giants”.

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