Research on the Influence of Cellulose Ether on the Performance of Gypsum-Based Self-Leveling Mortar

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Abstract

This study investigates the effects of hydroxypropyl methylcellulose ether (HPMC) content on the fluidity, setting time, mechanical properties, and water retention of gypsum-based self-leveling mortar (GSLM). The rheological behavior was analyzed using the Herschel-Bulkley (H-B) model. Key findings include:

1. **Fluidity**: HPMC reduces initial fluidity but enhances 30-minute fluidity.
2. **Mechanical Properties**: Increasing HPMC content (0–0.10%) decreases 28-day compressive strength from 19.5 MPa to 12.8 MPa.
3. **Water Retention**: At 0.07% HPMC, water retention reaches 81.6%, a 41% improvement over the control group.
4. **Rheology**: Low HPMC content (≤0.07%) increases plastic viscosity, while higher content (0.10%) induces pseudo-plastic behavior.

Keywords: Hydroxypropyl methylcellulose ether; Gypsum-based self-leveling mortar; Rheological properties; Water retention; Fitting analysis

1. Introduction

Gypsum-based self-leveling mortar (GSLM) is a sustainable alternative to traditional cement-based materials, offering advantages such as low shrinkage, high flatness, and eco-friendliness [[6]–[8]]. However, achieving high fluidity without segregation remains a challenge [[9]–[11]]. Cellulose ethers like HPMC are widely used to improve workability and water retention [[12]–[15]]. This study systematically evaluates HPMC's role in optimizing GSLM performance.

2. Experimental Methods

2.1 Materials

- **Gypsum**: Desulfurized gypsum (CaO: 41.92%, SO_3: 52.15%).
- **Cement**: P·O 42.5R (28-day compressive strength: 46.3 MPa).
- **HPMC**: HPMC-400 (viscosity: 400 mPa·s).

2.2 Mix Proportions

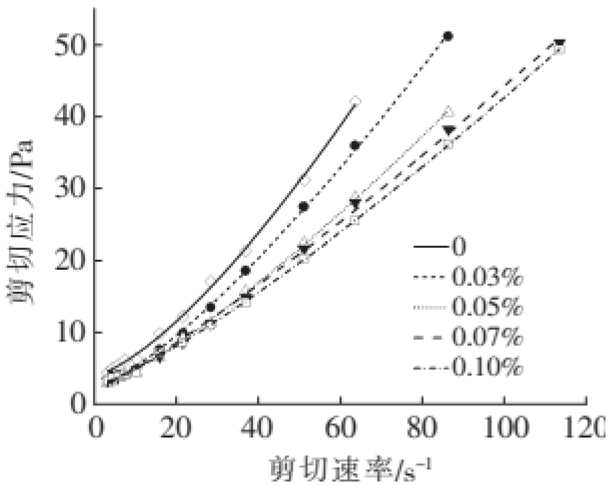
Five mixes (C1–C5) with HPMC content ranging from 0 to 0.10% (Table 4).

Table 4 Mix Proportions of GSLM

Group	Gypsum (g)	HPMC (%)	Other Additives (%)
C1	850	0	4.7
C5	850	0.10	4.7

2.3 Testing

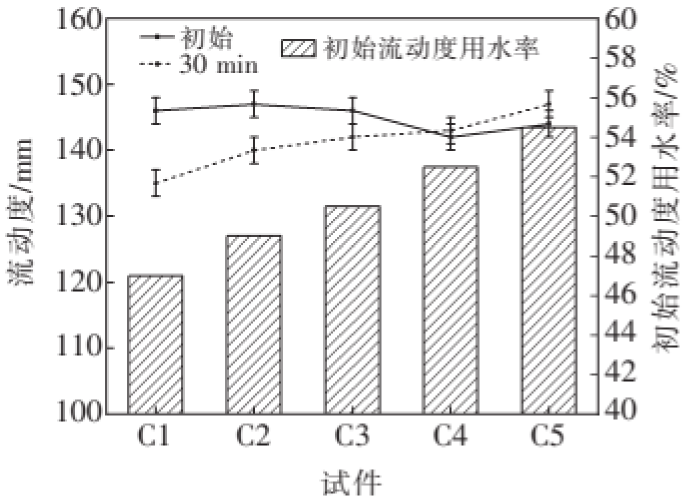
- **Fluidity**: Measured per JC/T 1023-2021.
- **Rheology**: H-B model fitted to shear stress-rate curves (Figure 5).
- **Water Retention**: JGJ/T 70-2009 standard.



3. Results and Discussion

3.1 Fluidity and Water Demand

- **Initial fluidity** decreases with HPMC due to hydrogen bonding [[16]].
- **30-minute fluidity** improves by 8.9% (Figure 2), indicating enhanced stability.



3.2 Mechanical Properties

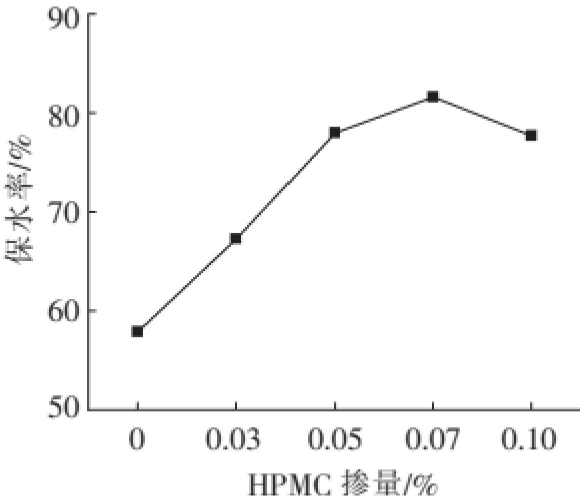
- **28-day compressive strength** drops by 34.4% at 0.10% HPMC (Figure 4), attributed to increased porosity and delayed hydration.

3.3 Rheology

- **Low HPMC (≤0.07%)**: Shear-thinning behavior (η↑, n↓).
- High HPMC (0.10%): Pseudo-plasticity (η↓, τ_0↑) due to entangled polymer networks [[19]–[20]].

3.4 Water Retention

- Optimal HPMC (0.07%): 81.6% water retention (Figure 6). Excess HPMC (>0.07%) reduces efficiency.



4. Conclusions

1. HPMC improves 30-minute fluidity and water retention but reduces strength.
2. Recommended HPMC content: 0.05–0.10% for balanced performance.
3. Rheological shifts (shear-thinning → pseudo-plastic) highlight HPMC's dual role as a thickener and stabilizer.

Practical Implications:

- For high-strength applications, minimize HPMC to <0.05%.
- For self-leveling requirements, prioritize 0.07% HPMC to enhance workability.