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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 WRA: 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 → Thermomechanical extraction → Endosperm → Grinding → Native guar gum obtained without chemical treatment

Irreversible nucleophilic substitution → **HPG**

HPG preparation

HPG Studied

- A native Guar Gum (**GG**) + 3 HPGs + 2 hydrophobically modified HPGs
- Roughly the same molecular weight (≈ 2.10⁶ Da)

Sample	MS _{HP}	Additional Substitution	DS _{AC}
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 ₃	CaMg(CO ₃) ₂	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_{HP} → 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_{HP} improves the WR capacity: MS_{HP HPG 1} < MS_{HP HPG 2} < MS_{HP 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_{AC} slightly reduces the WR capacity: DS_{HP HPG 4} < DS_{HP HPG 5}

Rheological properties of mortars

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

τ_0 : yield stress, K : consistency coefficient, n : fluidity index

τ₀ with HPGs 1, 2, 3

Bridging flocculation

MS_{HP} ↓ adsorption ↓ bridging compensated by ↑ η₀ 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_{HP} promotes WR by ↑ [HPG]
 - Hydrophobic side chain promotes WR by ↓ C*

Rheological properties

- HPGs act as VEA
- "Classical" HPGs ↑ the stability of mortars by ↑ τ₀
- Hydrophobically modified HPGs ↑ the resistance to the flow of admixed mortars by ↑ K

Chemical composition of HPGs is a key parameter of mortar formulation