NIAGARA REGION WIND FARM

2017 Ontario Concrete Awards

PROJECT CREDITS

OWNER
Boralex Inc.

DEVELOPER
Enercon Canada Inc.

ENGINEER OF RECORD
WSP Canada Inc.

GENERAL CONTRACTOR
Borea Construction

PUMPING CONTRACTOR
Pumpcrete Corporation

MATERIAL SUPPLIERS
Rankin Construction Inc.
Lafarge Canada Inc.

ADDITIONAL PARTICIPANTS
- BASF Canada Inc.
- Degrandis Pumping
- LIUNA Local 837
- Mammoet
- Salit Steel
- Stabilization Canada
- Stelcrete Industries

PROJECT FACTS

LOCATION Niagara Peninsula, Ontario

COMPLETION October 2016

QUICK PROJECT FACTS

Size: 77 wind turbines over a 43,200 hectare area

Power Generation: 627.4 GWh/year

Ready-Mix Concrete Components: 77 wind turbine bases totalling 967 m^3*77 = 74,459 m^3

Precast Concrete Components: 1740 cast concrete tower segments totalling 35,859 m^3

Construction of temporary heated tent for curing process: Space contained segments for 2 full turbines (78 segments) with a total surface of 39,697 sq.ft.



OVERVIEW:

The Niagara Region Wind Farm (NRWF), which comprises 77 ENERCON E-101 3MW wind turbines and has a 20-year feed-in tariff contract with the Independent Electricity System Operator of the Province of Ontario, was commissioned on October 30, 2016. In addition to bringing clean energy to the province, the wind farm has created 700 jobs during project construction and will create another 25 direct long-term jobs during operations.

The duration of the entire project was accelerated into a very short implementation time. The launch took place in May 2015 and the start-up was scheduled 16 months later – taking into account the size of the project and its technical and logistical challenges this was a remarkably short implementation period.

With the project extending over six municipalities on a total surface of 432 square kilometers and with installation originally being planned outside the winter months, a just-in-time delivery model was excluded and therefore ENERCON opted for a unique solution of using a nearby former quarry as its central storage area for large components.

Complying with local content requirements in Ontario, ENERCON had put in place a temporary concrete facility at Port Weller in St Catharines. In order to ensure proper temperature for the curing process of the concrete segments during the winter months, ENERCON built on site a heated tent and brought in a special crane for the safe transport of the concrete segments.

The construction of the NRWF project created 700 direct and around 1,500 indirect jobs with 25 long-term jobs for the 20 years of operating time of the wind park.

This windfarm is the first to be built with concrete towers in the province of Ontario. The concrete tower design allows for taller tower heights and additional wind power generation.

This project is a one of a kind example in Ontario of how innovative concrete structural design and production, along with specialty concrete construction can be used to build high-value, high-sustainability legacy infrastructure.

INNOVATION AT WORK:

Concrete Mix Designs - Precast

Concrete mixes for precast had to meet high, seemingly-conflicting properties:

- High performance 28-day strengths up to 80 MPa
- High early strengths for stripping and turning precast forms after 10 – 12 hours
- High pour rates
- Long pumping distances
- Near perfect surface finish
- Controlled temperature-generation

High-performance self-consolidating concrete was chosen as the suitable concrete for this application.

In designing the mixes, an optimal trade-off balance had to be developed on several fronts, such as:

- Conflict between higher and lower cement contents: Achieve early strengths and smooth surface finishes (use higher cement content) without compromising upper temperature generation limits (use lower cement content)
- Conflict between water content and admix use: Remove water to achieve high strengths but not use so much admixture that viscosity of concrete did not inhibit the achievement of high pour rates and long pumping distances.

Precasting Process

To meet Ontario content requirements, ENERCON chose to setup production in the old Port Weller structure.

Segments up to 14.5 m in diameter had to be cast in over 25 different moulds each presenting different challenges. ENERCON and Rankin Construction had to overcome many challenges to setup an efficient, quality precasting operation in this already constructed space, such as:

- L-shaped configuration of building – arrange a process to utilize cranes for both steel cage fabrication and movement of elements without compromising production
- Fans and heating solutions to maintain the temperatures needed for concrete placement and coating applications in the uninsulated structure
- Pump configuration to convey concrete efficiently without compromising quality from the external portable concrete plant inside to the concrete moulds.

The production of the concrete tower segments had to happen within very strict tolerances, for example:

- No bug holes greater than the size of a dime due to needed surface treatments – required advanced techniques in SCC, form oil use and application, placement techniques
- Very tight dimension and smoothness tolerances due to stacking / connecting / post-tensioning
- Very strict temperature control to avoid thermal cracking.

Concrete Mix Designs – Cast-In-Place Bases & Construction Site Concrete Solutions

Concrete bases had to meet 28 d strength requirements, while controlling heat of hydration to avoid thermal cracking risks of mass concrete pours.

Lafarge and Borea Construction opted for a mix design using fly ash, rather than the traditional slag approach, given fly ash's superior heat reduction capabilities.

Each base used 950 m^3 and 1 base was poured per day when pouring was occurring. A total of 83,000 m^3 was poured in the bases.

Using mix design and admixture technology, Lafarge worked with Borea Construction to establish desired slump / viscosity for different levels of the rings of a base. This facilitated ease of placement to form the exposed conical surface of each individual base.

Over 4-5 months, Borea Construction poured an extremely high volume of concrete. The volume poured was actually 2 times the volume of concrete in the CN Tower. An achievement of this nature is only pulled off with excellence in planning, communication, and sub-coordination. Given the original project plan had been shifted to include winter construction, these types of concrete volumes placed in this time period becomes even more impressive.

THE SUSTAINABILITY LEGACY:

In early 1990, ENERCON has started using modular concrete tower with pre-fabricated segments under controlled factory conditions.

Designing in concrete allows the towers to be designed taller than in steel. Taller wind towers means higher and more consistently-available winds. This fact lends to more overall power generation per tower, adding significant inherent sustainability to this approach. The following factors add further sustainability value to the concrete design approach:

Concrete:

Has higher material damping properties than other materials and pre-stressed concrete is inherently much less susceptible to fatigue failure due to the nature of the material and provides less risk from dynamic failure. Concrete also has greatly increased fire resistance.

Foundation:

The main role of the foundation is to provide ballast to the tower so as to keep it from tipping over. Because of this, the greater stabilizing weight of the concrete tower leads to a lower weight being required for the gravity foundation and therefore to a lower concrete volume at this level. The tower's greater base diameter gives the foundation a lower cantilever span, reducing forces on the foundation and lowering reinforcement ratios.

Recycling:

The post-stressed concrete segments can be cut and transported off site for crushing or crushed at the site, producing concrete gravel for new construction projects and scrap steel.

Transportation:

The dimensions of the precast concrete segments are optimized for the available means of transport by truck or ship. Rings for very tall towers can be wider than 5 m (larger than steel), but can be split into two or three segments, depending on the tower height, which are easy to transport and connected together again during installation of the tower.

Rather than using aggregates to build temporary access roads on the construction site, cement soil stabilization was used as an alternate method. This reduced the number of truck loads of material to perform this work to less than 30% of aggregate equivalent, among other environmental benefits.

Energy demand:

The energy demand required to manufacture a precast concrete tower and taking subsequent recycling of the segments into consideration as well, is ~2.5 times lower compared to a steel tower.

Local Production:

The Precast segments were produced within 50-100 km of the end-use location.