DESCRIPTION SHEET

Introduction

The US $883 million dollar expansion to an existing convention center will create an additional 1.1 million square feet of floor space and will serve as a world-class facility for conventions and meetings. Expected to be completed in the fall of 2009, it is designed to achieve a LEED® gold standard and will be a landmark addition to the city's waterfront.

Federal and provincial environmental agencies have worked for many years to enhance the marine habitat in the working harbour where the facility is located. Because the structure is built almost entirely over the water, supported on approximately 1000 piles, and will shade a significant portion of shoreline, an innovative series of marine habitat features were designed around and under the facility. The habitat features included an integrated "fish habitat skirt," a complex of new under-deck marine habitats, and specific enhancements that are creating new near-shore and artificial reef habitats at various locations around the marine perimeter of the structure.

This submission is specifically focused on the design, fabrication, and installation of the "fish habitat skirt," or habitat skirt, which was completed in May 2008 for US $8.3 million. The three offshore perimeter faces of the facility have been skirted by this bioengineered structure consisting of a series of stepped, precast concrete benches supported by precast concrete frames that are attached to a specially designed cast-in-place concrete beam. Extending outwards from the facility and downwards over the entire 17 foot tidal range, the habitat skirt is designed to maximize vertical and horizontal ecological connectivity that will create habitat for a diverse mix of intertidal marine life.

Design Process

When deciding on the most appropriate materials to realize the objectives of the habitat skirt, the structural engineers chose to use precast concrete components several reasons. First, the frames and benches are located in the tidal zone and are exposed to wave forces and impacts from floating debris such as logs. Concrete, due to its mass, is more resistant to upward wave slamming forces and denting from impacts than other materials. Second, the habitat skirt must facilitate rapid colonization of a wide diversity of marine life by providing ideal growing conditions. Exposed aggregate concrete surfaces can best replicate the conditions found on a natural shoreline and the surfaces will not rot or deteriorate over time. Finally, the habitat skirt frames are attached to a cast-in-place concrete foundation structure with typical construction tolerances. By using projecting steel reinforcing bars and shear keyways, the precast concrete frames have been completely locked into the foundation structure by a cast-in-place infill section

that was able to accommodate large deviations in the geometry of the foundation while still maintaining the alignment and aesthetics of the habitat skirt frames.

The habitat skirt frames have a unique geometry and connection requirements that prevented the incorporation of either pre-stressing strands or post-tensioning bars. Instead, the frame legs, which will resist both tension and bending forces, are heavily reinforced with regular deformed steel bars to limit the width of any concrete cracks and prevent corrosion.

The habitat skirt benches are pre-stressed with wire strands to further limit concrete crack widths. In addition, several features were added to the top surface of the benches to promote marine growth. A continuous depression, or trough, was placed in each bench so that as the sea level lowers with the tide water will remain in the benches to form tidal pools. The rest of the top surfaces are corrugated and finished to expose the aggregate within the concrete.

In order to extend the serviceable life of the structure and add to the sustainability goals of the overall project, a concrete mix design that has low permeability and contains approximately 25% flyash was specified.

Finally, special attention was directed towards ensuring that the structural system could be easily installed to reduce project costs and minimize risks to worker safety. To that end, temporary erection hooks were designed to support the habitat skirt frames on the foundation so that the frames could be clipped on to the foundation and held in place by gravity during construction. The benches were also designed so that they could be held in place by gravity during construction.

Sustainability

Several of the green goals for the habitat skirt component of the project with respect to the marine environment and how they have been achieved have already been described above. The project has a Sustainability Advisory Committee made up of scholars and local professionals that has identified eight goals critical to guiding the design if the project is to be considered as having environmentally sustainable credentials. The focus of sustainability efforts for the project is on best practices and their relationship to standards and certification rather than merely adopting a code or standard that may not stand scrutiny by the time the facility is open and is a showcase for the world to visit.

The overall project is designed to achieve a LEED® gold standard when complete. The habitat skirt has contributed specifically to three LEED® credits: Materials & Resources Credit 4 – Recycled Content and Credit 5 Regional Materials; and Innovation & Design Process Credit 1 – Innovation in Design. As noted above, the concrete specified for this project contains significant amounts of flyash, which is a recycled material. The habitat skirt was manufactured within 500

miles of the project site. And the concept of the habitat skirt, which is the first of its kind, has required innovative design approaches to successfully meet the stated objectives.

Fabrication

The unique geometry of the habitat skirt components proved to be a challenge, but a challenge easily overcome by the precaster. The frames were fabricated in a two stage process. First, the frame legs were cast in a specially fabricated steel form complete with chamfered edges along curved corners and hinged release mechanisms. Then, one left leg and one right leg were secured to another, specially fabricated, large steel casting frame. Once secured, each 13.0 ton leg, with several dozen projecting bars, was rotated 90 degrees into place so that three joining beams could be cast. The completed 42.9 ton frames were lifted and transported using specially fabricated steel struts.

In order to achieve the required surface finish on top of the benches, up to five benches were cast at a time orientated upside down in a pre-stressing bed. Many test casts were completed prior to arriving at the optimum corrugated and exposed aggregate concrete finish. The exposed aggregate finish was achieved by using surface retarder and sand blasting after the concrete had cured.

Installation

The special attention on installation procedures taken by the structural engineers during design as well as extensive preparation of the erection hooks by the precaster allowed for both the habitat skirt frames and benches to be installed faster than anyone had predicted. The 76 frames were installed using a 300 ton capacity marine crane in 4 days. Plastic shims were attached on the rear of the legs to act as a temporary bearing pad after the frames were hung on the erection hooks and rotated under the foundation. Once hung in place, the precaster used hydraulic jacks to slightly rotate the frames and replace the plastic shims with precast concrete bearing blocks that were locked in place with an epoxy adhesive. The gap between the top of the frames and the foundation around the erection hooks were then reinforced, formed, and cast with concrete.

The benches were also placed with a marine crane. The precaster chose, however, not to have their installation schedule driven by the tides and installed the benches with the assistance of divers. The divers guided the 362 benches on to rubber bearing pads placed on the frames in 4 days. Another crew followed behind installing threaded anchors to secure the benches in place.