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Reconstruction of Concrete Apron in Northern Environment

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September, 2025

Agenda

- Project Information
- Problem Statement
- Design Mitigations
- Construction Photos
- Lessons Learned

Abstract - Remove

This presentation outlines the reconstruction of a concrete apron at Erik Nielsen Whitehorse International Airport, a critical infrastructure upgrade designed to enhance operational resilience in extreme northern climates. The project focused on mitigating the effects of frost heave—an ongoing challenge in permafrost regions—through a comprehensive geotechnical and civil engineering approach. Key design strategies included the installation of thermal insulation to reduce frost penetration, the excavation and replacement of frost-susceptible soils with non-frost-susceptible materials, and the implementation of a sub-drainage system to manage subsurface moisture. These integrated solutions were tailored to the unique environmental conditions of the Yukon, ensuring long-term durability and safety of the airside pavement infrastructure. The presentation will detail the design rationale, construction methodologies, and performance expectations, offering insights into best practices for cold region airport engineering.

Project Information

Airport: Erik Nielsen Whitehorse International Airport

Client: Yukon Government

Contractor: Knelsen Sand & Gravel Ltd.

Major Subcontractors:

- Proform Concrete Services
- Cematrix Cellular Concrete

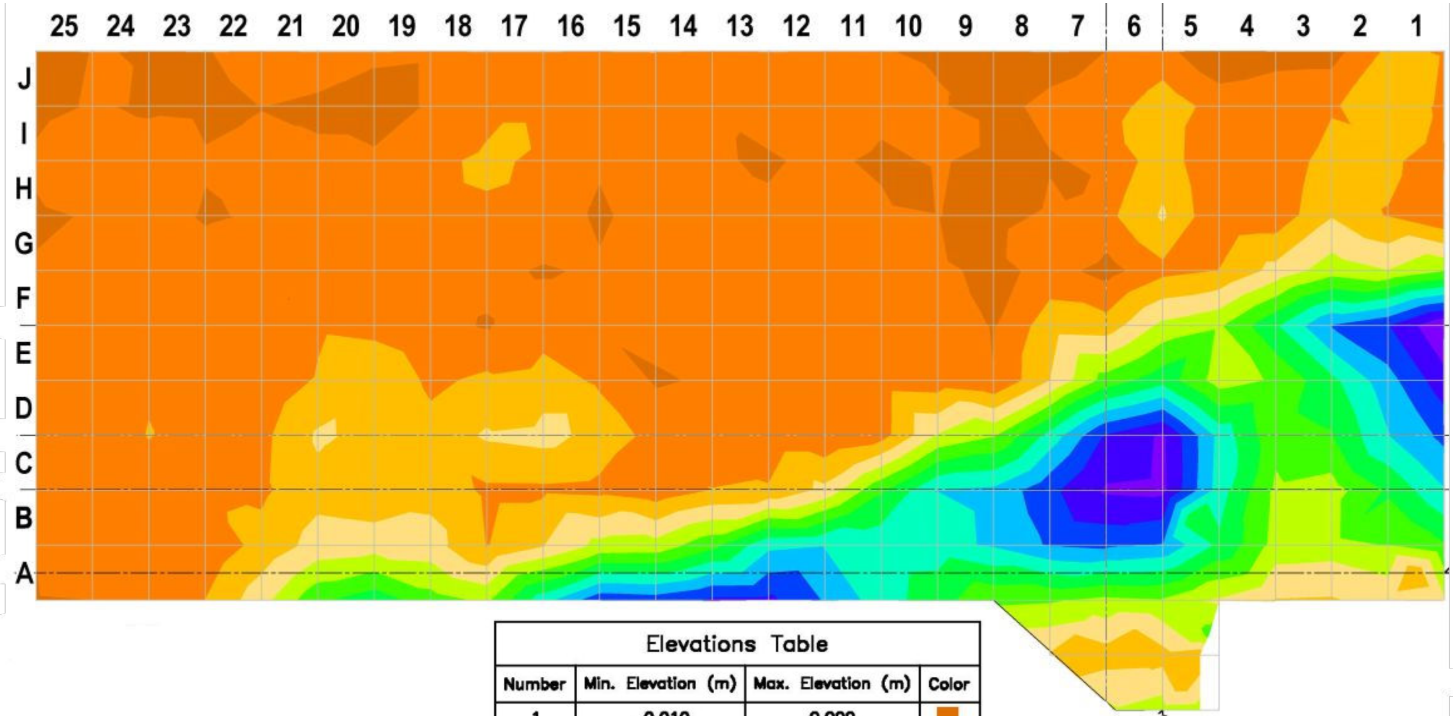
Dates: Completed May - October 2022

Project Location

Problem Statement

Replace the existing PCC apron at the Erik Nielsen Whitehorse International Airport with a design that is resilient to address the causes and/or effects of frost heave.

Survey of Existing Apron – April 2011 vs As-Built



Elevations Table

Number	Min. Elevation (m)	Max. Elevation (m)	Color
1	–0.010	0.000	
2	0.000	0.010	
3	0.010	0.020	
4	0.020	0.030	
5	0.030	0.040	
6	0.040	0.050	
7	0.050	0.060	
8	0.060	0.070	
9	0.070	0.080	
10	0.080	0.090	
11	0.090	0.100	
12	0.100	0.110	

Frost Heave

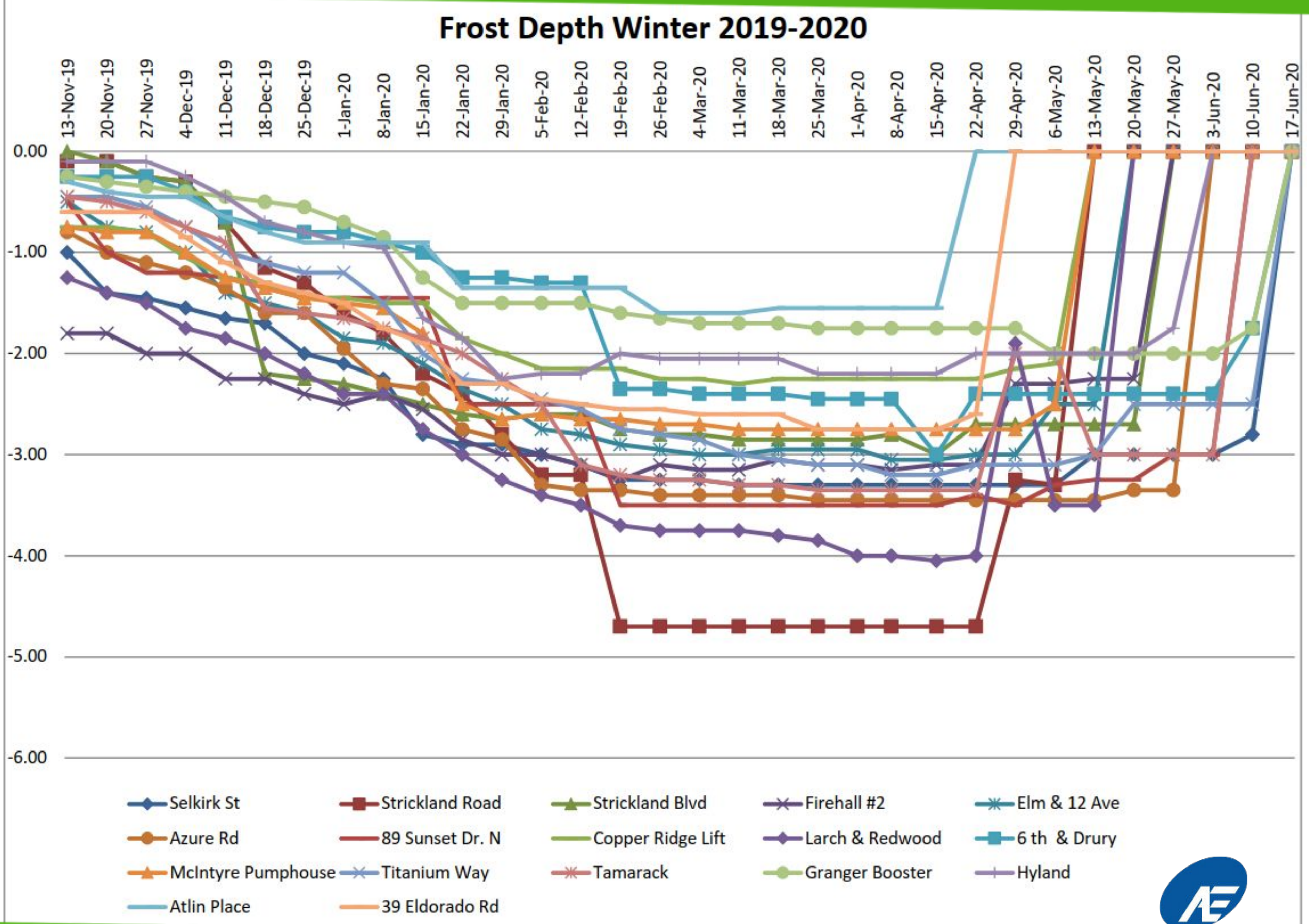
For frost heave to occur there needs to be three components:

#1 Cold temperatures:

This is a given for Whitehorse.

Analysis used freezing index = 2,492 Degrees Celsius X Days below zero (Winter 1996 to 1997) Coldest Winter from 1984 to 2021.

City of Whitehorse Data



Frost Heave

For frost heave to occur there needs to be three components:

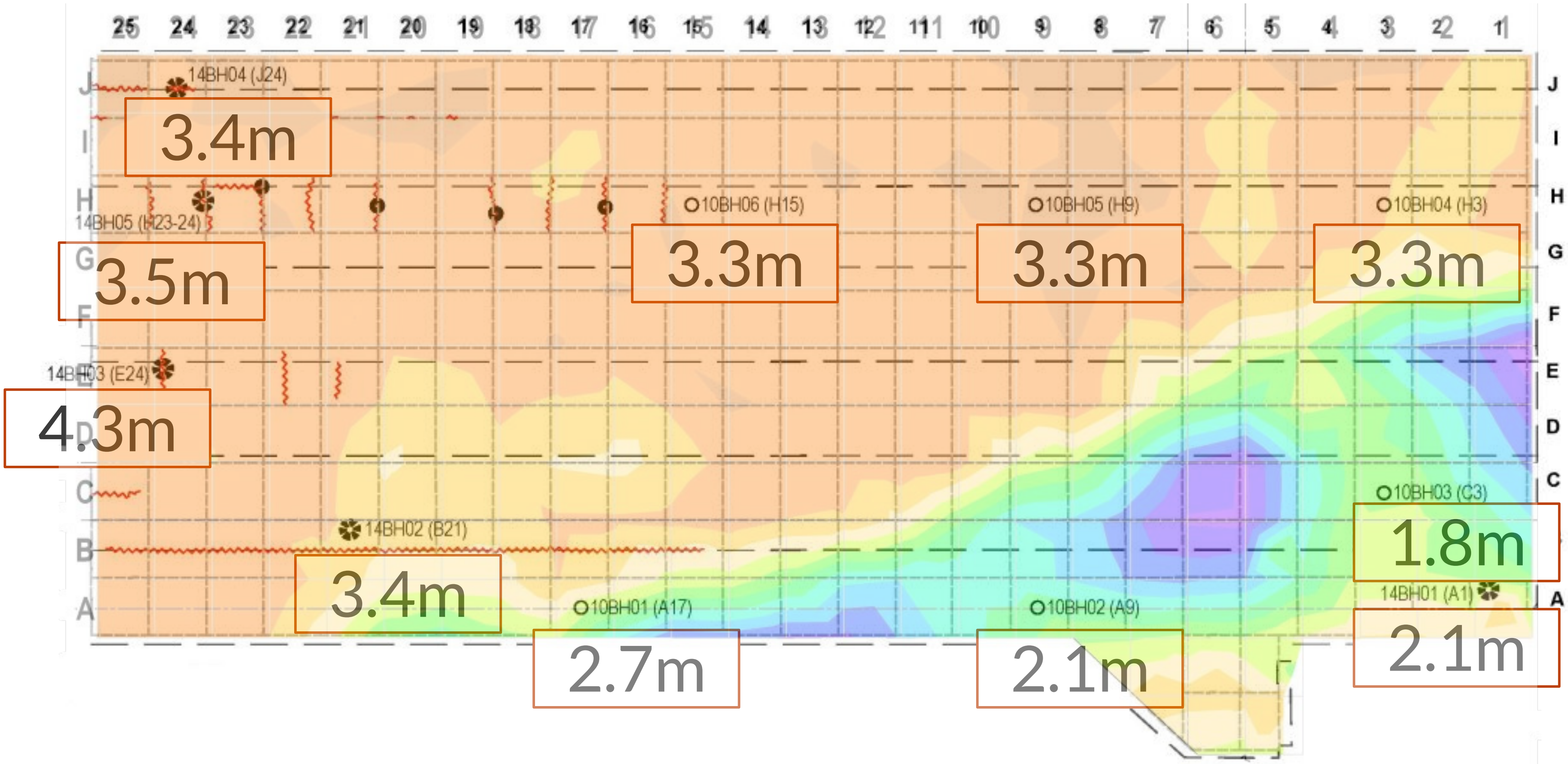
#2 Frost susceptible soils:

Soils with a high percentage of fine particles, particularly silts and fine sands, are more prone to frost heave

The presence of silts were confirmed at varying depths in the 11 boreholes completed as part of the two (2) previous geotechnical investigations

Geotechnical Information

Depth of Silt (m)



Frost Heave

For frost heave to occur there needs to be three components:

#3 Moisture:

Subsurface soils were consistently classified as damp, moist, very moist, or even saturated in the geotechnical borehole logs.

Further, ground water was measured at a depth of 2.8 m in numerous boreholes

Presence of Moisture Confirmed

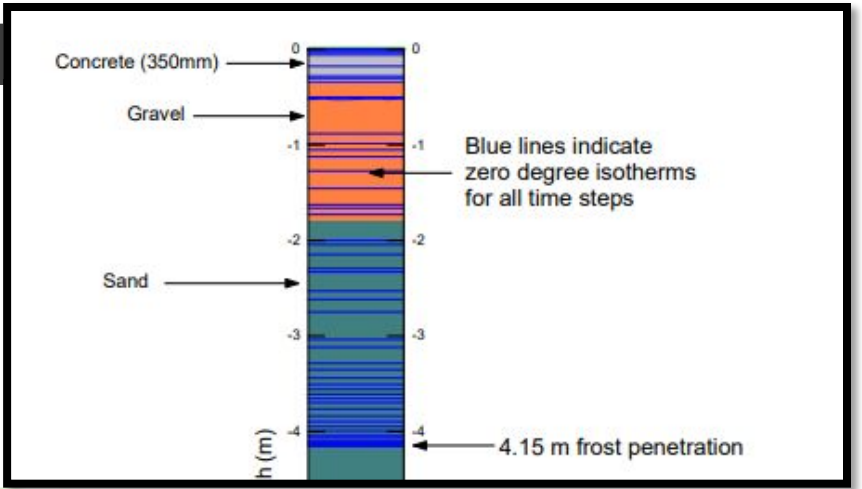
Design Mitigations

Mitigations – Cold Temperatures

Cematrix cellular concrete was recommended to be used in lieu of the cement stabilized base layer (CSB).

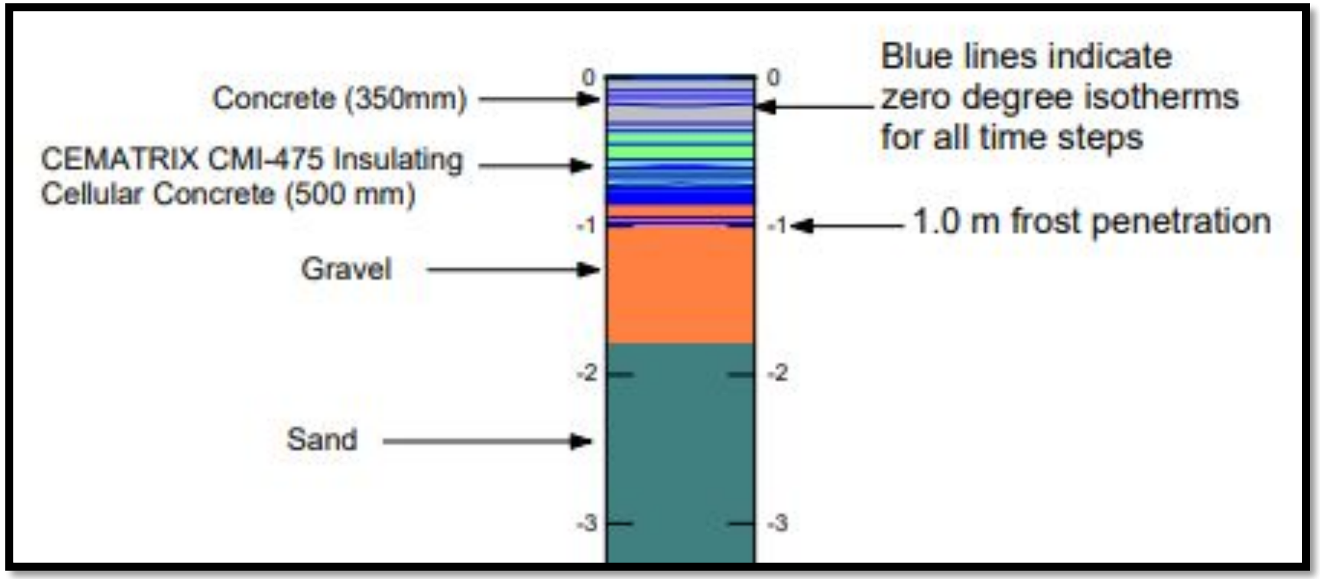
Cematrix completed a preliminary thermal analysis for the specific site at Whitehorse Airport:

- The base model with no insulation showed a frost depth penetration of 4.1



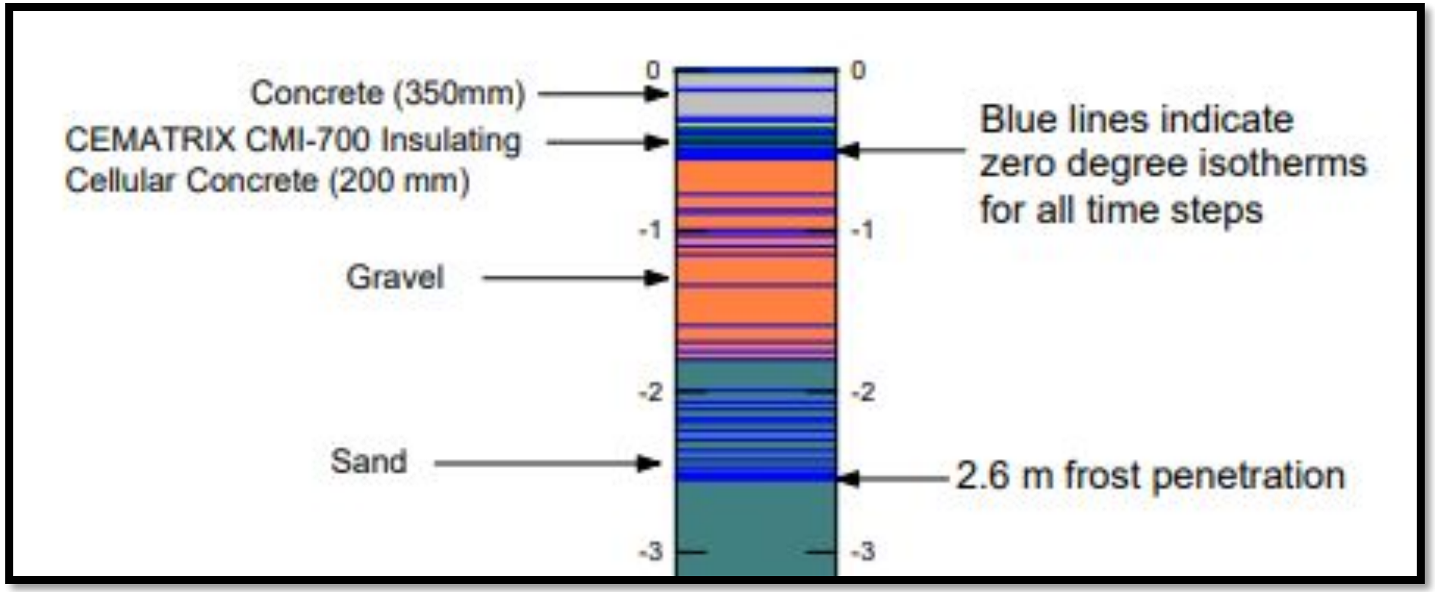
Mitigations – Cold Temperatures

- For a 500mm layer of Cematrix CMI-475, the depth of frost penetration is estimated to be 1.0m below the surface.



Mitigations – Cold Temperatures

- For a 200mm layer of Cematrix CMI-700, which would be the same thickness as the cement stabilized base layer it would replace, the depth of frost penetration is estimated to be 2.6m below the surface.



Mitigations – Frost Susceptible Soils

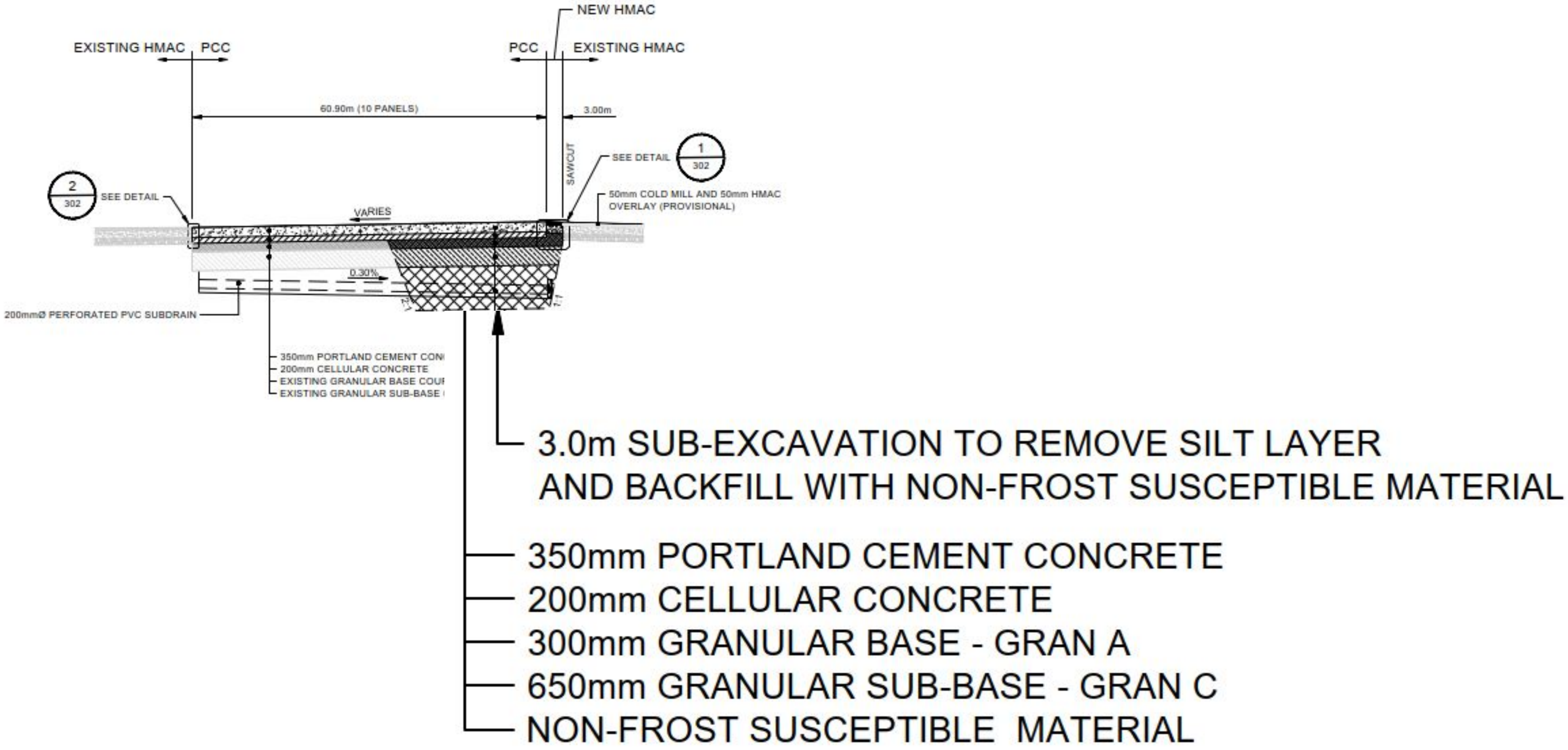
AE recommended to sub-excavate the silts to a depth of 3m. From interpolating the available borehole information, this was estimated to be required for approximately 20-25% of the apron area in the southwest corner.

The excavation was backfilled with a non-frost susceptible material.

The specification was kept fairly generic to allow the contractor to source the most cost-effective materials which could include sand, pit run or recycled crush concrete from the pavement removal scope of work.

The material specifications were to meet the Subbase requirements from Table 2.07: Base and Subbase Aggregate Standards from the

Mitigations – Frost Susceptible Soils



Mitigations - Moisture

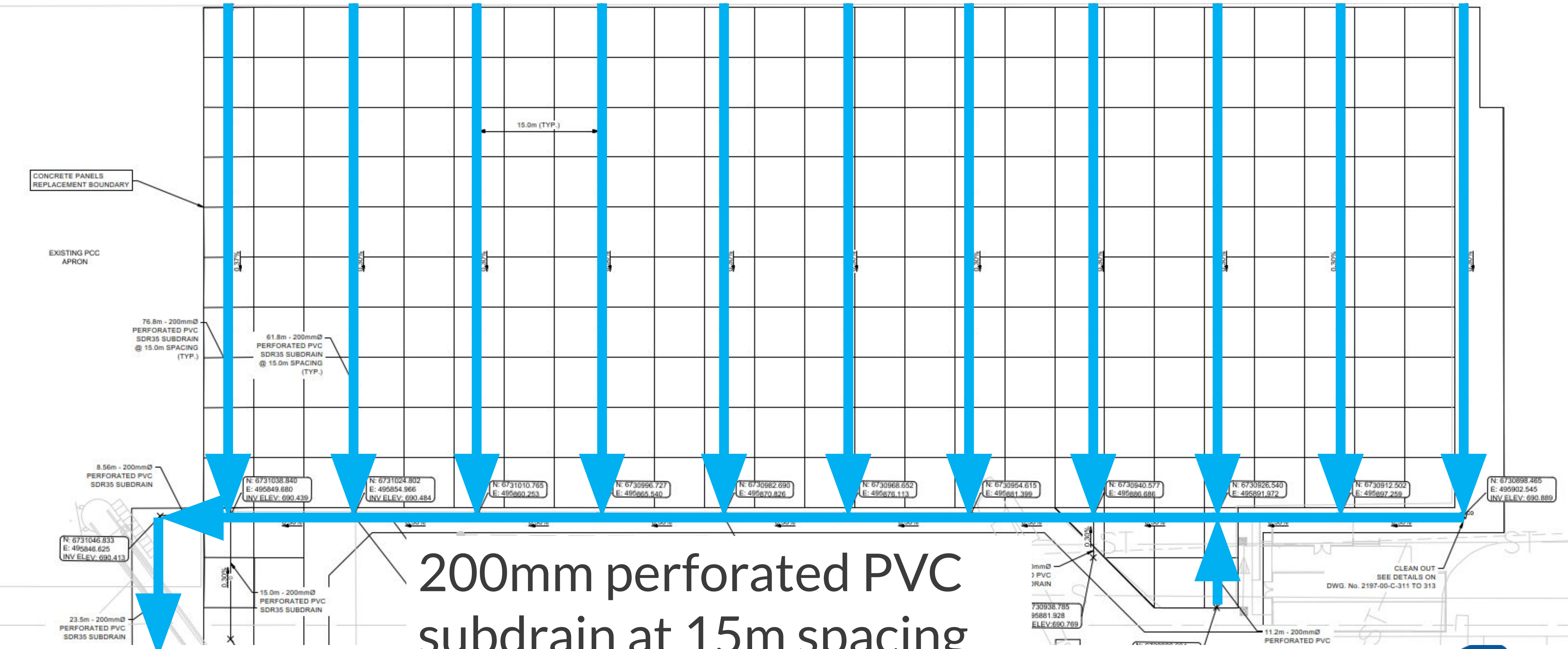
AE recommended the installation of sub-drains

The sub-drains would be installed at a minimum depth of 2.5m below pavement.

The sub-drain laterals slope conversely to the pavement surface to a main that is proposed along the west edge of the apron adjacent to the ATB.

Therefore, at the west edge of the apron, the sub-drains are in the 3.0m range below the pavement surface.

Mitigations - Moisture



200mm perforated PVC subdrain at 15m spacing

Construction Progress Photos

Demolition

Demolition

Phasing to reduce impacts of PBB down time

Subdrain Installation

Subdrain Installation

Subdrain Installation

Pouring Cematrix

Pouring Cematrix

Cematrix Completed Surface

Milling Cematrix to Grade

Bond Breaker Installation

Dowel Installation

PCC Placement

Dowel Placement

Dowel Installation – Gang Drill

PCC Placement

PCC Placement - Finishing

PCC Placement – Curing Compound Application

Thermistor Installation - Drilling

Thermistor Installation

Lessons Learned

Bond Breaker

- Added poly to the geotextile that was used as bond breaker

Cematrix

- Self leveling – needed to overfill some areas to get minimum grades in other areas
- Surface was milled to grade

Questions?

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