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https://geo4civhic.eu/
EU H2020 Project

Assessing grouting mix thermo-physical properties for shallow geothermal systems

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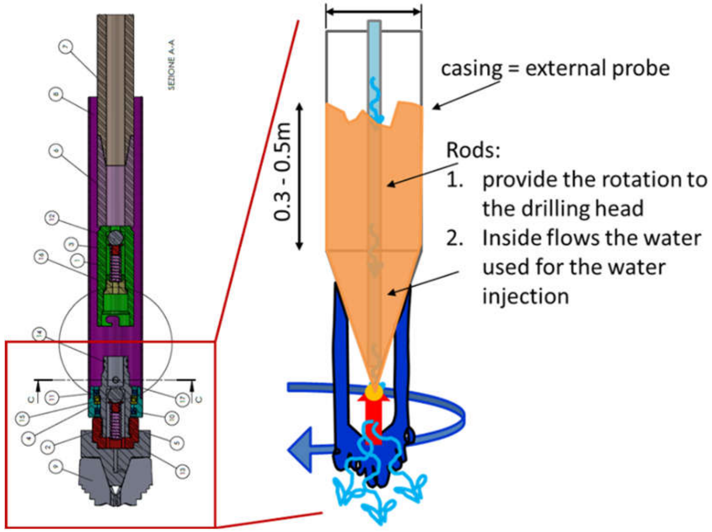
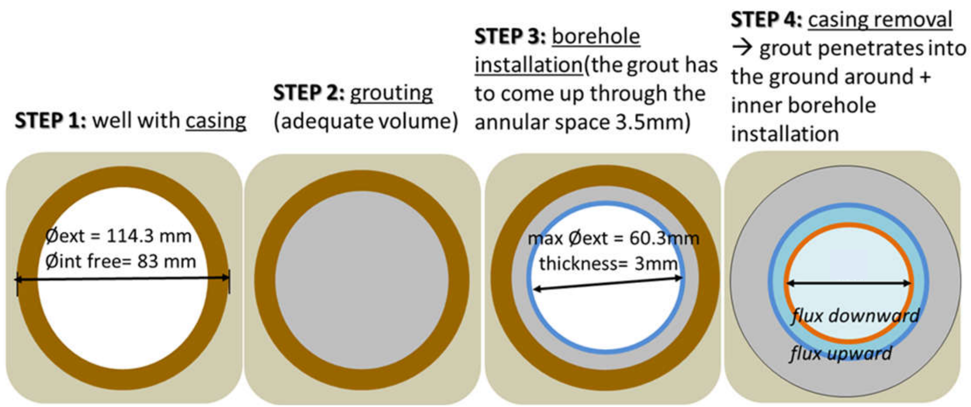
Main context

The main goal of the **EU H2020 GEO4CIVHIC** project is the development of more efficient and low-cost geothermal systems for conditioning refurbishment of civil and historical buildings. Within this framework, the **identification** of the most **suitable grout/slurry** for different heat exchangers is a key point for improving the overall efficiency of **shallow geothermal systems**. A dedicated task of the project was focused on the selection and optimization of the thermo-physical properties of products for:

1 - sealing of the coaxial geothermal probes' head.

2 - filling the annular gap for coaxial geothermal heat exchangers.

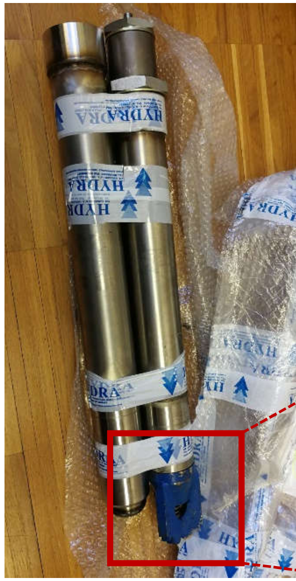


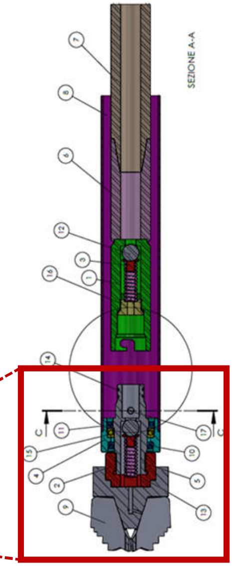


1 - Sealing of the coaxial geothermal probes' head

Targets for the sealing material:

- Ability in **sealing/clogging** the head of the probe in order to avoid any water loss, also in the possible presence of a small leakage from the spring ball-valve.
- Suitable **flowability** for pumping the grout up to 100 metres, while providing an adequate viscosity and mix composition for tolerating the in-situ presence of an excess of water.
- **Working time** larger than 1 hour.
- **Linear thermal expansion** coefficient similar to that of stainless steel (10 – 13 * 10^{-6}/K).
- **Shrinkage compensated** or slightly expansive behaviour during the fast setting and hardening.
- **Compressive strength** larger than **30 MPa** after **2 days** of curing.
- **Low water permeability** (corresponding to water/cement ratio below 0,40 thanks to the use of super-plasticisers).
- **Material cost ≤ 1,2 €/kg**.





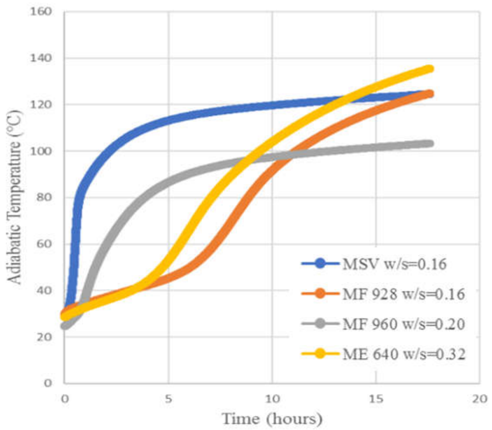
Cement grout mixing

1 - Sealing of the coaxial geothermal probes’ head

Tests on the selected cement grouts:

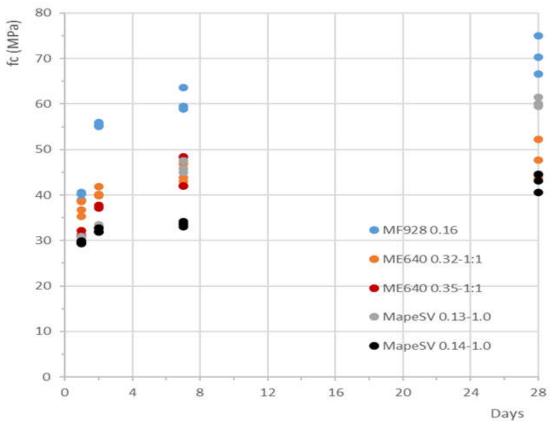
Ability in **sealing/clogging** (in-house percolation test through a 2mm Ø hole).

Suitable **flowability** (EN 1015-3, target flow diameter > 180 mm).



Working time (in-house calorimetry test).

The **linear thermal expansion** coefficient similar to that of stainless steel (10 – 13 * 10-6/K), the **shrinkage compensated** or slightly expansive behaviour and the **material cost ≤ 1,2 €/kg** are assured by selecting a cement-based grout for structural anchoring applications. These grouts are usually characterised by fast setting, high strength and low water permeability.



Compressive strength (in-house test set-up and EN 196-1).

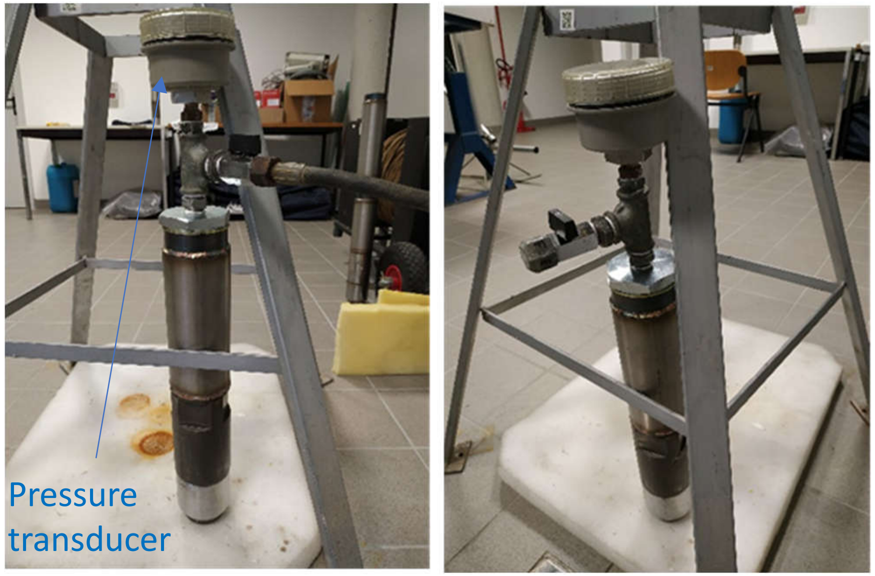
Water permeability (in-house pressure vessel for water penetration, target < 5 mm).

1 - Sealing of the coaxial geothermal probes' head

Coaxial probe sealing test in laboratory:

Two suitable commercial cement grouts with water/cement ratio < 0.4 were selected: 1 latex-modified shrinkage-compensated cement-based grout (MapeGrout SV) and 1 slightly expansive cement-based grout (MasterFlow 928).

The inner part of the coaxial probe head before (left) and after (right) the filling in with grout



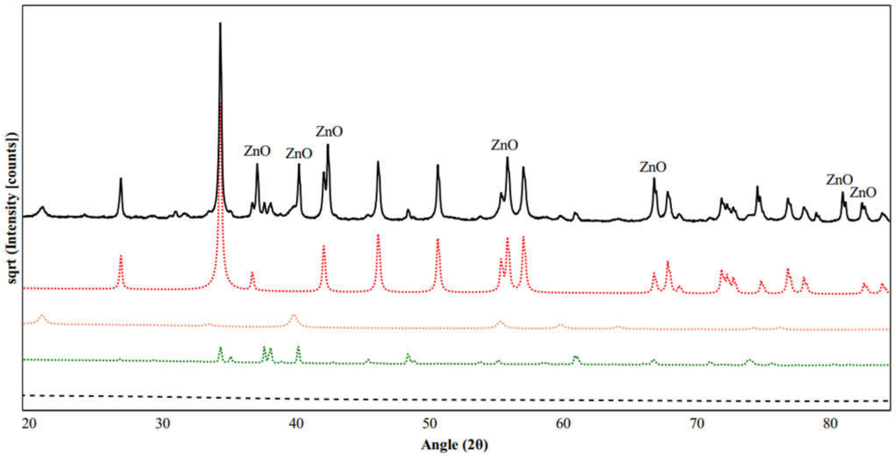
The coaxial probe head connected to the water pump (left) and ready to run the test (right)

Both grouts were able to ensure the sealing of the coaxial geothermal probes' head. No water leakages were observed. Nonetheless, both grouts before being fully effective they need to be water-saturated in their first 4-5 mm.

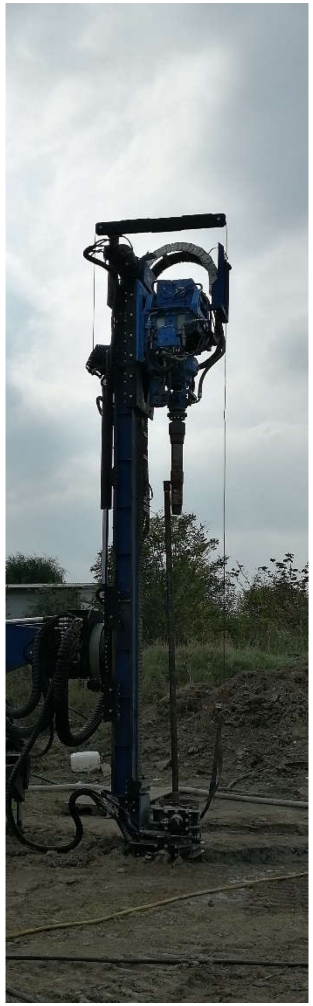
2 - Filling the annular gap for coaxial geothermal heat exchangers

Targets for the filling material:

- **Slurry composition** suitable for ground applications also in presence of groundwater.
- Suitable **fluidity** for pumping the slurry up to 100 metres and flowing in between casing and probe, while providing an adequate viscosity for tolerating the possible in-situ presence of groundwater.
- **Working time** larger than 4 hours.
- Absence or limited (< 2%) **water bleeding**.
- **Compressive strength** larger than **0,5 MPa** after **28 days** of curing in moist conditions.
- Adequate **thermal conductivity** for ensuring the largest heat exchange probe-soil.
- **Material cost ≤ 0,3 €/kg**.



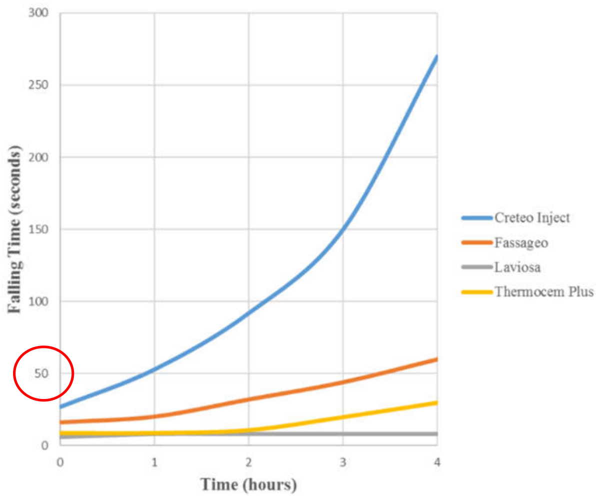
Composition of the commercially available slurry FassaGeo100 analysed via XRD (ZnO refers to the internal standard used for quantitative analyses)



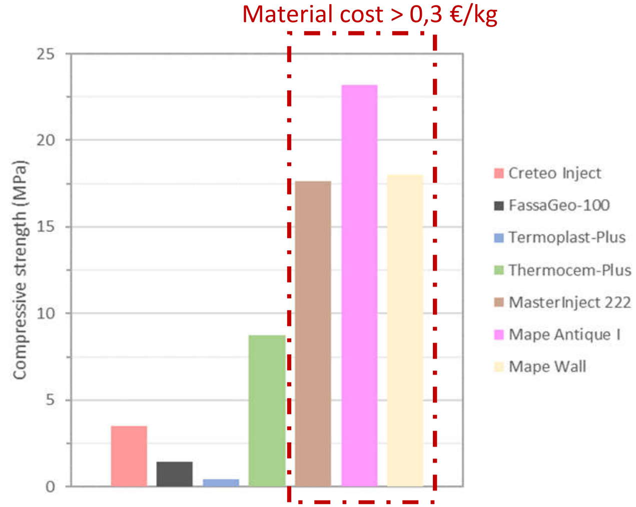
Trial installation of an heat exchanger

2 - Filling the annular gap for coaxial geothermal heat exchangers

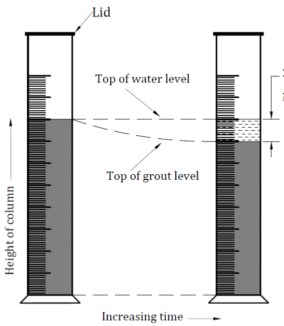
Tests on the selected slurries:

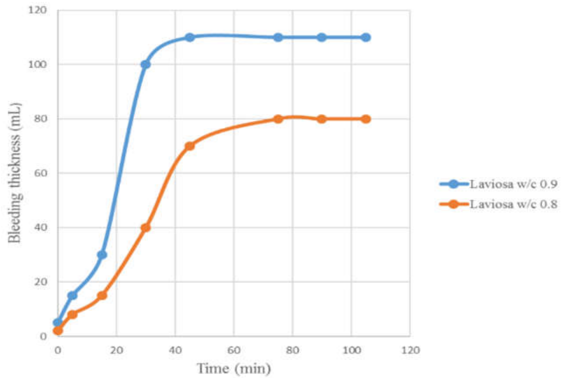


Fluidity and working time checked via EN 445 at different setting hours.

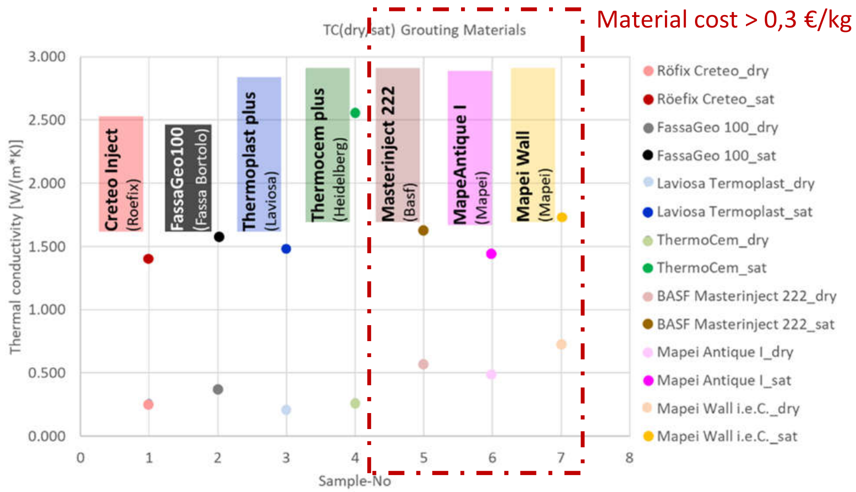


Compressive strength at 28 days of curing for the different slurries (ASTM C109)





Water bleeding checked via ASTM C940, example for the slurry Termoplast-Plus by Laviosa



Thermal conductivity measured by using the Thermal Conductivity Scanning (TCS) apparatus.

2 - Filling the annular gap for coaxial geothermal heat exchangers

The laboratory results identify 4 suitable commercially available slurries able to provide for different onsite installation conditions:

- Fassageo 100: negligible bleeding, fluid and workable for about 4 hours, apparently suitable for several soils.
- Creteo Inject: negligible bleeding, less fluid and workable for about 1 hour, probably suited for more granular soils.
- Thermocem-Plus: provided with bleeding over 2% (>6%), very fluid, workable for more than 4 hours, probably suited for non-granular soils, provided with the best thermal conductivity in saturated conditions thanks to graphite.
- Termoplast-Plus: provided with bleeding over 2% (>8%), extremely fluid, probably suited for non-granular and "dry" soils

Preliminary onsite test concerning the filling of the annular gap with FassaGeo 100:

Mixing procedure of the slurry (top) and slurry filling entirely the casing (bottom) at the onsite test in Molinella (Ferrara, Italy).

Conclusions

The experimental work allowed to identify the most suitable grout and slurry (e.g. availability on the market, low cost, ease of preparation, onsite workability, etc.) for two different heat exchangers being developed within the **EU H2020 GEO4CIVHIC project**.

For the **sealing of the coaxial geothermal probes' head**, 2 cement grouts were identified: MapeGrout SV and MasterFlow 928. Both grouts are efficient in sealing the reference probe, but the first grout is more fluid than the second. Therefore, it will be preferred for the 100 meters deep probes. Whereas, MasterFlow 928 thanks to its thixotropic behaviour appears more suitable for 10 meters deep well-point probes having large end-openings.

For the **filling of the annular gap of coaxial geothermal heat exchangers**, 4 slurries were identified: Fassageo 100, Creteo Inject, Thermocem-Plus and Termoplast-Plus. The use of one slurry over another depends on the different onsite installation conditions (e.g. soil stratigraphy, presence of groundwater, installation time, etc.)

The **feasibility** for both solutions, i.e. sealing and filling, was **assessed** via leakage tests under pressure and with an onsite installation using the slurry FassaGeo 100, respectively.

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Thank you for your attention