Issue 111
April 2021
Division of Technical Resources
Office of Research Facilities
National Institutes of Health
Technical News BULLETIN

Cold Weather Concreting

Introduction

According to the American Concrete Institute (ACI), "the conditions of cold weather concreting exist when the air temperature has fallen to, or is expected to fall below, 40°F (4°C) during the protection period"; the protection period is "the amount of time recommended to prevent concrete from being adversely affected by exposure to cold weather during construction" (ACI 306R-16). This definition streamlines an older, more complicated definition which included factors such as consecutive days and average daily temperature; the new definition focuses more directly on keeping concrete from being damaged by cold weather.

Damage Caused by Cold Weather

Concrete must be protected in cold weather until it can handle the cold on its own. The setting time of concrete increases significantly in colder weather because low concrete temperature has a major impact on the rate of cement hydration. Below 40°F, the hydration reaction slows and the concrete stops gaining strength. Early-age freezing (when the concrete is still saturated) may also cause permanent damage; concrete can lose up to 50% of its ultimate strength when it freezes at an early age. It is important to note that these are concrete temperatures, not air temperatures (concrete temperature is measured in accordance with ASTM C1064/C106M). Refer to Table 5.1 of (ACI 306R-16) for recommended concrete temperatures during placement.

Considerations and Precautions

Successful concrete work can be accomplished during the coldest weather if the appropriate precautions are taken. Critically, concrete should be protected from freezing until it attains a minimum compressive strength of 500 psi (3.5 MPa), which is about two days (48 hours) after placement for most concrete that is maintained at 50°F. Once concrete has reached at least 500 psi, it will not be damaged by exposure to a single freezing cycle (Powers, 1962). Per (ACI), correctly proportioned, produced, and protected concrete placed during cold weather will develop satisfactory strength and durability to meet the proposed service recommendations; the necessary degree of protection is inversely proportional to the ambient temperature. If cured properly, concrete placed in cold weather "has the potential to develop higher ultimate strength…and greater durability than concrete placed at higher temperatures…[and] is susceptible to less thermal cracking than similar concrete placed at higher temperatures" (ACI 306R-16).

The following are some of the best practices of cold weather concreting:

- Plan adequately (anticipate weather conditions prior to the placement of concrete; necessary equipment and materials should be on site before the cold weather is likely to occur).
- Keep surfaces in contact with concrete free of ice and snow and at a temperature above freezing.
- Use cold weather mix concrete (discuss the appropriate mix design and delivery temperature of the concrete with the concrete ready-mix producer).
- Use non-chloride accelerators to increase the rate of the hydration.
- Avoid the use of fly ash or slag cement, as they set slowly.
- Insulate subgrade with insulated blankets few days prior to pouring.
- Schedule concrete pouring for the warmest part of the day.
- Use insulation blankets or heated enclosures to protect the concrete from freezing.
- Use air-entrained concrete if the concrete will be exposed to freeze-thaw conditions during and/or after placement.
- Monitor and record the concrete surface temperature (the surface temperature reflects the effectiveness of protection, regardless of ambient temperature).
- Limit rapid temperature change of concrete when protective measures are removed.
- Ensure on-site management of concrete test cylinders agrees with the expectation of the project officer and the testing agency.

References

ACI 306R-16: Guide to Cold Weather Concreting.

Powers, T.C. 1962. Prevention of frost damage to green concrete.