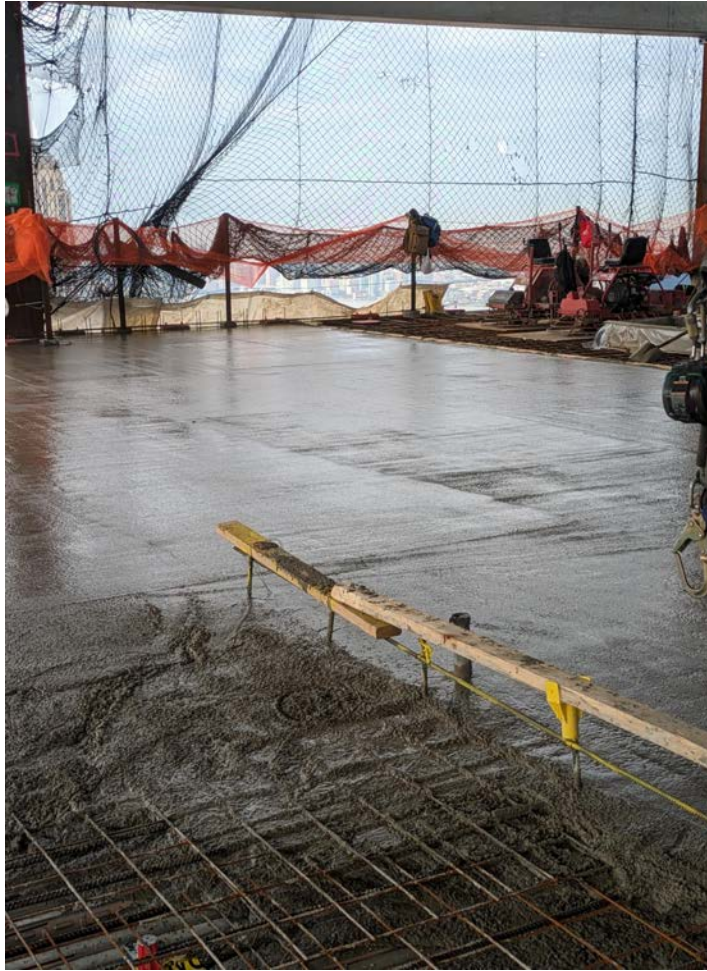


Darwin Bridge in Île-des-Sœurs

Quebec Province



Equivalent of 7,000 wine bottles, saving 40,000 kg of cement.





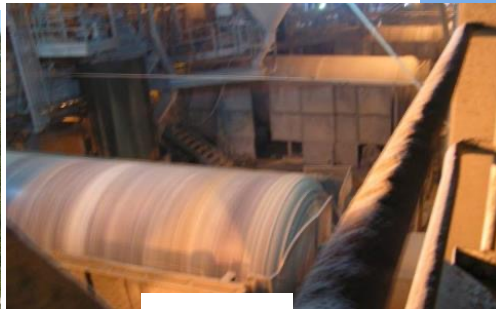
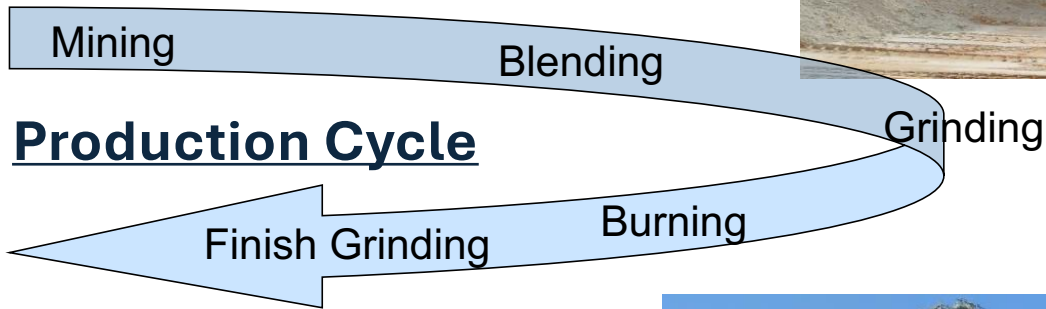
**JP Morgan Chase
high rise building
NYC 1388 feet tall
40,000 yds**

- GGP is in all concrete floor slabs
- 40% dosage rate of GGP
- Equivalent to 29 millions beer bottles
- This SCM equate to 5,000cy of carbon removed or not added to the atmosphere.



A large teal-colored shape on the left side of the page, consisting of a rectangle with a diagonal cutout on the right side, creating a trapezoidal form. The cutout is defined by two parallel white lines.

Portland Limestone Cements



A greener cement option

A blended cement with additional limestone content, optimized for performance

The easiest way to reduce your carbon footprint by up to 10%

Suitable for buildings, bridges, pavements, geotechnical applications

Readily available throughout the U.S. and Canada

What is PLC?

A screenshot of the PLC website homepage. The background is a blue-tinted image of a bridge over a river in a mountainous area. In the top left corner is the PLC logo, which consists of the letters 'plc' in a bold, lowercase font with three vertical bars to the right, and the text 'portland-limestone cement' below it. In the top right corner is a green navigation bar with four white links: 'Home', 'Why PLC', 'CO2 Calculator', and 'Resources'. The main content area features the headline 'Reduce Your Carbon Footprint With PLC' in large, white, bold letters. Below the headline is a sub-headline in smaller white text: 'The same durable, resilient concrete you depend on can now reduce your carbon footprint by up to 10%.' At the bottom of the main content area is the tagline 'Easy. Proven. Readily available.' in white text.

plc
portland-limestone
cement

Home Why PLC CO2 Calculator Resources

Reduce Your Carbon Footprint With PLC

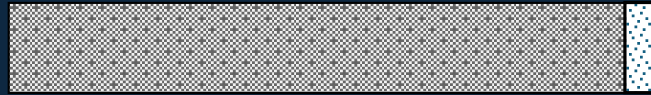
The same durable, resilient concrete you depend on can now reduce your carbon footprint by up to 10%.

Easy. Proven. Readily available.

OPC / Portland

~ 94% Clinker

≤ 5% Limestone



PLC Type IL / GUL

~ 82% Clinker

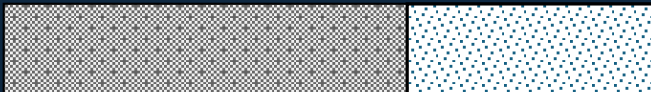
≤ 15% Limestone



**Blended Cements Type
IT (P20)(L13)**

~ 63% Clinker

~ 20% SCMS + 13% Limestone



Innovative Products

- Clinker reduction
- Key strategy for reducing embodied CO₂ aka GWP
- Performance Specifications enable use
- Significant reduction potential depending on available materials and type of application

Manufacturing Portland Limestone Cement

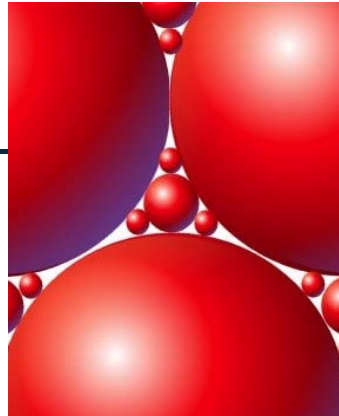
- Interground in cement finish mill with clinker, typical
- Limestone to be 5% to 15% by mass of cement
- Often 40 to 100 m²/kg higher Blaine fineness

- ➔ 2004: – ASTM International approves the inclusion of up to 5% limestone in all ASTM C 150 cements
- ➔ 2012: - Inclusion of up to 15% limestone approved in ASTM C 595 (Blended Hydraulic)
- ➔ 2022: - Major cement producers announce intention to stop producing ASTM C 150 Type I cement!

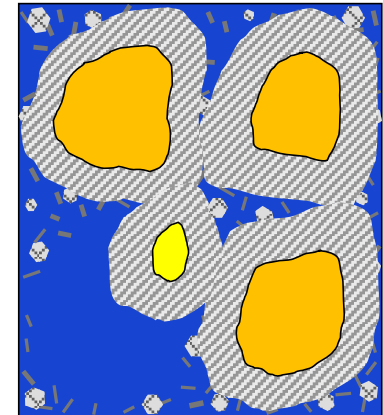
How Limestone Works

Strength can be enhanced through:

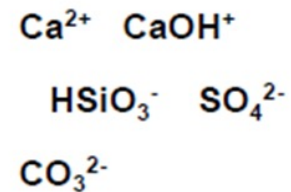
- Particle Packing



1. Nucleation - The limestone also acts as additional nucleation sites for initiating the hydration process. initial process that occurs in the formation of a crystal



- Chemical Reaction



National, Model, and State Specs

Type IL cements permitted in:

AIA MasterSpec 033000 Cast-in-Place Concrete

FAA P-501 Portland Cement Concrete Pavement

Accepted by 50 State DOT's

Multiple **ASTM Specifications** (incl.)

Ready-Mixed Concrete (C94)

Concrete pipe, culverts, tile (8 standards)

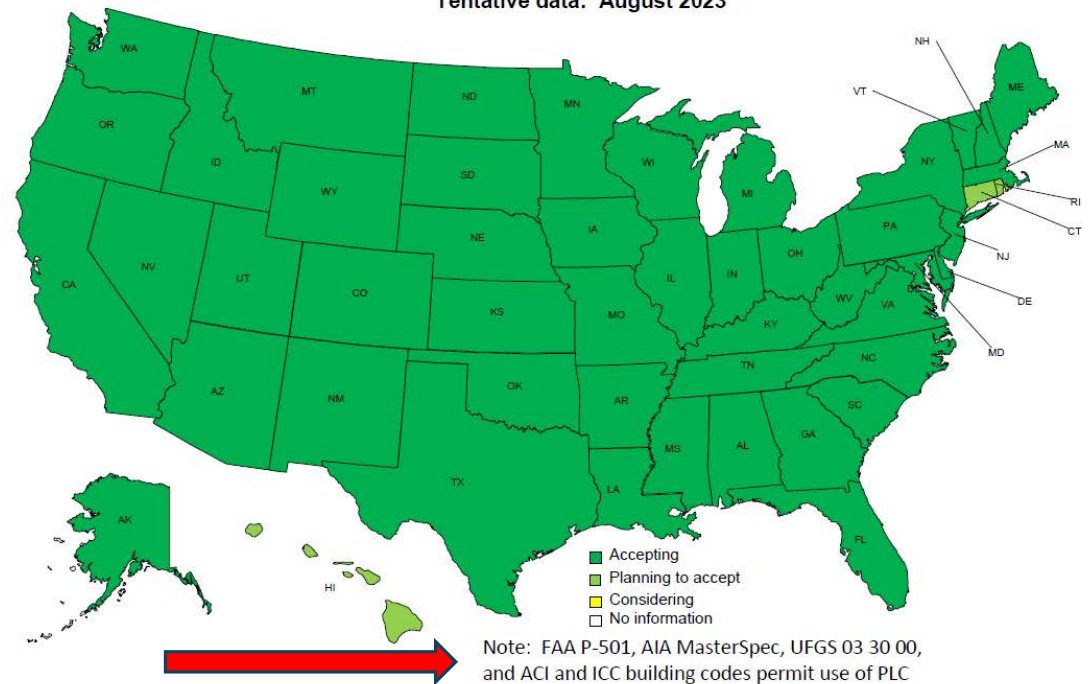
Grout for masonry (C476)

Plaster (C926)

ACI 301, 318

ICC codes

State DOT Acceptance of Portland-Limestone Cement
Tentative data: August 2023

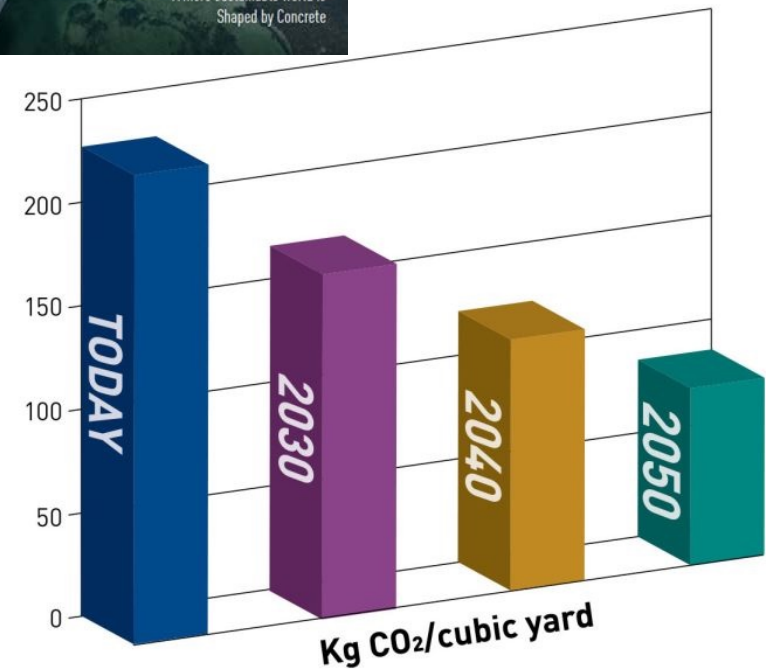
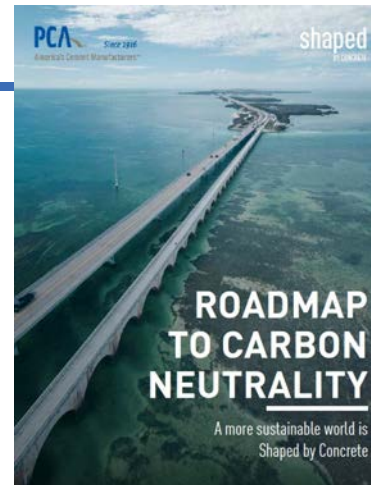


PCA 2050 Roadmap to Carbon Neutrality

Carbon dioxide intensity of concrete

“Nearly 2/3”

The expected decrease in concrete’s carbon footprint over the next 26 years...



Portland Cement Types (Major Change):

ASTM C150 (going away fast)

- Type I – Normal Use
- Type II – Moderate Sulfate Resistance
- Type III – High Early Strength
- Type IV – Low Heat of Hydration
- Type V – High Sulfate Resistance

More info:

www.GreenerCement.com

ASTM C595 – New Referenced Standard

- Type IL – Portland Limestone Cement
- Type IS – Portland Slag Cement
- Type IP – Portland Pozzolan (fly ash)
- Type IT – Ternary Blend (Ash + Slag + Limestone)
- **Specialty Cement Designations:**
 - Type HE – High Early Strength
 - Type MS – Moderate Sulfate Resistance
 - Type HS – High Sulfate Resistance
 - Type MH – Moderate Heat of Hydration
 - Type LH – Low Heat of Hydration

PLC - Here to stay

For instance, if all cement used in the U.S. in 2019 had been converted to PLC (Type IL), it would have reduced CO₂ emissions by 8.1 million metric tons, which the U.S. EPA says is the equivalent of taking 1.75 million cars off the road for an entire year.

PART 2 - PRODUCTS

2.1 CONCRETE MATERIALS AND PRODUCTION

A. Portland Cement:

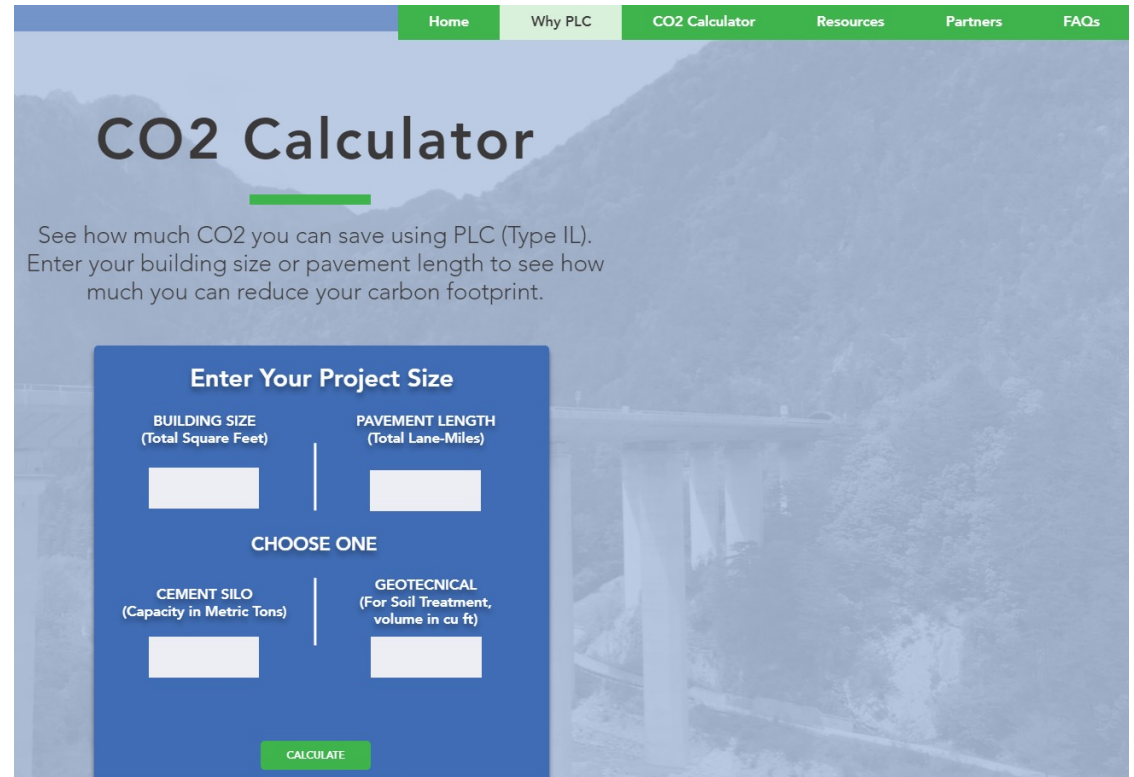
1. ASTM C150, Type I or Type II
2. ASTM C150, Type III, High-early Strength Portland Cement may be used subject to review and approval of the SER. The specified 28-day concrete compressive strength shall occur within 7 days for concrete using Type III Portland Cement.
3. ASTM C150, Type V
4. Provide the same brand of Portland Cement from a single source throughout the project, as required to meet Design Professionals' requirements.

B. Blended Hydraulic Cement:

1. ASTM C595, Type IL, Portland-Limestone Cement
2. ASTM C595, Type IS, Portland-Slag Cement
3. ASTM C595, Type IP, Portland-Pozzolan Cement
4. ASTM C595, Type IT, Ternary-Blended Cement
5. ASTM C595, Type IT (HS) plus pozzolan or slag cement for Exposure Class S3]

greenercement.com - Your PLC Resource

- Calculators for CO2 savings
 - Basic, advanced
- Benefits of PLC
- Spec language
- Case studies
- PLC availability map
- Industry partners
- FAQs
- Contact an expert
- Mobile friendly



The screenshot shows the 'CO2 Calculator' page on the greenercement.com website. The page has a green navigation bar with links for Home, Why PLC, CO2 Calculator, Resources, Partners, and FAQs. The main heading is 'CO2 Calculator' with a green underline. Below the heading is a sub-heading: 'See how much CO2 you can save using PLC (Type II). Enter your building size or pavement length to see how much you can reduce your carbon footprint.' The calculator form is titled 'Enter Your Project Size' and contains four input fields: 'BUILDING SIZE (Total Square Feet)', 'PAVEMENT LENGTH (Total Lane-Miles)', 'CEMENT SILO (Capacity in Metric Tons)', and 'GEOTECHNICAL (For Soil Treatment, volume in cu ft)'. A 'CHOOSE ONE' label is positioned between the second and third fields. At the bottom of the form is a green 'CALCULATE' button.

www.greenercement.com

Differences between ASTM C 150 and ASTM 595 **Fine and dandy** Lessons Learned

Type I/II cements are different

Type IL cements are “more” different

(See Webster’s Redneck Dictionary)

Addressing “PLC” Complaints

Type II is an incremental change,

All cement changes require adjustments to the mix

- Preplanning should include discussion with RMC producer
- Admixture doses may slightly change
- Reduce your variables, check weigh batch tickets, cement, admix?
- Bleeding – decreases with increased fineness, impt for flatwork.
- Setting time – can have slight increase with increased fineness.



Petrographic image courtesy of Wayne Wilson, H.M Tech Services Mgr.

Two excellent reports on PLC

TECHNOTE



U.S. Department of Transportation
Federal Highway Administration

Turner-Fairbank
Highway Research Center

Research, Development,
and Technology
Turner-Fairbank Highway
Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

<https://highways.dot.gov/research>

Portland Limestone Cement

FHWA Publication No.: FHWA-HRT-23-104

FHWA Contact:

Michelle Cooper
(ORCID: 0000-0001-8112-693X), HRDI-10,
202-493-3691, michelle.cooper@dot.gov

Robert Spragg
(ORCID: 0000-0001-9205-1486), HICP-40,
202-366-0120, robert.spragg@dot.gov

INTRODUCTION

Portland limestone cement (PLC) is a binary blended cement manufactured according to ASTM International (ASTM) C595⁽¹⁾ or American Association of State Highway and Transportation Officials (AASHTO) M 240⁽²⁾. PLC contains 5- to 15-percent blended or interground limestone and is alternatively identified with the term “IL,” which indicates portland cement-limestone blended cement in ASTM C595 and AASHTO M 240^(1,2). PLC is engineered to provide 28-d performance equivalent to that of ordinary portland cement (OPC) (ASTM C150⁽³⁾ or AASHTO M 85⁽⁴⁾) for 1:1 replacement while reducing global-warming potential (GWP) 8.3 percent on average, thanks to its lower clinker content.⁽⁵⁾ Cement suppliers are typically producing PLC with 10- to 12-percent limestone powder because such a blend results in a more optimal, 1:1 performance.

Though PLC has now become widely available throughout the United States, several agencies and contractors have reported challenges with its implementation due to limited field experience using the material in the United States.⁽⁶⁾ This TechNote is designed to help State highway agencies (SHAs) and contractors become more acquainted with technical and background information regarding PLC and to promote its successful application nationwide. The document provides information regarding the history, specifications, sustainability, manufacture, engineering principles, and performance of PLC. In addition, the document presents successful case studies and best practices for implementing PLC.

History of PLC in the United States

ASTM C150 began allowing the use of up to 5-percent interground limestone in OPC types I-V in 2004.⁽¹⁾ Before then, in North American specifications, limestone had not been permitted as an addition to cement. AASHTO M 85 was harmonized with ASTM C150 in 2007, when the 5 percent allowable limestone content for OPC was balloted and accepted.⁽⁴⁾ PLC was introduced in the United States in 2005 through ASTM C1157 as a performance cement.⁽⁷⁾ While cements with high ground limestone contents have been successfully used in Europe for 15–20 yr, North American PLC differs in that it was designed to have mechanical properties similar to those of OPC at 28 d, and the concrete producers often add supplementary cementitious materials (SCMs) to PLC.⁽⁸⁾ Beginning in 2012, ASTM C595 and AASHTO M 240 standard specifications for blended hydraulic cements started allowing up to 15-percent blended or interground limestone to be used in binary blended cements, and the specifications defined the product as IL or PLC.^(1,2) While PLC has been allowed in many States since 2012,

ACI-ASCC Survey on Portland-Limestone Cement Concrete

Summary of responses and comments

by James Klingler, Kevin A. MacDonald, Jerry A. Holland, Scott M. Tarr, Beverly A. Garnant, and Bruce A. Suprenant

The transition from Type I portland cement (also referred to as ordinary portland cement [OPC]) to Type II portland cement (also known as portland-limestone cement [PLC]) is well underway. The change has prompted many discussions among industry professionals in the United States. Unsurprisingly, the topic has been raised in many committee meetings at ACI Concrete Conventions.

At the Spring 2022 convention in San Francisco, CA, USA, Kevin MacDonald, Chair of ACI Committee 302, Construction of Concrete Floors, proposed a survey to gather information on contractors' experiences with PLC concrete. Beverly Garnant, Executive Director of the American Society of Concrete Contractors (ASCC) at the time, volunteered ASCC's assistance in the development and evaluation of the survey; and we, the co-authors of this article, served on the ensuing Joint ACI-ASCC Task Group that developed the survey questions. We also worked with Dean Frank, Executive Director of NEU, an ACI Center of Excellence for Carbon Neutral Concrete, and Michael Tholen, ACI Senior Managing Director of Technical Operations, to refine the questions.

This article presents 15 survey questions and a summary of answers provided by 173 respondents, as well as information from previous PLC surveys conducted by ASCC in March 2023,⁽⁹⁾ the Tennessee Concrete Association (TCA) in June 2023,⁽¹⁰⁾ and the National Ready Mixed Concrete Association (NRMCA) in October 2023.⁽¹¹⁾ Readers are encouraged to evaluate the ACI-ASCC PLC survey data and draw their own conclusions.

Survey Basics

The Joint ACI-ASCC Task Group developed survey questions to gather information regarding the construction of concrete floors and slabs using Type I and Type II portland cement. The following paragraphs discuss survey distribution, sampling methods, and responses.

Distribution

ASCC's staff generated the survey in SurveyMonkey[®] and provided ACI staff with a URL link. The survey was distributed as an embedded link in the following media:

- Once per week in the Concrete SmartBrief—August 22 through September 30;
- In each ACI eNews—August 24 and September 7; and
- On ACI's LinkedIn and Facebook social media pages—August 16.

In addition, we (the authors) sent emails to our contacts at the Portland Cement Association (PCA), NRMCA, the California Nevada Cement Association (CNCA), and other groups to raise awareness of the survey and to encourage responses. The survey ended on September 30, 2023, with data collected from 173 respondents. While this may appear to be a small response, ACI staff has indicated that the largest previous survey, on the ACI Code 318 reorganization, included data from only 74 respondents.

Sampling

This survey featured nonprobability sampling based on links in emails to ACI members and contacts as well as postings on ACI's social media pages. Respondents had to take it upon themselves to submit responses, so the survey used a combination of convenience sampling and voluntary sampling. In contrast to the results of probability sampling based on random selection from a population, the results of this sampling approach are not suitable for statistical inference, and the results cannot be considered representative of all PLC users in the concrete industry.

Responses

The survey comprised multiple-choice questions, with each accompanied by a text box for comments. Table 1 summarizes

So, What is next?

So, What is next?

Type IL HE

- This is an ASTM C595 PLC cement that will replace the current ASTM C150 Type III (High Early) cement.
- Using similar ideas of Type IL, the IL HE can have a finer blaine and more than 5% limestone addition.
- In testing Type IL HE has shown a slight increase in early compressive strength breaks while similar in initial Setting times.
- Potential Rollout is scheduled for 2025.

So, What is next?

Type IL HE

- This is an ASTM C595 PLC cement that will replace the current ASTM C150 Type III (High Early) cement.
- Using similar ideas of Type IL, the IL HE can have a finer blaine and more than 5% limestone addition.
- In testing Type IL HE has shown a slight increase in early compressive strength breaks while similar in initial Setting times.
- Potential Rollout is scheduled for 2025.

Type IT

- This is a ternary blend C595 cement. It will incorporate PLC at a defined %, but add an additional supplemental cementitious material like:
 - GGBF Slag
 - Fly Ash
 - Other manufactured or natural pozzolanic materials
- Percentages to be explored by Cement Manufacturers.
- Potential rollout is scheduled for 2026/27.

So, What is next?

Type IL HE

- Has had product review and certified for use by local DOT's/AOT/s in New York and Vermont.

Type IT

- Has had product review and certified for use by NYSDOT.



Utilizing FRC to
reducing the carbon
footprint

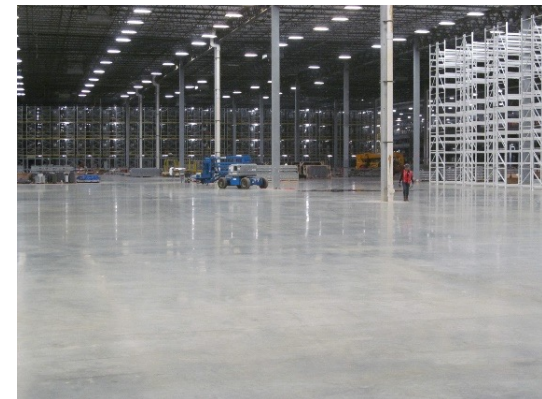
The Future of FRC and ‘Green’ Construction

- Fiber Reinforced Concrete (FRC) technology has advanced significantly over the past two decades:
 - definitions for micro and macro fibers
 - calculations for equivalent reinforcing options to conventional steel
 - industry acceptance (ICC, UL, SDI, ACI, public agencies etc.)
 - structural designs and software tools
 - multi-million dollar research programs
 - high profile projects and applications
- **Many prospective clients and engineers are now asking:**
- **“What are the environmental impacts and/or benefits of using FRC for concrete construction?”**



What types of projects should be considered for application using macro-fibers? Remember - micro-fibers are for plastic shrinkage only.

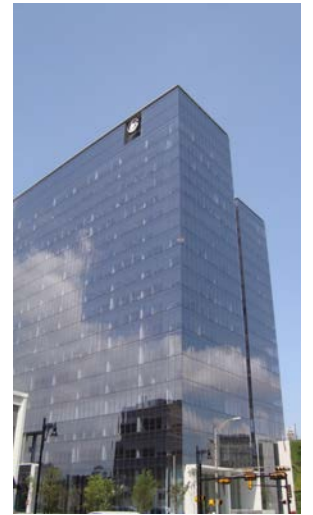
- Slab on Grade applications where WWM and light bar reinforcing is used as secondary reinforcing and light structural reinforcing are prime candidates for macro synthetic fiber use.
- Slabs on Grade with WWM or small bars (#'s 3, 4, 5) at spacings greater than 12" c.c.
- Slabs on metal decks – 4 lbs of macro fibers per SDI
- Topping slabs
- Horizontal decks
- ICF walls, Shotcrete
- Pavements
- Bridge Decks







SOD Prudential Headquarters –



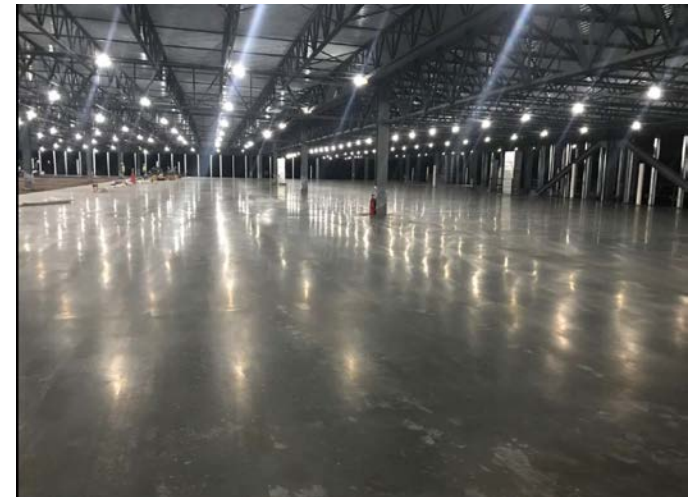
2 ¾ in bonded topping for a town library with radiant heat in slab

Convention Center - SOG





Amazon Fulfillment Centers





Lucas Museum CA

