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# Impact of Guar Gum Derivatives on Properties of Freshly-Mixed Cement-Based Mortars

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Cement + Admixture + Sand = Mortar

**Water Retention Agent (polysaccharide)**  
Most widely used admixture: **Cellulose Ethers**  
~ 1/3 of raw materials cost for only **0,5 wt%**

### Water Retention

= Capacity of fresh mortar to keep its mixing water

With Water Retention Agent vs Without Water Retention Agent

**Desired Effect:** Mixing water stay into the fresh mortar → Good Mechanical and adhesive properties

**Without Agent:** Absorption of water by the substrate → Adhesion failure, Cracking

**Polysaccharides are also expected to act as VEA**

**Major drawback: Cement hydration delay**

**Study of bio-based Water Retention and VEA admixture : Hydroxypropyl Guar (HPG)**

## Materials

### HydroxyPropyl Guars

Seed → Endosperm → Grinding → Native guar gum obtained without chemical treatment

Thermomechanical extraction

Irreversible nucleophilic substitution

CC(O)C1OC(O)C(O)C(O)O1

**HPG**

**HPG preparation**

**HPG Studied**

- A native Guar Gum (**GG**) + 3 HPGs + 2 hydrophobically modified HPGs
- Roughly the same molecular weight (≈ 2.10<sup>6</sup> Da)

| Sample | MS <sub>HP</sub> | Additional Substitution | DS <sub>AC</sub>  |
|--------|------------------|-------------------------|-------------------|
| HPG 1  | Low              | -                       | -                 |
| HPG 2  | Medium           | -                       | -                 |
| HPG 3  | High             | -                       | -                 |
| HPG 4  | High             | Short alkyl chain       | Higher than HPG 4 |
| HPG 5  | High             | Short alkyl chain       | Higher than HPG 4 |
| GG     | -                | -                       | -                 |

### Mortar Formulation

| Component             | CEM II/B-LL 32.5R | Lime | CaCO <sub>3</sub> | CaMg(CO <sub>3</sub> ) <sub>2</sub> | Water |
|-----------------------|-------------------|------|-------------------|-------------------------------------|-------|
| % mass of dry mixture | 12 %              | 3 %  | 18 %              | 67 %                                | 22 %  |

- Water-to-Binder ratio: **W/B = 0.22**
- Admixtures in addition to the binder: **0.05% – 0.15% bwob**

## Adsorption

**TOC - Centrifugation - Depletion method**

Low dissolution kinetics of GG

MS<sub>HP</sub> ↑ Adsorption because of ↓ free -OH and polarity

Hydrophobic alkyl chain: Low ↑ Adsorption

Change in conformation of HPG (Simon et al.)

Alkyl chains inside the coils / Hydrophilic groups at the outskirts of the coils

## Water Retention

**Standard ASTM C 1506-09:**  $WR(\%) = \frac{W_0 - W_1}{W_0} \times 100$

- Excepted **GG**, HPGs improve the WR capacity of mortars
- MS<sub>HP</sub> improves the WR capacity: MS<sub>HP</sub> HPG 1 < MS<sub>HP</sub> HPG 2 < MS<sub>HP</sub> HPG 3
- Thanks to ↓ Adsorption and thus ↑ [HPG] in pore solution
- Positive impact of the additional alkyl chain
- ↑ Adsorption compensated by ↓ in coil overlapping concentration
- DS<sub>AC</sub> slightly reduces the WR capacity: DS<sub>HP</sub> HPG 4 < DS<sub>HP</sub> HPG 5

## Rheological properties of mortars

**Herschel-Bulkley model:**  $\tau = \tau_0 + K\dot{\gamma}^n$

$\tau_0$ : yield stress,  $K$ : consistency coefficient,  $n$ : fluidity index

- τ<sub>0</sub> with HPGs 1, 2, 3
- Bridging flocculation
- MS<sub>HP</sub> ↓ adsorption ↓ bridging compensated by ↑ η<sub>0</sub> and [HPG]
- K and ↓ n with HPGs 4, 5
- Rheological behavior of mortars imposed by the more and more shear thinning behavior of pore solution

## Conclusions

### Water Retention

- HPGs are good water retention agents
- Huge impact of HPG chemical composition
- ↑ MS<sub>HP</sub> promotes WR by ↑ [HPG]
- Hydrophobic side chain promotes WR by ↓ C\*

### Rheological properties

- HPGs act as VEA
- "Classical" HPGs ↑ the stability of mortars by ↑ τ<sub>0</sub>
- Hydrophobically modified HPGs ↑ the resistance to the flow of admixed mortars by ↑ K

**Chemical composition of HPGs is a key parameter of mortar formulation**