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

Rob Shogren – MBA, PE, Ph.D.

LafargeHolcim

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

IL - In the PNW Market since 2017, having looked back

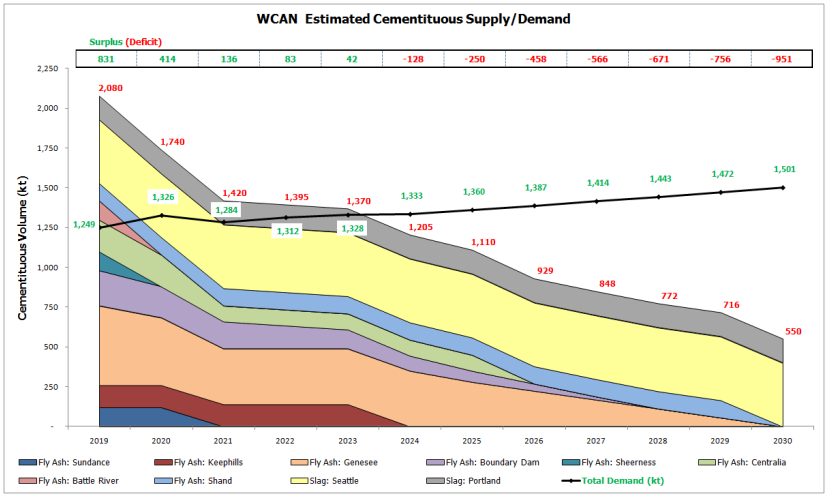
Why have other markets had issues?

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



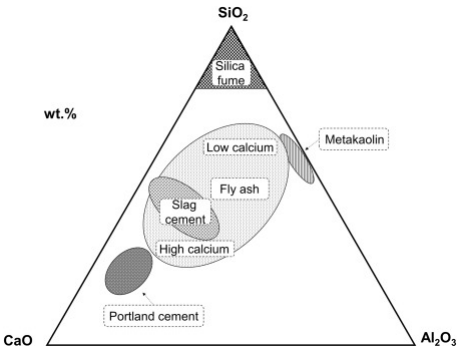
- **Theoretical** cementitious demand to outstrip **theoretical** supply (current sources) by 2024 due to planned coal powerplant closures or fuel changes. No declining slag availability in the PNW anticipated.

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



LafargeHolcim

Alkali Activated Slag

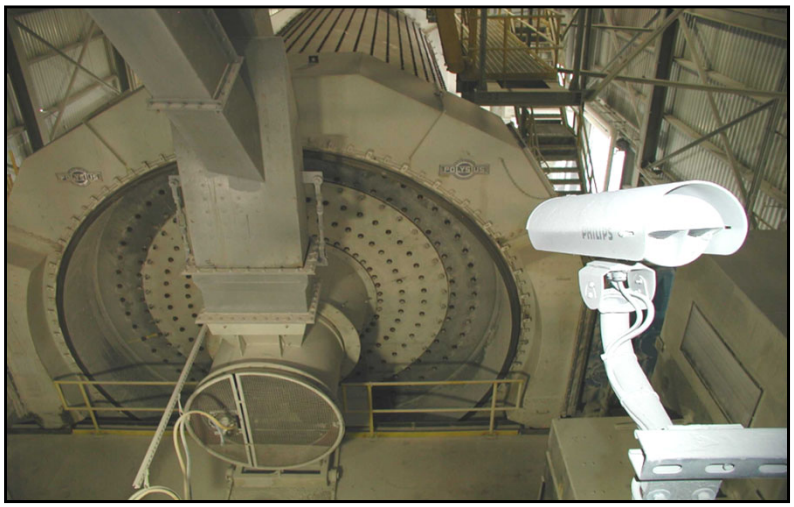
- Currently Added to improved PNW Seattle Slag
- Alkali activated slag used in Europe
- Don Davies – MKA, Alkali activated slag used in Seattle

LafargeHolcim

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

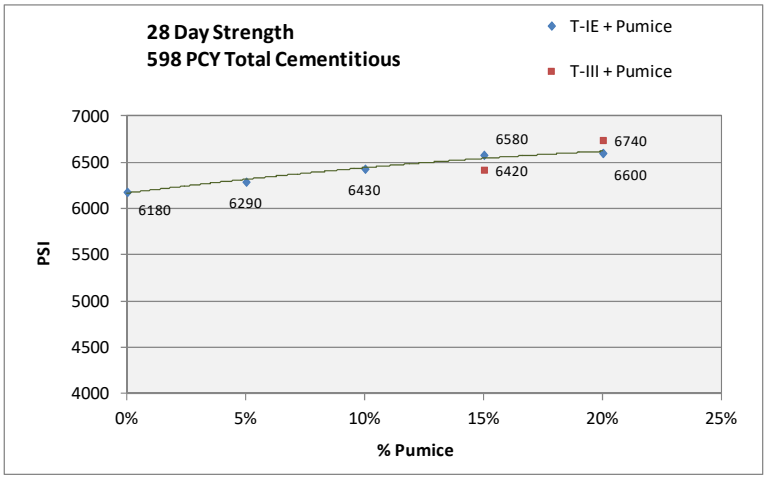
Pumice Grinding Ball Mill – Same as Cement and Slag



Pumice

Concrete Testing

Later strengths are better than control



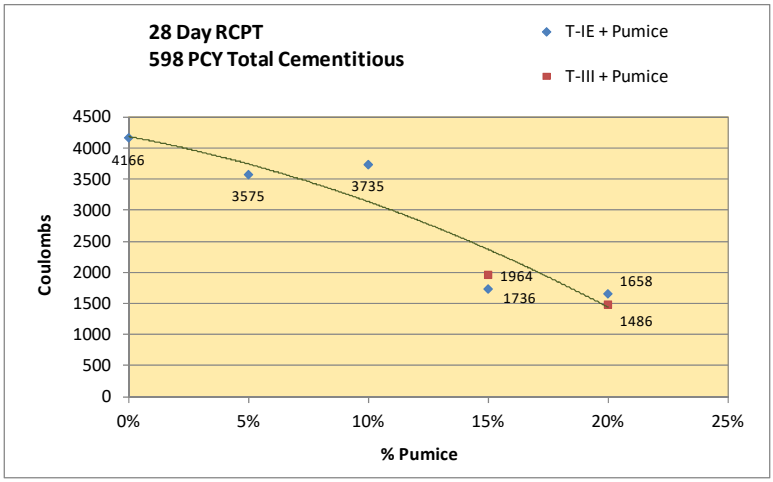
LafargeHolcim

 9

RCP

Concrete Testing

Permeability is improved



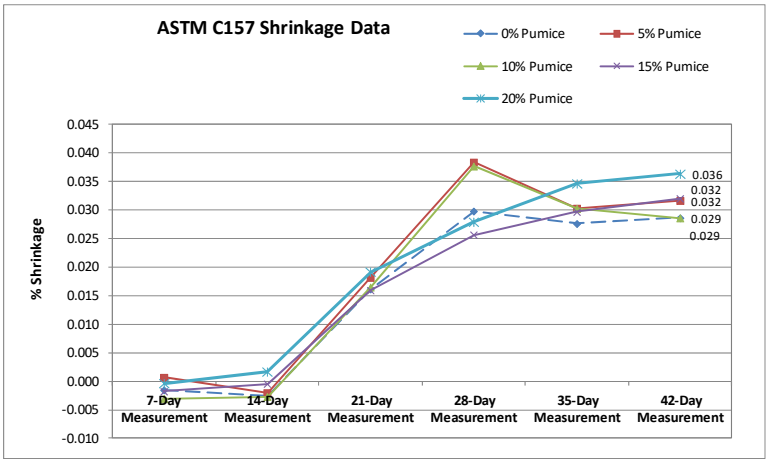
LafargeHolcim

 10

Pumice

Concrete Testing

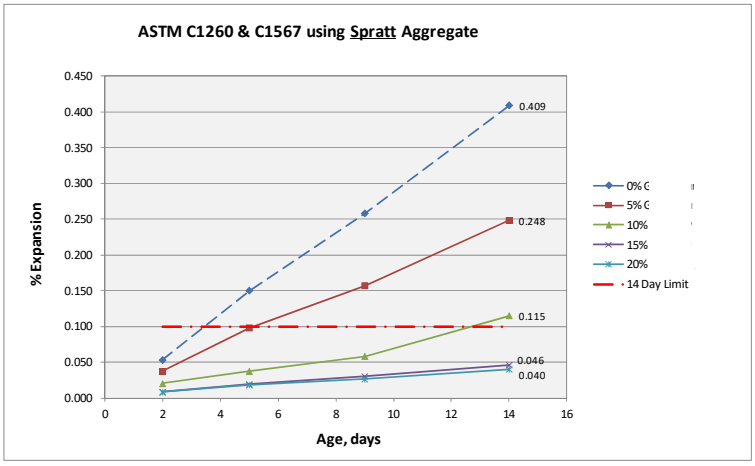
Shrinkage is not significantly affected



Pumice

Pumice Testing at Avro Lab

ASR mitigation is very good



Pumice

C1012 Sulfate Testing

Resistance to sulfates is greatly improved

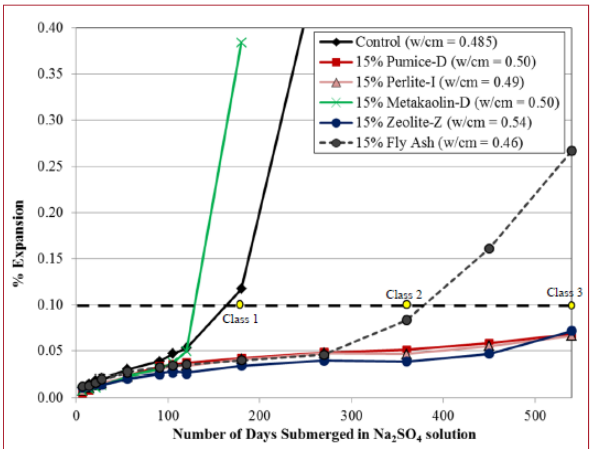


Figure 3.10: Expansions of ASTM C 1012 mortars bars, with 15% SCM replacement

LAFARGE NORTH AMERICA

Cement

TS100 - Pumice TEST REPORT

Analysis by: Lafarge Seattle
Sample from : Kamloops Grinding Plant
Average Analysis: September 2019
Test Report Number 10-19 Pumice

Chemical Analysis

		Limits
Silicon Dioxide (SiO_2)	65.7 %	
Aluminum Oxide (Al_2O_3)	16.0 %	
Iron Oxide (Fe_2O_3)	4.2 %	
Total (SiO_2) + (Al_2O_3) + (Fe_2O_3)	85.9 %	70% Min - ASTM
Sulphur Trioxide (SO_3)	0.2 %	4% Max - ASTM
Calcium Oxide (CaO)	4.2 %	
Magnesium Oxide	1.5 %	
Moisture Content	0.59 %	3% Max - ASTM
Loss on Ignition	2.39 %	10% Max
Available Alkalies as Equivalent Na_2O	0.73 %	1.5% Max
Total Alkalies as Equivalent Na_2O	4.86 %	

Physical Analysis

Fineness Retained on 45 um (No. 325 Sieve)	13.7 %	34% Max - ASTM
Strength Activity Index with Portland Cement		
% of Control at 7 Days	79 %	75% Min - ASTM
% of Control at 28 Days *(previous month's result)*	97 %	75% Min - ASTM
Water Requirement, Percent of Control	100 %	115% Max- ASTM
Autoclave Expansion	0.00 %	0.8% Max - ASTM
Density	2.55 g/cm^3	

Uniformity Requirements

Density, Variation from Average	0.00 %	5% Max - ASTM
Fineness 45um Sieve, Variation from Average	0.60 %	5% Max - ASTM

We hereby certify that the composite natural pozzolan sample above meets the chemical and physical requirements of CAN/CSA A3001 for Type N and ASTM C-618 Class N.

Calcined Clays

What Are Calcined Clays

- Kaolinte 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.

Whitemud Resources Inc.

Bulk rail and truck loading facilities

Located southwest of Regina, Saskatchewan

WHITEMUD RESOURCES INC.

Ground Glass - ASTM C-1866

- Two Types
  - GW and GE

TABLE 1 Chemical Requirements

	Classification	
	Type GS	Type GE
Silicon dioxide (SiO_2), min %	60.0	55.0
Aluminum oxide (Al_2O_3), max %	5.0	15.0
Calcium oxide (CaO), max %	15.0	25.0
Iron oxide (Fe_2O_3), max %	1.0	1.0
Sulfur trioxide (SO_3), max %	1.0	1.0
Total equivalent alkalies, Na_2O_{eq}, max %[A]	15.0	4.0
Moisture content, max %	0.5	0.5
Loss on ignition, max %[B]	0.5	0.5

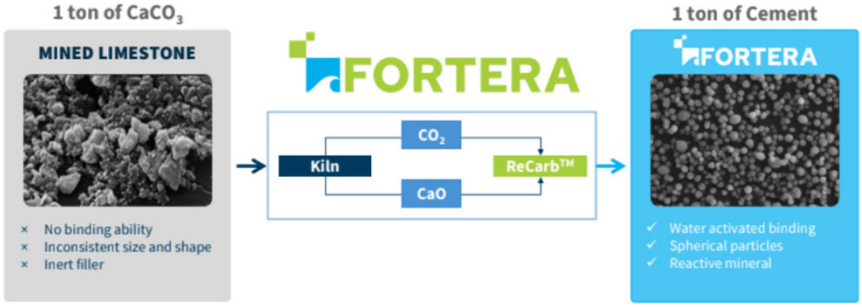
[A] Na_2O_{eq} % = Na_2O + 0.658K_2O. See Notes 1 and 2 for total equivalent alkali content ranges.
[B] Loss on ignition shall be conducted at 600° C in accordance with CSA A3003.

Ground Glass – Possible Carbon Sinc

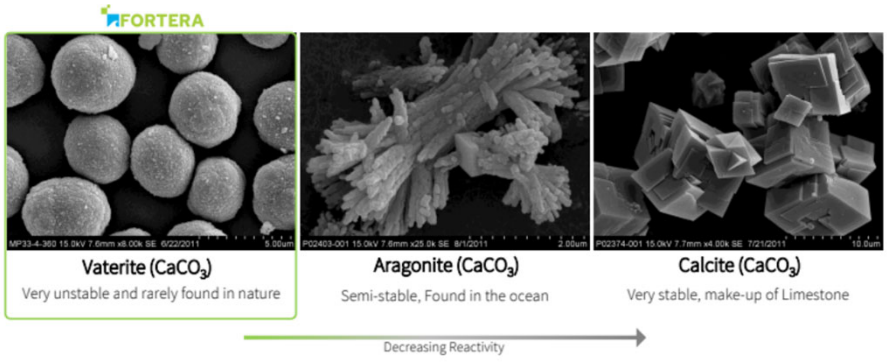
- Problem with Ground Glass is soluble Alklai
- Remove Soluble Alkali with CO2 to produce NaCO3
- Improves ASR
- Improves Later age strengths

Synthetic Limestone

Fortera is competitive with cement production because we do not lose the CO_2 during production, reducing mining, grinding, and calcining of the limestone by 44%.



Not emitting process CO_2 allows for more efficient use of infrastructure from the quarry to the kiln which is where Fortera gains an economic advantage.



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

100% CO_2 Emissions (50% from Fuel, 50% from Limestone Decomposition)

Limestone + Clay, Silica, Iron → Grinder → Kiln (1450°C) → Clinker Grinding → Portland Cement 820 kg CO_2/ton

Fortera ReCarb™ Process

50% CO_2 Emissions from Fuel

Benefit: No CO_2 Emissions from Limestone Decomposition

50% CO_2

Limestone → Grinder → Kiln (900 °C) → Fortera Process → Fortera Cement 325 kg CO_2/ton

Benefit: No Post Grinding Required

Benefit: Less Feedstock Requirements

Benefit: Less grinding energy and intensity

Benefit: Lower Temp of 900°C for Limestone

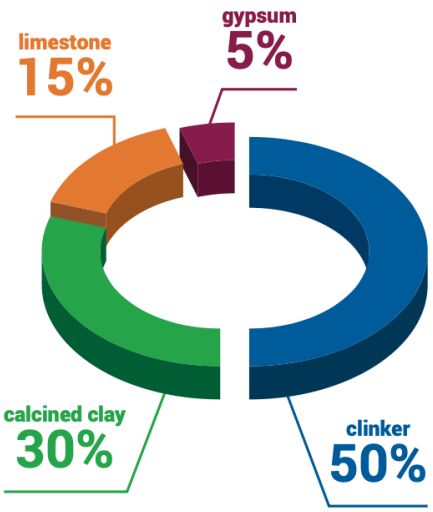
Benefit: Capturing CO_2 Adds 44% More Product Reducing Grinding and Energy Per Ton of Product

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



What is Stopping us?

- Standards
- Government