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Specially Customized System for Cementing Glass Reinforced Epoxy (GRE) Casings – Development and Field Trials in a Geothermal Project

Abstract

For a geothermal project in France, our customer planned to cement 7" glass reinforced epoxy (GRE) tubulars in old corroded 9 ⅝" carbon steel casings. Through extensive laboratory research, Fangmann Energy Services developed and applied a new low-weight cement system specially customized to isolate the annular interval. The premium quality of the first trials and hence the supreme adhesion efficiency of this state-of-the-art system onto GRE and steel surfaces was verified by cement bond logging.

Introduction

In geothermal projects, the use of glass reinforced epoxy (GRE) casing has increased significantly during the last decade. Corrosion resistance, even under harsh borehole conditions, is this materials main advantage when compared to steel [1]. Reduced thermal conductivity resulting in less heat losses of thermal water to the formation and extremely smooth inner-pipe surfaces leading to an optimized flow profile are further characteristics, which are ideal for geothermal applications. However, the reduced collapse resistance compared to steel tubular demands specially customized cement slurries. To ensure zonal isolation and hence well integrity, appropriate adhesion of hardening cement onto the outer-surface of GRE casings is essential [2]. This paper introduces a customized low-weight cement system specially adapted to such tubular and presents its field trials in a geothermal project.

Materials

Two GRE materials, namely aliphatic and aromatic, as well as different cement systems were tested and characterized under lab conditions. The following tables summarize important characteristics of the respective samples:

Characteristics of GRE samples		
Elastic modulus - axial	10,300 – 20,700	N/mm²
Elastic modulus - radial	22,800 – 31,100	N/mm²
Poisson's ratio	0.16 – 0.38	
Thermal conductivity	0.30 – 0.40	W/m/°C
Material density	1.80 – 1.96	kg/L

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Cement system	Composition	ρ, g/L
Slurry A	Highly resistant cement, bentonite, retarder, **low-weight additive A**	1.32
Slurry B	Highly resistant cement, bentonite, retarder, *low-weight additive B*	1.32
Tail slurry	API Class G	1.90

Figure 1 depicts the compressive strength development of the two low-weight cement systems tested here. In comparison to Slurry B, the compressive strength of Slurry A is nearly twice as high (1,300 vs. 2,500 psi).

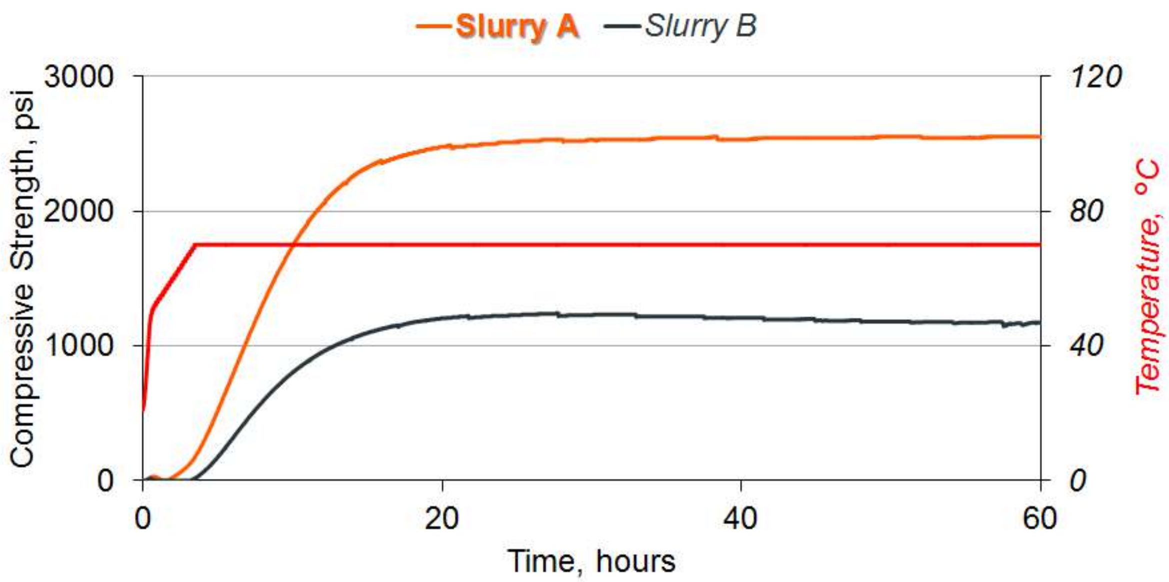

Figure 1: Compressive strength development of Slurry A (orange) and Slurry B (gray) @ ρ = 1.32 g/L, as measured via ultrasonic cement analyzer at 70°C

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Lab Experiments

In close cooperation with the TU Bergakademie Freiberg, we developed two new laboratory tests to evaluate the adhesion behavior of cement systems on GRE casings (see Figure 2 and Figure 3).

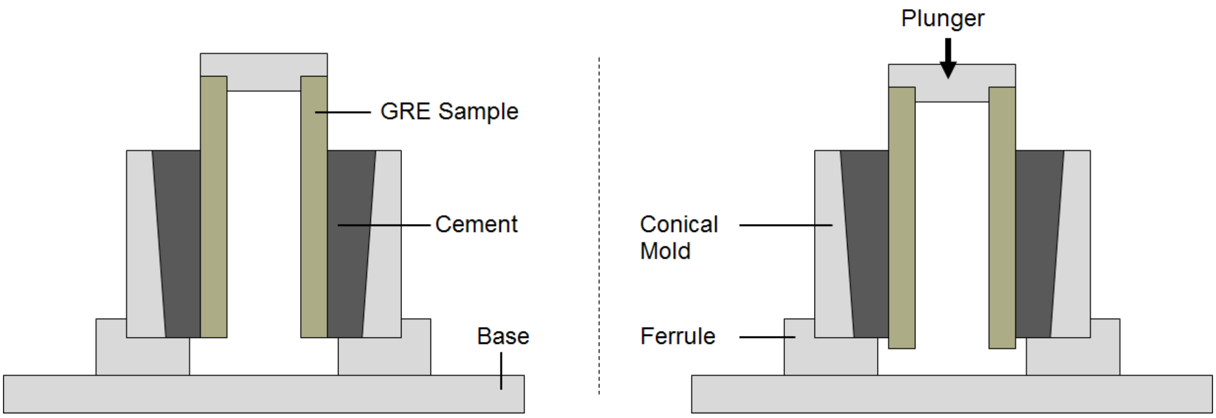

Figure 2: Schematics of the shear bond test (left: before; right: after)

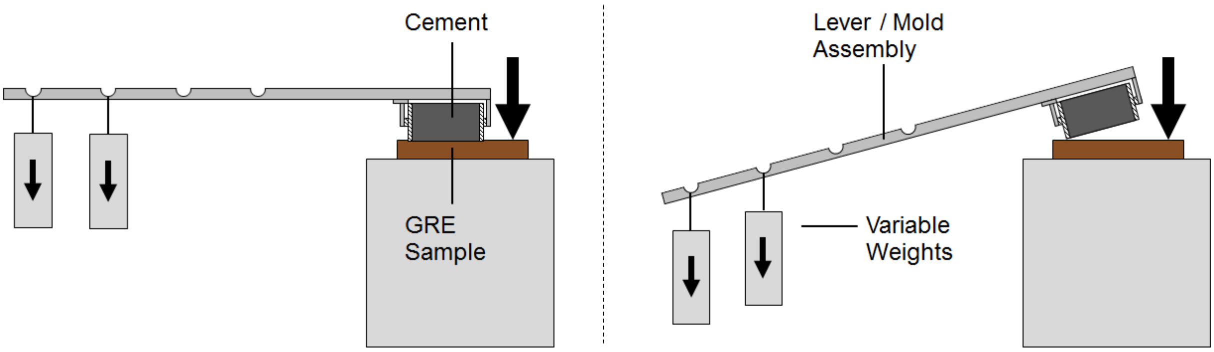

Figure 3: Schematics of the tension bond test (left: before; right: after)

Both methods aim to quantify the strength needed to separate hardened cement from GRE material and focus on the comparison between Slurry A vs. Slurry B.

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Lab Results

As confirmed by both test methods, Slurry A adheres more effectively than Slurry B on GRE materials (see Figure 4). This result is congruent with the improved compressive strength development of this system.

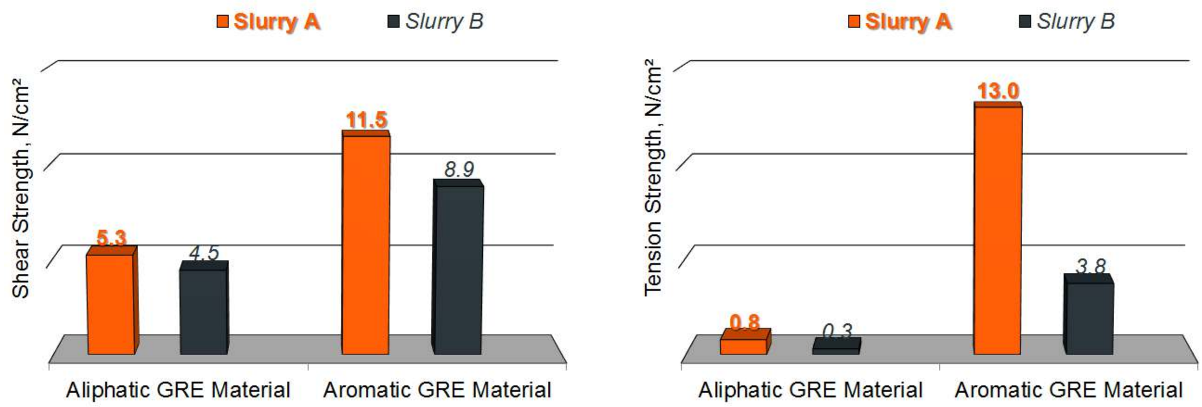

Figure 4: Shear and tension strength as measured via different test methods (left: shear bond test; right: tension bond test) for aliphatic and aromatic GRE material

Pre-treatment of aromatic GRE samples resulted in higher tension strength values (13 N/cm^2 without wash vs. 17 N/cm^2 with wash). As shown in Figure 5, the use of an alkaline pre-flush leads to an impressive adhesion of Slurry B.

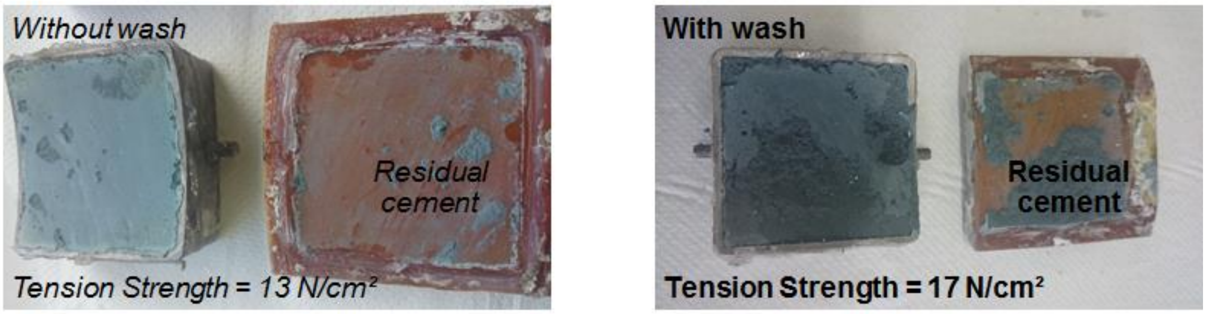

Figure 5: Aromatic GRE surface after tension bond test

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Field Trials

First, we calibrated the logging tool employing a 1m 7" GRE tubular cemented into a 9 ⅝" steel casing. For the preparation in our facilities, we used 20 L of Fangmann's GT Blend (Slurry A). The following tables summarize characteristics of the four wells and the pumping schedule employed during this geothermal project.

Well Conditions			
MD, m	1,690 – 1,940	BHST, °C	64 – 69
TVD, m	1,630 – 1,640	BHCT, °C	46 – 53

Fluid	**ρ, g/L**	**Vol., m³**	**Rate, L/min**
Bentonite Pill	1.02	2	600
GT Blend	1.32	19 - 27	600
Class G	1.90	1 - 2	600

Via wireline logging, the quality of the cement jobs was evaluated and deemed satisfying (see Figure 6). Nonetheless, we at Fangmann Energy Services will continue our R&D-activities and further improve our innovative cement system.

Figure 6: Results of wireline logging

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Conclusion

Through extensive laboratory research, we formulated an optimized slurry primary containing blast furnace slag cement and lightweight additives. Reduced thermal conductivity, low density for increased collapse control, and premium cement bonding on GRE and steel tubular are some advantages of this specially customized cement system. Lab and field results impressively manifest Fangmann's GT Blend as an alternative to commonly used API Class G-based slurries.

Fangmann's GT Blend

- ✓ Innovative system specially customized for cementing GRE casings
- ✓ State-of-the-art low-weight cement for casing collapse control
- ✓ Adhesion verified by two separate lab test methods
- ✓ Premium cement bonding on GRE and steel tubular
- ✓ Enhanced adhesion through the use of washes

Acknowledgement

We would like to thank our customer and GRE supplier for the close cooperation. We would also like to acknowledge the BMWi for financing this R&D project in the course of their ZIM initiative.

Literature

[1] Peralta, D., Maggioni, A., Garcia, R., Martin, D.: "*Successful Application of Glass Reinforced Epoxy (GRE) Casing in Hydraulically Fractured Water Injection Wells*" SPE 102144, (2006).

[2] Morris, W., Peacock, H., Robles, J., Romera, G.: *"Glass Reinforced Epoxy Casing: Lessons Learned After Cementation of 70 Wells"* SPE 116020, (2008).

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