

Cold Weather Concreting and the Effects of Carbonation

Cold weather installations of floor surface hardeners, toppings and mortars carry a responsibility to assure that proper cold weather concreting practices are observed. Portland cement products yield the highest quality results when placed during ambient temperatures of 55 to 85 °F (13 to 29 °C). As temperatures (ambient, water, and packaged product) approach the freezing mark, conditions become more conducive for a floor surface to exhibit one or more of several undesirable characteristics:

- As temperatures dip below 40 °F (4 °C), proper hydration of concrete is severely retarded.
- While calcium chloride and chloride laden admixtures are frequently used to speed the set of concrete, this practice must be avoided when iron aggregate and colored surface hardeners are installed.
- In colder weather, set times are greatly extended, and slabs are in a plastic state for a longer period of time; therefore, application of toppings or dry shake hardeners is delayed. In these cases, the water present in the slab remains dormant and the likelihood of "carbonation" increases.

CARBONATION

Carbonation results when atmospheric carbon dioxide reacts with the moist hydration products of a drying concrete or a surface topping in the plastic state. Temperatures near 40 °F (4 °C) and relative humidities around 50% create opportune conditions for carbonation. The longer the floor slab is plastic, the more chance of surface drying

and exposure to carbonation. Carbonation ends strength gain and results in an ultimate low compressive strength coupled with low abrasion resistance. In short, hydration of Portland cement (as well as Portland cement based toppings, hardeners and mortars) stops, and strength gain ends as soon as carbonation takes place.

It should also be noted that the process of carbonation can be progressive, starting at the surface and producing a thicker zone of carbonated cement paste, depending on the depth of drying and to some extent the concentration of atmospheric carbon dioxide gas. This is why it may be possible to produce a thicker carbonation zone in low temperature application of a cementitious product than at relatively moderate temperatures.

Temperatures near, at, or below the freezing mark also lead to the needed hydration water freezing prior to completing its task. When this happens, again there is no strength gain. Essentially, all development of the slab ends when water freezes, thus forming ice lenses and disrupting the concrete. As is the case in more optimal temperatures, prompt curing is extremely important during low temperatures. If a slab is allowed to begin to set without a heavy coat of membrane curing compounds, the floor surface is inviting the inevitable carbonation previously discussed.

During cold temperatures, slump tests may be misleading and point to an improper amount of mixing water being added to a topping being

installed. There is no specific rule regarding slump being a given "percent high or low," but one must remember that a true slump cannot be routinely measured when air, water, and material are cold. As a result of the previous points, BASF recommends that all flatwork and the placement of our products containing Portland cement be conducted when the daytime ambient temperatures are above 55 °F (13 °C) and the floor will be allowed to gain sufficient strength. When this is not possible, it is recommended that the slab be protected from the elements by erecting walls, covering with tents, using vented heating units, etc., in an effort to keep the ambient and mixed product temperatures as close to being above 55 °F (13 °C) as possible.

Regarding heating units, it is extremely important that any fuel-burning heaters be vented by attaching hoses to the exhaust and venting outside the properly enclosed work area. As discussed in ACI 306 (1.7), "Heating units should be vented and not be permitted to heat or dry the concrete locally...."

For further information, refer to:

- ACI 301 (7.6.1) regarding delivered concrete temperatures in cold weather.
 - ACI 302 (8.3.1) regarding proper enclosing of work area and venting of heaters.
 - ACI 306 ("Cold Weather Concreting").
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