# Type IL Cements and Adjustments to the Construction Process

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Concrete & Construction Consultants

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# Introduction & Affiliations

- Construction or Service Issues
  - Materials
  - Flatwork
  - Structural
  - Mass concrete
  - Moisture
- ACI Committees




# Overview

- Type IL cement
- Implementation
- Experiences
- Adjustments

# Type IL – Overview

- Ordinary Portland Cement (OPC)
  - ASTM C150 – Portland Cement
  - Type I/II  (Type III, IV, V)
  - Limestone:  0 to 5 percent
- Portland Limestone Cement (PLC)
  - ASTM C595 – Blended Cements
  - Type IL  (Type IP, IS)
  - Limestone:  >5 to 15

# Type IL – Local Markets

- Indiana – March 2021 First Type IL SOG
- Supply of Type I/II – Jan to Mar 2022
- Iowa – 2023
- Varies in United States
- Canada – 2008

# Type IL – Why?

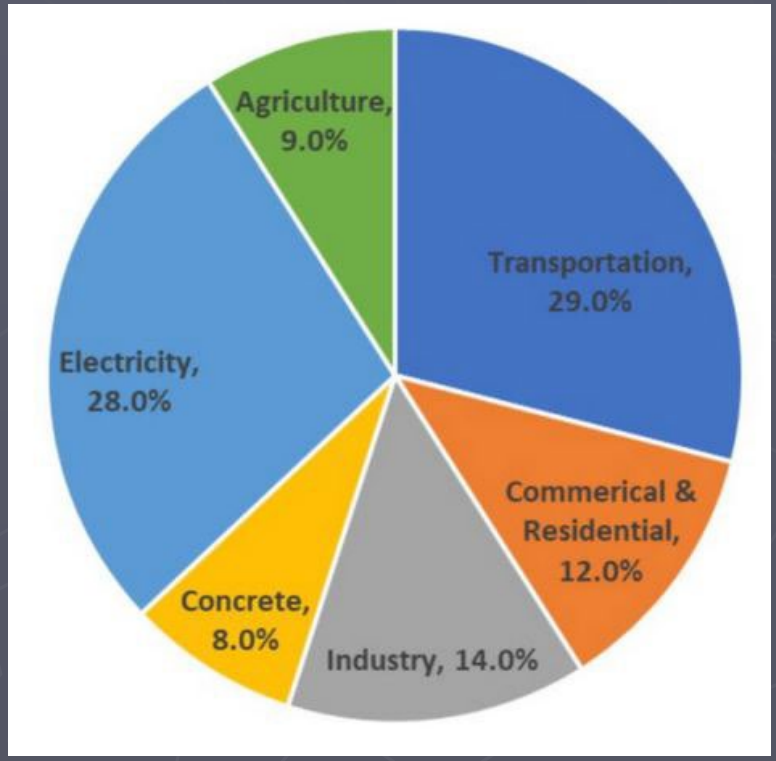



## CONCRETE'S 'Cobra' Effect

The unintended consequences of 'simple solutions' in reducing embodied carbon in concrete

# Concrete's "Cobra" Effect

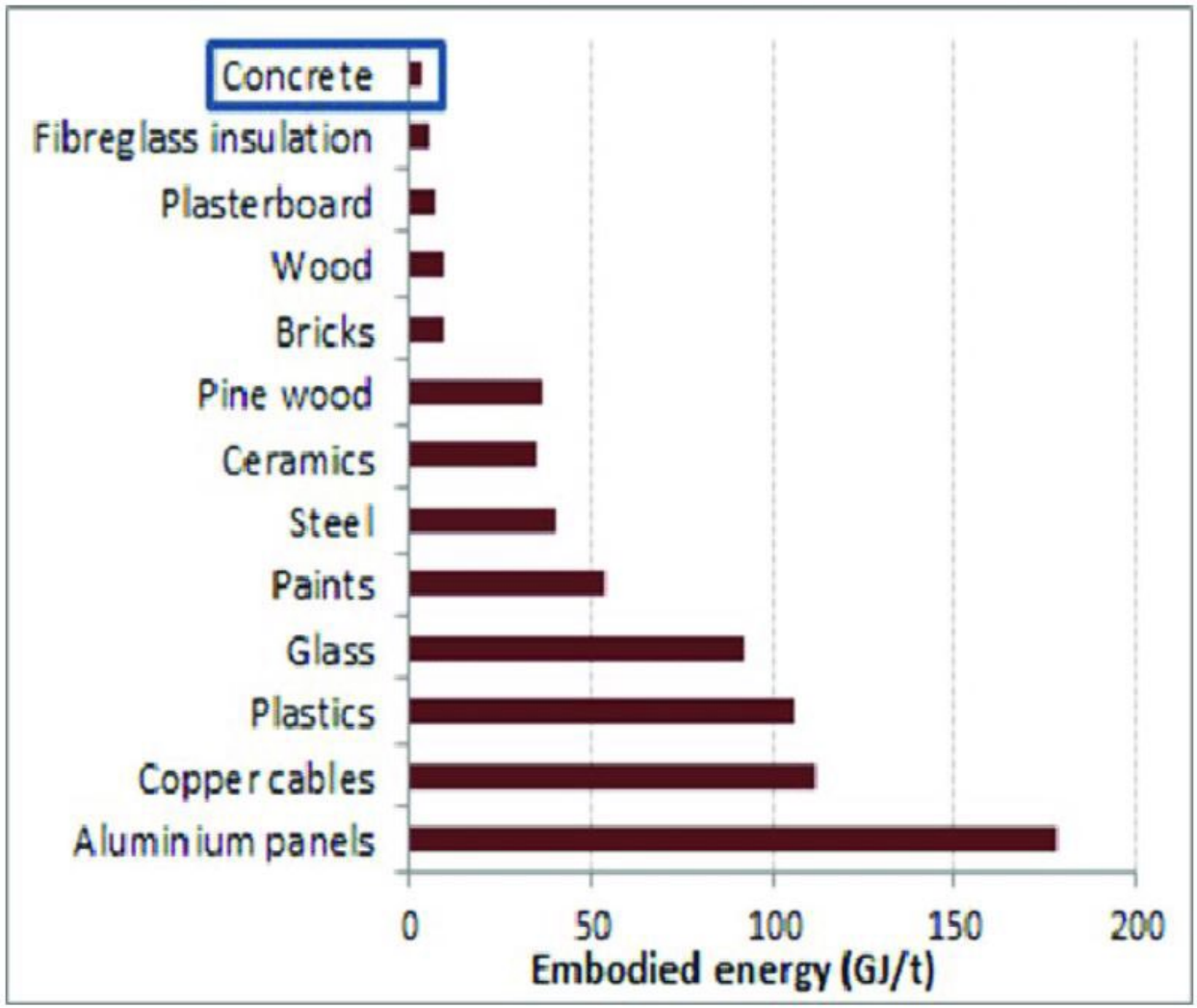
- Cement & concrete responsible for 8% of global carbon emissions
- Industry Goal: Carbon Neutral by 2050
- Environmental Product Declarations (EPDs) embodied carbon
- Concrete Paving Industry Sustainability



# Concrete's "Cobra" Effect

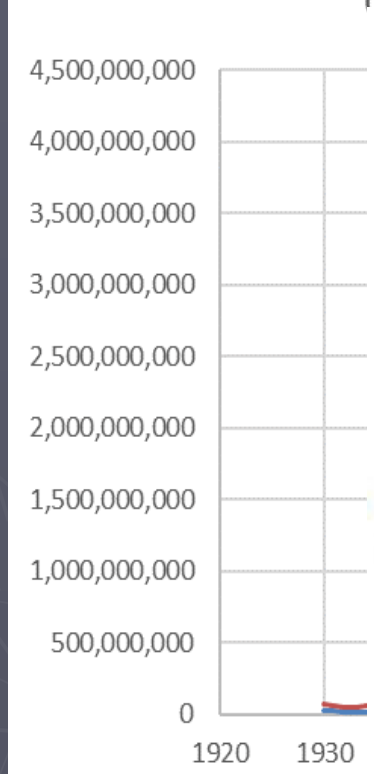
- Current approaches to reduce
  - SCMs (fly ash, slag, limestone, kaolin, etc.)
  - Designs (thinner slabs, strength, timber walls, etc.)
- Type IL cement
- Quality curing to develop alternative mixes
  - Wet curing, curing compounds, curing "aids"
  - Nanosilicate internal curing

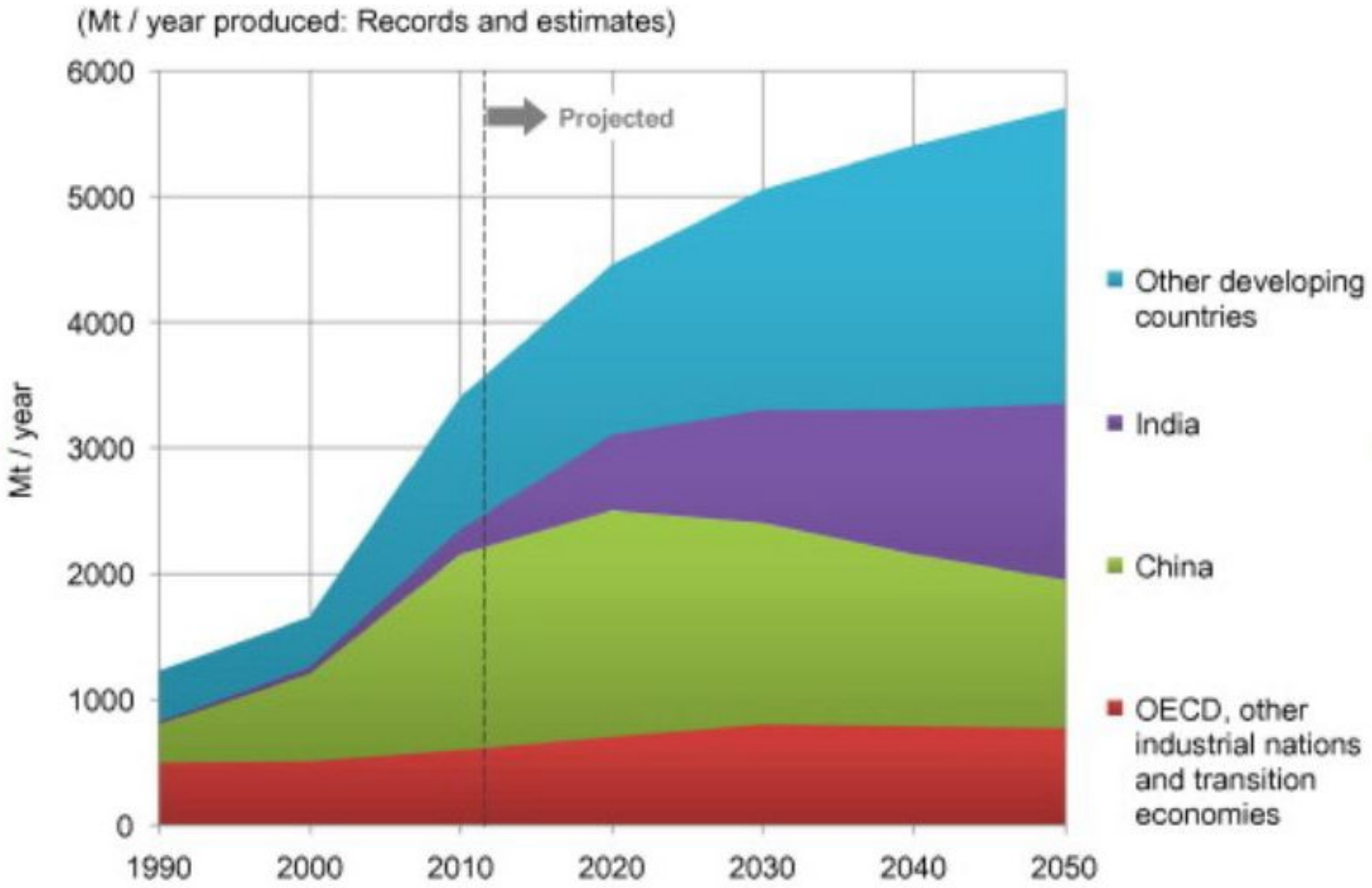
# Embodied Carbon Energy




Comparison of embodied energy of construction materials per ton of product [9]

# Cement Production




World Portland cement production 1990–2050.

# Industry – Sustainability

Member Sign-In

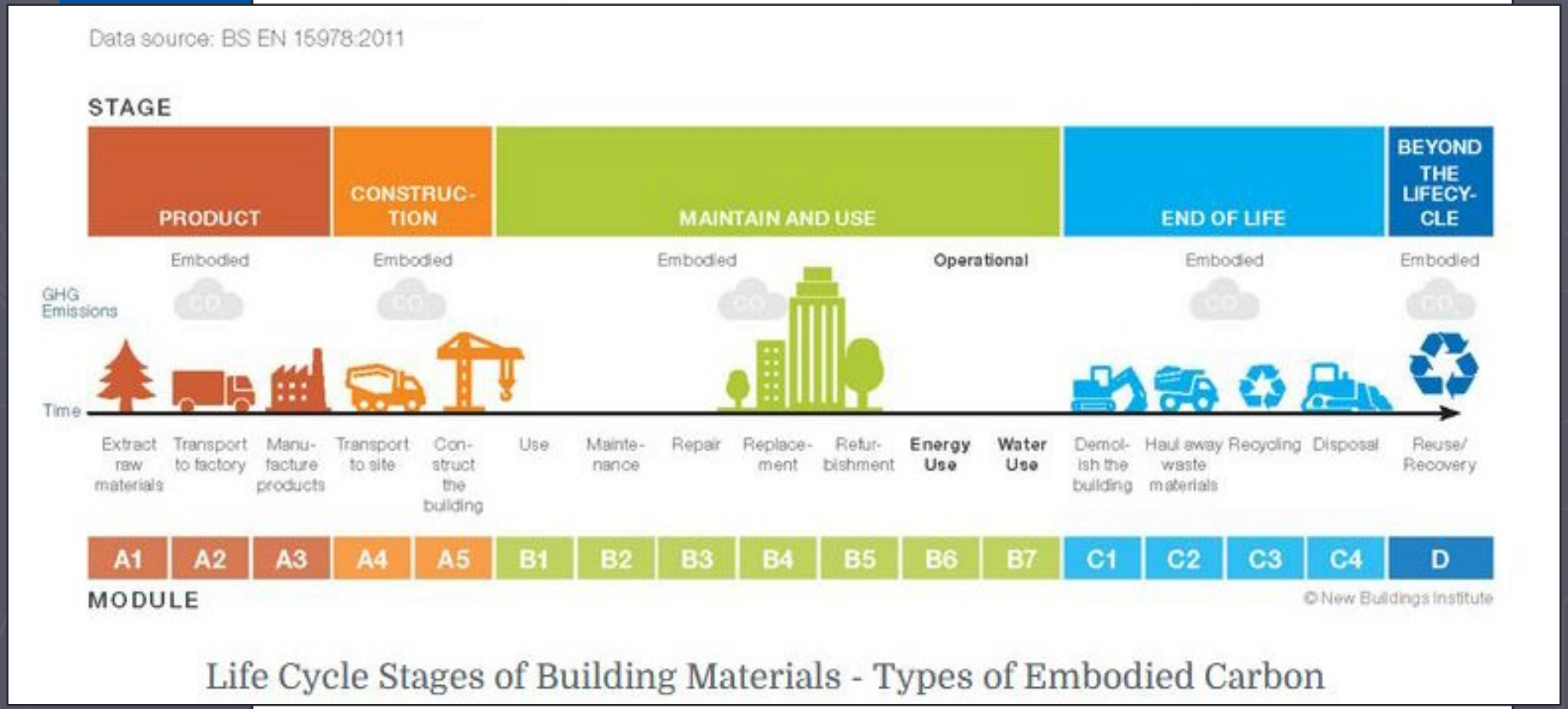
PCA
America's Ceme

About C

Home > Sustain

## The value chain

| CLINKER | CEMENT | CONCRETE | CONSTRUCTION | CARBONATION |
|---|---|---|---|---|
| Key chemically reactive ingredient | The binder | Critically useful material to society | Service life / use phase impacts | Concrete is a $CO_2$ sink |




Life Cycle Stages of Building Materials - Types of Embodied Carbon

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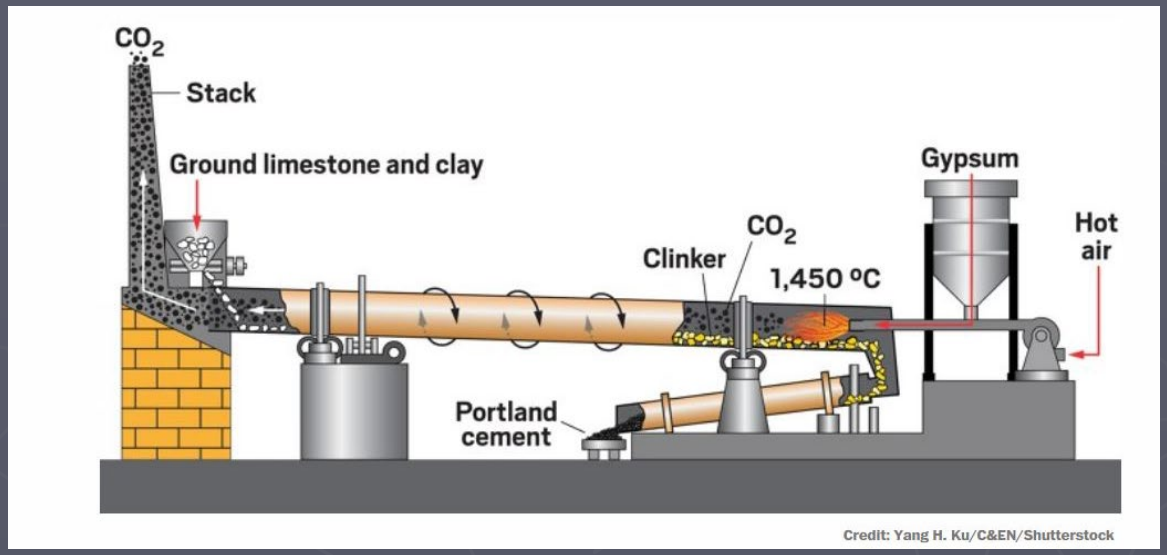
# Type IL – Manufacturing




$CaCO_3 \rightarrow CaO + CO_2$

# Type IL – Implementation

plc
portland-limestone cement

Home | Why PLC | CO2 Calculator | Resources | Partners | FAQs

## 1:1 Replacement & Performance

The same durable, resilient concrete you depend on just got better.

Now you can reduce the carbon footprint of your structure with one simple change.

That easy change will have a big, sustainable impact. Swapping out ordinary portland cement (OPC) for portland-limestone cement (PLC) 10% reduces CO2 by roughly 10%. And because PLC works with other supplementary cementing materials, you can still use fly ash or slag to reduce the carbon footprint of your concrete even further.

Ready mix producers know materials in their market and work with many of them. If a material changes, some testing is warranted until they understand how it works with other ingredients in the mix.

A switch to PLC (Type IL) is handled the same way as a switch to any other new material, with an investigation of fresh mixture

VOTORANTIM cimentos

## Blended Hydraulic Cement Typ

Production Period : 11/1/2022 To 11

### STANDARD REQUIREMENT

**Chemical Data**

| Item | Spec. Limit | Results |
|---|---|---|
| $SiO_2$ (%) | | 17.9 |
| $Al_2O_3$ (%) | | 4.5 |
| $Fe_2O_3$ (%) | | 2.9 |
| CaO (%) | | 60.2 |
| MgO (%) | | 3.5 |
| $SO_3$ (%)* | *3.0 max* | 3.5 |
| Loss of ignition (%) | *10.0 max* | 5.9 |
| $Na_2O$ (%) | | 0.09 |
| $K_2O$ (%) | | 0.86 |
| $CO_2$ (%) | | 5.1 |
| Limestone (%) | *15.0 max* | 11.9 |
| $CaCO_3$ in limestone (%) | *70 min* | 95 |
| Inorganic process addition(%) | *5.0 max* | 0.0 |

| Item | Results |
|---|---|
| Air Content of mortar (v | |
| Blaine fineness ($m^2/kg$) | |
| Retained 325 (%) | |
| Specific Gravity (g/cm3 | |
| Autoclave expansion (% | |
| Compressive strength (M | |
| 1 day | |
| 3 days | |
| 7 days | |
| 28 days *(previous mo* | |
| Time of setting (minutes | |
| (Vicat) Initial | |
| (Vicat) Final | |
| Mortar Bar Expansion ( | |

### OPTIONAL REQUIREMENT

| Item | Spec. Limit | Results |
|---|---|---|
| Equiv. Alkalies (%) | *A* | 0.66 |

**Additional Data**

| Type | Limestone | Inorganic Processing Addition |
|---|---|---|
| Amount (%) | 11.9 | 0.0 |
| $SiO_2$ (%) | 3.8 | |
| $Al_2O_3$ (%) | 0.7 | |
| $Fe_2O_3$ (%) | 1.0 | |
| CaO (%) | 50.9 | |
| $SO_3$ (%) | 0.0 | |

*This cement meets ASTM C595 and AASHTO M 240 Specification for Blended Hydraulic Type IL Cements. T C114, C151, C155, C185, C191, C204, C430, C451 and C1038*

*It is permissible to exceed the max value for SO3 content, provided it is demonstrated by C1038 that the cen

December 15, 2022
St. Marys Cement
Charlevoix Cement Plant
16000 Bells Bay Road
Charlevoix, MI 49719
Tel: (231) 547-1362 - Fax: (231) 547-6202

HOLCIM NSF

Brand: OneCem
Material: Blended Cement
Type: IL(8)

## Material Certification Report

Test Period: 1-Apr-2023 to 30-Apr-2023
Date Issued: 15-Apr-23

**Certification**

This cement meets the specifications of ASTM C595 and AASHTO M240 for Type IL cement.

**General Information**

| | | | |
|---|---|---|---|
| Supplier: | Holcim (US) Inc. | Source Location: | Ste. Genevieve Plant |
| Address: | 8700 West Bryn Mawr Ave<br>Chicago, IL 60631 | | 2942 US Highway 61<br>Bloomsdale, MO 63627 |
| Contact: | | Contact: | Ben Kist / (636) 524-8197 |

The following is based on average test data during the test period. The data is typical of product shipped from this source; individual shipments may vary.

**Test Data on ASTM Standard Requirements**

| Chemical | | | Physical | | |
|---|---|---|---|---|---|
| Item | Limit * | Result | Item | Limit * | Result |
| Sulfate as SO3 (%) | 3.0 max[2] | 3.18 | +45 µm (No. 326) Sieve (%) | - | 1.9 |
| Loss on Ignition (%) | 10.0 max | 4.60 | Blaine Fineness ($m^2/kg$) | - | 472 |
| $CaCO_3$ in Limestone (%) | 70 min | 89 | Density ($g/cm^3$) (Specific Gravity) | - | 3.10 |
| | | | Autoclave Expansion (%) (C151) | -0.20 to +0.80 | 0.01 |
| | | | Initial Vicat (minutes) | 45-420 | 88 |
| | | | Air Content (%) | 12 max | 7 |
| | | | Compressive Strength Mpa (psi) | | |
| | | | 3 day | 13.0 (1890) min | 31.7 (4600) |
| | | | 7 day | 20.0 (2900) min | 37.4 (6430) |
| | | | 28 day (previous month's data) | 25.0 (3620) min | 44.3 (6430) |
| | | | Mortar Bar Expansion (%) (C1038) | 0.02 | 0.007 |

**Test Data on ASTM Optional Requirements**

| Chemical | | | Physical | | |
|---|---|---|---|---|---|
| Item | Limit * | Result | Item | Limit * | Result |
| Equivalent Alkalies (%) | - | 0.62 | | | |

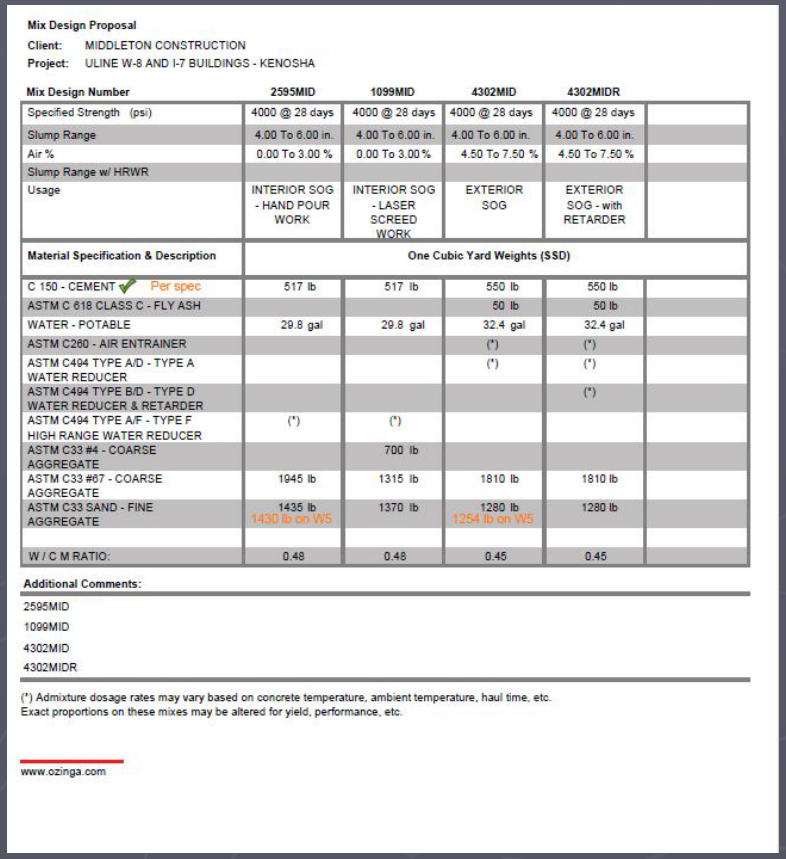
**Notes (*1-9)**

1 - Dashes in the Limit / Result columns mean Not Applicable.
2 - It is permissible to exceed the specification limit provided that ASTM C1038 Mortar Bar Expansion does not exceed 0.020% at 14 days. This data may have been reported on previous mill certificates.

Benjamin Kist,
Quality Manager

# Type IL – vs. Type I/II Mixes

- 517 lbs./yd³ Type I/II (2.2% Limestone)
  - 11 lbs./yd³ Limestone
  - 506 lbs./yd³ Cement
- 517 lbs./yd³ Type IL (11.9% Limestone)
  - 62 lbs./yd³ Limestone
  - 455 lbs./yd³ Cement



**Mix Design Proposal**

**Client:** MIDDLETON CONSTRUCTION
**Project:** ULINE W-8 AND I-7 BUILDINGS - KENOSHA

| Mix Design Number | 2595MID | 1099MID | 4302MID | 4302MIDR |
|---|---|---|---|---|
| Specified Strength (psi) | 4000 @ 28 days | 4000 @ 28 days | 4000 @ 28 days | 4000 @ 28 days |
| Slump Range | 4.00 To 6.00 in. | 4.00 To 6.00 in. | 4.00 To 6.00 in. | 4.00 To 6.00 in. |
| Air % | 0.00 To 3.00 % | 0.00 To 3.00 % | 4.50 To 7.50 % | 4.50 To 7.50 % |
| Slump Range w/ HRWR | | | | |
| Usage | INTERIOR SOG - HAND POUR WORK | INTERIOR SOG - LASER SCREED WORK | EXTERIOR SOG | EXTERIOR SOG - with RETARDER |
| **Material Specification & Description** | **One Cubic Yard Weights (SSD)** | | | |
| C 150 - CEMENT ✔ Per spec | 517 lb | 517 lb | 550 lb | 550 lb |
| ASTM C 618 CLASS C - FLY ASH | | | 50 lb | 50 lb |
| WATER - POTABLE | 29.8 gal | 29.8 gal | 32.4 gal | 32.4 gal |
| ASTM C260 - AIR ENTRAINER | | | (*) | (*) |
| ASTM C494 TYPE A/D - TYPE A WATER REDUCER | | | (*) | (*) |
| ASTM C494 TYPE B/D - TYPE D WATER REDUCER & RETARDER | | | | (*) |
| ASTM C494 TYPE A/F - TYPE F HIGH RANGE WATER REDUCER | (*) | (*) | | |
| ASTM C33 #4 - COARSE AGGREGATE | | 700 lb | | |
| ASTM C33 #67 - COARSE AGGREGATE | 1945 lb | 1315 lb | 1810 lb | 1810 lb |
| ASTM C33 SAND - FINE AGGREGATE | 1435 lb 1430 lb on W5 | 1370 lb | 1280 lb 1254 lb on W5 | 1280 lb |
| | | | | |
| W / C M RATIO: | 0.48 | 0.48 | 0.45 | 0.45 |

**Additional Comments:**

2595MID

1099MID

4302MID

4302MIDR

(*) Admixture dosage rates may vary based on concrete temperature, ambient temperature, haul time, etc.
Exact proportions on these mixes may be altered for yield, performance, etc.

www.ozinga.com

# Type IL – Implementation

- 1:1 Replacement
  - Differences/compared to Type I/II
  - Cement shipments timing/availability
  - Trial batches and testing
  - Submittals
  - % Limestone/manufacturing variability
- Strength

# Overview

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# Type IL – Performance/Experience

- Feedback
  - Contractors
  - Concrete suppliers
  - ACI meetings
  - World of Concrete
  - ASCC survey
- Variability + OPC differences
- Depends on location

# Type IL – Performance/Experience

- Strength development
- Finishing / Workability
  - Water demand varies / admixtures
  - Bleeding characteristics vary / unpredictable
  - Setting time (finishing / sawcutting)
  - Cold weather placements / admixtures
  - Delaminations / surface scaling
- Shrinkage & curling
- Surface durability or wear resistance
- Aesthetics (Color and uniformity)

# Type IL – ASCC Survey

American Concrete Institute
*Always advancing*

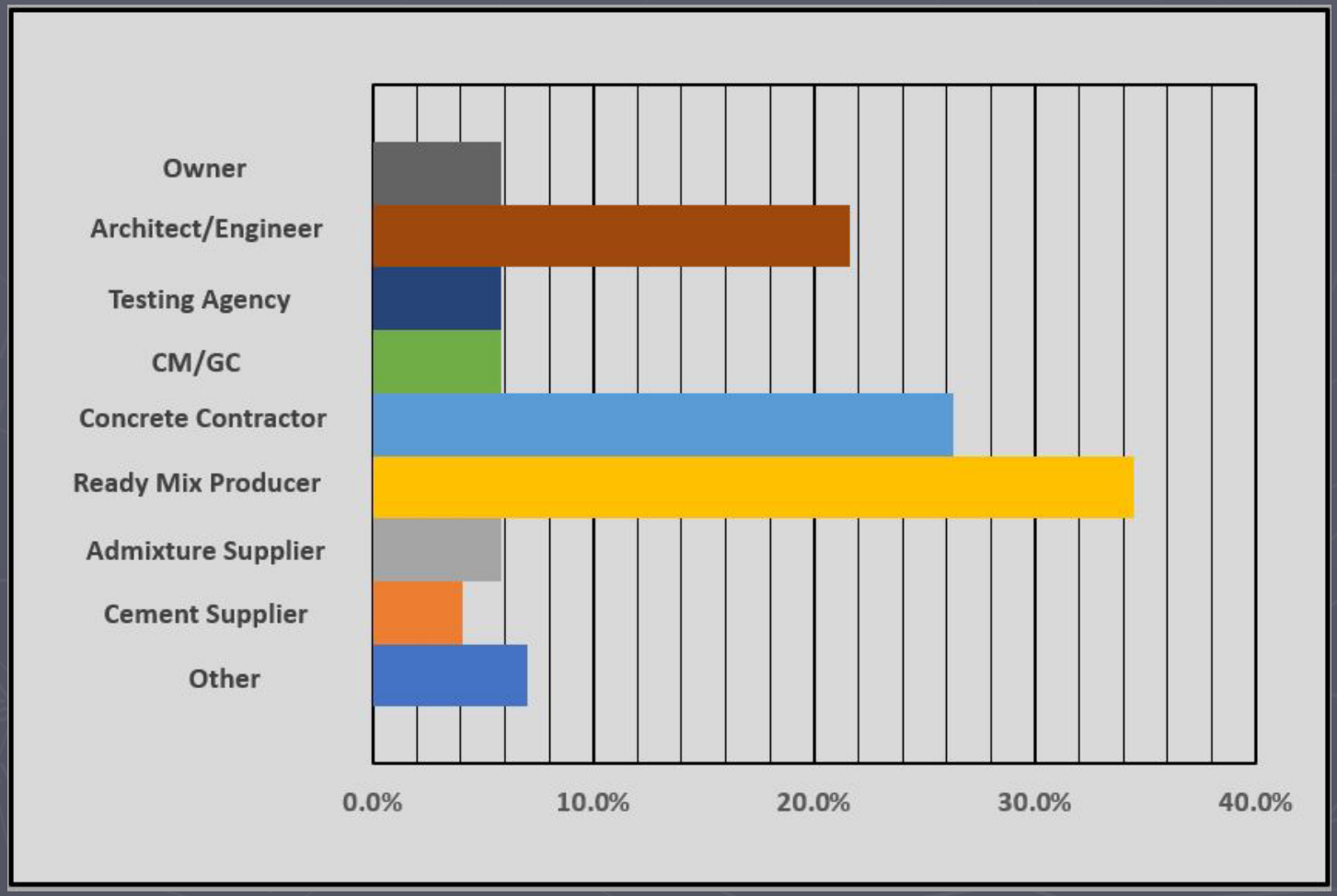
AMERICAN SOCIETY OF CONCRETE CONTRACTORS
Enhancing the Capabilities of Those Who Build with Concrete

## ACI-ASCC Concrete Floor and Slab Construction Survey on Type IL Portland-Limestone Cement Concrete

ACI 302 and ASCC are collaborating to survey ACI members on their use and experiences with Type IL Portland-limestone cement concrete. Currently, Type IL cement (ASTM C595) is available in about 40% of the United States and in less than a year is likely to be about 80% of the market. The responses will be used to evaluate the current state-of-the-art for Type IL cement concrete to provide feedback to the concrete industry.

# Type IL – ASCC Survey

- 173 Respondents



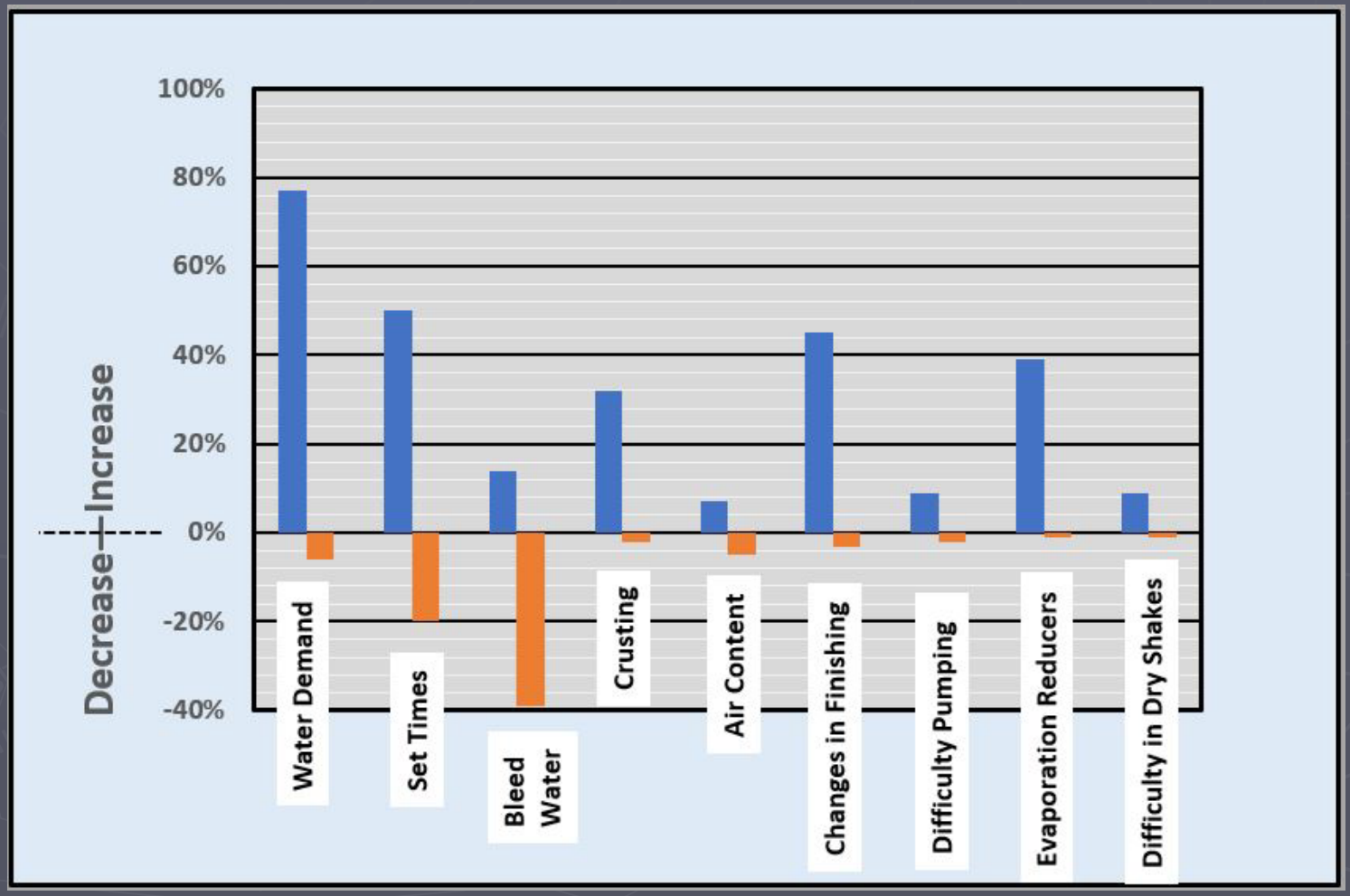
# Type IL – ASCC Survey

- Experience problems with Type IL?

| Profession | Occur at the Same Frequency | Occur at a Lower Frequency | Occur at a Greater Frequency |
|---|---|---|---|
| Owner | 20% | 0% | 80% |
| Architect/Engineer | 47% | 0% | 53% |
| Testing Agency | 40% | 0% | 60% |
| CM/GC | 40% | 0% | 60% |
| Concrete Contractor | 26% | 2% | 72% |
| Ready Mix Producer | 60% | 2% | 38% |
| Admixture Supplier | 11% | 0% | 89% |
| Cement Producer | 86% | 0% | 14% |
| Other | 30% | 0% | 70% |

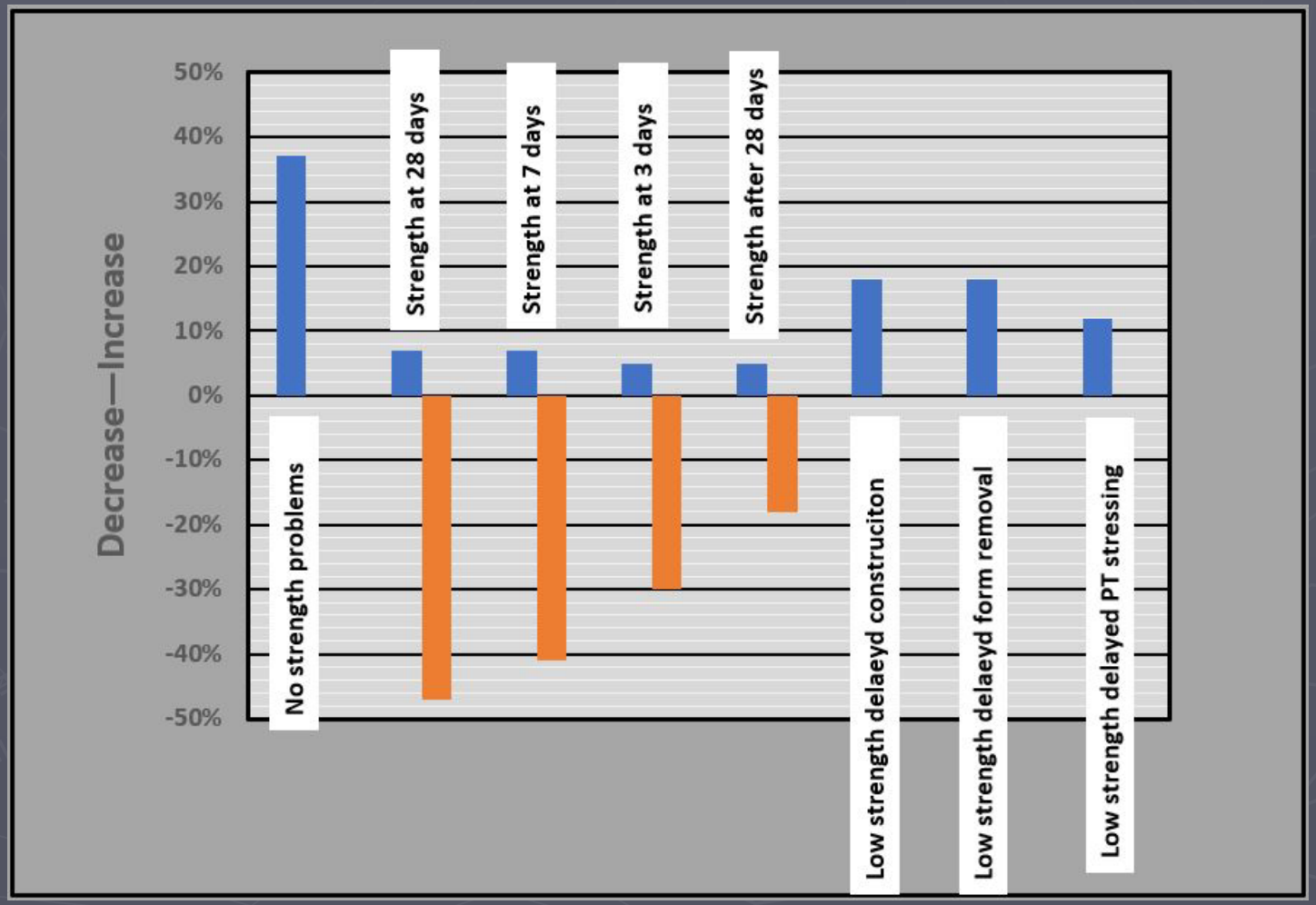
# Type IL – ASCC Survey

- Experience the following w/Type IL?



# Type IL – ASCC Survey

- Type IL strength vs. OPC?



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  - Cold weather placements / admixtures
  - Delaminations / surface scaling
- Shrinkage & curling
- Surface durability or wear resistance (Curing)
- Aesthetics (Color and uniformity)

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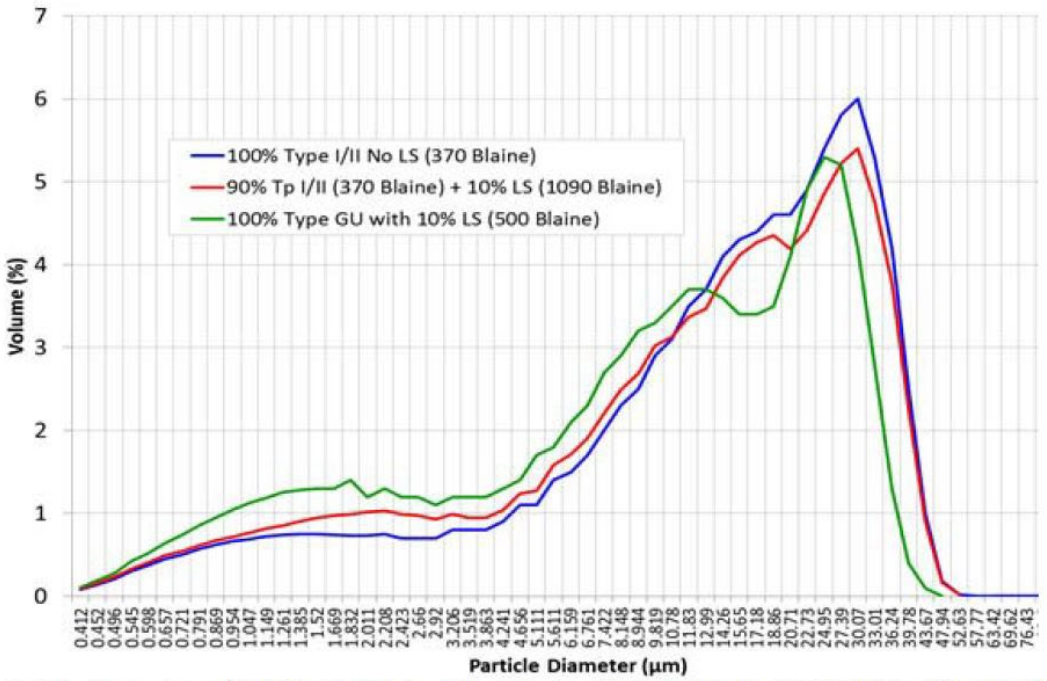
# Type IL – Strength/Grinding

- Type I/II Blaine Fineness ~ 390 to 420 $m^2/kg$
- Particle Size Distribution (PSD)

Example
for 2 Bla

**PSD (differential volume) compared, Type I/II with and without 10% added LS vs. mill-ground 10% LS Type GU**




Particle size analyses of individual materials performed using a Beckman Coulter LS 13 320 laser diffraction PSA

# Type IL – Blaine Fineness/PSD

- Type IL higher Blaine?
- +100 $m^2/kg$?
- Particle Size Distribution
- Depends on % limestone
- 20% more grinding time
- Production
- Strength – Monitor/TBD

# Type IL – Strength Adjustments

- Trial batches and testing
- Historical performance data
- Source / changing sources
- Production variability
  - Materials generally
  - % Limestone
  - Grinding – Blaine fineness or PSD
  - More cement?
- QA/QC Testing (ASTM C31)

# Type IL – Scaling

# Type IL – Finishing/Processes

# Type IL – Finishing/Processes

# Type IL – Finishing Adjustments

- Experience based skills / processes
  - Bleeding
  - Setting
  - Timing
  - Variability / different
- Source / changing sources or production
  - % Limestone
  - Grinding – Blaine fineness or PSD
- Field bleeding and setting tests

# Type IL – Cold Weather Adjustments

- ACI PRC-306 Guide to Cold Weather Concreting
  - Manage placement temperatures/conditions
  - Heated mix water
  - Heated aggregates
  - Increase cement / decrease SCMs
  - Curing and protection period length
  - Accelerating admixture dosages

# OPC – Curing Processes


Source: Gomaco

# OPC – SOG Curing/Appearance

# Type IL – Curing Options/Risk

- Full development of strength and durability characteristics
- Placement & protection conditions
- Common approaches
  - Wet cure (ASTM C171)
  - Membrane forming (ASTM C309)
  - Cure & seal (ASTM C1315)
  - Tilt-up bond breakers
  - Silicate-based “curing aids”

# Spray Applied “Curing Aids”

# Type IL – SOG Curing/Appearance

# Type IL – Curing Adjustments

- Strength and durability characteristics more susceptible?
- Processes: More robust methods for certain applications + longer?
  - Curing/protection environment
  - % Limestone
  - SCMs
  - Functional + Aesthetics

# Type IL – Adjustments

- Re-evaluate practices and processes
- Strength
  - Trial batches and testing
  - Historical performance data
- Finishing
  - Field bleeding and setting tests
  - Timing varies significantly (cold weather)
- Curing
  - Full strength and durability potential

# Questions?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