Master Builders Solutions

from BASF

Building on partnership. The Master Builders Solutions experts find innovative and sustainable solutions to meet your specific construction needs. BASF’s global experience and network help you to be successful – today and tomorrow.

Master Builders Solutions
The Master Builders Solutions brand brings all of BASF’s expertise together to create chemical solutions for new construction, maintenance, repair and renovation of structures. Master Builders Solutions is built on the experience gained from more than a century in the construction industry.

The know-how and experience of a global community of BASF construction experts form the core of Master Builders Solutions. We combine the right elements from our portfolio to solve your specific construction challenges. We collaborate across areas of expertise and regions and draw on the experience gained from countless construction projects worldwide. We leverage global BASF technologies, as well as our in-depth knowledge of local building needs, to develop innovations that help make you more successful and drive sustainable construction.

The comprehensive portfolio under the Master Builders Solutions brand encompasses concrete admixtures, cement additives, chemical solutions for underground construction, waterproofing solutions, sealants, concrete repair & protection solutions, performance grouts, performance flooring solutions.

Our reference near to Forth in Lanarkshire (UK):
Black Law onshore windfarm
BASF’s MasterFlow is an ultra high strength, fatigue resistant cement based Exagrout with metallic aggregates for grouting onshore wind turbine installations. MasterFlow 9300 has been especially formulated for:

- Grouting of wind turbine installations, e.g. under the load transfer plate or T-flanges of pre-stressed towers.
- Grouting under very harsh conditions, e.g. at temperature ranging from as low as 2°C to 30°C.
- All void filling from 25 mm to 200 mm where high strength, fatigue resistance and high modulus is important.

MasterFlow 9300 Exagrout shows excellent long term durability and guarantees safe and cost effective onshore wind farm installations. Wind turbines are special - their safe and durable installation largely depends on the correct design and interaction of all components. Our MasterFlow Exagrout’s high performance guarantees a long-term and maintenance free operation of the wind farm.

MasterFlow 9300 Exagrout for onshore wind turbine installations:

**Excellent durability:**
- Contains metallic aggregates
- Excellent abrasion resistance
- High toughness index
- Freeze / thaw resistant
- Very low porosity and water absorption

**Secure maintenance free installation:**
- Autogenous swelling; volume stable
- No need for permanent post-tensioning of anchors
- Excellent long term load transfer
- High ultimate strengths
- Installation by BASF Licensed Contractors

**Fast and cost effective installation:**
- Rapid strength build-up, even at temperatures as low as +2°C
- Earlier pre-stressing of anchors at all temperature ranges
- Short overall installation times and earlier operation of the wind farm

BASF helps the wind industry to be more successful by better understanding the needs of our partners and reducing the risks involved in the construction and exploration of modern wind farms. Managing risks means for BASF Construction Chemicals amongst others:

- MasterFlow 9300 Exagrout installed by BASF Licensed Contractors
- Independent documentation of the material properties
- Detailed installation methods as part of the Quality Assurance
- Extended warranties for correctly installed and operated wind farms
- Compulsory training of BASF Licensed Contractors

**Product validation**

Early designs of onshore wind turbine installations, had towers directly embedded into the concrete using single or double flange anchors. All loads acting on the structure are transferred directly from the tower into the reinforced concrete foundation. As such constructions are not pre-stressed, large stress amplitudes occur that can lead to major cracking and/or concrete delamination.

More recent designs, which are also considered more durable and reliable, use pre-stressed ring or T-flanges with which stress amplitudes can be controlled. Grouting materials to fill the gap between flange and foundation need to be carefully selected. The grout is exposed to many millions of dynamic loads in the lifespan of the wind turbine structure. Any defect underneath the flange will therefore lead to a rapid increase of deformation and to a failure risk of the structure. Grouts not resisting dynamic loads will eventually lead to the premature failure of the construction.

BASF has developed the Exagrout, MasterFlow 9300, for application in onshore wind turbine installations. Typically the product is used between the concrete foundation and the flange of the steel towers. Another field of application is the use of MasterFlow 9300 in concrete towers of onshore wind turbines.

MasterFlow 9300 has been validated by:
- Aalborg University DCE Laboratory, Denmark
- TUM (Technische Universität München), Germany
- Applus - LGAI Technological Center, S.A., Spain
- CTL, USA
MasterFlow 9300
Mechanical Properties

Compressive strength
The compressive strength of BASF’s MasterFlow 9300 was tested at Aalborg University using:
- prisms 40 x 40 x 160 mm and carried out in accordance with EN 196-1. At each testing age, 3 prisms were tested, yielding 6 compressive strength results.
- 75 mm cubes and carried out in accordance with EN 12390-3. At each testing age, 3 cubes were tested.
- 100 x 200 mm cylinders and carried out in accordance with EN12390-3. At each testing age, 3 cylinders were tested.

The compressive strengths for MasterFlow 9300 tested at 20°C are plotted as a function of age in Figure 1. The results at 5°C are given in Table 1.

For design reasons, calculations for concrete are typically made according to Eurocode 2. A conversion factor of 80% is normally considered for the conversion of cube concrete strength to cylinder concrete strength. Equally, a conversion factor of 85% is considered for prism strength to cube strength. This yields a conversion factor of 0.68 for concrete when converting prism strength into cylinder strength.

Since MasterFlow 9300 is not a concrete, but a mortar with a maximum aggregate size of only 3.5 mm, the conversion rule as described in Eurocode 2 does not apply. Comparing the strength measurements for prisms and cylinders at 20°C, a conversion factor of 0.90 to 0.92 has been determined. Compressive strength was also measured at TUM (Technische Universität München) over a temperature range of +2°C to +30°C in accordance with EN 196-1. At each testing age, 3 prisms were tested, yielding 6 compressive strength results. The compressive strength results for MasterFlow 9300 are shown as a function of age in Figures 2 and 3.

Flexural strength – Tensile splitting strength
The flexural strength was measured in accordance with EN 196-1 on 40 x 40 x 160 mm prisms, while the splitting tensile strength was determined in accordance with EN 12390-5 on cylinders ø 100 x 200 mm. Results are shown in Table 2.

Static and dynamic modulus of elasticity
The static modulus of elasticity was measured on cylinders ø 100 x 200 mm cured 28 days in water at 20°C in accordance with EN 13412. Results are shown in Table 3. Dynamic modulus of elasticity at cold temperatures was measured on prisms cured in water at +2°C and +5°C according to the guideline for the “protection and repair of concrete structures” of the German Committee of Reinforced Concrete (Rili-SIB DAFStb). The results are plotted in Figure 4.

Table 1

<table>
<thead>
<tr>
<th>Time (days)</th>
<th>Prisms 40x40x160 mm</th>
<th>Cubes 75 mm</th>
<th>Cylinders 100x200 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>116.2 MPa</td>
<td>124.8 MPa</td>
<td>88.5 MPa</td>
</tr>
</tbody>
</table>

Table 2

<table>
<thead>
<tr>
<th>Time</th>
<th>Flexural Strength (MPa)</th>
<th>Tensile splitting strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 days</td>
<td>28</td>
<td>7.6</td>
</tr>
</tbody>
</table>

Table 3

<table>
<thead>
<tr>
<th>Time</th>
<th>Modulus of elasticity (GPa)</th>
<th>Poisson’s ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 days</td>
<td>44.9</td>
<td>0.213</td>
</tr>
</tbody>
</table>
Autogenous shrinkage
What is autogenous shrinkage?
Autogenous shrinkage is the result of the chemical reaction between water and a cementitious material. The volume of the components before the reaction is typically larger than the volume of the end products i.e. hydrated cement (see Figure 5).
Autogenous shrinkage can occur in wet conditions, in contradiction to drying shrinkage which occurs only in dry conditions.

Autogenous shrinkage can result in de-bonding of the grout from the steel flange of the wind turbine and consequently poor load transfer of the dynamic loads that act on the foundations in onshore wind turbine installations.

Volume stability is of utmost importance in the long term durability of foundations in onshore wind turbine installations. Verification of the autogenous shrinkage is therefore vital in the validation of the grouting material used between the concrete foundation and the flange of onshore wind turbines.

Laboratory testing:
Autogenous shrinkage was measured using a method developed at Aalborg University. After mixing MasterFlow 9300, corrugated plastic tubes, approximately 410 mm long and 30 mm in diameter, were filled with the grout and then sealed by a plastic stopper in each end of the tube and placed in a temperature controlled room at 20°C. After final set, the length of each specimen was measured as a function of time, using a micrometer gauge, cf. Figure 6.

Autogenous shrinkage results found in the technical literature most often refer to measurements starting at an age of 1 day when the specimens are de-moulded. Figure 7 shows the autogenous shrinkage measured over time starting at the age of one day. No autogenous shrinkage is measured after approximately 1/2 year. A small volume increase was actually determined.

Fatigue behaviour
Fatigue resistance is the resistance to the progressive and localised structural damage that occurs when a material is subjected to cyclic loading. The nominal maximum stress values are less than the ultimate stress limit and may be below the yield stress limit of the material.

Fatigue occurs when a material is subjected to repeated loading and unloading. If the loads are above a certain threshold, microscopic cracks will begin to form. Eventually a crack will reach a critical size, and the structure will suddenly fracture.

The design standard DNV-OS-C502 gives design guidelines for how to take into account maximum and minimum stress levels for fatigue life predictions (see Figure 8). Fatigue calculations are made according to the formulation

\[
\log_{10} N = C_1 \cdot \left( \frac{\sigma_{\max} - \sigma_{\min}}{\sigma_{f,rd} - \sigma_{f,rd}} \right)
\]

where:

- \( C_1 = 12 \) for structures in air
- \( C_1 = 10 \) for structures in water, and stress blocks having variation in the compression-compression range
- \( C_1 = 8 \) for structures in water, and stress blocks having variation in the compression-tension range
- \( \sigma_{\min} = \) the numerically lowest compressive stress, calculated as average within each stress-block
- \( \sigma_{\max} = \) the numerically largest compressive stress, calculated as average within each stress-block (for tension = 0)
- \( \sigma_{f,rd} = \) strength reduction factor for the specific grout,
- \( \sigma_{f,rd} = 0.85 \) shall be taken for MasterFlow 9300

The behaviour of MasterFlow 9300 under cyclic loading was studied using cylindrical specimens, 60 mm in diameter and 120 mm high. The grout material has been tested for fatigue resistance in air. Tests were performed at high frequency (10Hz).

The observed number of cycles to failure in the tests under cyclic loading corresponds well with the prediction according to DNV-OS-C502 (Figure 9). It can be concluded that MasterFlow 9300 shows a performance under cyclic loading that is as good as for reinforced concrete. Based on the tests, it is concluded that the design for fatigue can be carried out using formulations for fatigue life prediction in DNV-OS-C502 for reinforced concrete.

MasterFlow 9300
Load Transfer Capacity

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9
Lorem Ipsum
Aboreper chician ditatum delita:
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