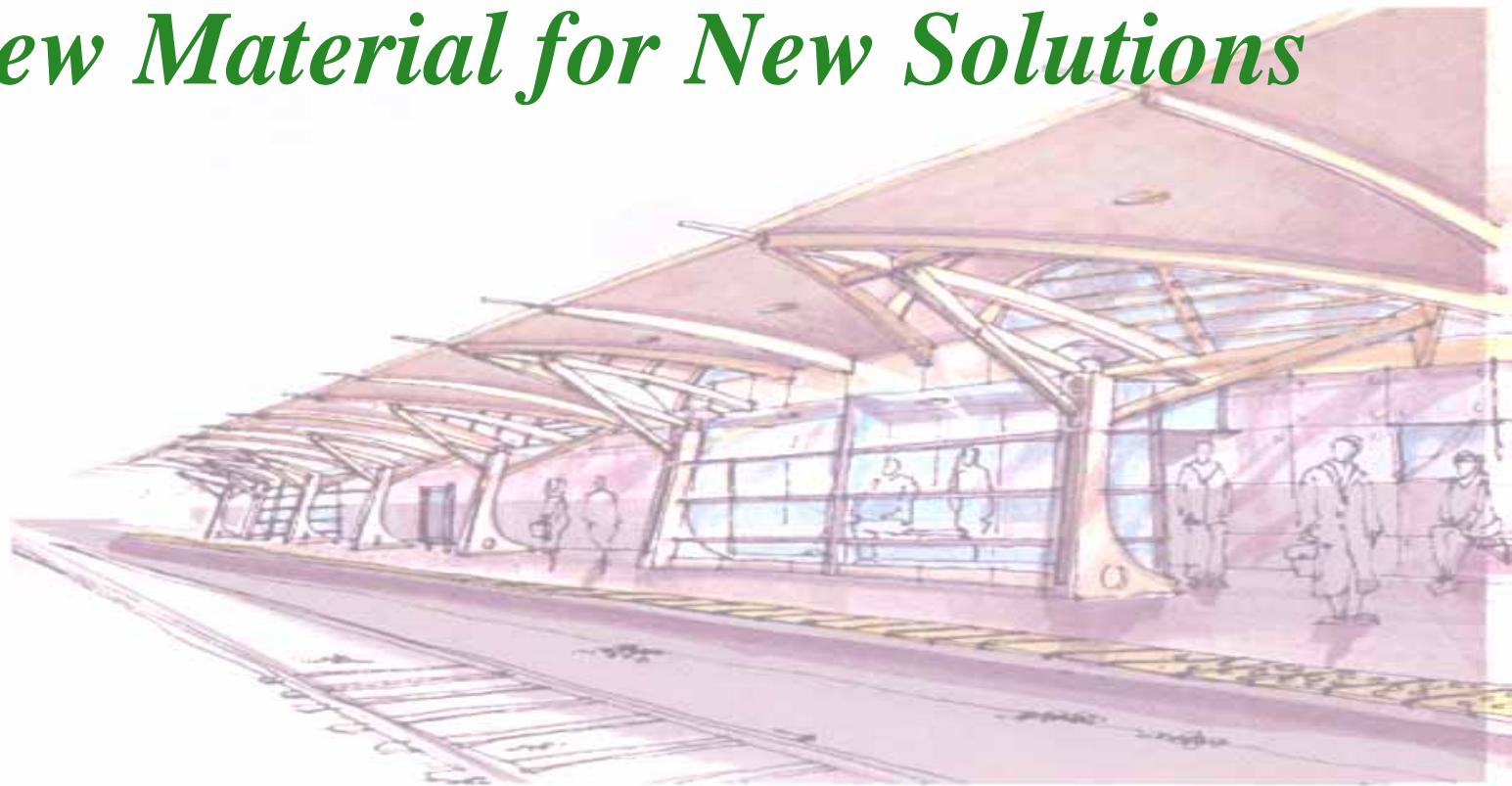


*A Revolutionary
New Material for New Solutions*



Imagine if it were made out of Ductal.

Leading innovations

The Solution

Lafarge was able to help
the architect transform
his **dream...**



...to reality!

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Leading innovations

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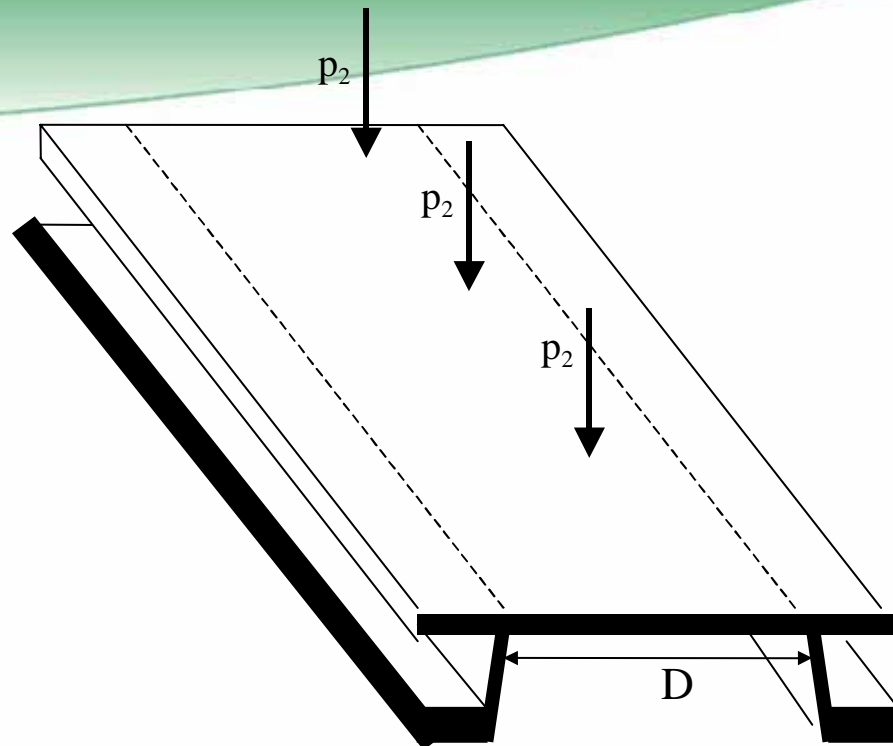
Leading innovations

The Bridge of the Future

Lafarge is helping the FHWA & MIT transform

their **vision** of the *Bridge of the Future ...*

to reality!



Imagine if it were made out of Ductal.

Leading innovations



The Lafarge Group

- Over €15 billion in sales worldwide
- Over 83,000 people in 75 countries

Products

- Cement
- Aggregate and Concrete
- Roofing
- Gypsum
- Specialty Products

Innovation

A major research collaboration resulted in a technological breakthrough.

A new material with a unique combination of superior characteristics:

- **ultra-high performance with ductility**
 - ✓ strength, ductility, durability
- **easy to use & highly mouldable**
 - ✓ flowable, dry-cast, form replication
- **superior aesthetics & quality surface aspect**
 - ✓ colors, textures, surface

Compressive Strength:
150 MPa to 200 MPa

Flexural Strength:
20 MPa to 50 MPa

Ductility:
Greater capacity to deform and support flexural and tensile loads, even after initial cracking

Abrasion Resistance:
Similar to natural rock

Impermeability:
Almost no carbonation or penetration of chlorides

Imagine if it were made out of Ductal.

Leading innovations

Key points of the *Ductal*[®] mix design:

- Ductility
- Synergy of two sizes of fibers
- Grading optimization (*modified Compactness Theory*)
- An efficient Cement-Superplasticizer couple

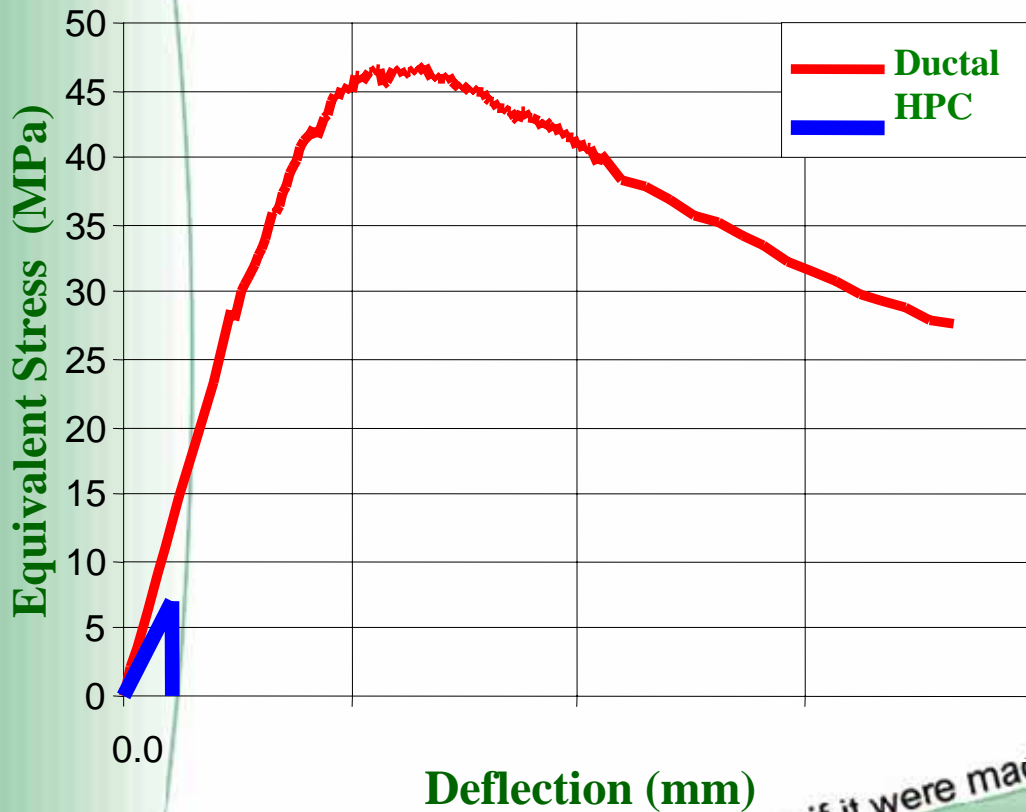


Imagine if it were made out of Ductal.

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Ductility

Greater capacity to deform and support flexural and tensile loads, even after initial cracking!

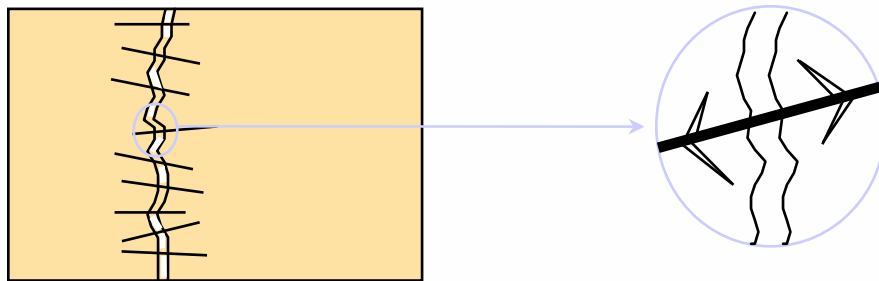


**Batimat -
French Construction Show**

Imagine if it were made out of Ductal.

Leading innovations

Synergy of two sizes of fibers:

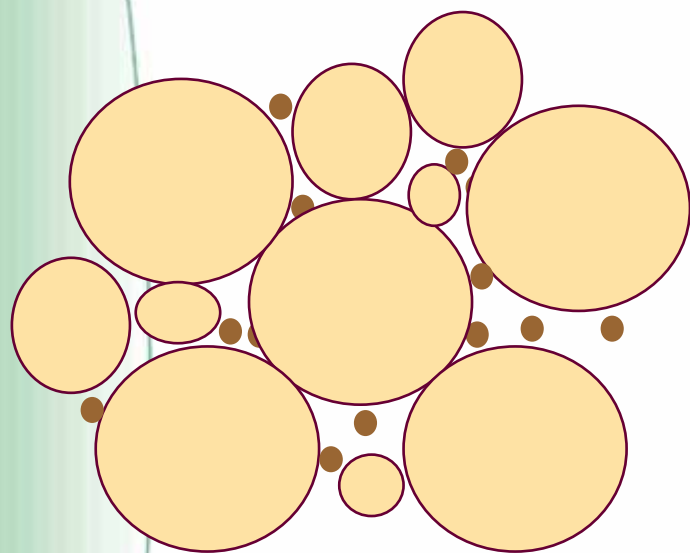


Activation of bond → microcracking → micro-reinforcement

Imagine if it were made out of Ductal.

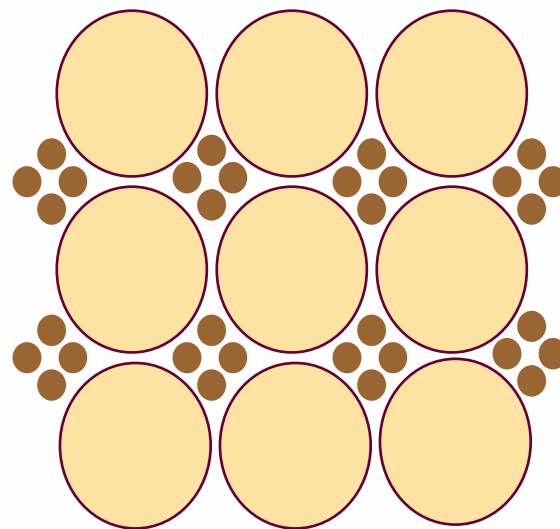
Leading innovations

Optimum Mix Compactness:



Shear/ no place for fibers!

Modified Mix:



Modified compact grading

Imagine if it were made out of Ductal.

Leading innovations

Typical Values for Ductal[®] FM

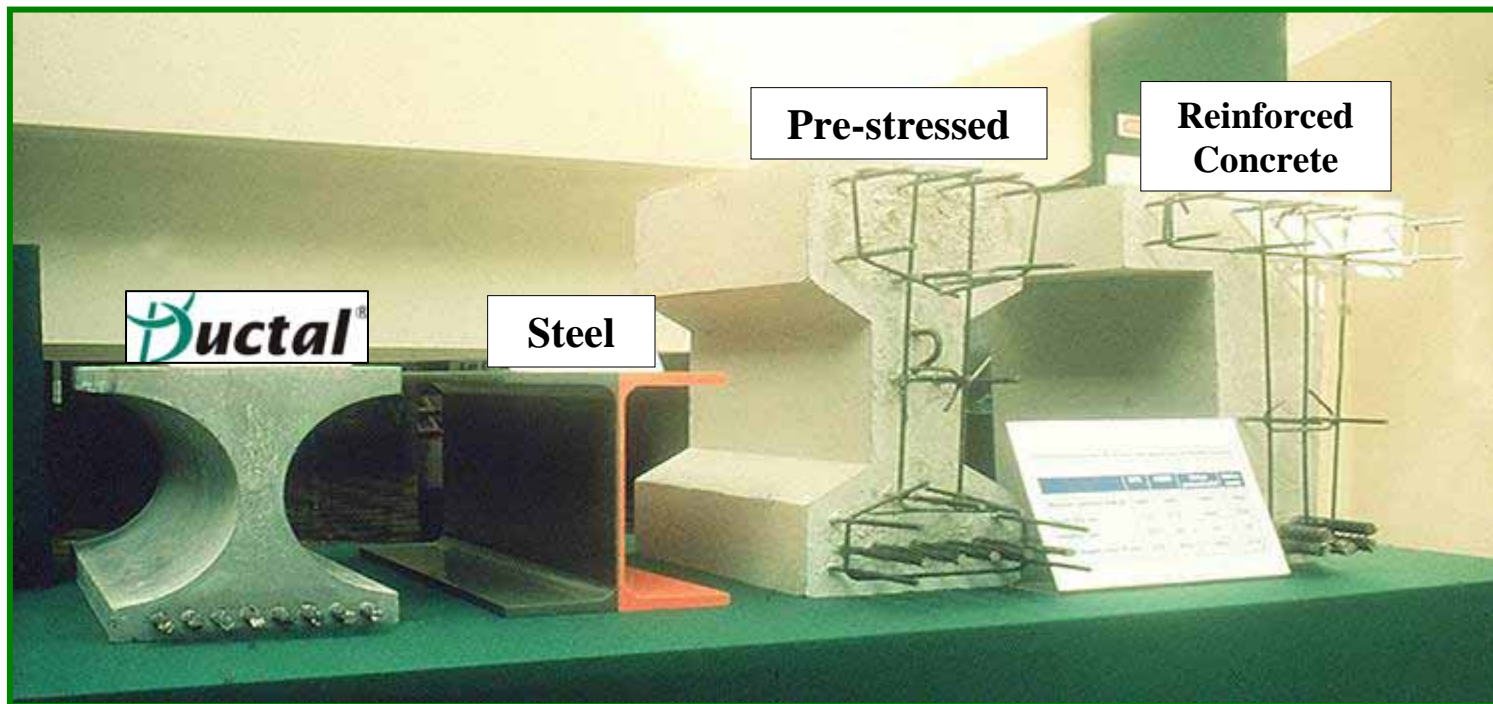


		Ductal FM (2% volume Steel Fibres)	
		3 days (incl. thermal treatment at 90°C for 48 hr)	28 days (wet room curing)
Compressive Strength (75 mm dia. X 150 mm length)	MPa	235	195
Flexural Strength (40 mm X 40 mm X 160 mm bending test)	MPa	45	40
E-Modulus	GPa	60	57

Imagine if it were made out of Ductal.

Leading innovations

Equal Load Carrying Capacity



MASS (WEIGHT) OF BEAMS

lbs/lineal ft.	94	75	313	355
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		HPC (60 MPa)	Ductal (2% Steel Fibers 90°C Thermal Treatment)
Abrasion (relative volume loss)	Index I	2.75	1.2
Freeze-thaw (residual E-mod after 300 cycles)	%	90%	100%
Carbonation (depth of penetration)		2 mm	0
Chloride ion diffusion	X10 ⁻¹² m ² /s	0.5	0.02
Post-curing shrinkage	10 ⁻⁶	300	0

Imagine if it were made out of Ductal.

Leading innovations

U.S. Army Corp. of Engineers Long Term Exposure Site



Three samples of Ductal installed in 1996

EXPOSURE: 500 freeze/thaw cycles and
4500 wet/dry cycles in saturated sea water



Treat Island, Maine, USA

August 14, 2002

Imagine if it were made out of Ductal.

Leading innovations

DUCTAL® PROJECTS



Ductal®

Urban Furniture



Imagine if it were made out of Ductal.

Leading innovations





LITHO PLANTERS



Imagine if it were made out of Ductal.

Leading innovations



Imagine if it were made out of Ductal.

Leading innovations

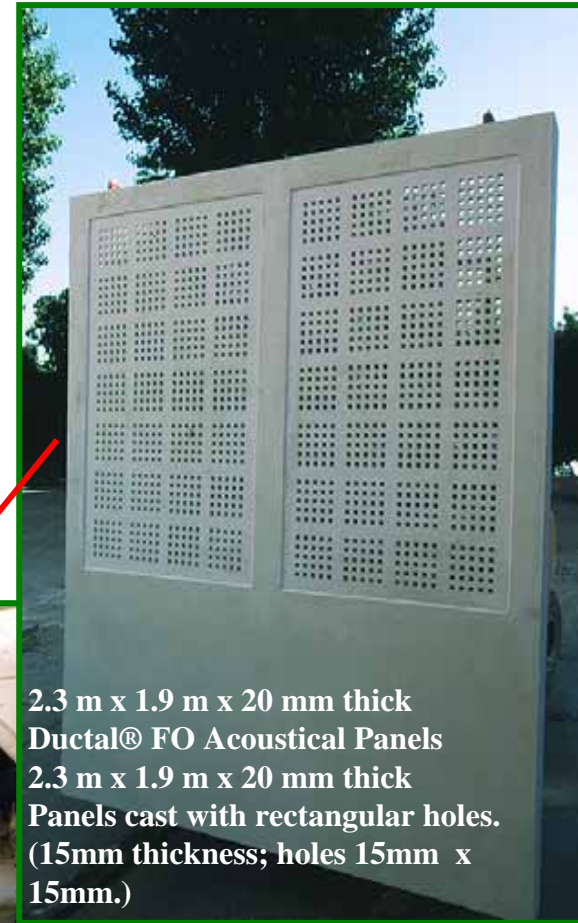




Imagine if it were made out of Ductal.

Leading innovations

Architectural Cladding



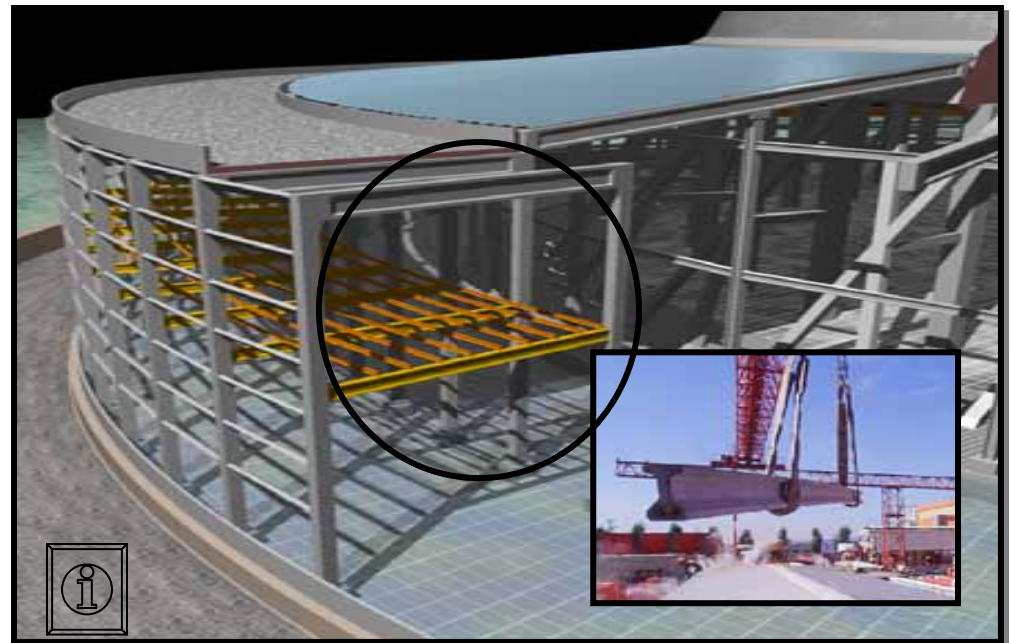
Imagine if it were made out of Ductal.™

Leading innovations

- Safety Vaults for USA & Canadian Market.
- High Impact Resistant Containers for material storage.
- Impact Resistant Containers for the Military
- Explosion protection wall panels for high Security Buildings



Industrial Applications





Overview

Quantity – 19 Ductal Anchor Blocks
- 1.88 m³ of Ductal

Client: Alberta Infrastructure
Completed – Fall '04



Deerfoot Meadows – Calgary, AB

Imagine if it were made out of Ductal.

Leading innovations

Foot Bridges



Ecosmart Ramp, Vancouver, BC



Yamagata Footbridge, Japan



Sherbrooke Footbridge, Quebec



Footbridge of Peace, Seoul, Korea



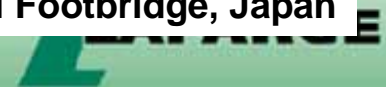
Papatatoe LRT Bridge, NZ



Sakata Mirai Footbridge, Japan

Imagine if it were made out of Ductal

Leading the way in concrete



Highway Bridges



McLean, Virginia



Washington, DC



Wapello, Iowa



NSW, Australia

Showcase Project: Shawnessy LRT Station



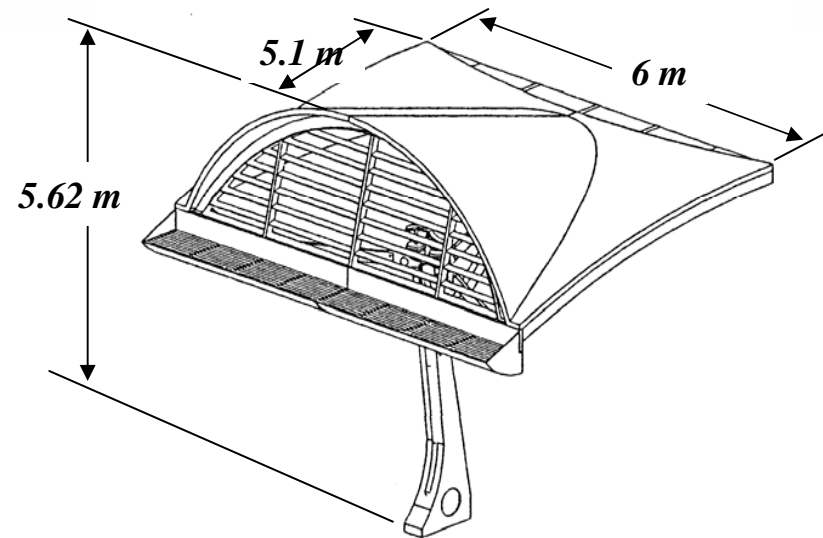
Shawnessy LRT Station



Precaster:
Owner:
Architect:
Ductal Volume:
Description:

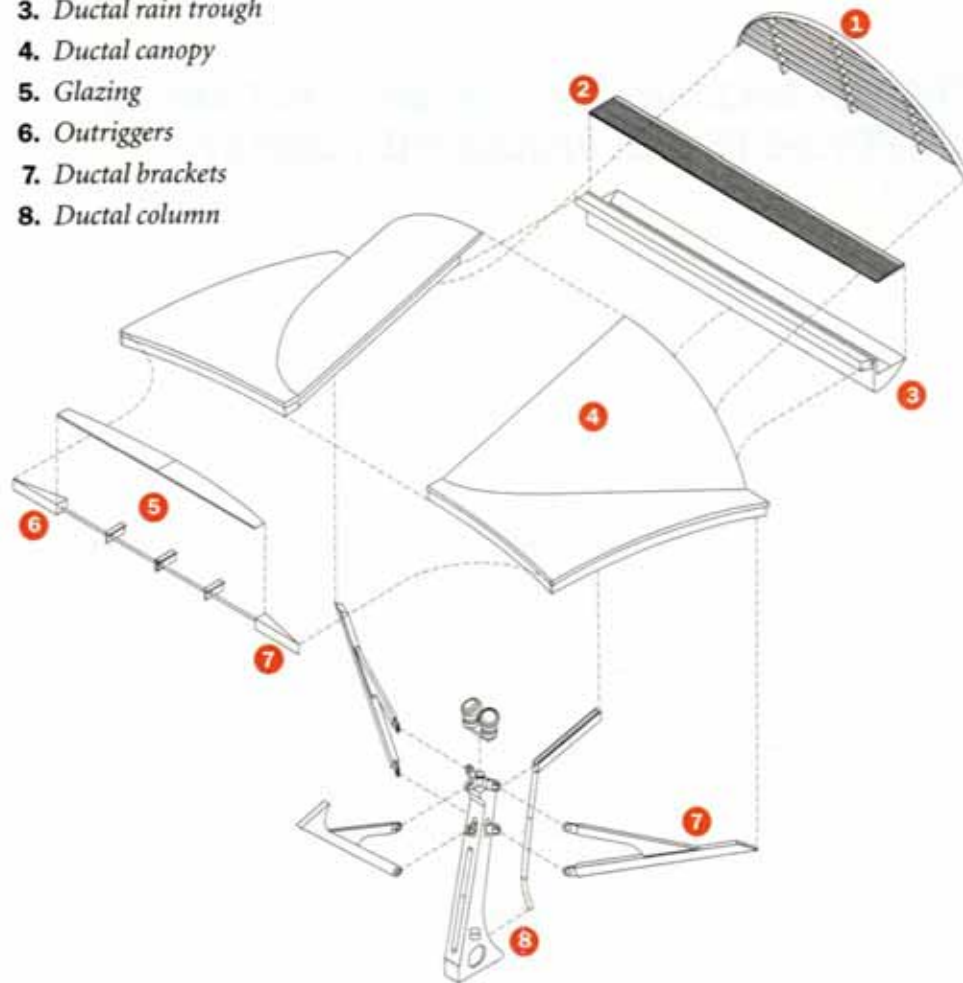
Advantages:

Lafarge (Calgary)
City of Calgary
Culham, Pedersen & Valentine (CPV)
80 m³
Architectural roof over a pedestrian unloading area.
Aesthetics, reduced maintenance light weight system, fewer pilings, speed of installation, economics



Ductal Components

1. Louvers and glazing
2. Grate
3. Ductal rain trough
4. Ductal canopy
5. Glazing
6. Outriggers
7. Ductal brackets
8. Ductal column



CANOPY MODULE

Forming / Casting / Demolding



Canopy Production



Canopies



Struts



Tie Beams



Columns

Imagine if it we

ERGE

Installing the Canopies



were made out of Ductal.

Leading innovations



Ductal[®]

Installed Canopies





1-Scale Load-Testing at the U of C

1-Scale Load-Testing at the U of C



- full snow load

At full factored loads,
maximum strains were
60% of cracking strain

- Full Wind Uplift



Imagine if it were made out of Ductal.

Leading innovations

“Ductal provided the ability to achieve the free-flowing form design of the canopies.”

*Shawnessy LRT Station Architect
Enzo Vicenzino*



Ductal[®]

**Architect's
dream...**



...to reality!

ere made out of Ductal.

Leading innovations

LAFARGE

Collaborations with Universities



Columns, Terminal, Detroit

- *MIT* - 2-D & 3-D modeling.
- *Ohio University* - Pullout Tests for Strand
- *Iowa State University* - Seismic Modeling (Short term, high amplitude low frequency response).
- *Michigan Technical University* - size effects
- *NY State, Buffalo* - Cutting and recycling
- *U of Calgary* - Full Scale Load Testing
- *Virginia Tech* – Punching Shear
- *Georgia Tech* – Full Scale Beam Tests
- *UNB* – Durability @ Treat Is(US Army Corp)
- *others.....*

Imagine if it were made out of Ductal.

Leading innovations



The End

Visit our web site at:

www.imagineductal.com