New Generation of High-Range Water Reducers

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New Generation HRWR’s

- New performance space still possible decades after initial PCE discovery
- Value to producers beyond performance in concrete

**Dispersant (Dispersing Agent):** Material added to a solid in liquid suspension to separate flocculated particles, under shearing forces, into individually suspended particles and to reduce their natural tendency to re-associate.
**PCE Basics**

- Key structural features of a PCE dispersant
  - Main chain
  - Side chain
  - Charge centers
- Purposeful modifications to key structural features enable new areas of performance
  - Faster cement dispersion
  - Less sensitivity to changes in cement chemistry
**Experiment- Materials**

- **Concrete Materials**
  - High Alkali Cement
    - ~23,000 ppm soluble SO$_4$\(^{2-}\)
  - Low Alkali Cement
    - ~3,800 ppm soluble SO$_4$\(^{2-}\)
  - Class F Fly Ash
  - Fine Aggregate (natural sand)
  - Coarse Aggregate (crushed limestone)

- **Cement Dispersants**
  - PCE1 (faster dispersion)
  - PCE2 (general purpose)

**Experiment- Mix Design**

<table>
<thead>
<tr>
<th></th>
<th>Design 1</th>
<th>Design 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement (lbs/yd3)</td>
<td>850</td>
<td>675</td>
</tr>
<tr>
<td>F-Ash (lbs/yd3)</td>
<td>0</td>
<td>130</td>
</tr>
<tr>
<td>Fine Agg (lbs/yd3)</td>
<td>1275</td>
<td>1275</td>
</tr>
<tr>
<td>Coarse Agg (lbs/yd3)</td>
<td>1740</td>
<td>1740</td>
</tr>
<tr>
<td>Water (lbs/yd3)</td>
<td>275</td>
<td>275</td>
</tr>
<tr>
<td>Air (%)</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Results - High Alkali Cement

Concrete Workability With Mix Time
High Alkali Cement

Concrete Workability With Mix Time
High Alkali Cement + F Ash

PCE1 Dosage
0.225% of cmts

PCE2 Dosage
0.300% of cmts

PCE1 Dosage
0.180% of cmts

PCE2 Dosage
0.210% of cmts

• Fastest Workability generation
• Lower dosage requirement
• Less sensitive to changes in mix
Results- Low Alkali Cement

Concrete Workability With Mix Time
Low Alkali Cement

Concrete Workability With Mix Time
Low Alkali Cement + F Ash

PCE1 Dosage
0.125% of cmts

PCE2 Dosage
0.130% of cmts

PCE1 Dosage
0.110% of cmts

PCE2 Dosage
0.150% of cmts

Performance advantages observed across multiple cement chemistries
Advancements in PCE’s provide benefits beyond the concrete

**Improved Concrete Performance**
- Faster workability generation
- Promotes concrete consistency

**Improved Robustness**
- Reduced sensitivity to changes in cement
- Ability to produce more high performance concrete

**Operational Efficiencies**
- Enables faster batching processes
- Increased overall concrete production potential
## Capturing the Value - Example

<table>
<thead>
<tr>
<th></th>
<th>Standard PCE</th>
<th>PCE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average batch size (yd³ or m³)</strong></td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td><strong>Average hours per work day</strong></td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td><strong>% of mixtures using HRWR</strong></td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td><strong>1 - Position truck under mixer</strong></td>
<td>Minutes</td>
<td>Minutes</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>2 - Mix concrete</strong></td>
<td>3.25</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>3 - Discharge concrete</strong></td>
<td>0.75</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>4 - Truck exits chute</strong></td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td><strong>Total time</strong></td>
<td>5.75</td>
<td>3.75</td>
</tr>
<tr>
<td><strong>Batches per hour</strong></td>
<td>10.4</td>
<td>16.0</td>
</tr>
<tr>
<td><strong>yd³ or m³ per hour</strong></td>
<td>104.3</td>
<td>160.0</td>
</tr>
</tbody>
</table>

### Production Increase

- % increase: 53%
- Additional batches per hour: 1.11
- Additional yd³ or m³ per hour: 11.13
- Additional batches per day: 13.4
- Additional yd³ or m³ per day: 133.6

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**New Generation HRWR technology enables a 53% increase in production!**

- Establish Baseline
- Capture *ACTUAL* field performance
- Assess your “as-is” situation
- See the impact
- Quantify the value to your operations
### Capturing the Value - Case Study, Inventory Precast

<table>
<thead>
<tr>
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<th>Evaluation 2</th>
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</thead>
<tbody>
<tr>
<td><strong>Standard PCE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average batch size (yd³ or m³)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Average hours per work day</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>% of mixtures using HRWR</td>
<td>75%</td>
<td>75%</td>
</tr>
<tr>
<td><strong>PCE 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average batch size (yd³ or m³)</td>
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</tr>
<tr>
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</tr>
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</tr>
<tr>
<td><strong>Minutes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - Position truck under mixer</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2 - Mix concrete</td>
<td>3</td>
<td>2.6</td>
</tr>
<tr>
<td>3 - Discharge concrete</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4 - Truck exits chute</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total time</strong></td>
<td>3</td>
<td>2.6</td>
</tr>
<tr>
<td><strong>Batches per hour</strong></td>
<td>20.0</td>
<td>23.1</td>
</tr>
<tr>
<td><strong>yd³ or m³ per hour</strong></td>
<td>80.0</td>
<td>92.3</td>
</tr>
</tbody>
</table>

- Baseline Established
- Mixing time savings in both evaluations
- No change to discharge time
- 15-50% increase in production
- 26-75 more batches/day

**New Generation HRWR technology enables producer to increase production volume by 26 and 75 additional batches per day!**
Advances in PCE’s still yield impactful results

Faster Workability generation and decreased sensitivity to changes in cement

Value to producer beyond concrete properties & performance

Operational efficiencies yield increased profit potential
Thank you

For the most up-to-date information please visit the American Concrete Institute at:
www.concrete.org