APPLICATION and VISUALIZATION TECHNIQUES for ADVANCED SENSOR NETWORKS

Case Study: Sensor Installation in Skilled Trades & Technology Centre -Red River College

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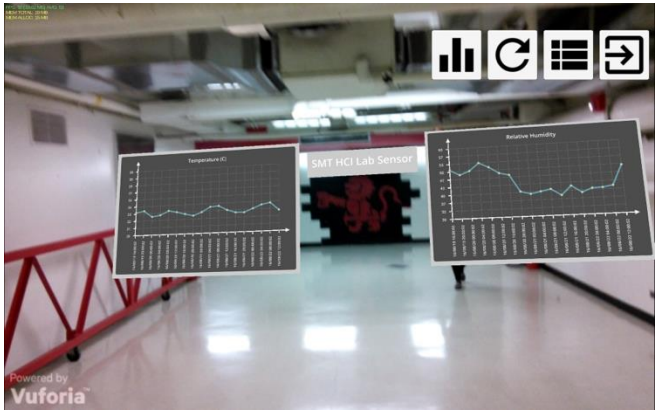
SMT Structure Monitoring Technology

RS1, RS10: Smart materials, Structures and Rehabilitation, Smart Sensors

Overview

- Background
- Case Study - RRC STTC
- Data Visualization Techniques and Analysis Tools
- Applied Research Projects



Manitoba Environment

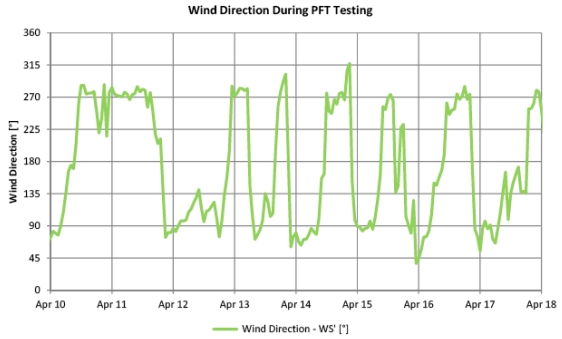
- 49th to 60th parallel
- 548,000 km2 (~size of Germany)
- ~1.3M people
- Ocean access (summer)
- Winnipeg (capital) weather
  - Extreme humid continental climate
  - 306 days with measureable sunshine
  - 521.1 mm precipitation annually
  - 132 days of snow cover – 110.6 cm average snowfall
  - -47.8ºC (1879) to 42.2ºC (1937) = 90ºC difference
  - Windchill (temperature + wind) record = -57.1 (1996)
  - Humidex record (temperature + humidity) = 48 (2007)
- Net After-Tax Cost of Corporate R&D: 45¢ to 47¢ per $1 of R&D

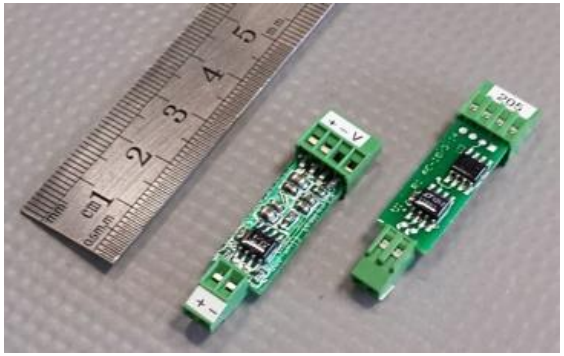
Red River College

- Manitoba's largest institute of applied learning
- Over 200 full- & part-time academic programs
  - Personal Development to Trades & Technologies to Degree Programs
- ~ 22,000 unique students
- Eight campuses across Manitoba
- Annual operating budget ~$200M
- Annual research enterprise ~$6.0M
- **Support the growth of enterprises and entrepreneurs** through training & research, i.e. **Accelerate Research & Innovation**
  - **CLEAN, GREEN & EXTREME TECHNOLOGIES**
    - Leading in research and programming that supports clean transportation, sustainable construction, advanced design technologies, green buildings & extreme weather testing
- **BETAC: Building Envelope Technology Access Centre** - http://blogs.rrc.ca/betac/

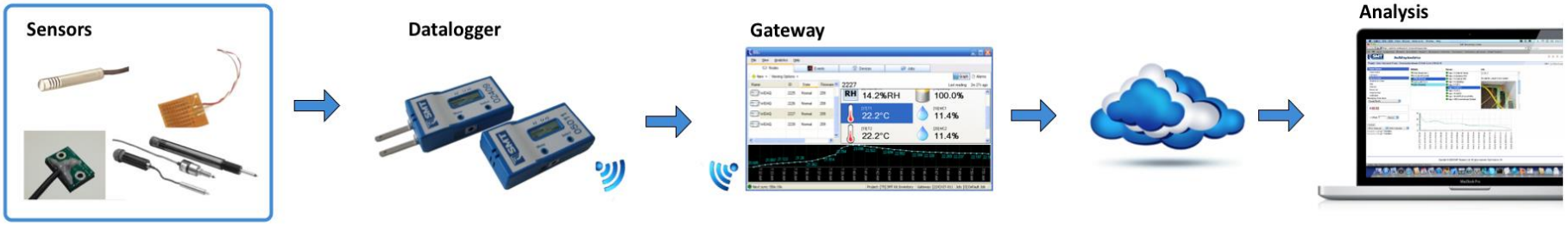
SMT Research Background

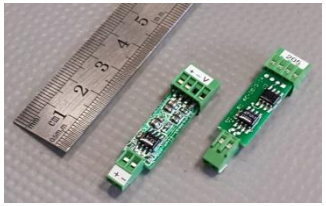
- SMT designs software and electronics used to evaluate the integrity and performance of buildings.
- Incorporated in 2006 in Manitoba
- Primary technology was designed for NRC-IRC to validate materials and methods to produce more durable and efficient buildings.
- Sensors and DAQs used for Investigative Research
- Headquarters is now in Vancouver, BC





Monitoring Technology





- http://www.smtresearch.ca/smt-product-list for list of Compatible Products
- High resolution sensors can be connected to wireless, wired and cellular based DAQS.
- Cloud based software allows for easy data retrieval and analysis.

Structural Health Monitoring Technology

Examples of SHM sensor deployments

Monitor moisture absorption in masonry - Tomb of Jesus

Moisture monitoring at the Parliament of Canada

Compression and moisture analysis of the world's tallest wood building located at UBC

SIMTReC Structural Innovation and Monitoring Technologies Resource Centre

… The Internet of Things

RRC Skilled Trades & Technology Centre

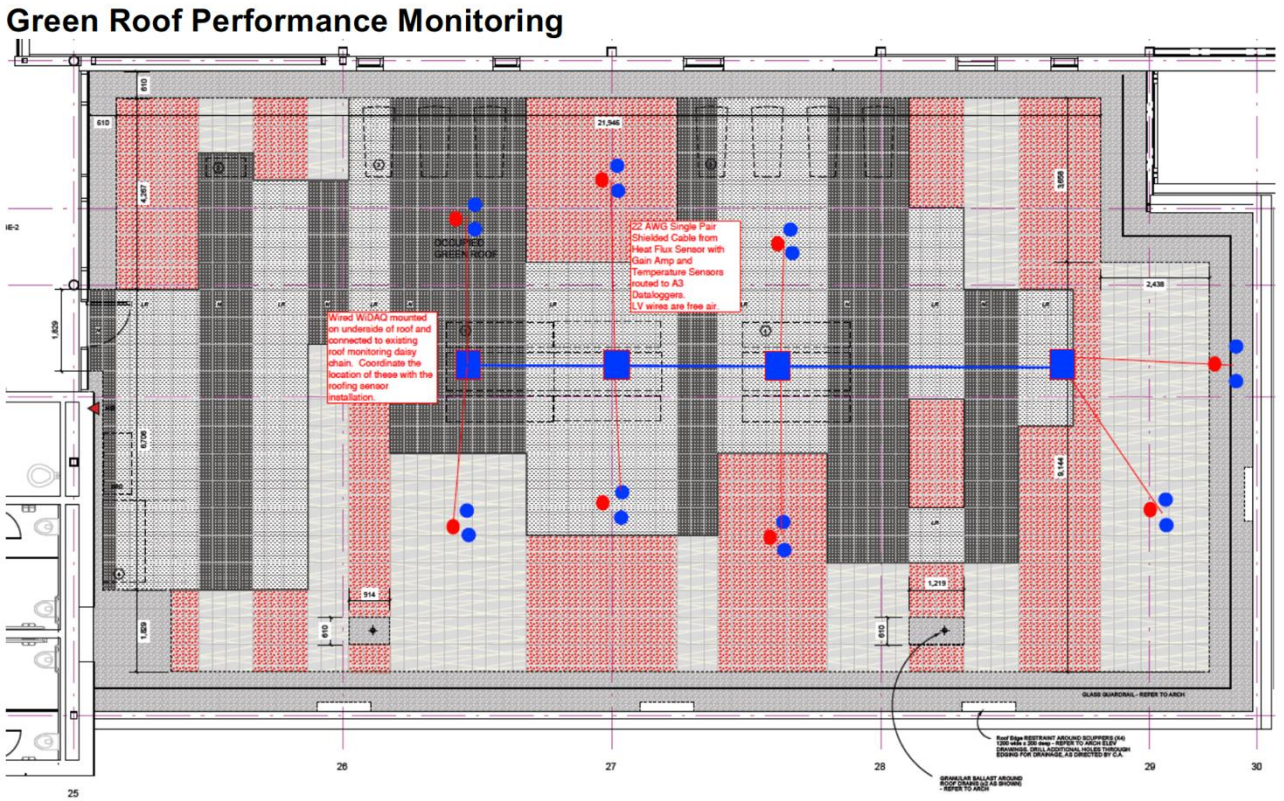
- Goal is to instrument RRC-STTC with sensors and technology to create an educational living-lab
- One of the first comprehensive buildings to be "Connected" using IoT (Internet of Things) concept
- Sensor suite provides complete analysis of the roof integrity as well as specialized sensors to monitor the performance of the green roof.
- Building envelope sensors monitor the thermal performance of all building components throughout the building.
- Real world research is possible in Building Science, Civionics, Material Engineering and Mechatronics.

Roof Sensor Installation Grid

- Roof Monitoring – 10’ x 10’ spaced grid placed on roof for moisture detection. 5’ x 5’ grid on the green roof.
- Monitors for leaks over the entire roof membrane.

Green Roof Sensor Installation

- Green Roof Performance Monitoring
- Thermal Transfer (Temperature and Heat Flux)



Automated Data Collection Methods

- Green Roof Monitoring using Drone Technology
- Drone will collect moisture and temperature data by hovering/driving over sensors embedded in the roof/soil.

Building Envelope Sensor Installation

2nd Floor East (6 locations)

- Moisture detection around curtain wall windows
- Temperature differential through various different wall assemblies
- Solar effectiveness from Skylights
- RH in different assemblies to detect condensation
- Thermal transfer through different materials

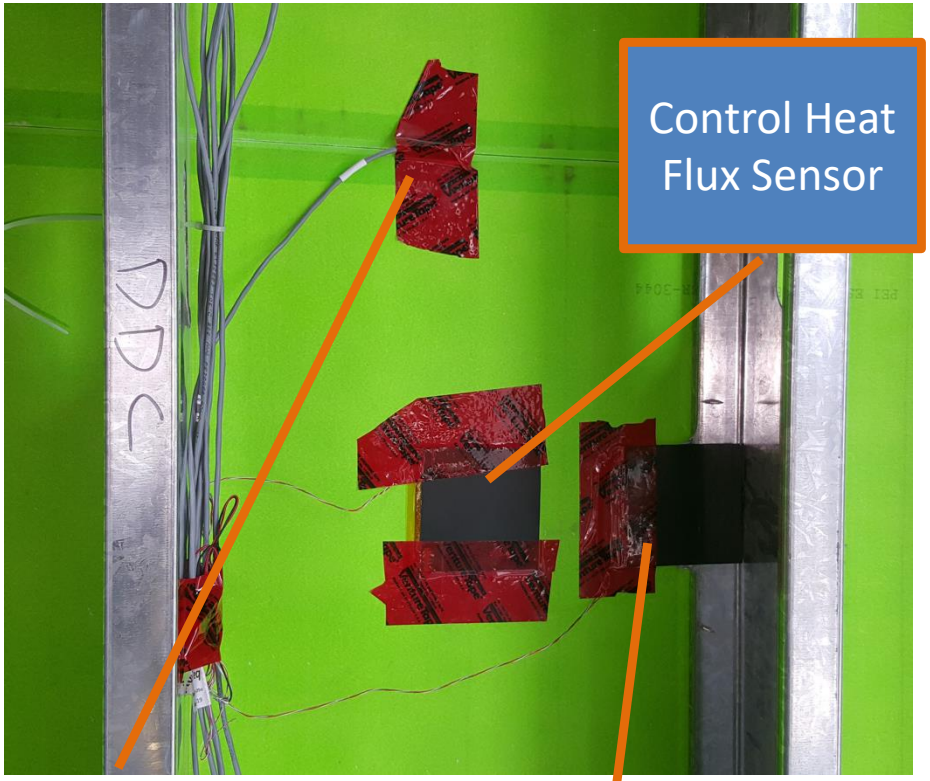
Building Envelope Sensor Installation

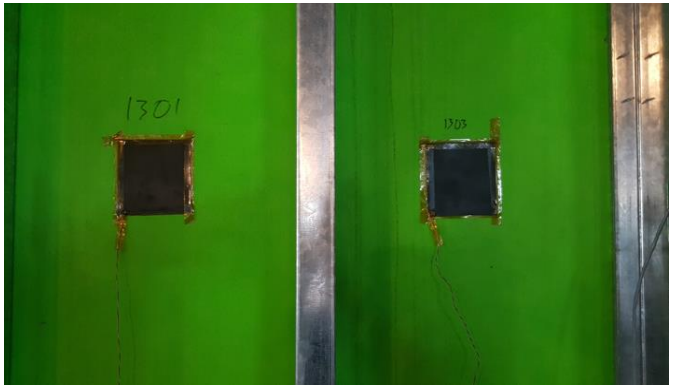
- Thermal transfer analysis of different wall systems
- New heat flux sensors were designed in conjunction with BETAC to allow us to analyze in-situ R-value of full assemblies.

Evaluating Heat Flux sensors in CARSI Dual chamber

Designed new heat flux sensor capable of covering larger areas

Heat Flux Sensor Installation

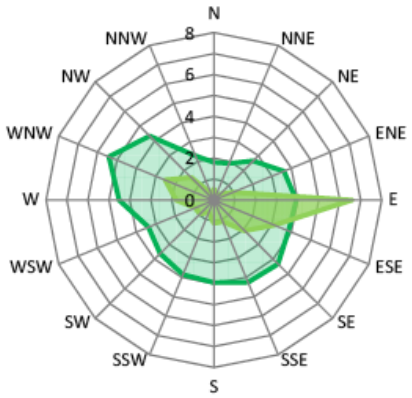


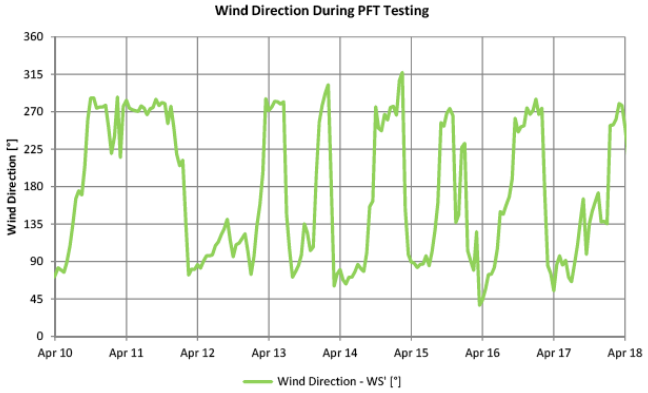


Test Heat Flux on Different Insulation Types and Configurations

Environmental Weather Correlation

- Correlation of weather data with building systems.
- Weather station on roof will provide pertinent data that can be correlated with building performance data for cause and effect analysis.





Monitor Specific Details

- Monitoring specific details
- Parapet details, Sky lights etc.
- Helps validate new materials and processes and construction techniques.

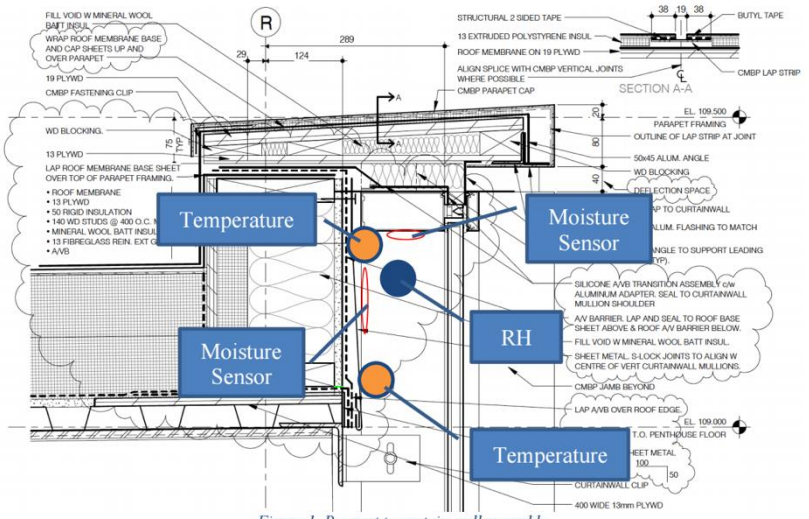
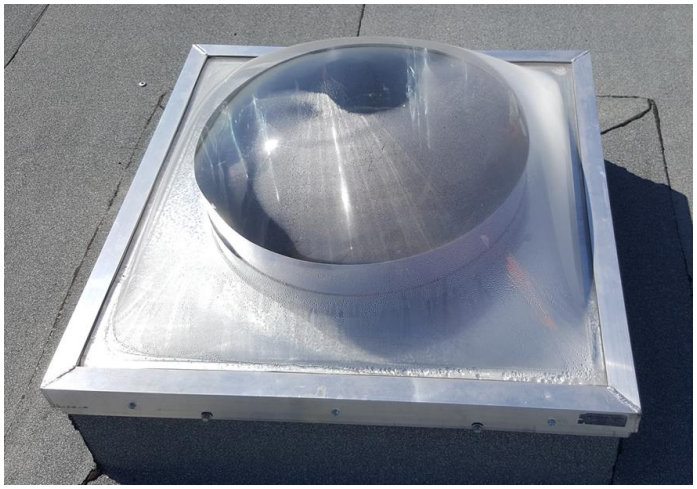
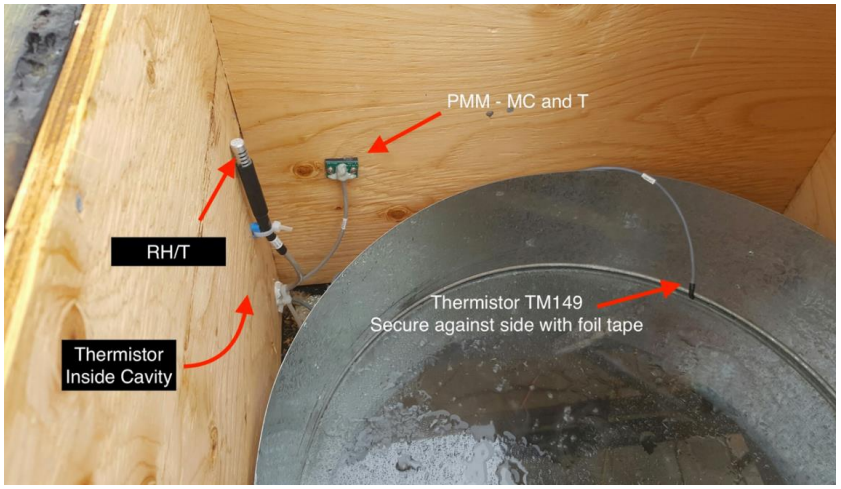


Figure 1. Parapet to curtain wall assembly

Instrumentation During Construction

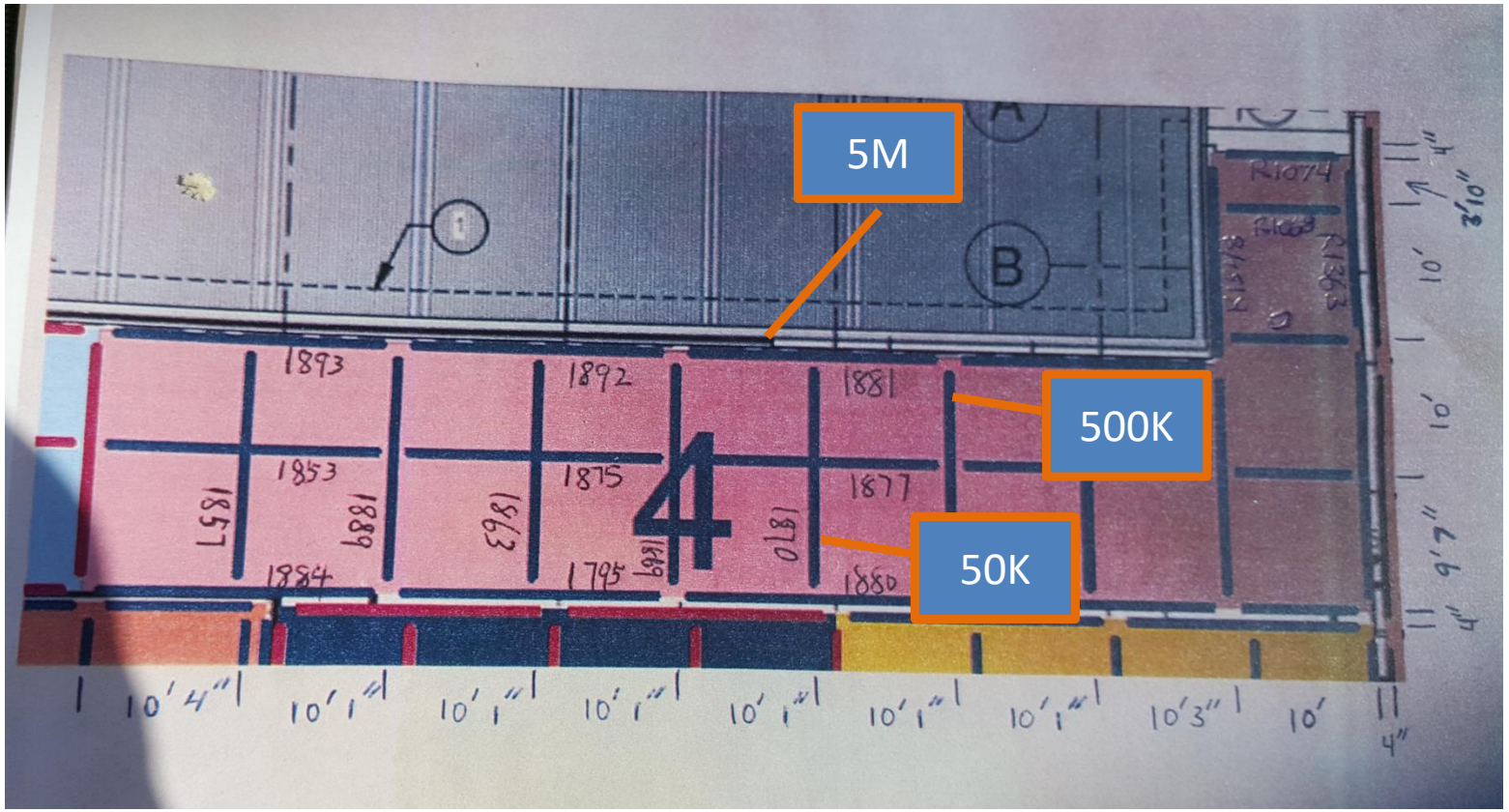




Solar Tube Monitoring

Sensor Installation

Leaks Identified on System Software



- Tape sensors revealed potential moisture under the roof membrane
- Dry tape sensors are 10M ohms

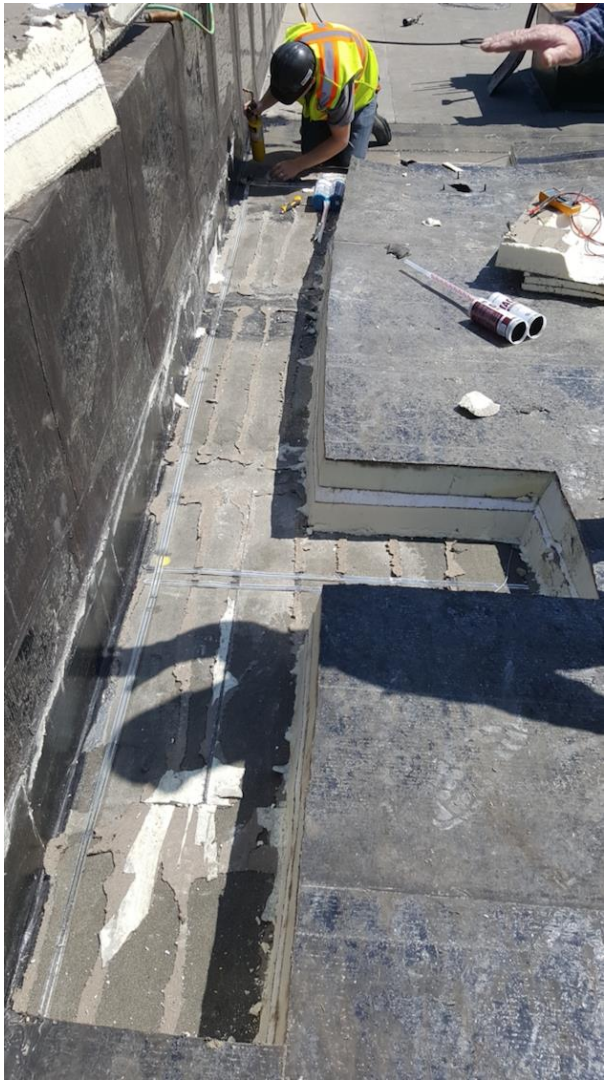
Roof Leak Investigation

Cut roof section open, confirmed water was present.

Identified Breaches in Roof Membrane

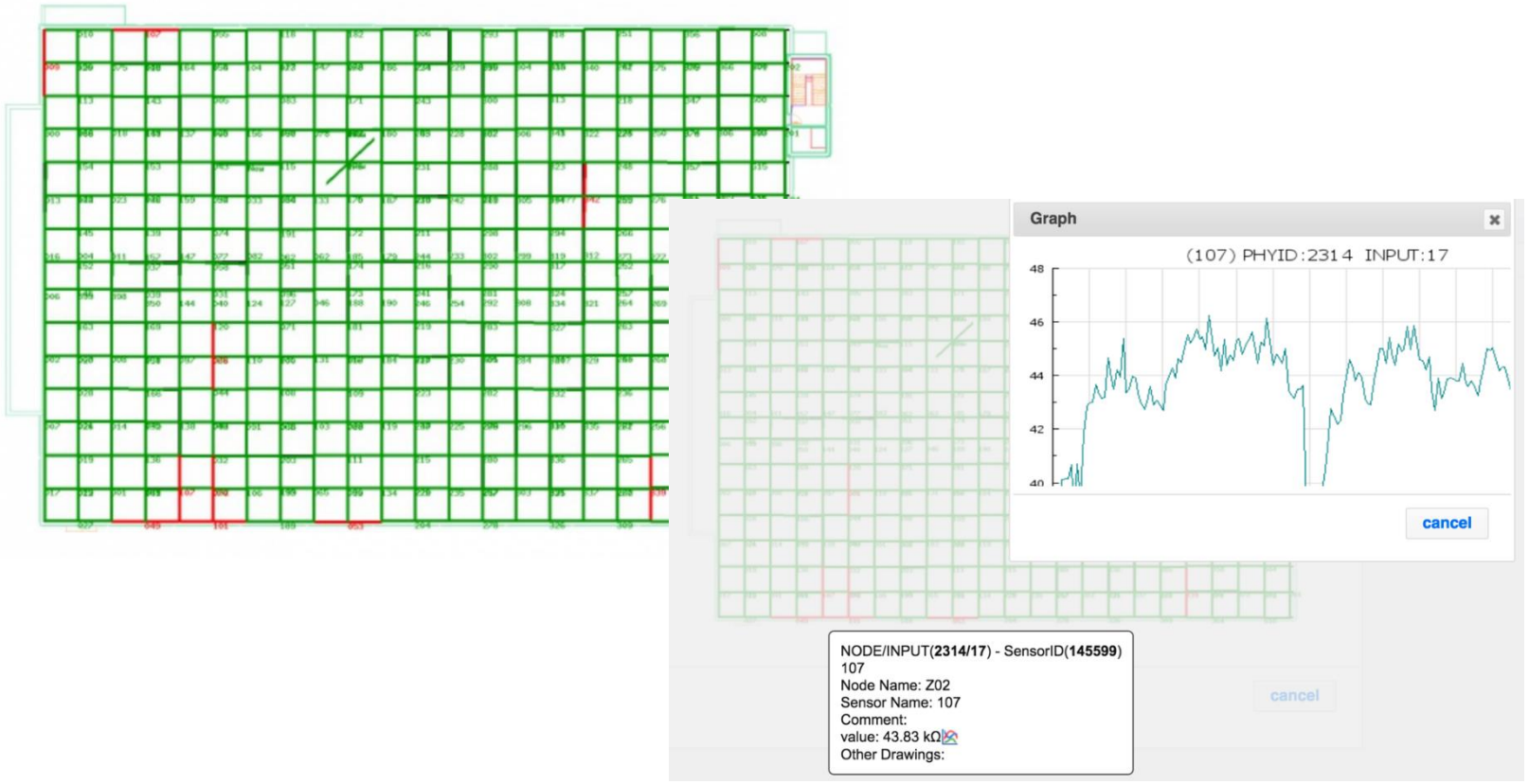
Leak may have been due to this puncture in the membrane.

Identified Roof Leaks



- Entire area was dried, tapes retested and area was re-roofed.
- Similar issues were identified in other areas.
- System activated to validate entire roof system.

Analytics Output – Standard Visualization



Using standard graphing tools and color coded graphics to indicate leaks and/or areas that exceed a specific threshold.

Data Visualizations – Augmented Reality

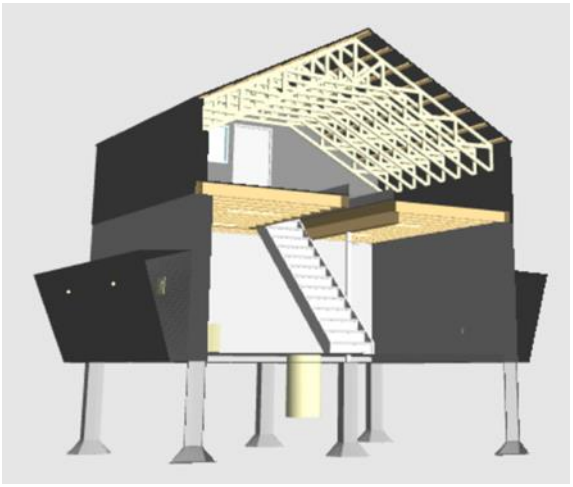
Extract data from embedded sensors and overlay on smart phone display

Data Visualizations - Interactive Interface

Using Unity Gaming Engine users will be able to navigate building and view sensors embedded through building

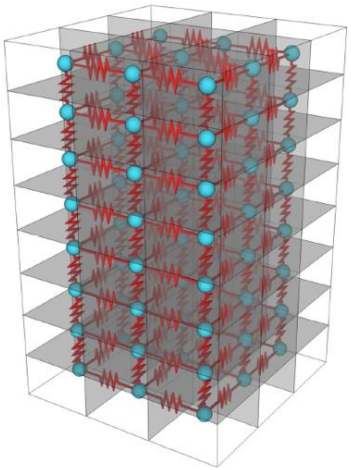
Data Visualizations – BIM/Sensor Interface

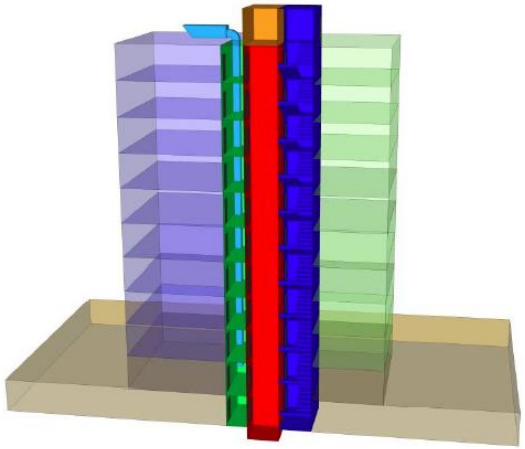
- Integrate sensor data with Building Information Modelling (BIM) Tools
  - Create a web browser and mobile device visualization of BIM model
  - Provide advanced analysis and processing tools including:
    - Machine learning for data filtering
    - Deep learning for pattern analysis of alert conditions
    - Heat map visualization

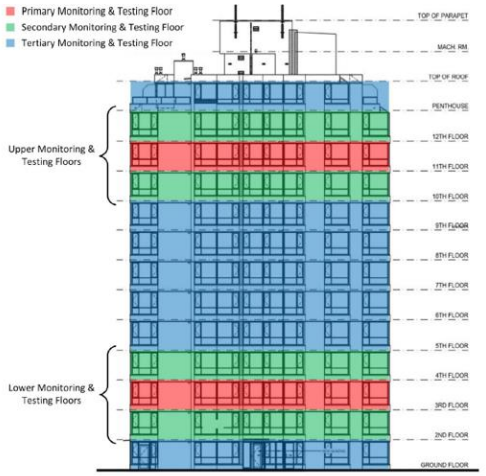


Applied Research Projects Initiated

- Model the thermal efficiency of the building using building energy simulation tools such as WUFI, HOT2000, Therm etc.
- Compare results to actual readings from heat flux and temperature sensors installed throughout the building.
- Part II of the paper this presentation is based upon.

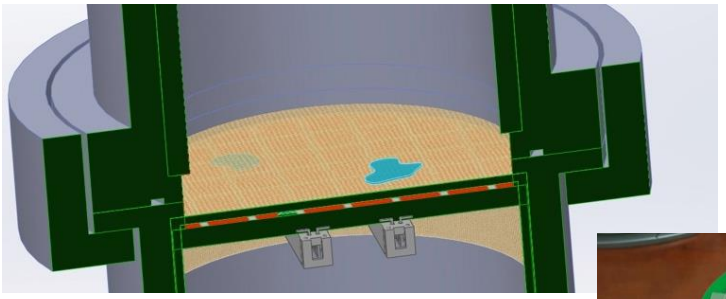


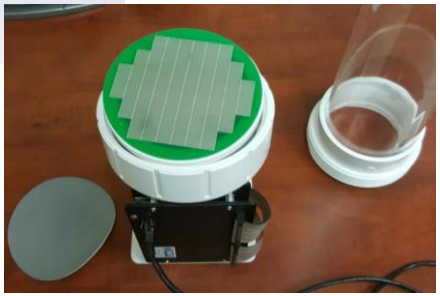


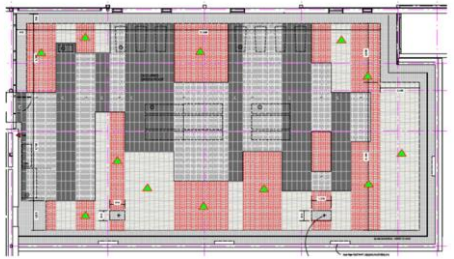


Applied Research Projects Initiated

- New Methods for Material Testing
- AATCC Test Method 127 Proposed with Sensor Plate
- Using a Hydrostatic Pressure Test
- New test apparatus devised to validate materials
- Data collection using drone technology: by UBC IGEN team - using a land based drone to analyze roofs for leaks and presence of moisture.

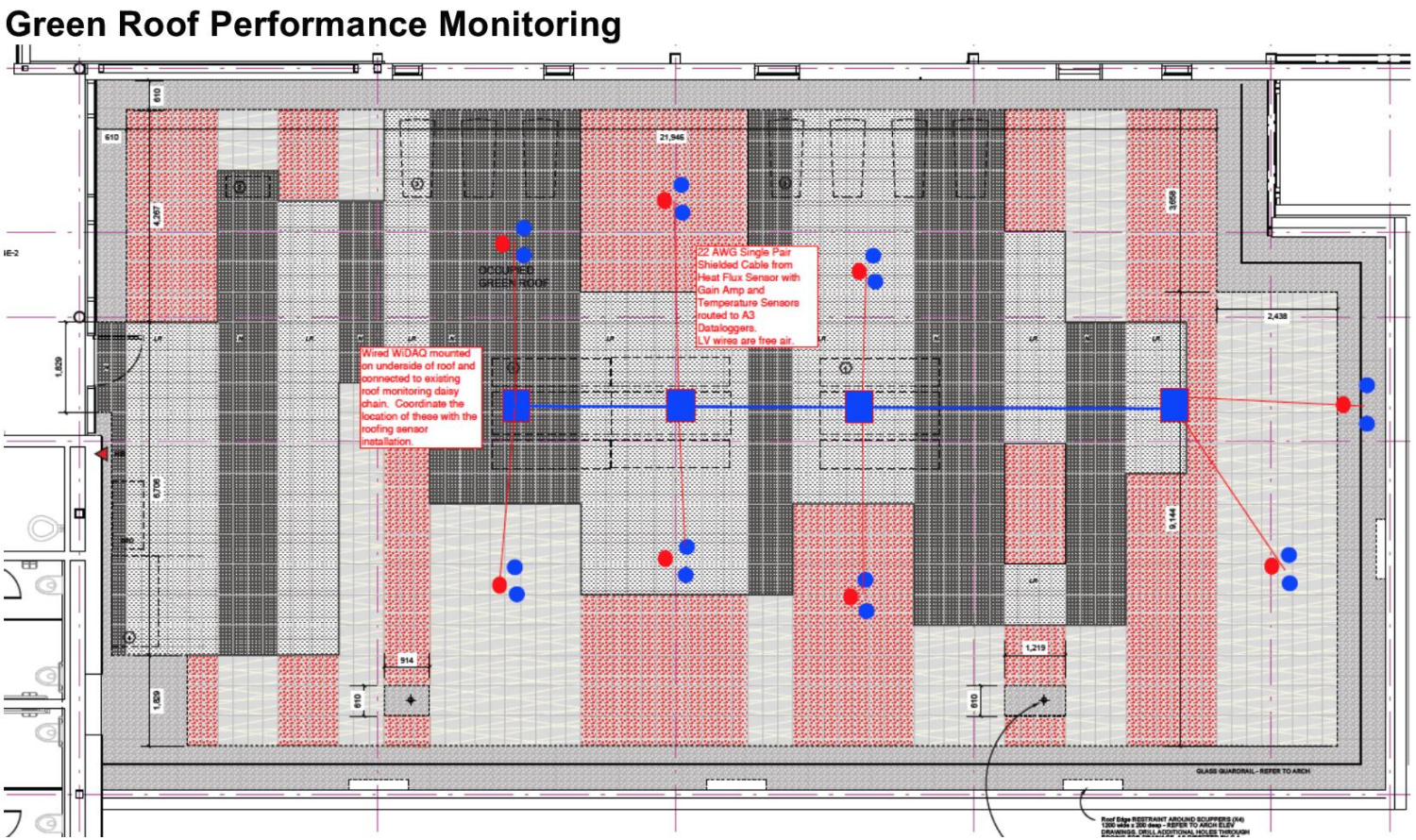






Proposed Applied Research Project

Green Roof Thermal Analysis



Questions & For More Information

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