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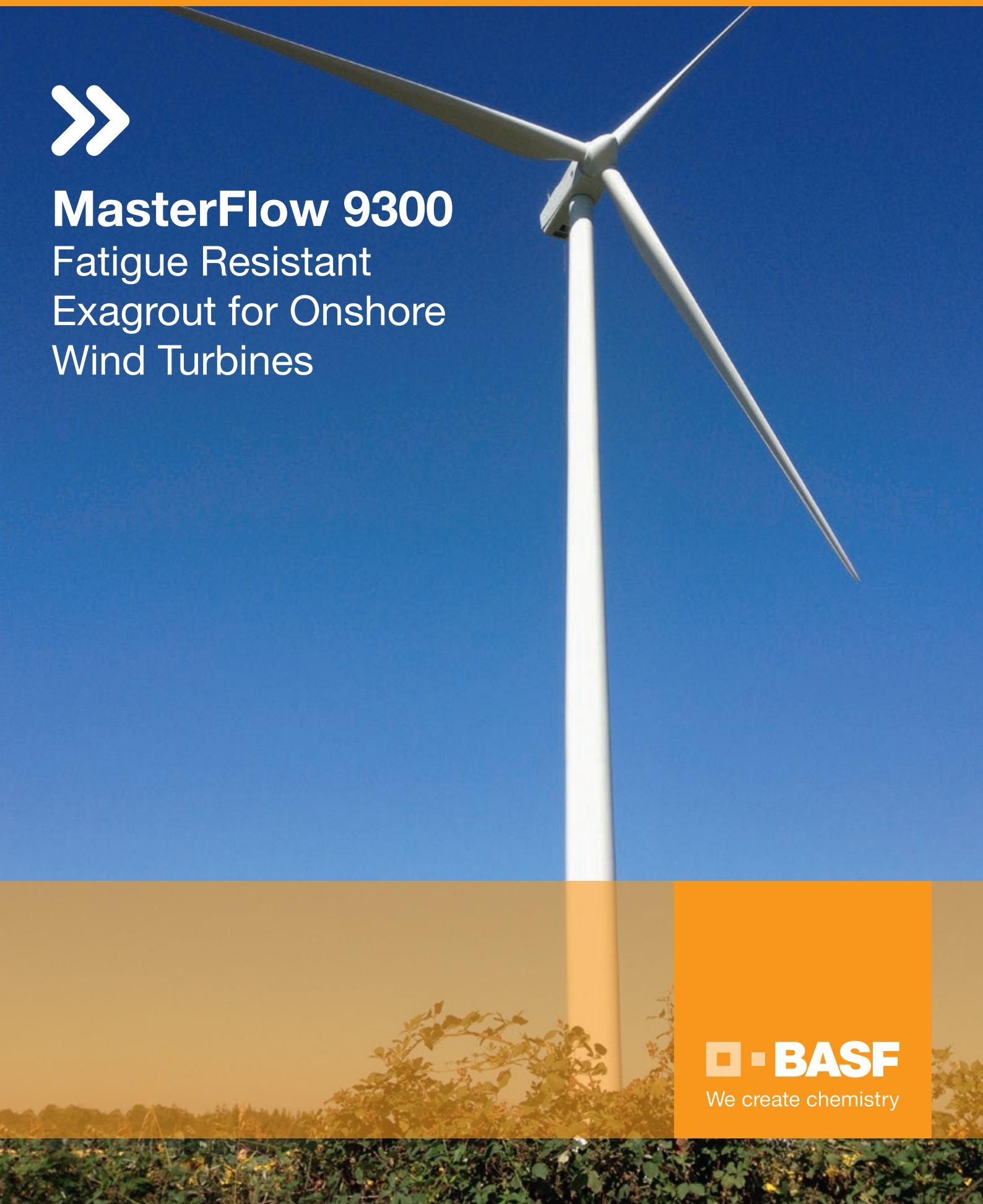

MasterFlow 9300

Fatigue Resistant Exagrout for Onshore Wind Turbines

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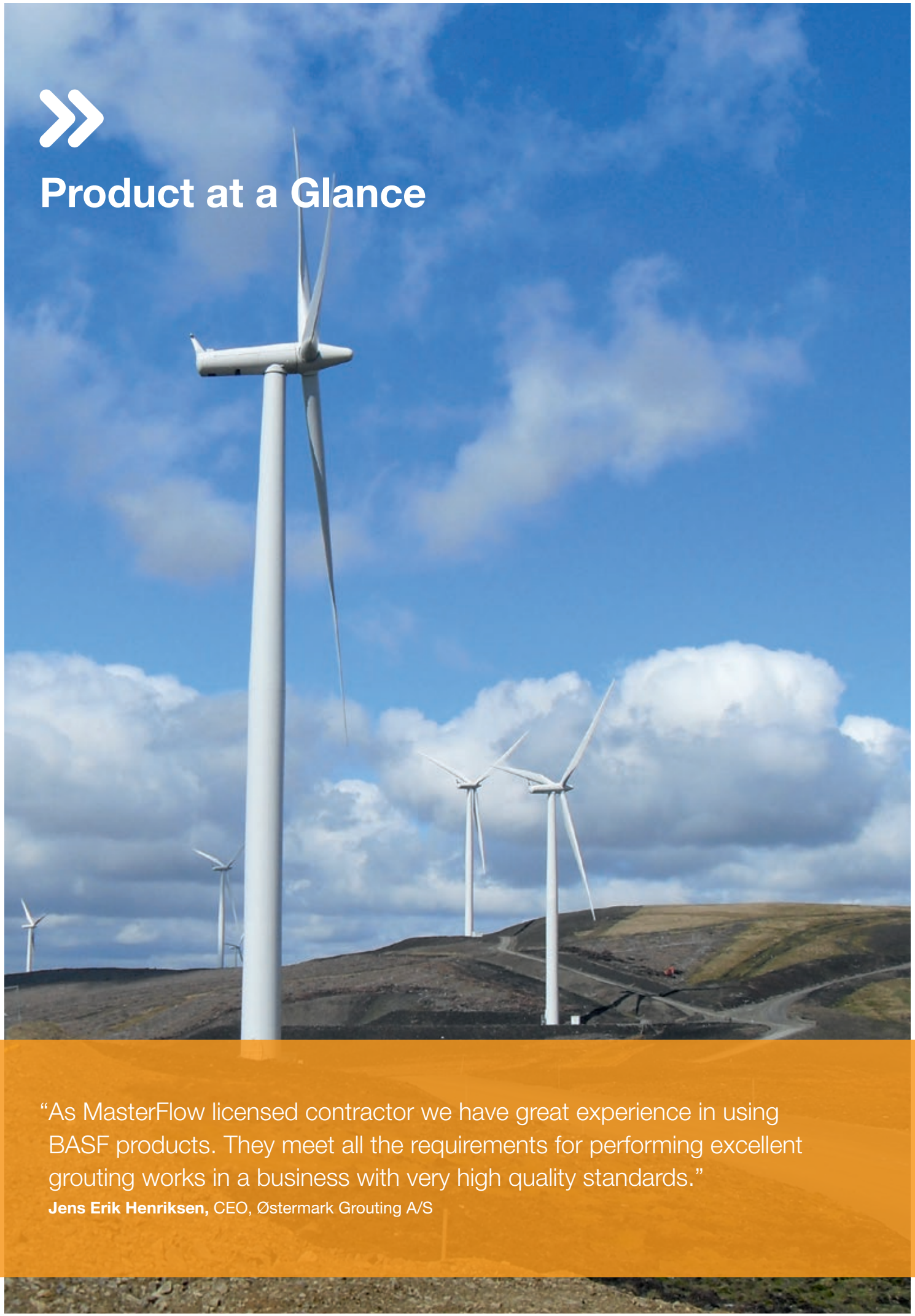
We create chemistry

Product at a Glance



"As MasterFlow licensed contractor we have great experience in using BASF products. They meet all the requirements for performing excellent grouting works in a business with very high quality standards."

Jens Erik Henriksen, CEO, Østermark Grouting A/S

MasterFlow 9300: Fatigue Resistant Exagrout for Onshore Wind Turbines

MasterFlow 9300 is an ultra-high strength, fatigue resistant cement based Exagrout with metallic aggregates for grouting onshore wind turbines – making wind energy projects more cost effective during installation, and more durable and secure over the entire lifetime of the wind farm.

Typically MasterFlow 9300 is used in onshore installations where the bottom flange of the turbine tower is to be grouted and connected to the concrete foundations.

The material has been especially formulated for onshore wind turbines:

- Grouting under the load transfer plate or T-flanges of pre-stressed towers
- Grouting under harsh conditions and temperatures as low as 2 °C
- All void filling from 30 to 200 mm where high early and final strength, and fatigue resistance are required

Early designs of onshore wind turbine installations had towers directly embedded into the concrete foundations, the so called can design. Such installations have suffered major problems like concrete cracking and poor load transfer, resulting in lower electricity production and even stand-still.

More recent designs, more durable and reliable, use pre-stressed ring or T-flanges that control and better distribute any load acting on the foundation. This is the so-called anchor cage design. MasterFlow 9300 is especially designed to fill the gap between flange and concrete foundation, and guarantee long term load transfer and electricity production.

Product benefits at a glance:

High fatigue resistance
Absorbing dynamic loads

2 °C
Cold weather application
More installation opportunities and fast project completion

Excellent durability
Guaranteeing longterm electricity production

High early strength
Allows earlier pre-stressing of the anchor bolts

Secure installation
Application by BASF Licensed Contractors

Proven high quality
Validated by external institutes and various OEM's

Excellent Mechanical Properties

Meeting the high specifications of various turbine suppliers

MasterFlow 9300 has been developed by Master Builders Solutions experts especially to meet the highest requirements of the turbine manufacturers and designers in onshore wind.

Designs of the concrete foundation and the grout connecting the turbine to the foundation are made to guarantee the minimum 25 years lifetime of the wind farm. High fatigue resistance of the grout is of utmost importance to guarantee the long term transfer of all dynamic loads that are occurring over the lifespan of a wind turbine installation.

To meet the requirements of the designers and wind turbine suppliers, high early and final characteristic strengths are required for long term durability of the grout and thus complete installation.

Application of MasterFlow 9300 by BASF Licensed Contractors guarantees that the highly specialized grout material is correctly installed. Mechanical properties are therefore also secured on the jobsite.

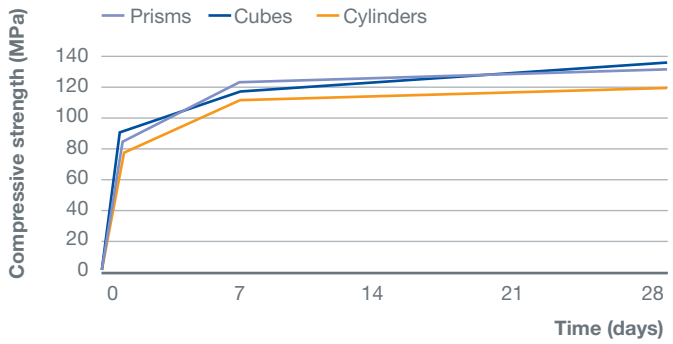
Early Strength Development Even at Low Temperatures

Compressive strength

The compressive strength of MasterFlow 9300 was tested using variable size specimens ranging from 150 x 300 mm cylinders to 75 mm cubes and 40 x 40 x 160 mm prisms. Figure 1 shows the strength measurements of MasterFlow 9300 tested at 20 °C after different ages.

Strength development at 20 °C

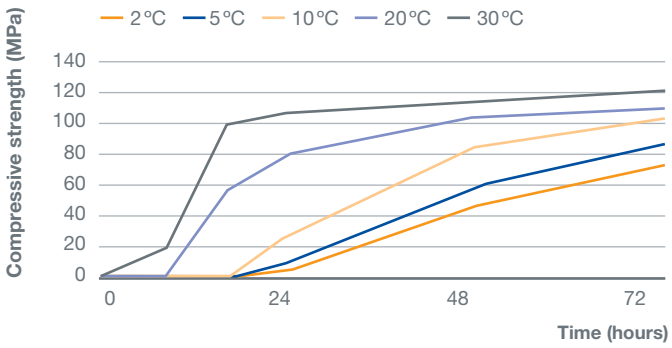
Figure 1



Pre-stressing of the anchor bolts of the turbine installation is very much dependent on the rapid strength development of the grout. Figure 2 shows the early strength development of MasterFlow 9300 at various temperatures between 2 °C and 30 °C.
The grout strength requirement before tensioning the anchor bolts is around 50 MPa depending on the turbine manufacturer and type. Such value is typically achieved with MasterFlow 9300 at 20 °C well within 24 hours, and in approximately 48 hours at temperatures as low as 2 °C.

Early age compressive strength

Figure 2



Flexural strength – Tensile splitting strength – Modulus of elasticity

The flexural strength of MasterFlow 9300 was measured in accordance with EN 196-1 using 40 x 40 x 160 mm prisms, while the splitting tensile strength was determined according EN 12390-5 on 100 x 200 mm cylinders.
The static modulus of elasticity was measured in line with EN 13412 using 100 x 200 mm cylinders.
Results obtained after 28 days of curing are summarized in Table 1.

Table 1

Flexural strength (MPa)	Tensile splitting strength (MPa)	Static modulus of elasticity (GPa)
21.6	7.6	44.9

Outstanding Fatigue Resistance

Long term load transfer and control of cyclic loading

Fatigue resistance is the resistance to the progressive and localized 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 resistance

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.

Fatigue equation according DNV-OS-C502

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

$$\log_{10} N = C_1 \cdot \frac{\left(1 - \frac{\sigma_{max}}{C_5 \cdot f_{rd}}\right)}{\left(1 - \frac{\sigma_{min}}{C_5 \cdot f_{rd}}\right)}$$

where:

C_1 = 12 for structures in air
$\sigma_{max.}$ = the numerically largest compressive stress, calculated as average within each stress-block
$\sigma_{min.}$ = the numerically lowest compressive stress, calculated as average within each stress-block (for tension = 0)
C_5 = strength reduction factor for the specific grout

Fatigue resistance of MasterFlow 9300

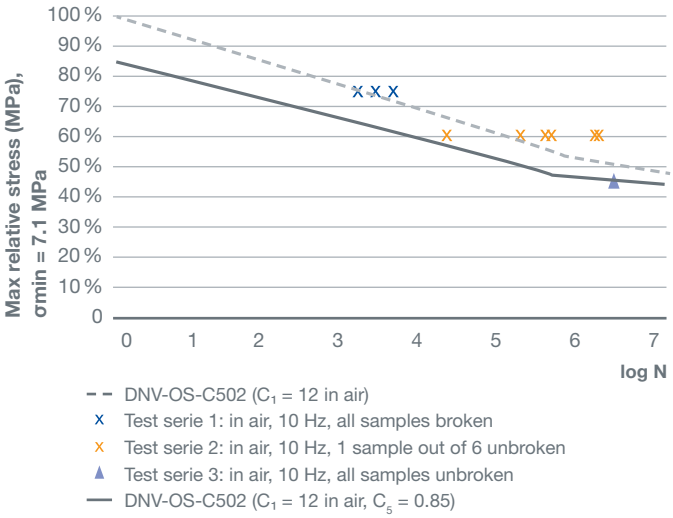
The behavior of MasterFlow 9300 under cyclic loading was studied using cylindrical specimens, 60 mm in diameter and 120 mm high. The grout material has been tested for fatigue resistance in air. Tests were performed at high frequency (10 Hz).

The observed number of cycles to failure in the tests under cyclic loading corresponds well with the prediction according to DNV-OS-C502 (Figure 3). 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.

In the fatigue life calculations C5 = 0.85 shall be taken for MasterFlow 9300.

Fatigue resistance

Figure 3



Master Builders Solutions from BASF

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 world-wide. 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.

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BASF Construction Solutions GmbH
Product Management
c/o PCI Augsburg GmbH
Piccardstrasse 11
86159 Augsburg ▪ Germany
www.master-builders-solutions.basf.co.uk

BASF plc
Construction Chemicals
19 Broad Ground Road ▪ Lakeside ▪ Redditch
Worcestershire ▪ B98 8YP ▪ United Kingdom
P +44 (0)1527 512 255 ▪ F +44 (0)1527 503 576
www.master-builders-solutions.basf.co.uk

BASF A/S
Hallandsvej 1
6230 Rødekro
Denmark
P +45 74 66 1511
www.master-builders-solutions.basf.dk

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