Effect of differently shaped recycled PET plastic on the early-age properties of cement mortar

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Introduction

- Production of plastics has been steadily increasing in the last 50 years,
- Plastic demand mostly comes from the packaging industry, construction and building, and the automotive industry,
- Polyethylene terephthalate (PET) - most commonly used plastics in the packaging industry (bottles, smaller containers),
- PET plastic products:
  - easily available
  - affordable
  - mostly made for single use only
  - large amount of PET plastic waste
Introduction

Recycled PET plastic use in building materials (cement mortar)

PET plastic waste reduction

Reduction of natural aggregate consumption
Materials and Methods

- 3 differently shaped recycled PET plastics 0/4 mm,
- Ordinary Portland cement CEM I 42.5 N,
- Natural aggregate (sand) 0/4 mm,
- Water to cement ratio (w/c) of 0.45,
- Cement content in mortar: 450 kg m⁻³.

Figure 1. Different shapes of recycled PET plastic.
Materials and Methods

→ Recycled PET plastic as a partial natural aggregate replacement → 5% of the volume of natural aggregate in mortar,

• Compressive and flexural strength tests (SIST EN 1015-11:2020),

• Fresh density (SIST EN 1015-6:1998),

• Flowability of fresh mortar (SIST EN 1015-3:2001),

• X-ray diffraction (XRD) analysis → phase composition.
Results

Compared to plain mortar:
• Increase in flow diameter,
• Slight decrease in fresh density.

<table>
<thead>
<tr>
<th>Mortar mix</th>
<th>Flow diameter (mm)</th>
<th>Fresh density (kg m⁻³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain mortar</td>
<td>127±2.5</td>
<td>2342.10±0.30</td>
</tr>
<tr>
<td>PETG</td>
<td>127±0.7</td>
<td>2285.15±0.95</td>
</tr>
<tr>
<td>PETS</td>
<td>171.3±5.3</td>
<td>2336.20±1.40</td>
</tr>
<tr>
<td>PETF</td>
<td>168.3±2.4</td>
<td>2308.80±1.00</td>
</tr>
</tbody>
</table>

PETG - mortar with PET granules
PETS - mortar with PET particles ground like sand
PETF - mortar with PET flakes

Figure 2. Flowability and fresh density of fresh mortar mixtures.
Results

Flexural strength test:

- PET granules and flakes in mortar decreased flexural strength compared to plain mortar,
- PET particles (ground like sand) increased 3-day and 7-day flexural strengths.

Figure 3. Flexural strength of mortars.
Results

Compressive strength test:
• PET granules decreased compressive strength compared to plain mortar,
• PET particles (ground like sand) and flakes increased compressive strengths.

up to 5% higher than control

Figure 4. Compressive strength of mortars.
Results

- Lower intensity of peaks in PET-containing mortars than in the plain mortar,
- Fewer hydration products.

Figure 5. XRD patterns of mortar mixtures.
Conclusions

• Different shapes of PET plastic differently affect fresh and early-age properties of mortar.
• Importance of the similarity of PET particles to natural aggregate (shape and roughness).
• Great potential of recycled PET flakes and PET particles (ground like sand) as partial replacement of natural aggregate in mortar.

![Image showing different samples of mortar with PET particles]