INSTITUTIONAL BUILDING

REACTOR MATERIALS TESTING LABORATORY

PROJECT CREDITS

OWNER
Queen's University

ARCHITECTS OF RECORD
Diamond Schmitt Architects/Shoalts & Zaback Architects Ltd., In Joint Venture

Engineer of Record
Read Jones Christoffersen Ltd.

General Contractor
T.A. Andre & Sons (Ontario) Ltd.

Material Supplier
Sousa Ready Mix

Additional Participants

- Carpenters Local 249
- Du Toit Allsopp Hillier
- HH Angus
- Ironworkers Local 765
- Josselyn Engineering Inc.
- Kimco Steel
- LIUNA Local 183 (Kingston)
- Sika Canada Inc.
- Turner & Townsend Inc.

PROJECT FACTS

LOCATION Kingston, Ontario

BUILDING AREA 813 m^2 (8,750 sq. ft.)

COMPLETION September 2014

COST $6,000,000

CONCRETE VOLUME 1,200 m^3

PROJECT SUMMARY
The new Reactor Materials Testing Laboratory (RMTL) is used to conduct metallurgical research into the alloys used to fabricate components for CANada Deuterium Uranium (CANDU) reactors.

2016 Ontario Concrete Awards

Dimensions:

- Overall building – 47.5 m at longest point x 18.1 m at widest point
- Accelerator chamber – 9.5 m wide x 17 m long x 6 m high Inner dimensions
- Target rooms – 3.1 m x 3.5 m x 5.6 m High

Flooring:

- Densified polished concrete with a deep grind exposed aggregate

Walls:

- Concrete thickness varies from 80 cm to 190 cm
- Designed to act as radiation shielding to absorb stray neutrons
- Normal density concrete is ideal for this
- Slip formed as through wall ties were not permitted
- Steel rebar not permitted near inner face of walls & slabs
- FRP rebar used – not affected by radiation
- Thermal mass of concrete structure acts as chamber temperature stabilizer

Roof Structure:

- Accelerator chamber: 60 cm thick flat slab
- Target rooms: 90 cm thick flat slab
- Labs: composite structure of 20 cm concrete on steel columns

Shielded Sliding Doors:

- Thickest door (at outer target rooms) is 66 cm thick and weighs 8 Tonnes

25-Year De-commissioning Plan:

- The design allows the shielded spaces to be used for other uses once the metal components are removed

The Reactor Materials Testing Laboratory (RMTL) at Queen's University in Kingston, Ontario, is a specialized lab that is able to simulate conditions that materials experience inside a nuclear reactor and will be used to advance research into next generation power plants. The investigators in this facility conduct metallurgical research into the alloys used to fabricate components for CANada Deuterium Uranium (CANDU) reactors. The laboratory, a purpose built standalone facility, was designed using a fast track schedule and tendering process. The Canadian Nuclear Safety Commission (CNSC) licensed the RMTL for operation after a multi-stage design and construction review process.

The RMTL building has a gross floor area of 8,750 square-feet. Roughly half of this area is dedicated to a shielded chamber, which houses a 4MV tandem accelerator (capable of accelerating protons or He ions to 8 Mev or 12 MeV respectively). The accelerator infrastructure includes adjacent equipment rooms that contain associated support components such as pumps, cooling equipment, specimen storage, experimental equipment storage and inert gas storage reservoirs. The balance of the program space consists of four laboratories used for specimen preparation and characterization using electron microscopy; an open concept office for up to six researchers; a meeting room; and amenity spaces. The building is one storey high, supported by a hybrid structural system of concrete and steel components. Cladding elements include; double glazed aluminum curtainwall with exterior solar shading devices, formed metal panels and exposed board formed concrete foundation walls.

The central feature of the off campus one-storey structure is a large accelerator that generates a beam and bombards alloy samples with high-energy neutrons, The unit is encased in a massive reinforced concrete chamber. Metals behave quite differently in a nuclear power reactor environment than in more conventional applications, so it's critical to the experimental work that the researchers are able to accurately simulate the effects of radiation, temperature and other stresses that impact the strength of metallic components of an operational reactor core over it's lifespan while they develop new alloys.

Experiments are set up in one of two target rooms and a stream of neutrons is directed to a metal alloy sample for up to 2,000 hours. The two rooms are separated from each other by a 1.9 m thick concrete wall that allows researchers to work in safety on the set up of the next experimental trial.

In order for researchers to safely access the target rooms and accelerator chamber, to set up experiments and calibrate equipment, a complex system of physical barriers, fail safe devices and safety interlocks were put in place by the design team. These include a series of sliding doors, some weighing as much as 8 tonnes; and an analogue electrical system of warning devices, radiation detectors and sequential keyed activation system. The system uses a single key that must be used to activate more than twenty check points in the correct sequence in a timely manner before it can then be used to activate power to the accelerator.

This is a highly shielded facility with concrete walls up to 1.9 m thick separating the accelerator chamber from the exterior, other labs, offices and amenity spaces. Concrete is the material of choice as it effectively absorbs neutrons without degrading or becoming radioactive and dissipates their energy in the form of heat. The only other material with similar properties is borated polyethylene (BPe), developed for use in nuclear submarines, which is quite expensive by comparison. BPe was used selectively at opening for sliding doors, ducts and pipes to form absorbent baffles in tandem with the concrete structure.

The building also includes a fully glazed corridor to bring natural light into the laboratory work areas that support research activities. This corridor also functions as a passive heat collector in the winter, utilizing the thermal mass of the exposed concrete roof structure and polished concrete floor slab, while external shading devices limit the solar gain in the summer months. Densified concrete with a deep grind to expose the natural beauty of the aggregate and polished to a high luster was used throughout the facility as the floor finish.

Steel and other metallic components within the facility that are exposed to the particle beam over the projected 25-year life span of the facility, will gradually become activated and emit very low levels of radiation over time. Part of the design mandate was to enable eventual de-commissioning of the interiors of the accelerator chamber and target rooms so that these spaces can be repurposed for other uses free of residual radiation. All metals within the chamber were required to be installed in a manner that will allow them to be easily removed in the future. This prohibition included any steel embedded in the concrete that is with 20 cm of the inner surface of the concrete. This precluded the use of steel reinforcing, form ties or any other through wall penetrations from the interior to exterior unless they were doglegged and shielded with BPe baffle plates.

Fiberglass reinforced plastic (FRP) reinforcing rods were used throughout for the inner layer of all three spaces within the shielded zone. Although FRP rods were also considered as potential form ties, the project's nuclear physicist was concerned about potential leakage around these penetrations. The decision was made to use a modified slip form method and pour the walls in small lifts, which were allowed a minimum set time before proceeding with the next lift. The wet joints between each pour were sufficient to ensure a good bond and tight seal.

One other celebration of concrete is the exposed foundation and entry feature wall. The design team wanted to give the concrete in these locations a unique finish using pine boards that had been sandblasted to expose the annular ring structure of the wood's grain. After a few mock-ups at the contractors site a repetitive pattern was designed and formwork constructed that could be reused in successive pours horizontally. The module is large enough that the repetition is not noticeable in the finished concrete. A tinted concrete mix was used for the board formed areas to ensure a consistent look across many pours.

"The uniqueness of this facility is a testament to the innovative approaches being used by the Faculty of Engineering and Applied Science to enable world-leading research and to educate our students," - Dr. Mark Daymond, RMTL Director.