LAFARGE NORTH AMERICA

PRESS RELEASE

CONTACT: Lisa Birnie
403-292-9246

LOCAL PROJECT WINS GLOBAL RECOGNITION

The Innovative Shawnessy LRT Station Wins Multiple Awards

CALGARY, AB, September 15, 2006 **--** Today, hundreds of light rail transit stations (LRTs) are being planned, built and expanded around the world. There is one very unique station in Calgary – with an ultra-thin canopy roof system that is truly one-of-a-kind. Made with a revolutionary, ultra-high performance material called Ductal®, the innovative "Shawnessy LRT Station" has captured significant national and international attention by winning the following prestigious awards:

- **The 2006 fib** (fédération internationale du béton/ International Federation for Structural Concrete) **Award for Outstanding Concrete Structures.** Attributed every four years, this highly esteemed award serves to enhance international recognition of concrete structures that demonstrate the versatility of concrete as a structural medium. Selected projects represented 14 different countries from North America, Europe and Asia.
  Presented at the fib Congress in Naples, Italy, in June/06.

- The **2006 CERF** (Civil Engineering Research Foundation) **Charles Pankow Award for Innovation.** This award recognizes the contribution of organizations involved in a collaborative effort that demonstrate innovative approaches to design, materials use or construction research and development that transfer into practice and result in increased productivity and performance in the industry. This competition is open to all U.S., international public, private, academic and government organizations. *Presented at the ASCE (American Society of Civil Engineers) OPAL (Outstanding Projects & Leaders) Awards Gala in Washington, DC, in April/06.*

Vic Perry, *left*, vice president and general manager - Ductal®, Lafarge North America, accepts the CERF Charles Pankow Award for Innovation from Joseph A. "Bud" Ahearn, chair of the group's Industry Leaders Council.

- The **2005 PCI** (Precast/Prestressed Concrete Institute) **Design Award** for **Best Custom Solution** (Best in Class/ Specialized Category).

- The **2005 PCI/ Harry H. Edwards Industry Advancement Award:** The purpose of this award is to unleash fresh, uninhibited concepts that hold the potential to move the industry to the next generation of technology for industry materials, products, processes and applications. *The above two awards were presented at the PCI Awards Gala in Palm Springs CA, in October/05.*

- **2005 Finalist - ASTech** (Alberta Science & Technology Foundation) "Outstanding Leadership in Alberta Technology" category. This award recognizes individuals or teams that play a leadership role in a technological innovation or breakthrough and is based on criteria such as technological sophistication, a potential for commercial impact, international peer recognition and overall contribution to Alberta technology. *Recognized at the ASTech Gala in Calgary, in October, 2005.*

- The **ACI** (American Concrete Institute/Alberta Chapter) **2005 Award of Excellence for Design & Construction in Concrete.** This award recognizes originality of architectural and engineering design utilizing concrete, achievement of owners' needs through the use of concrete, construction complexity and quality of execution, uniqueness of concrete application, advantages in use of concrete compared to other construction materials and innovation in materials, applications or design. *Presented at the ACI Awards Gala in Calgary, in May, 2005.*

- The **2005 APEGGA** (Association of Professional Engineers, Geologists and Geophysicists of Alberta) **Project Achievement Award.** This award recognizes projects that demonstrate engineering, geological or geophysical skills and represent a substantial contribution to technical progress and the betterment of society. *Presented at the APEGGA "Summit Awards®" Gala in Calgary, in April 2005.*

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The innovative solution was the result of solid collaboration between: The City of Calgary, the University of Calgary (CCIT), Stantec Architecture Ltd. (formerly CPV Group Architects & Engineers Ltd.), Lafarge North America (Precast & Ductal®), Speco Engineering and Strudes Inc. *(See Collaborators /Contact List attached.)*

What makes this LRT Station so unique?

1. It has the world's first ultra-thin-shelled canopy system constructed with the new Ductal® technology and opened the door for architects to create structures that were once unimaginable.

2. The innovative production process involved the first-known use of injection mold casting techniques (for structural precast elements) in Alberta and altered conventional paradigms within the precast concrete industry.

3. It involved the first collaboration between industry and the University of Calgary – who put to use their new, state-of-the-art structural test bay facility at the "Calgary Center for Innovative Technology" (CCIT). It was here that a full-scale, single canopy prototype was assembled for crucial, extensive load tests (snow-load and wind uplift), utilizing a series of 90 strain gauges. The tests concluded that the canopy would not only carry full-factored live and dead loads without cracking, it surpassed the test criteria as outlined in the contract.

The new material technology called "Ductal®" is Lafarge North America's ultra-high performance, fiber reinforced concrete (UHPFRC) material that offers superior strength, durability, ductility and aesthetics, while providing highly moldable products with a quality surface. Compressive strengths reach up to 200 MPa (30,000 psi) and flexural strengths reach up to 40 MPa (6,000 psi). This unique combination of properties enables architects and engineers to create thinner sections and longer spans that are lighter, more graceful and innovative in geometry and form, while providing improved durability and impermeability against corrosion, abrasion and impact.

The Design
Community involvement was an integral component in the design of this station. To encourage public communication and involvement, consultation with the Shawnessy community was undertaken in February 2002 to develop a common understanding and vision.

Stantec Architecture Ltd. (formerly CPV Group Architects & Engineers Ltd.) created four designs and the community selected two for further refinement. The final design was a culmination of this positive, cooperative effort between consultant, client and community -- resulting in a dynamic structure, a visual metaphor of tree-like structures inspired by the natural setting of the nearby, extensive community greenbelt. The community's input established the importance of scale, massing, uniqueness and density of development -- alongside the acknowledgement of the natural, cultural and historical setting.

The station consists of twenty-four ultra-thin canopies (5.1 m x 6 m and just 20 mm thick /16′-9″ x 19′-8″ and ¾″ thick), supported on single columns, providing protection from the elements and lighting to the platform below. The canopies, curved in two planes, challenged the structural engineer in his design of the canopy shell without reinforcement. Stantec Architecture Ltd. (formerly CPV Group Architects & Engineers Ltd.), the project Engineer of Record, completed static and dynamic analysis to determine how the canopies should be configured and provided the engineering requirements for geometry, dead load, wind, snow, earthquake, dynamic and durability.

Since Canadian concrete design codes are incomplete when designing with a fiber reinforced, ultra-high performance material without reinforcement, the structural engineering firm, Strudes Inc., as part of the precast team, designed the Ductal® canopies through finite element modeling (FEM) analysis, which was subsequently validated through two separate FEM analyses performed by Kassian Dyck Associates and Speco Engineering.

The design, modeling and novel manufacturing processes created an original precast concrete structure by combining function with innovation. Originally conceived in a steel design, the canopies were changed early in the process to a precast concrete solution for economic, durability and aesthetic reasons. With an architectural design evoking images of the first-conceived steel system, the weightless appearance and airy environment created by the station surprises many. Upon closer examination, commuters realize that the canopies are not constructed of steel, but with sleek precast concrete with a high aspect surface finish and a once unimaginable structural thickness of only 20 mm (¾ in.).

Production
The canopy forms were constructed out of plate steel. A 3-D model of the casting and form was generated by computer technology. Form deflections and stresses were analyzed by FEM to ensure the form would meet the required tolerance and deflection criteria. Electronic representations (DXF files) were then transferred to a CNC high-definition plasma cutting bed, which produced the diaphragm profiles.

The mold was assembled on accurate jigs, which controlled location of the diaphragms. The rolled steel skin was drawn to the diaphragms and welded. It was determined that the form would have to rotate after casting to orientate the product with the curve down to allow unrestrained shrinkage to occur while, at the same time, supporting the casting. Since the form already had a rotation feature, the next logical step was to use the form to turn the product right side up when casting had sufficient strength. The steel form for the canopy was designed to rotate 90° in either direction from vertical. The first 90° rotation turned the canopy shell upside down. The top portion of the form was released to allow for unrestrained shrinkage as the Ductal® set. Once the material gained sufficient strength, the top portion of the form was re-secured and the form rotated 180° to an upright position, to allow for de-molding.



Full Scale Testing

Since the project involved the first use of a new material technology in a thin-shelled application, the owner (The City of Calgary) requested that a full-scale load test program be completed before accepting for use in a canopy system. FEM Modeling on critical load combinations by Speco Engineering (consultant to the City of Calgary) provided the location for strain gauges and end conditions for canopy-to-canopy connections. In a collaboration agreement with the University of Calgary, a full-scale canopy prototype was then assembled and installed at the new CCIT test facility. Extensive load tests (snow-load and wind uplift), utilizing a series of 90 strain gauges, concluded that the canopy would not only carry full-factored live and dead loads without cracking, it surpassed the test criteria.

The full scale testing and modeling of the canopy system with FEM provided not only a level of confidence but enabled the designers to re-validate the design assumptions and FEM techniques for future designs. This information will also be valuable for the development of a new design guideline and future Canadian codes for use with UHPFRCs. Upon successful completion of the testing program, manufacturing of the precast elements started in July of 2003 and the first precast elements were installed on site in September 2003.

Transportation

The canopies were supported by struts in three locations when assembled into the final structure. To transport the assembled canopies, special support frames were designed that would provide similar three-point contact and enable the transfer of these loads to the truck deck. Consideration was given to ensure that any flexing of the truck deck would not result in unexpected loads being imposed on the precast canopies.

Erection of the LRT Station

Erection of the precast components began in September of 2003. Due to scheduling and co-ordination requirements, the columns for the two station platforms were erected two weeks ahead of the remaining components. Nine columns on each platform were erected in one day.

After erection, the columns were aligned, the anchor bolts connecting the columns to the cast-in-place platform cross beams were tightened, and the gaps between the column bases and the cross beams were grouted with a high strength, non-shrink grout. After erection of the columns, temporary scaffolding was erected to support the canopies and position them at their proper elevation and alignment.

Because the canopies are supported at three points with a long moment arm to the column, each individual canopy had little resistance to torsion. Therefore, the design required a series of three canopies to be connected together to develop the capacity to resist torsion. Supporting the canopies on the scaffolding allowed for the connection of the series of three canopies before any load was introduced into the system.

Pre-positioning the canopies before connecting them to the columns addressed the tight tolerances of the canopy system. Because of the three dimensional nature of the design, the tolerances of the canopy system were very small and a shift in one plane could result in a larger movement in another dimension. By using conventional erection methods (connection of struts to columns followed by connection of canopy to struts), concerns arose about possible deflections of individual canopies after each canopy was erected.

On site, the canopies were lifted onto temporary supports and adjusted to their proper alignment and elevation. Once the canopies were installed, the struts were lifted into position using the assembly frame as support for the chain hoist. The struts were connected to the canopies and columns with stainless steel connections and attachment was accomplished through pinning and welding the struts to the columns and underside of the canopies.

An Architect's "Dream" becomes a "Reality"

A comparison of the architect's rendering (left) and the finished project (right).

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Press

Since completion of the Shawnessy LRT Station in June 2004, media coverage on the project and the material technology has been extensive, with related articles in numerous publications including:

- PCI Journal*
- Architectural Record ("Editor's Pick 2004")
- Architectural Products
- Composites Technology
- Report on Industry
- Concrete Products
- CAM (Construction Association of Michigan)
- MC (Manufactured Concrete) Magazine
- Sustainable Industries Magazine
- Concrete Décor Magazine
- Alberta Construction Magazine
- Canadian Journal of Civil Engineering
- E-Pegg (APEGGA)
- ASCE News
- The Calgary Sun
- The Calgary Herald**

*As a result of its two PCI Awards, the "**PCI Journal"** featured the Shawnessy Station on the front cover of the Sept/Oct/05 issue, together with a comprehensive 18-page article *(magazine cover at right is provided courtesy of PCI Journal.)*

**As an ASTech Award "Finalist", the Shawnessy Station was featured in a one-hour television special production titled "Alberta Innovation", on Oct. 15/05.
The video can be seen on the Alberta Innovation website at:
http://www.innovation.gov.ab.ca/general/video/innovation.html
Finalists were also highlighted in the Calgary Herald (Oct. 06/05).

Other Communications

- The Shawnessy Station is featured in the CCPE (Canadian Council of Professional Engineers) 2006 Commemorative (70th Anniversary) Calendar, "show-casing remarkable engineering works across Canada". Distribution includes 250,000 licensed Canadian Professional Engineers, Engineers-In-Training and Licensed Foreign Engineers.

- Lafarge featured the project in their 2005 wall calendar, with vast distribution to the company's North American employees and customers.

- Several related papers have been written and presented to numerous architectural/industry professionals.

SUMMARY

The project required commitment from all stakeholders and a common level of trust to enable utilization of a new material technology in a new application that had never before been attempted anywhere in the world. Although the canopies were originally conceived to be of steel, early in the design process it was recognized that Ductal® would provide a better solution and the City of Calgary approved this in the summer of 2002. The City of Calgary has been recognized as a leader in supporting technological innovations and using cutting edge innovative solutions in transportation infrastructure and other applications. It was through this support and leadership that this project has been realized to the benefit of Calgarians and advancement of the construction product technology.

Using a new material technology in a thin-shelled application had never before been attempted therefore it was imperative that technical issues be addressed to ensure the project could be completed as designed. In order to meet project schedule, design of the precast components and R&D testing started in the fall of 2002, to enable completion of a full-scale prototype for testing at the University of Calgary in the spring/summer of 2003.

The use of a new material demonstrated its successful performance in the world's first thin-shelled canopy system *and* demonstrated the advancement in precast concrete technology and the enormous potential of this innovation for future generations of concrete construction. The ability to use a "moldable" material to create newly conceived shapes and designs previously restricted by the characteristics of other construction materials is now possible.

The challenge ahead is to find the optimized shapes for each use. When this is determined, precasters, manufacturers and contractors can invest in the formworks to produce these pieces. The true economics of these systems will eventually bring value to the users in the standard mass production of optimized shapes.

Ductal's combination of properties (strength, durability, ductility, and aesthetics with design flexibility) facilitate the architect's and engineer's abilities to create new optimized shapes for construction. Overall, it offers solutions with advantages such as speed of construction, improved aesthetics, superior durability and impermeability against corrosion, abrasion and impact, which translates into reduced maintenance and a longer life span for the structure.

It is clear that the true benefits of this material technology are not yet fully recognized or realized. Within the next few years, much progress is anticipated in the area of optimized solutions. Further project developments with this technology in other applications will demonstrate and validate its true value.

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Lafarge in North America is the largest diversified supplier of construction materials in the United States and Canada. Its materials are used for residential, commercial, institutional and public works construction. It is a wholly-owned subsidiary of Lafarge S.A., the world leader in building materials, with top-ranking positions in all four of its businesses: Cement, Aggregates & Concrete, Roofing and Gypsum. With 80,000 employees in 76 countries, Lafarge posted sales of 16 billion euros in 2005. See: www.lafargenorthamerica.com or, for more information about Ductal®, see: www.imagineductal.com.

The Shawnessy LRT Station

The world's first thin-shelled precast canopy system constructed from Ductal®,
a revolutionary, ultra-high performance, fiber-reinforced concrete.

COLLABORATORS/ CONTACT LIST

NAME, TITLE & ORGANIZATION	ADDRESS (Canada)	PHONE	EMAIL
Vic Perry, FCSCE, MASc., P. Eng., Vice President & General Manager - Ductal®/ Lafarge North America	1200, 10655 Southport Road SW, Calgary, Alberta T2W 4Y1	403-292-9423	Vic.Perry@Lafarge-na.com
Don Zakariasen, Director of Marketing – Concrete Products/ Lafarge North America	9028 - 44th Street, SE Calgary, Alberta T2C 2P6	403-292-9222	Don.Zakariasen@Lafarge-na.com
Enzo Vicenzino, AIA, MRAIC, AAA, NCARB, Director of Architectural Design, Stantec Architecture Ltd.	325 – 25 Street SE, Suite 200 Calgary, Alberta T2A 7H8	403-569-5355	evicenzino@stantec.com
Gerry Culham, P. Eng., Principal, Stantec Consulting Ltd.	325 – 25 Street SE, Suite 200 Calgary, Alberta T2A 7H8	403-569-5352	gculham@stantec.com
Jadwiga Kroman, M.Sc., P. Eng., FCSCE, Manager, Bridges and Structures, City of Calgary/ Transportation Infrastructure	125 – 9 Avenue SE Calgary, Alberta T2G 0P6	403-268-3239	Jadwiga.Kroman@calgary.ca
Dr. Tom Brown, B.Sc., M.SC., Ph.D., Professor/Civil Engineering/ Schulich School of Engineering/ The University of Calgary	2500 University Drive NW Calgary, Alberta T2N 1N4	403-210-9804	ice@ucalgary.ca
Dr. Nigel Shrive, M.A., D. Phil., Professor/Civil Engineering/ Schulich School of Engineering/ The University of Calgary	2500 University Drive NW Calgary, Alberta T2N 1N4	403-220-6630	shrive@ucalgary.ca
Henry Nowodworski, P. Eng., President, Strudes Inc.	4700 De La Savane, Suite 218 Montreal, Quebec H4P 1T7	514-737-4146	nowodworski@strudes.ca
Dr. Gamil Tadros, B.Sc., Ph.D., Structural Consultant/ Speco Engineering Ltd.	43 Schiller Crescent NW Calgary, Alberta T3L 1W7	403-537-2196	gtadros@telus.net