MANNVIT
ENGINEERING

High pressure and temperature grouts

GEORG – General Assembly Meeting 21-05-2010

Partners:

- Mannvit Engineering
- Reykjavik University
- Innovation Center Iceland
- Icelandic GeoSurvey

Work plan – duration one year – 5 tasks:

1. Improved mix-design, material selection and testing of grout
2. Assessment of temperature and pressure conditions in boreholes
3. Testing of behavior of selected mixes at high pressure
4. Full –scale testing of selected mixes
5. Final report

Improved mix design, …

Performed at 1 bar and 25 °C

Cements tested:
Icelandic Portland, Rapid Danish Portland, Blast furnace slag cement (Irish/Chinese), Dyckerhoff well cement, Norcem well cement, Danish White cement

Solid additives:
Fly ash, silica flour, bentonite, perlite

Admixtures:
Water reducing agents, retarders, plasticizers, viscosity modifying agents

Improved mix design, …

Common mixture in Iceland (kg/m^3):

Cement (OPC):	717
Silica flour:	287
Bentonite:	17.9
Perlite:	14.3
Water:	575

Mixture used in IDDP in Krafla 2008/2009 (kg/m^3):

Cement (Dyckerhoff):	801
Silica flour:	534
Bentonite:	
Perlite:	
Water:	506

Example of mixture from this work (kg/m^3):

Cement (Norcem G):	757
Silica flour:	418
Bentonite:	18.9
Perlite:	15.1
Water:	560

Improved mix design, …

Work done by Mannvit, testing program:

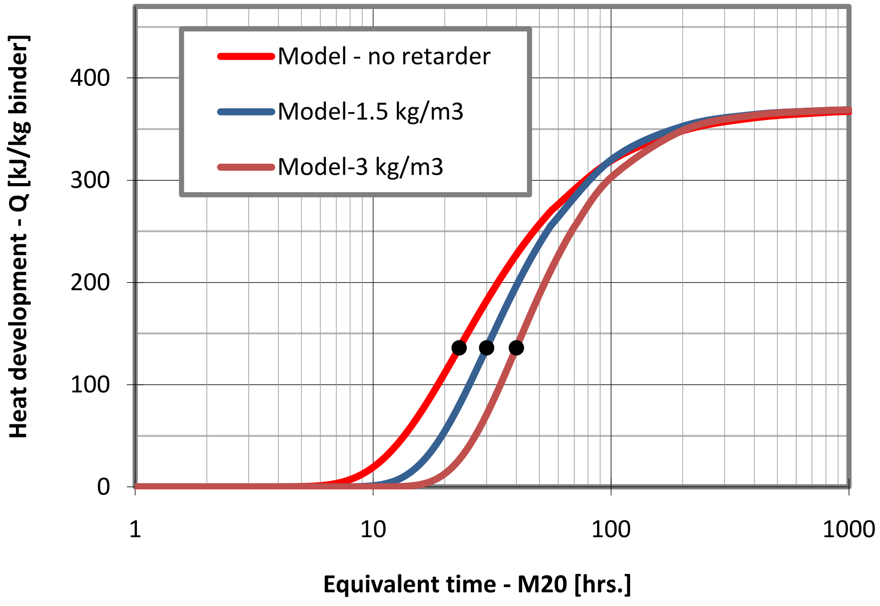
Density, flowability, flow stability, setting time, adiabatic heat development, bleeding, thermal expansion, compressive strength (1, 2, 7 and 28 days).

Improved mix design, …

Work done by Mannvit, examples from testing

Retarders with Icelandic cement

Adiabatic heat development

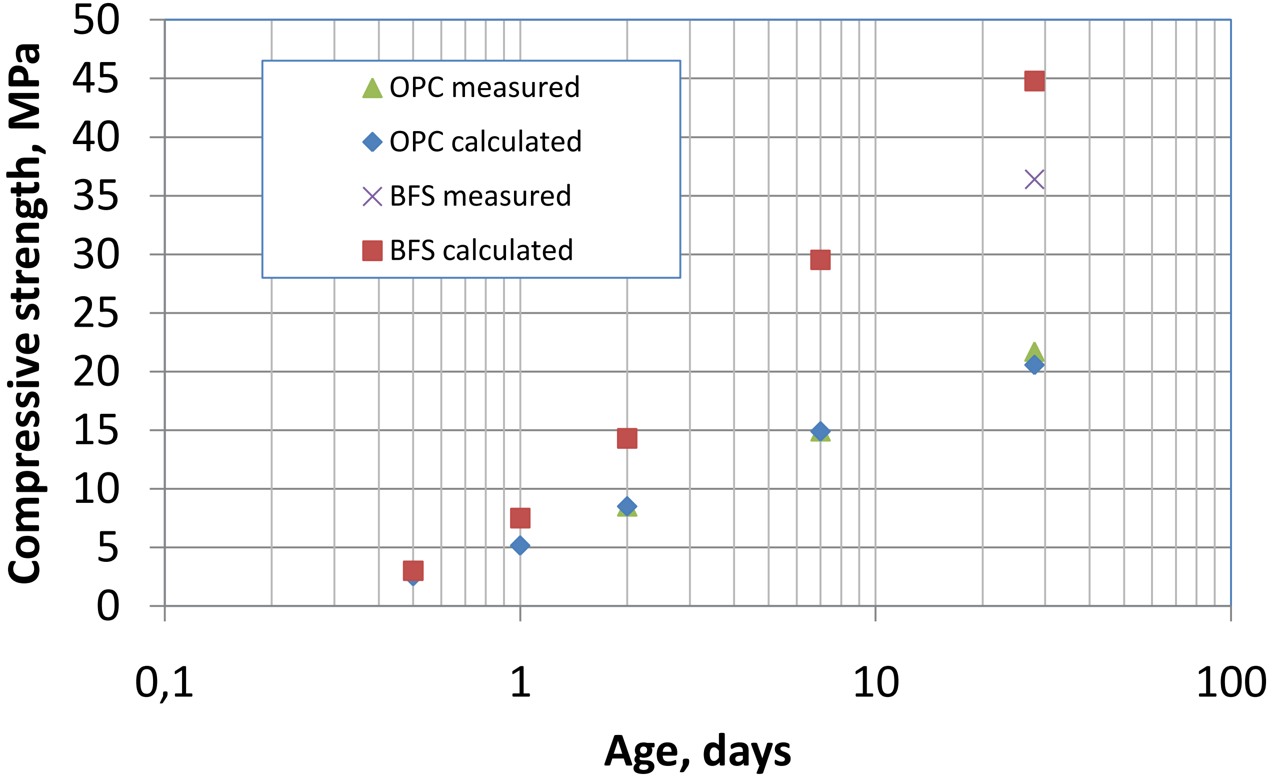


Retarder dosage (kg/m^3)	Setting time (hrs)
0	23
1.5	30
3.0	40

Improved mix design, …

Work done by Mannvit, examples from testing

Compressive strength development



Improved mix design, …

Work done by Mannvit, examples from testing

Compressive strength development

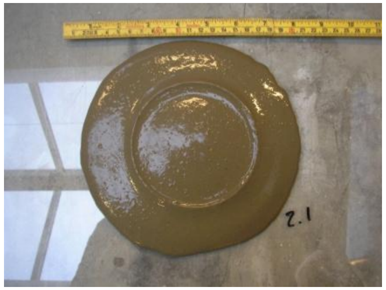
Difficult if not impossible to measure compressive strength of immature (young) grout, must rely on calculated values.
The results of this will be used in Task 2.

Improved mix design, …

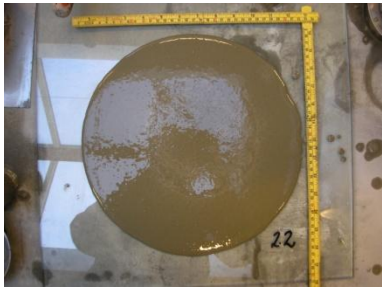
Work done by Mannvit, examples from testing

Flowability of grout

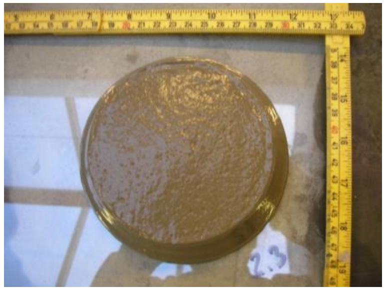
2 series – OPC Icelandic



No water reducer
no plasticizer



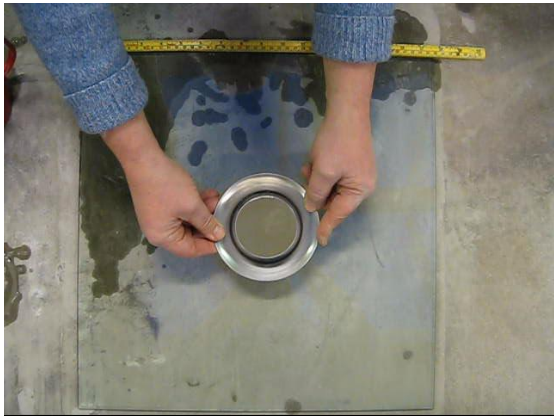
High dosage of water reducer
no plasticizer



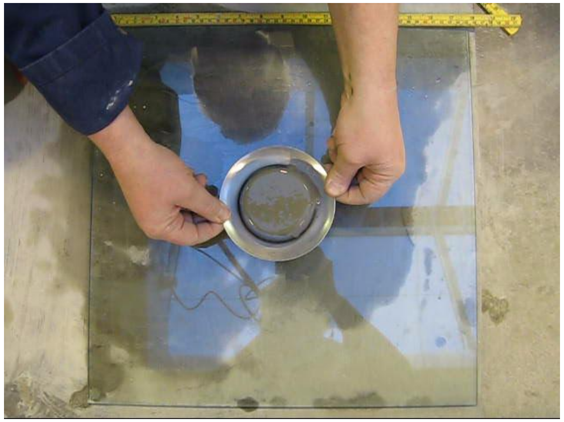
Low dosage of water reducer
no plasticizer

Improved mix design, …

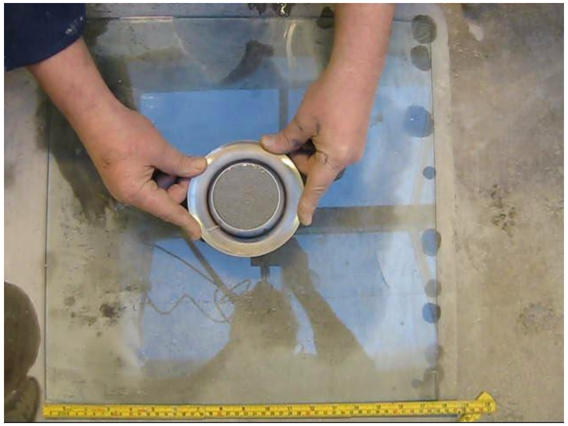
Work done by Mannvit, examples from testing
Flowability of grout
3 series – rapid Danish cement with fly ash



Medium dosage of plasticizer – no stabilizer



Low dosage of plasticizer – high dosage of stabilizer



High dosage of plasticizer – low dosage of stabilizer

Improved mix design, …

Work done by ICI, examples from testing

Yield value of different binders

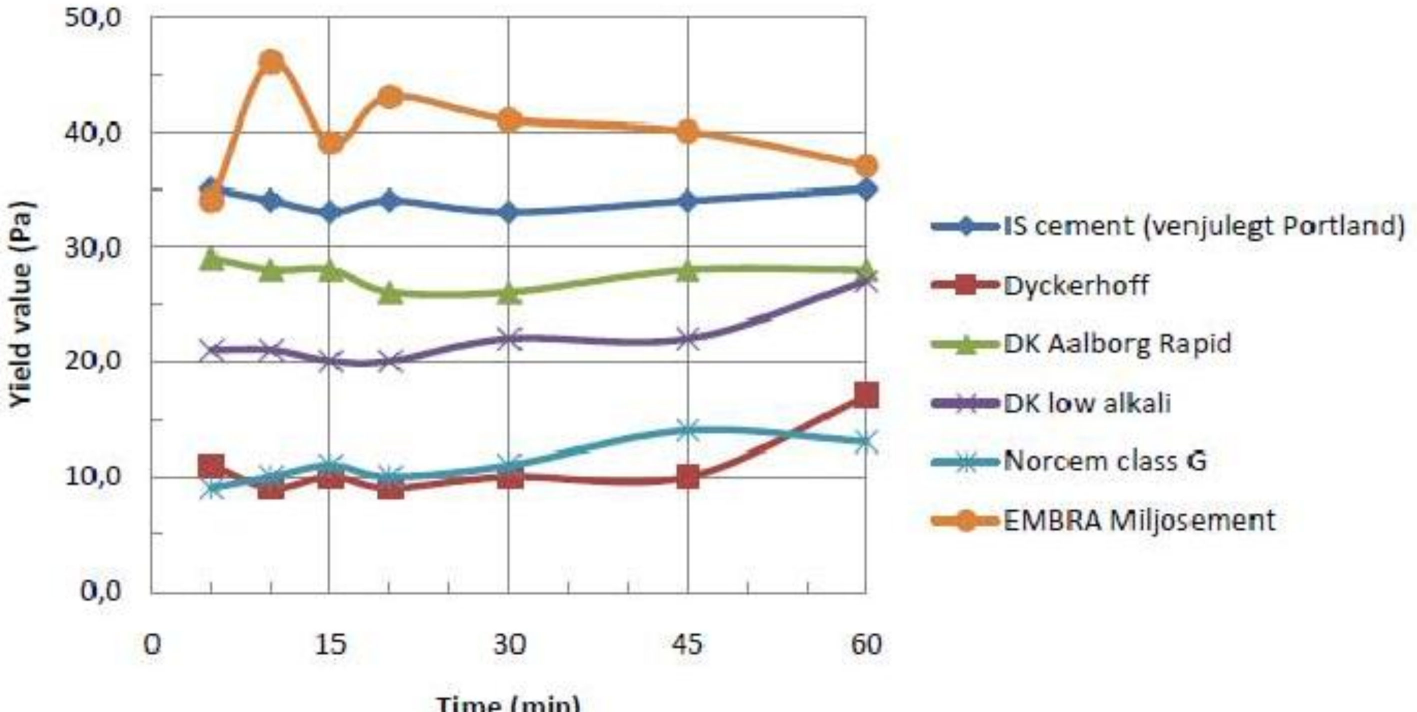


Figure 1: Yield value of six different binders at a w/c-ratio of 0,80

Improved mix design, …

Work done by ICI, examples from testing

Plastic viscosity of different binders

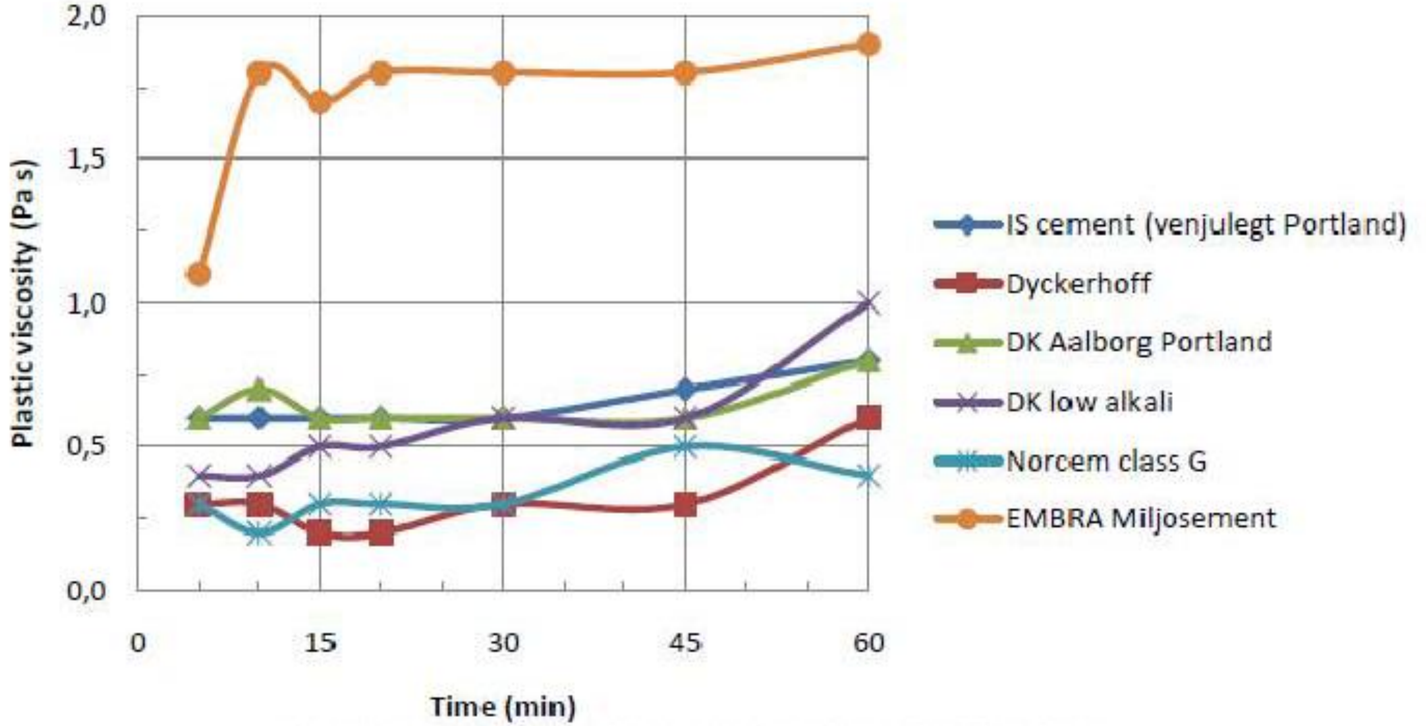


Figure 2: Plastic viscosity of six different binders at a w/c-ratio of 0,80

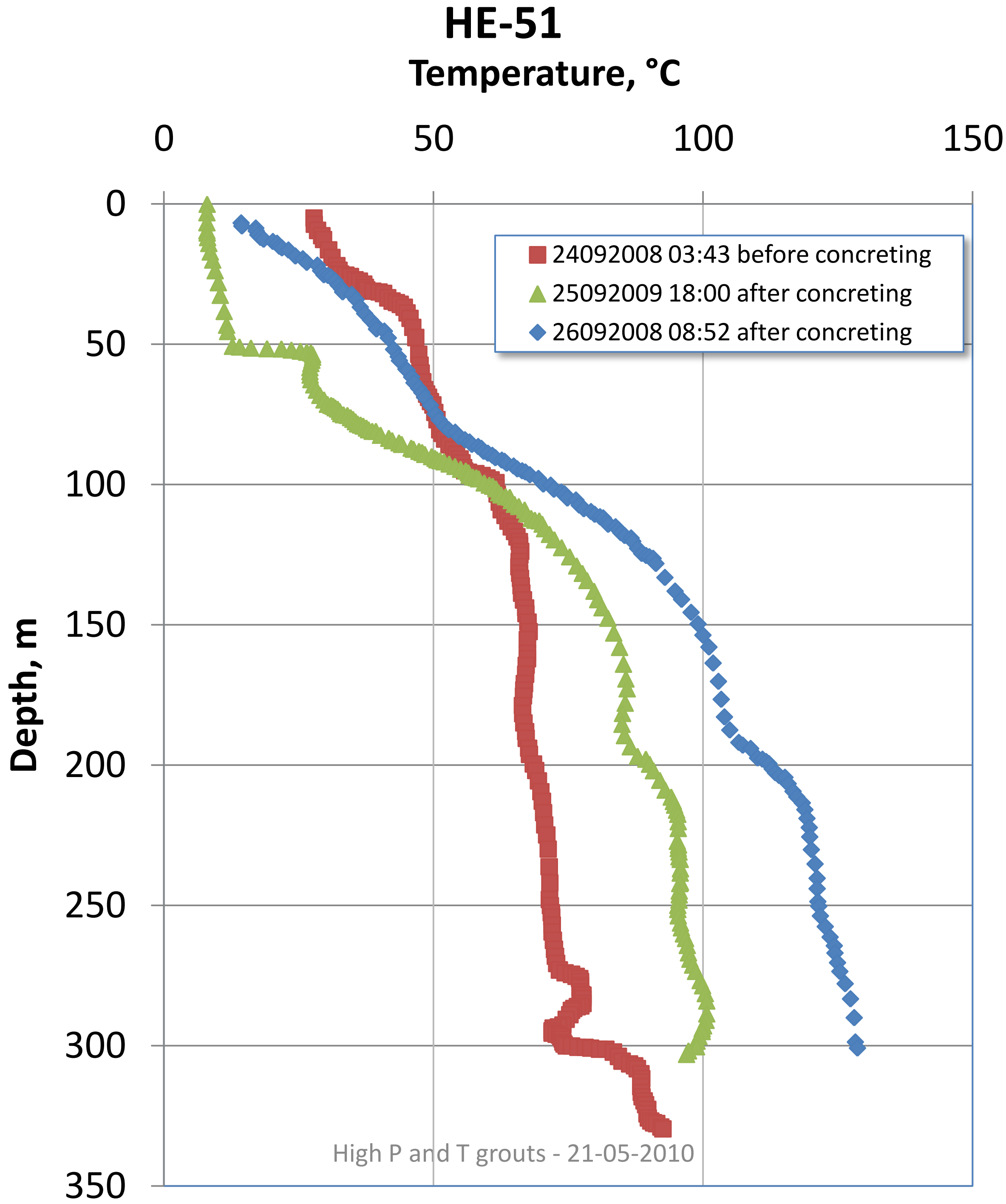
Assessment of T and P conditions in wells

Work done by Mannvit and ISOR, testing just underway:

Computer simulations on early age strength development in wells
Attempt to use a computer program HACON^3

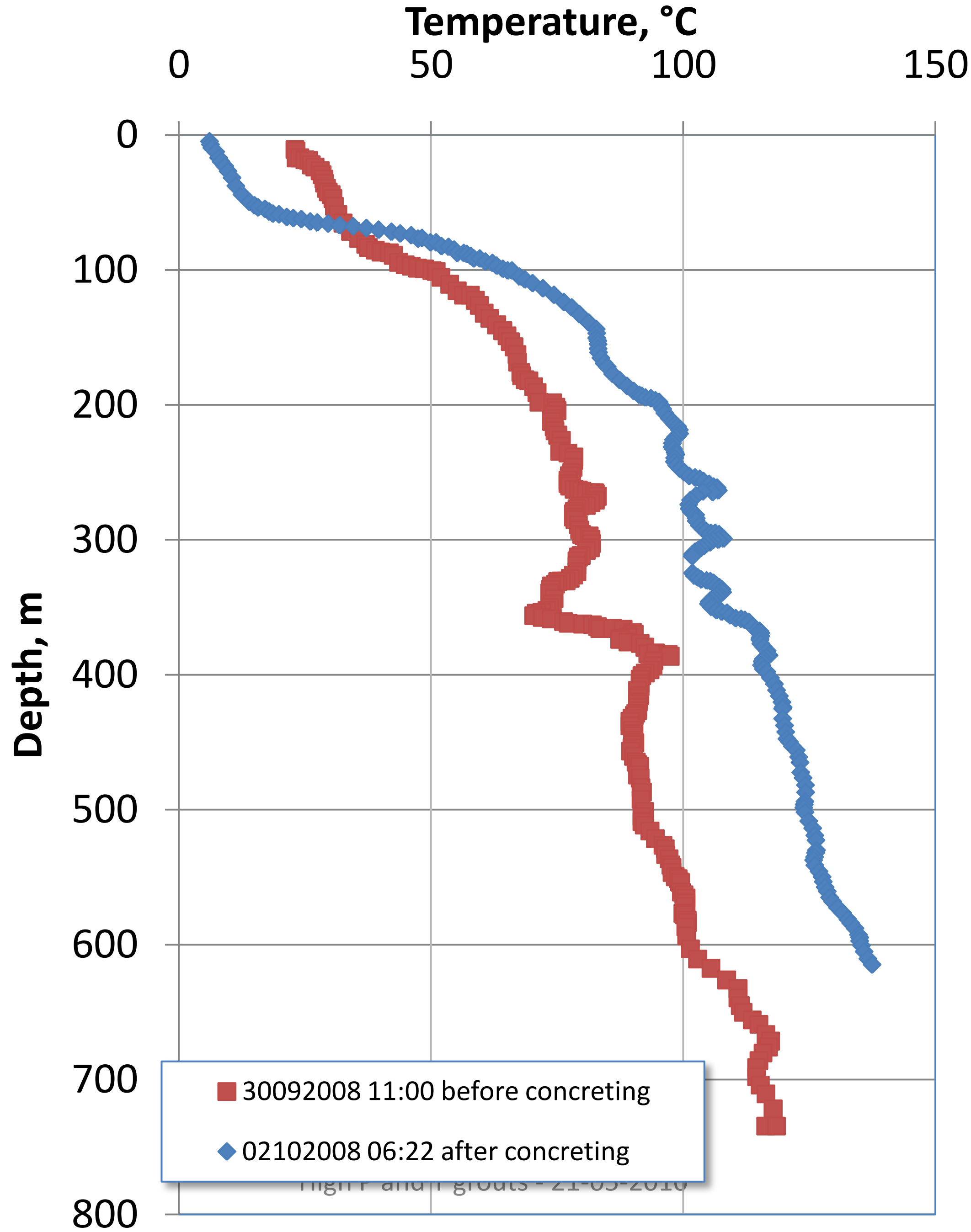
Measure strength development of well grouts at temperatures < 100 °C

Collect data from well, mainly temperature in wells before and after concreting



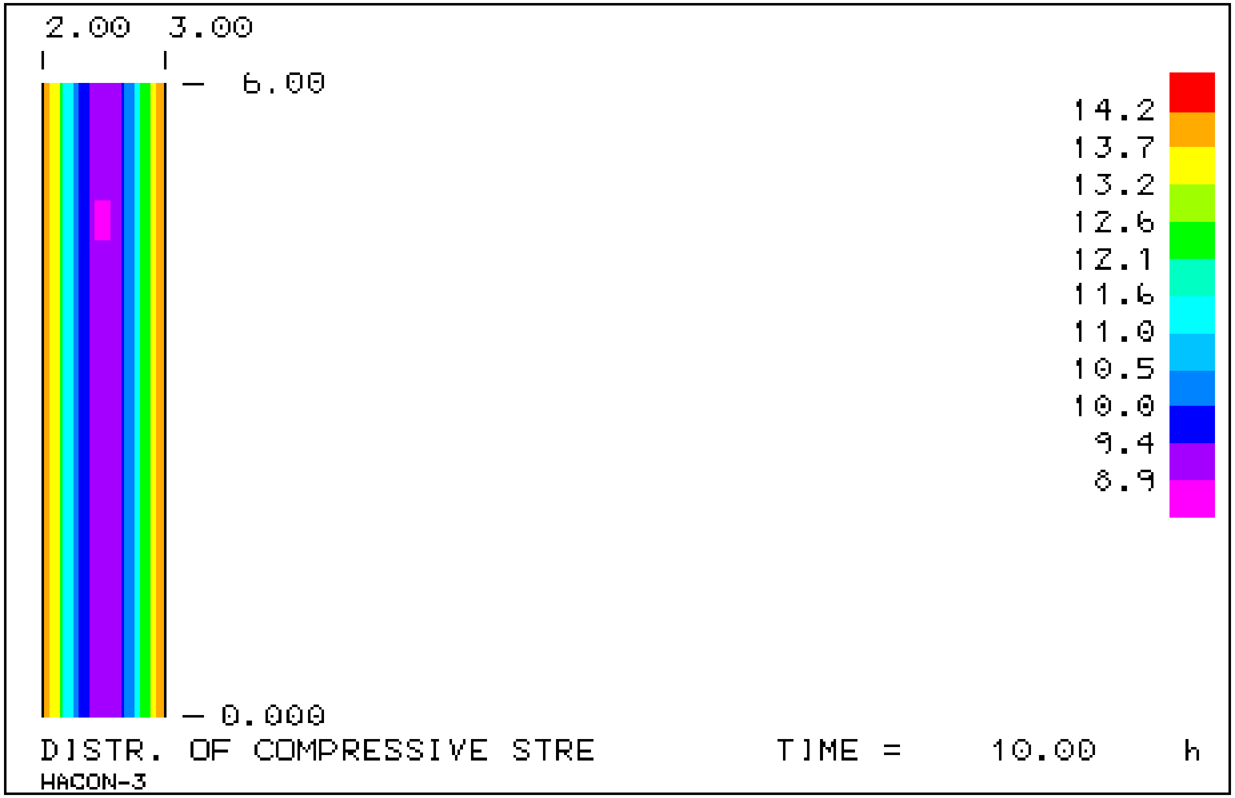
HE-51
Temperature, °C
0
50
100
150
Depth, m
0
50
100
150
200
250
300
350
24092008 03:43 before concreting
25092009 18:00 after concreting
26092008 08:52 after concreting
High P and T grouts - 21-05-2010

HE-51

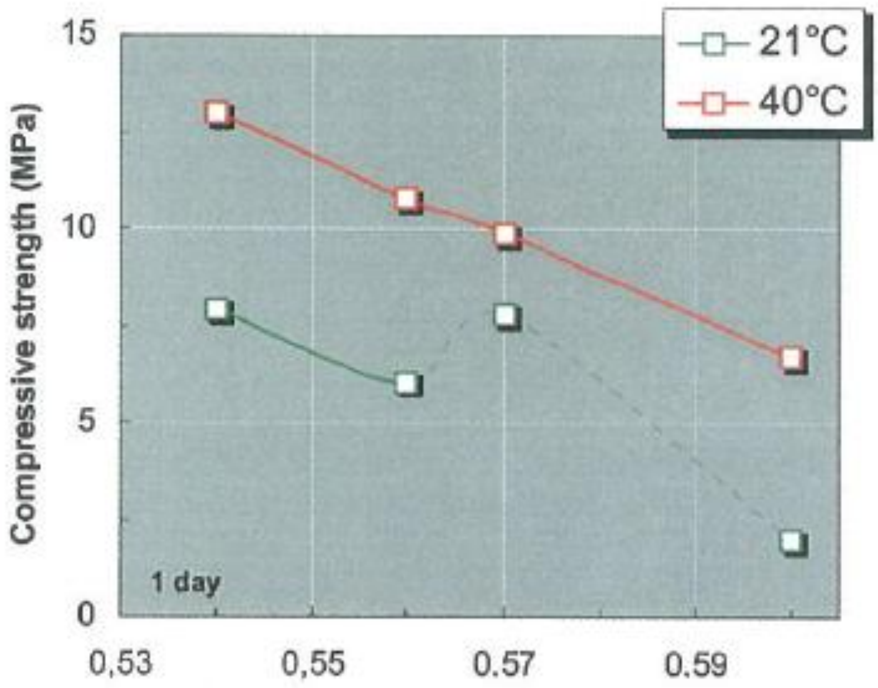

Temperature, °C
0
50
100
150
Depth, m
0
100
200
300
400
500
600
700
800
30092008 11:00 before concreting
02102008 06:22 after concreting

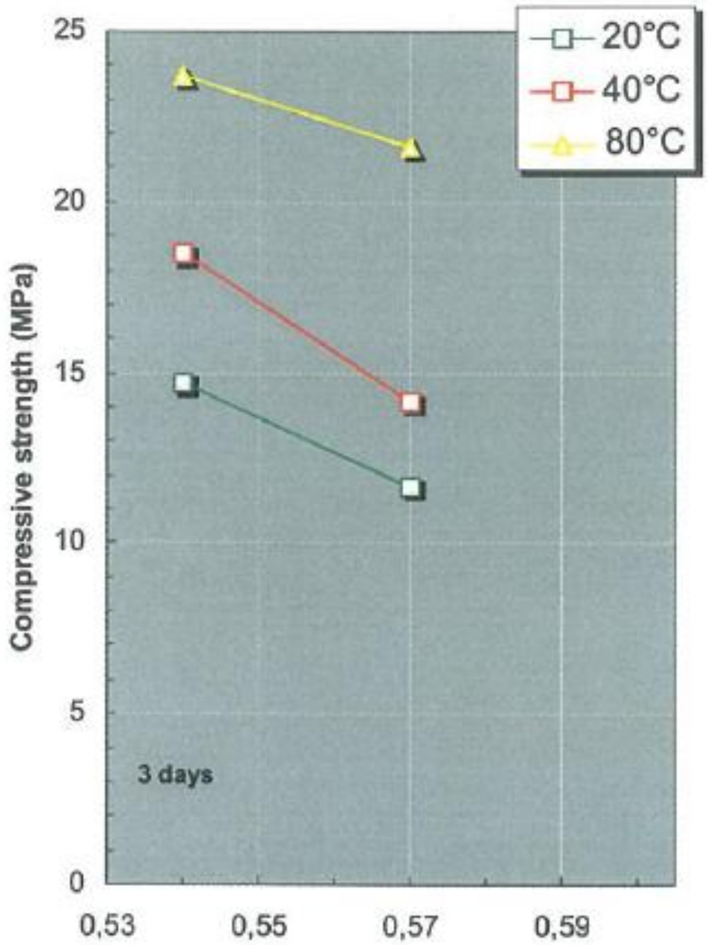
Computer simulation, compressive strength

A simple example to show compressive strength development of “well grout” in a “well” with 130 °C hot bed rock



Compressive strength development at 20, 40 and 80 °C, data from IBRI



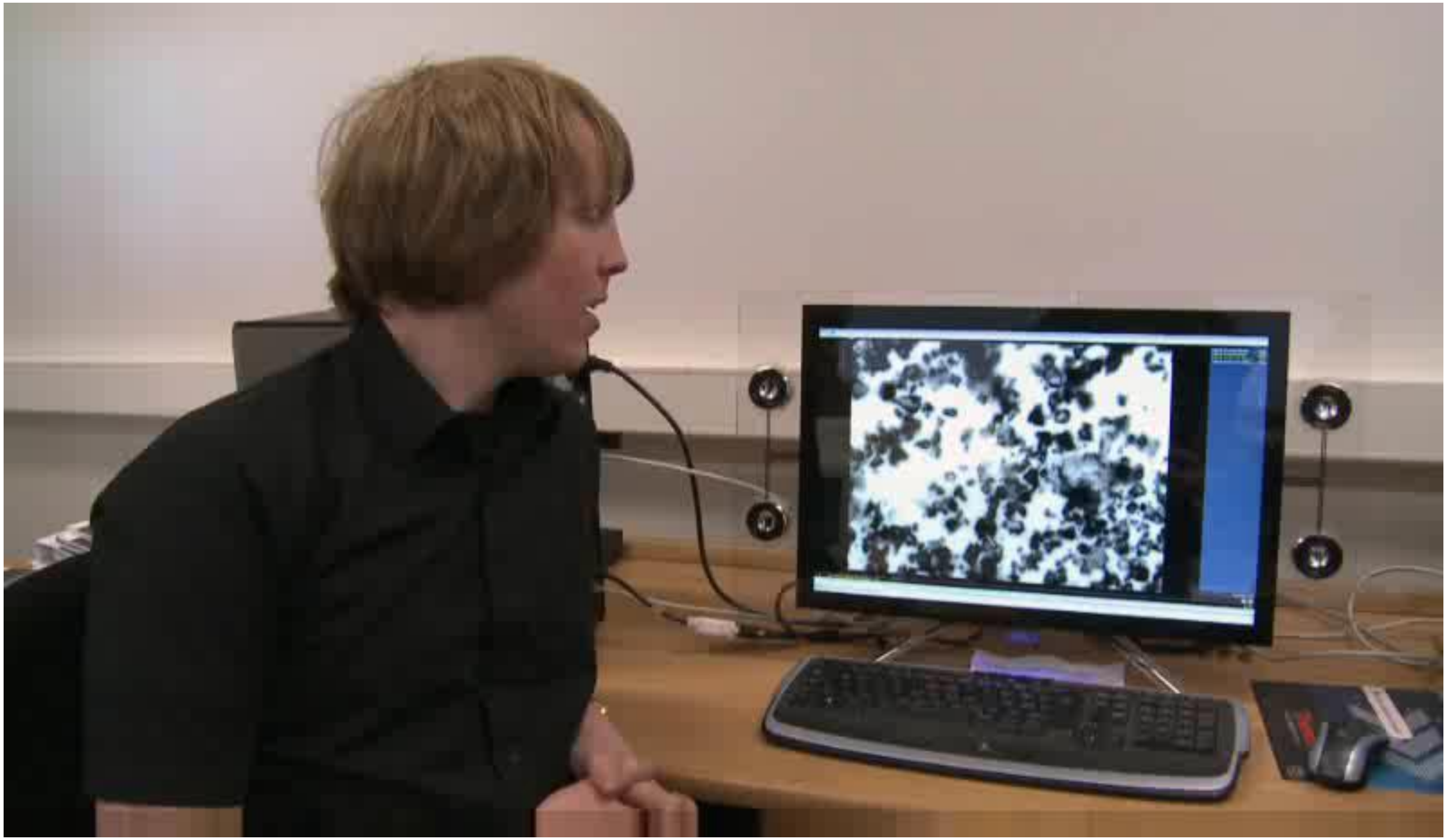


Testing of behavior of selected mixes at high pressure

Work done by ICI, testing just underway

- Rheo-microscope - Physica MCR 101
- P and T rheometer - the Modular Rheometer Series

Producer: Anton Paar Germany GmbH - Helmuth-Hirth-Str. 6, D-73760 Ostfildern, Germany-Europe

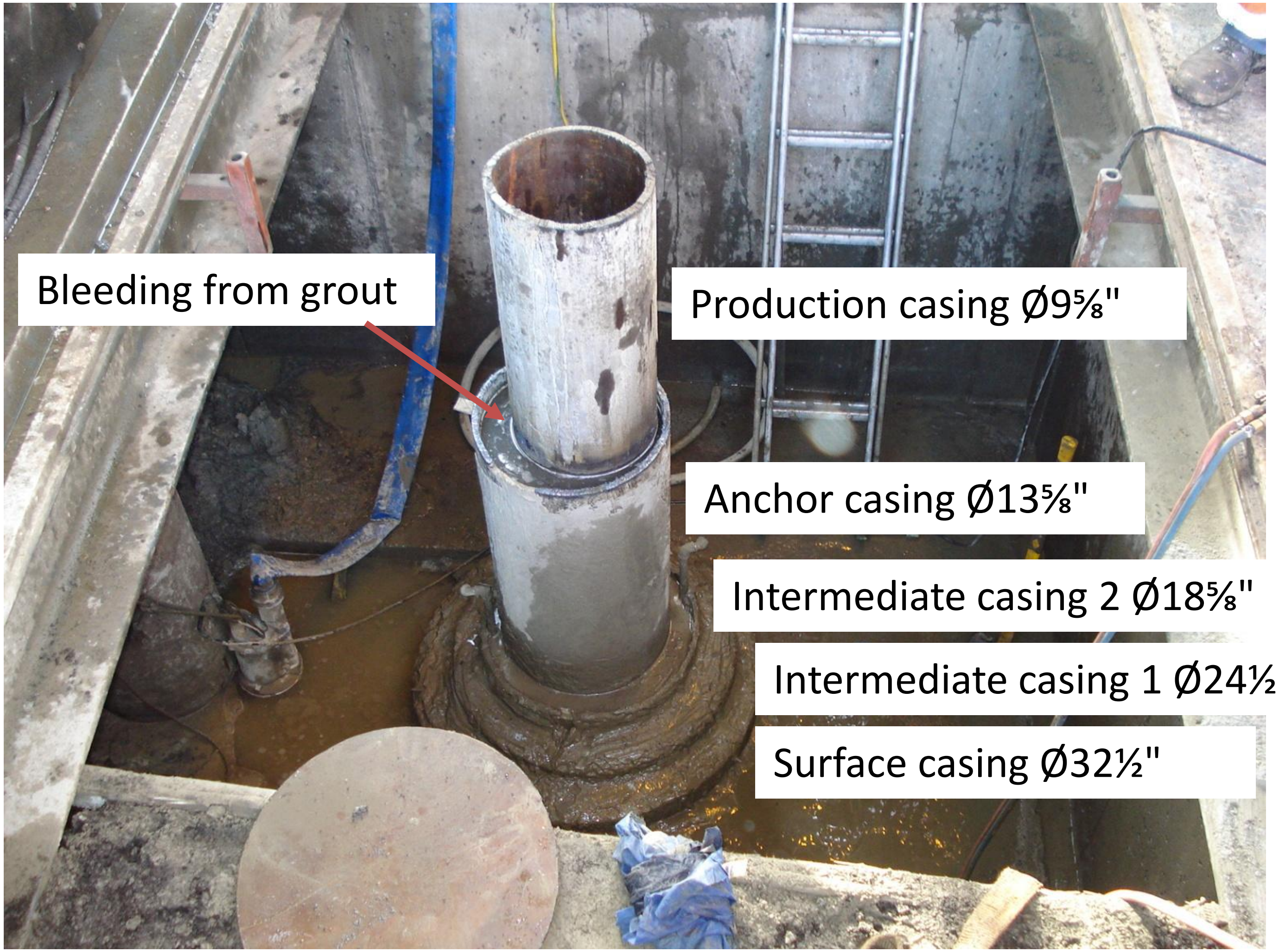


Applications

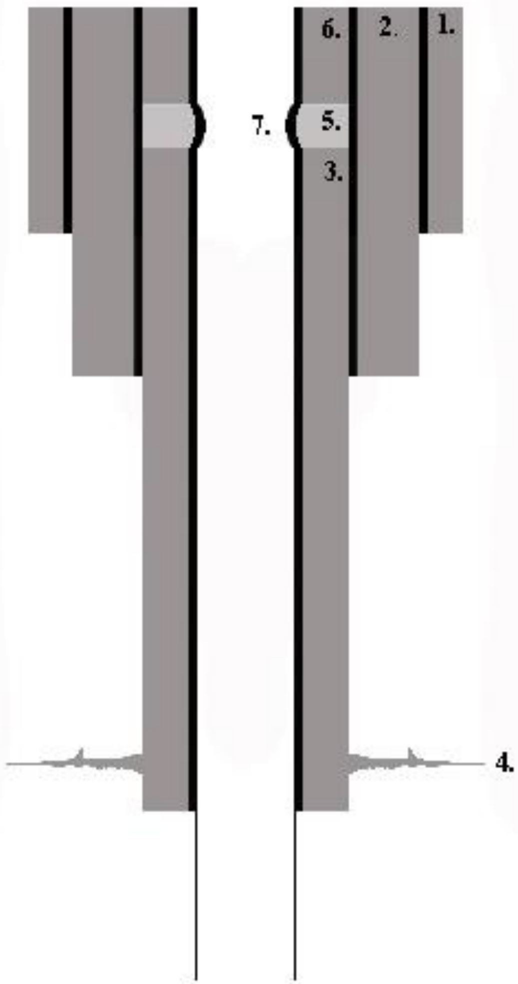
- Applies to “ordinary” grouts
    - rheological properties best described as a Bingham fluid ($\tau = \tau_0 + \mu\dot{\gamma}$)
    - reduce wait on cement
    - reduce/eliminate bleeding

- High P and T grouts (at about 3.5 km depth: 220-250 bar and 450- 500 °C)
    - improve knowledge on high P and T grouts
    - suggest mixture and dosages for high P and T grouts
    - much more effect of T than P on rheological properties of grouts
    - rheological properties still as a Bingham fluid

Casings in IDDP-1



Schematic explanation of damaged to casings due to expansion of vapor



1. Casing and concreting
2. Casing and concreting
3. Casing and concreting
4. Loss of grout into cracks
5. Bleeding water from grout
6. Concreting and sealing in a water pocket
7. Damaging of casing due to vapor expansion

Conclusions

Work underway, 1 bar and 25 °C work finished
We believe that we can improve the stability of ordinary grout
Possibly reduce wait on cement

Work at high P and T just started