HAHN READY MIX

IL Cement: Two Years Later, What We've Learned.

Technical Bulletin #26, February 2024

First, the good news...

Much of the U.S. Cement industry has made the transition from Type I or Type I/II (Also known as Ordinary Portland Cement, or OPC) to a Type IL (also known as Portland Limestone Cement, or PLC). Current estimates suggest that around 3 Million tons of CO_2 emissions were avoided in 2023. Many of these IL Cements are being produced with 8-12% limestone interground into the regularly produced portland cement. If most OPC's we're utilizing 4% limestone prior to the switch to PLC, then the industry in the U.S. will have **effectively lowered it's carbon footprint by about 6%.** Once all producers have transitioned to PLC, that works out to about **5 Million tons of CO_2**, annually, that will not be released into the atmosphere in the United States. This is a big deal, as cement production worldwide makes up between 8-9% of human CO_2 emissions. Many of the cement producers are targeting an eventual limestone content of 15%, which would mean an additional 4.1 Million tons of CO_2 emissions reduction.

PLC Cement Plants and Terminals

And then a caveat...

Unlike traditional OPC, there is a great deal of variability in the performance of the PLC from producer to producer or even from plant to plant. For the discussion below, not all cements are experiencing these issues, and some are experiencing none at all. This is merely meant to be an awareness tool to help with diagnosing issues should you encounter them.

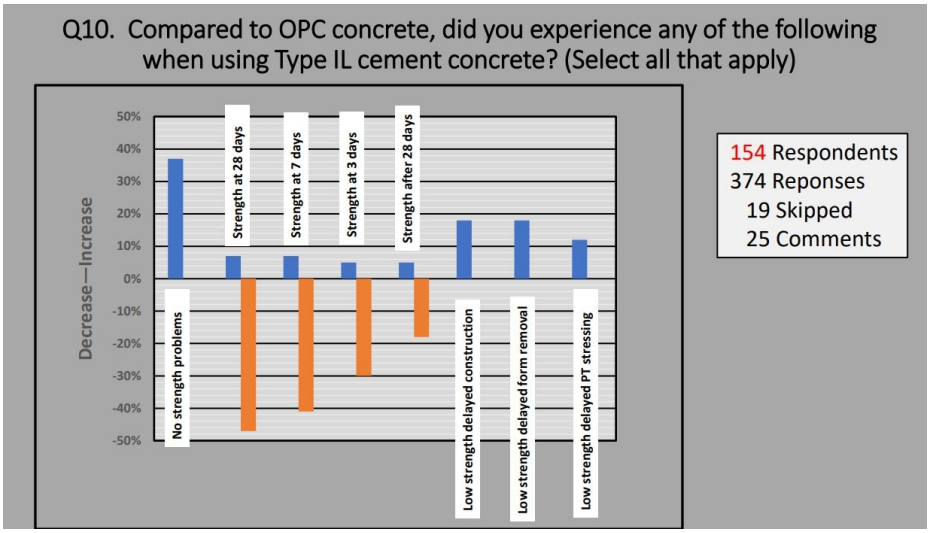
The Challenges…

A recent survey done by the ACI 302 committee on concrete floor slabs polled 173 Concrete Contractors, Ready Mixed Producers, Architects, Engineers, Testing Agencies, General Contractors, Admixture Suppliers, and Cement Producers for their experience using IL Cements nationwide. This information was voluntary, not random, and only made it to ACI members. The information is also the anecdotal evidence of the respondents experiences and not necessarily backed up by scientific research. However, the survey did reveal some interesting and perhaps alarming trends.

Strength

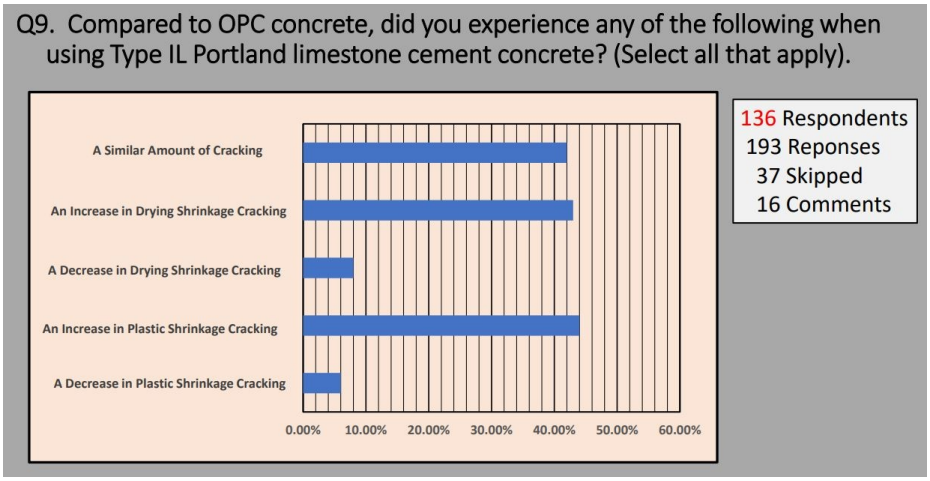
The first concern for many when the idea of IL cements were introduced, was "what happens to strength?". Diluting the cement would logically result in less reactive material and therefore lower strengths. However, the cement industry countered this argument that the cement would be ground finer and thus be more reactive and mitigate the loss of reactive material to make it an equivalent performance. Much was made on a 1:1 replacement, and it still says this on the Portland Cement Association's Greener Cement website.

However, this has proven to not always be the case.



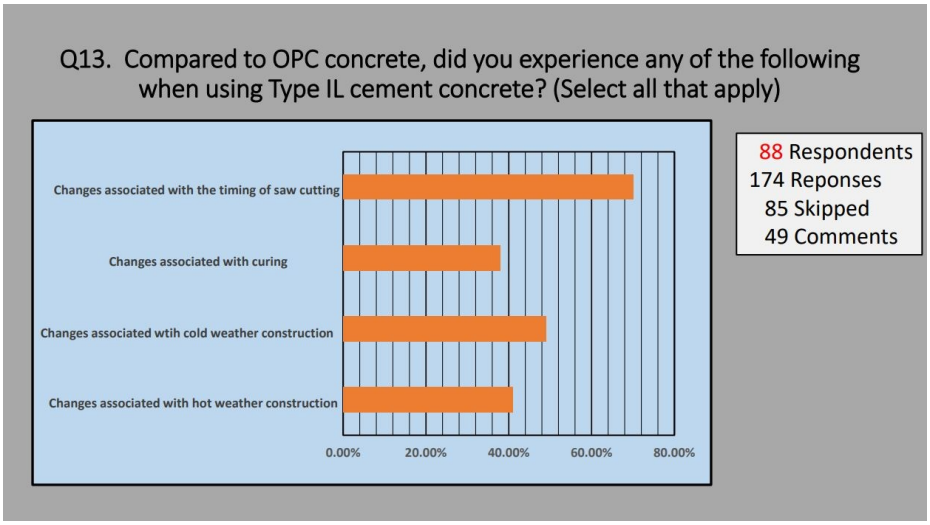
Results from the ACI 302 survey report a 45% occurrence of reduced strength at 28 days. Closer to home, much of Iowa was experiencing intermittent strength loss in the 2022 construction season, causing extensive industry discussions and even had the City of Des Moines questioning the use of concrete in roadways. This reduction in strength could be a function of a loss of reactive portland cement or an increased water demand, resulting in higher water/cement ratios. The 2023 construction season seems to not have experienced those strength issues in Iowa. Extensive internal testing done with our quality control department in fall of 2022 showed that with our materials, tested at a variety of air contents and water-cement ratios, only had a 1% decrease in strength with the IL at 3 days, 9% decrease at 7 days and 2% decrease at 28 days. Certainly the 3 and 28 days results are not statistically significant. In general, we have no major concerns with strength development of concrete mixes using IL at this time.

Cracking

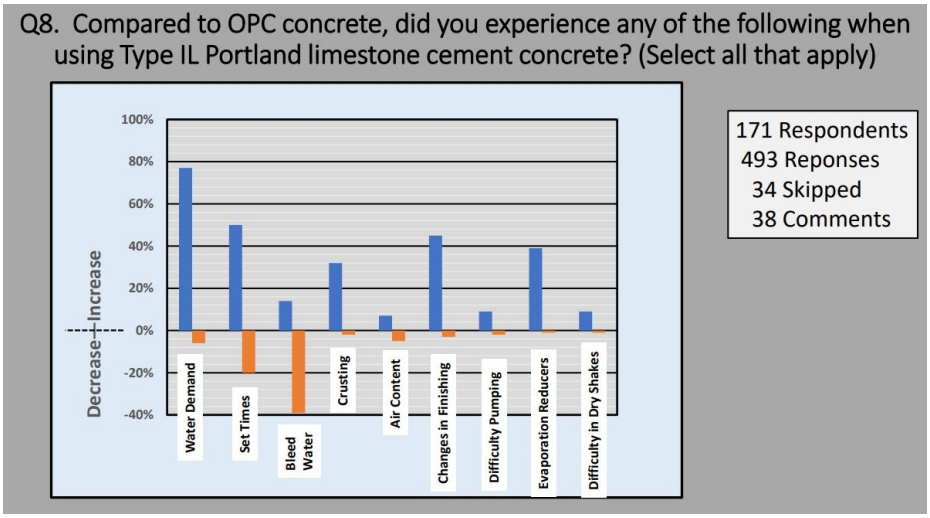


There has also been a great deal of discussion on cracking. 41% of respondents in the ACI 302 survey reported an increase in drying shrinkage cracking, 43% an increase in plastic shrinkage cracking and 40% reported a similar amount of cracking observed. The reported rise in plastic shrinkage is likely connected to the widely-observed loss or delay in bleed water formation. Drying shrinkage cracking could be resulting from changes in set times and mistimed jointing (72% of survey

respondents reported a change in set time, interestingly, 51% reported an increase and 21% saw decreased set times). Another theory is that as the fineness of the cement has increased for reactivity purposes, the shrinkage potential of the cement has accordingly increased, as finer cements are known to shrink more. There are reports of plastic shrinkage cracking on days with low evaporation rates and drying shrinkage cracking forming before the concrete can be sawed. For our part, we can attest that we have seen a *significant* increase in both plastic and drying shrinkage cracking in 2023, including the two befuddling phenomena mentioned in the prior sentence.

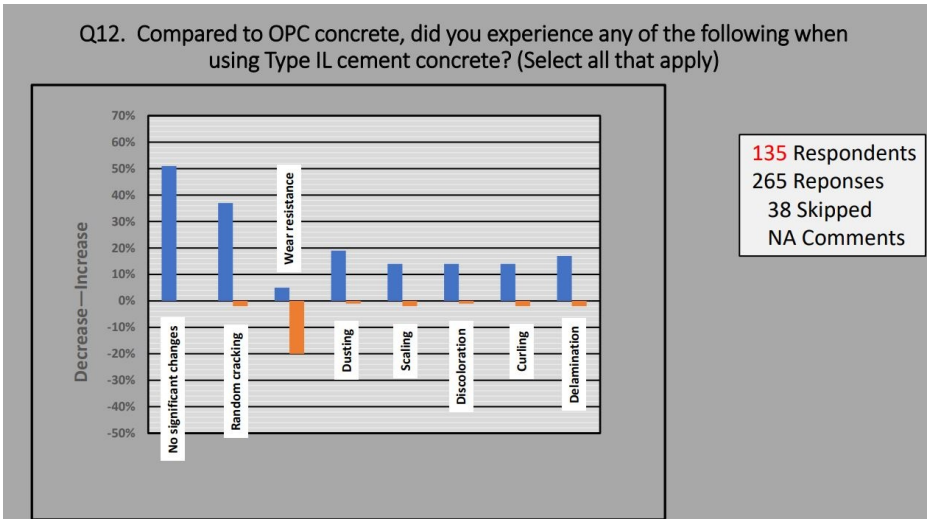


Finishability

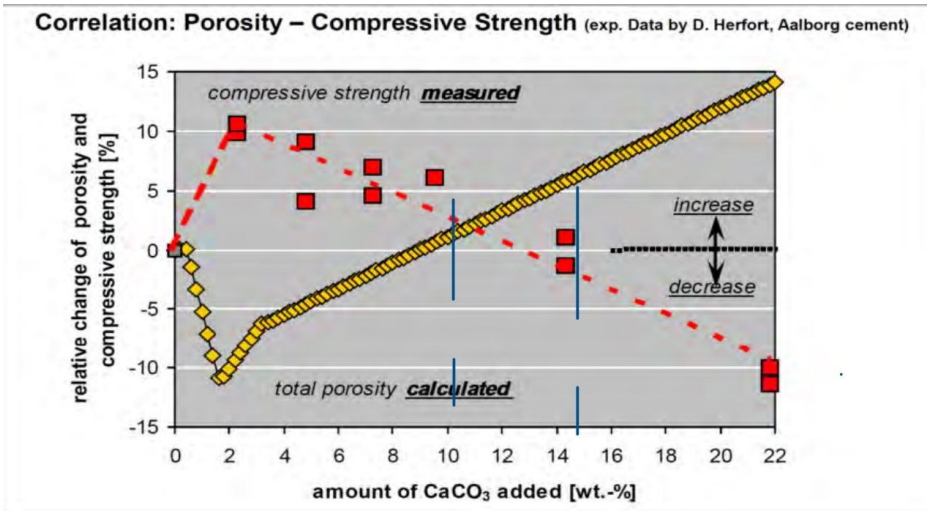


The primary discussion around finishability has been the increased water demand, in other words, needing more water to achieve the same slump, and a lack of bleed water. The domino effect of lack of bleed water can result in plastic shrinkage cracking, crusting, and the need for evaporation retarders. Some areas of the country have reported not a loss of bleed water, but a delay, which has resulted in delamination of concrete surfaces. Our feedback from customers seems to be that there is slightly less bleed water present on our concrete than before, but this has not been a major area of complaint.

Durability



A final concern is regarding concrete durability. There was some reporting of decreased wear resistance on concrete slabs and increased scaling potential. Much more research needs to be done on the wear resistance, as this is a difficult issue to quantify in the field. Some work has been done in Minnesota to help investigate a very severe scaling experience in the winter of 2022/2023. Their research indicates that aside from the traditional scaling causes of improper curing, overfinishing and a lack of air entrainment; above a threshold of about 15% limestone fines, concrete is significantly more susceptible to scaling. Considering most IL producers are currently in the 8-12% range, if the IL is being used in conjunction with carbonate aggregates such as crushed limestone, it would be easy to approach or exceed that 15% threshold. This is a significant concern for the proposed increases to 15% limestone in the IL. Additionally, some work done in 2010 and published by the Portland Cement Association suggests that IL cements used in conjunction with fly ash are more susceptible to scaling than an OPC cement. This is a double edged sword in our area, as SCMs such as fly ash and slag are critical for prevention of calcium oxychloride formation in pavement joints exposed to deicing salts. We at Hahn Ready Mix have not noticed an increase in scaling after making the switch to IL cement.



Conclusions

In many instances, IL cement will perform nearly the same as OPC. However, there may be variability in performance based on cement producer, region, environmental conditions, admixtures, aggregates, or finishing practices where the cement does not act the same. We must be

aware of these possible differences, and vigilant to their identification and mitigation for the sake of the stakeholders of the concrete construction process and the reputation of concrete itself. Quality concrete can and is made everyday with IL cements, but potential difficulties do exist that must be accounted for.

So what can we do about it?

Let's reiterate, these issues are a summary of what has been reported nationwide and not at all representative of cement performance in any one area. However, there are a number of ways to mitigate or minimize these threats to concrete performance.

1) Use proper curing techniques. Proper curing helps protect against plastic and drying shrinkage cracking, strength issues, scaling issues, and improves wear resistance. **Curing has long been the most neglected step of the concrete construction process and it has never been more critical than now.**
2) Evaporation retarders. A commonly used product on high evaporation days, they may be beneficial more often with IL cements to help prevent plastic shrinkage cracking, crusting, and loss of bleed water.
3. Strength Enhancing Admixtures. If strengths are a concern, a new wave of strength enhancing admixtures are available to help gain early strength. More on this in a future Tech Bulletin.
4. Trial batches for critical or unusual pours. If there is a pour that has no room for error or experimentation, a trial pour to determine set times, bleed rates, strengths and finishing characteristics may be helpful.
5. Feedback. Please let us know if you observe any of these issues. There may be adjustments to the mix design or materials that can be made to improve the problem.

A great article that just was released in Concrete International Magazine relating to all of this and including a project case study can be found here.

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