# Buried Structures Technical Bulletin Cold Weather Construction Guideline

## 1.0 Scope

The scope of this Guideline is to:

- Define construction techniques associated with cold weather installation of the backfill zone; and,
- Identify measures that have been used successfully to allow winter construction to proceed.

These measures are intended to assist Contractors with the development of an application specific installation program for cold weather construction. This document is a general guideline and is not intended to be used as a project specific procedure.

The guideline is not applicable for construction in areas subject to continuous or discontinuous permafrost. For assistance with projects subject to these conditions please contact CSPI.

## 2.0 Definitions

Cold weather construction – refers to working in temperatures whereby either in-situ or imported materials are at risk of freezing and/or in conditions where materials may be affected by ice and/or snow.

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### 3.0 Typical Challenges Encountered During the Backfill Process:

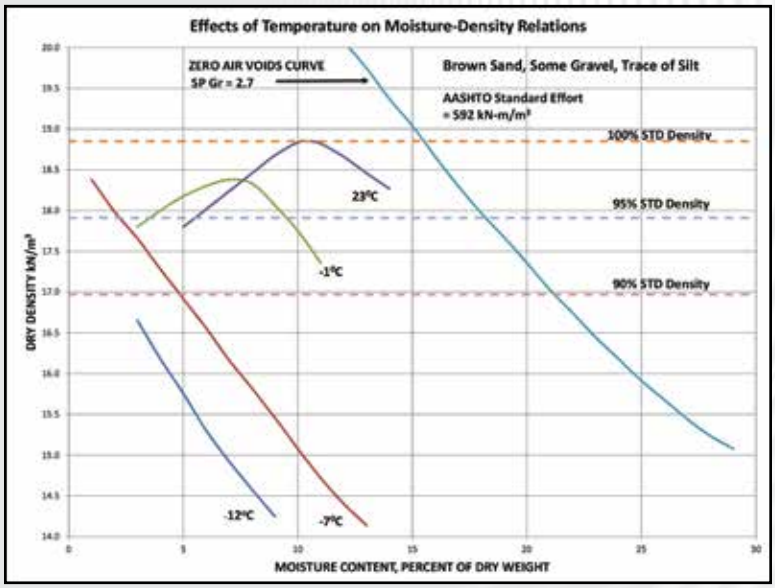
Cold weather construction presents environmental conditions that may adversely affect the properties of the engineered backfill, as well as the stability and load carrying capacity of the structure.

Some of the challenges that have been documented include:

- During construction – Weather changes that can cause shut-downs, unpredictable snow events, breakdowns in heating the underlying foundation and backfill (stockpiles, placement), equipment breakdowns, snow-melt infiltrating the backfill zone causing frost lensing, complications in pouring concrete, freezing of the backfill zone from the structure interior, safety issues (ice).

- After construction – Long term consolidation of the foundation and/or backfill material as it thaws over time (i.e. months or even years). This can cause the backfill to “sink” relative to the structure, applying unquantifiable loads on the structure causing the structure to deform over time.

- The figure below illustrates how ineffective compaction effort can be at sub-zero temperatures.



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### 4.0 Engineered Backfill – Material Pre-Selection

Backfill Installation measures include:

1. Pre-selection of the backfill material by the Contractor to comply with the backfill design parameters plus accommodate cold weather construction.

2. Engineered backfill used for cold weather installation should be a non-frost-susceptible clean crushed stone that is not dependent on water to achieve compaction. The gradation requirements should be as per the recommendation of a Geotechnical Engineer.

3. Additives are sometimes used to lower the freezing temperature of the water within the engineered backfill. Calcium chloride should not be used in a steel structure installation under any circumstances as it is corrosive to the metal. Non-corrosive additives shall not be used without completion of laboratory investigations that evaluate the additive's impact on compaction. The Contractor should seek the advice of a Geotechnical Engineer if considering the use of additives.

### 5.0 Backfill Stockpile

Backfill materials are commonly sourced from nearby pits or stockpiles which can be exposed to weather and segregation and may not reflect the material that was pre-selected by the Contractor. When left uninsulated or unheated, backfill material can become frozen, making it unsuitable for use.

Measures that can be taken to protect the backfill material include:

1. The stockpile of engineered backfill should be placed on a smooth hard surface.

2. The storage surface should be sloped away from the stockpile to promote water and snow melt run off. An accumulation of moisture within the stockpile is undesirable as it may become frozen and adversely affect the workability of the fill.

3. Depending on site conditions, consideration should be given to insulating and/or heating the stockpile otherwise freezing may occur.

4. Only unfrozen material may be used.

5. Monitor temperature of material being hauled to confirm it is unfrozen.

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### 6.0 Prior to Backfill Placement

During cold weather construction, the structure can be exposed to freezing temperatures at various locations including:

- Foundation below the backfill zone – If excavated and left exposed to cold weather, frost can penetrate this surface.
- Interior of the structure – If left open to cold weather, the metal can act like a “heat sink” transferring heat from the backfill zone and allowing frost penetration.

To mitigate these risks, Contractors commonly:

- Maintain heat at the foundation areas directly beneath the backfill zone; and
- Close off the ends of the structure and install heaters. Monitoring of the air quality should be done in compliance with work safety regulations.

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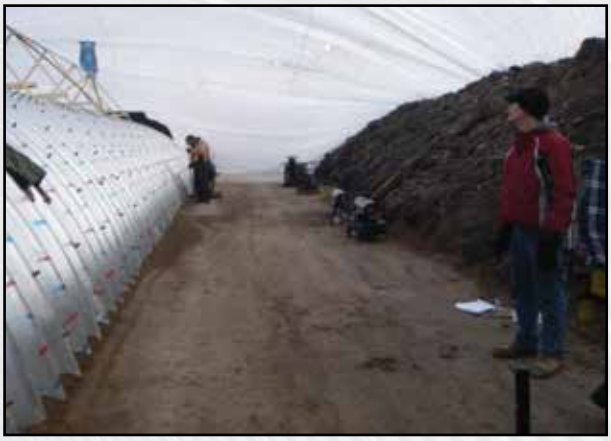

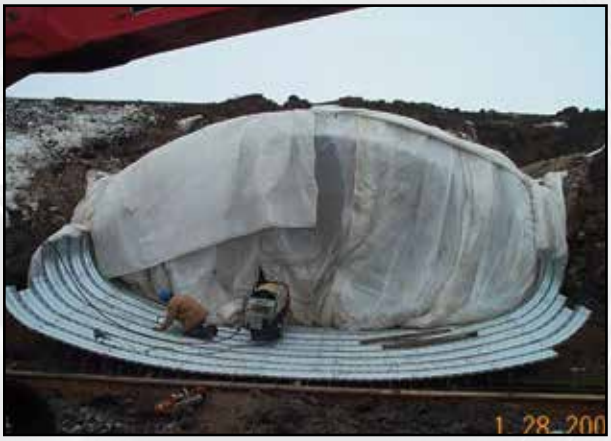


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## 7.0 Engineered Backfill Installation & Monitoring

It is imperative to ensure that transport, placement and compaction of the backfill material can be achieved without it freezing and becoming unsuitable for use. Below are some measures to assist the Contractor with the development of this installation process:

- Transport the backfill material to the site with minimal haul distance and time (i.e. stockpile to placement), and use heated truck boxes. During transport, protect the backfill in the truck boxes against freezing and/or mixing with snow.
- Haul only unfrozen material.
- The backfill zone should be protected with insulation and heaters. Areas that have backfill added should be kept to a small footprint to minimize exposure. Minimize delays and interruptions to the backfill placement/compaction process.
- The temperature of the backfill material should be checked at the time of placement to confirm that it is unfrozen.
- Graders or dozers should be used to blade off any frozen uncompacted fill before additional fill is placed. As well, high ruts should be leveled before they freeze.
- Thicker lifts will provide more time before freezing, provided the full lift thickness can be compacted to the design requirements.
- Compact the backfill to the design requirements immediately after placement to minimize the time loose backfill is exposed to snow and/or freezing temperatures.
- In extreme cold, consideration should be given to 24/7 backfill placement to avoid overnight frost penetration during the course of construction.
- Snow and ice should not be present on the engineered backfill zone. Snow piles should be situated down-grade from the engineered backfill zone to keep melt runoff from the engineered backfill zone.
- Current weather forecast conditions should be continuously monitored to anticipate and control the thawing of water within the backfill during intermittent warmer weather. Any increase in weather temperature can cause the thawed moisture at the surface to re-freeze on the lower level frozen backfill resulting in ice lensing build up. Ice lenses can cause significant settlement and deformation when temperatures remain above freezing.
- Shut down backfill placement during extreme cold and snow conditions.

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A QA/QC program should be prepared to monitor the engineered backfill and the structure shape as the backfill proceeds. The contractor may wish to enlist the expertise of a Geotechnical Engineer to direct the activity.

- Identify heaving and loosening of the backfill due to frost penetration;
- Monitor compaction, soil temperature and moisture content of each lift (nuclear densometer moisture contents should be spot checked with oven dried moisture contents), then subsequently check for frozen material after compaction and prior to construction of the next lift. If frozen material is found, it should be removed and replaced with unfrozen material that is properly compacted.
- Conduct additional shape monitoring of the structure as a precaution.

### 8.0 Temporary Installation Shut-Downs

Following a project shut down, the following measures should be considered:

- Cover the Backfill –To protect against damage from frost and moisture penetration of the backfill zone, it should be tarped and heated. Records should be made of all temporary covering locations to ensure all coverings are located and removed prior to resuming backfilling operations.
- Drainage of the Backfill - Peripheral surface drainage system should be checked and reworked where necessary to provide positive drainage of any surface water away from the structure.
- Additional Structural Checks. The structure is designed to be backfilled, not left exposed to heavy wind and snow loads over the course of months. If the structure is to be left partially backfilled, the supplier should be contacted to evaluate the need to perform a wind and snow load analysis if a winter shutdown is anticipated. The analysis should indicate whether any precautions, such as snow removal, are required.
- At Project Re-start: Upon resuming installation of the structure all temporary coverings shall be removed. The engineered backfill shall be inspected for any heaving or loosening and the compaction should be checked. Any frozen or compromised material shall be removed and replaced with properly placed engineered backfill.

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### 9.0 Concrete Placement

Concrete shall not be placed and/or cured against frozen materials. Adequate frost protection of the footings shall be maintained throughout the construction process. Concrete placed during cold weather should be enclosed and properly cured at an appropriate temperature through the use of heaters and insulation if necessary. The footing designer should be made aware of the construction controls put in place.