Mechanical Properties of Pozzolan and Magnesium Phosphate-based Rapid Repair Materials
Main Users

**DOT’s**

**US Military**
USMC, USAF, USN, USACE

**Tollway Authorities**

**Airports**

**Ports**

**Industrial**

**Petro-Chemical**
Challenges of Repair Materials

Needs of the users

• Overnight repairs
• Limit traffic disruption
• Maintain safety of crews by minimizing time exposed to traffic

Implications

• Difficult repair circumstances
• Traffic vibrations
• Varying skill levels of applicators
Challenges of Repair Materials

Typical DOT Requirements

- High Early Strengths (typical DOT requirements demand >2000 psi in 2 hrs, or >3000 psi in 3 hrs)
- Flexural strength requirements >400 psi flex in 3 days
- Bond strength requirements >1000 psi in 24 hrs, >1500 psi in 7 days

- Low Cl\textsuperscript{−} permeability (<0.15% Cl\textsuperscript{−} concentration at 0.5 or 1.0”)
- Max. length change of ± 0.15%
- Freeze-Thaw resistance
- Scaling, less than 1 lb/ft\textsuperscript{2}
CTI’s Rapid Repair Products

Main Reaction Products:
- Calcium aluminosilicate Hydrates

Main Reaction Products:
- Truvite
Compressive Strength 24 hrs

\begin{center}
\begin{tikzpicture}
\begin{axis}[
    title={Compressive Strength (psi), ASTM C 39},
    xlabel={Time (hrs)},
    ylabel={Compressive Strength (psi), ASTM C 39},
    xmin=0, xmax=26,
    ymin=0, ymax=10000,
    xtick={0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26},
    ytick={0,1000,2000,3000,4000,5000,6000,7000,8000,9000,10000},
    grid=both,
]

\addplot[mark=*,blue] coordinates { (2, 2400) (4, 3000) (6, 3500) (8, 4000) (10, 4500) (12, 5000) (14, 5500) (16, 6000) (18, 6500) (20, 7000) (22, 7500) (24, 8000) (26, 8500) };
\node at (axis cs:2,2400) {Typical DOT Requirements, 3000};
\node at (axis cs:0,1000) {0};
\node at (axis cs:1,2000) {1};
\node at (axis cs:2,3000) {2};
\node at (axis cs:3,4000) {3};
\node at (axis cs:4,5000) {4};
\node at (axis cs:5,6000) {5};
\node at (axis cs:6,7000) {6};
\node at (axis cs:7,8000) {7};
\node at (axis cs:8,9000) {8};
\node at (axis cs:9,10000) {9};
\node at (axis cs:10,11000) {10};
\node at (axis cs:11,12000) {11};
\node at (axis cs:12,13000) {12};
\node at (axis cs:13,14000) {13};
\node at (axis cs:14,15000) {14};
\node at (axis cs:15,16000) {15};
\node at (axis cs:16,17000) {16};
\node at (axis cs:17,18000) {17};
\node at (axis cs:18,19000) {18};
\node at (axis cs:19,20000) {19};
\node at (axis cs:20,21000) {20};
\node at (axis cs:21,22000) {21};
\node at (axis cs:22,23000) {22};
\node at (axis cs:23,24000) {23};
\node at (axis cs:24,25000) {24};
\node at (axis cs:25,26000) {25};
\node at (axis cs:26,27000) {26};
\end{axis}
\end{tikzpicture}
\end{center}
Compressive Strength 24 hrs

- SLQ (Magnesium phosphate)
- SL (Pozzolanic)
Compressive Strength 28 days

Compressive Strength (psi), ASTM C 39

Time (hrs)

SLQ (Magnesium phosphate) — SL (Pozzolanic)

<table>
<thead>
<tr>
<th>Time (hrs)</th>
<th>SLQ (Magnesium phosphate)</th>
<th>SL (Pozzolanic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3550</td>
<td>4907</td>
</tr>
<tr>
<td>24</td>
<td>6105</td>
<td>7970</td>
</tr>
<tr>
<td>48</td>
<td>5503</td>
<td>9135</td>
</tr>
<tr>
<td>72</td>
<td>6563</td>
<td></td>
</tr>
<tr>
<td>96</td>
<td>7970</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>144</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>168</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>192</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>216</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>240</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>264</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>288</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>312</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>336</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>360</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>384</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>408</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>432</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>456</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>480</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>504</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>528</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>552</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>576</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>600</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>624</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>648</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>672</td>
<td>9135</td>
<td></td>
</tr>
<tr>
<td>696</td>
<td>9135</td>
<td></td>
</tr>
</tbody>
</table>
Flexural Strength

- SLQ (Magnesium phosphate)
- SL (Pozzolanic)

Flexural Strength (psi), ASTM C 78

Time (days)
Bond Strength

- SLQ (Magnesium phosphate)
- SL (Pozzolanic)

Typical DOT Requirements, 1000

Typical DOT Requirements, 1500
Elastic Modulus

Modulus of Elasticity x 10^6 (psi), ASTM C 469

SL (Pozzolanic)  SLQ (Magnesium phosphate)

Time (hrs)

Modulus of Elasticity x 10^6 (psi)

0 24 48 72 96 120 144 168 192 216 240 264 288 312 336 360 384 408 432 456 480 504 528 552 576 600 624 648 672 696

0 1 2 3 4 5 6

3.43 3.18 4.44 5.02 2.02
Length Change

SLQ (Magnesium phosphate), Air
SLQ (Magnesium phosphate), Water
SL (Pozzolanic), Air
SL (Pozzolanic), Water

Length change (%), ASTM C 928

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Max. C928
Min. C928
Chloride Ion Penetration

Chloride ion concentration measured at two depths after NaCl solution ponding for 90 days.

ACI 318 limit for steel reinforced concrete

Control

SLQ

SL
Summary – Both meet ASTM C 928 and most DoT requirements

Magnesium Phosphate

• Higher early compressive strength – faster return to service
• Lower MOE – Exceptional performance on thin section repairs
• Expansion <0.05%

Pozzolanic

• Higher compressive strength @ 28 days
• Higher flexural strength @ 28 days
• Stronger bond
• Shrinkage <0.05%
• MOE matches existing concrete for full structural repairs required
  • Low Chloride ion permeability
  • Resistance to salt scaling (<1lb/ft²)
  • Freeze thaw resistance (DF >95% after 300 cycles)
CTI’s Rapid Repair Products