Construction material development using fly ash based geopolymer

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Background

Lampang Province - Mae Moh

Mae Moh Generating Plants
Coal stocking area
Fly ash dumping area

3,500,000 tons/year
Background

Introduction

Geopolymerization → WASTE → Sustainable Development → Geopolymer → Construction materials
**Oxide-mole ratios of reactant mixture**

<table>
<thead>
<tr>
<th>Molar ratio</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na$_2$O / SiO$_2$</td>
<td>0.20-0.48</td>
</tr>
<tr>
<td>SiO$_2$ / Al$_2$O$_3$</td>
<td>3.50-4.50</td>
</tr>
<tr>
<td>H$_2$O / Na$_2$O</td>
<td>10.0-25.0</td>
</tr>
<tr>
<td>Na$_2$O / Al$_2$O$_3$</td>
<td>0.80-1.60</td>
</tr>
</tbody>
</table>
- Fly ash produced by Mae Moh plant,
- Sodium hydroxide (10M)
- Sodium silicate solution (SiO$_2$:Na$_2$O = 3:1)
<table>
<thead>
<tr>
<th>Component</th>
<th>Composition (mass %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>32-38</td>
</tr>
<tr>
<td>Al&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt;</td>
<td>20-24</td>
</tr>
<tr>
<td>CaO</td>
<td>16-19</td>
</tr>
<tr>
<td>Fe&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt;</td>
<td>14-16</td>
</tr>
</tbody>
</table>
Objectives

1. Effect of alkali solution ratio (WR = 1.0-2.5)
2. Compressive Strength
3. Microstructure SEM / EDS Analysis
Weight Ratio of \( \text{Na}_2\text{SiO}_3 : \text{NaOH} < 0.50 \)

Weight Ratio of \( \text{Na}_2\text{SiO}_3 : \text{NaOH} > 3.00 \)
Mixed Experimental Program

**Mixture**

<table>
<thead>
<tr>
<th>Mix no.</th>
<th>Fly ash (gm.)</th>
<th>$\text{Na}_2\text{SiO}_3$ (gm.)</th>
<th>NaOH (gm.)</th>
<th>Weight ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>650.0</td>
<td>175.0</td>
<td>175.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>650.0</td>
<td>210.0</td>
<td>140.0</td>
<td>1.5</td>
</tr>
<tr>
<td>3</td>
<td>650.0</td>
<td>233.3</td>
<td>116.7</td>
<td>2.0</td>
</tr>
<tr>
<td>4</td>
<td>650.0</td>
<td>250.0</td>
<td>100.0</td>
<td>2.5</td>
</tr>
</tbody>
</table>

+ Sand 2000 (gm.)
The geopolymer mortar was poured into mould and stored in the ambient temperature.
Testing method

Compression test
At the ages of 1, 2, 4, 7, 28 and 90 days, specimens were taken from the storage room and tested for compressive strength.
The small pieces of tested specimens were examined using scanning electron microscope (SEM)/energy dispersive X-ray (EDX) to determine the composition of products.
Compressive strength

- Mix-1
- Mix-2
- Mix-3
- Mix-4

Results & discussion

Compressive strength (MPa)

Age (Days)

- 24.4
- 20.1
Effect of alkali solution ratio

Results & discussion

Effect of alkali solution ratio

Compressive strength (MPa)

Na$_2$SiO$_3$/NaOH

- 90 d.
- 28 d.
- 7 d.
- 4 d.
- 2 d.
- 1 d.

24.4

20.1
SEM/EDS

(a) Fly ash [5000X]
(b) Mix-1 [5000X]
(c) Mix-4 [5000X]
Si/Al atomic ratio
2.64 - 2.85
Conclusions

Alkali solution

+ 

Fly ash from Mae Moh Plant

Geopolymer product
Conclusions

NaOH content

Na$_2$SiO$_3$ content

Compressive strength
The microstructure of fly ash based geopolymer revealed a homogeneous structure.
Geopolymer mortar and OPC mortar immersed in sulfuric acid 5% after 120 days.

OPC

8M Geopolymer

10M Geopolymer

12M Geopolymer
Conclusions

- Applications
- Development
- Research
- Raw materials
Thank you for your attention

(in THAI)

khobkun-Krub – for male
khobkun-Ka – for female