

ce200TM-140G

Non-Shrinkage Grout for Offshore and Subsea

Peter W Weber
ceEntek Pte Ltd
200917002E

Offshore wind, an emerging industry in SEA

- Stronger and more consistent wind speeds than onshore wind farms
- Higher yield
- Contribute about 2% of total wind power capacity in 2016 ¹



1 Wind Europe Annual Offshore Statistics 2016

Grouting Requirements

Critical factors: Cost, durability, ease of use

— Cost:

- Completion of grouting within 48 hours to limit equipment rental time
- Drives need for early strength to remove support brackets and similar
- No repairs during expected lifespan of 25 years

— Durability:

- Must meet overall wind-load requirements
- No structural repairs over lifespan; Turbines can be replaced relatively easy
- Withstand saltwater wash-out
- High ductility without microfiber enhancement

— Ease of use:

- Offshore installations are always under weather and time constraints
- Training of installation team
- Potential temporary break-down of equipment during installation

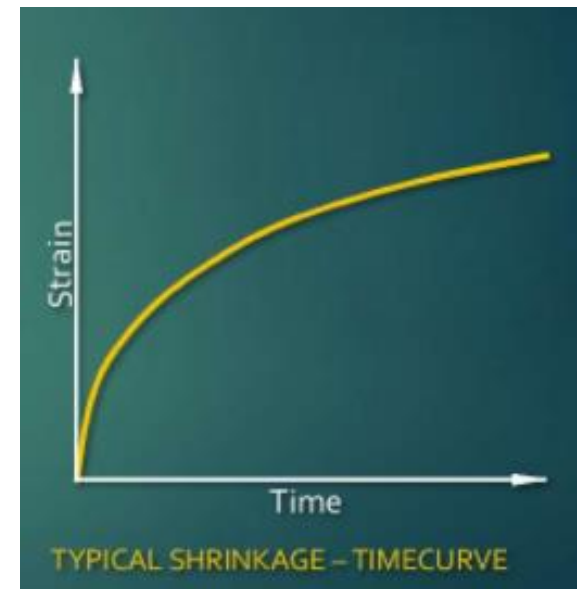
Grouting Problems

- Wear failure mode considered during design: ²
 - Wear occurring and water ingress providing transportation for grout material worn down
 - Gaps forming between grout and outer face of monopile
 - Lacking fit and significant dynamic effects on structure as tower oscillates
 - Overall length of grouted connection reducing
 - Unconfined grout fracturing at top and bottom of annulus
 - Reducing lever arm over which the loading is transferred from the transition piece to the monopile
 - Shear and compressive stresses increasing between grout and steel due to overturning moment at base of tower

- Grout wear – a significant issue for long term integrity of foundation

Grouting Problems

- Crack formation due to shrinkage
 - Generally observed that 14-34% of shrinkage occurs in 2 weeks ³
 - Within a year of being poured, concrete has 66-85% of 20 year shrinkage ³
 - Lower water to cement ratio in concrete reduces shrinkage
 - Cement rich concrete has higher shrinkage
 - Fine and soft aggregate increases shrinkage



Offshore-/Subsea Grouting: Today's Issues

- Only two suppliers with DNV qualification: BASF, Durocrete
- Material on exclusive basis in certain geographic areas
- Highly complex chemical systems; cannot be adapted to local materials
- Very expensive, plus high shipment costs
- No further developments

ce200™- 140G

- Two phase cementitious Grout
 - Pre-blended OWC plus graded Sands
 - Dilutable paste of CNF plus plasticizer
- No shrinkage
- Low water to cement ratio, 0.25
- Standard mixing procedure, (pan-mixer)
- Pumpable, self leveling
- Non-abrasive
- Meets DNV target specifications

ce200™ – 140G System

- ce200™-140G

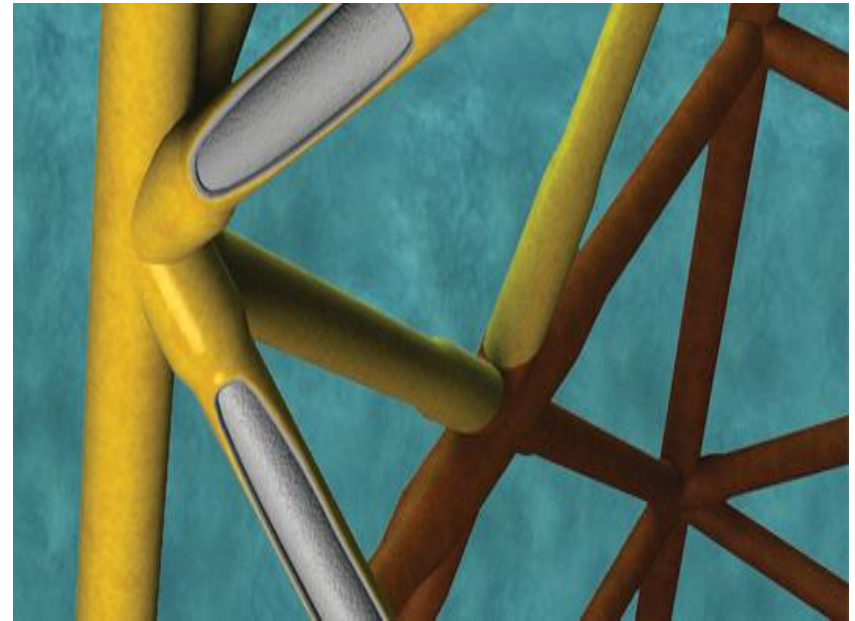
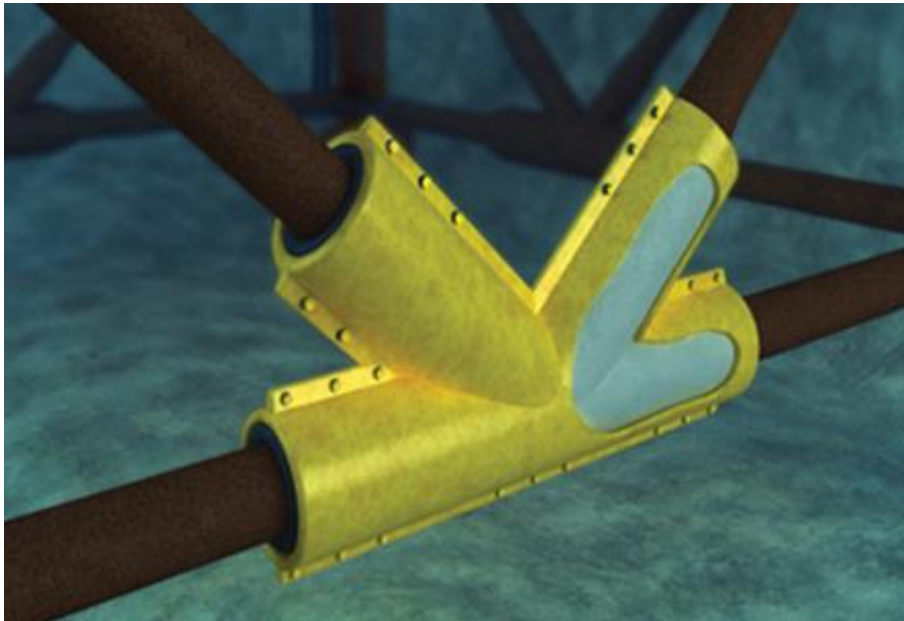
- Offshore grouting, subsea repair, wind-turbine stabilization
- Compression 140MPa; flexural >18MPa
- Shrinkage controlled
- Non permeable, seawater resistant
- Pumpable
- High early strength, >60MPa in 24hrs



June 2018



ce200™-140G: HPC for Offshore and Marine application



Jacket joint structural repair

- High early and later strengths
- Replaces BASF Masterflow 9500

140G - Certified by ABS Consulting in Vietnam

ce200™-140G: 1day strength

ce200™-140G: 7day strength



Report no. 17-34636-SG	Project no. 3923375	Report date: 17.08.2017	Office: Singapore
----------------------------------	-------------------------------	-----------------------------------	-----------------------------

Report no. 17-34672-SG	Project no. 3923375	Report date: 23.08.2017	Office: Singapore
----------------------------------	-------------------------------	-----------------------------------	-----------------------------

2.0 Details:

2.0 Details:

Index No.	Description	Loading Rate	MPa
1.	50*50*50 mm Cube Sample 1 Curing Duration: 1 day	60 kN / min	85.96
2.	50*50*50 mm Cube Sample 2 Curing Duration: 1 day	60 kN / min	89.16
3.	50*50*50 mm Cube Sample 3 Curing Duration: 1 day	60 kN / min	71.48
4.	50*50*50 mm Cube Sample 4 Curing Duration: 1 day	60 kN / min	86.44
5.	50*50*50 mm Cube Sample 5 Curing Duration: 1 day	60 kN / min	83.28
6.	50*50*50 mm Cube Sample 6 Curing Duration: 1 day	60 kN / min	86.12

Index No.	Description	Loading Rate	MPa
1.	50*50*50 mm Cube Sample 1 Curing Duration: 7 days	60 kN / min	123.92
2.	50*50*50 mm Cube Sample 2 Curing Duration: 7 days	60 kN / min	128.44
3.	50*50*50 mm Cube Sample 3 Curing Duration: 7 days	60 kN / min	109.68
4.	50*50*50 mm Cube Sample 4 Curing Duration: 7 days	60 kN / min	132.24
5.	50*50*50 mm Cube Sample 5 Curing Duration: 7 days	60 kN / min	130.32
6.	50*50*50 mm Cube Sample 6 Curing Duration: 7 days	60 kN / min	133.92

ABS* witnessed results

	ce200™-140G			
	compressive strength			
measurement units of property	MPa			
sample dimensions	50*50*50mm cube			
testing parameters	100kN/min			
curing duration (days)	1	3	7	28
results	72.5	109.0	124.6	143.2
mix design details	ce200™-140G design (based on 4 sets of results with 3 cubes specimen per set)	ce200™-140G design (based on 4 sets of results with 3 cubes specimen per set)	ce200™-140G design (based on 4 sets of results with 3 cubes specimen per set)	ce200™-140G design (based on 4 sets of results with 3 cubes specimen per set)

*All testing performed at NTU CEE lab.
www.absconsulting.com

ce200™-140G: Total shrinkage (on-going)

