Cement Association of Canada
Association Canadienne du Ciment

A TECHNICAL INTRODUCTION TO

Portland-Limestone Cement

for Municipal and Provincial Construction Specifications

MAY 2021

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Acknowledgments

The Cement Association of Canada would like to thank its members for their contributions to this resource, in addition to R. Douglas Hooton, Professor, University of Toronto and Michael D.A. Thomas, Professor, University of New Brunswick.

Photography

COVER
Top left: BC Children's Hospital Teck Acute Care Centre, Vancouver, BC. Architect: HDR and ZGF Architects.
Right: Vancouver House, Vancouver, BC. Architect: Bjarke Ingels, DIALOG and Janes K.M. Cheng Architects. Recipient of a 2015 Canadian Architect Award of Excellence.
Bottom left: Blair Station, Ottawa Light Rail Transit Confederation Line, Ottawa, ON

APPENDIX A
Left: 1 Yorkville Condominium, Toronto, ON. Architect: Rosario Varacalli. Recipient of the 2020 Ontario Concrete Award for Mid-to-High Rise Residential: Cast-in-Place.
Top right: Lafarge-Lake Douglas Station, Evergreen Line, Coquitlam to Vancouver, BC. Architect: DIALOG. Photo credit: Brett Hitchins Studio.
Bottom right: Simon Fraser University's Living Lab building, Surrey, BC. Architect: Revery Architecture.

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Contents

Introduction

With recent updates to the Canadian Standards Association (CSA) specifications relating to concrete and cementitious materials, the Canadian cement industry is fully poised to transition from the manufacturing of traditional Portland Cement (PC) to Portland-limestone Cement (PLC), including PLC-based blended Hydraulic Cement. In order to facilitate the transition towards PLC across Canada, the Cement Association of Canada has compiled this information package to assist agencies in their due diligence assessment for product adoption in local specifications.

Should additional information be required, or if your jurisdiction is interested in a webinar session with CAC staff, please contact us.

What is Portland-limestone Cement?

Portland-limestone cement is a more sustainable, lower carbon cement that reduces CO_2 emissions by up to 10% while still producing concrete of equivalent performance, including comparable strength and durability, to concrete produced with Portland cement.

Portland-limestone cement's 10% reduction in CO_2 emissions occurs during the cement manufacturing process. While Portland cement may contain up to 5% ground limestone, Portland-limestone cement is made by intergrinding up to 15% limestone, reducing the amount of clinker required. By reducing the amount of clinker used in the manufacturing process, the associated energy demand and process emissions per tonne of PLC is reduced. As a result, the CO_2 emissions associated with PLC are less than those of traditional PC, while equivalent performance is maintained. Overall, the transition to PLC has the potential to save Canada approximately one megatonne of CO_2 emissions annually.

Why Portland-limestone Cement?

Concrete is the most widely used construction material on earth and increasing quantities are being produced to meet the needs of increased global population and urbanization. Portland cement, the main binder used in the production of concrete, is responsible for up to 90% of the embodied energy and carbon of concrete, and up to 8% of global anthropogenic CO_2 emissions. Over the last 30 years, the cement industry, especially in Canada, has invested in new production facilities that have substantially reduced its energy use and CO_2 emissions. In addition, the cement and concrete industry has widely adopted the use of supplementary cementing materials (SCMs) and chemical admixtures to improve performance and further reduce the cement clinker content of concrete, but global demand for concrete continues to increase.

In the last ten years, Portland-limestone cements have been introduced and adopted in standards to meet the challenge of further reducing its CO_2 emissions by reducing the clinker content of cement without impacting on the performance of concrete.

How is Portland-limestone Cement Manufactured?

Portland-limestone cement’s manufacturing process involves modifying the clinker, calcium sulphate and limestone proportions before the final grinding takes place. The limestone, being a softer material, is ground finer than the clinker, though both the clinker and the limestone in PLC are ground finer than in traditional Portland cement. The finer particle size and the particle size distribution in PLC have a significant impact on the properties of the final product — concrete. Along with selection of component proportions, this process of achieving the proper size and distribution of particles in PLC is commonly referred to as “optimizing” the cement.

The result of this optimization process is shown in Figures A and B below:

Figure A: Portland Cement

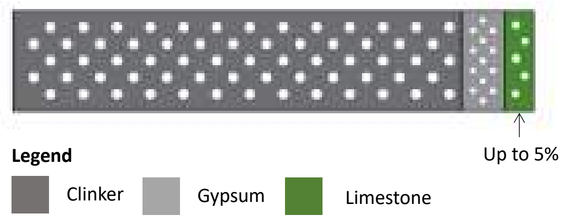
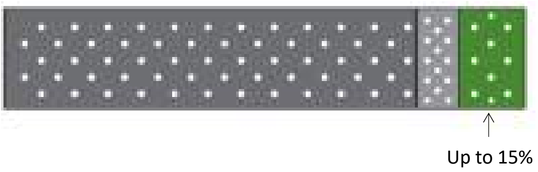


Figure B: Portland-limestone Cement



History of Portland-limestone Cement Use

Portland-limestone cement has been used in Europe for over 35 years and has a long-established record of field performance in a variety of exposure conditions and applications. In Europe, Portland cement is considered a premium product, as low-clinker cements (i.e. cements with a low clinker-to-cement ratio) are more prevalent than in North America. European cement standards allow up to 35% limestone content in PLC, which can restrict the use of such concrete mixes to select applications as limestone content increases. Canadian standards, meanwhile, have limited the inclusion of limestone in PLC to 15% in order to maintain equivalent performance when compared to tradtional Portland cement concretes.

Research on PLC with Canadian source materials began in 2006 before PLC was first introduced to the Canadian Standards Association cementitious materials standard in 2008 and concrete materials standard in 2009.

Canadian Specifications for PLC

The definition and specifications for PLC are contained in the CSA A3000 Cementitious Materials Compendium Standard. The specifications for using PLC in manufacturing concrete are contained in the CSA A23.1 Concrete Materials and Methods of Concrete Construction Standard.

CSA A3000 defines PLC and specifies its requirements in Clause 4.1, as highlighted below in Table 1. “The proportion of limestone in Portland-limestone cement shall be > 5% and ≤ 15% by mass”, and performance limits are the same as for traditional Portland cement of the same type.

Table 1: CSA A3000 Cement Types

Name	Portland cement type	Portland-limestone cement type‡	Blended hydraulic cement type	
			Blended portland cement*	Blended portland-limestone cement†
General use cement	GU	GUL	GUb	GULb
Moderate sulphate-resistant cement	MS	MSL	MSb	MSLb
High early-strength cement	HE	HEL	HEb	HELb
High sulphate-resistant cement	HS	HSL	HSb	HSLb

** The suffix “b” indicates that the product is a blended portland cement.*
† The suffix “Lb” indicates that the product is a blended portland-limestone cement.
‡ The suffix “L” indicates that the product is portland-limestone cement.

Note: Moderate and low heat of hydraftion cement types were removed as part of the latest CSA A3000 ammendment in May 2021.

Testing and Performance

Extensive research in Canada has demonstrated that PLC produces concrete with strength and durability properties equal to that produced using traditional Portland cement. A series of relevant documents containing testing information and performance analysis can be found in the References section of this report. Of particular relevance are reports prepared for the Portland Cement Association (Tennis et al. 2011, Thomas and Hooton 2010, and Hooton et al 2007), which identify the effects of PLC on both fresh and hardened concrete, as well as microstructure and chemical composition. For ease of reference, selected properties have been highlighted below.

Workability

The workability of a PLC concrete mix is influenced most significantly by the fineness of the limestone. PLC is handled and can be used following the same workability approaches as for conventional Portland cement (i.e. use of superplasticizers and other additives will achieve the same desired results).

Setting Time

Cements with increased fineness and increased levels of fine limestone may have a slight accelerating effect on setting time (Hooton et al, 2007), but there have been no significant differences in time of set reported from field use to date.

Particle Size Distribution

In comparing PC to PLC at 15% limestone substitution, the Blaine fineness is approximately 5-10 m^2/kg higher for every 1% increase in limestone content. This maintains equal clinker particle size to be obtained and the increased level of microscopic particle packing allows PLC to achieve equivalent performance in strength, resistance to freeze-thaw and de-icer salt scaling, chloride permeability and chloride diffusion, and alkali silica reactivity with a lower clinker factor and lower embodied energy and carbon.

Strength

Concrete strengths achieved by PLC concrete mixes containing up to 15% interground limestone are consistently comparable to that of PC concrete, both in terms of early strength development and ultimate compressive strength. As with all concrete properties, the type of cementitious material is not the sole variable affecting concrete strength, but PLC concretes provide similar strength performance as traditional PC concretes when equivalent materials are used, as shown in Figures 1 and 2 below.

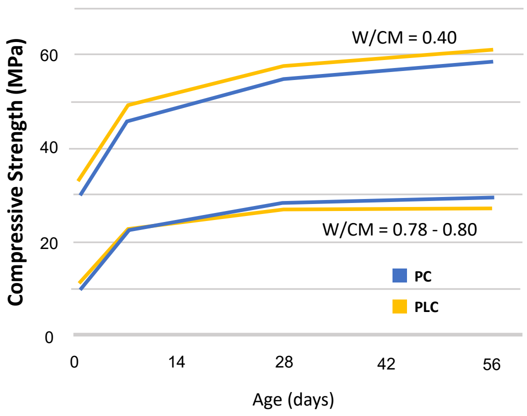


Figure 1: Strength development of PC and PLC without SCM at W/CM – 0.78 to 0.80 and 0.40 (Thomas and Hooton 2010)

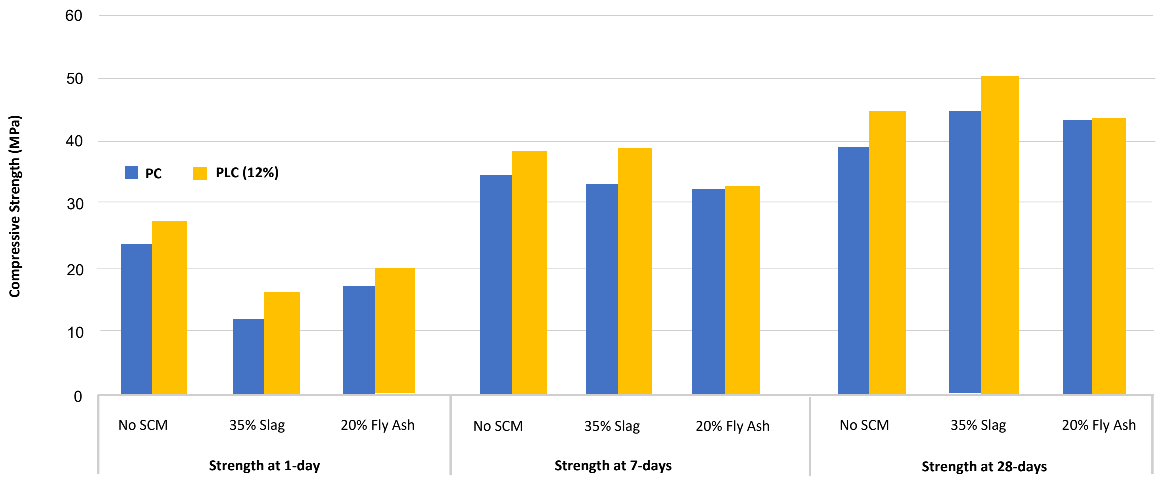
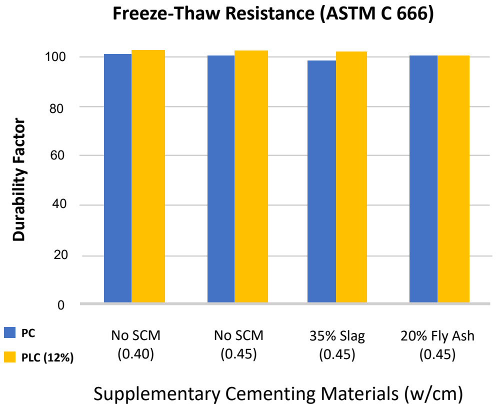
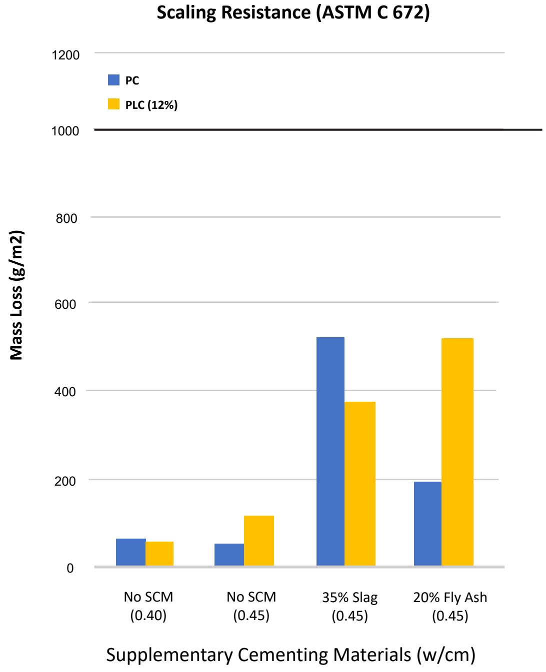


Figure 2: Strength development of PC and PLC mixes with and without SCM at W/CM = 0.45 (Thomas and Hooton 2010)

Freeze Thaw Durability and Scaling

The freeze-thaw and deicer-salt scaling data collected to date, as it pertains to PLC concretes, has shown no consistent difference between the behavior of equivalent PC mixes.





Note: While ASTM C 672 does not specify a limit for mass loss, some transportation agencies in North America have set maximum acceptable criteria, typically 1,000 g/m² or greater as determined by separate test protocols.

Figure 3: Results of freeze-thaw and de-icer salt scaling tests for PC and PLC concretes with and without SCM (Thomas and Hooton 2010)

Resistance to Chloride Penetration

Studies to date indicate that PLC concrete provides similar resistance to the penetration of fluids as PC concrete.

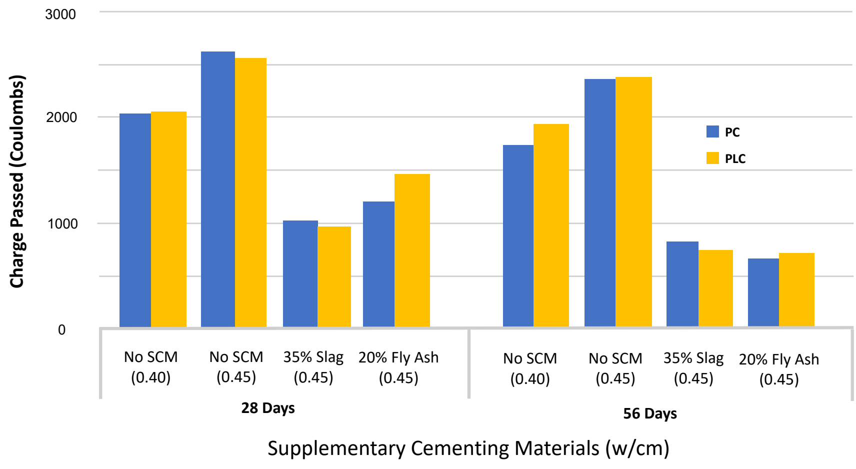
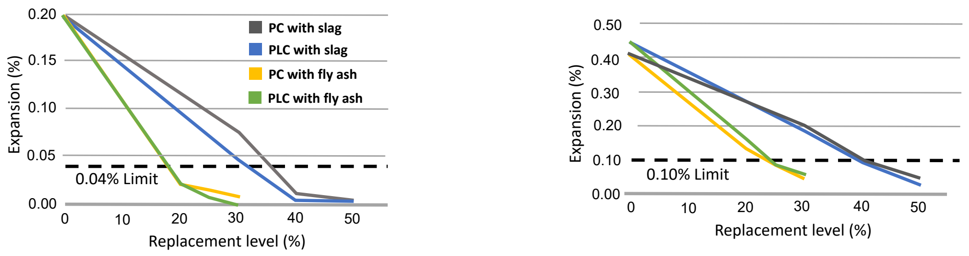


Figure 4: "Rapid Chloride Permeability Test" (ASTM C1202) data for PC and PLC concrete with and without SCM (Thomas and Hooton 2010)

Mitigating Alkali Silica Reactivity

For Alkali Silica Reactivity (ASR), tests have been performed on PC and PLC mortar bars and concrete prisms containing alkali silica reactive aggregates, as highlighted in Figure 5. The data has shown that there is no consistent difference between expansions produced with PC compared with PLC. There has also been no difference observed in the level of SCMs needed to mitigate ASR expansion.



a) Concrete prisms stored for 2 years over water at 38°C (100°F)

b) Mortar bars immersed for 14 days in an NaOH solution at 80°C (176°F)

Figure 5: Expansion results for concrete (ASTM C1293) and mortar (ASTM C1567) produced with alkali-silica reactive aggregate and blends of PC-SCM or PLC-SCM (Thomas et al 2013)

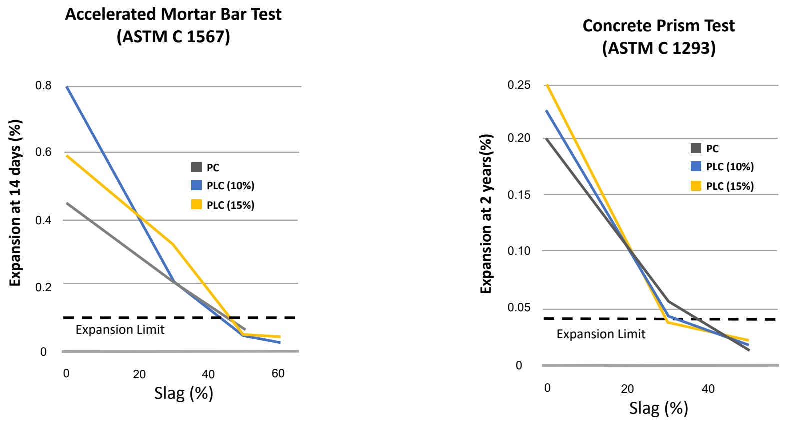


Figure 6: Expansion results from accelerated mortar bar test (left) and concrete prism test (right) from Study 4 using alkali-silica reactive siliceous limestone (Thomas et al 2010)

Shrinkage

The drying shrinkage of concrete prisms produced with PC with and without SCMs is similar to concrete prisms produced with PLCs containing limestone contents of 10% and 15% with and without SCMs.

Table 2: CSA A23.1 (ASTM C157) Drying Shrinkage (2009 Field Data, w/cm = 0.40)

Length change (%)	GU 100%	PLC10 100%	PLC15 100%	GU 70% Slag 30%	PLC10 70% Slag 30%	PLC15 70% Slag 30%
28 days	0.036	0.037	0.037	0.026	0.027	0.025
1 year	0.069	0.061	0.062	0.058	0.052	0.053
2 years	0.067	0.068	0.065	0.062	0.06	0.067

High Early Strength

As part of the cement and concrete industry's testing in the product development of PLC, a series of high early strength gain tests were performed, including collaboration with the precast concrete industry and Canadian Precast/Prestressed Concrete Institute (CPCI), primarily to demonstrate performance where early stripping of formwork, accelerated curing and handling of elements is common practice. As demonstrated in Figure 7 below, early strength gains for PLC concretes are equal to traditional mixes.

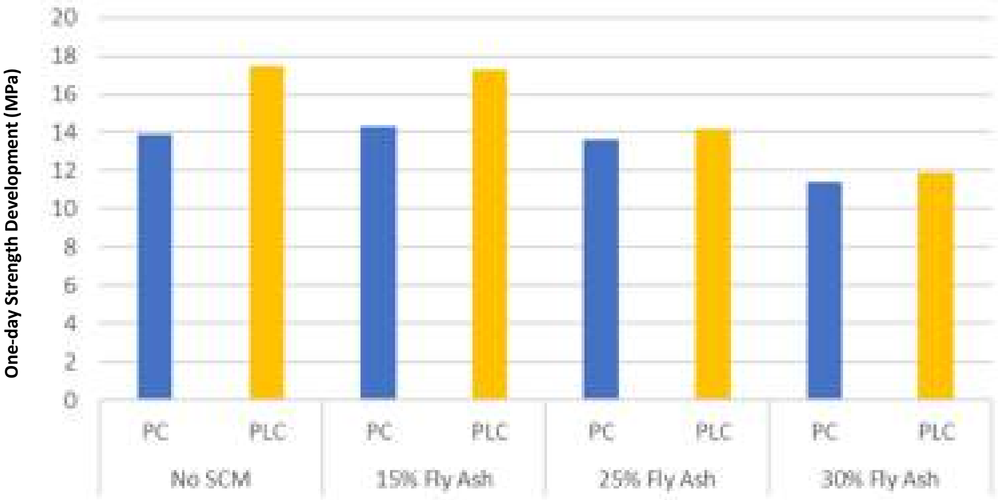


Figure 7: High early strength gain in PC and PLC concrete (Tennis et al. 2011)

Sulphate Exposure

In 2010, the Cement Association of Canada initiated, with the University of Toronto and the University of New Brunswick, a PLC concrete sulphate resistance test program (Hooton and Thomas 2016). The program includes several different PLC and PC mix designs that include various levels of SCM replacements that are exposed in several different sulphate solutions and is ongoing. This program has produced consistent test results demonstrating the ability of PLC to produce durable sulphate-resistant concrete, even in low-temperature exposures. This program contributed to the extensive testing and review of PLC before it was adopted by the CSA standards and approved for use in sulphate exposure environments.

It should be noted that the current Canadian PLC sulphate test program is among the longest running programs of its kind in the world. The test specimens continue to be monitored by the Canadian cement industry to evaluate and record their performance over time.

An update to the sulphate resistance test program (Hooton and Thomas 2016) was completed in 2018. An excerpt from this update for sodium and magnesium sulphate solutions is highlighted in Tables 3 and 4, respectively.

Table 3: Visual Ratings of 0.40 w/cm concretes in outdoor exposure for up to 90 months exposure in Sodium Sulphate solution (Concentration 15,000 SO4 mg/L) (Hooton and Thomas 2016 - 2018 Update)

Exposure Period (months)	12	24	36	54	90
GU	Severe	Severe	Severe	Severe	Severe
GU 40% Slag	Undamaged	Minor	Minor	Minor	Moderate
PLC9	Severe	Severe	Severe	Severe	Severe
PLC9 40% Slag	Undamaged	Minor	Minor	Minor	Moderate
PLC15	Severe	Severe	Severe	Severe	Severe
PLC15 40% Slag	Undamaged	Undamaged	Undamaged	Minor	Moderate
HS1	Undamaged	Minor	Moderate	Severe	Severe

From the visual assessments of the field prisms highlighted in Table 3, after 90 months exposure, the performance of Type GU cement combined with 40% slag is similar to those of Type GUL PLC-9 and PLC-15 cements with 40% slag, showing moderate levels of surface damage

Exposure Period (months)	8	21	33	70
PLC10.5	Minor	Moderate	Severe	Severe
PLC10.5 25% Fly Ash	Undamaged	Undamaged	Undamaged	Minor
PLC10.5 35% Fly Ash	Undamaged	Undamaged	Undamaged	Undamaged
PLC10.5 40% Slag	Undamaged	Undamaged	Undamaged	Minor
PLC10.5 50% Slag	Undamaged	Undamaged	Undamaged	Undamaged
HS2	Undamaged	Undamaged	Minor	Minor-Moderate
HS3	Undamaged	Undamaged	Minor	Minor

After 70 months exposure, Type GUL cement, PLC-10.5 with 40% slag is performing the same as two Type HS Portland cements (minor damage), and PLC-10.5 with 50% slag is performing better with no visual damage. The PLC-10.5 with 25% Class F fly ash is performing similarly to the two HS cements while the PLC-10.5 with 30% Class F fly ash is showing no evidence of damage.

Table 4: Visual Ratings of 0.40 w/cm concretes in outdoor exposure for up to 90 months exposure in Magnesium Sulphate solution (Concentration 15,000 SO4 mg/L) (Hooton and Thomas 2016 - 2018 Update)

Exposure Period (months)	12	24	36	54	90
GU	Severe	Severe	Severe	Severe	Severe
GU 40% Slag	Minor	Minor	Minor	Minor	Minor-Moderate
PLC9	Severe	Severe	Severe	Severe	Severe
PLC9 40% Slag	Minor	Minor	Minor	Minor	Minor-moderate
PLC15	Severe	Severe	Severe	Severe	Severe
PLC15 40% Slag	Minor	Minor	Minor	Minor	Minor-Moderate
HS1	Undamaged	Minor	Minor	Moderate	Severe

From the visual assessments of the field prisms given in Table 4, after 90 months exposure, the performance of Type GU cement combined with 40% slag is similar to those of Type GUL PLC-9 and PLC-15 cements with 40% slag, showing minor-moderate levels of surface damage. The Type HS cement concrete is showing a moderate level of damage.

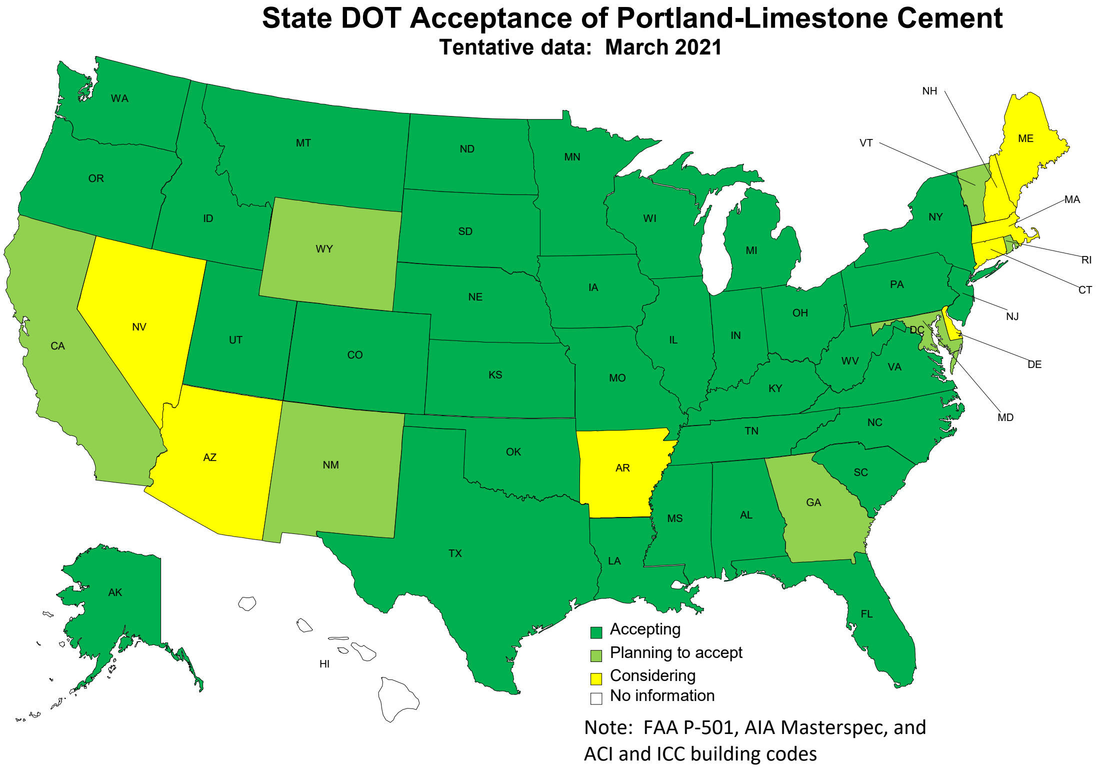
Exposure Period (months)	8	21	33	70
PLC10.5	Minor	Moderate	Severe	Severe
PLC10.5 25% Fly Ash	Undamaged	Undamaged	Minor	Minor
PLC10.5 35% Fly Ash	Undamaged	Undamaged	Minor	Minor
PLC10.5 40% Slag	Undamaged	Undamaged	Minor	Minor
PLC10.5 50% Slag	Undamaged	Undamaged	Minor	Minor
HS2	Undamaged	Minor	Minor	Minor
HS3	Undamaged	Undamaged	Minor	Minor

After 70 months exposure, the PLC-10.5 mixtures with 40% slag, 50% slag, 25 and 30% Class F fly ash are performing the same as the two Type HS Portland cements (minor damage).

Use in Other Jurisdictions

Portland-limestone cement has an extensive proven track record in Europe in a variety of commercial and residential applications for over 35 years. The most popular cement sold in Europe today is PLC (CEM IIA-L) with a limestone content of up to 20%, though cement standards allow for PLC to be manufactured with up to 35% limestone content. It should be noted, however, that equivalent performance to regular Portland cement is not the objective of the European cement standards, in contrast to Canada where equivalent performance has limited PLC to 15% limestone content.

In the United States, PLC was introduced into ASTM and AASHTO specifications in 2012. The level of acceptance and inclusion by Departments of Transportation in the US continues to grow and are shown in darker green-coloured states set out in Figure 8. Acceptance of PLC in most of the states bordering Canada is noteworthy.



State DOT Acceptance of Portland-Limestone Cement
Tentative data: March 2021

🟩 Accepting
🟩 Planning to accept
🟨 Considering
☐ No information

Note: FAA P-501, AIA Masterspec, and ACI and ICC building codes

Figure 8: Map of acceptance by transportation authorities in USA (PCA 2021)

Use in Canada

Since its introduction in Canadian project specifications, over 10,000,000 m^3 of PLC concrete has been placed. Through its inclusion in the CSA A3000 and CSA A23.1/A23.2 standards for cement and concrete, PLC is recognized within the National Building Code of Canada, and has been utilized in both private and public construction projects across Canada. A limited list of projects that have incorporated PLC in Canada is included in Appendix A. With respect to transportation agencies, a summary of the standing of PLC by province is highlighted in the figure below.


🟩 Accepting
🟩 Planning to Accept
▨ Not accepting at this time

Figure 9: Map of acceptance by provincial transportation agencies in Canada (CAC 2021)

Accepting:

British Columbia (except structural precast concrete and severe sulphate environments)

Alberta (approved as “Potential Product”, except bridge decks >1,500 m^2)

Saskatchewan

Manitoba (limited to surfacing and grading)

Ontario

Quebec (limited to concrete pavements)

Nova Scotia (limited to Roller Compacted Concrete)

New Brunswick

Planning to Accept:

Newfoundland and Labradour (planning to accept in 2021)

Not Accepting

Prince Edward Island

Yukon

Northwest Territories

Nunavut

Carbon Reduction Potential

Portland-limestone cement reduces CO_2 emissions compared to traditional Portland cement, yet produces concrete of equivalent strength and durability, so it can be adopted without any changes in concrete proportions or performance. Once widely adopted across the country, PLC will reduce Canada's greenhouse gas emissions by up to one megatonne annually.

PLC is also unique as it can be combined with other processes and technologies to further reduce the carbon intensity of concrete. For example, use of Type GUL to replace GU cement in concrete does not preclude the use of other carbon reducing strategies, such as:

a) the use of supplementary cementing materials (SCMs) like fly ash and slag in blended cements and/or concrete, or;

b) the use of newer processes involving the addition of carbon dioxide in concrete production (Carbon Capture, Utilization and Storage (CCUS) technologies that are becoming a key technology in concrete's low-carbon transition).

An example of the clinker reduction potential of PLC using SCMs at various substitution rates is highlighted in the figure below.

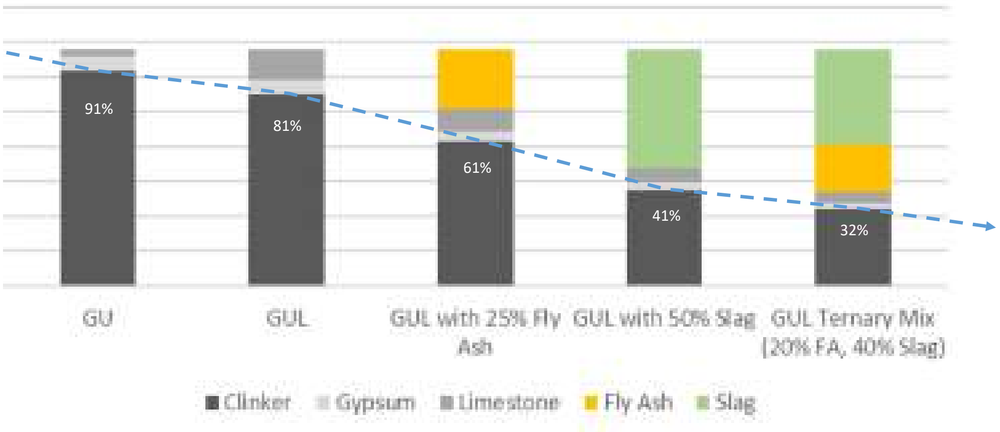


Figure 10: Clinker reduction potential of Portland Cement and PLC with and without SCMs (example for 340 kg cementitious content concrete mixture)

Summary

Introduced to Canadian concrete standards in 2009, Portland-limestone cement (PLC) concrete is now being commonly used in many jurisdictions in Canada as a sustainable direct replacement for Portland cement (PC) concrete with equivalent performance. It can be poured, pumped or placed using conventional means and can be finished as well or better than PC-based concrete.

As of 2020, all members of the Cement Association of Canada produce PLC, including facilities in British Columbia, Alberta, Ontario, Quebec, and Atlantic Canada. Local expertise is available to assist designers and regulators in the specification, implementation, and review of PLC concretes, as outlined in the following section.

Key Contacts

For more information on Portland Limestone Cement, please contact the following individuals:

- **Cement Association of Canada**
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- **Lehigh Hanson**
  Walter Dobslaw, P. Eng., Technical Sales Engineer
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- **St. Marys Cement Group**
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- **Ash Grove, a CRH Company**
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- **Professor Doug Hooton, University of Toronto** (d.hooton@utoronto.ca)
- **Professor Mike Thomas, University of New Brunswick** (mdat@unb.ca)

References

Hooton, R. D.; Nokken, M. R.; and Thomas, M. D. A., Portland-Limestone Cement: State-of-the-Art Report and Gap Analysis for CSA A3000, Portland Cement Association, SN3053, 2007, 59 pages. Available at: http://www2.cement.org/pdf_files/sn3053.pdf.

Tennis, P. D.; Thomas, M. D. A.; and Weiss, W. J., State-of-the-Art Report on Use of Limestone in Cements at Levels of up to 15%, Portland Cement Association, SN3148 by, 2011, 78 pages.

Thomas, M.D.A. and Hooton, R. D., The Durability of Concrete Produced with Portland-Limestone Cement: Canadian Studies, Portland Cement Association, SN3142, 2010, 28 pages.

Thomas, Michael D.A; Delagrave, Anik; Blair, Bruce; and Barcelo, Laurent, Equivalent Durability Performance of Portland Limestone Cement, Concrete International, December 2013, 7 pages.

Hooton, R.D. and Thomas, M. D. A., Sulfate Resistance of Mortar and Concrete Produced with Portland-Limestone Cement and Supplementary Cementing Materials: Recommendation for CSA A3000, Portland Cement Association, SN3285b, 2016, 28 pages. Data updated for 2018.

Portland Cement Association. (2021). Status of acceptance of portland-limestone cement in state DOT specifications. Retrieved from https://www.cement.org/cement-concrete/cement-and-concrete-basics-faqs/lists/cement-concrete-basics-faqs/what-is-portland-limestone-cement

Additional References

A more fulsome collection of technical reports, white papers and studies on the use of Portland-limestone cement can be found in the Dropbox link provided. The information is organized according to the folder contents as described in the list below.

PLC Reference File Folder

Environmental Benefits

a) Cement Association of Canada, "Environmental Product Declaration (EPD) for General Use (GU) and Portland-limestone (GUL) Cements", CSA Group, March 31, 2016.

b) Bushi, Lindita and Meil, Jamie, "An Environmental Life Cycle Assessment of Portland- limestone and Ordinary Portland Cements in Concrete", Athena Sustainable Materials Institute, January 2014.

Performance Testing and Analysis

a) Hossack, A. M.; Thomas, M. D. A.; Barcelo, Laurent; Blair, Bruce; and Delagrave, Anik, “Performance of Portland Limestone Cement Concrete Pavements Canadian field trials show equivalence”, Concrete International, January 2014.

b) Hooton, R. D., Nokken, M. R., and Thomas, M. D. A., Portland-Limestone Cement: State-of-the-Art Report and Gap Analysis for CSA A3000, Portland Cement Association, SN3053, 2007, 59 pages.

c) Aqel, M. A., Steam Cured Self-Consolidating Concrete and the Effects of Limestone Filler, Ph.D. Thesis, University of Toronto, 2016.

d) Hooton, R. D. and Thomas, M. D. A., Sulfate Resistance of Concretes Containing Portland-Limestone Cement, Presentation for American Concrete Institute, Alberta Chapter, March 2013.

e) Hossack, A. M. and Thomas, M. D. A., “Evaluation of the Effect of Tricalcium Aluminate Content on the Severity of Sulfate Attack in Portland Cement and Portland Limestone Cement Mortars,” Cement and Concrete Composites, Vol. 56, 2015c, pages 115 to 120.

f) Hossack, A. M. and Thomas, M. D. A., “The Effect of Temperature on the Rate of Sulfate Attack of Portland Cement Blended Mortars in Na2SO4 Solution,” Cement and Concrete Research, Vol. 76, 2015a, pages 136 to 142.

g) Hossack, A. M. and Thomas, M. D. A., “Varying Fly Ash and Slag Contents in Portland Limestone Cement Mortars Exposed to External Sulfates,” Construction and Building Materials, Vol. 78, 2015b, pages 333 to 341.

h) Smartz, B.W.; Laker, T.S.; and Van Dam, Thomas, Performance and Sustainability Application of Portland-limestone cements in concrete paving, Concrete International September 2013.

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APPENDIX A

Bayshore Shopping Centre, Redeveloped Parking Garage
Ottawa, ON

64,000 m³ (2011 – 2016)

- PLC with 40% to 60% Slag and 40mm Limestone
- Low Heat requirement, <0.04% Linear Shrinkage, Salt Scaling requirements, RCP <1000
- 3-feet thick raft slabs, 4 Parkades with 35 MPa-C1 up to 55 MPa concrete

YMCA: Building & Retaining Wall
Brantford, ON

~ 7,500 m³ (2016 – 2017)

- 75-80% PLC with 20-25% Slag and 20mm Limestone
- 25-N, 32-C2, 35-N/F2, and 50-F2 mixes
- Footings, slabs, walls, columns, retaining wall, high-early crane pads

Pan AM Soccer Stadium
Hamilton, ON

~ 11,000 m³ (2013 – 2014)

- Strengths ranging from 10 MPa for mud matt to 35 MPa-C1 structural walls
- Specialty mixes including SCC, Early Strength, and Cold Weather Setting
- LEED Silver

Milton Velodrome
Milton, ON

13,250 m³ (2013 – 2014)

- Strengths ranging from 10 MPa for mud matt to 40-C1 structural walls and slab
- Specialty mixes including Early Strength, and Cold Weather Setting
- LEED Silver

Hwy 401 & Hurontario Off-ramp
Mississauga, ON

~ 450 m³ (2010)

- 75% PLC and 25% Slag cement
- 30 MPa w/air concrete, tested for AVS, RCP, Salt Scaling, and Drying Shrinkage
- MTO Contract with 500 linear meter section, one lane wide

Repair of Hwy 6 & 403 Overpass
Hamilton, ON

~ 60 m³ (2017)

- 75% PLC and 25% Slag cement
- 30 MPa w/air concrete patch work mix design, meeting AVS and RCP (<2500C)
- MTO night work project
- Project example highlights compatibility of PLC with existing Portland Cement infrastructure

The Mark

Vancouver, BC

(2014)

- First building started with PLC in Vancouver area
- 47 storeys residential
- LEED Gold

Brock Commons
Vancouver, BC

~ 37,123 m^3 (2017)

- 18-storey hybrid building
- 2 x concrete elevator and staircase cores
- concrete topping on all floors
- UBC student residence building
- LEED Gold

Saint John Field House
Saint John, NB

2,700 m^3 (2018 – 2019)

- 127 000 ft^2 Complex features two indoor turf fields, 200 meter indoor track, fitness center, child care and newcomer connection services.

Highway 40
L'Assomption, QC

338 m^3 (2010)

- 100% PLC
- 35 MPa w/air concrete, tested for AVS, RCP, Salt Scaling, and Drying Shrinkage
- Left lane and shoulder of concrete pavement (228 m length)

Sidewalks for City of Montreal
Montreal, QC

±10 000m^3/year (2017 - 2020)

- 80% PLC with 20% of GUb-8SF
- 32 MPa w/air 0.45 W/C
- A23.2-22C Scaling resistance (<500g/m² mass loss)

Huron Church Road
Windsor, ON

1,050 m^3 (2020)

- Cement treated Open Graded Drainage Layer (OGDL) with PLC

Pay Center (Federal Government)
Miramichi, NB

5,500 m³ (2015- 2016)

- 107 000 ft² office space
- LEED Gold
- 25-N, 30-N, 30-F1, 32- C2, 35-N, 35 C1, 40-N

Cyberpark
Fredericton, NB

3,300 m³ (2018-2019)

- 150,000 ft² building, housing cybersecurity for Canada's infrastructure including defence systems, finance, transportation, hydro-electric production and water.
- 25-F2, 30 N-CF 35 N-CF, 32-C2 25 N Blockfill wall infill

Metro Distribution Facility
Toronto, ON

2,000 m³ (2020)

- Roller Compacted Concrete (RCC) truck yard with PLC

Charlie West Condo
Kitchener, ON

27,000 m³ (2018-2020)

- 2,700 m³ in raft slab foundations
- Concrete up to 65 MPa in Strength

One Wellington Condominium
Brantford, ON

7,500 m³ (2018-2020)

- Waterproof Concrete, Tempo High Early Concrete helped keep the customers schedule
- 1,200 m³ raft slab

Google Building
Kitchener, ON

17,000 m³ (2019-2021)

- 6,000 m³ of raft slabs
- Included low heat concrete mixes

Library and Archives Preservation Facility
Ottawa, ON

22,000 m³ (2020- 2021)

- GUL with up to 40% Slag
- CSA Class C-1, including Salt Scaling requirements, RCP <1500
- 3’ thick Type LH raft slabs and interior wall sections of 30’ in height.

Mattawa Plains Compound
CFB Petawawa, ON

30,000 m³ (2018-2020)

- 100% GUL with 20-30% Slag and 20mm Limestone.
- 25-N, 30-N/F-1, 32-C2, 35-N/C-1.
- 10 Structures on 80 acres including Parking structures with both High-early strength and Corrosion Inhibitor.

Centre Slush Puppie Four Ice Center
Gatineau, QC

10,000 m³ (2019-2021)

- 100% GUL with 20%-30% Slag.
- CSA Class C-XL 50 MPa with Granite for the Zamboni slabs to all 4 ice pads.
- CSA Class C-1 35 MPa with 30% Slag, Corrosion Inhibitor and HR Superplasticizer for the parking garage portion.

National Holocaust Monument
Ottawa, ON

3,350 m³ (2018-2020)

- Architectural mixes with Type GUL with up to 20%-60% Slag.
- CSA Class C-1 35 MPa SCC mix with 50% Slag.
- CSA Class C-1 35 Mpa with 30% Slag, Corrosion Inhibitor and HR Superplasicizer.
- Received the Ontario Concrete Award for Architectural Hardscape.

Additional Projects

Concrete Pavement Test Sites (2007)

- Gatineau Ready Mix Concrete Plant, Gatineau, QC
- Exshaw Cement Plant, Exshaw, AB
- Brookfield Cement Plant, Brookfield, NS

Ontario

- Reliance Construction Condos, Oakville (2019-2021)
- Trafalgar Heights, Oakville (2018-2021)
- Buttcon Limited, Hyatt Hotel, Niagara Falls (2020-2022)
- Berkeley Parliament Developments Condo Tower, Toronto (2016-2019)
- Bel East Corporation 25-storey Condo, Toronto (2017-2020)
- Lash Distinction 14-storey Condo, Toronto (2017-2020)
- Mattamy Homes, Trafalgar Rd and Highway 5, Oakville
- Blair Station, Ottawa Light Rail Transit Confederation Line, Ottawa
- SOHO Italia Condominiums, 2020-2021, Ottawa (15,000 m^3)
- Parkdale Condominiums, Ottawa (16,000 m^3)
- Petrie’s Landing Condominiums, Ottawa (12,000 m^3)
- Le Colombia Condominiums, Ottawa, (8,000 m^3)
- Baseline Condominiums, Ottawa (14,000 m^3)
- Metal Works Phase 3 Condo, Guelph (9 000 m^3)
- Jackson Condos, Hamilton (7,000 m^3)
- Gallery Condos, Burlington (20,000 m^3)
- Casa Di Torre Condo, Hamilton (7,000 m^3)
- Multiple Industrial Buildings, Guelph and Brantford (20,000 m^3)
- Gaslight District Condos Cambridge

Ontario Ministry of Transportation (limited basis)

- Barrier Wall, QEW – Burloak Drive to Brant Street (Nov 2009)
- Concrete Pavement, Highway 401 to Hurontario Street (Sep 2010)
- Slipform Barrier, Hwy 2 (west), east of Front Street, Sarnia (Oct 2011)
- Sidewalk, Airport Road near Collingwood (Jun 2012)
- Precast Median Barrier, Hwy 401 near Trenton, Glen Miller Road to Hillaire Road (Nov 2012)
- Sidewalk, Laird Overpass, Guelph (Oct 2013)

British Columbia

- Telus Gardens, West Georgia and Seymour, Vancouver
- Solo District, Willingdon and Lougheed, Burnaby
- Vancouver House, Pacific and Howe, Vancouver
- Teck Acute Care Centre, BC Children’s Hospital, Vancouver
- Wall Centre False Creek
- Anthem Station Square, Burnaby
- Axiom Cadero 26-storey residential building, Vancouver
- Arbutus Shopping Centre, Vancouver
- Evelyn residences by OMNI, West Vancouver
- HWY 1 248st overpass
- HWY 1 Mountain Highway Interchange
- Ongoing work on interchange updates on HWY 1 in Vancouver
- Annacis Island Wastewater Treatment Plant
- North Shore Wastewater Treatment Plant
- Iona Wastewater Treatment Plant upgrade
- All City of Vancouver works
- YVR projects have been supplied PLC for the last two years

Atlantic Canada

- Dr. Georges-L.-Dumont Surgical Suite Addition, 2018-2019, Moncton, New Brunswick (3,400 m^3)
- Horizon Place Apartments, 2016-2017, Moncton, NB (15,600 m^3)
- Hyatt, 2018-2019, Moncton NB (5,200 m^3)
- Emma Place, Moncton, New Brunswick
- iHop, Moncton, New Brunswick
- Day and Ross, Moncton, New Brunswick
- East Hants Pool, 2018-2020, Truro, Nova Scotia (1,600 m^3)
- Hilton, Fredericton, New Brunswick
- Sobeys, Fredericton, New Brunswick
- Shannex, Fredericton, New Brunswick
- 81 Regent Street, Fredericton, New Brunswick
- Integrated Health Services CFB Gagetown, Fredericton, New Brunswick
- Waverly Mixed-Use Office Building, 2019-2020, Fredericton, New Brunswick (3,400 m^3)
- Marshalls, Fredericton, New Brunswick

Atlantic Canada (continued)

- Centennial Bridge, Miramichi, New Brunswick
- 2 Shannex, Miramichi, New Brunswick
- Saint John, New Brunswick
- Brunswick Square, Saint John, New Brunswick
- Giant Tiger, Saint John, New Brunswick
- Petrocan/A&W, Saint John, New Brunswick
- Saint John Laundry Building, Saint John, New Brunswick
- Shepody Bridge, Sussex, New Brunswick
- Compound Maintenance Facility Fundy Park, Sussex, New Brunswick
- Wharf Repairs at Metaghan, Yarmouth, Nova Scotia
- Wharf Repairs at Wedgport, Yarmouth, Nova Scotia
- TRU Hotel by Hilton, 2019-2020, Yarmouth, Nova Scotia (650 m^3)
- Net Zero Energy Building, Yarmouth, Nova Scotia
- Par en Bas School, 2020, Yarmouth, Nova Scotia (1,150 m^3)

Quebec

- Approved for all City of Montreal buildings
- Approved for MTQ concrete paving
- Sobeys warehouse Pointe-Claire (2020)
- 50 Storey condos ‘’Tour des Canadiens’’, Montreal
- REM project (2020-2023)
- Centre Hospitalier Universitaire Sainte-Justine, Montreal