Case Study
ONTARIO CAST-IN-PLACE CONCRETE DEVELOPMENT COUNCIL
Volume 11, Issue 2



FUNG LOY KOK INSTITUTE OF TAOISM

2014 ONTARIO CONCRETE AWARD WINNING PROJECT FOR MATERIAL DEVELOPMENT & INNOVATION

PROJECT OVERVIEW

To achieve the desired architectural profile, the steel superstructure is supported on a two-way concrete slab system with a pair of long cantilever spans on the east and west sides of the structure. The long 10.2 m span on the west side of the structure spans over the drive aisle and acts as support for the majority of the interior program space. A smaller 5.2 m cantilever on the east side of the structure accommodates an exterior terrace area over the parking below, and serves as a counter balance for the main span. Both slabs are supported on a series of closely spaced concrete shear walls beneath the main span, and a series of smaller tie members at the root of the terrace span.

The use of bonded post tensioning was required in order to achieve the desired 10.2 m cantilever span on the west side of the structure while limiting the concrete depth to a maximum of only 800 mm. The fully prestressed design features a sloping underside, which tapers to a minimum depth of 250 mm at the cantilever end. The harped tendon profile runs opposite to the slope, maximizing the available eccentricity at the point of maximum moment and minimizing the eccentricity at the ends of the span. The tapered concrete profile also serves to maximize the efficiency of the concrete as the structure's form mirrors the shape of the applied internal bending moment, with the point of maximum depth corresponding with the point of maximum flexural demand.

The underside of the main cantilever span is exposed in the finished structure, and features a series of architectural concrete forms which mirror the angled contours of the structure above. The use of cast-in-place concrete allowed for the creation of complex geometries without the need for additional cladding or framing. Exposed concrete was also used for the two cantilever staircases which provide access to the structure above. The concrete stair treads cantilever out from the bottom of the supporting walls, which in turn are cantilevered to match the terrace slab above.

STRUCTURAL DESIGN INNOVATION

The long cantilever spans required to meet the architectural and site requirements demanded a structural solution that would allow for an efficient and economical use of materials. A fully prestressed cantilever concrete slab proved to be a fitting solution to the structural demands, as it makes use of the entire cross section to resist the applied forces. The high stiffness afforded by the fully prestressed system allows the long cantilever spans to meet strict serviceability requirements, and the tapered form provides an efficient shape that maximizes the effectiveness of the bonded stressing tendons while minimizing the amount of wasted material towards the ends of the cantilever spans. The mass afforded by the cast-in-place concrete slabs ensures that the vibration response of the cantilevered spans is well controlled, and helps to reduce the impact of unbalanced live loading on the structure.

OWNER
Fung Loy Kok Institute of Taoism

ARCHITECT OF RECORD
Shim-Sutcliffe Architects

ENGINEER OF RECORD
Blackwell Structural Engineers

GENERAL CONTRACTOR
Gillam Group Inc.

FORMING SUPPLIER
Alliance Forming Ltd.

FLOORING CONTRACTOR
Metro Concrete Floors (1990) Inc.

MATERIAL SUPPLIER
St Marys CBM

ADDITIONAL PARTICIPANTS
- Albion Glass • All Stone
- AZ Comfort Air
- BASF Canada Inc.
- Blu-Mar Excavating & Grading
- Canadian BBR Inc.
- Canadian Washroom Products
- Carpenters Local 27
- Champion Flooring
- Cherrywood Roofing
- Commercial Doors and Hardware
- Enerium Drywall
- Fortis Electric • Harris Rebar
- Husky Heating & Air Conditioning
- Ironworkers Local 721
- Krypton Steel
- LIUNA Local 506
- Mirmil Custom Millwork
- Pengelly Iron Works
- Polycor • Savaria
- Steel Art Signs
- StonCor Canada
- StoneHouse Custom Painting
- Superior Door
- TenPlus Architectural Products
- Tradewood Industries

PROJECT FACTS

LOCATION Markham, Ontario

COMPLETION September 2014

QUICK PROJECT FACTS
- One of Canada's largest post-tension cantilevered structures
- Two-way post-tensioned cantilever concrete slab system
- Exposed concrete structure throughout
- Polished concrete floors
- Hydronic in-floor heating system
- Structural glass floors embedded in exposed concrete terrace slab

OCCDC

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MATERIAL DEVELOPMENT & INNOVATION AND SPECIALTY CONCRETE CONSTRUCTION

The project involved construction of a two-way concrete slab system with a pair of long cantilever spans on the east and west sides of the structure. Each cantilever featured complex geometric shapes and a high-level surface finish which required a superior concrete mix and specialized construction techniques to achieve the owner's vision. The entire project team participated in a highly collaborative design-assist approach to the project and contributed in both the planning and on-site implementation.

Key challenges included the coordination of structural elements and building services within the cantilevered concrete slab, precision of the formwork to achieve elegant exposed concrete contours and angles, and various water management systems including a roof designed to act as a reservoir to hold rain water. This project demanded absolute precision to ensure the structure's post-tension system and steel reinforcement conformed to strict structural design tolerances. To ensure that clashing of the various elements within the cantilevered slab did not occur, a computer 3D model was created to identify possible problems prior to installation. The various triangular concrete fins required close attention to ensure that a smooth surface and sharp edge was achieved. It was particularly challenging to effectively vibrate these areas due to obstructions created by the rebar, post-tension cables, and services within the slab. Once the pour was in progress the concrete vibrator was able to utilize the 3D model to ensure all areas were properly treated. Survey monitoring of the slab was also performed to ensure creep did not exceed project tolerances.

The project was delivered using a superior cast-in-place concrete which enabled the creation of complex geometric shapes and a high-level finish for all exposed surfaces. St Marys CBM SmoothBlue was selected for the exposed structure due to its ability to enhance workability and finishability of close-tolerance surfaces. The flow enhancement of the SmoothBlue dramatically improved the concrete's ability to flow around the rebar and post-tension system to ensure all intricate shapes of the forms were filled.

St Marys CBM ShrinkGuard was selected for the topping mix to reduce ultimate shrinkage, ensuring a durable and crack-free surface. The crack-resistant low shrink capability of ShrinkGuard allowed the concrete to be finished without any special placement or finishing requirements. Due to the high-level tolerance surface requirements of the project, the reduced curling performance was also a major benefit to the durability and finish quality.

For interior comfort the exposed concrete floors are equipped with a hydronic in-floor heating system. By choosing to polish the concrete floor, the owner was able to enhance the surface to achieve a smooth and shiny concrete finish. The salt and pepper aggregate exposure adds to the overall natural appearance of the space. Polished concrete involves the application of a concrete densifier. The densifier reacts chemically with the free lime in the concrete to create a hardening effect which extends the life of the concrete surface, increases its overall durability, and dust proofs the floor making it much easier to clean.

A corrosion inhibitor was also used to increase the durability and service life of the building. The longterm performance of this project was a major consideration in going with high performance concrete mixes and a quality ready mix concrete supplier. The performance of all the products was exceptional and successful in achieving the architect's and owner's vision.

In 2000, the Ontario Cast-In-Place Concrete Development Council (OCCDC) was formed to aid the owner/developer, architect/engineer and design-build contractor in the decision-making process of choosing the best construction material for the framing system of new cast-in-place structures.

OCCDC promotes the benefits of reinforced concrete as the construction material of choice based upon the following advantages:

- fast-track construction
- costs savings
- structural advantages
- environmental considerations
- local economy benefits

The Members of the OCCDC include (alphabetical order):

Aluma Systems Inc.
Carpenters District Council of Ontario
Concrete Forming Association of Ontario
Ironworkers District Council of Ontario
LIUNA—Ontario Provincial District Council
Ontario Formwork Association
PERI Formwork Systems Inc.
Ready Mixed Concrete Association of Ontario
Reinforcing Steel Institute of Ontario

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