Masonry Made EZ

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COLD WEATHER CONSTRUCTION

Canada's weather conditions vary throughout the year with temperatures well below zero degrees Celsius. As a result, Canadian construction practices have adapted to ensure that work can continue year round with appropriate modifications. It might seem that winter is a never-ending season that drags on for most of the year in some Canadian locations. This bulletin will outline the major points for cold weather masonry construction in Canada including materials handling and provisions required by Canadian codes.

Materials

Masonry assemblages contain many different types of material that work together. This interaction of materials is drastically affected by cold weather and can result in poor performance when proper provisions are not ensured. It is important that materials arrive at the job site dry and that they are stored in a manor that prevents wetting from rain or melting snow. This will help reduce future costs of heating and drying of materials (blocks, bricks, sand, etc) prior to placing them in the masonry assemblage.

Masonry Units

In masonry construction, mortars and grouts are mixed with the understanding that moisture is absorbed into the units during construction. In a similar manor, frozen units will drain heat from the mortar or grout by resulting in the mortar or grout freezing before enough moisture has been removed. It has been demonstrated that if the mortar moisture content is less than 6% when it freezes, typically no damage will occur.[3]

Frozen units containing moisture will result in less moisture absorption resulting from the unit's pores being blocked. This may cause the units to float on the mortar resulting workmanship issues. In addition, using wet frozen units will decrease quality of the bond between the units and the mortar.

Mortar

During cold weather construction, mortar made with cold constituent materials will exhibit plastic properties that are much different than mortar made with materials at normal temperature. These plastic properties include lower water content, increased air content, reduced early strength and reduced workability. By heating the constituent material used in mortar during cold weather construction it is possible to achieve mortar that exhibits similar properties to mortar mixed in normal temperatures. **Mortar must not be over heated and the temperature shall be less than 50°C when being placed to avoid flash setting.**[2] As previously indicated mortar that has less than 6% moisture content will not result in damage if frozen. When mortar with a moisture content less than 6% freezes, damage as a result of freezing is limited, however, its hydration process is also stopped. The hydration process will continue and additional strength will be gained if the masonry is wetted by natural conditions or the masonry may need to be manually wetted.

Grout

Grout has similar constituent material to mortar, however, the moisture content is much higher. In order to facilitate placement of the grout, its slump is typically around 200 to 250 mm with a high water/cement ratio. When grout freezes it exhibits large amounts of volumetric changes due to the high amount of water (water increases in size by about 9% when changing into ice). Typically the grout is confined within the cells of concrete block resulting in damage to the block from large volumetric changes.

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When placing the grout it must have a minimum temperature of 20°C and a maximum temperature of 50°C and must be kept above 0°C for 48 hours after placement.[2] If the grout is made with high-early-strength Portland cement then the grout needs only to be kept above 0°C for 24 hours. It is recommended that the masonry receiving the grout be kept at a temperature above 0°C for the same amount of time required by the grout to ensure that the grout does not freeze.

Admixtures

Admixtures are compounds that are added to mortar and grout to alter their plastic and hardened properties. Admixtures such as antifreeze compounds, accelerators, corrosion inhibitors and colouring agents are sometimes encountered during cold weather construction. Admixtures that produce desired property changes to the plastic state of mortar and grout can have adverse effects of the hardened state such as decreased compressive strength, decreased flexural bond capacity, increased corrosion and increased occurrence of efflorescence. For this reason, designers must take extra caution when choosing to use an admixture and it is extremely important that masonry contactors strictly adhere to the mixing directions provided. **Admixtures are not typically recommended for cold weather construction since the risk of detrimental effects to the hardened state tends to be high.**

Antifreeze Compounds

Antifreeze compounds are not recommended for use in mortar or grout. Antifreeze compounds are admixtures that reduce the freezing point of substances. **Many "antifreeze" admixtures on the market typically do not reduce the freezing point, but actually act as accelerators.** It is possible to purchase "true" antifreeze compounds that are typically made with alcohols or combinations of salts. In order for these antifreeze compounds to be effective, the required quantities will typically reduce the compressive

Figure 1. A bond beam with a horizontal crack along its length resulting from placing the grout in freezing temperatures without proper heating and protection.

strength and flexural bond capacity. In addition, antifreeze compounds that are based on calcium chloride, salts or other similar substances used to reduce the freezing point **shall not** be used in mortar or grout since they lead to premature corrosion of metals and increased amounts of efflorescence.[1]

Accelerator Compounds

Accelerator compounds are admixtures that increase the rate of hydration of the cement within the mortar or grout. Accelerators are **not** able to solve cold weather construction problems alone since the grout or mortar will still freeze if not protected. Accelerators may allow the masonry contractor to decrease the amount or time required for protection after construction has been completed since the hydration process has been increased. Typical accelerators are commonly based on calcium chloride, calcium nitrite, soluble carbonates and a limited number of organic compounds. Any accelerator used in masonry construction needs to be evaluated to ensure that it does not cause detrimental effects such as corrosion of metal within the masonry, efflorescence or other staining and strength characteristics.

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Heating Requirements

At this point it has been established that mortar and grout must not freeze until the moisture content is low enough that detrimental damage is not caused as a result of volumetric changes. Additionally, when the mortar or grout freezes the hydration process is halted until it thaws and the hydration process is reinitiated. Therefore, the mortar and grout need to develop enough strength prior to freezing so that the building is structurally sound until additional strength can be gained after it thaws. As a result, masonry contractors must ensure that certain heating requirements are fulfilled during construction. In addition, masonry contractors must also provide proper protection after construction has been completed to ensure that the mortar and grout does not freeze prematurely. Table 1 highlights the minimum general requirements for heating and protection during construction. The air temperature at the time of construction dictates the heating and protection requirements during construction. In many instances the masonry contractors are responsible for only a portion of the heating and protection requirement and the general contractor is responsible for the rest. This may lead to confusion if the general is not aware of the required protection. **For this reason it is important to clearly define the responsibilities of both the masonry contractor and the general contractor prior to commencing construction.**

Water and sand may be heated individually or in combination to meet the requirements in Table 1 when mixing mortar or grout. Water is typically the easiest of materials to heat on the jobsite. Conversely the sand tends to be the most labour intensive and costly material to heat. One of the most common methods of heating the sand is to place a series of culverts beneath the sand pile with a heating source in the pipe. It is important to heat the sand slowly to avoid scorching it. Scorched sand will have a reddish tint to it and should not be used.[4] In extremely cold weather smaller batches may be required to ensure that the mortar is used before it loses its workability and the grout can be placed before its temperature drops below 20°C.

As the temperature decreases, heating will be required along with protection requirements outlined below to ensure that the masonry assemblages do not freeze prematurely. Work may continue in the open with heat being applied to both sides of the masonry as outlined in Table 1. Once the temperature falls below -7°C enclosures are required along with supplementary heat so the air temperature on both sides of the masonry work is above 0°C. Some of the increased cost of heating will be offset with increased mason productivity as a result of the warmer work area.

Air Temperature, °C	General Requirements During Construction
0 to 4	1) Either the sand **OR** mixing water shall be heated to a min of 20°C and a max of 70°C
-4 to 0	1) **BOTH** the sand and mixing water shall be heated to a min of 20°C and a max of 70°C
-7 to -4	1) **BOTH** the sand and mixing water shall be heated to a min of 20°C and a max of 70°C 2) Heat shall be provided on **BOTH** sides of walls under construction 3) Windbreaks shall be employed when wind is in excess of 25 km/h
-7 and below	1) **BOTH** the sand and mixing water shall be heated to a min of 20°C and a max of 70°C 2) Enclosures and supplementary heat shall be provided to maintain an air temperature above 0°C 3) The temperature of the unit when laid shall be not less than 7°C

Table 1. General heating and protection requirements during construction

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Heat is supplied using many different types of fuels and equipment based upon location and job size. Gas salamanders are widely used throughout the masonry industry during the construction period. Upon completion of the construction, it is possible to use electric blankets with protective coverings to keep the masonry heated during the curing period. This may be more cost effective if the curing period is extended for a lengthy period in special projects.

Protection

The main purpose of the protection is to ensure that the masonry does not freeze prematurely. Cold weather masonry construction requires protection during and upon completion of masonry construction. Protection requirements vary from simple windbreaks to complicated enclosures that may completely cover the entire building.

During construction, protection requirements are determined as indicated in Table 1 based on the current air temperature. When work is stopped, even for a short period, the top surface should be covered and the cover should extend 1m down each side.

Upon completion of the construction (end of the day, or when the wall is finished) the protection requirements are outlined in Table 2. The mean temperature for a day is measured by adding the maximum and minimum temperature for that day (24 hour period, midnight – midnight) and dividing by two.

When the masonry is required to be covered with insulating blankets the amount of insulation will depend on the expected environmental conditions (Air Temp, Wind) in conjunction with the size and shape of the masonry element. The insulating blankets must keep the masonry at a temperature that will facilitate proper curing of the masonry. It is recommended that the masonry be kept above 0°C for the protection period to ensure proper curing conditions.

Mean Daily Air Temperature, °C	Protection Required Upon Completion of Construction
0 to 4	Masonry Shall be protected from rain or snow for 48 hours
-4 to 0	Masonry shall be completely covered for 48 hours
-7 to -4	Masonry shall be completely covered with insulating blankets for 48 hours
-7 and below	The masonry temperature shall be maintained above 0°C for 48 hours by enclosure and supplementary heat

Table 2. Protection Required Upon Completion of Construction

Summary

Masonry assemblages typically perform well when constructed using the information provided in this bulletin in conjunction with the guidance found in the appropriate codes and standards. The information presented in this bulletin and its appropriate use is left to the discretion of the designer. For further information please contact the Ontario Masonry Contractors' Association.

References

1) Canadian Standards Association, "Mortar and Grout for Unit Masonry," CSA A179, Rexdale, Ontario, 1994
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3) R. G. Drysdale , A. A. Hamid, L. R. Baker, *Masonry Structures -Design and Behavior*, 2nd Ed., The Masonry Society, Boulder, Colorado, 1999
4) Brick Institute of American, "All-Weather Construction", Technical Notes on Brick Construction Volume 1, Reston, Virginia, March 1992
5) International Masonry Industry All-Weather Council, "Recommended Practices & Guide Specifications for Cold Weather Masonry Construction", 1993
6) W. C. Panarese, S. H. Kosmatka, F. A. Randall, Jr., *Concrete Masonry Handbook*, 5th Ed., Portland Cement Association, Skokie, Illinois, 1991

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