Durability Studies on Fiber-Reinforced Siderurgic Concrete

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1 Introduction

The viability of Electric Arc-Furnace Slags (EAFS) is studied for use as aggregate in Fiber-Reinforced Concrete (FRC) for rigid pavements and industrial slabs. To do so, tests are performed on siderurgic concrete containing approximately 50% EAFS and 0.5% (metallic or synthetic) fibers, in both cases by volume.

2 Materials and Methodology

The siderurgic concretes consisted of the following materials: Ordinary Portland Cement (OPC), water, natural siliceous aggregates, superplasticizers, EAFS aggregates, steel fibers and/or polypropylene fibers. Two reference mixtures were designed (P and E); and two experimental reinforced mixtures (EM and ES).

3 Results and Discussion

3.1 Mechanical Properties

The mechanical properties (in Table 1) of the concretes were suitable for use in pavements.

<table>
<thead>
<tr>
<th>Property</th>
<th>Standard</th>
<th>P</th>
<th>E</th>
<th>EM</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressive Strength at 28 days (MPa)</td>
<td>UNE 83507</td>
<td>46.3</td>
<td>66.1</td>
<td>72.6</td>
<td>74.0</td>
</tr>
<tr>
<td>Flexural Strength at 28 days (MPa)</td>
<td>UNE 83509</td>
<td>5.2</td>
<td>6.8</td>
<td>7.0</td>
<td>7.1</td>
</tr>
<tr>
<td>Splitting Tensile Strength at 28 days (MPa)</td>
<td>UNE 12390-6</td>
<td>4.3</td>
<td>4.2</td>
<td>5.5</td>
<td>5.2</td>
</tr>
<tr>
<td>Flexural toughness (N·m)</td>
<td>UNE 83510</td>
<td>-</td>
<td>8.74</td>
<td>39.2</td>
<td>35.0</td>
</tr>
<tr>
<td>LOP (CMOD ≤ 0.05 mm) (MPa)</td>
<td>EN-14651</td>
<td>-</td>
<td>6.1</td>
<td>6.4</td>
<td>6.2</td>
</tr>
<tr>
<td>Number of blows until breakage in impact strength test</td>
<td>UNE 83514</td>
<td>-</td>
<td>13</td>
<td>155</td>
<td>88</td>
</tr>
</tbody>
</table>
3.2 Freeze/Thaw and Moist/Dry Test, MIP Analyses and SEM Images.

The results of freeze/thaw and moist/dry test are shown in Table 2.

Table 3. Freeze/thaw and moist/dry results of the siderurgic concretes.

<table>
<thead>
<tr>
<th>Property</th>
<th>E</th>
<th>EM</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight variation after 56 cycles of freeze/thaw (%)</td>
<td>-62.41</td>
<td>-2.92</td>
<td>-4.49</td>
</tr>
<tr>
<td>Variation of compressive strength after 56 cycles of freeze/thaw (%)</td>
<td>-</td>
<td>-3.45</td>
<td>0.93</td>
</tr>
<tr>
<td>Weight variation after 30 cycles of moist/dry (%)</td>
<td>0.23</td>
<td>0.14</td>
<td>0.34</td>
</tr>
<tr>
<td>Variation of compressive strength after 30 cycles of moist/dry (%)</td>
<td>-15.2</td>
<td>-1.12</td>
<td>12.16</td>
</tr>
</tbody>
</table>

Specimen E lost a significant amount of material after 56 freeze/thaw test cycles, while the results for concrete specimens ES and EM were, in general, good, with a slight decrease in compressive strength.

After 30 cycles of the moist/dry test, all the concrete specimens showed good surface appearance and a slight weight gain. Specimen E, the concrete with no fibers, showed an appreciable loss of compressive strength.

The porosity values, measured with Mercury Intrusion Porosimetry (MIP), were: 12.3% for mix E, 10.3% for mix EM and 11.5% for mix ES; standard values for well-performed concretes.

All the Scanning Electron Microscopy (SEM) images revealed cementitious matrices of good quality, with excellent adherence of both aggregates and fibers within the cement matrix.

4 Conclusions

- The siderurgic concrete mixtures reinforced with EAF fibers showed good mechanical properties, among which the results of the steel-fiber-reinforced concretes were the best.
- Durability tests delivered good results for the fiber-reinforced siderurgic concretes, yielding smaller variations of weight and strength after several conditions.
- MIP and SEM analyses underlined the good internal cohesiveness between the aggregates, fibers and cement matrices of the concretes that favored the durability of the cements.

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