1P and 1T Cements: What’s next and what follows PLC?

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Type IL, IP and IT Cements – What’s Next?

IL - In the PNW Market since 2017, having looked back
Why have other markets had issues?

IT Cements – IT(L)(S), IT(L)(P)
What is missing? IQ……..

This is almost old news so WHAT IS NEXT?
Projected General Cementitious Supply/Demand

- Theoretical cementitious demand to outstrip theoretical supply (current sources) by 2024 due to planned coal powerplant closures or fuel changes. No declining slag availability in the PNW anticipated.

Current SCMs

- Slag
- Fly Ash
- Blended SCMs (Slag Fly Ash)
- Silica Fume
New SCM and Cement Technologies

- Alkali Activated Slag
- Natural Pozzolans
- Calcined Clays
- Ground Glass
- Reactive Synthetic Limestone
- High Limestone Replacements
- LC3

Alkali Activated Slag

- Currently Added to improved PNW Seattle Slag
- Alkali activated slag used in Europe
- Don Davies – MKA, Alkali activated slag used in Seattle
BC/Oregon/Utah Pumice & Expanded Shale

- Volcanic Origin
- Pumice is amorphous if cooled rapidly in air
- Mined by both blasting and simply digging from a bank
- Contains roughly 14% Moisture – Dried before grinding

Pumice Grinding Ball Mill – Same as Cement and Slag
**Pumice**

Concrete Testing

Later strengths are better than control

![Graph showing 28 Day Strength of Pumice Concrete]

**RCP**

Concrete Testing

Permeability is improved

![Graph showing 28 Day RCPT of Pumice Concrete]
Pumice

Concrete Testing

Shrinkage is not significantly affected

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Pumice

Pumice Testing at Avro Lab

ASR mitigation is very good
Pumice

C1012 Sulfate Testing

Resistance to sulfates is greatly improved

Figure 3.10: Expansion of ASTM C 1012 wasters here, with 35% SCM replacement
What Are Calcined Clays

- Kaolinite Clay
- Clay heated to 1500 Degrees
- ASR & Sulfate Resistance
- More Reactive Typically than Fly ash or Slag
- Some see it as a silica fume replacement
- Increase Water Demand
- More Super P
Whitemud Resources Inc.

Mineral leases >150,000,000 tonnes
Proven reserves >50,000,000 tonnes
175,000 tonnes per year patented Metakaolin processing facility

Whitemud Resources Inc.

Bulk rail and truck loading facilities
Located southwest of Regina, Saskatchewan
Ground Glass - ASTM C-1866

- Two Types
  - GW and GE

**TABLE 1 Chemical Requirements**

<table>
<thead>
<tr>
<th></th>
<th>Class/Location</th>
<th>Type GS</th>
<th>Type GE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium oxide (SO₂) (0₂), max %</td>
<td>40.0</td>
<td>55.0</td>
<td></td>
</tr>
<tr>
<td>Aluminum oxide (Al₂O₃), max %</td>
<td>15.0</td>
<td>15.0</td>
<td></td>
</tr>
<tr>
<td>Calcium oxide (CaO), max %</td>
<td>15.0</td>
<td>35.0</td>
<td></td>
</tr>
<tr>
<td>Iron oxide (Fe₂O₃), max %</td>
<td>1.0</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Sulfate content (SO₃), max %</td>
<td>1.0</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Total equivalent alkalies, Na₂O₄ max %</td>
<td>4.0</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Moisture content, max %</td>
<td>0.5</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Loss on ignition, max %</td>
<td>0.5</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>

*Na₂O₄, % = Na₂O × 0.685R₂O₃. See Notes 1 and 2 for total equivalent alkali content ranges.

Ground Glass – Possible Carbon Sinc

- Problem with Ground Glass is soluble Alkali
- Remove Soluble Alkali with CO₂ to produce NaCO₃
- Improves ASR
- Improves Later age strengths
Synthetic Limestone

Fortera is competitive with cement production because we do not lose the CO₂ during production, reducing mining, grinding, and calcining of the limestone by 44%.

1 ton of CaCO₃

MINED LIMESTONE

No binding ability
Inconsistent size and shape
Inert filler

Kiln

CO₂

CaO

ReCaB™

1 ton of Cement

Water activated binding
Spherical particles
Reactive mineral

Not emitting process CO₂ allows for more efficient use of infrastructure from the quarry to the kiln which is where Fortera gains an economic advantage.

Vaterite (CaCO₃)

Very unstable and rarely found in nature

Aragonite (CaCO₃)

Semi-stable, found in the ocean

Calcite (CaCO₃)

Very stable, make-up of Limestone

Decreasing Reactivity
Cement
100% Replacement
Will require significant development in new standards and R&D to speed up strength development

SCM
15-35% Replacement
Able to safely phase in product as 20-40% supplement and work towards 100%

Decorative/White
15-100% Replacement
Unserved SCM market with higher cement margins

Aerated Concrete
5-70% Replacement
Large product offering, but already capitalizing on waste materials and efficient production

Bricks/Blocks
20-100% Replacement
Able to safely phase into this market with control over production through finished product

Boards/Panels
20-100% Replacement
Safely phase into this market with control over production through finished product

Portland Cement Process
Limestone + Clay, Silica, Iron → Grinder → Kiln (1450°C) → Clinker Grinding → Portland Cement 820 kg CO₂/ton

Fortera ReCarb™ Process
Limestone → Grinder → Kiln (900°C) → Fortera Process → Fortera Cement 325 kg CO₂/ton

Benefit: Less Feedstock Requirements
Benefit: Less grinding energy and intensity
Benefit: Lower Temp of 900°C for Limestone
Benefit: Capturing CO₂
Benefit: 44% More Product Reducing Grinding and Energy Per Ton of Product

Benefit: No Post Grinding Required
Benefit: 60% Lower CO₂ Emissions per Ton
IL – But higher Limestone

- Remy Winery
- Microsoft
- MISC work in Seattle
- Works well with high alumina slags and calcined clays

Limestone Calcined Clay Cement

- Limestone: 15%
- Gypsum: 5%
- Calcined Clay: 30%
- Clinker: 50%
What is Stopping us?

• Standards
• Government