High-performance self compacting Geopolymer mortar based on flash-calcined materials

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Geopolymer Camp
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• Outline

• Materials and Flash Calcination
• Geopolymer cement design
• Verifying the design
• Mixing Procedure
• Results
• Upcoming results
Cement industry

OPC
1,000 kg

CO2
1,100 kg

5-7% of all man-made CO2 emissions

Excavated Materials

Dredged Sediments
56 million m³ per year

Excavated soils
130 million tons per year

Waste Materials

Treating Materials

Flash Calcination
Flash-calcined-based geopolymer cement with **room temperature setting**

1. Flash Calcined Sediments (FCS) = %
2. Metakaolin (MK*) = %
3. Slag (GBFS) = %

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1. Flash Calcined excavated clay (FCC) = %
2. Metakaolin (MK) = %
3. Slag (GBFS) = %

*MK= Argeco Commercial Product*
Geopolymer Design

Mineralogical char.

<table>
<thead>
<tr>
<th>Elements</th>
<th>MK</th>
<th>GBFS</th>
<th>FCS</th>
<th>FCMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si</td>
<td>27,4</td>
<td>14,9</td>
<td>20,8</td>
<td>28,8</td>
</tr>
<tr>
<td>Al</td>
<td>16,5</td>
<td>6,8</td>
<td>6,7</td>
<td>9,8</td>
</tr>
<tr>
<td>SiO2</td>
<td>58,6</td>
<td>31,8</td>
<td>44,4</td>
<td>61,6</td>
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<tr>
<td>Al2O3</td>
<td>31,1</td>
<td>12,84</td>
<td>12,6</td>
<td>18,5</td>
</tr>
</tbody>
</table>

Si/Al=?

Rigid 3D Macromolecular structure

% chosen according to design

Note: In geopolymers the % of materials used is important to have a good precursor

-important-
This ratio is dependent on

- **MK** = 100%
- **GBFS** = 50%
- **FCS** or **FCC**

**Tests and Results**

- Total % of Al₂O₃ reacting
- Na,K: Al =?
- nK₂O: Al₂O₃ =?

Geosil / Binder

Total % of Al₂O₃ reacting?
Geopolymerization of silicates and alumino-silicates in alkaline or acidic medium

Si:Al=2 + nK_2O:nAl_2O_3=1 + T(Al_2O_3)_reacting

Geopolymer

3D network

Boiling water at 100°C for 10 mins+ still solid

Chemical formula

Verifying the correct design
To ensure Geopolymerization when experimenting

Mixing Design Procedure

Least reactive material + reagent for 10 mins

Add MK for 5 mins

Add Slag which is most reactive so we add it at last for 3 mins

Add sand for 5 mins

Curing

Note: At room temp
Results

**Si:**Al=2 + nK$_2$O:nAl$_2$O$_3$=1 + T(Al$_2$O$_3$)$_{reacting}$

- **MK** = 100%
- **GBFS** = 50%
- **FCS** = 100%

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**Compressive Strength (MPa)**

- **Day 1**: R1S23,5K76,5G0 (16 ± 2), R1S19,8K70,2G10 (29 ± 3), R1S16,6K63,8G20 (35 ± 4)
- **Day 3**: R1S23,5K76,5G0 (33 ± 3), R1S19,8K70,2G10 (39 ± 4), R1S16,6K63,8G20 (35 ± 4)
- **Day 7**: R1S23,5K76,5G0 (35 ± 4), R1S19,8K70,2G10 (40 ± 4), R1S16,6K63,8G20 (42 ± 5)

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**Compressive Strength (MPa)**

<table>
<thead>
<tr>
<th>Time (Days)</th>
<th>R1S23,5K76,5G0</th>
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<th>R1S16,6K63,8G20</th>
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<tr>
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<td>29 ± 3</td>
<td>35 ± 4</td>
</tr>
<tr>
<td>Day 3</td>
<td>33 ± 3</td>
<td>39 ± 4</td>
<td>35 ± 4</td>
</tr>
<tr>
<td>Day 7</td>
<td>35 ± 4</td>
<td>40 ± 4</td>
<td>42 ± 5</td>
</tr>
</tbody>
</table>
Si:Al=2 + nK_2O:nAl_2O_3=1 + T\% (Al_2O_3)_{reacting}

As

T\% (Al_2O_3)_{reacting} \rightarrow \text{Mass Binder} \rightarrow \text{Alkaline/Binder}

Coming Soon

\text{MPa} \rightarrow ?
Thank you!