Moisture Performance and Vertical Monitoring of Pre-Fabricated CLT

Featured Case Study: UBC Tall Wood House

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Moisture Performance and Vertical Monitoring of Pre-Fabricated Cross Laminate Timber

Project Partners and Contributions

SMT Structure Monitoring Technology

UBC PROPERTIES TRUST

FPInnovations

AOA

NRC·CNRC Canada

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Agenda

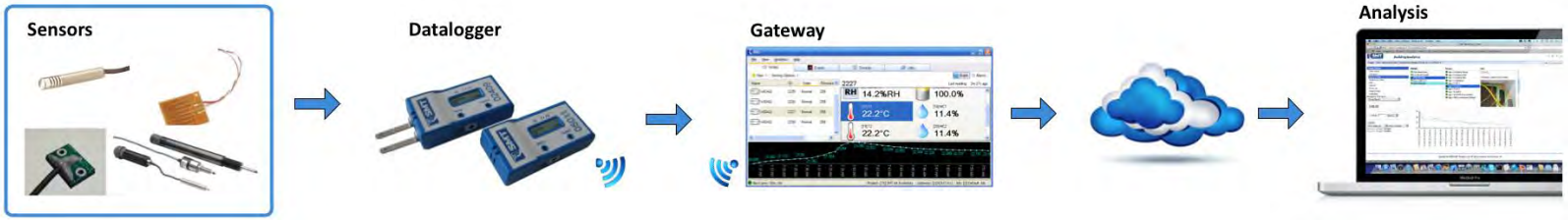
- Overview of Monitoring Technology

- Moisture Monitoring
  - Case Study – UBC Tall Wood Building
    - Monitoring During Transportation and Storage
    - Monitoring During Installation
    - Results

- Vertical Displacement Monitoring
  - Case Study – UBC Tall Wood Building
    - Implementation
    - Results

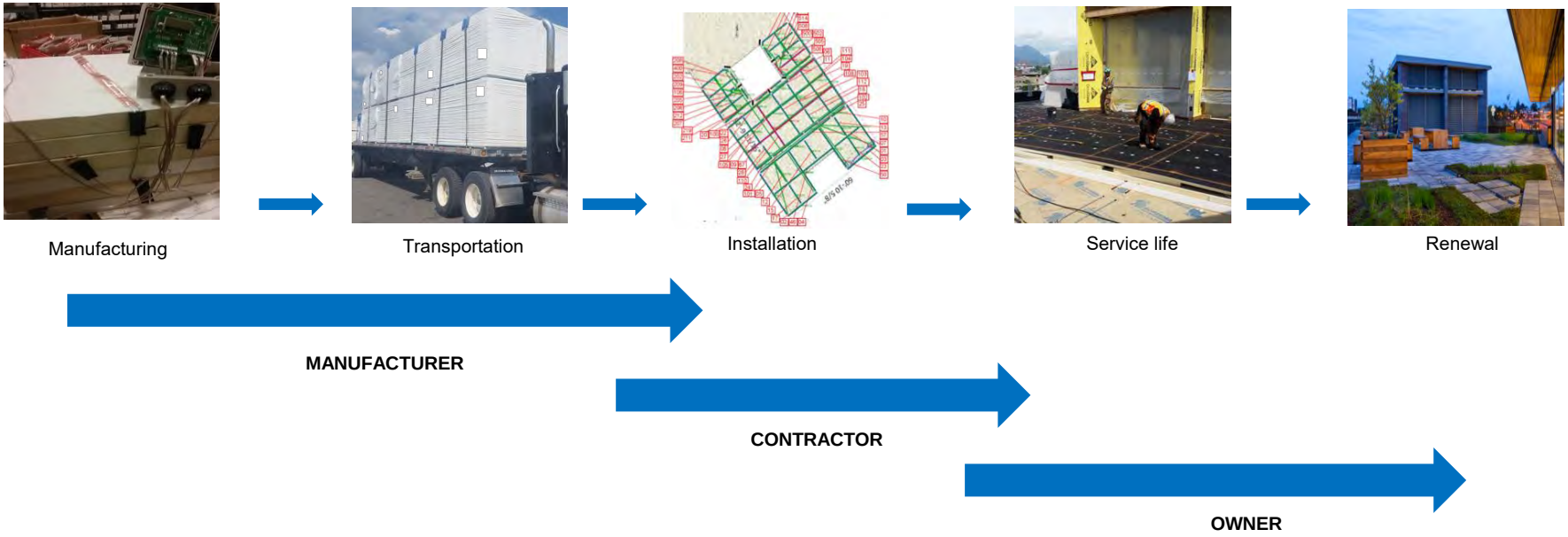
- Data Visualization Techniques and Analysis

Monitoring



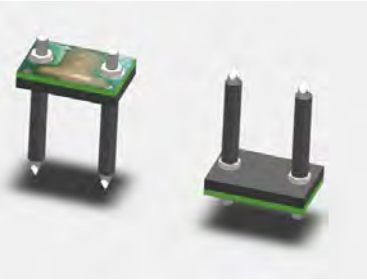
- See http://www.smtresearch.ca/smt-product-list for list of Compatible Products
- High resolution sensors can be connected to wireless, wired and cellular based DAQS.
- Cloud based software allows for easy data retrieval and analysis.

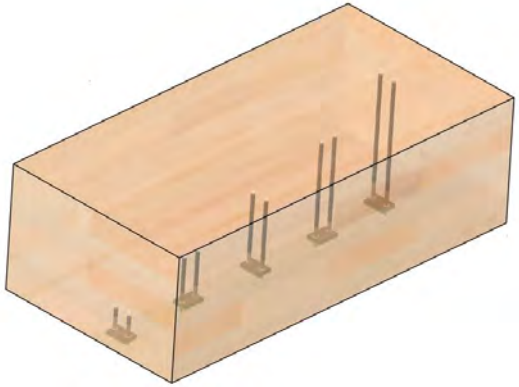
Monitoring

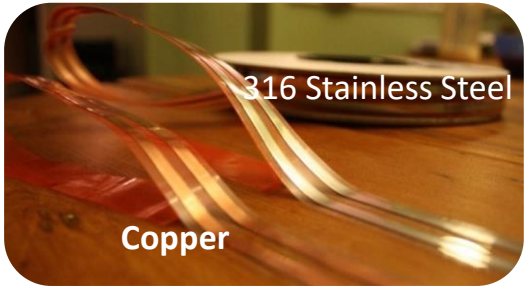


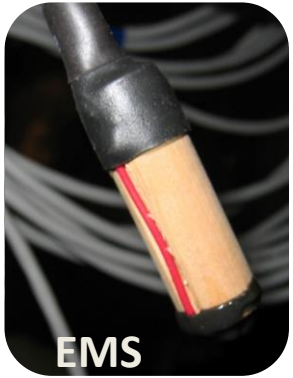
- Monitoring technologies track products throughout their entire lifecycle and ownership

Moisture Monitoring



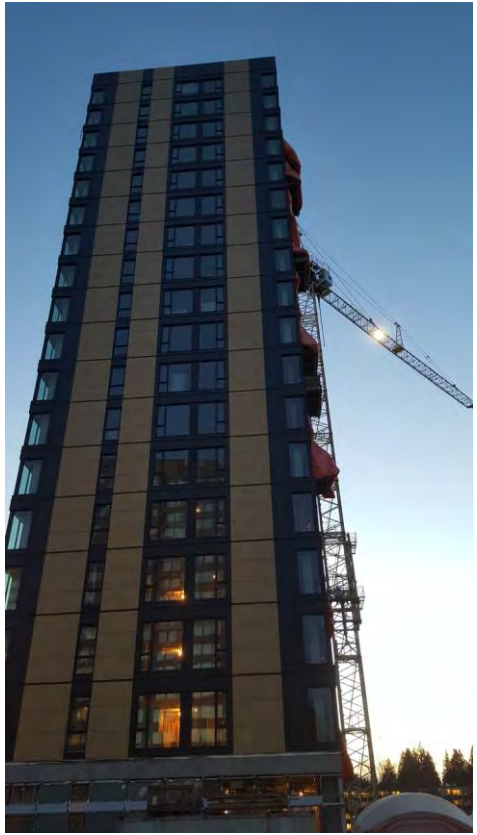






Case Study – Tall Wood Building

- The 18-storey Tall Wood Building at UBC is constructed of prefabricated Cross Laminated Timber (CLT) panels where each panel is pre-cut and drilled according to a computer designed model. All penetrations, notches and holes have been precut and drilled and ready to be installed systematically into the building.



Case Study – Tall Wood Building

Video: NaturallyWood

Case Study – Tall Wood Building

Wood components of the building are as follows:

Glulam Columns: 78 glulam columns per floor except level 18, equating to 1302 columns in the building.

CLT Panels: 29 5-ply panels per floor, equating to 464 panels on 16 floors equating to a weight of 954 tons.

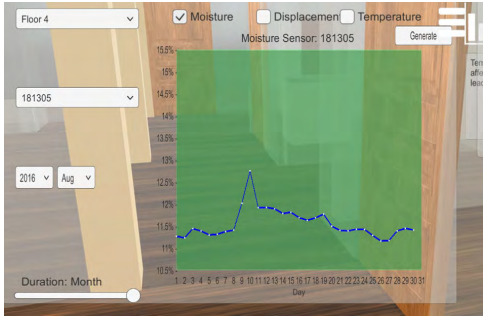
Total volume of wood in the building is 2233 cubic meters

Credit: Acton Ostry

Case Study – Tall Wood Building

- Evaluate the life cycle moisture performance of prefabricated cross laminated timber (CLT) from the manufacturing plant, during transport and storage and during the construction process.

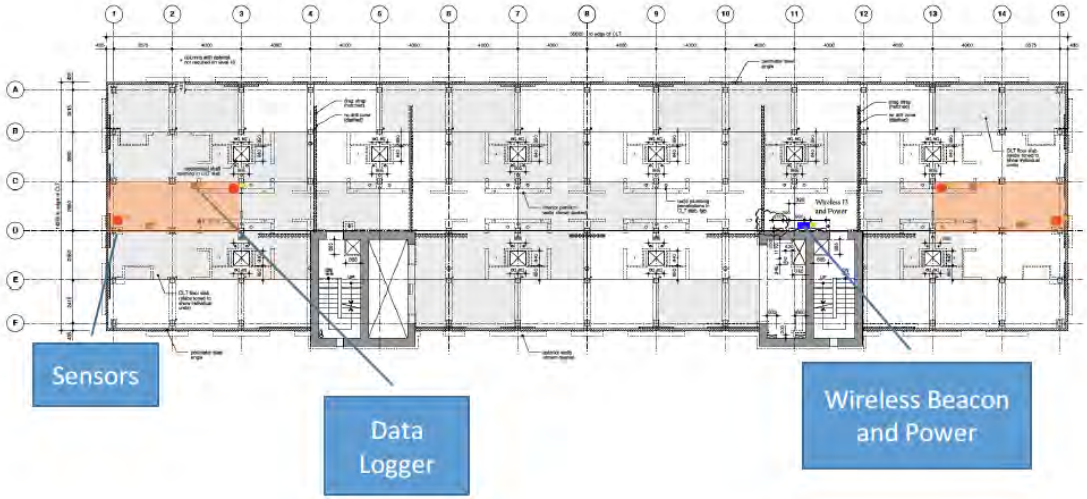
Sensor Type	Quantity
String Pots	18
Moisture Sensors	192
Temperature	96
RH	32
Total Sensors	338

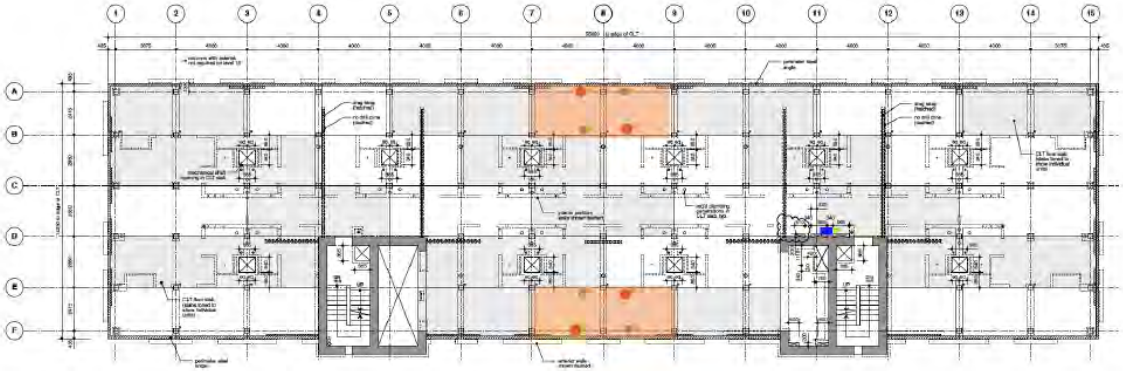


Case Study – Tall Wood Building

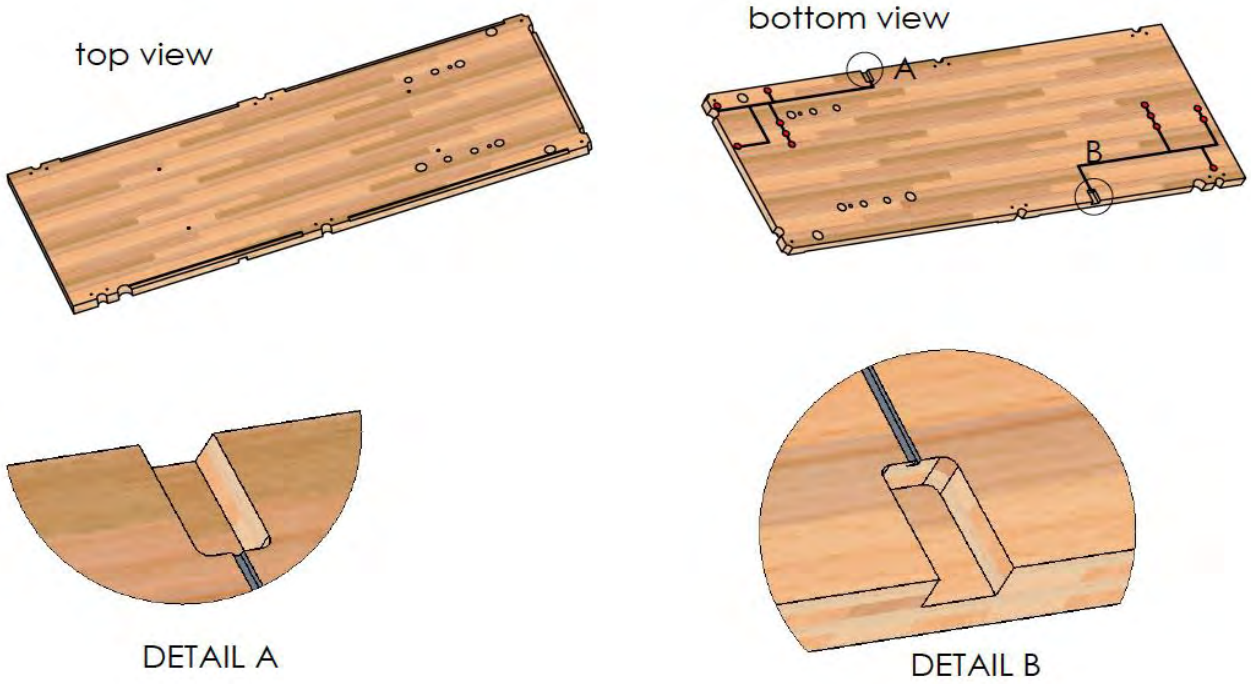
Moisture Sensor Plan

- CLT panels selected to monitor are every second floor alternating between the North/South and East/West locations





- Plan was to have sensors and electronics installed inside the panels during prefabrication.

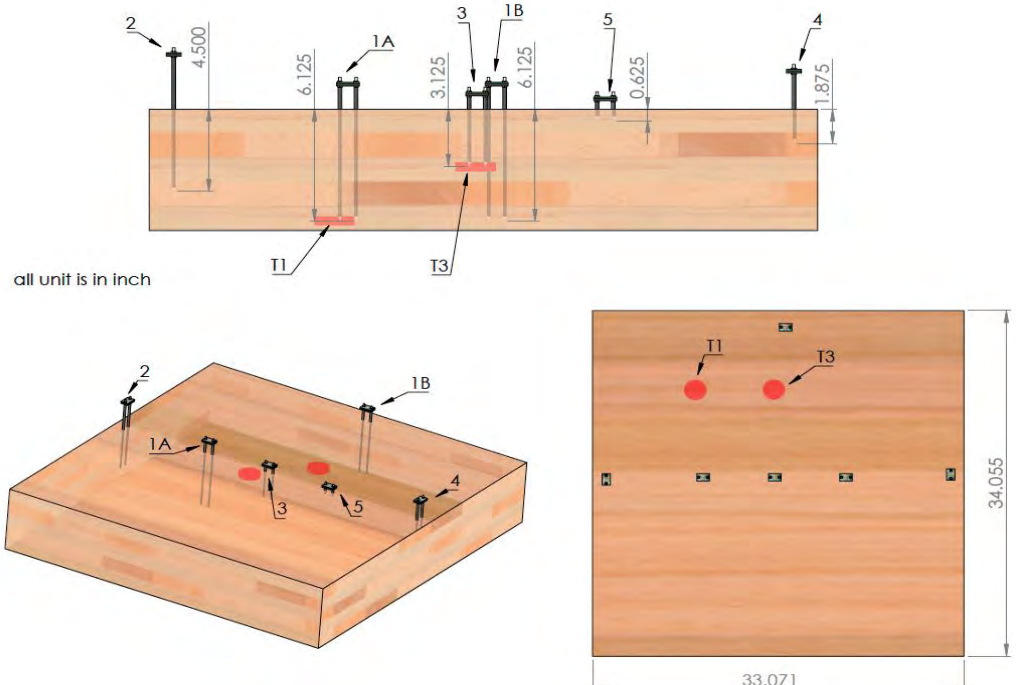


Case Study – Tall Wood Building

- Due to logistics at the plant this was not possible, as a result, offcuts were instrumented and stored and transported with the CLT panels.

Case Study – Tall Wood Building

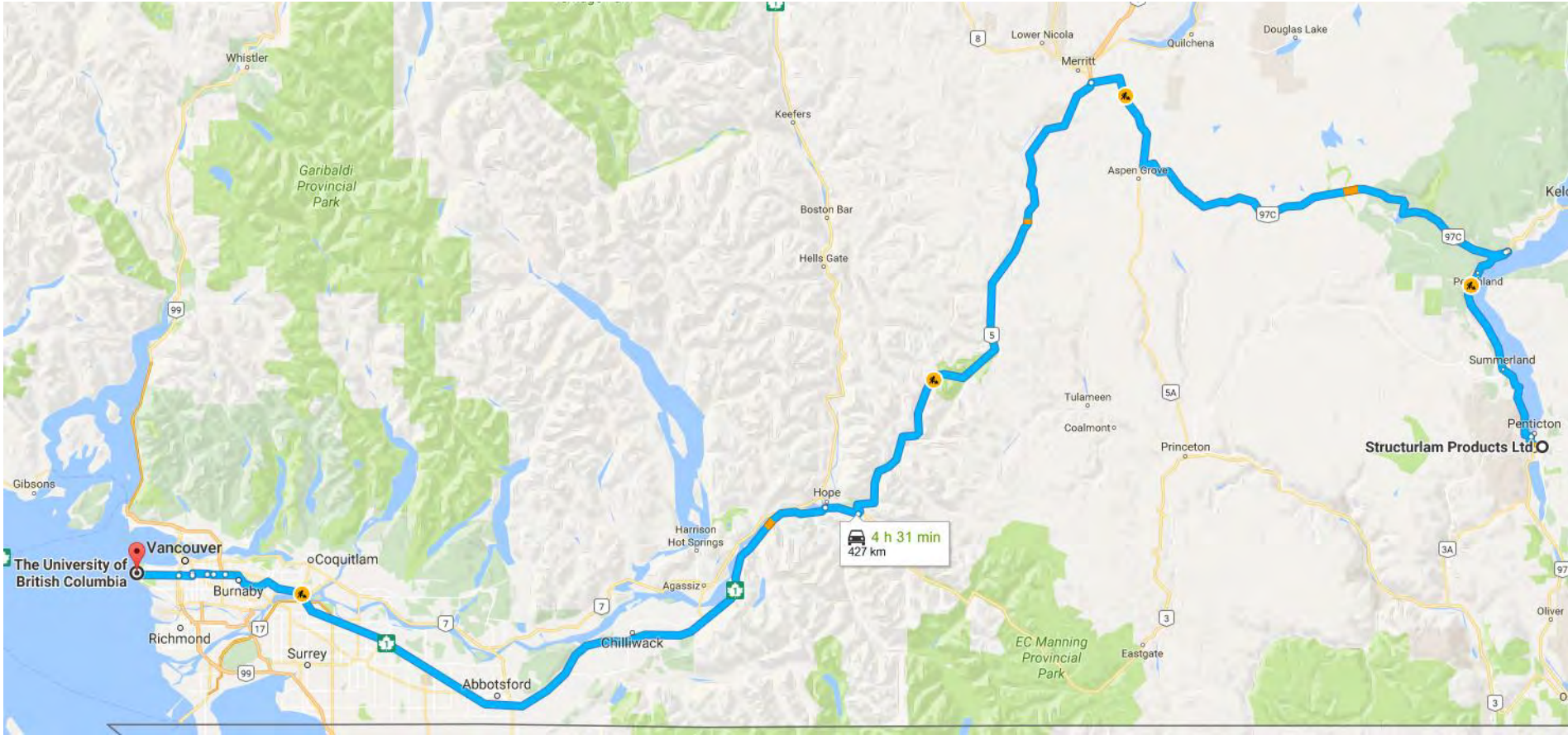
- Each offcut had 6 moisture sensors installed so that moisture can be measured in each layer and at the edge and center of the CLT.
- Two temperature sensors were also installed at different depths in the CLT



Case Study – Tall Wood Building

- Monitoring During Transportation and Storage

Case Study – Tall Wood Building

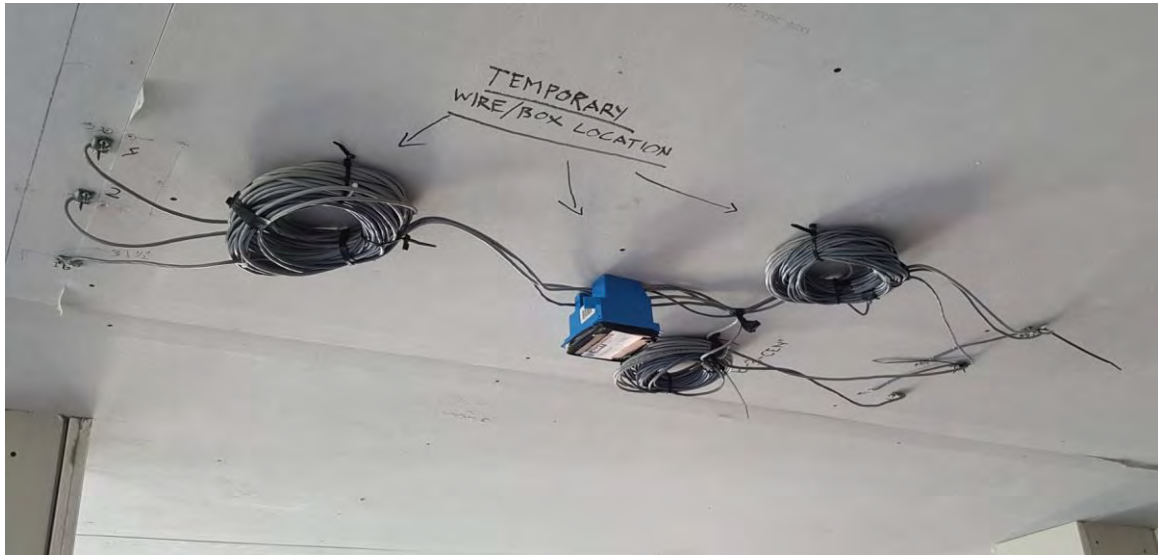


Case Study – Tall Wood Building

- Upon arrival at UBC, the CLT panels were moved directly from the truck to their assigned position
- CLT panel and column installation occurred during a typical Vancouver season which involved heavy downpours.

Case Study – Tall Wood Building

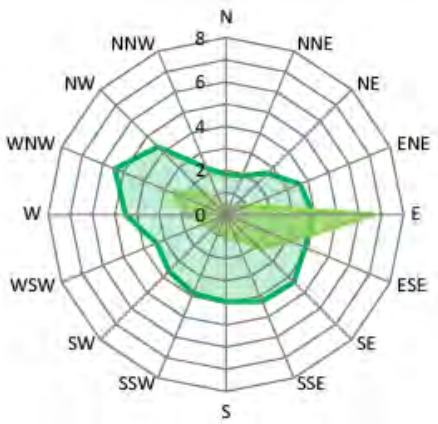
- Due to code constraints 4 floors were permitted to be erected until they were dry walled.
- Sensors and electronics were then moved from the CLT off cuts to the building.



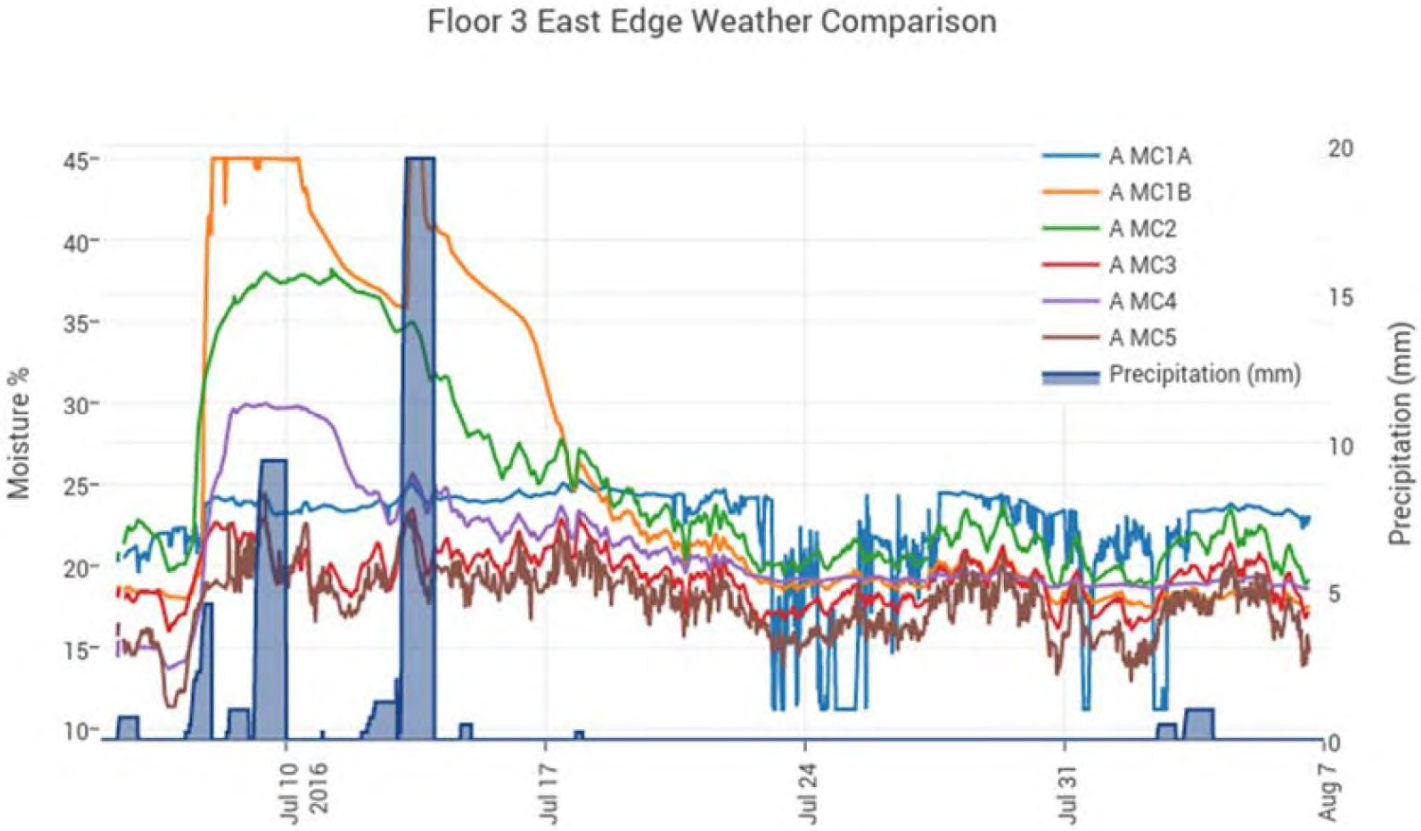
- After hat track was installed data acquisition electronics were relocated prior to another two layers of dry wall.

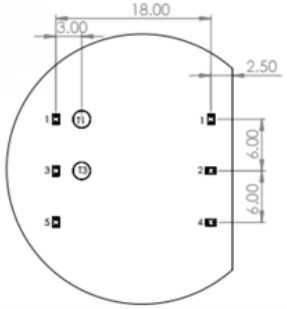
Case Study – Tall Wood Building

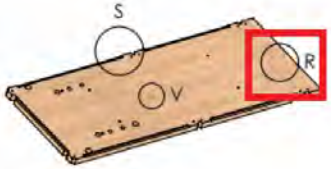
- Moisture performance results will continue to be collected over time and compared to indoor environmental conditions as well as outdoor conditions.



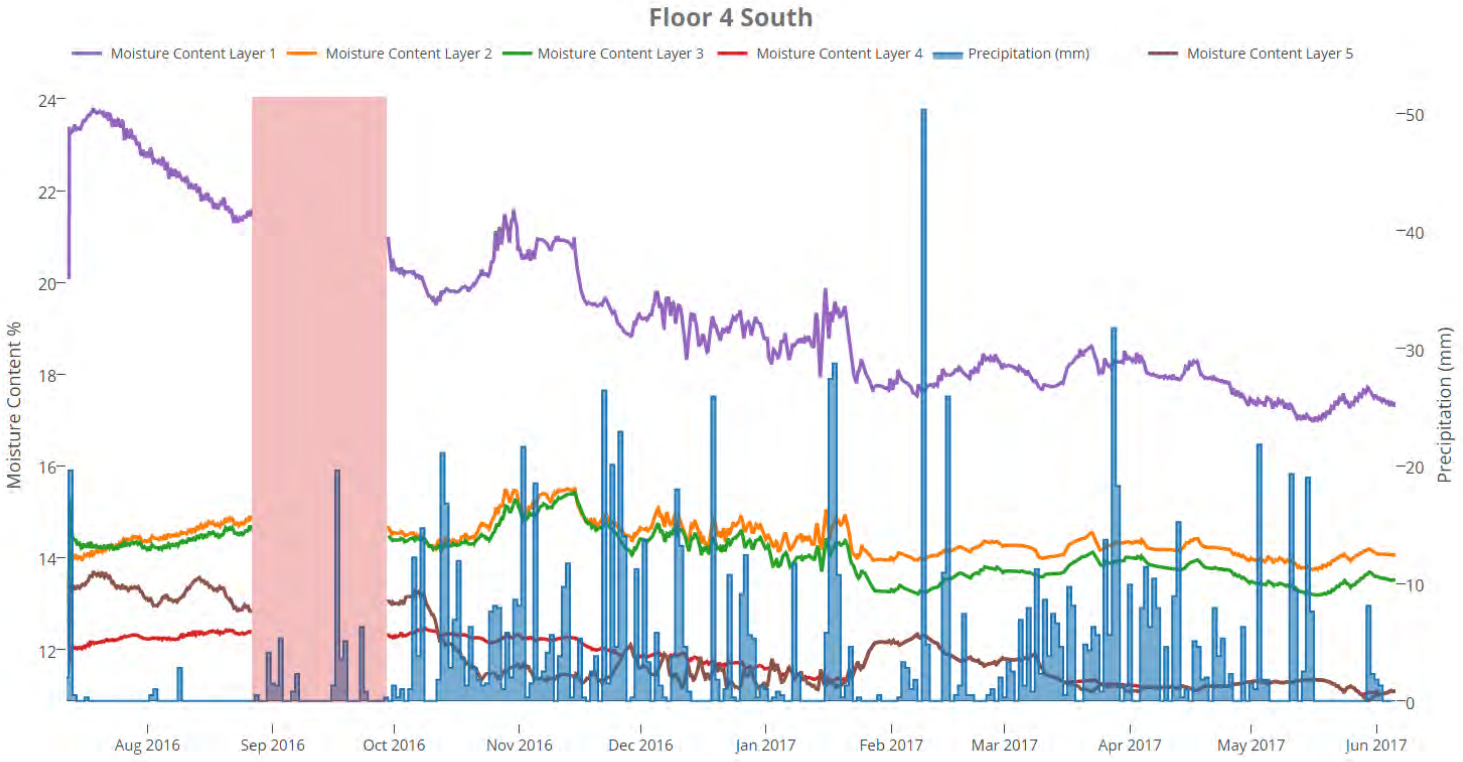
Case Study – Tall Wood Building – Results

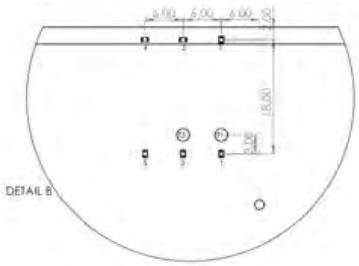


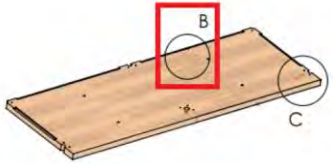




Case Study – Tall Wood Building – Results







Displacement Monitoring

- FPInnovations and SMT have instrumented several buildings constructed in BC to determine the vertical movement during and after construction in various conditions including rainy, cold and dry conditions.
- Methods published in ASTM publication Volume 41 were applied to the Tall Wood House

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Volume 41, Issue 4 (July 2013)

Monitoring of Vertical Movement in a Four-Story Wood-Frame Building in Coastal British Columbia

(Received 21 September 2012; accepted 4 February 2013)

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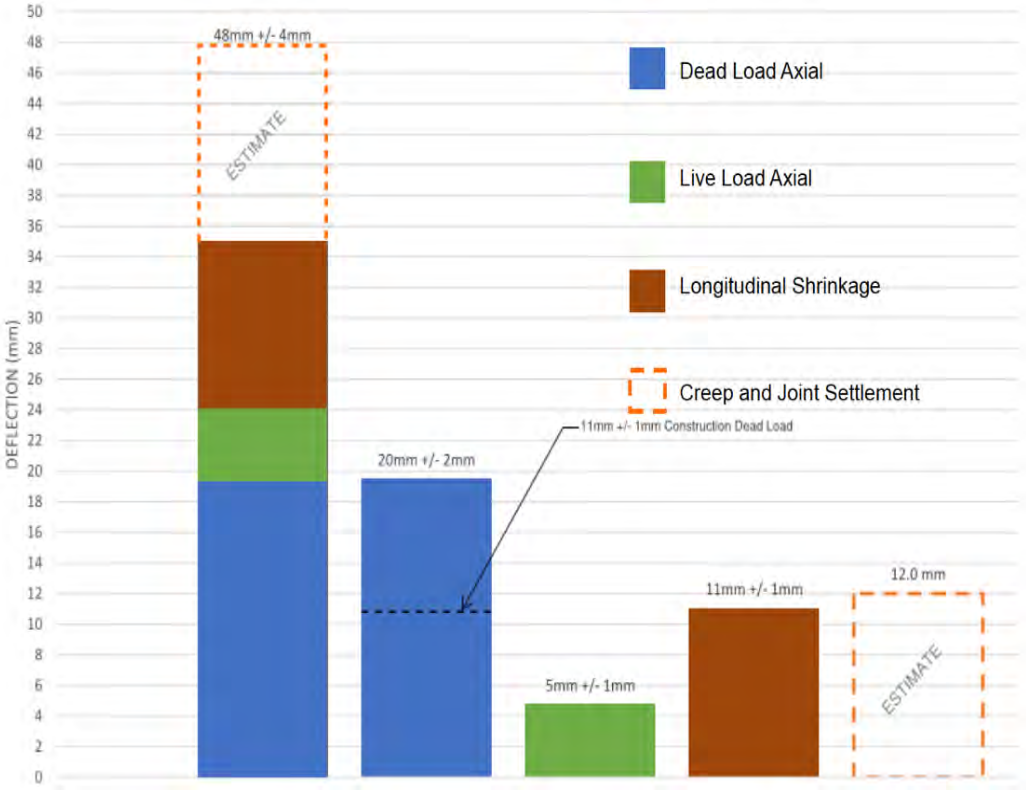
CODEN: JTEOAD

Displacement Monitoring

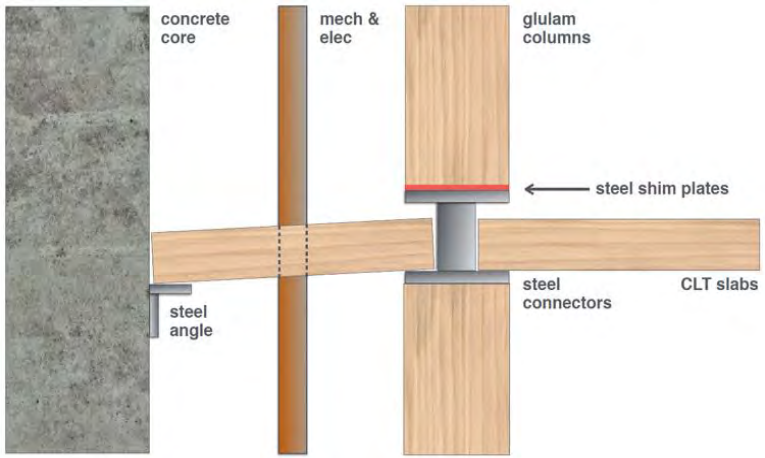
- The main concerns of axial shortening are the impact on vertical mechanical services as well as movement between the wood structure and concrete core.
- The axial column shortening was calculated to be 48mm. Of this, an estimate of creep and joint settlement is 12mm

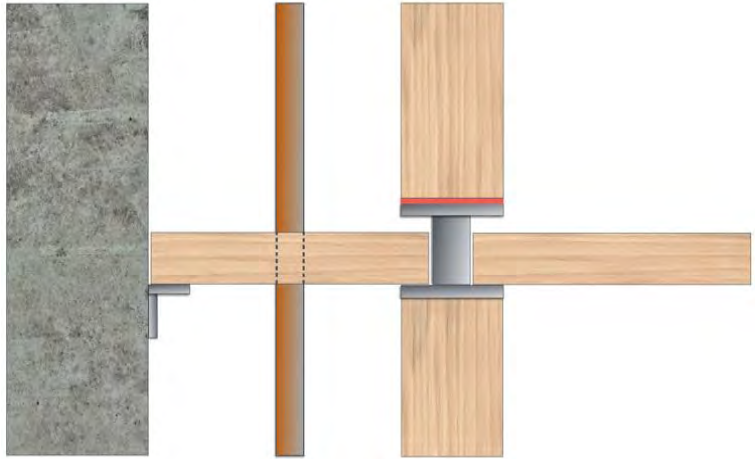


Credit: Jackson

Displacement Monitoring

- The difference between the axial concrete core shortening and the timber shortening is calculated to be 24mm. Provisions for axial shortening were mitigated by offsetting the connections for the CLT slabs so that they will naturally align after the building settles.

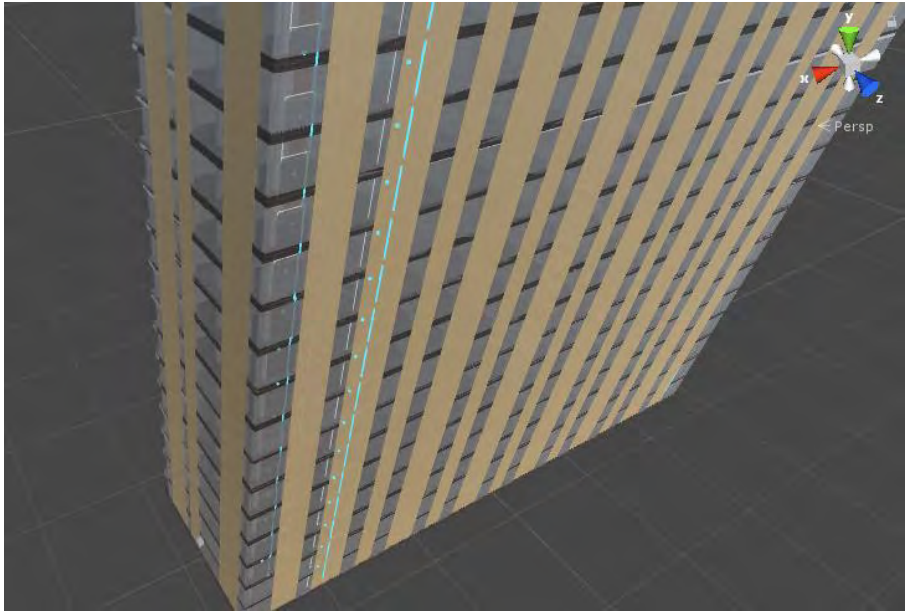




Credit: Acton

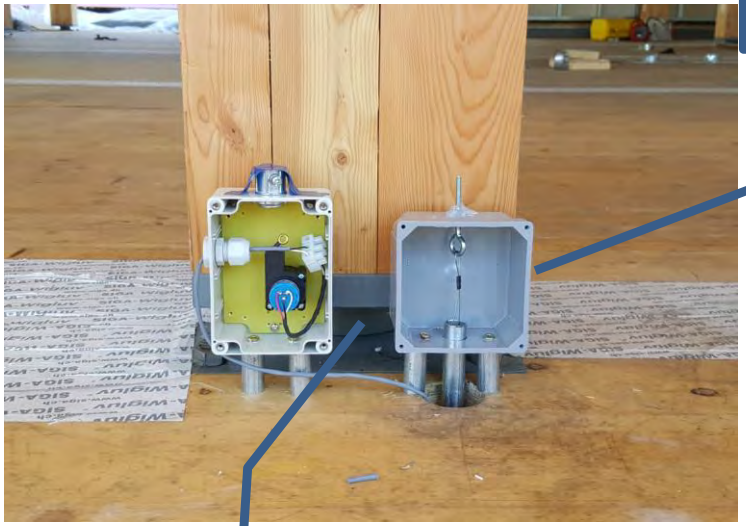
Displacement Monitoring

- Sensor installation uses a string pot sensor connected to a non-stretch cable suspended from the bottom of one floor to the top of the next floor. The assembly is repeated on each floor allowing a floor by floor comparison to be achieved.



Displacement Monitoring

- String pot installation



Hook Box (string from floor below)

String Pot

Conduit protecting string

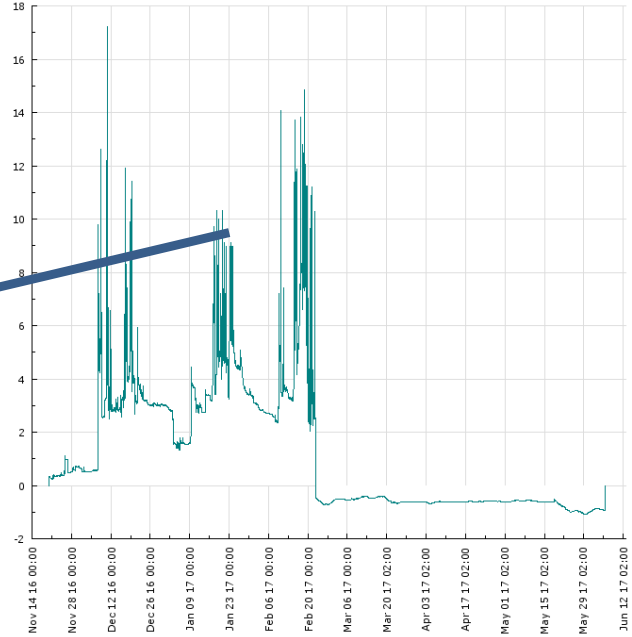
Case Study – Tall Wood Building

- Installation
- Shoring was used to support Outriggers which impacted the readings from vertical movement sensors during initial construction

Case Study – Tall Wood Building – Results

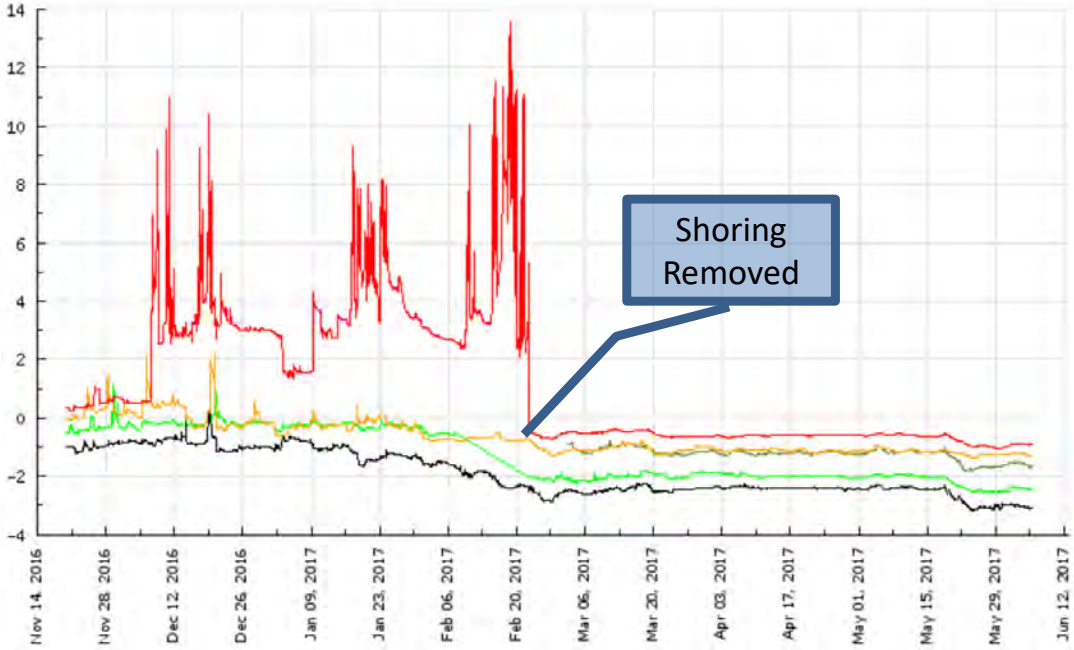
- String pot sensors were calibrated prior to adding shoring in the vicinity to support outriggers.
- Displacement of string pot sensors on floors 1-5

Floor	Displacement Nov - Jun
2 (edge)	-1.387 mm
3 (edge)	-1.077 mm
3	-1.821 mm
4	-3.182 mm
5	-2.604 mm



Shoring and Outrigger disturbance

Case Study – Tall Wood Building – Results



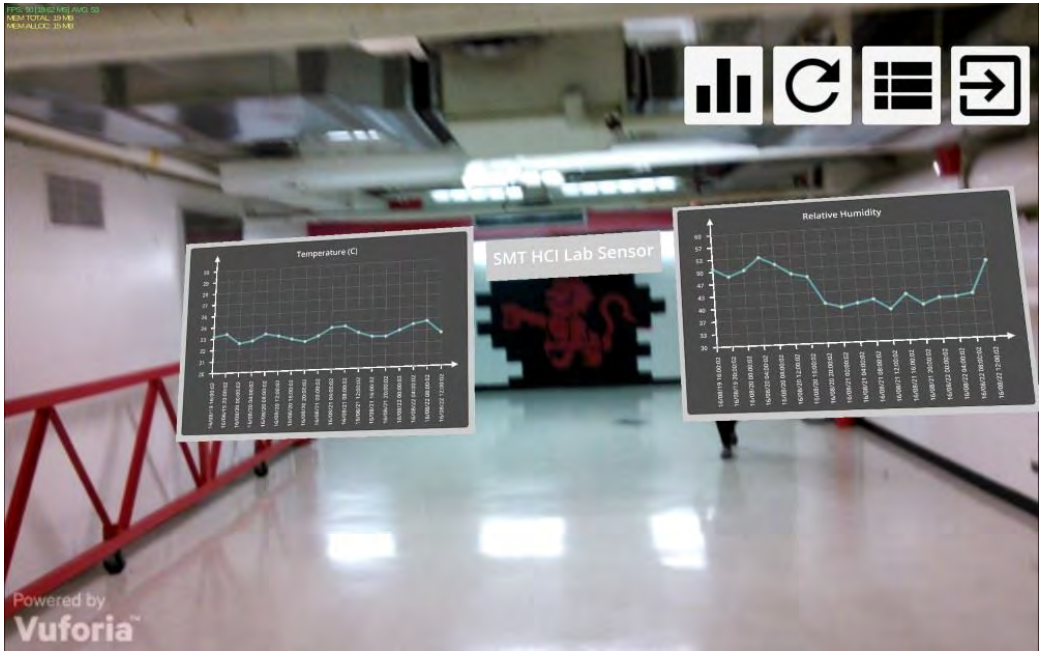
- 5th Floor String Pot (8917/18)
- 4th Floor String Pot (8917/17)
- 3rd Floor String Pot (8931/19)
- 2nd Floor String Pot (edge) (5587/2)
- 3rd Floor String Pot (edge) (5589/2)

Augmented Reality

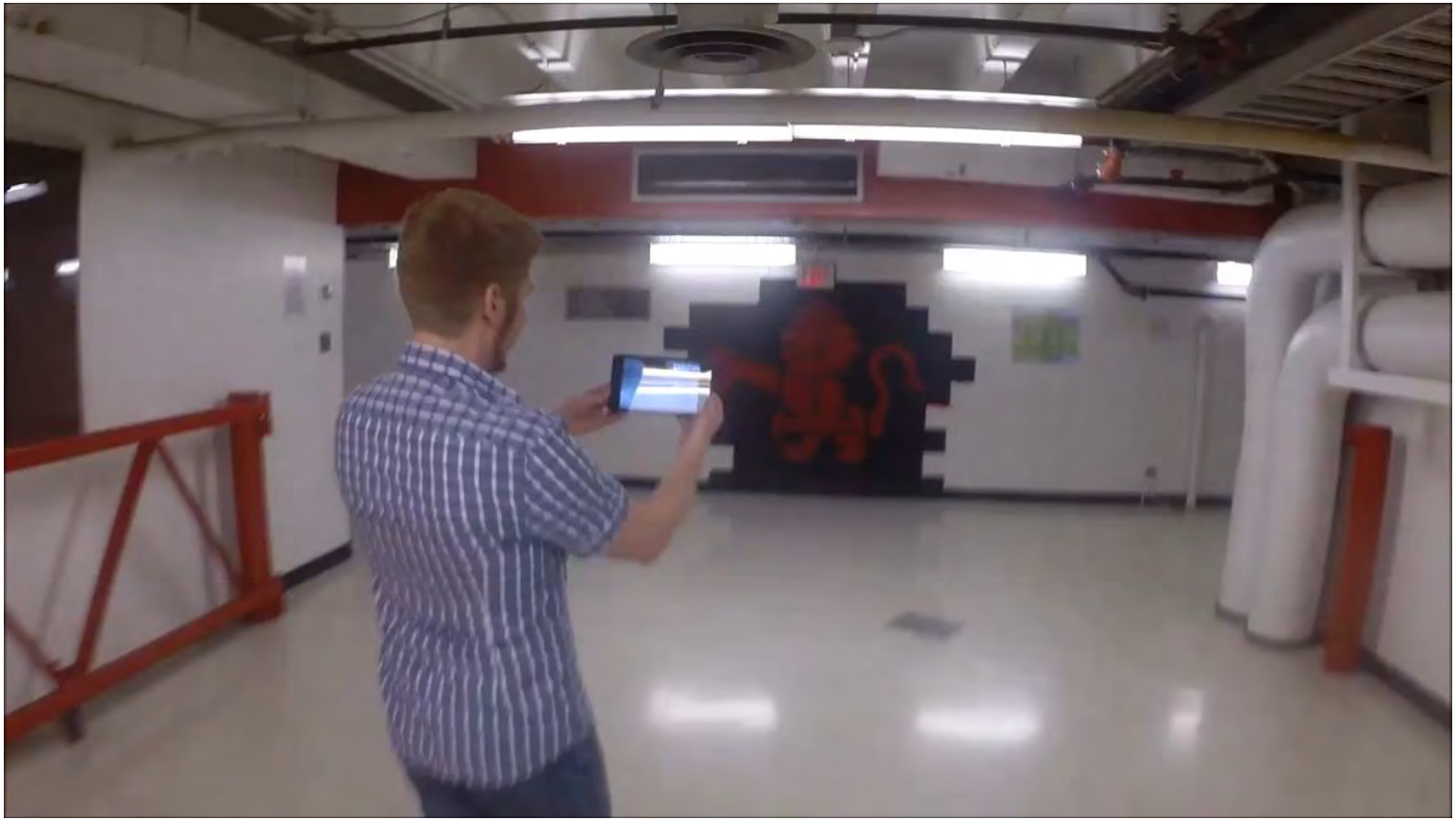
Extract data from embedded sensors and overlay on smart phone display

Data Visualizations

Using a Smartphone camera, identify the surface in view and augment the surroundings by overlaying sensor data on the image.



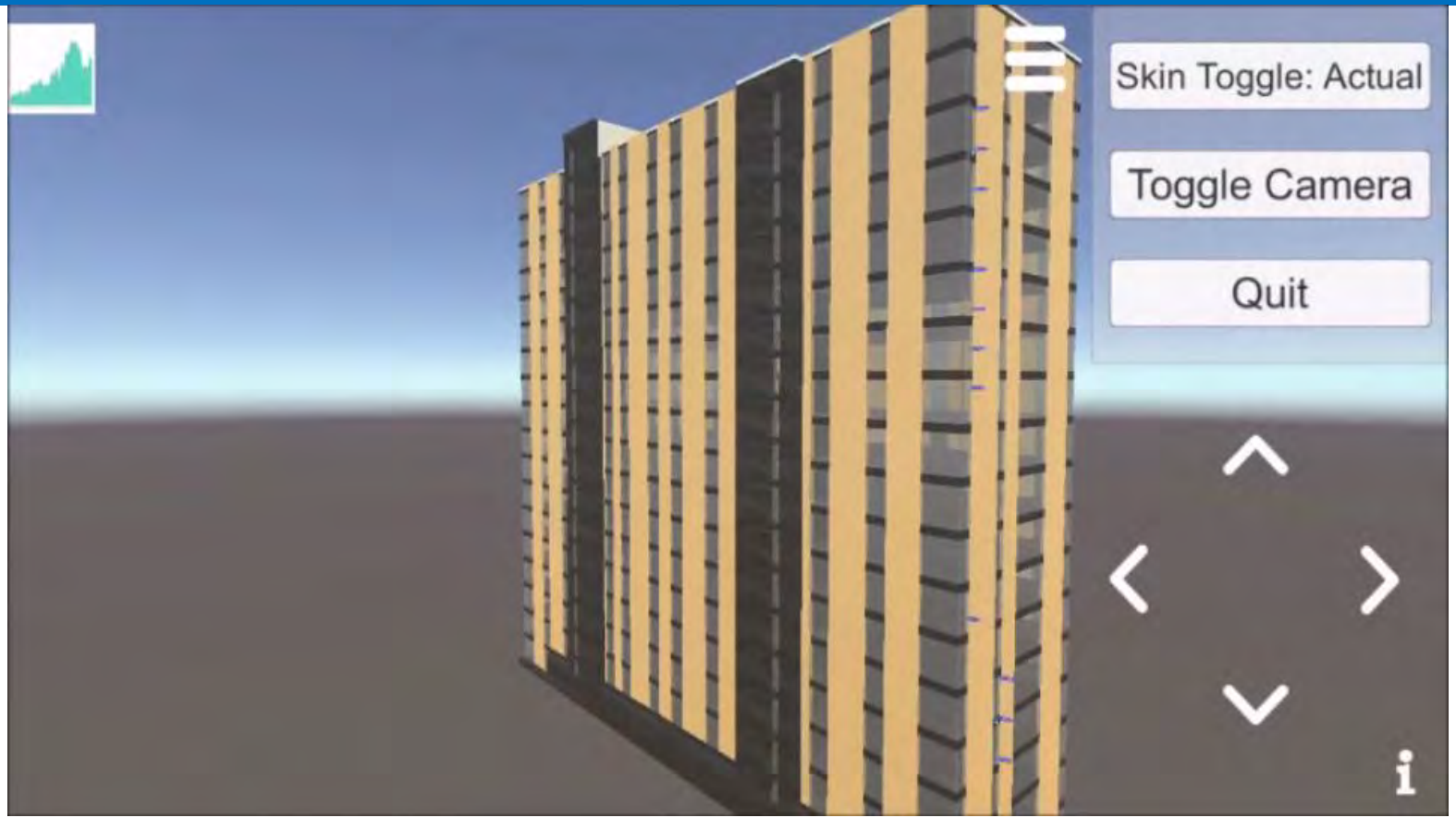
Data Visualizations



Interactive Interface

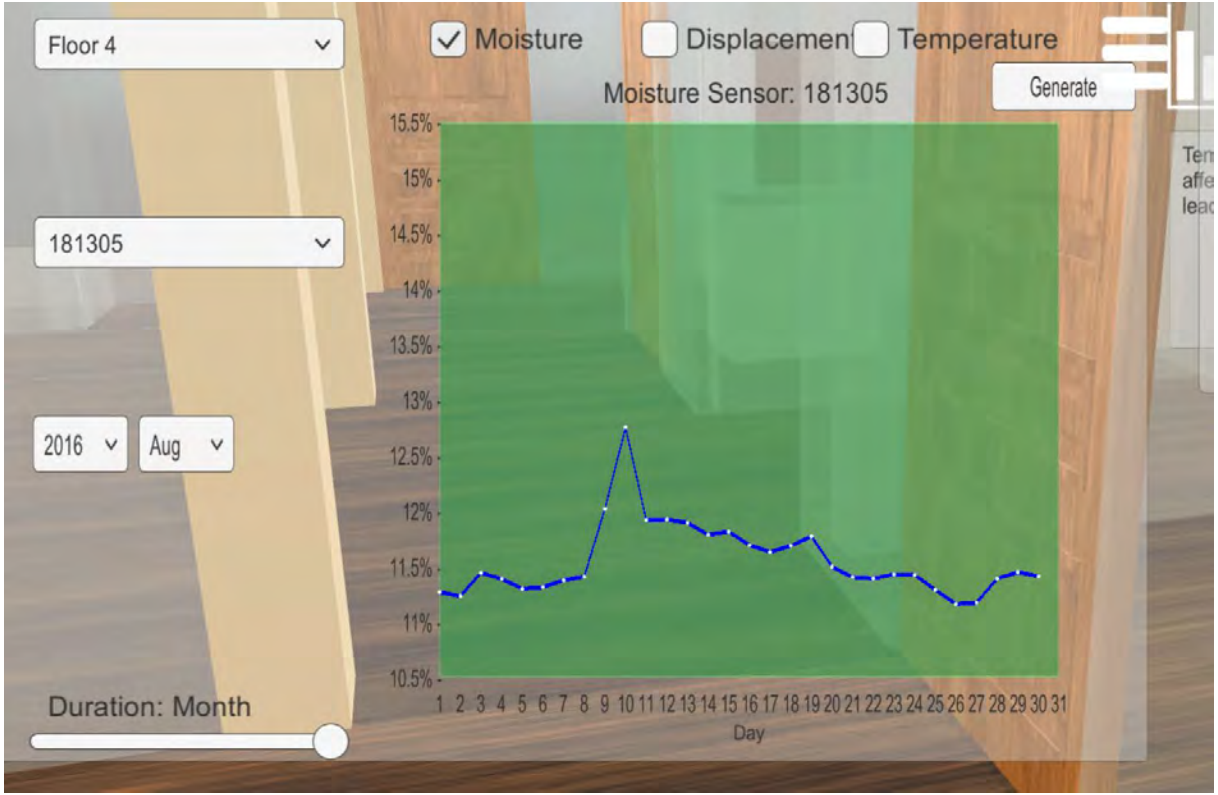
Using Unity Gaming Engine users will be able to navigate building and view sensors embedded through building

Interactive Interface



Interactive Interface

Select sensors to view historical data trends



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