NATIONAL PLASTERERS COUNCIL

PLASTIC SHRINKAGE
(TEMPERATURE VS. WIND SPEED)

NPC Technical Bulletin #6 states: "There is no Standard or Specification that sets limits on the ambient hot air temperature for plastering. In fact, most cement and concrete trades have no such limitation. The reason for this is because hot weather placements are more complex than any one factor." It goes on to give five (5) dominant factors that cause abnormal water loss at the upper surface, and the potential for abnormal drying shrinkage to occur:

- Temperature of the ambient air
- Temperature and absorption rate of the substrate
- Temperature of the plastering materials
- Humidity of the ambient air
- Wind speed.

In fact, hot temperature, low humidity, high winds, or a combination of these, can be detrimental if appropriate measures are not taken to offset the prevailing conditions when necessary. Potential issues may include:

- Decreased set time (less time to pump, place, and finish)
- Increased rate of surface drying (potential for abnormal shrinkage cracking)
- Increased water demand (to offset evaporation and substrate absorption)
- Increased potential for cold joints (from a decrease in set time and/or an increase in moisture loss)
- Increased potential for uneven surface coloration due to variation in moisture content and hydration of the cementitious material (e.g., areas in the sun versus areas in the shade).

While the above factors and considerations are very important, this Technical Bulletin focuses on the predominant factor, which is wind speed. To illustrate this, the nomograph charts below combine the effects of the four main factors that cause abnormal upper-surface water loss, resulting in abnormal plastic shrinkage. These four factors are: air temperature, relative humidity, material temperature, and wind speed. The nomograph charts have been highlighted in yellow, blue, and red to show three different wind speeds on a day with a normal (mild) temperature and on a day with a high (hot) temperature condition. Any result where the maximum evaporation rate exceeds 0.2 lb/yd^2/Hr. is likely to experience abnormal plastic shrinkage cracking.

Chart #1:

Air Temperature	75ºF	(normal 'mild' temperature)
Relative Humidity	35%	
Material Temperature	82ºF	
Wind Speed	2 mph; 5 mph; and 10 mph	

Chart #2:

Air Temperature	100ºF	(high 'hot' temperature)
Relative Humidity	25%	
Material Temperature	95ºF	
Wind Speed	2 mph; 5 mph; and 10 mph	

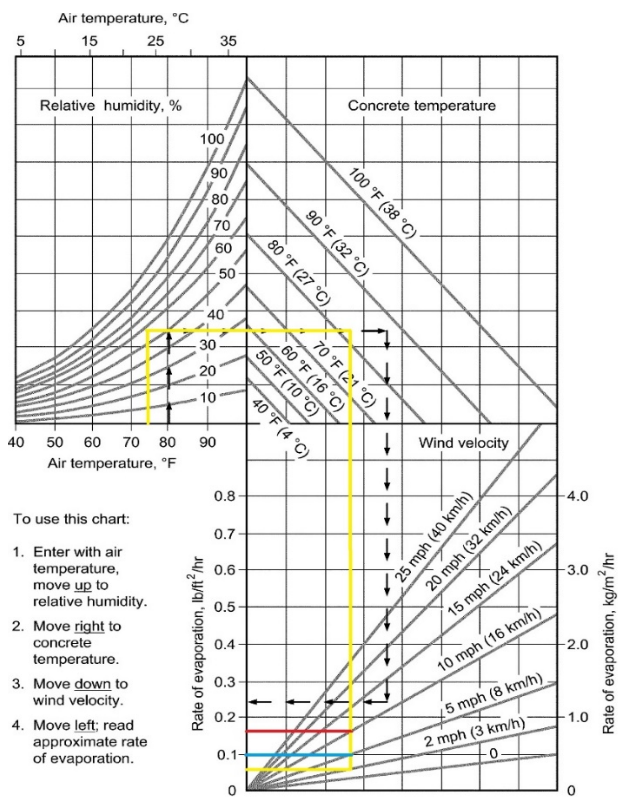

CHART #1

NOTE: If the rate of evaporation exceeds 0.2 lb/ft^2/h (1 kg/m^2/h) precautions against plastic shrinkage cracking are necessary.

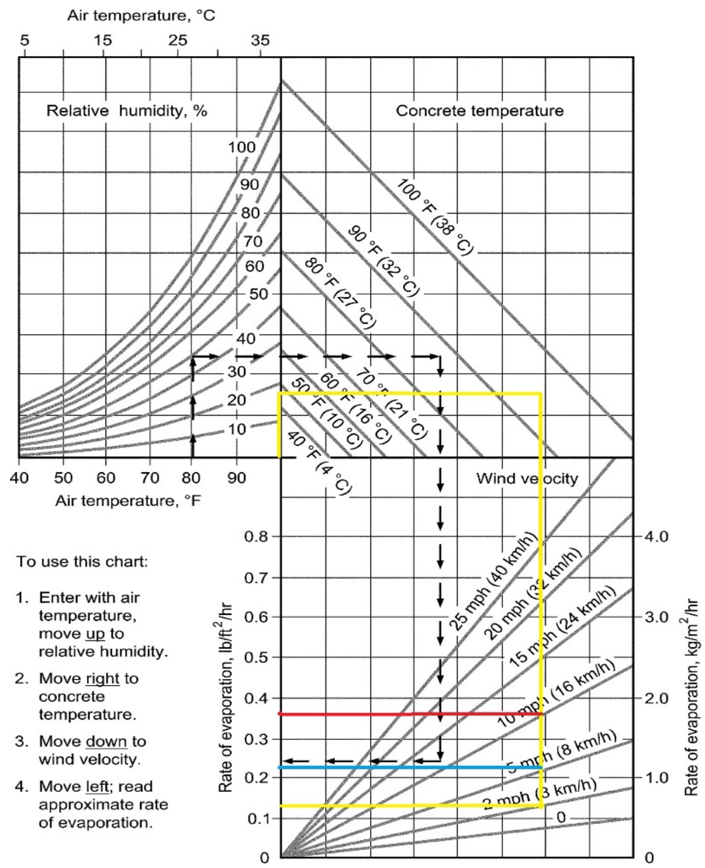

CHART #2

The charts show that in a high (hot) temperature condition (ambient temperature = 100^{o}F; material temperature = 95^{o}F) the critical upper-surface water loss level of 0.2 lb/yd^2/hr. necessary to cause plastic shrinkage cracking will not be reached, as long as there is little to no wind present. It is not until sustained wind speed exceeding 5mph is reached that the critical upper-surface water loss level is exceeded. Furthermore, the nomograph charts show that even in a normal (mild) temperature condition (ambient temperature = 75^{o}F; material temperature = 82^{o}F) can exceed the critical upper-surface water loss level if sustained wind speeds exceed 12mph - 13mph. Therefore, the dominant factor in determining whether a cementitious material may experience abnormal upper-surface water loss resulting in abnormal plastic shrinkage cracking is wind speed.

NPC Technical Bulletin #6 also gives jobsite guidance and considerations to implement during hot weather, which also applies to conditions where sustained wind speed may be a concern, as follows:

- Pre-soak (pre-wet) the substrate to reduce the temperature and the absorptive capacity (substrate should be free of standing water prior to application)
- Ensure that equipment is in good condition and running well (more frequent maintenance) to avoid any downtime or delays during placement

- Increase the number of experienced plasterers to compensate for the limited amount of time to properly pump, place, and finish the material
- Expedite/minimize time of mixing, pumping, and placing to extend finishing time
- Start plastering earlier in the morning, and if possible, avoid the windiest time of day
- Use light-colored pump hoses or lay white (or light-reflecting) tarps over hoses and the cement and sand/aggregate
- Reduce the absorptive capacity of the substrate, and produce a more uniform drying time, by applying a separate pre-plaster coating such as brown coat or a bond coat
- Tent the swimming pool.

The following mix design guidance and considerations also apply:

- Reduce the temperature of the material (use cold water or ice; tarp materials)
- Use a slower setting cement
- Use a pozzolan or other supplementary material (follow manufacturer's recommendation)
- Use a set retardant (follow manufacturer's recommendation)
- Use supplemental (retemper) mix water (increase amount of water to offset water loss from substrate absorption, evaporation, and wind)
- Use water reducers (follow manufacturer's recommendation).

References:

1.) 'Guide to Hot Weather Concreting', ACI 305R, American Concrete Institute, 38800 Country Club Dr., Farmington Hills, MI 48331, www.concrete.org
2.) 'Plastic Shrinkage' (Hot Weather Nomograph), W. Lerch, ACI Journal, *Proceedings*, Vol. 53, No. 8, February 1957, pp 797-802.
3.) 'Design and Control of Concrete Mixtures', Steven Kozmatka, Michelle Wilson, 16th edition, EB001, Portland Cement Association, 5420 Old Orchard Road, Skokie, IL. 60077, www.cement.org

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