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ALL-WEATHER CONCRETE MASONRY CONSTRUCTION

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Construction (2002)

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INTRODUCTION

Masonry construction can continue during hot, cold, and wet weather conditions. The ability to continue masonry construction in adverse weather conditions requires consideration of how environmental conditions may affect the quality of the finished masonry. In some cases, environmental conditions may warrant the use of special construction procedures to ensure that the masonry work is not adversely affected.

One of the prerequisites of successful all-weather construction is advance knowledge of local conditions. Work stoppage may be justified if a short period of very cold or very hot weather is anticipated. The best source for this type of information is the U.S. Weather Bureau, Environmental Science Services Administration (ESSA) of the U.S. Department of Commerce which can be accessed at their web site http://www.ncdc.noaa.gov.

In the following discussion, ambient temperature refers to the surrounding jobsite temperature when the preparation activities and construction are in progress. Similarly the mean daily temperature is the average of the hourly temperatures forecast by the local weather bureau over a 24 hour period following the onset of construction. Minimum daily temperature is the lowest temperature expected during the period. Temperatures between 40 and 90°F (4.4 and 32.2°C) are considered "normal" temperatures for masonry construction and therefore do not require special procedures or protection protocols.

COLD WEATHER CONSTRUCTION

When ambient temperatures fall below 40°F (4.4°C), the *Specification for Masonry Structures* (ref. 3) requires consideration of special construction procedures to help ensure the final construction is not adversely affected. Similarly when the minimum daily temperature for grouted masonry or the mean temperature for ungrouted masonry falls below 40°F (4.4°C) during the first 48 or 24 hours after construction respectively, special protection considerations are required.

Mortar and Grout Performance

Hydration and strength development in mortar and grout generally occurs at temperatures above 40°F (4.4°C) and only when sufficient water is available. However, masonry construction may proceed when temperatures are below 40°F (4.4°C) provided cold weather construction and protection requirements of reference 3 are followed.

Mortars and grouts mixed at low temperatures have longer setting and hardening times, and lower early strength than those mixed at normal temperatures. However, mortars and grouts produced with heated materials exhibit performance characteristics identical to those produced during warm weather.

Effects of Freezing

The initial water content of mortar can be a significant contributing factor to the resulting properties and performance of mortar, affecting workability, bond, compressive strength, and susceptibility to freezing. Research has shown a resulting disruptive expansion effect on the cement-aggregate matrix when fresh mortars with water contents in excess of 8 %mortar are frozen (ref. 2). This disruptive effect increases as the water content increases. Therefore, mortar should not be allowed to freeze until the mortar water content is reduced from the initial 11% to 16% range to a value below 6%. Dry concrete masonry units have a demonstrated capacity to achieve this moisture reduction in a relatively short time. It is for this reason that the specification requires protection from freezing of mortar for only the first 24 hours (ref. 3).

Grout is a close relative of mortar in composition and performance characteristics. During cold weather, however, more attention must be directed toward the protection of grout because of the higher water content and resulting disruptive expansion that can occur from freezing of that water. Therefore, grouted masonry needs to be protected for longer periods to allow the water content to be dissipated.

Cement

During cold weather masonry construction, Type III, high-early strength portland cement should be considered in lieu of Type I portland cement in mortar or grout to accelerate setting. The acceleration not only reduces the curing time but generates more heat which is beneficial in cold weather.

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Admixtures

The purpose of an accelerating type of admixture is to hasten the hydration of the portland cement in mortar or grout. However, admixtures containing chlorides in excess of 0.2% chloride ions are not permitted to be used in mortar (ref. 3) due to corrosion of embedded metals and contribution to efflorescence. While specifically not addressed by the Specification, the use of chloride admixtures in grout is generally discouraged.

Noncloride accelerators are available but they must be used in addition to cold weather procedures and not as a replacement for them. Antifreezes are not recommended for use in mortars and are prohibited for use in grouts.

Material Storage

Construction materials should be protected from water by covering. Bagged materials and masonry units should be protected from precipitation and ground water by storage on pallets or other acceptable means.

Coverings for materials include tarpaulins, reinforced paper, polyethylene, or other water repellent sheet materials. If the weather and size of the project warrant, a shelter may be provided for the material storage and mortar mixing areas.

Material Heating

When the ambient temperature falls below 40°F (4.4°C) during construction, or mean daily temperature is predicted to fall below 40°F (4.4°C) during the first 24 hours following construction of ungrouted masonry, or the minimum daily temperature is predicted to fall below 40°F (4.4°C) during the first 48 hours for grouted masonry, *Specification for Masonry Structures* (ref. 3) requires specific construction and protection procedures to be implemented as summarized in Tables 1a and 1b. As indicated in

Table 1a—Cold Weather Masonry Construction Requirements (ref. 3)

Ambient temperature	Construction requirements
32 to 40°F (0 to 4.4°C)	Do not lay masonry units having a temperature below 20°F (-6.7°C). Remove visible snow and ice on masonry units before the unit is laid in the masonry. Remove snow and ice from foundation. Heat existing foundation and masonry surfaces to receive new masonry above freezing. Heat mixing water or sand to produce mortar temperatures between 40 and 120°F (4.4 and 48.9°C). Grout materials to be 32°F (0°C) minimum. Do not heat water or aggregates above 140°F (60°C).
25 to 32°F (-3.9 to 0°C)	Same as above for mortar. Maintain mortar temperature above freezing until used in masonry. Heat grout aggregates and mixing water to produce grout temperatures between 70 and 120°F (21.1 and 48.9°C). Maintain grout temperature above 70°F (21.1°C) at time of grout placement.
20 to 25°F (-6.7 to -3.9°C)	Same as above, plus use heat masonry surfaces under construction to 40°F (4.4°C) and install wind breaks or enclosures when wind velocity exceeds 15 mph (24 km/hr). Heat masonry to a minimum of 40°F (4.4°C) prior to grouting.
20°F (-6.7°C) and below	Same as above, plus provide an enclosure for the masonry under construction and use heat sources to maintain temperatures above 32°F (0°C) within the enclosure.

Table 1b—Cold Weather Masonry Protection Requirements (ref. 3)

Mean daily temperature for ungrouted masonry Minimum daily temperature for grouted masonry	Protection requirements
25 to 40°F (-3.9 to 4.4°C)	Protect completed masonry from rain or snow by covering with a weather-resistive membrane for 24 hours after construction.
20 to 25°F (-6.7 to -3.9°C)	Completely cover the completed masonry with a weather-resistive insulating blanket or equal for 24 hours after construction (48 hr for grouted masonry unless only Type III portland cement used in grout).
20°F (-6.7°C) and below	Maintain masonry temperature above 32°F (0°C) for 24 hours after construction by enclosure with supplementary heat, by electric heating blankets, by infrared heat lamps, or by other acceptable methods. Extend time to 48 hours for grouted masonry unless the only cement in the grout is Type III portland cement.

Table 1a, the temperature of dry masonry units may be as low as 20°F (-6.7°C) at the time of placement. However, wet frozen masonry units should be thawed before placement in the masonry. Also, even when the temperature of dry units approaches the 20°F (-6.7°C) threshold, it may be advantageous to heat the units for greater mason productivity.

Masonry should never be placed on a snow or ice-covered surface. Movement occurring when the base thaws will cause cracks in the masonry. Furthermore, the bond between the mortar and the supporting surface will be compromised.

Glass Unit Masonry

For glass unit masonry, both the ambient temperature and the unit temperature must be above 40°F (4.4°C) and maintained above that temperature for the first 48 hours (ref. 3).

HOT WEATHER CONSTRUCTION

High temperatures, solar radiation, and ambient relative humidity influence the absorption characteristics of the masonry units and the setting time and drying rate for mortar. When mortar gets too hot, it may lose water so rapidly that the cement does not fully hydrate. Early surface drying of the mortar results in decreased bond strength and less durable mortar. Hot weather construction procedures involve keeping masonry materials as cool as possible and preventing excessive water loss from the mortar. Specific hot weather requirements of the *Specification for Masonry Structures* (ref. 3) are shown in Tables 2a and 2b.

Additional Recommendations

Store masonry materials in a shaded area. Use a water barrel as water hoses exposed to direct sunlight can result in water with highly elevated temperatures. The barrel may be filled with water from a hose, but the hot water resulting from hose inactivity should be flushed and discarded first. Additionally, mortar mixing times should be no longer than 3 to 5 minutes and smaller batches will help minimize drying time on the mortar boards.

To minimize mortar surface drying, past requirements contained within *Specification for Masonry Structures* (ref. 3) were to not spread mortar bed joints more than 4 feet (1.2 m) ahead of masonry and to set masonry units within one minute of spreading mortar. This is no longer a requirement in the current document but the concept still merits consideration. If surface drying does occur, the mortar can often be revitalized by wetting the wall but care should be taken to avoid washout of fresh mortar joints.

WET WEATHER CONSTRUCTION

Even when ambient temperatures are between 40 and 90°F (4.4 and 32.2°C), the presence of rain, or the likelihood of rain, should receive special consideration during masonry construction. Unless protected, masonry construction should not continue during heavy rains, as partially set or plastic mortar is susceptible to washout, which could result in reduced strength or staining of the wall. However, after approximately 8 to 24 hours of curing (depending upon environmental conditions), mortar washout is no

Table 2a—Hot Weather Masonry Preparation and Construction Requirements (ref. 3)

Ambient temperature	Preparation and construction requirements
Above 100°F (37.8°C) or above 90°F (32.2°C) with a wind speed greater than 8 mph (12.9 km/hr)	Maintain sand piles in a damp, loose condition. Maintain temperature of mortar and grout below 120°F (48.9°C). Flush mixer, mortar transport container, and mortar boards with cool water before they come into contact with mortar ingredients or mortar. Maintain mortar consistency by retempering with cool water. Use mortar within 2 hours of initial mixing.
Above 115°F (46.1°C) or above 105°F (40.6°C) with a wind speed greater than 8 mph (12.9 km/hr)	Same as above, plus materials and mixing equipment are to be shaded from direct sunlight. Use cool mixing water for mortar and grout. Ice is permitted in the mixing water as long as it is melted when added to the other mortar or grout materials.

Table 2b—Hot Weather Masonry Protection Requirements (ref. 3)

Mean daily temperature	Protection requirements
Above 100°F (37.8°C) or above 90°F (32.2°C) with a wind speed greater than 8 mph (12.9 km/hr)	Fog spray all newly constructed masonry until damp, at least three times a day until the masonry is three days old.

longer of concern. Further, the wetting of masonry by rainwater provides beneficial curing conditions for the mortar (ref. 2).

When rain is likely, all construction materials should be covered. Newly constructed masonry should be protected from rain by draping a weather-resistant covering over the assemblage. The cover should extend over all mortar that is susceptible to washout.

Recommended Maximum Unit Moisture Content

When the moisture content of a concrete masonry unit is elevated to excessive levels due to wetting by rain or other sources, several deleterious consequences can result including increased shrinkage potential and possible cracking, decreased mason productivity, and decreased mortar/unit bond strength. While reinforced masonry construction does not rely on mortar/unit bond for structural capacity, this is a design consideration with unreinforced masonry. As such, the concerns associated with structural bond in reinforced masonry construction are diminished.

As a means of determining if a unit has acceptable moisture content at the time of installation, the following industry recommended guidance should be used. This simple field procedure can quickly ascertain whether a concrete masonry unit has acceptable moisture content at the time of installation.

A concrete masonry unit for which 50% or more of the surface area is observed to be wet is considered to have unacceptable moisture content for placement. If less than 50% of the surface area is wet, the unit is acceptable for placement. Damp surfaces are not considered wet surfaces.

For this application, a surface would be considered damp if some moisture is observed, but the surface darkens when additional free water is applied. Conversely, a surface would be considered wet if moisture is observed and the surface does not darken when free water is applied.

It should be noted that these limitations on maximum permissible moisture content are not intended to apply to intermittent masonry units that are wet cut as needed for special fit.

WINDY WEATHER CONSTRUCTION

In addition to the effects of wind on hot and cold weather construction, the danger of excessive wind resulting in structural failure of newly constructed masonry prior to the development of strength or before the installation of supports must be considered. TEK 3-4B *Bracing Concrete Masonry Walls During Construction* (ref. 1) provides guidance in this regard.

REFERENCES

1. *Bracing Concrete Masonry Walls During Construction*, TEK 3-4B. National Concrete Masonry Association, 2000
2. *Hot & Cold Weather Masonry Construction*. Masonry Industry Council, 1999.
3. *Specification for Masonry Structures*, ACI 530.1-02/ASCE 6-02/TMS 602-02. Reported by the Masonry Standards Joint Committee, 2002.

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