Valorization of industrial waste for the development of fire resistant materials

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**Services:**
- Development of material prototypes
- Turning waste into valuable product
- (Novel) products commercialisation
- Product/Process Life Cycle Cost Analysis
- Technological support and progress monitoring
- Product/Process Designing and Development

**Office Base:**
Kifisias 125-127, 11524 Athens,
SMART-G (ERA-MIN)

**PROJECT AIM**
Development of innovative low-cost building materials valorising mining wastes.

PASSENGER (EU H2020)

**PROJECT AIM**
Development of REE-free permanent magnets for electromobility, pumps and motors and wind turbines.

MINE4BUILD (C.FUNBDING)

**PROJECT AIM**
Development of REE-free permanent magnets for electromobility, pumps and motors and wind turbines.

Vrije Universiteit Brussel - Physical chemistry and polymer science

University of Aveiro - Department of Materials and Ceramic Engineering

MNLT Innovations GP - Research and Development

Cracow University of Technology - Faculty of Civil Engineering; Faculty of Material

IESL/FORTH - Institute of Electronic Structure and Laser

ResourceFull – Research and Development

Mytilineos S.A. - Metallurgy Business Unit
**Problem to solve**

- Steel rebars lose their mechanical strength and thus their structural integrity at temperatures in-between 550 °C and 600 °C requiring external fireproofing to avoid their damage in a fire event.
- The spalling phenomena of concrete are expected at temperatures higher than 180-200 °C (Khoury 2000, Phan 2008)

*The temperature at the concrete should not exceed* 200 °C

An effective passive fire protection can be achieved if the temperature on the concrete lining/fireproofing material interface is always restricted at values lower than 180-200 °C, avoiding in this way both concrete spalling and steel rebars softening.
Target

1. Development of lower density materials (density <1400 kg/m³)
2. Non combustible
3. Resistance to ISO – 834
4. Satisfactory mechanical properties

Evaluation

- Temperature limits at the interface:
  - ISO 834 : 180 °C
  - RABT : 380 °C
  - RWS : 380 °C
Evaluation

Fire Resistance Test (EFNARC Guidelines)

Regulation

Construction Sector
- EFNARC, “Specification and Guidelines for passive fire protection testing in tunnels”
**Geopolymers**

- **First stage**
  - NaOH or KOH
  - water

- **Second stage**
  - Preparation of the paste

- **Third stage**
  - Solid aluminosilicate material / other solid material
  - Forming and casting the paste in appropriate types and curing at temperatures ranging from room temperature to 100 °C

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**Theoretical Approach**

The idea was to focus on phases which are stable at temperatures up to 1100°C.

- **Waste streams**
  - Slags

- **Alkali Activator**
  - NaOH, KOH solution

- **Synthesis parameters**
  - Ratios: S/L; Si/Al; K/Si

- **Evaluation of Thermal stability**

- **Fire resistant materials**

- **Ternary diagram**: Al₂O₃ – K₂O (Na₂O) – SiO₂

- **Corrections of synthesis / additions**

- **Modifications of material's composition**

- **(Factsage Software)**
### Implementation

The temperature at the interface is lower than the limit defined by the ISO-834 curve.

The temperature in the concrete is 60-160°C which is lower than the spalling temperature.

### Results

**Before Testing**

**After Testing**

**Excellent Behavior after fire testing**
**Implementation**

- The temperature at the interface is lower than the limit defined by the RABT curve
- The temperature in the concrete is 60-200°C which is lower than the spalling temperature

<table>
<thead>
<tr>
<th>Element</th>
<th>%w/w</th>
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<tbody>
<tr>
<td>Slag</td>
<td>67</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>8.2</td>
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<tr>
<td>KOH</td>
<td>9.2</td>
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<tr>
<td>Al powder</td>
<td>0.14</td>
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<tr>
<td>H₂O</td>
<td>15.46</td>
</tr>
<tr>
<td>Density</td>
<td>1020 kg/m³</td>
</tr>
</tbody>
</table>

**Results**

**Before Testing**

- No spalling of concrete
- No yielding of the materials
- No damage

**After Testing**
Thank you

www.smartg.info

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