Cold Weather Masonry Construction

Introduction

As cold weather arrives, builders must take precautions when doing masonry construction. By changing procedures, equipment, or supplies, mason contractors can avoid seasonal delays associated with cold weather. This permits better utilization of a mason contractor's resources, particularly manpower. Successful masonry construction can proceed despite cold temperatures by following an effective cold weather construction program.

The *Specification for Masonry Structures* (ACI 530.1-08/ASCE 6-08/TMS 602-08) contains minimum requirements for cold weather masonry construction. When ambient temperature falls below 40°F (4.4°C), cold weather construction applies. As the temperature of mortar materials falls below normal:

- water requirement to reach a given consistency is reduced
- a given amount of air-entraining agent yields more entrained air
- initial and final set of the mortar are significantly delayed
- heat-liberating reaction rates between portland cement and water are substantially reduced, becoming minimal as mortar temperature drops below 40°F (4.4°C)
- strength gain rates are reduced

Figure 1. Masonry construction can proceed through winter months if an effective cold weather construction program is adopted. *(IMG12504)*

Cold masonry units lower the temperature of mortar placed in contact with those units. Not only does this slow reaction rates between cement and water and reduce strength gain rates, it delays tooling and setting times. If the units are cold enough, the temperature of the mortar may drop below freezing and result in disruptive expansion of the mortar as water in the mortar freezes. Wet or ice-covered unit surfaces prevent development of good bond between mortar and unit.

Figure 2. Masonry materials stored at the project need to be protected from rain, snow, and ice. *(IMG12505)*

In addition to affecting the performance of masonry materials, cold weather may also affect the productivity and workmanship of masons. During cold weather, masons must first ensure their personal comfort and safety, then attend to normal construction tasks and any additional materials preparation, handling, and protection of masonry. These extra activities consume more time as temperatures continue to drop.

The goal of a cold weather construction plan is to eliminate or minimize the undesirable effects of cold temperatures on materials and people in a cost-effective manner. The mason contractor must evaluate the effectiveness and practicality of techniques in the context of specific project and weather conditions encountered. Depending on the severity of weather, one or more of the following strategies can be considered:

- optimize the selection of masonry materials for cold weather performance
- protect materials
- heat materials
- protect or enclose work areas
- heat work areas and in-place work

Masonry Materials

Selection. Masonry units are typically selected on the basis of aesthetic or structural properties rather than consideration of performance in cold weather construction. Mortar type is also generally determined by structural or other performance criteria. However, knowledge of how mortar and unit properties interact in cold weather enables the mason contractor to modify construction procedures to accommodate the specified materials.

The initial water content of mortar required for workability is in the range of 11% to 16%. Mortar used to lay units stiffens as mixing water contained in the mortar is absorbed by units, evaporates, or reacts with the portland cement in the mortar. To avoid disruptive expansion upon freezing, water content of mortar needs to be below 6%. Units having high initial rates of absorption (suction) will accelerate stiffening by drawing water from the mortar. Low absorption or wet units remove very little water from the mortar.

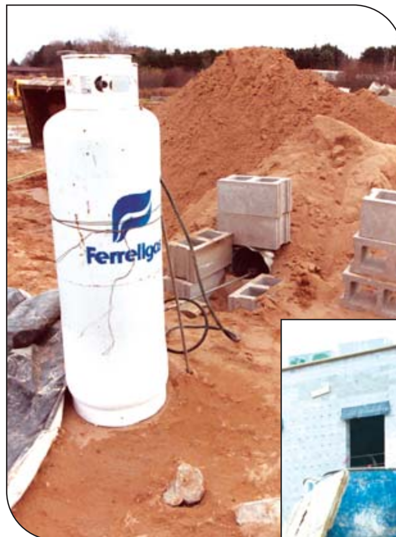
Likewise, the water-retentive properties of mortar affect its rate of moisture loss and stiffening. Mortars having high lime content or fine sands tend to have higher water demands and higher water retentivity than higher strength mortars or mortars made using well-graded sands. Although air entrainment increases water retentivity, it also reduces initial water demand required to achieve a workable consistency and has been shown to reduce susceptibility of mortar to damage by early freezing.

The rate at which portland cement reacts with water is primarily influenced by the temperature of the mortar or grout. The use of higher fineness cements (such as ASTM C 150 Type III) or accelerators increases reaction rates. *These materials can be used in mortar to augment, but not substitute for, other cold weather construction practices*.

Accelerators are sometimes mistakenly called "antifreeze" admixtures. Their function is not to reduce the freezing point of mortar, but to increase the rates of early-age strength development. Thus, they don't eliminate the need to protect mortar from freezing, but may limit the amount of time that protection is required. Calcium chloride (at a limit of 2% by mass of cement) is commonly used in concrete as an accelerator, but its use in mortar is prohibited by the *Specification for Masonry Structures* because it contributes to corrosion of embedded metal such as wall ties, anchors, and joint reinforcement. Only non-chloride based accelerators, as verified by the admixture manufacturer, should be allowed.

ASTM C 270 indicates that admixtures are not to be used unless specified. Therefore, unless project specifications call for the use of an accelerator, the mason must request permission from the specifier in order to use one.

Protection, Storage, and Heating. All masonry materials should be protected from rain, snow, and ice. Masonry units and packaged mortar materials should be securely wrapped with canvas or polyethylene tarpaulins and stored above the reach of moisture migrating from the ground. Sand piles should also be covered and care taken to avoid contamination of the sand with mud and clay.



Figures 3a and 3b. Sand can be heated over fire in a pipe, and water can be heated in metal drums. ***(IMG12506, IMG12507)***

Masonry materials may need to be heated prior to use to assure cement hydration in mortar. At temperatures of less than 40°F (4.4°C), cement hydration necessary for strength development is minimal. At temperatures of 120°F (48.9°C) or higher, flash set is imminent. When mixed, the mortar should be in the range of 40°F to 120°F (4.4°C to 48.9°C) and kept above freezing until used in masonry. If ambient temperatures are falling below freezing, a minimum grout temperature of 70°F (21.1°C) is recommended at the time of grout placement.

Figure 4. A temporary shelter protects the mortar preparation area from rain and snow. ***(IMG24817)***

Water can be heated in barrels or tubs. It is the easiest material to heat and it can store much more heat (per unit mass) than the other materials used in mortar. Although recommendations vary as to the highest temperature to which water should be heated, the *Specification for Masonry Structures* places a maximum of 140°F (60°C) because higher temperatures pose a safety hazard and could result in flash set. To avoid flash set, heated water should be combined with cold sand in the mixer before adding cement.

Sand is typically delivered to the project and used in a damp loose condition. Even though sand piles are covered, it may be necessary to heat sand to thaw frozen lumps when temperatures fall below freezing. Generally, sand is heated to about 50°F (10°C), although higher temperatures are permissible as long as the sand is not scorched and as long as resultant mortar or grout temperatures do not exceed 120°F (48.9°C). Sand piles can be heated with electric heating pads, by placing sand over a heated pipe, or by using steam heating systems.

Masonry units should not have any visible ice on bedding surfaces when used, nor should the temperature of masonry units be less than 20°F (- 6.7°C) to avoid rapid lowering of mortar or grout temperatures. Better productivity is often attained by using units that have a minimum temperature of 40°F (4.4°C). Masonry units are usually heated on pallets in an enclosure or stored in a heated area. The units should be kept dry, although very high-absorption fired-clay brick may need to be wetted, but not saturated, prior to use.

Table 1. Cold Weather Construction Requirements

Ambient temperature	**Cold weather procedures for work in progress**
Above 40°F (4.4°C)	No special requirements.
Below 40°F (4.4°C)	Do not lay glass unit masonry.
32°F to 40°F (0°C to 4.4°C)	Heat sand or mixing water to produce mortar temperature between 40°F and 120°F (4.4°C and 48.9°C) at the time of mixing. Heat materials for grout only if they are below 32°F (0°C).
25°F to 32°F (-3.9°C to 0°C)	Heat sand or mixing water to produce mortar temperature between 40°F and 120°F (4.4°C and 48.9°C) at the time of mixing. Keep mortar above freezing until used in masonry. Heat materials to produce grout temperature between 70°F and 120°F (21.1°C and 48.9°C) at the time of mixing. Keep grout temperature above 70°F (21.1°C) at the time of placement.
20°F to 25°F (-6.7°C to -3.9°C)	In addition to requirements for 25°F to 32°F (-3.9°C to 0°C), heat masonry surfaces under construction to 40°F (4.4°C) and use wind breaks or enclosures when the wind velocity exceeds 15 mph (24 km/h). Heat masonry to a minimum of 40°F (4.4°C) prior to grouting.
20°F (-6.7°C) and below	In addition to all of the above requirements, provide an enclosure and auxiliary heat to keep air temperature above 32°F (0°C) within the enclosure.
Ambient temperature (minimum for grouted; mean daily for ungrouted)	**Cold weather procedures for newly completed masonry**
Above 40°F (4.4°C)	No special requirements, except for the following: Maintain glass unit masonry above 40°F (4.4°C) for the first 48 hours after construction. Maintain autoclaved aerated concrete (AAC) above 32°F (0°C) for the first 24 hours after thin-bed mortar application.
25°F to 40°F (-3.9°C to 4.4°C)	Cover newly constructed masonry with a weather-resistive membrane for 24 hours after being completed.
20°F to 25°F (-6.7°C to -3.9°C)	Cover newly constructed masonry with weather-resistive insulating blankets (or equal protection) for 24 hours after being completed. Extend the time period to 48 hours for grouted masonry, unless the only cement used in the grout is ASTM C 150 Type III.
20°F (-6.7°C) and below	Keep newly constructed masonry above 32°F (0°C) for at least 24 hours after being completed. Use heated enclosures, electric heating blankets, infrared lamps, or other acceptable methods. Extend the time period to 48 hours for grouted masonry, unless the only cement used in the grout is ASTM C 150 Type III.

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Protecting Work Areas and Construction

Figure 5. Enclosure and heating of a work area protects materials, workers, and installed masonry from severe weather. *(IMG12508)*

Wind breaks, heated wall coverings, and plain or heated enclosures are used to maintain adequate mortar temperatures and to improve the comfort and efficiency of masons and laborers. The level of protection required will depend on the severity of weather encountered. The *Specification for Masonry Structures* defines certain cold weather construction requirements as summarized in Table 1. It includes provisions needed during the work day while masonry is being laid, as well as protection requirements for newly constructed masonry. Several means of implementing these provisions are available to the mason contractor. Regional climatic differences and project-specific factors must be taken into account when selecting the most effective methods of protection for a given project. Basic principles required for satisfactory cold weather masonry construction described here and in the reference documents are well established. The use of innovative construction and protection techniques based on these established principles can improve the effectiveness and efficiency of a cold weather construction program.

References

1. *All-Weather Concrete Masonry Construction*, NCMA TEK 3-1C, National Concrete Masonry Association, Herndon, Virginia, 2002.
2. *Cold and Hot Weather Construction*, BIA Technical Notes 1, Brick Industry Association, Reston, Virginia, June 2006.
3. *Concrete Masonry Handbook for Architects, Engineers, Builders*, Farny, J. A., Melander, J. M., and Panarese, W. C., EB008, Portland Cement Association, 2008, pages 128–137.
4. *Recommended Practices & Guide Specifications for Cold Weather Masonry Construction*, International Masonry Industry All Weather Council, Washington, D.C., twelfth printing, 1993. (Available from PCA as LT107.)
5. *Specification for Masonry Structures and Commentary (ACI 530.1-08/ASCE 6-08/ TMS 602-08)*, Masonry Standards Joint Committee, comprising the American Concrete Institute, Farmington Hills, Michigan, the Structural Engineering Institute of the American Society of Civil Engineers, Reston, Virginia, and The Masonry Society, Boulder, Colorado, 2008.
6. *Hot & Cold Weather Masonry Construction*, Masonry Industry Council, Lombard, Illinois, 1999. (Available from PCA as LT232.)

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