Advanced Polymers for Monolithic Refractories

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SKW Polymers GmbH
Self-Flow Castables - Trends

Trendency in the Castable Technology
During the past two decades significant changes occurred in the application of refractories.
Shift from shaped (bricks) to unshaped (monolithics)

CAC in Refractory Applications (from LCC to NCC)

Value of refractory shipments from 1998 to 2002
Self-Flow Castables - Trends

Castables

became a sophisticated product due to new requirements and more challenging characteristics.

Possible influences, requirements and characteristics:

- flowability, workability, pumpability, finishability, w/c-ratio, cohesion, air, bleeding
- cement (type, quality, content), additives (RA, MS)
- sand and aggregate (quality, grading, fines, etc.)
- mixing, transport, formwork, placing, type of lining
- setting and hardening properties, strength development
- durability, temperature,
- climatic conditions, exposures, specific performances
- costs, shape of structure, energy consumption, metallurgical aspects, corrosion

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Today’s Refractory Market is very complex and further improvements can only be achieved by tailor-made solutions.
Polycarboxylate Ethers

The brandname for polycarboxylate ethers from SKW Polymers GmbH is Castament®

- Castament FS 10
- Castament FW 10
- Castament FS 20
How does Castament Work?

Plasticizing admixtures enable a better dispersion (= equal distribution) of the cement particles.

Reduction of internal friction

Flocculation without Plasticizer

Deflocculation with Plasticizer
How does Castament Work?

Conventional Polymers

Electrostatic repulsion

Before Cement Hydration

Polycarboxylate Ethers

Electrosteric repulsion
How does Castament work?

Conventional Polymers

SP are "overgrown"
--> early slump loss

Polycarboxylate Ethers

During Cement Hydration

Better dispersion stability
--> longer workability

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Effects of Castament

Plastification: improved workability
Water reduction: improved physical properties

Flow / Spread

Water content of system

1. Plastification improved workability
2. Water reduction improved physical properties
Means of Castament

**Product**
- Additive Castament®

**Effects**
- Plastification
- Reduction water content

**Practical Means**
- Self-flowing Castables
- Improved physical properties

**Advantages**
- Improved Workability
- Pumpability
- Easier and cheaper placement
- Fast lining
- Increased strength properties
- Reduced apparent porosity
- Increased density
- Prolonged service life
# Basic Recipe of Tested Ultralow Cement Castables

## Andalusite

<table>
<thead>
<tr>
<th>Material</th>
<th>[Mass-%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement (70 % Al₂O₃)</td>
<td>2</td>
</tr>
<tr>
<td>Andalusite</td>
<td></td>
</tr>
<tr>
<td>3 – 6 mm</td>
<td>20</td>
</tr>
<tr>
<td>1 – 3 mm</td>
<td>26</td>
</tr>
<tr>
<td>Kerphalite</td>
<td></td>
</tr>
<tr>
<td>0.3 – 1.6 mm</td>
<td>15</td>
</tr>
<tr>
<td>0 – 0.16 mm</td>
<td>8</td>
</tr>
<tr>
<td>0 – 0.55 mm</td>
<td>16</td>
</tr>
<tr>
<td>Reactive Alumina</td>
<td>10</td>
</tr>
<tr>
<td>Microsilica 971 D</td>
<td>3</td>
</tr>
<tr>
<td>Water</td>
<td>4.0 - 5.0</td>
</tr>
<tr>
<td><strong>Additive</strong></td>
<td></td>
</tr>
<tr>
<td>Dispersant</td>
<td>0.1</td>
</tr>
</tbody>
</table>

## Bauxite

<table>
<thead>
<tr>
<th>Material</th>
<th>[Mass-%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement (70 % Al₂O₃)</td>
<td>2</td>
</tr>
<tr>
<td>Bauxite</td>
<td></td>
</tr>
<tr>
<td>3 – 6 mm</td>
<td>20</td>
</tr>
<tr>
<td>1 – 3 mm</td>
<td>26</td>
</tr>
<tr>
<td>0 - 1 mm</td>
<td>23</td>
</tr>
<tr>
<td>DIN 70</td>
<td>16</td>
</tr>
<tr>
<td>Reactive Alumina</td>
<td>10</td>
</tr>
<tr>
<td>Microsilica 971 D</td>
<td>3</td>
</tr>
<tr>
<td>Water</td>
<td>4.1 - 4.6</td>
</tr>
<tr>
<td><strong>Additive</strong></td>
<td></td>
</tr>
<tr>
<td>Dispersant</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Basic Recipe of Tested Ultralow Cement Castables

Test Programme

Performance of Castament FS 20 was evaluated in comparison to a commonly used polyacrylate.

⇒ T = 20° C
⇒ Cone dimensions: 100 mm (bottom), 70 mm (top), 80 mm (height) according to ENV 1402-4
⇒ Dry components were mixed first for 1 minute. Then, addition of measured quantity of water, followed by an additional 4 minutes of mixing at constant temperatures.
⇒ Determination of flowability at different times
⇒ Determination of physical properties

Recipe Variations:
Comparison of different: Reactive Aluminas
Calcium Alumina Cements
Water Content
Ultralow Cement Castables - Results

Flow Properties

**Bauxite**

- Self Flow Value [%] vs. Elapsed time [min]
- Dosage: 0.1%
- Water content: 4.6% bwc

**Andalusite**

- Self Flow Value [%] vs. Elapsed Time [min]
- Dosage: 0.1%
- Water content: 5.0% bwc
Ultralow Cement Castables - Results

Water Reduction Properties

**Bauxite**

Dosage : 0.1%
Water content : variable

**Andalusite**

Dosage : 0.1%
Water content : variable

- 20 % water
Ultralow Cement Castables - Results

Refractoriness under Load

<table>
<thead>
<tr>
<th>Characteristic Value</th>
<th>Polyacrylate</th>
<th>Castament FS 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load [MPa]</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>$D_{\text{max}}$ [%]</td>
<td>0.99</td>
<td>1.122</td>
</tr>
<tr>
<td>$T_{\text{Dmax}}$ [°C]</td>
<td>1610</td>
<td>1610</td>
</tr>
<tr>
<td>$T_{0.5}$ [°C]</td>
<td>1680</td>
<td>1690</td>
</tr>
</tbody>
</table>

- 1100° C: Start of sintering process
- 1300° C: Expansion due to Mullit formation
- 1600° C: Increased formation of low melting phases
Ageing of Refractory Castables

**Ageing Experiments**

- **Hardening time increased**
- **Working time decreased**
- **Additives**
- **Poor flow properties**
- **Fine Fillers**

CAC
Ageing of Refractory Castables

Water Adsorption of Different Plasticizers

T = 20 °C

humidity of the surrounding atmosphere
relative weight increase [%]

Polyacrylate
Castament FS 20
Features and Benefits of Castament

**Feature**
- Very efficient dispersant
- Excellent flowability / workability / pumpability
- Reduced hygroscopity
- Improved and prolonged storage stability
- Compatible with many other chemical additives
- Reduced apparent porosity
- Improved physical properties
- ISO Quality Management 9002

**Benefit**
- Water content as low as 4 % bwc
- Easier placement
- Better powder properties
- Constant product quality
- More formulation alternatives
- Enhanced infiltration resistance
- Prolonged service life
- Reliable quality and performance
Conclusions

The newly developed Castament FS 20 is a highly efficient dispersant which helps to improve the hardened properties and to push the technology of self-flow castables.

Bottom Line

Castament FS 20 is more than an alternative to conventional polyacrylates.
Thank you for your attention
Muchas gracias por su atención