

## **Ultra-High Performance Concrete with Ductility**

### **THE WORLD'S FIRST LONG-SPAN ROOF CONSTRUCTED IN DUCTAL®**

#### **THE INNOVATION**

In 2001, a clinker silo in Joppa, Illinois became the first building in the world to have a long-span roof constructed with Ductal®. Ductal is a revolutionary, ultra-high performance concrete (UHPC) material that provides a unique combination of ductility, strength, durability, and aesthetic flexibility - with compressive strengths up to 32,000 psi (220 MPa) and flexural strengths of up to 7,200 psi (50 MPa).

The project, estimated at \$34M (US), was an upgrade to a cement manufacturing facility. Ductal was used to construct one of three clinker silo roofs while at the same time a conventional steel solution was used on the other two. The steel and Ductal options were each designed by the engineers and tendered competitively. The Ductal roof consists of 24 precast, pie-shaped panels with a 1/2" (12.7 mm) skin thickness for the 58' (18 m) diameter silo. The panels were designed to act as a thin ribbed plate, supporting a two story mechanical penthouse, centered at the top of the cone shaped roof.

#### **INNOVATIVE FEATURES:**

- Ductal's unique combination of superior properties enabled the designer to create thinner sections and longer spans for a tall structure that is lighter, more graceful and innovative in geometry and form.
- This is the first known use of UHPC used in a long-span roof system.
- The ultra light, thin, precast panels did not use any reinforcing bars.
- It took just 11 days to install the Ductal roof, vs. 35 days for the steel roof.
- The Ductal roof panels were more accommodating to the construction tolerances for out-of-roundness and flatness of the top of the slip-formed silo walls.
- The lightweight system did not impact the foundation design.
- Improved site safety: there were fewer personnel climbing over the structure during installation, thereby reducing potential for fall accidents and fewer protruding obstacles such as rebar or steel elements which could cause tripping.
- Reduction in non-renewable resources: due to a reduction in the total quantity of materials consumed and the use of recycled materials in Ductal (such as Silica Fume).
- The Ductal roof is air and water-tight, thereby resulting in reduced environmental impact *and* reduced maintenance: due to Ductal's low permeability and improved durability, and the elimination of a waterproofing membrane.
- Due to the lightweight design, the precast roof panels were easily transported (approx. 1200 miles), in loads of 8/truck.
- The ductile behavior of this material is a first for concrete. It has the capacity to deform and support flexural and tensile loads, even after initial cracking.

#### **DUCTAL VS. STEEL**

Upon completion, the comparative study proved that the new Ductal solution was the best alternative. The innovative details and advantages reported above provide a strong case in support of this fact.

#### **THE EVOLUTION OF DUCTAL**

Three innovative companies, Lafarge SA, Bouygues SA and Rhodia SA, with combined expertise in building materials, construction methods and chemicals, formed a collaboration with the objective of creating a new material with a combination of strength, ductility, durability and aesthetic flexibility. In 1997, 1998 and 2000, several patents were taken, covering a series of inventions in the area of UHPC's, all under the trademark, "Ductal®". In 2000, Lafarge North America Inc. entered a license agreement with the partnership and a team was formed, dedicated to the production, marketing and selling of Ductal. To date, Ductal has been used for a number of innovative solutions including projects such as: acoustic sound panels, seawall and bridge anchor plates and beams for a power plant cooling tower.

#### **DUCTAL PROJECTS: PAST, PRESENT AND FUTURE**

To date, Ductal has been used for a number of innovative solutions including projects such as: acoustic sound panels, seawall and bridge anchor plates and beams for a power plant cooling tower. In Seoul, Korea, a pedestrian bridge named "The Foot-bridge of Peace", has a 425' (130 m) arch constructed entirely with Ductal. Considered a building feat, the bridge has no middle supports and a platform thickness of just 1 3/4" (3 cm)!

In North America, Ductal products are supplied by Lafarge and custom formulated for each new application or project. Currently the team is focusing efforts on priority target markets with a medium to long-term strategy geared towards applications such as structural wall panels, leave-in-place forms, poles/piles, seismic elements and bridges.

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