Technical Committee Advisory to CPCI Members

Adoption of Portland Limestone Cement (PLC) in the Production of Precast and Prestressed products

*Note: Portland Limestone Cement (**PLC**) is a generic term describing a family of cements, on the same level as Portland cement. In the CSA standards, **GUL** is a PLC cement type (general use) similar to **GU** cement. Also, **HEL** is a PLC cement type (high early) similar to **HE** cement. PLC was introduced into the CSA standards with the understanding that it provided equivalent 28-day performance to normal Portland cement.*

Scope of this Advisory

This advisory is issued by the CPCI Technical Committee through the work of the PLC Task Group of the committee. The advisory intends to provide an overview of Portland limestone cements (PLCs) and offer guidance to CPCI members on the technical considerations of integrating these cements into their operations.

Introduction and Background

Following many government initiatives to minimize the environmental impacts of construction activities, the cement industry and concrete producers continue to introduce more sustainable practices with the intent of reducing their environmental impact. Concrete is one of the most consumed material in the construction industry and, with cement as the primary binder, it certainly draws attention as a sector with opportunities for environmental impact reductions. It is widely recognized that the production of cement is one of the largest emitters of carbon to the atmosphere (approximately one tonne of CO_2 per tonne of cement). Over the last several years the cement industry in Canada has developed Portland Limestone Cement (PLC) as a means of reducing their carbon footprint. Likewise, precast concrete producers have also been taking action to reduce their own carbon emissions by partially replacing Portland cement with supplementary cementitious

materials (SCMs), using fillers and improving the efficiency of their daily production operations.

Portland limestone cement (PLC) was introduced in 2008 into CSA A3000 with some limitations, and in the most recent edition of the standard (2018) all of these limitations were removed, essentially accepting PLC as a direct replacement for normal Portland cements by the standards. PLC is a blend of Portland cement with up to 15% of limestone as a replacement of the Portland cement clinker. In Canada, although the focus of the cement industry has been on GUL production (as a replacement for GU), some cement suppliers are looking at the production of HEL cement (as a replacement for HE) however this varies regionally. In addition, CSA A23.1/2 also permits the use of PLC to provide equivalence for all three sulphate exposures, very severe (S-1), severe sulphate (S-2) and moderate (S-3).

In addition to this codification, the Cement Association of Canada (CAC) has requested Provincial and Federal agencies mandate the use of PLC as an effective measure to further lower the carbon footprint of infrastructure built with concrete. Interground PLC (from a cement plant), or limestone addition at the concrete plant, is already being specified or permitted in some regions [check with your local municipal or provincial authorities]. More recently the Federal government through the LCA^2 initiative [click here] has indicated intentions to mandate the use of PLC (or approved alternatives) in all Federal government projects, potentially starting as early as 2021.

It is expected that PLC could be the sole cement in the Canadian market in the near future. At this time we know that there will be a more immediate transition from GU to GUL, but we do not know how long this transition will take. The transition to other PLCs such as HEL is uncertain at this time. However, the Cement Association

of Canada has recently indicated that their members are planning to work with our industry on a high early strength limestone cement to achieve equivalent performance to that of HE.

Use and Understanding of PLC in the Precast Industry

The PLC Task Group conducted email and telephone surveys of CPCI member precast producers across Canada to gauge their awareness and experience with PLC. In general, there are three types of respondents:

(1) those who are unaware of PLCs,

(2) those who have heard of PLCs but not used them, and

(3) those who have heard of PLCs and have had some limited experience.

The vast majority of precasters still have a limited understanding and knowledge of PLC and/or have reservations about using it in their operations.

Replacing Portland Cement (PC) with Portland Limestone Cement (PLC)

Based on the existing information on PLC, and the feedback from the precast producers, the PLC Task Group recommends the following:

1. Each precast operation should discuss the status and availability of either GUL or HEL with their cement supplier who will also be able to provide information on any differences between the relevant GU and GUL or HE and HEL cement that may impact precast operations.
2. Each precast operation, before replacing PC with PLC, should investigate the acceptance criteria with all the relevant jurisdictions in their region and discuss these requirements with their cement supplier.
3. Each precast operation should develop a plan and work with their cement supplier to evaluate the plastic and hardened characteristics of their concrete, unique to their product range, and to their operations and curing practices. Some of the characteristics that should be considered, at a

minimum (because they are directly or indirectly required by CSA A23.1/2 or CSA A23.4), include; setting time profiles, compressive strength profiles (0 – 24 hours, as well as 7 and 28-days strength tests), internal temperature profile/heat of hydration, air void spacing and rapid chloride permeability. The strategies listed in this advisory under "Additional Information" are recommended as potential starting points. Other properties that may be of interest to certain precasters may include colour uniformity, carbonation, or efflorescence (since PLC has less clinker it is expected to have a lower susceptibility to efflorescence).

4. Each precast operation should internally review the state-of-the-art reports from both the Cement Association of Canada [1] and the Portland Cement Association [2] to gain a better understanding of other properties that their clients may enquire about, or that they may need to confirm for their own engineering design department. These include properties such as sulphate resistance, Alkali-Silica Reactivity (ASR), Delayed Ettringite Formation (DEF) potential, Young's modulus, tensile strength, linear shrinkage and creep.

   [1] Portland Limestone Cement: State-of-the-Art Report - CAC

   [2] State-of-the-Art Report on Use of Limestone in Cements - PCA

5. Each precast operation should share their experiences, in confidence, with CPCI Technical staff who intend to build a repository of information that can be shared across the membership.

Additional Information:

A few precast producers have reported that a straight replacement of GU or HE with GUL will have an impact on early strength gain, including stripping strength, and minimum strand release strength which will eventually effect the 24-hour production cycles (setup-pour-strip). As explained earlier a complete performance evaluation of the concrete mix is required when replacing Portland cement with

PLC.

Below are some potential measures for consideration as a starting point.

Replacing GU or HE with GUL; or Replacing HE with HEL (where available):

- Concrete mixes with a direct replacement of GU with GUL have reportedly offered the same, or better flow, characteristics
    - Reduce the w/c ratio in increments of (0.01), keeping the cement content the same as normal.
    - For each trial, evaluate the slump or slump flow of the mix to develop a graphical representation and comparison to the original mix with GU. Adjust water reducers or superplasticizers as required.
    - Once the optimal reduction in w/c ratio is determined, conduct an expanded trial with the new w/c ratio and all other materials the same except for water content, any admixture changes, and cement type.
        - Conduct set time, strength development, and temperature profile tests with match-cast cylinders under your typical curing conditions.
        - If satisfied with the above, conduct hardened air void and rapid chloride permeability tests on additional cylinders.
        - Evaluate any other properties and characteristic unique to your plant and product requirements (colour uniformity, finishability, strand bond).
        - If not satisfied with the above, consider a combination of reduced w/c ratio and an increase in total cementitious content.

Note: This advisory provides a general recommendation to CPCI producer members regarding the use of PLC in precast concrete. The information provided in this document is based on the current information available on PLC. As more information becomes available, the document will be updated accordingly.