

Northern Built Infrastructure Program

***Introducing A New CSA
Standard for:
Moderating the effects of
permafrost degradation on
existing building
foundations***

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Working Group Member
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National Standard of Canada

**Moderating the effects of permafrost
degradation on existing building
foundations**



Presentation Outline

1. Working Group Members
2. Objective and Scope
3. Intended Users
4. Content of the Standard – Sections 1 to 7
5. Reference Materials (Annex A and B)
6. Questions?

Wording in the Standards (per CSA editors)

“Shall” – required

“Should” – recommended

“May” - optional

Working Group Members

- 60% from the North
 - Ed Cormier (Government NWT)
 - Ed Hoeve (Tetra Tech EBA Yellowknife)
 - Steven Kokelj (NWT Geoscience Office)
 - Antoni Lewkowicz (Chair) (University of Ottawa)
 - Jim Oswell (Naviq Consulting)
 - Richard Trimble (Tetra Tech EBA Whitehorse)
 - John Watson (Nunavut Housing)
 - Stephen Wolfe (Natural Resources Canada)

Objective and Scope

- Develop a Canadian Standard for moderating the effects of permafrost degradation on **existing** building foundations.
- The Standard document provides a sequence of steps to be followed, from pre-emptive maintenance through assessment to mitigation to long-term maintenance.
- The standard applies to the following foundation types:
 - Shallow foundations
 - Footings supported at the ground surface or buried, with a ventilated air space
 - Slab-on-grade with no air space.
 - Deep foundations
 - Adfreeze piles with a ventilated air space
 - Rock socket or end-bearing piles with or without a ventilated air space

Intended users of the Standard

- The Standard is destined for use by:
 - Owners and operators of buildings
 - Owners and operators of other community infrastructure
 - Building contractors
 - Design professionals and reviewers
 - Educators
 - Regulators

Section 1

Summary of various techniques for moderating the effects of permafrost degradation (See Clauses 6.1 and 7.)

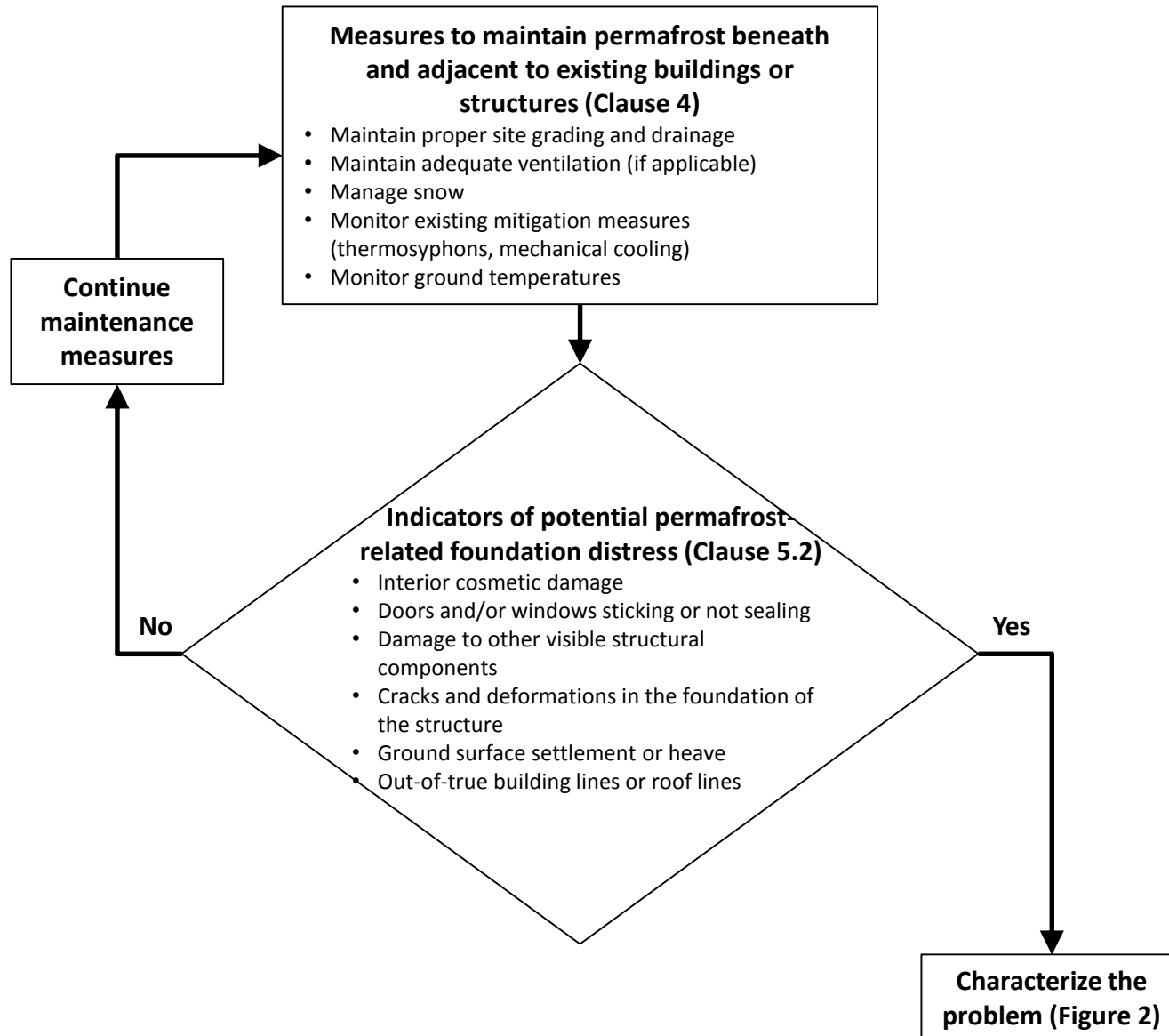
Technique	Shallow Foundations			Deep Foundations	
	Surface Footings	Buried Footings	Slab-on-Grade	Adfreeze Piles	Grouted/End-bearing Piles
Shading (6.3.1)	Yes	Yes	Yes	Yes	Yes
Drainage and grading (6.3.2)	Yes	Yes	Yes	Yes	Yes
Ground cover and snow management (6.3.3)	Yes	Yes	Yes	Yes	Yes
Ventilation (6.4.2)	Yes	Yes	No	Yes	No ⁵
Ground insulation (6.4.3)	Yes	Yes	No ¹	Yes	Maybe ²
Foundation adjustment & leveling (6.4.4)	Yes	Yes	Maybe ³	Yes	Yes
Mechanized refrigeration (6.4.5)	Yes	Yes	Maybe ⁵	Yes	Yes
Thermosyphons (6.4.5)	Yes	Yes	Maybe ⁵	Yes	Yes
Foundation replacement (6.4.6)	Yes	Yes	No ⁵	Maybe ⁴	Maybe ⁴

Sections 2 and 3: References and Definitions

Section 4: Measures to maintain permafrost beneath and adjacent to existing buildings or structures

- Emphasizes that proactive preventative maintenance is required to maintain permafrost beneath and adjacent existing buildings. **Difficult to stop thaw once it starts.**
- Maintenance includes maintaining/managing specific standards on permafrost sites relative to:
 - Site grading and drainage
 - Ventilation systems
 - Snow
 - Monitoring existing mitigation measures
 - Monitoring of ground temperatures
- (see Figure 1 for more details)

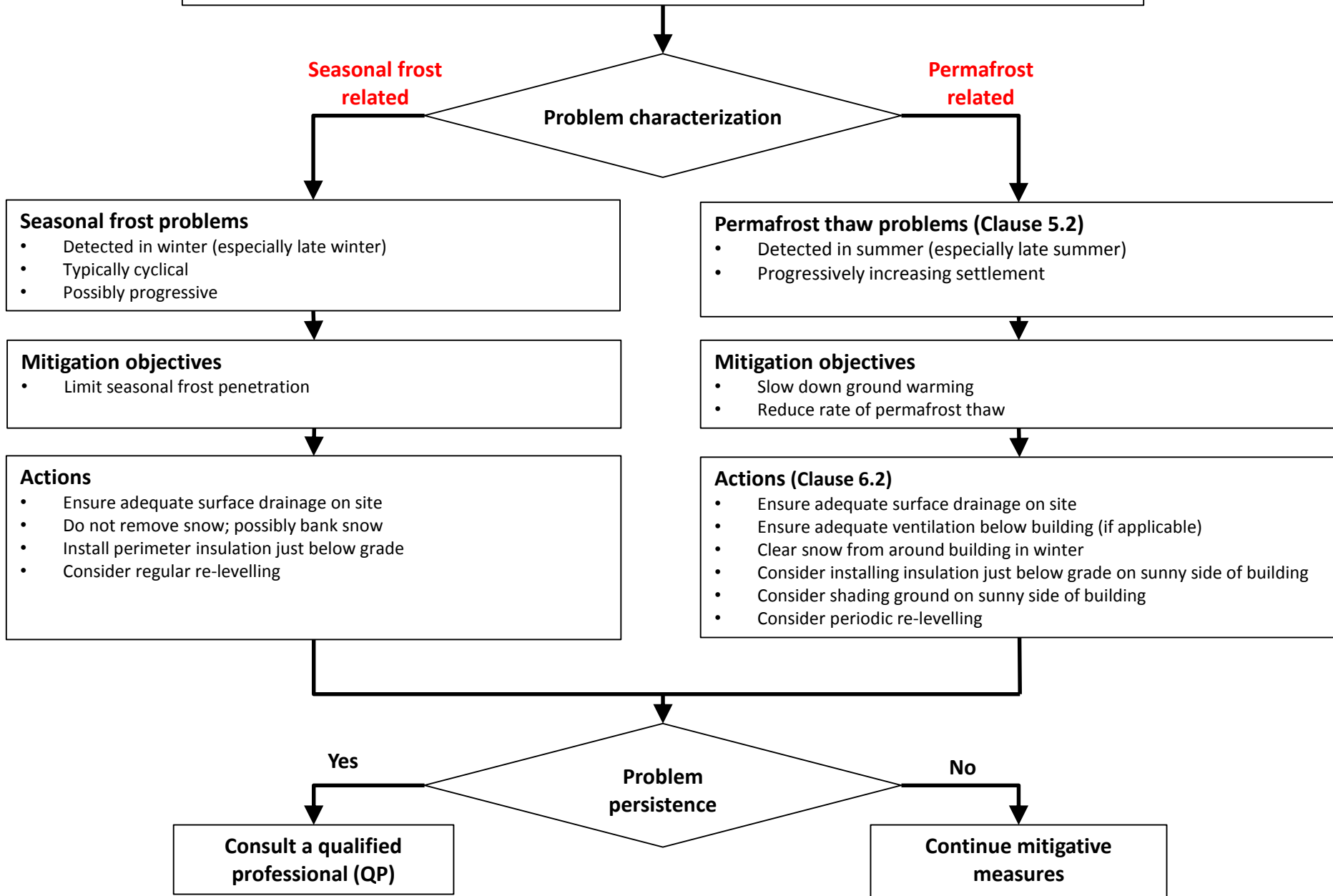
Figure 1: Measures to maintain permafrost and indications of potential permafrost-related foundation distress (see Clauses 4.1 and 5.2)



Section 5: Assessment of structures impacted by changing permafrost conditions

- Characterize the problem -- Must distinguish between seasonal frost-related movements and permafrost degradation issues
- See Figure 2

Figure 2: Indicators of potential permafrost-related foundation distress (Clause 5.2; see Figure 1)



Clause 5.3: Site Investigation by QP

The first step in the assessment of existing structures for suspected permafrost related surface displacement is the initial site investigation. The Standard states that the investigation should be undertaken by a qualified professional and should include three phases:

- Collection and documentation of background information (e.g. site history, maps, aerial photos, climate data)
- Inspection of the structure, foundation and site
- Collection of site specific subsurface data (e.g. ground temperatures, ground ice content, permafrost depth and thickness)

Clause 5.4 Establishing a Monitoring Program

- A monitoring program shall be established to verify the structural integrity of the building, as directed by an Engineer. The standard also details:
 - Observations and documentation to be included (progression of deformations)
 - Recommendations and requirements for collecting ground temperature data

Clause 5.5: Final evaluation report

- After the monitoring period, the monitoring data, together with the other investigations completed shall be used to propose:
 - Alternative mitigative measures for the structure, including estimated costs to implement and maintain each alternative;
 - Recommendations for implementation of the appropriate mitigative measures; and
 - Development of an implementation plan, including a schedule for implementing the recommendations.

Section 6: Applicability of various site and structure techniques for moderating the effects of permafrost degradation (See Clauses 6.1 and 7.)

Technique (for Site or Structure)	Shallow Foundations			Deep Foundations	
	Surface Footings	Buried Footings	Slab-on-Grade	Adfreeze Piles	Grouted/End-bearing Piles
Shading (6.3.1)	Yes	Yes	Yes	Yes	Yes
Drainage and grading (6.3.2)	Yes	Yes	Yes	Yes	Yes
Ground cover and snow management (6.3.3)	Yes	Yes	Yes	Yes	Yes
Ventilation (6.4.2)	Yes	Yes	No	Yes	No ⁵
Ground insulation (6.4.3)	Yes	Yes	No ¹	Yes	Maybe ²
Foundation adjustment & leveling (6.4.4)	Yes	Yes	Maybe ³	Yes	Yes
Mechanized refrigeration (6.4.5)	Yes	Yes	Maybe ⁵	Yes	Yes
Thermosyphons (6.4.5)	Yes	Yes	Maybe ⁵	Yes	Yes
Foundation replacement (6.4.6)	Yes	Yes	No ⁵	Maybe ⁴	Maybe ⁴

- Perimeter insulation might be effective. Insulation under slab likely not feasible, except as per Note 3.*
- Perimeter insulation will be feasible in any case. Feasibility of insulation under building will depend on access.*
- Relevelling by grout or foam injection may be feasible.*
- Replacing piles with adjustable footings could be considered. It might be feasible to replace piles under building with beams and outrigger piles. Less likely would be underpinning with micropiles.*
- Might be possible under rare circumstances.*

Section 6.3 Site Techniques

- A number of requirements and recommendations are provided in the Standard for a number of site techniques, including:
 - Shading
 - Drainage
 - Snow accumulation management

Section 6.4: Structure Techniques

- Requirements and recommendations are provided in the Standard for a number of techniques applied to the structure, including:
 - Ventilation
 - Ground insulation (e.g. technique used depends on permafrost temperatures)
 - Foundation adjustment and levelling
 - Mechanized refrigeration or thermosyphons
 - Foundation replacement

Section 6.5: Abandonment and demolition

- **Site abandonment**

- If the structure is considered to be repairable and/or reusable, but located on permafrost (especially warm permafrost) that cannot be preserved, the site should be abandoned and the structure should be moved to a new location with a foundation designed specifically for site conditions.

- **Structure demolition**

- If the structure is considered to be damaged beyond repair or is a public safety hazard, the structure should be demolished.

Section 7: Long-term performance after foundation rehabilitation

- If the decision is made to rehabilitate the structure, then a number of recommendations are provided concerning the long-term performance of foundation rehabilitation efforts. This includes options for performance monitoring to include:
 - routine visual inspections,
 - recording and assessing crack monitoring points,
 - conducting floor elevation and foundation element surveys,
 - thermal monitoring of the subgrade, open air gaps, and floors,
 - leak checks on water supply and sewage disposal systems
 - surface and groundwater monitoring, and
 - operational monitoring of thermosyphons or other cooling techniques, if present.
- Collaborative efforts by all parties are needed to be successful, including a continuing monitoring program

Annex A: Information on foundation types in permafrost areas (see also CSA Plus 4011-10)

- Annex A provides background information on foundation types, including:
 - General information
 - The different types of foundations
 - Footings at ground surface (including Triodetic foundations)
 - Buried spread footings
 - Grade-supported foundations (including thermosyphons)
 - Deep foundations (piles of several types)

Annex B: Information on permafrost

(see also CSA Plus 4011-10)

- Annex B provides background information on permafrost, including:
 - What is permafrost?
 - Characteristics of permafrost (including the active layer and ground ice)
 - Effects of climate change on permafrost in Canada
 - Effects of permafrost thaw on structures
 - Frost heave

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Available now through CSA On-line

Questions?

