The Utilization of Waste-to-Energy Incineration Ash in Clay Fired Brick Manufacturing

Tiffany Kalu 1, Yixi Tian 2,3, Athanasios Bourtsalas 2,3, Shiho Kawashima 4
1 Harvard University, Cambridge, MA
2 Department of Earth and Environmental Engineering, Columbia University, New York, NY
3 Earth Engineering Center, Columbia University, New York, NY
4 Department of Civil Engineering and Engineering Mechanics, Columbia University, New York, NY

Introduction

- In the US, millions of tons of municipal solid waste (MSW) are produced annually, most of which are sent to landfills.
- Waste-to-Energy (WTE) plants combust the MSW with energy recovery, effectively reduces the weight and volume of MSW, and ends up with WTE ash.
- Coarse WTE ash is suitable to be used as stone aggregate substitute in concrete production.
- The fine fractions of WTE ash are difficult to incorporate in building materials due to its fine particle size.
- This research aims to investigate the feasibility of using the fine fractions of WTE ash in partial replacement of clay in fired bricks.

Materials

- Kaolin (clay)
- WTE combined ash as received (max size 30 mm)
- Separated into two samples after sieving: < 2 mm and < 9 mm
- Ash samples were grinded for homogenization
- The base water to solid ratio of 0.35 was adjusted throughout the experiment.

Methods

Brick Manufacturing

- Clay-ash dry mixture mixed for 4 minutes. Water was added and mixed for 6 minutes.
- Mixtures pressed into three 50 x 50 x 50 mm molds and demolded.
- Dried in ambient conditions for 24 hours.
- Dried in oven at 100°C for 24 hours.
- Bricks were fired at either 950°C and 1000°C in furnace for 2 hours.
- After firing, bricks were allowed to cool down.

Compression Testing

- Sample in compression testing machine
- Sample post-compression test

Results

<table>
<thead>
<tr>
<th>Sample</th>
<th>Kaolin clay (%)</th>
<th>&lt; 2 mm WTE combined ash (%)</th>
<th>&lt; 9 mm WTE combined ash (%)</th>
<th>Firing temperature (°C)</th>
<th>Water to solid ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control1</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>950</td>
<td>0.35</td>
</tr>
<tr>
<td>Control2</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>1000</td>
<td>0.37</td>
</tr>
<tr>
<td>CA2</td>
<td>70</td>
<td>30</td>
<td>0</td>
<td>1000</td>
<td>0.35</td>
</tr>
<tr>
<td>CA9</td>
<td>70</td>
<td>0</td>
<td>30</td>
<td>1000</td>
<td>0.45</td>
</tr>
</tbody>
</table>

Figure 1. Sample preparation process.

Figure 2. Brick manufacturing process.

Figure 3. Compression testing.

Figure 4. Firing shrinkage.

Figure 5. Compressive strength.

Figure 6. Elastic modulus.

Figure 7. Bricks after firing.

Discussion

- All samples experienced microcracking during firing to some degree.
- The CA2 sample had the greatest firing shrinkage, while also having the highest compressive strength and elastic modulus.
- The Control1 sample had the lowest firing shrinkage, while also having lowest compressive strength and low elastic modulus.

Future Work

- After firing, many bricks cracked. One solution might be to hydraulically press the clay into the molds for a more uniform molding process.
- Other parameter combinations of drying times, firing temperatures, water to solid ratios, and ash replacement should be investigated to improve workability and mechanical properties.
- Leaching tests should be performed to determine the environmental risk of these bricks in building applications.

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