Gel formation capacity in mortars using mineral rheological additives

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Rheology of Building Materials Conference, Regensburg, March 7th, 2018
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2- FLOW TABLE MEASUREMENTS
3- GEL FORMATION CAPACITY
4- SEDIMENTATION CONTROL CAPACITY
5- ORGANIC THICKENERS
6- RHEOLOGY OF SEPIOLITE vs. BENTONITE
7- CONCLUSIONS
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MINERAL RHEOLOGICAL ADDITIVES STRUCTURE

Smectites (Bentonites)  Sepiolite  Attapulgite
BENTONITE SWELLING

Swelling in presence of water
BENTONITE GELLING MECHANISM
SEPIOLITE GELLING MECHANISM

-O-H Groups
CLAYS GELLING MECHANISM

SHEET LIKE

SWELLING

GEL STRUCTURE

STRUCTURE TEMPORARY DESTROYED

NEEDLE LIKE
RHEOLOGICAL CURVES

Shear Stress vs. Shear Rate

SHEAR THINNING

Low Shear Rate

High Shear Rate

Viscosity vs. Shear Rate

SHEAR THINNING

THIXOTROPY

Low Shear Rate

High Shear Rate

Time
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FLOW TABLE MEASUREMENTS
FLOW TABLE: VISKOMAT NT

• Rotational in Control rate mode (CR):

The shear rate (rpm) is set and the shear stress is measured.

• Three type of tests:

- Constant shear rate or rpm
- Reducing shear rate
- Increasing shear rate
FLOW TABLE: VISKOMAT NT PROFILES

1. BREAKDOWN LINES
   (Constant Shear rate)

2. GEL FORMATION CAPACITY
   (Decreasing Shear rate)

3. FLOW CURVE
   (Increasing Shear rate)
FLOW TABLE MEASUREMENTS: Constant Rate

- Breakdown lines
- Control (water: 25%, flow: 160 mm)
- Straight and homogeneous lines at constant shear rate or rpm

Torque (Nmm) vs. Time (minutes) graph
FLOW TABLE MEASUREMENTS

- **Acceleration from 0 to 50 rpm**
- **50 rpm (cte)**

**BREAKDOWN LINES**

- **Additive 1** (water: 25%, flow: 132 mm)
- **Control** (water: 25%, flow: 160 mm)

Torque increase is observed when a mineral additive is included.

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FLOW TABLE MEASUREMENTS

Acceleration from 0 to 50 rpm

50 rpm (cte)

Torque (Nmm)

Additive 1 (water: 25%, flow: 132 mm)
Additive 1 (water: 27.5%, flow: 147 mm)
Control (water: 25%, flow: 160 mm)

Water ratio increase is required to overlap lines with the control

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FLOW TABLE MEASUREMENTS

But under the same torque or shear stress the flow is different.
FLOW TABLE MEASUREMENTS

Water absorption can be accurately assessed.
FLOW TABLE MEASUREMENTS

• Flow table test could not be the most accurate method to verify water demand under shear stress, strokes applied during the flow table test are actually not strong enough to break the three dimensional network formed.

• Rheometers could also be an interesting way of testing the water absorption of additives under a specific shear stress.
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GEL FORMATION CAPACITY
GEL FORMATION CAPACITY

Water ratio adjusted to obtain same torque under constant rpm

1% Additive 30.7% water
0.5% Additive 27.5% water
Control 25.3% (no additive)
Reducing shear rate, lines separate depending on the gel formation capacity.
GEL FORMATION CAPACITY

1% Additive 30.7% water
0.5% Additive 27.5% water
Control 25.3% water (no additive)

rpm

Torque (Nmm)
GEL FORMATION CAPACITY: NET BEHAVIOR

Subtracting the control graph the net behavior is observed.
GEL FORMATION CAPACITY or DYNAMIC CONDITIONS

- Net gel formation capacity of mineral thickeners when the shear rate is decreasing could be quantify
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SEDIMENTATION CONTROL: FLOW CURVE
SEDIMENTATION CONTROL: FLOW CURVE
Increasing the shear rate or rpm the gel peak is observed (Static conditions)
Subtracting the control graph the net behavior of the gel peak is observed.
SEDIMENTATION CONTROL: WORKABILITY

Workability could be defined as the torque reduction from the gel peak when shear rate increase.
SEDIMENTATION CONTROL or STATIC CONDITIONS

• In the shear rate increase test, the gel peak gives information about sag/slip control and sedimentation resistance. Workability in this test could also be quantified.
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ORGANIC THICKENERS: GEL FORMATION

Reduced gel formation capacity of starch ethers

Torque (Nmm) vs. rpm

- 1% Additive 30.7% water
- 0.5% Additive 27.5% water
- 0.1% Starch 26.8% water
- 0.05% Starch 26.5% water
- Control 25.3% water

GEL FORMATION CAPACITY
ORGANIC THICKENERS: NET BEHAVIOR

No gel capacity in “dynamic conditions” of starch ethers is observed

- 1% Additive
- 0.5% Additive
- 0.1% Starch
- 0.05% Starch

GEL FORMATION CAPACITY

Torque (Nmm)

rpm
ORGANIC THICKENERS: FLOW CURVE

However in “static conditions” starch ether provides higher performance
ORGANIC THICKENERS

• While mortars with mineral thickeners additives have an increase in the sag control capacity when shear stress is decreasing, starch ethers do not. Starches are not able to form as stable three dimensional structures under low shear conditions.
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RHEOLOGY OF SEPIOLITE vs. BENTONITE

Robustness or gel strength of bentonite is higher compared to Sepiolite & Attapulgite.

- 1% Bentonite (27.8%)
- 0.5% Sepiolite (28.2%)
- 1% Attapulgite (28.0%)
- Control (25.3%)

Breakdown lines

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RHEOLOGY OF SEPIOLITE vs. BENTONITE

Equivalent shear stress is obtained but after some minutes.
RHEOLOGY OF SEPIOLITE vs. BENTONITE

But Bentonite torque reduction after the gel peak (workability) is much smaller.
RHEOLOGY OF SEPIOLITE vs. BENTONITE

- Strength of Bentonite gels are higher than the one shown for sepiolite, so Bentonite provide better slip or sag control under static conditions, but sepiolite achieve better workability at similar magnitude of the gel formed.
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CONCLUSIONS I

• Flow table test could not be the most accurate method to verify water demand under shear stress.

• Rheometers could also be an interesting way of testing the water absorption.

• Net gel formation capacity of mineral thickeners when the shear rate is decreasing could be quantify.

• The gel peak gives information about sag/slip control and sedimentation resistance.
CONCLUSIONS II

• Workability could be quantified.

• Starches are not able to form as stable three dimensional structures under low shear conditions.

• Sepiolite and Attapulgite gels provide better workability and gel formation capacity than bentonites, but bentonites give better sagging and slip control at static conditions.
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