ULTRA HIGH PERFORMANCE FIBRE-REINFORCED CONCRETES

Presentation by Serge Montens, using documents from Bouygues-VSL, Eiffage and Vinci companies
# ULTRA HIGH PERFORMANCE FIBRE-REINFORCED CONCRETES

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>BOUYGUES – LAFARGE - RHODIA</th>
<th>EIFFAGE - SIKA</th>
<th>VINCI - VICAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAME</td>
<td>DUCTAL</td>
<td>BSI-Céracem (Béton Spécial Industriel)</td>
<td>BCV (Béton Composite Vicat)</td>
</tr>
</tbody>
</table>
Ductal Mix Design

- 710 kg/m$^3$
- 230 kg/m$^3$
- 210 kg/m$^3$
- 1020 kg/m$^3$
- 40 - 160 kg/m$^3$
- 13 kg/m$^3$
- 140 kg/m$^3$

- Cement
- Silica Fume
- Crushed Quartz
- Sand
- Fibres
- Plasticiser
- Total Water

No coarse aggregate
ADVANTAGES

• VERY HIGH COMPRESSION STRENGTH

• HIGH TENSILE STRENGTH

• HIGH ELASTICITY MODULUS

• DUCTILE BEHAVIOUR

• HIGH DURABILITY
## Structural properties

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Ductal®-FM</th>
<th>Ductal®-FO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>2500 kg/m³</td>
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</tr>
<tr>
<td>Compressive strength</td>
<td>150 - 180 MPa</td>
<td>100 - 120 MPa</td>
</tr>
<tr>
<td>Bending strength</td>
<td>32 MPa</td>
<td>24 MPa</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>8 MPa</td>
<td>6 MPa</td>
</tr>
<tr>
<td>Young modulus</td>
<td>50 000 MPa</td>
<td>50 000 MPa</td>
</tr>
<tr>
<td>Poisson ratio</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Shrinkage</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Creep factor</td>
<td>0.15 - 0.3</td>
<td>0.15 - 0.3</td>
</tr>
<tr>
<td>Resistance to fatigue</td>
<td>&gt; 10 millions cycles</td>
<td>/</td>
</tr>
<tr>
<td>Thermal expansion coefficient</td>
<td>12.10⁻⁶ m/m</td>
<td>12.10⁻⁶ m/m</td>
</tr>
</tbody>
</table>

*Characteristic values of Ductal® after heat treatment*
# Durability properties

<table>
<thead>
<tr>
<th></th>
<th>ORDINARY CONCRETE</th>
<th>HIGH PERFORMANCE CONCRETE</th>
<th>ULTRA HIGH PERFORMANCE FIBRE-REINFORCED CONCRETE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WATER POROSITY (%)</strong></td>
<td>12 - 16</td>
<td>9 - 12</td>
<td>1.5 – 6</td>
</tr>
<tr>
<td><strong>OXYGEN PERMEABILITY (m²)</strong></td>
<td>10^{-15} to 10^{-16}</td>
<td>10^{-17}</td>
<td>&lt; 10^{-19}</td>
</tr>
<tr>
<td><strong>TRITIUM-ION DIFFUSION FACTOR (m²/s)</strong></td>
<td>2. 10^{-11}</td>
<td>2. 10^{-12}</td>
<td>2. 10^{-14}</td>
</tr>
<tr>
<td><strong>PORTLANDITE CONTENT (kg/m3)</strong></td>
<td>76</td>
<td>86</td>
<td>0</td>
</tr>
</tbody>
</table>
References of Ductal

- Sherbrooke footbridge, 1997
- Cattenom Power Station beams, 1997-98
- Martel tree, 1998
- Bercy school panels, 1999
- Monaco station panels, 1999
- La Réunion soil anchorage plates, 1999
- Rhodia panels, France, 2000
- Seonyu footbridge, Korea, 2001-2002
- Shower cabins, France, 2002-2003
- Sofia Queen Museum, Madrid, Spain, 2003
- Shepherds bridge, Australie, 2003-2004
- Eraring Power Station, Australia, 2004
- Papatoetoe Railway Station, New Zealand, 2005
Sherbrooke footbridge - Canada

First application of Ductal: Sherbrooke, Canada - 1997

60m span prestressed structure without passive reinforcement

3 cm thick slab with ribs

Ductal®-FM confined in stainless steel pipes
Ductal - Sherbrooke footbridge, Canada
Ductal - Seonyu Footbridge, Korea
Ductal - Papatoetoe Railway Station, New Zealand
Ductal - Maeta Footbridge, Japan
Replacement of corroded beams, Cattenom Power Station, France
• Use of Ductal® allows reduction of the structure self weight by a factor of 3

• Durability properties of Ductal allow reduction of maintenance costs
Precast pretensioned Ductal beams

Reinforced concrete slab

Driven steel piles

Precast concrete walls

Ductal - Shepherds Gully Creek Bridge, Australia

15100
Precast segment
• Prestressing

Les poteaux HEA 140, supports des écrans bois sont mis en place. Ils serviront de supports au garde-corps provisoire. Les câbles de précontrainte longitudinale sont mis en place, puis mis en tension.
• Lifting
BCV - CHABOTTE BRIDGE, FRANCE
BSI - EAST HIGH SPEED RAIL LINE AQUEDUCT, FRANCE
BSI - MILLAU VIADUCT TOLL GATE, FRANCE
Ductal - Shawnessy Light Rail Train Station
Calgary, Canada

24 Ductal® white, ultra-thin (only 20 mm) curved shell-shaped canopies
BSI - THE FOLLY, NETHERLANDS
Ductal®-FO has been chosen by the architect because:

• it is the only mineral material which allows building the sculpture with thin sleeves

• for its durability and its aspect
Ductal – Anchorages for retaining wall –
La Réunion island
Ductal - Monaco Railway Station panels
BSI - DECORATIVE WINDOW RAILINGS, PARIS, FRANCE
Bétons fibrés à ultra-hautes performances

Ultra High Performance Fibre-Reinforced Concretes

Recommandations provisoires

Interim Recommendations

janvier 2002