ONTARIO POWER GENERATION NIAGARA TUNNEL PROJECT

PROJECT CREDITS

OWNER
Ontario Power Generation

DESIGN ENGINEER
ILF Consulting Engineers

ENGINEER OF RECORD
David F. Wood Consulting Ltd.

GENERAL CONTRACTOR
Strabag Inc.

MATERIAL SUPPLIER
Dufferin Concrete, A division of Holcim (Canada) Inc.

ADDITIONAL PARTICIPANTS
- BASF Canada Inc.
- Dufferin Aggregates
- Dufferin Construction
- Euclid Chemical
- Harris Rebar
- Holcim (Canada) Inc.
- Ironworkers Local 736
- LIUNA Local 837
- Peri Formwork Systems Inc.

PROJECT FACTS

LOCATION Niagara Falls, Ontario

COMPLETION March 2013

QUICK PROJECT FACTS
The Niagara Tunnel Project is a cast-in-place concrete tunnel, 10.1 km long and 14.4 m diameter that will provide 500 m^3 of water per second to Sir Adam Beck Power Station.

2014 Ontario Concrete Awards

The Niagara Tunnel Project commissioned by the Ontario Power Generation was secured by the Strabag Canada Inc., the tunneling experts from Austria. The tunnel is 10.1 kilometers in length, 14.4 metre bore diameter with a cast in-place concrete liner with an inside diameter of 12.8 meters that will provide 500 m^3 per second to the upgraded Sir Adam Beck Power Generating Station. Strabag engaged Dufferin Concrete to provide the innovative concrete solutions for the entire project – the cast-in-place tunnel liner and all concrete outside the tunnel. This is enough concrete to build 10 CN Towers and was done 150 meters below the City of Niagara Falls.

Dufferin Concrete designed and made three very different types of concrete for the tunnel. 'Shotcrete' is sprayed onto the tunnel walls immediately after Big Becky passes. This stabilizes the rock to provide temporary support for the tunnel wall until the liner concrete is cast. Tunnel Liner concrete for the cast in place walls, and Self Consolidating Concrete (SCC) to fill the voids of the over break of loose rock. Due to poor ground conditions, when "Big Becky" the Tunnel Boring Machine (TBM) made her way 150 meters below the surface of Niagara Falls, the loose rock was falling from the ceiling making the tunnel more like a tear drop shape in small sections throughout. This is where the SCC was used as it would seep into every crevasse and fill the void 100%.

Due to two separate "fall of ground" occurrences (cave in), the first on September 11, 2009, and the second on July 2, 2011, the processes in which the tunnel was scheduled to be built had to be changed to accommodate the new timelines and restoration of the tunnel ceiling. This caused tunnel traffic and congestion issues for the concrete delivery. Strabag came to us with 2 different solutions that would change the way the concrete was to be delivered into the tunnel. The first idea was to deliver the concrete via concrete pump stationed just outside the tunnel at the outlet, the Strabag's Agitator drums were not set up to feed the pump, so Dufferin Concrete mixers were used in order to pump the concrete about 500 m into the tunnel. The mix had to be modified to accommodate the pressures involved in pumping long distances. Our first challenge was that the mix proportions, sources and elements could not be changed due to the required creep testing (it takes 1 year for results), the mix had been accepted and testing completed prior to the project start up. The original designed mixes started out as conventional pumpable concrete with a 200 mm slump. We revisited the mix design and developed it to make the mix into a pseudo Self Consolidating Concrete (SCC) mix while leaving the original proportions the same. As the Arch form progressed into the tunnel, the pumping distances grew by 25 meters per day, reaching a total pumping distance of 1.8 km; the mix was revisited weekly and modified accordingly, the mix ended up becoming a full SCC mix when we passed the 1 km mark. After 1.8 km, it was no longer time and cost effective to pump any further, so Strabag came to us with the second idea. The idea was to drill and install 8" diameter drop shaft pipes from the surface so that the concrete can be dropped up to 150 meters (450 feet) vertical free-fall into a waiting agitator drum below, and then delivered to the form where the concrete is to be placed. There were 4 selected locations through the 10 km tunnel and a 9 m^3 concrete re-mixer was added to the operations. Dropping concrete, free fall contravenes the way structural concrete is to be handled; Grout and shotcrete are dropped into mines thousands of feet below the surface; however this was structural concrete that had to meet specifications for the tunnel liner. This was the best solution for concrete logistics, so a “Dropshaft Mix” was created. Again, the original proportions and elements of the mix could not be changed. Also, the onsite “Wet Batch” plant would not be available due to the increased restoration concrete that was required. Our first challenge was to reproduce the mixes required through our existing ‘Dry Batched” ready mix plant located in Niagara Falls not far from the proposed dropshafts.

The concrete mixes that were designed for the tunnel are unique. The cast-in-place, unreinforced concrete that has to set quickly and cannot shrink, creep (the technical term for the time-dependent deformation that occurs in concrete when it is subjected to load), or crack. It also has to be wear-resistant to last a century. The concrete needed to be pumped distances up to 1,800 meters and a redesign was required to be able to drop the same mix 140 meters below the surface in free fall through an 8 inch drop shaft pipe. Then the concrete needed to maintain the characteristics to be able to be placed, and we are proud to say they exceeded the contract specifications.

Despite the delays, it will go down as a significant engineering achievement. More importantly, it will provide environmentally sustainable power for the local population for many decades to come – all without disturbing the natural beauty and majesty of Niagara Falls. The 14.4 meter wide Niagara Tunnel has been opened since the beginning of March 2013 and is making electricity for Niagara Falls. The Tunnel will divert 500 cubic meters per second to Sir Adam Beck Hydroelectric Station for the next 100 years without closing for inspections or repairs. The tunnel will provide enough clean hydroelectricity to supply 160,000 homes in Ontario.