Field Guide to Placing and Finishing Type IL Cement Concrete

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With the dramatic increase in manufacturing since 2021, ASTM C595/C595M Type IL cement, also known as portland-limestone cement (PLC), has become the most common type of cement used in the United States. While many contractors have successfully placed millions of ft^2 of slabs and paving comprised of Type IL cement, contractors in some regions have reported plastic and hardened concrete issues, including slower strength gain and slab surface defects such as early surface crusting, cracking, excessive crazing, and delamination. Developing an understanding of how PLC differs from ordinary portland cement (OPC) can help contractors modify and adapt finishing means and methods to meet these challenges. This article is an attempt to explain the differences between the two binder types, based on direct observation and reports from finishers placing concrete with Type IL cement. Readers should note, however, that these observations cannot represent all situations, as local materials, weather, and finishing processes can heavily influence performance.

The key difference between traditional ASTM C150/C150M Type I/II/V cement and ASTM C595/C595M Type IL cement is the maximum limestone content by mass of the blended cement (5% and 15%, respectively). While early promotional materials touted PLC as a one-for-one replacement for OPC, field observations and subsequent work have indicated that the changeover is not that simple. For example, the additional limestone in PLC can impact admixture effectiveness. Furthermore, PLC performance appears to be more sensitive to variances in physical properties and chemical composition. Changes in performance have been correlated with variations in product from the same cement mill and, more significantly, with differences in product from different cement mills.

Using Type IL Cement

When using PLC (Type IL cement), considerations include:

- Be aware of the blended limestone content. Type IL(8) cement, with 8% limestone content, will perform differently than Type IL(14), with 14% limestone content;
- When using supplementary cementitious materials (SCMs) or slag cement in combination with PLC, the strength gain behaviors appear to be less predictable than historically seen with OPC (Type I/II cement). The ready mixed concrete producer's history with each PLC concrete mixture provides important information;
- PLC concrete may not have the same strength gain at a given age as compared to OPC concrete. Most Type IL cement produced in the United States is produced by intergrinding of the limestone and clinker. As a result, the clinker constituent in PLC may be finer than in Type I/II cement. Also, many cement manufacturers have increased the alite-to-belite ratio in their clinker—increasing the percentage of the faster reacting alite can provide comparable early strengths to Type I/II cement. The behavior of the cement will vary with the fineness of the grind as well as the alite-belite ratio;
- Intergrinding of limestone and clinker can also increase the fineness of PLC, so PLC concrete mixtures tend to have a higher water demand (an additional 1.0 to 3.0 gal/yd^3 [5 to 15 L/m^3]). Be mindful of the total amount of water being held back on batch tickets and ask the concrete producer to maximize the use of water up to the allowable water-cement ratio (w/c) to obtain slump before using water-reducing admixtures. Once the mixture is dialed in, the held-back water should typically be no more than 1.0 to 1.5 gal/yd^3 (5 to 7 L/m^3);

Placement and finishing of a PLC (Type IL cement) concrete slab

- The fineness of PLC also affects bleeding. PLC mixtures can be slower to develop surface bleed water, their bleeding times may be extended, and the total bleed water is typically lower than for the same mixture using OPC;
- Under certain conditions, the noted bleeding behaviors, fineness, and different chemistry make PLC mixtures more prone to surface crusting, a condition in which the slab surface dries faster than moisture can rise from below;
- Setting times and bleeding rates for PLC mixtures may be more sensitive to temperature variations and environmental conditions than OPC mixtures; and
- Admixtures affect the setting time, strength, and finishability of concrete. Choose Type A or Type F water-reducing admixtures that do not retard the set of concrete. Individual water-reducing admixtures that meet all the requirements of Types A, B, and D may have a set-retarding effect, especially at higher dosages. If necessary, use the minimum dosage of these materials. Polycarboxylate-based mid-range and high-range water-reducing admixtures that meet the requirements of Type A and Type F are not likely to delay the set and will improve workability, finishability, and later-age strengths. Consider testing any proposed admixture or combination of admixtures with the PLC in mortar or concrete mixtures for setting time and strength development. Using more than one water-reducing admixture in a PLC mixture appears to result in less predictable finishability performance than using a similar practice with an OPC mixture. Admixture manufacturers are developing water-reducing and workability-modifying admixtures specifically for PLCs.

Pre-Placement Considerations

Before placing PLC concrete:

- Review mixture designs and their histories. Conduct trial batches on all new mixtures that have not been used successfully in multiple projects. Key considerations include total limestone content in the PLC, total cementitious material content in the mixture, water-cementitious materials ratio (*w/cm*), and admixtures to be used. Optimizing combined aggregate gradations and proportioning is critical to achieving the best concrete outcomes in both the plastic and hardened states. Because no one mixture analysis method (for example, coarseness/workability factors, combined aggregate percent retained, power 0.45, mortar percent, paste percent, or Tarantula Curve) will ensure an optimum mixture, several mixture analyses should be performed;
- Select a target *w/cm* of 0.47 to 0.55 for interior slabs, the recommendation of ACI PRC-302.1-15, Section 8.4.4,[1] based on the water demand of the materials, and a slump of 3 to 4 in. (75 to 100 mm) before the introduction of admixtures. Once dialed in and if needed, use admixtures to meet pumping, placement requirements, and finishing operations. If the mixture is not performing as needed, check for admixture incompatibilities;
- Discuss with your ready mixed concrete producer any changes to their coarse aggregate and sand supplies since they started using Type IL cement. Some producers are modifying the manufactured sand versus natural sand proportions due to limited natural sand availability. Also discuss intermediate-sized aggregate options, like

substituting a moderate amount of mostly 3/8 in. (9.5 mm) for smaller aggregates like No. 78, No. 8, or No. 89 [9.5 to 2.36, 2.36, or a nominal maximum size of 9.5 mm], based on local availability. To maintain yield, reduce both the larger aggregate and sand quantities when adding the intermediate aggregate;

- Consider the conditions in which the slab will be placed and the size of the placement. Understanding how the forecasted ambient temperatures and environmental conditions during slab placements may impact the slab finishing process is vital to incorporating the proper means and methods to produce a successful concrete slab. Sun, wind, and low humidity are the enemies of all concrete slab placements and may be exacerbated with PLC mixtures. Making slab placements during nighttime hours and reducing the size of placements and finishing done in direct sunlight should be strongly considered;
- Have the tools available to make intelligent decisions. Evaporation rates, wind speed, humidity levels, and ambient and slab surface temperatures are vital information for the finishing crew to have in real time. (Note: The slab surface temperature at the time of testing, not the delivered concrete temperature, is used for determining the evaporation rate.) All concrete crews should have access to weather measuring devices and infrared thermometers to monitor the slab surface temperature. Evaporation rates should be monitored throughout the placement, finishing, and until the final curing processes are complete;
- Slab mockups and test placements are vital to understanding concrete mixture behaviors and finishing challenges that may be encountered. Test placements should be large enough to evaluate all equipment and methods employed during slab installation. Multiple loads of concrete should be checked so that variability in concrete setting times, bleeding rates, and workability can be determined; and
- Review the flooring specification and note the locations and types of finishes. Also check for restrictions on using chemicals while finishing or curing the slab. Plan concrete operations accordingly. Surface densifiers, for example, may make the concrete so impervious that it will not pass the "drip test" per ASTM F3191-23, "Standard Practices for Field Determination of Substrate Water Absorption (Porosity) for Substrates to Receive Resilient Flooring," which means that water-based adhesives may not stick to the surface.

Placing and Finishing Type IL Cement Mixtures

When placing and finishing PLC (Type IL cement) mixtures:

- Control the concrete setting time to encourage more uniform full depth setting of the concrete and reduce the amount of time the slab surface is subject to moisture loss. Assuming adequate crew and equipment are available, faster setting mixtures will experience fewer issues with surface crusting and the associated surface defects such as plastic shrinkage cracking, excessive crazing, and delamination. Accelerating admixtures may become an essential part of the finisher's toolkit;
- Manage evaporation rates and surface bleed water to ensure the slab surface doesn't dry out too quickly. Due to the higher fines content of PLC and reduced bleeding rates, mitigation efforts must become a routine part of the finishers' means and methods. Field experience indicates that when evaporation rates reach 0.05 to 0.08 lb/ft^2/hr (0.24 to 0.39 kg/m^2/hr), applying evaporation retarders, fogging the slab area, or other mitigation efforts are vital to a successful slab installation. Mitigation efforts must be maintained throughout the entire placement, finishing, and curing processes. Multiple applications of evaporation retarder or fogging may be required during the placement and finishing, especially during adverse weather conditions. Topical monomolecular evaporation retarders or water from fogging/misting operations should not be worked into the slab surface;
- Don't seal the slab surface with trowel blades too early in the finishing process. It is critical that first troweling with combination blades be conducted with the blades as flat as possible, leaving no chatter or machine trowel marks. The first troweling with combination blades should produce a fuzzy finish. Allowing the surface to breathe for as long as possible during finishing operations significantly reduces the potential for delamination. A tight finish, just starting to shine, should be the goal before the final finishing pass. Remember that PLC generally has less clinker and more fines in the paste than OPC, so surface density and abrasion resistance must be developed gradually during the entire troweling process;
- Don't over-trowel the slab surface during late-stage finishing. Steel or plastic blades should be used only for the final pass. Premature use of plastic blades does not give the slab surface the durability required. The goal should be to achieve a uniform semi-glossy, machine-troweled finish with minimal cosmetic blemishes or surface defects; and
- Recently, numerous topical, internal curing, densifying,

Application of an evaporation retardant on a PLC (Type IL cement) concrete slab

Properly timed saw-cutting of joints in a PLC (Type IL cement) concrete slab

and finishing aids have been introduced into the market to improve the finishing operation and reduce crusting and surface-related issues. It is important to understand when and how to apply these products and to recognize that as they are new, there is minimal guidance or industry standards established for their use. Therefore, follow the manufacturer's directions and test each product for approval to determine compatibility issues with other products to be used for the slab.

Curing, Saw-Cutting, and Test Cylinders

When curing and saw-cutting slabs and storing test cylinders:

- Prompt curing of the slab surface after the final finishing is important for all concrete mixtures and even more vital when using PLC mixtures, as PLC mixtures may decrease the amount of time available to initiate the curing process. No matter what curing method is employed, it must be applied correctly and according to the manufacturer's and ACI's recommendations. A well-trained crew using the correct equipment is vital to a successful curing application. Depending on environmental conditions, slab curing may need to be undertaken before saw-cutting operations. While this is different than past practices and may be more difficult, what is best for the concrete must be done;
- Saw-cutting contraction (control) joints may need to be adjusted with mixtures that have slower setting characteristics or different bleeding rates. Patience and discipline are required to minimize spalling and raveling of the saw cut while still getting the saw cuts installed before out-of-joint cracking can occur. In this transition, the little things become more critical, and making test cuts must become standard practice. Delayed starts and stops during the saw-cutting operations should be expected to minimize spalling and raveling of saw cuts, but be watchful for long delays that could lead to out-of-joint cracking; and
- Confirm that concrete cylinders are initially cured at temperature between 60 and 80°F (16 and 27°C), specified by ASTM C31/C31M-25, "Standard Practice for Making and Curing Concrete Test Specimens in the Field." This standard is frequently violated and can result in low cylinder breaks, particularly in concrete cylinders stored in temperatures above 90°F (32°C) or below freezing in the first 24 to 48 hours.

Final Thoughts

Type IL cement (PLC) is not going away. We in the cement and concrete industries are being asked by multiple stakeholders and end users to reduce our carbon footprint, and reducing clinker content is the primary lever for accomplishing this. Furthermore, we can expect the future will see increased use of ternary blended cements, consisting of portland cement clinker with either a combination of two different pozzolans, slag cement and a pozzolan, a pozzolan and a limestone, or slag cement and limestone. While the long-term impacts are yet to be fully understood, we can expect these blends to create challenges for those responsible for installing durable, wear- and abrasion-resistant, trouble-free slab surfaces that meet the aesthetic and operational demands of owners. However, the challenges are not insurmountable.

The fundamentals and "best practices" for placing and finishing concrete slabs remain unchanged. The mixtures we use today and will use in the future are less forgiving and will require greater adherence to good concrete practices. Better communication and understanding of the issues between specifiers, designers, contractors, ready mixed producers, cement manufacturers, owners, and end users are crucial as we navigate our way forward. New ideas and experimentation should be encouraged, and compromise will be inevitable. Concrete contractors are a part of this complex process and are held accountable for producing quality products that are in a constant state of change. As an industry, we must consider a more holistic approach to placing, finishing, and curing our slabs.

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References

1. ACI Committee 302, "Guide to Concrete Floor and Slab Construction (ACI PRC-302.1-15)," American Concrete Institute, Farmington Hills, MI, 2015, 76 pp.

Note: Additional information on the ASTM International standards discussed in this article can be found at **www.astm.org**.

Selected for reader interest by the editors.

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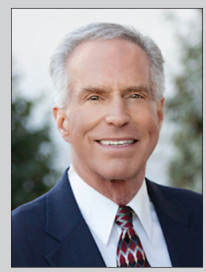

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