THE Concrete DIFFERENCE

Concrete Information for the Owner, Designer, Contractor and Producer

Portland-Limestone Cement: An Option to Make Concrete Even GREENER

In 2012, blended cement specifications AASHTO M 240 and ASTM C595 were updated, including a definition for a new type of cement: Portland-limestone cements (PLC), which contain between 5% and 15% finely ground limestone as an ingredient. These cements are referred to as Type IL.

Concrete is among the most sustainable construction material choices, particularly when life cycle impacts are factored in. Because of the vast amount of concrete used around the world annually even modest improvements to cement sustainability attributes can have a significant benefit. Portland-limestone cements are a new technology in the United States, although they have been used in Europe and other places around the world since the 1960s. This technology has been introduced primarily for environmental reasons: Portland-limestone cements offer similar performance to Type I portland cements, but with about 10% lower CO_2 footprint.

It surprises some people that a relatively inert material like limestone can be used as an ingredient in a blended cement in these amounts and achieve similar properties like strength development as a portland cement. This behavior can be explained by both physical and chemical effects. Limestone is a softer material than portland cement clinker and will grind finer during milling. This fine material helps with particle packing at the paste level, making it denser, possibly requiring slightly less water. In addition, these fine particles provide surfaces for cement hydrates to form on, away from the clinker grains, freeing up those grains somewhat for additional hydration to occur. These effects are small, but positive, and good performance has been demonstrated in the field over the last several years in the US and Canada, and over several decades in Europe and other places around the world. Between 2012 and 2016, almost 2 million tons of PLC were produced in the US. Currently thirty US state transportation agencies currently allow for the use of IL cement in their specifications.

The first figure on the following page (Thomas et al. 2010) provides information on compressive strength development of field concretes made with portland cement (PC) and PLC with and without supplementary cementing material (SCM) (in this case the SCM was a blend of 33% fly ash and 67% slag cement). Early strength decreased in concretes that included SCMs in both PC and PLC concretes, but 28- and 56-day strengths increased up to the 40% replacement level. Also at the 40% replacement level, the strength of the cores taken from the PC and PLC mixtures were nearly equal to the respective 28-day compressive strengths for standard-cured cylinders.

The second figure (from the same study) shows the ASTM C1202/ AASHTO T 277 ("rapid chloride permeability test") that both PC and PLC have lower permeability when cured longer and when using SCMs, as expected, and both concretes have very similar trends. This indicates a broadly similar durability traits for several concrete distress mechanisms. For specific exposures, like sulfate conditions, AASHTO M 240/ASTM C595 has specific testing (ASTM C1012) to qualify materials as sulfate resistant. If cements qualify, MS and HS suffixes are added to the cement type to indicate moderate- or highly-sulfate resistance, respectively.

Although PLCs are used in the same wide range of applications of Type I and other general use blended cements, some sports themed example projects that have extensively used PLC include Mattamy National Cycling Centre (Milton, ON velodrome) (17,000+ yd3), Tim Horton's Field (Hamilton, ON) (14,000+yd3), and Davis Wade Stadium renovation (2400+ yd3) (home of Mississippi State University football). More broadly, PLCs have been used in pavements, bridges, government and residential buildings, schools, hotels, parking garages, and many other concrete structures.

If you are interested in using portland-limestone cement, check with your cement supplier who can provide detailed information on its availability and properties.

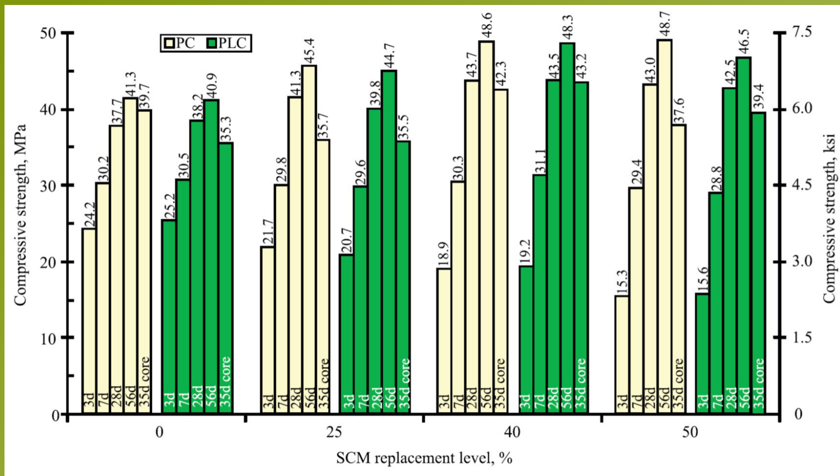

Figure 1: Compressive strength test results for site-cast, standard-cured concrete cylinders, and cores tested at 35 days. "PC" is portland cement and "PLC" is portland-limestone cement. From Thomas et al. 2010.

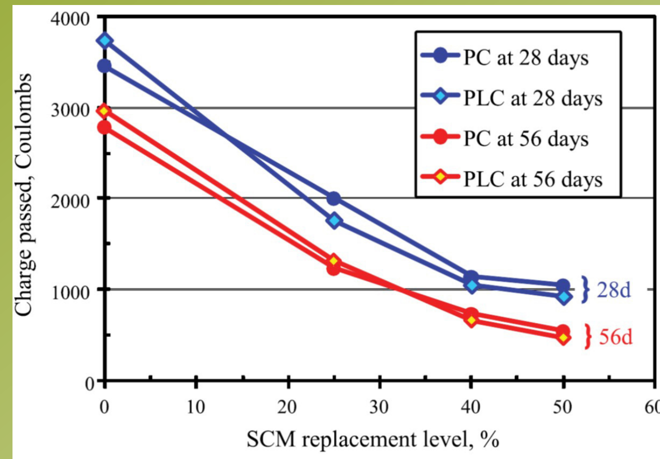

Figure 2: AASHTO T 277/ASTM C1202 testing of portland cements (PC) and portland-limestone cements (PLC) with various levels of an SCM. Cylinders were cast on site during field trials. From Thomas et al. 2010.

Mattamy National Cycling Center (Velodome), Milton, Ontario
(Photo courtesy of the Cement Association of Canada)

Tim Horton's Field, Hamilton, Ontario
(Photo courtesy of the
Cement Association of Canada)

Davis Wade Stadium, Starkville, Mississippi
(Photo courtesy of Prof. I. Howard)

References:

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