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HOT WEATHER CONCRETE CONSTRUCTION

Of all the materials that go into a construction project, concrete is unique in that it is finished at the project site. The vast majority of the other raw materials used in construction are finished where they are manufactured, delivered and then sized to fit once they arrive on site. Concrete arrives mixed and then is placed into forms to define the shape needed. Many variables are encountered that can affect the finishing and quality of the final concrete product include:

- Mix Design Properties (cement content, aggregate size, mix design water, admixtures)
- Jointing Design (slab-on-grade floors)
- Subgrade Preparations (type of material and moisture content)
- Reinforcing Steel (placement location and temperature)
- Available Labor (quantity and quality)
- Finishing Methods
- Curing Methods
- Weather (temperature, wind, humidity, solar radiation)

CONCRETE TEMPERATURE: Hot weather is defined as one or a combination of the following conditions that tend to impair the quality of freshly mixed or hardened concrete by accelerating the rate of moisture loss and rate of cement hydration, or otherwise causing detrimental results: high ambient temperature, high concrete temperature, low relative humidity and high wind speed. As soon as the mixing water contacts the cement, complex chemical reactions begin to take place. These chemical reactions are affected by temperature. Hot weather conditions create a situation where the concrete temperature is increased and, as a result, the setting time of the concrete mix will be reduced. A general rule of thumb estimates that a 20 degree increase in concrete temperature will reduce the set time by as much as 50%. **TIP:** To measure concrete temperature and to be able to learn to anticipate set times, have a thermometer available at the project site. They are inexpensive and well worth the price.

Methods of reducing the concrete mix temperature in order to create additional time for finishing operations include using chilled water, ice as part of the mixing water or the introduction of liquid nitrogen. Additionally, sprinkling coarse aggregate stockpiles can help keep concrete temperatures down. These methods will require advanced planning with your concrete supplier and may increase the cost of your concrete but may well be worth

the investment. Check with your concrete sales rep to see what is available in your area and what additional costs might be involved. As concrete mix temperatures increase and chemical reactions are accelerated, concrete will set at a faster rate. High temperatures tend to accelerate the rate of slump loss. Concrete mixed in the laboratory with a given water content at 70 degrees F. may exhibit a 4-inch slump. When the concrete temperature increases to 95 degrees F., it is possible that a slump of only 2 ½" may be realized with the same mix proportions. Don't over-truck a job. Extended mixing time in a truck will tend to raise concrete temperatures. Schedule deliveries so that trucks can be unloaded very soon after arrival at the job site. Prior to the arrival of the concrete, thoroughly moisten the subgrade and forms. Avoid standing water. To additionally help reduce the negative effects of hot weather, if possible try to place concrete in the cooler part of the day.

PLASTIC SHRINKAGE CRACKING: Once the concrete has been placed in the forms, water loss from the surface will begin and will be accelerated by hot and windy weather conditions. After placing concrete in slab construction, aggregates will tend to settle slightly down under the weight of gravity and water will be forced to the surface. This is the mechanism for the formation of bleed water. If the rate of moisture evaporation from the surface does not exceed the rate at which moisture is naturally migrating to the surface from within, there are no problems. Once the rate of surface water evaporation exceeds the rate at which it is replaced from within, the possibility of the formation of plastic shrinkage cracks can occur. The use of a surface evaporation retardant will help reduce surface moisture loss during finishing operations. These products should be applied after every finishing operation (floating and troweling) to realize all their benefits. Mist fogging the surface can also help reduce surface moisture loss. In a slab, when the top surface has lost water and begins to dry it wants to contract (shrink) while the remainder of the slab below the surface has not lost water and does not want to contract. The slab surface attempts to curl upwards as the surface dries and shrinks. This curling action causes stresses that exceed the low tensile strength of the fresh concrete. Restrained from curling upwards by its own weight, the surface cracks to relieve the internal surface stresses. These are plastic shrinkage cracks. They are often three pronged in appearance and are only at the surface. They do not impair the structural strength of the concrete. They can, however, create surface problems on a concrete floor subject to traffic and heavy use. Being unsightly, they should be avoided whenever possible. By understanding that plastic shrinkage cracks are a result of water loss created by adverse weather conditions (heat, wind, low humidity), these can serve as signals to the concrete finisher that extra steps must be taken in the finishing operations. It is vitally important to retain water in the concrete, especially in its fresh (plastic) state and early days of maturing.

CONCRETE CURING: After the concrete has been successfully placed and finished, the final operation that must be performed is curing. The best

products (aggregates and cement) can be used to manufacture the concrete and the best finishing procedures can be used to place and finish it, but the process cannot stop there….it must be properly cured. The potential strength and durability of the concrete mix will never be realized if the curing operations are not started as soon as possible after the final finishing operation. The most practical method for curing is the use of commercially produced chemical curing compounds applied at a rate not less than the manufacture's recommendations. These products allow for additional foot traffic on the surface the following day so other trades can start their work with no delays. Some chemical curing compounds may create problems with the adhesives used to secure flooring products to the concrete. These should be reviewed with the flooring contractor at the pre-pour conference. Ponding with water for seven days is a good way to cure concrete as long as the water is monitored and does not evaporate away during that time thus exposing portions of the slab surface to drying conditions. Following trades must wait until the water ponding operation is completed. Spraying the slab with cool water and allowing the surface to dry in between sprayings will create surface thermal cracks as the surface is alternately warmed (expanded) and cooled (contracted) while it has very little surface tensile strength. To be done correctly the spraying must be done for several days (and nights) and as a result may become impractical. Plastic sheeting can be used to retain moisture but will leave the surface with irregular color patterns which may, or may not, be an issue. Plastic sheeting should definitely never be used for architectural concrete. Water soaked burlap or old carpeting can serve as a good curing medium but again may prevent following trades from beginning their work.

HOT WEATHER CONCRETE CONSTRUCTION presents challenges over and above those encountered under lower temperature conditions. Discussions with all involved at a pre-pour conference will get everybody on board as to how things will come together. Knowing how concrete will react in hot weather and preparing properly will provide options that can go a long way to insuring a successful project outcome. Having the proper equipment and products available at the job site and making sure that adequate man-power is on hand and they are educated to the anticipated reactions of the concrete to these high temperature conditions will help in the overall preplanning.

References from American Concrete Institute and the National Ready Mix Concrete Association:

ACI 305R-20—Guide to Hot Weather Concrete

NRMCA-CIP12, Hot Weather Concreting

NRMCA-CIP 5, Plastic Shrinkage Cracking

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