Cellulose Ethers for Improved Hot-Temperature Performance in External Insulation Finishing Systems and External Skim Coat Mortars

Abstract
A new concept to improve water retention capability at high, elevated temperature conditions has been developed. Further optimization of this concept resulted in specially developed products for external insulation finishing systems (ETICS) and exterior skim coat mortars. These products were designed to increase the efficiency and effectiveness of the corresponding mortars, especially in hot, challenging weather conditions. While using these grades in ETICS and external skim coat mortars relevant workability related parameters like water retention, pot life and open time could be significantly improved.

Background
Hard-coat stucco has been used since ancient times and synthetic stuccos and exterior ETICS have been used in construction in many countries for more than 50 years. Among others, the advantage of ETICS is the improved insulation which these systems provide over traditional stuccos. Rising energy prices and increasing environmental awareness enhance the attractiveness of ETICS mortars. They reduce the costs of heating and air conditioning and help to reduce carbon dioxide emissions. Approximately 50 percent of the energy used for heating or cooling buildings is lost through non insulated walls. Accordingly insulation can cut these losses by as much as 80 percent.

In many regions of the world and at various times of the year, ETICS and skim coat mortars are applied on hot substrates and in hot environments. Under these conditions the application of the mortars used in the base coat for the ETICS is challenging, because of the rapid evaporation of water from the mortar, which results in inferior or poor workability as well as insufficient hydration of the mortar. As the physical characteristics of a hardened traditional mortar are strongly influenced by its hydration process, proper water control during the setting process is essential.

Skim coat mortar is applied in thin layers on absorbing substrates. High water retention capability is important for skim coat mortar. Hot climate conditions limit workability and smoothing time and often result in crack formation and sanding effect. Hot-temperature cellulose ether clearly enhances efficiency and quality of skim coat mortar.

Experiment methodology
The current study was divided into two parts. The first part contains the method adaptation and product development for ETICS mortar, whereas the second part is related to skim coat. Both development activities were run while simulating hot temperature conditions and evaluating the performance under these circumstances. Workability, pot life and open time, as well as abrasion and crack resistance are key parameters which normally suffer under these conditions. Although standard cellulose
Ethers are considered as state of the art technology, the high-temperature performance of mortars containing such cellulose ethers is lacking. Even at higher dosages workability, crack resistance, pot life and open time of the ETICS mortars or skim coats are still not acceptable.

Insufficient hot-temperature performance might result in too-short workability / smoothening times, too-quick hardening in bucket, crack formation and sanding effects of the prepared or applied mortar.

There is a need for an ETICS as well as skim coat mortar showing the necessary pot life and open time / smoothing time under hot-weather conditions to permit the application of a mortar while retaining enough water during mixing and upon application to result in a finished mortar with the necessary functionality and aesthetics.

The formulations were tested at elevated temperatures of 70°C and/or 40°C at a relative air humidity of 50 percent in a drying cabinet or special climate room. To simulate the job site conditions, all materials were conditioned overnight under the specified climatic conditions before usage.

Test results

Part 1: ETICS Mortar

The study was based on the following, designed formulations of an ETICS mortar:

24.0 wt % Portland Cement CEM I 52.5N  
20.0 wt % fine silica sand 0.5-1mm  
53.0 wt % silica sand  
3.0 wt % AQUAPAS redispersible powder (EVA co-polymer)  
0.2 wt % zinc stearate  
0.15 wt % cellulose ether.

For quality assessment, various test methods were applied. Water/drymix ratio was adjusted to achieve comparable (350,000 to 400,000 mPa•s) Helipath viscosity for ETICS mortar. The determination of mortar consistency was carried out using a viscometer and spindle system (Helipath device).

In cement-based systems, such as ETICS mortar, the water retention of the system is mainly influenced by cellulose ether (CE). Typical cellulose ethers such as methylhydroxypropylcellulose (MHPC) or methylhydroxyethylcellulose (MHEC) perform well at temperatures up to 30°C and 35°C, respectively, but at higher temperatures water retention capability of cement-based systems, e.g., ETICS mortars, relying solely on these typical cellulose ethers, suffers significantly. Crack formation and powdering effects observed in ETICS mortars are the consequences of insufficient water retention. Figure 1 shows the water retention capability of various ETICS mortar
compositions at 70°C (heated walls) with the new Aquatherm concept in comparison to standard cellulose ethers.

![Graph showing water retention values at 70°C for ETICS mortars with different CEs]

Figure 1: Water retention values at 70°C for ETICS mortars with different CEs

The new Ashland Aquatherm concept exhibits outstanding ETICS performance providing an excellent water retention capability at regular as well as high temperatures in combination with good paste stability.

In the next step the new Ashland Aquatherm concept was taken as basis for a further optimization of application performance. The outcome is the new Ashland Aquathem product series.

Pot life of a mortar is an important attribute which permits proper workability of the mortar over a long period of time. The ETICS mortar containing Ashland Aquatherm grades exhibits a prolonged pot life under extreme conditions.

Figure 2 shows the pot life of the ETICS mortars at 40°C. In the mentioned tests, pot life is defined as that time to reach a viscosity of 600 Pa·s. If consistency is exceeding 600 Pa·s, unacceptable consistency will result.
Open time for ETICS mortar is another desirable attribute of a mortar which permits a long workability and smoothening time of applied mortar. Use of Ashland Aquatherm products prolongs open time of the ETICS mortars at high temperatures by about 50 percent to 100 percent as shown in Figure 3.

As indicated in Figure 1-3 and Table 1, the new Ashland Aquatherm cellulose ethers show clear advantages under hot conditions over the standard type, especially in pot life and open time. Furthermore, the improvement of tensile strength and flexibility of ETICS
mortar produced with Ashland Aquatherm cellulose ethers under standard conditions is remarkable.

Table 1: Comparison of ETICS properties

<table>
<thead>
<tr>
<th></th>
<th>Standard CE-product</th>
<th>Ashland Aquatherm AM 40051HPF</th>
<th>Ashland Aquatherm AM 40061HPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water/drymix ratio</td>
<td>0.17</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>Workability</td>
<td>++</td>
<td>+++</td>
<td>+++(+)</td>
</tr>
<tr>
<td>Pot Life 40°C [min]</td>
<td>180</td>
<td>240</td>
<td>230</td>
</tr>
<tr>
<td>Open Time 40°C [min]</td>
<td>15</td>
<td>30</td>
<td>33</td>
</tr>
<tr>
<td>Tensile Strength [N/mm²] at 20°C</td>
<td>0.09</td>
<td>0.13</td>
<td>0.14</td>
</tr>
<tr>
<td>Flexibility</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Crack</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Rating:</td>
<td>Excellent (++++)</td>
<td>Good (+++)</td>
<td>Satisfactory (+)</td>
</tr>
</tbody>
</table>

Tensile strength according to ETAG 004

**Part 2: Exterior Skim Coat**

The study was based on the following, designed formulation:

- 35.0 wt % Portland Cement CEM I 52.5N
- 5.0 wt % lime
- 59.2 wt % silica sand 0.1-0.35 mm
- 0.5 wt % AQUAPAS redispersible powder (EVA co-polymer)
- 0.3 wt % cellulose ether.

Mortar consistency was adjusted to a Helipath viscosity of 350,000 – 400,000 mPa•s which reflects job site conditions.

Skim-coat mortar is applied in thin layers on absorbing substrates. Therefore, high water retention capability is essential for this kind of dry mortar. Water retention capability is mainly influenced by cellulose ether. Typical cellulose ethers like methylhydroxypropylcelluloses (MHPC) perform well at moderate temperatures. Typically, at higher temperatures water retention capability suffers clearly. Crack formation and sanding effects are the consequences. Hot-temperature cellulose ether clearly enhances efficiency and quality of skim-coat mortar under these conditions. Figure 5 shows the water retention capability of various skim coat mortars at 70°C (heated walls).
The new Ashland Aquatherm products provide skim-coat mortar with outstanding water retention capability at moderate temperatures, but especially at hot temperatures. Hot climate conditions often result in too-short workability / smoothening times and too-quick hardening in the bucket (pot life). Ashland Aquatherm cellulose ethers clearly improve workability and pot life of skim-coat mortars. These effects should have a positive effect on craftsmen’s efficiency and cost because of less loss of material and complaints at the job site.

Figure 5: Water retention values at 70°C of skim coat

Figure 6 illustrates the positive effect of Ashland Aquatherm grades on skim coat open time/smoothening time at 40°C.
Figure 6: Smoothening time / open time of skim coat at 40°C

Figure 7 shows that while using Ashland Aquatherm grades for skim coat the resulting pot life at 40°C can clearly be prolonged.

Fig. 7: Pot life of skim coat at 40°C
Figure 8 gives a comparable overview on the application characteristics of skim-coat mortar based on Ashland Aquatherm in comparison to state of the art cellulose ether.

![Application characteristics of skim coat mortars](image)

**Figure 8: Application characteristics of skim coat mortars**

**Conclusion:**

A new concept to improve water retention capability at high, elevated temperature conditions has been developed. Further optimization of this concept resulted in the new Ashland Aquatherm products for ETICS and exterior skim-coat mortars. These products were designed to increase the efficiency and effectiveness of the corresponding mortars, especially in hot, challenging weather conditions. While using these grades in ETICS and external skim-coat mortars relevant workability related parameters like water retention, pot life and open time could be significantly improved.

In another study, the outcome was validated for different formulations representing different geographic regions as well as regional application habits. Besides a nice workability other important properties like prolonged open time / smoothening time and longer pot life, as well as high and stable water retention at hot temperatures could be obtained.

Tests have also shown that the use of Ashland Aquatherm will improve quality of the end product while offering a cost saving opportunity resulting from lower use levels.