In situ testing of early age energy absorption in sprayed fiber reinforced concrete - HyEA – test

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In-Situ testing of early age energy absorption in sprayed fiber reinforced concrete – HyEA test

Motivation

• FRSC used often for rock support and first safety layer
• Sometimes already removed after 12 hrs.
• Performance (load bearing) within first hours after spraying essential
• 28d Energy absorption values according standards and specifications not very relevant in this view
Objectives

- Define test procedure to obtain repeatable results at early ages
- Test energy absorption in dependence of strength (age and acc. dosage)
- Correlate energy with strength and fiber content
- Compare performance of mixes with steel and synthtic macro-fibers at early ages
- Confirme earliest age of energy absorption tests

Conditions defined:

- Test at real Tunnel conditions
- Test Propex proposed mixes according ASTM C 1550 only

Test location and equipment

- Hagerbach Test Gallery with own concrete plant with 1m3 TEKA batch mixer
- Aliva telescope spraying robot with hose diameter of 65 mm served by Meyco Suprema concrete pump
Test procedure

Defined metal formwork, easy to remove

Operated by EFNARC certified nozzle man

Screeing of samples immediate after spraying to get smooth surface and constant thickness

Plate covered with plastic for curing and protection

Plate remains in place and not removed until 15min before testing

Test moment defined by needle test on comparison samples

Time of earliest RDP testing

Mix C (7 kg/m3 fibers)

3h - 0.6 MPa

5h
2 MPa
73 J

4d
32 MPa
322 J

⇒ Testing from ca. 1.5 MPa feasible!!
Hagerbach young Energy Absorption - Test

- Ruggedized, mobile equipment for construction site use
- Highly automatized
- Standalone operation to max peak load of 40kN
- Simple operation and presentation of test results

Investigation Program

<table>
<thead>
<tr>
<th>Mix designs</th>
<th>Holcim CEM I 42.5 N</th>
<th>Microsilica SikaFume HR/TU</th>
<th>Propex Fibre</th>
<th>Aggregate 0-8 mm</th>
<th>TamCem HCA Plus</th>
<th>TamCem 60</th>
<th>TamCem HCA w/c eq (w/b)</th>
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<tbody>
<tr>
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<td>425</td>
<td>20</td>
<td>HE07535</td>
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<td>Fibremesh 665 M-S</td>
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<td>1658</td>
<td>1.18</td>
<td>1.14</td>
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</table>

Accelerator: TamShot 80 @ 7% bwc (A,B,D) or 6.5% bwc (C,E)
Air Pressure: 4-5bar
Concrete volume: 6.5 m³/h
Mix design comparison - Fresh concrete properties

<table>
<thead>
<tr>
<th>Mix Design</th>
<th>Units</th>
<th>50P10615_S_A</th>
<th>50P10615_M_B</th>
<th>50P10615_M_C</th>
<th>50P10615_M_D</th>
<th>50P10615_M_E</th>
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<tr>
<td>CEM I 42.5</td>
<td>kg/m$^3$</td>
<td>425</td>
<td>424.55</td>
<td>425</td>
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<td>Steel Fibre</td>
<td>kg/m$^3$</td>
<td>35</td>
<td>35</td>
<td>5</td>
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<td>7</td>
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<tr>
<td>Mixing time</td>
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<td>180</td>
<td>347</td>
<td>180</td>
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<tr>
<td>w/c$_{eq}$</td>
<td>-</td>
<td>0.44</td>
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<td>600</td>
<td>690</td>
<td>600</td>
<td>510</td>
<td>600</td>
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<td>density</td>
<td>kg/m$^3$</td>
<td>2358</td>
<td>2429</td>
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<td>air content</td>
<td>Vol.-%</td>
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<td>17.3</td>
<td>-</td>
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</table>

- Fibers influence consistency
- Pumpability and sprayability direct the mix

Mix design comparison – Cube compressive strength

Cube compressive strength [MPa]

- 7d
- 28d
Early age compressive strength development

Energy absorption capacity according ASTM C 1550
**Energy absorption vs. Compressive strength**

![Energy absorption vs. Compressive strength](image)

**Summary**

- The HyEA-Test procedure is reproducible and repeatable
- A mobile test equipment for onsite tests was presented
- Crack behaviour at early ages is the same as at 28d
- Fibermesh 655 M-S showed superior early age (3-12 h) performance
- Fiber content further affects energy absorption capacity
- Mix designs with fibers need proper adjustment to keep workability, pumpability and sprayability
- Limit for testing is related to strength, not to time
Acknowledgment

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Glück auf!

Questions?

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