# Northern Built Infrastructure Program: Thermosyphon-supported Foundations for New Buildings in Permafrost

CSA Group

***Draft standard for public review***

***October 31, 2013***

# Outline

1. Overview
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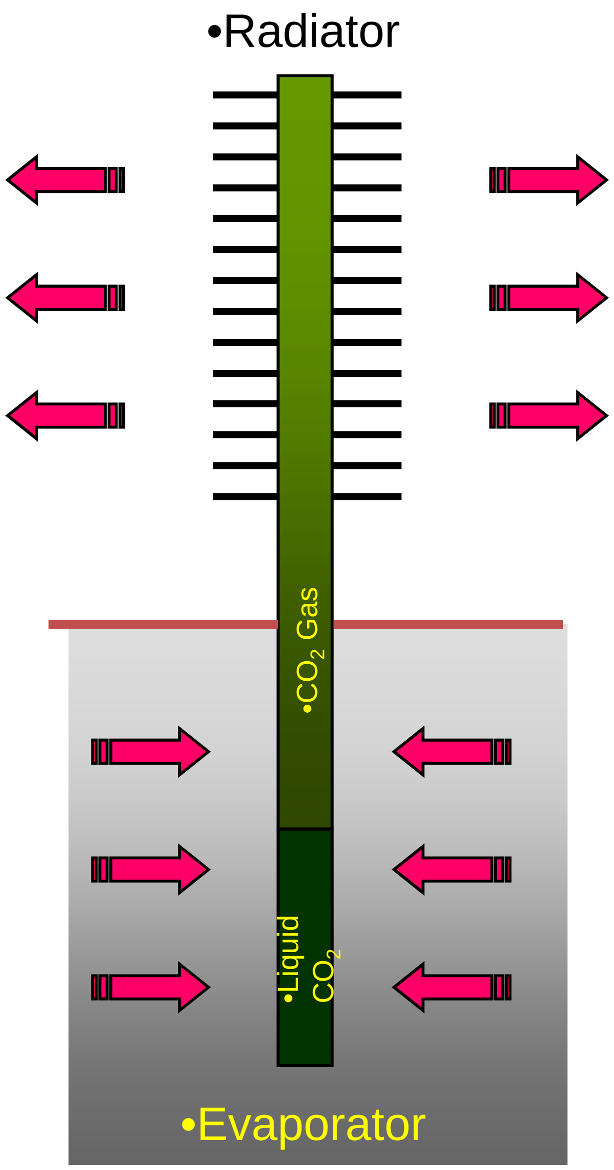

# Some History

**Alyeska Pipeline, 1975-77**

**The first major use of thermosyphon-like heat pipes to cool permafrost**

# Hospital, Inuvik

***A complex design that included a warm, below ground level, crawl space on deep ice-rich till soils***

# School--Ross River, Yukon

*A challenging site with deep discontinuous warm permafrost.  There was no reasonable alternative to thermosyphons for a structure the size of the school given the architects functional requirements*

# Working Group Members (62% northerners)

| | | | | | |
|---|---|---|---|---|---|
| Don | Hayley (Chair) | Principal | Hayley Arctic Geoconsulting | Kelowna | BC |
| Rick | Campbell | Director of Public Works | Town of Inuvik | Inuvik | NT |
| Edward | Cormier | Architectural Structural Officer | Northwest Territories Public Works & Services | Yellowknife | NT |
| Ed | Hoeve | Project Director | EBA Engineering Consultants Ltd. | Yellowknife | NT |
| David | Malcolm | Senior Partner | Malcolm & Associates | Yellowknife | NT |
| Jim | Oswell | Principal Consultant | Naviq Consulting Inc. | Calgary | AB |
| Richard | Trimble | Principal Consultant | EBA Engineering Consultants Ltd. | Whitehorse | YT |
| Brent | Wall | President & CEO | Achieve Engineering Inc. | Winnipeg | MB |
| | | | | | |
| Mark | Braiter | Project Manager | CSA Group | Mississauga | ON |
| Paul | Steenhof | Project Manager | CSA Group | Ottawa | ON |

# Scope

## Driving Issues

- The permafrost is warming (climate change)
- Thermosyphons offset warming passively
- System design/installation is more complex than most building professionals realize
- Some installations have performed poorly
- Poor performance has been linked to evolving technology, lack of understanding and missing operational diligence

## Section 1.1 Scope (Page 10)

This standard provides requirements for all lifecycle phases of thermosyphon foundations for new buildings in permafrost, including site characterization, design, installation, and commissioning phases as well as for monitoring and maintenance. This Standard is meant to ensure the long-term performance of thermosyphon-supported foundation systems under changing environmental conditions.

# Intended Users

## Focus Group:

- Planners and Land Developers
- Design Professionals working in the north
  - Architects, civil and geotechnical Engineers
- Contractors
- Thermosyphon fabricators/installers
- Building owners and/or operators

## Scope Exclusions

- Retrofit of existing buildings
- Non- permafrost sites

# Table of Contents

# Our Style—Standard or Guideline (or both)

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## Say what must be done—then follow it up with "why"

### 5.3 Requirements for a subsurface investigation

A subsurface investigation shall be undertaken to determine site-specific conditions appropriate for foundation design. In some cases, where there is significant appropriate geotechnical and geothermal data for sites in close proximity, the scope of the investigation can be significantly reduced.

**Note:** *Planning and executing the geotechnical investigation is more important for the design of a thermosyphon foundation than other foundation systems because the foundation system performance is contingent on several important factors, including:*

- *Confirmation that the site is underlain by permafrost and that thermosyphons are an appropriate design option*
- *Confirmation of the depth and variability of the active layer soils*
- *Determination of ground temperature and ice content*
- *Identification of deep seasonal thawing or potential presence of a talik*
- *Identification of surface and groundwater flow within the active layer within the site*

# Sections 1, 2, 3 Background

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## Section 1:  Scope and Application

- Scope
- Objectives
- Application
- Exclusions
- Terminology

## Section 2  Definitions

## Section 3  Reference Publications

# Section 4 Performance and Service Life

## Performance Requirements

- Maintain permafrost below foundation elements throughout the service life of the structure
- Establish the design maximum subgrade temperature
- Set service life requirements
  - Typically 30 years but increasing trend
  - Requires a system-wide approach.
  - The system is only as good as the weakest link

# Section 5 Geotechnical Site Characterization

## Basic Requirements

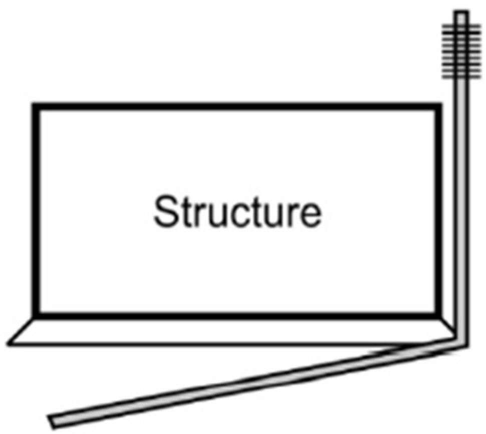
- When and how much
- Unique requirements for permafrost
  - Ground temperature
  - Ice content and salinity

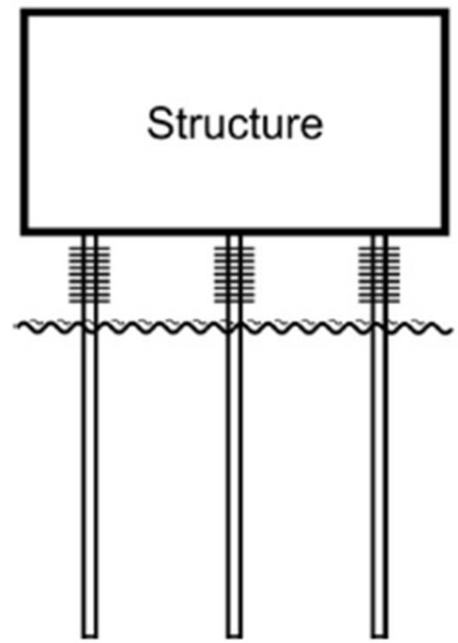
## Phased Approach

- Site history, topography and geomorphology
- Drilling and sampling
- Ground temperature data
- Laboratory testing

## 6.2  Assess Applicability of a Thermosyphon System

- Confirm permafrost and ground temperature
- Influence of surface water
- Thaw-instability risk
- Architectural limitations (crawl spaces and floors on grade)
- Heated vs unheated structures
- Location and constructability



## 6.3 Thermal Analysis and Modeling

- Why we need it
  - Does the design meet our max. annual temp. criteria at the end of design life? If not what changes are necessary
- Model input parameters and steps in the process
- Who should do it
- Qualifications of the Engineer and necessary documentation

## 6.4 Necessary Analytical Tools

- 2-D finite element models
- Input parameters
- Importance of calibration to available site data

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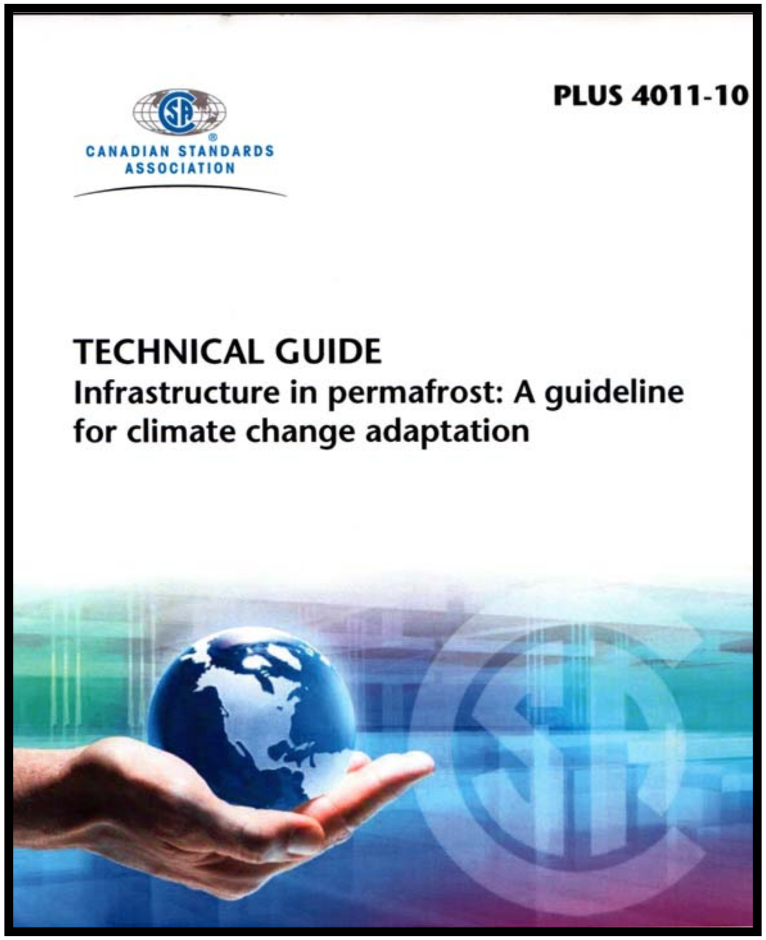
## 6.5 Climate Parameters for System Design

- Follow Procedures in CSA Plus 4011-10



## 6.6 System Design Integration Considerations

- Steps to integrate the foundation system with the structure
- Site grading
- Granular pad requirements and insulation placement
- Evaporator and Radiator Layout
- Piping specifications
- When liners may be required
- Managing runoff
- Sumps and underground utilities

# Section 7 Construction and Commissioning

## Construction

- Site Preparation
  - Timing for site work in preparation for excavation or pad construction
- Development of operating procedures (specifications)
- Materials handling
- Installation of evaporator piping
- Installation of radiators
- Charging the system
- Documentation

## Monitoring Plan and its Implementation

- Overall project monitoring program
  - Visual Inspection
  - Ground temperature
  - Structure deformation
- Post-construction thermosyphon system performance
  - Scan radiators for surface temperature annually
- Installed ground temperature instrumentation
  - Download data loggers
  - Take manual readings as required
- Reading frequency
- Data review and documentation
- Roles and responsibilities

# Annex A, B, C

## Annex A

Thermosyphon Basics

## Annex B

Finite Element models in common use for thermal modeling of thermosyphon systems (2-dimensional)

## Annex C

Bibliography

# We are looking for feedback