weather but this may not be possible if the mixture has been specifically designed for durability. The appropriate decision should afford an economically viable solution with the least impact on the ultimate concrete properties.

Concrete should be placed at the lowest practical slump as this reduces bleeding and setting time. Adding 1 to 2 gallons of water per cubic yard [5 to 10 L/m^3] will delay set time by ½ to 2 hours. Retarded set times will prolong the duration of bleeding. Do not start finishing operations while the concrete continues to bleed as this will result in a weak surface.

Adequate preparations should be made prior to concrete placement. Snow, ice and frost should be removed and the temperature of surfaces and metallic embedments in contact with concrete should be above freezing. This might require insulating or heating subgrades and contact surfaces prior to placement.

Materials and equipment should be in place to protect concrete, both during and after placement, from early age freezing and to retain the heat generated by cement hydration. Insulated blankets and tarps, as well as straw covered with plastic sheets, are commonly used measures. Enclosures and insulated forms may be needed for additional protection depending on ambient conditions. Corners and edges are most susceptible to heat loss and need particular attention. Fossil-fueled heaters in enclosed spaces should be vented for safety reasons and to prevent carbonation of newly placed concrete surfaces, which causes dusting.

The concrete surface should not be allowed to dry out while it is plastic as this causes plastic shrinkage cracks. Subsequently, concrete should be adequately cured. Water curing is not recommended when freezing temperatures are imminent. Use membrane-forming curing compounds or impervious paper and plastic sheets for concrete slabs.

Forming materials, except for metals, serve to maintain and evenly distribute heat, thereby providing adequate protection in moderately cold weather. With extremely cold temperatures, insulating blankets or insulated forms should be used, especially for thin sections. Forms should not be stripped for 1 to 7 days depending on the setting characteristics, ambient conditions and anticipated loading on the structure. Field-cured cylinders or nondestructive methods should be used to estimate in-place concrete strength prior to stripping forms or applying loads. Field-cured cylinders should not be used for quality assurance.

Special care should be taken with concrete test specimens used for acceptance of concrete. Cylinders should be stored in insulated boxes, which may need temperature controls, to insure that they are cured at 60°F to 80°F [16°C to 27°C] for the first 24 to 48 hours. A minimum/maximum thermometer should be placed in the curing box to maintain a temperature record.

Cold Weather Concreting Guidelines

1. Use air-entrained concrete when exposure to moisture and freezing and thawing conditions are expected.
2. Keep surfaces in contact with concrete free of ice and snow and at a temperature above freezing prior to placement.
3. Place and maintain concrete at the recommended temperature.
4. Place concrete at the lowest practical slump.
5. Protect plastic concrete from freezing or drying.
6. Protect concrete from early-age freezing and thawing cycles until it has attained adequate strength.
7. Limit rapid temperature changes when protective measures are removed.