

Innovative Non-Destructive Techniques for Assessing Quality of Building Envelopes

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Introduction

Non-destructive tests (NDTs) are a type of experimental method useful in determining the quality of structures. They can be utilized to analyze multiple different aspects of a building such as energy efficiency, strength, flaws, and damage. NDTs are valuable because they can help to assess and monitor the health of existing structures without altering any physical qualities.

The First Peoples House

The University of Victoria First Peoples House is an academic building on campus for Indigenous students. It was constructed in 2008 and is a LEED® Gold building [1]. The building has 2 rammed earth walls on its east and west face.



Rammed Earth Walls

Rammed earth walls are composed mainly of compacted soil and aggregates. It is a green and sustainable construction material. Benefits include [2]

- Reduced CO₂ emissions and waste produced
- High thermal mass
- High fire resistance
- Low embodied energy
- Natural aesthetics

Objective

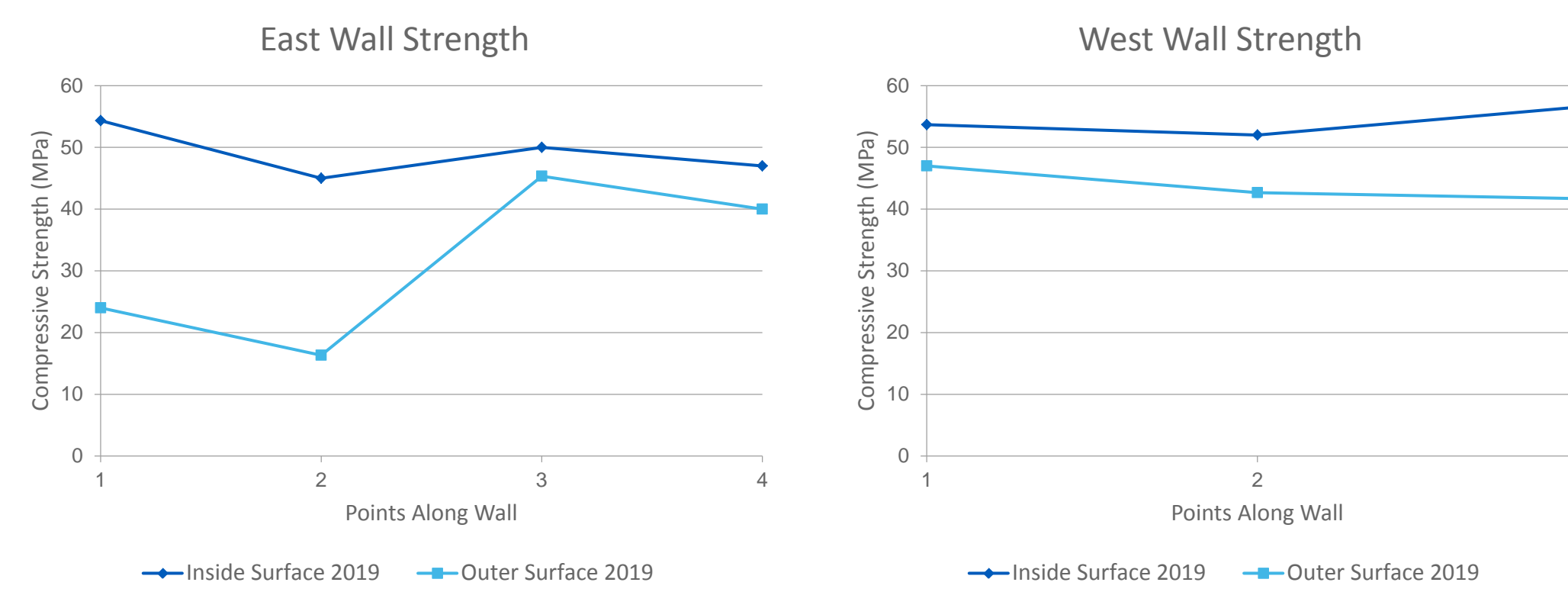
To determine performance of both rammed earth walls at the First Peoples House after 11 years of exposure. Non-destructive tests are used and results are compared to data from previous studies from the 7 year and 9 year mark after construction [1],[3].

Non-Destructive Tests

Use 7 measurement locations on the walls for testing

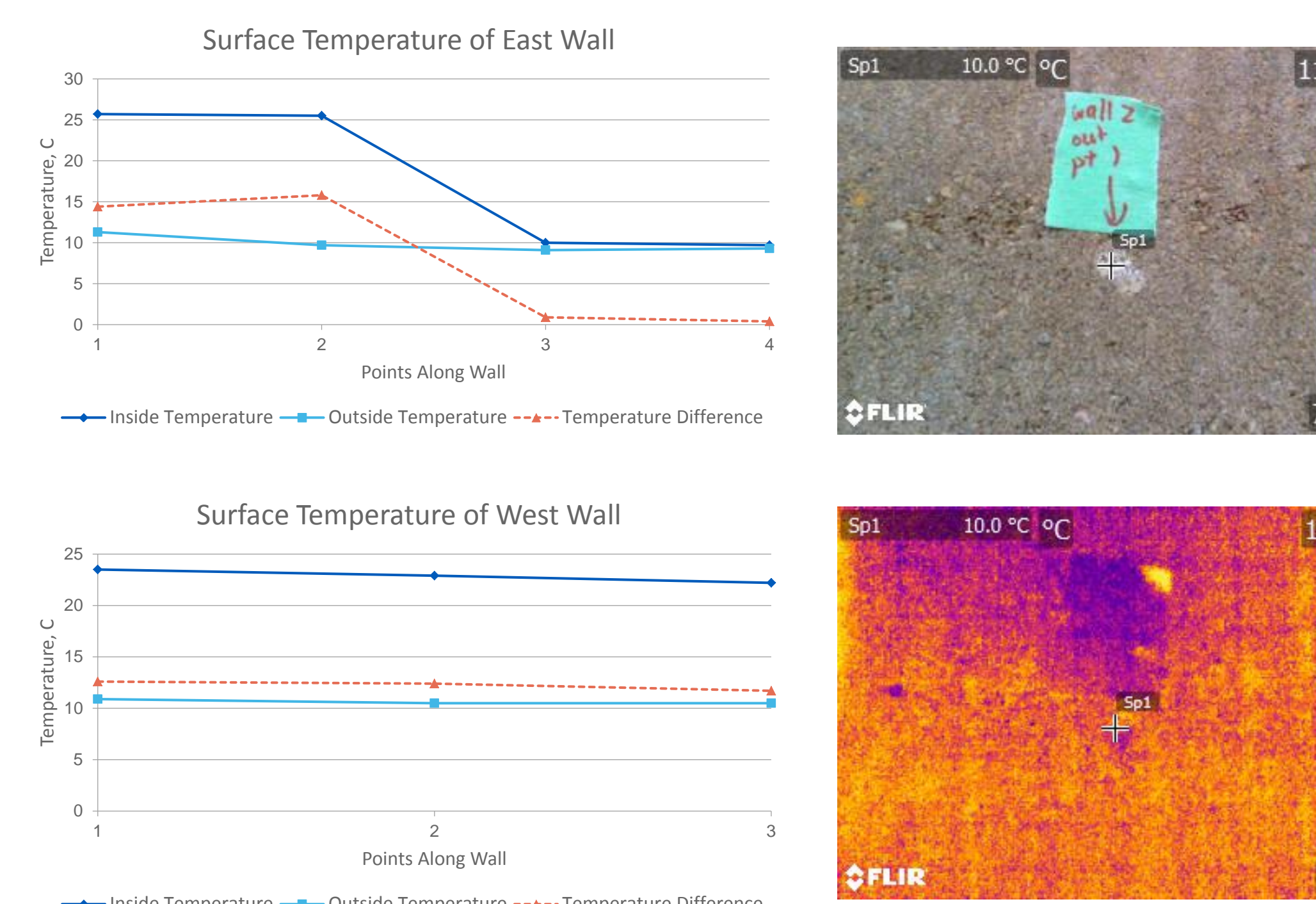
1. Rebound Hammer

Determines compressive strength of walls. Impact energy is sent into the wall and a rebound energy is returned to the device. The energy is then correlated to wall strength.



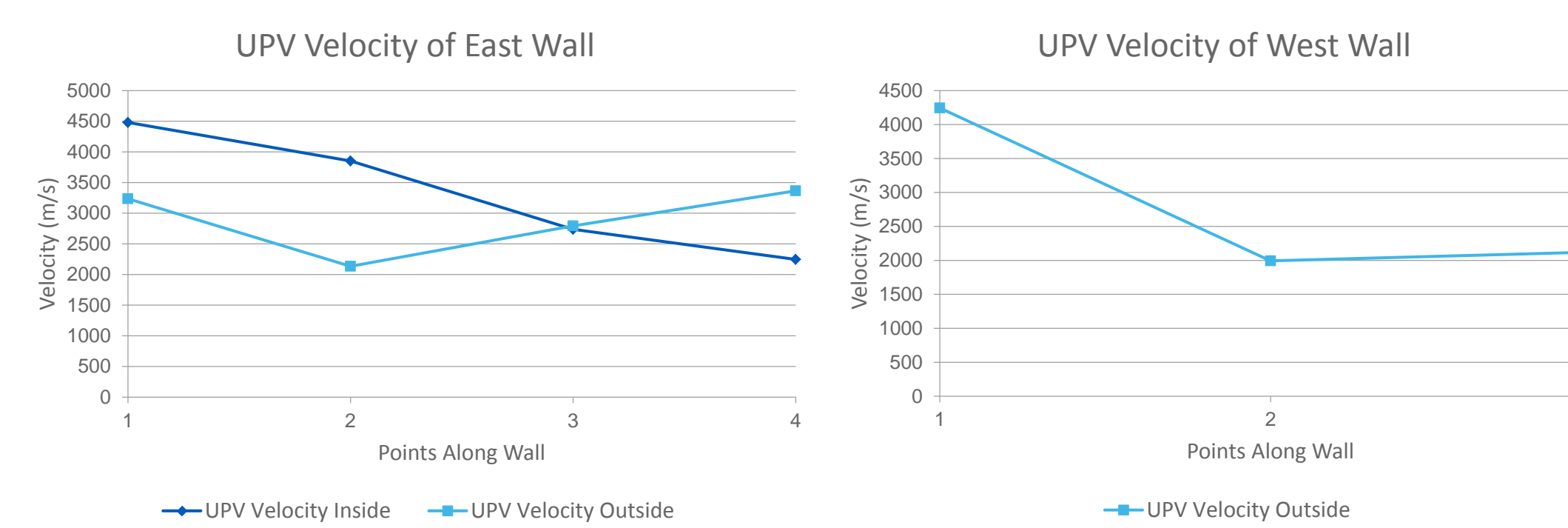
2. Infrared Camera

Surface temperature of the walls is determined with the camera. Using the wall U-Value and change in surface temperatures, calculations are completed to determine heat transfer through walls by conduction.



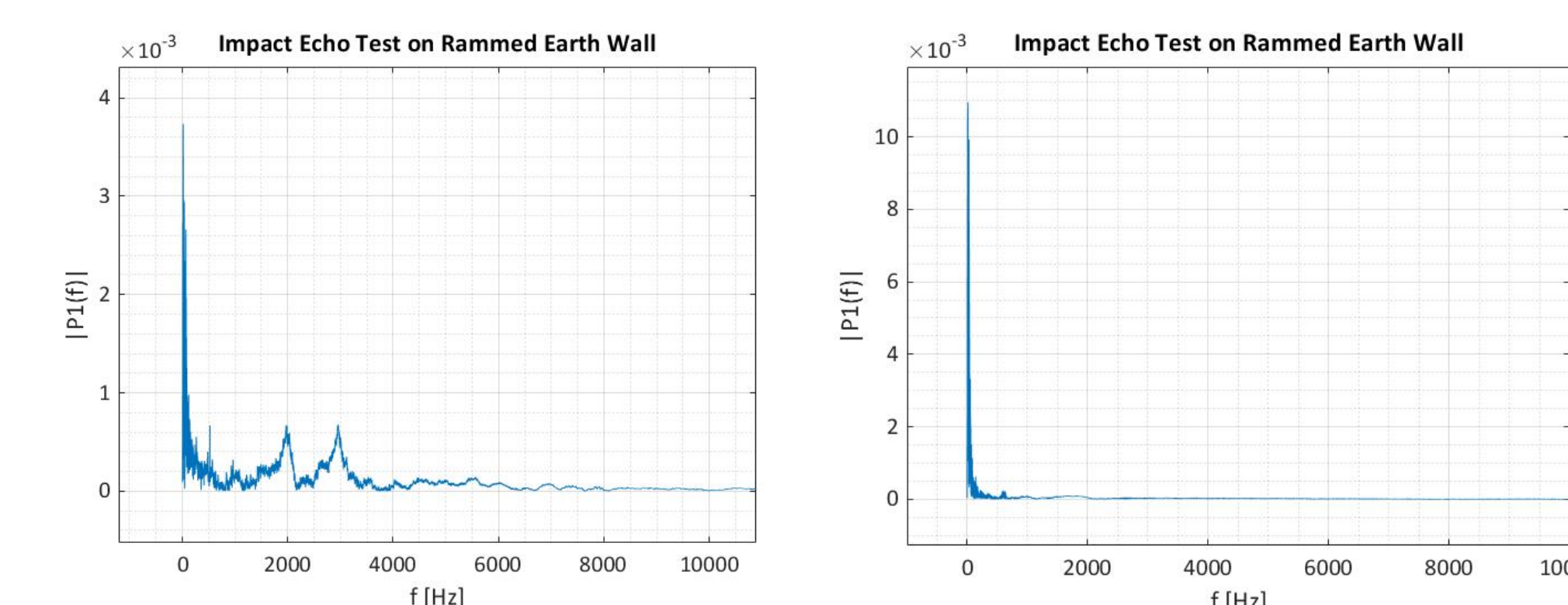
3. Ultrasonic Pulse Velocity

An indirect energy pulse is sent and received through the walls. Pulse distance and travel time collected are then converted to velocity. With this, the quality of walls can be found.



4. Impact Echo

Locates flaws within the walls. A hammer is used to strike the wall surface. Sounds are recorded and analyzed in frequency and amplitude.

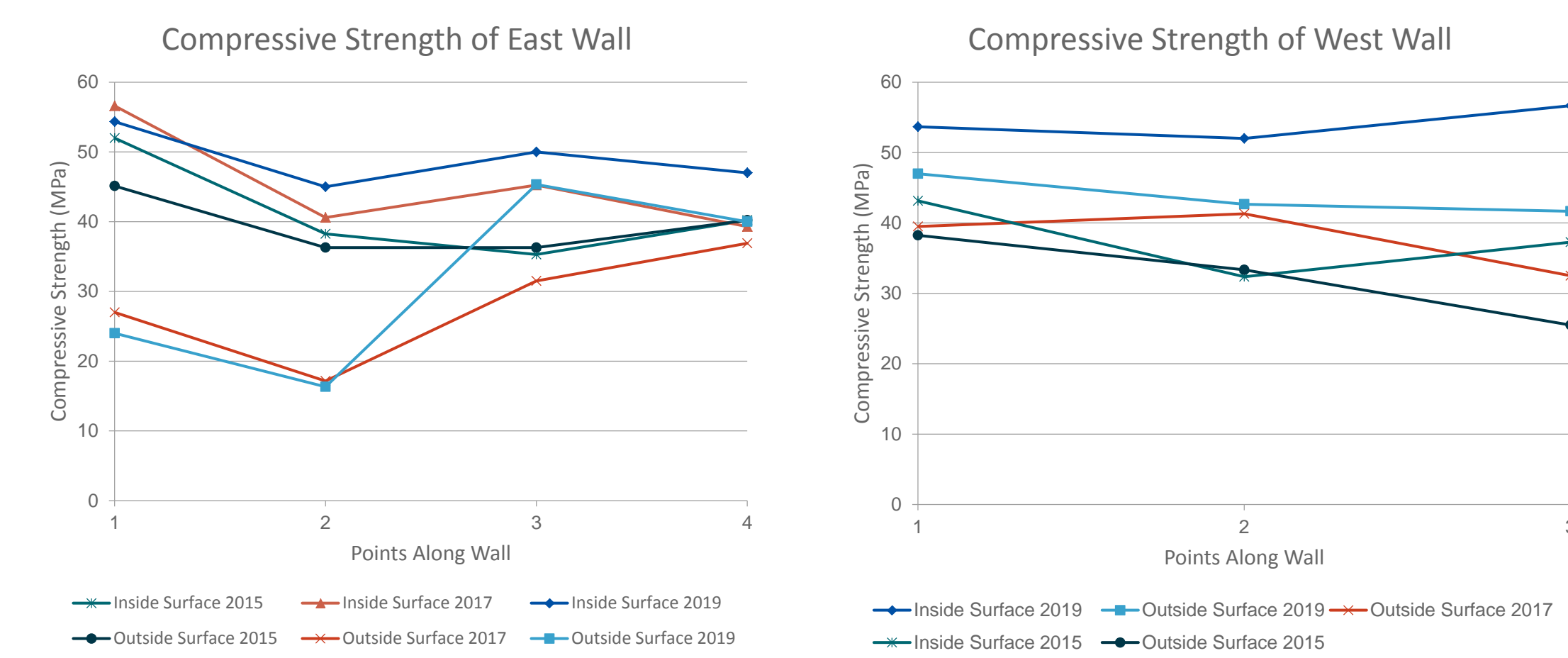


Results

- Quality of the interior wall face is higher than the exterior wall face
 - Increased compressive strength on interior
- Heat loss is greater on the east wall than the west wall
 - Temperature change is larger on east wall
- Quality of the east wall is greater than the west wall
 - Increased average velocity on east wall
- West wall may contain more flaws than the east wall
 - Impact echo graphs from the west wall show more peaks

From comparison of rebound hammer and infrared imaging data from 2 years ago and 4 years ago [1],[3]

- Compressive strength increased for west wall
- Compressive strength results vary for east wall
- Heat loss increased on average



Average Heat Loss Per Room (W/m ² K)			
	E. Wall Room 1	W. Wall Room 1	W. Wall Room 2
2015	4.46	4.81	3.56
2017	4.31	-	-
2019	5.12	4.27	4.08

Limitations

- Testing was completed on two different days, which could alter results due to changes in weather
- Assumptions are made regarding the wall U-Value and emissivity in order to calculate heat transfer through walls, actual values may vary
- Background noise affected acoustic testing results
- Some test values had large deviations, a higher accuracy in results can be achieved through further testing

References

1. K. Allen and R. Gupta, "Current State of Modern Rammed Construction: A Case Study of First Peoples House after Seven Years Exposure," in "Key Engineering Materials," Dept. Mech. Eng., Univ. Victoria, 2016.
2. Rammed Earth Constructions. *Information About Rammed Earth* [Online]. Available: <http://www.rammedearthconstructions.com.au/rammed-earth-info/>
3. G. Kutturu, "Boundary effects and material behaviour of Rammed Earth Construction," M.S. thesis, Dept. Mech. Eng., Univ. Victoria, Victoria, 2017.

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