A Revolutionary New Material for New Solutions
The Solution

Lafarge was able to help the architect transform his dream... to reality!
The Solution

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

...to reality!
The Bridge of the Future

Lafarge is helping the FHWA & MIT transform their vision of the Bridge of the Future …

to reality!
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
Key points of the *Ductal*® mix design:

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

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

Batimat - French Construction Show
Synergy of two sizes of fibers:

Activation of bond → microcracking → micro-reinforcement
Optimum Mix
Compactness:

Modified Mix:

Shear/ no place for fibers!

Modified compact grading
## Typical Values for Ductal® FM

### Ductal FM
(2% volume Steel Fibres)

<table>
<thead>
<tr>
<th></th>
<th>3 days</th>
<th>28 days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(incl. thermal treatment at 90°C for 48 hr)</td>
<td>(wet room curing)</td>
</tr>
<tr>
<td><strong>Compressive Strength</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(75 mm dia. X 150 mm length)</td>
<td>MPa 235</td>
<td>MPa 195</td>
</tr>
<tr>
<td><strong>Flexural Strength</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(40 mm X 40 mm X 160 mm bending test)</td>
<td>MPa 45</td>
<td>MPa 40</td>
</tr>
<tr>
<td><strong>E-Modulus</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GPa 60</td>
<td>GPa 57</td>
</tr>
</tbody>
</table>
### Equal Load Carrying Capacity

<table>
<thead>
<tr>
<th>Material</th>
<th>Lbs/Lineal Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>94</td>
</tr>
<tr>
<td>Pre-stressed</td>
<td>75</td>
</tr>
<tr>
<td>Reinforced Concrete</td>
<td>313</td>
</tr>
<tr>
<td></td>
<td>355</td>
</tr>
</tbody>
</table>

**MASS (WEIGHT) OF BEAMS**
<table>
<thead>
<tr>
<th></th>
<th>HPC (60 MPa)</th>
<th>Ductal (2% Steel Fibers 90°C Thermal Treatment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrasion (relative volume loss)</td>
<td>Index I 2.75</td>
<td>1.2</td>
</tr>
<tr>
<td>Freeze-thaw (residual E-mod after 300 cycles)</td>
<td>% 90%</td>
<td>100%</td>
</tr>
<tr>
<td>Carbonation (depth of penetration)</td>
<td>2 mm</td>
<td>0</td>
</tr>
<tr>
<td>Chloride ion diffusion</td>
<td>$10^{-12}$ m²/s</td>
<td>0.5</td>
</tr>
<tr>
<td>Post-curing shrinkage</td>
<td>$10^{-6}$</td>
<td>300</td>
</tr>
</tbody>
</table>
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
DUCTAL® PROJECTS
Urban Furniture

Imagine if it were made out of Ductal.
Sinks, Counters & Tiles

Imagine if it were made out of Ductal.
Decorative

Imagine if it were made out of Ductal.
Architectural Cladding

120 m² of Ductal® FO Cladding Panels
2.5 m x 1.6 m x 25 mm thick

2.3 m x 1.9 m x 20 mm thick
Ductal® FO Acoustical Panels
2.3 m x 1.9 m x 20 mm thick
Panels cast with rectangular holes.
(15 mm thickness; holes 15 mm x 15 mm.)
Security Applications

- 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 m\(^3\) of Ductal

Client: Alberta Infrastructure
Completed – Fall ‘04

Deerfoot Meadows – Calgary, AB
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
Highway Bridges

McLean, Virginia

Washington, DC

Wapello, Iowa

NSW, Australia
Showcase Project:
Shawnessy LRT Station
Shawnessy LRT Station

Precaster: Lafarge (Calgary)
Owner: City of Calgary
Architect: Culham, Pedersen & Valentine (CPV)
Ductal Volume: 80 m³
Description: Architectural roof over a pedestrian unloading area.
Advantages: 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
Forming / Casting / Demolding
Canopy Production

Canopies

Struts

Tie Beams

Columns
Installing the Canopies
Installed Canopies
1-Scale Load-Testing at the U of C
1-Scale Load-Testing at the U of C

- Full Wind Uplift

- full snow load

At full factored loads, maximum strains were 60% of cracking strain
“Ductal provided the ability to achieve the free-flowing form design of the canopies.”
Shawnessy LRT Station Architect
Enzo Vicenzino
Architect’s dream...

...to reality!

Ductal®

Lafarge
Collaborations with Universities

- **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**…. 

Columns, Terminal, Detroit
The End

Visit our web site at:

www.imagineductal.com