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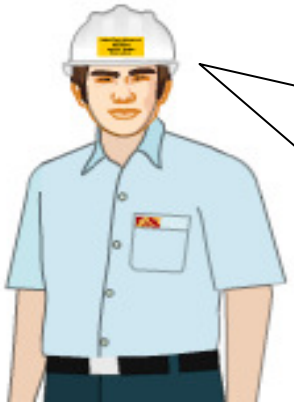
Tech Mailer



Dear Reader,

Welcome to the Technical Mailer from UltraTech Cement Ltd. Every issue carries an article related to Concrete & Construction that we feel would be of value to our clients.

As we move into the warmer period of the year it is appropriate to remind ourselves the responsibility of informing the clientele about the problems associated with Hot Weather Concreting. This issue is all about Concreting in Hot Weather Conditions.

We hope you find the mailer informative and useful. ***Happy Reading!!***

Issue Highlights

- *Hot Weather Concreting*
- *Effects of Hot Weather Conditions*
- *Factors to be considered during Hot Weather Concreting*
- *Precautions to be taken during Concreting in Hot Weather*

Introduction

Hot weather in the context of concreting may be defined as any period of high temperature in which special precautions need to be taken to ensure proper handling, placing, finishing and curing. High temperature, Low relative humidity and High winds are common in arid or tropical climates during summer. Hot weather conditions can produce a rapid rate of evaporation of moisture from the surface of the concrete and accelerated setting time, among other problems[1]. Concrete placed at higher temperatures (above 40°C as per IS Code[2]) exhibits problems during its fresh and hardened state. These will adversely affect the properties of concrete and its durability.

It is important that hot weather be taken into account when planning concrete projects because of the potential effects on fresh and hardened concrete. When the heat rises, maintaining the structural integrity and aesthetic appearance of newly placed concrete members can be a challenge. The adverse affects on various properties of concrete can be mitigated by taking certain precautions.

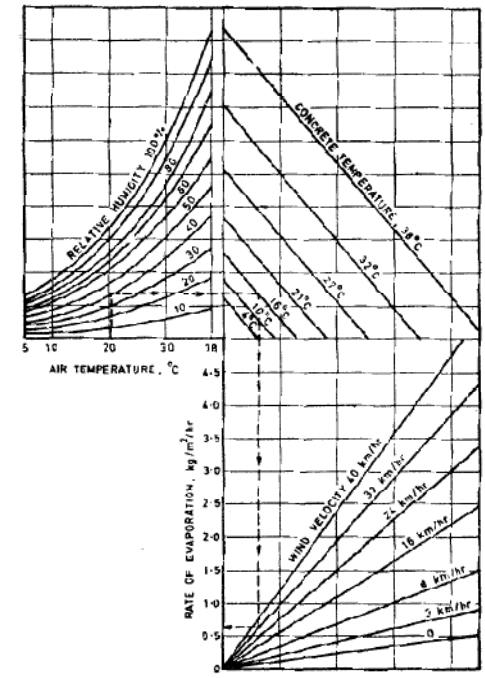
What is Hot Weather Concreting?

Hot weather concreting is defined as any operation of concreting done at atmospheric temperatures above 40°C or any operation of concreting (other than steam curing) where the temperature of concrete at the time of placement is expected to be beyond 40°C.

Effects of Hot Weather on concrete:

The combination of High ambient temperature, Low relative humidity and high wind velocity adversely affects the desirable properties of concrete e.g., strength, impermeability, dimensional stability, resistance to weathering, wear and chemical attack.

Figure below[2] can be used to estimate the possibility of occurrence of plastic shrinkage cracks, and hence determine the need for suitable precautions to be taken. This nomograph is used to combine the effects of air temperature, relative humidity, concrete temperature and wind speed, to estimate the rate at which water will evaporate from the surface of the concrete. As a general rule, if the rate of evaporation is greater than 1 kg of water per square metre of concrete per hour (1kg/m^2/h), then precautions against premature drying and plastic shrinkage cracking should be taken.



Effect of concrete and air temperatures, relative humidity and wind velocity on the rate of evaporation of surface moisture from concrete

Accelerated Setting:

- High temperature increases the rate of setting of the concrete.
- Reduction in concrete handling time.
- Quick stiffening may necessitate undesirable re-tempering by addition of water.
- May lead to formation of cold joints.

Effect on Compressive Strength and Durability:

- Increase in the quantity of mixing water to maintain the workability reduces strength and durability.

- Where water is not added, the reduced setting time and workability increase the potential for inadequate compaction thus reducing strength and durability.
- Concretes mixed, placed and cured at higher temperatures develop early strength but the strength at 28 days or later age is lower.

Increased Tendency to Crack:

- Rapid evaporation of water from surface - not replenished by bleed water, causes plastic shrinkage cracks in the partially hardened concrete.
- Rapid changes in the temperature of the external concrete surface, such as when concrete slabs, walls or pavements are placed on a hot day followed by a cool night, lead to thermal gradients between the warm/hot interior and the colder external surface. The warmer interior provides a restraint to the colder external surface which wants to contract, causing thermal cracks.

Rapid Evaporation of Water during Curing Period:

- Difficulty in retaining moisture for hydration.
- Difficulty in maintaining reasonably uniform temperature conditions during the curing period.

Difficulty in Control of Air Content in Air-Entrained Concrete:

- Difficult to control air content in air-entrained concrete which adds to the difficulty of controlling workability.
- For a given amount of air-entraining agent, hot concrete will entrain less air than concrete at normal temperatures.

Problems during Hot Weather Concreting	
Problems for concrete in the Fresh state	**Problems for concrete in the Hardened state**
• Increased water demand • Increased rate of slump loss • Increased rate of setting • Greater difficulty with handling, compacting & finishing • Greater risk of cold joints • Increased tendency for plastic shrinkage cracking • Increased difficulty in controlling entrained air content	• Decreased 28 day strengths • Increased tendency for drying shrinkage and differential thermal cracking • Decreased durability • Greater variability of surface appearance such as cold joints or colour differences • Increased permeability • Increased potential for reinforcing steel corrosion

Factors to be considered during Hot Weather Concreting:

Control concrete temperature: IS 7861(Part I)[2] requires that concrete temperatures at the time of placing be within 40°C. There are a number of options to control the temperature of concrete, including adjusting the temperature of the ingredients and/or cooling of the concrete mix.

- Because aggregates make up the bulk of the concrete, and also have the highest heat capacity, they have the greatest effect on the temperature of the freshly mixed concrete. Unfortunately the temperature of the aggregates is also the most difficult to control. Some benefit can be gained from shading stockpiles from the sun and/or keeping them moist with sprinklers. Storage in bins (painted white) will also assist.

- The mix water offers the most potential for temperature reduction, particularly by adding crushed ice to it, as the latent heat of the ice is considerably higher than that of water.
- The temperature of the cement does not usually contribute significantly to the temperature of freshly mixed concrete because of its low specific heat and relatively small mass in the mix.
- Liquid nitrogen, injected into the concrete while mixing, may also be utilized (economical only on major projects involving large concrete elements).

Admixtures: Various types of chemical admixtures can be beneficial in hot weather conditions.

- Water reducers (plasticizers) can be used to reduce the water content or to aid the workability. This enables rapid placement and consolidation of the concrete with beneficial effects on the ultimate strength and durability.
- Set-retarders can provide additional time to place and finish flatwork. With rapid drying of the surface, caution is required with the use of set retarders, as the surface may appear ready for finishing, but the concrete below may still be plastic from the retarder, leading to a 'spongy' feel under foot. This could affect the uniformity of the surface finish.

Cement type: Selection of a particular cement type may provide additional benefits. Using slower hydration cements (e.g., Blended Cements) with lower rate of heat development can provide extra time for placing and finishing, reduce the concrete temperature and the risk of thermal cracking upon cooling of the concrete.

Cement content: The temperature increase from hydration of cement in a given concrete is proportional to its cement content. The cement content therefore should be limited to that required to provide strength and durability.

Precautions in Hot Weather conditions:

- **General**: Ensure that site personnel are aware of the effect of weather conditions. Improvised responses to unexpected changes are not recommended.
  The first option to be considered in hot, adverse weather conditions is whether or not to postpone the placement of concrete. It is often better to wait than risk costly repairs (or even replacement) of defective work.

- **Planning**: A successful, well-run, hot-weather project is the result of thorough and careful planning. Planning for hot weather conditions is essential because of the potential effects on fresh/recently placed concrete. The builders and sub-contractors should also be aware/alert to all of the possibilities.

  - Have standby equipment and manpower for all stages.
  - Use the largest size and amount of coarse aggregate compatible with the job. This also helps minimize the tendency of the concrete to crack.
  - In arriving at the slumps of the concrete to be used, consider the effects of hot weather on the ability to place and finish the concrete.
  - Program concreting for the cooler parts of the day, or even schedule night-time placement if possible.
  - Avoid delays at all stages.
  - Plan the locations of construction joints ahead of time with hot weather contingencies in mind.
  - Consider spacing contraction (control) joints at slightly smaller intervals than when concreting at lower temperatures.
  - Use sunshades or windbreaks.
  - Delay construction of indoor slabs on grade until the walls are up and the roof is on.
  - Pay attention to the rate of concrete placement.
  - Keep an evaporative retarder (aliphatic alcohol) on site in case conditions require its use.

- **Concrete Production and delivery by RMC Supplier:** The following methods can be used by the RMC supplier to assist with the placing of concrete in hot weather.

  - Shade stockpiles, sprinkle aggregates ahead of time for evaporative cooling, or cool them by other means.
  - Paint the mixer and storage bins white to minimise absorption of heat from the sun.
  - Use ice as part of the mix water or cool the concrete with liquid nitrogen.
  - Delays in delivery can undo the best mixing practices. The concrete supplier should set up and maintain a good delay-free schedule for delivering the concrete to the required location on the site. Transport time should be minimized and unnecessary delays should be avoided.
  - Prolonged mixing should be avoided. Transit mixer trucks should be discharged as soon as possible after the water has been added to the mix.
  - For large projects, batching and mixing the materials using a job-site plant can be considered.
  - Water should not be added to pre-mixed concrete at the job site unless it is part of the amount required initially for the specified maximum water-cement ratio and the specified slump.

- **Placing and Finishing:** For successful placing and finishing it is necessary to provide an environment in which workers and equipment can function well, and concrete can be adequately protected from rapid warming and/or drying.

  - Schedule placement for the cool time of the day such as early morning or late afternoon. On some jobs, concreting at night (if permitted) may be more advantageous.
  - Have all forms, equipment and workers ready to receive and handle concrete, especially the first delivery.
  - Use sunshades and/or windbreaks.
  - Keep all equipment that touches the concrete cool (chutes, conveyors, pump lines, tremies, reinforcement and buggies). Protecting equipment from the direct sun will assist. If it can't be kept continuously cool, spray cool it as necessary with water.
  - For a slab without a vapour barrier under it, dampen the sub-grade before placing concrete.
  - Use cool water to dampen side forms for slabs or walls.
  - Use a thermometer to monitor the temperature at which concrete is being delivered, and call for adjustments at the plant if necessary.
  - Expect concrete to set more rapidly and have a shorter finishing time.
  - Ensure that slabs have a 'minimum' front to which fresh batches of concrete are added.
  - Perform all operations rapidly, but don't finish slabs prematurely, eg while bleed water is still on the surface.

- **Evaporation Control:** Protect the surface of concrete slabs at all stages against excessive evaporation and premature drying out by covering with white or light colored plastic sheet/thin tarpaulins/burlap. Where available, an evaporative retarder can also be used. By controlling the premature drying out of the surface layer of concrete, the tendency for the concrete to shrink and for plastic shrinkage cracking to occur is reduced or eliminated. These benefits are usually realized with no effect on the cement hydration and/or setting time of the concrete.

- **Curing and Protection:** It is essential that all surfaces be kept continuously moist by curing the concrete, since drying, even intermittently, can produce drying shrinkage and/or crazing type cracking on the concrete surface.

  - Curing should commence immediately after the slab has been finished, and is particularly important during the first day after placement, and in hot or windy conditions.

- Curing methods include ponding with water, use of wet hessian or burlap mats, continuous spray mist, covering with plastic sheeting or sprayed on curing compounds.
- When forms are removed, curing should be provided to the newly exposed surfaces.
- Some means of water curing is advantageous in hot weather as the water also assists in cooling the concrete while it hardens and gains strength. Care is required, however, as the surface needs to be sufficiently hard before water curing can be undertaken without risk of surface damage. This may leave the surface exposed to drying and possible cracking between completion of the finishing and commencement of the curing.
- Note that aliphatic retardants are NOT curing compounds and should not be specified or used as a substitute for them.

References:

1. *ACI 305, "Hot Weather Concreting," ACI Manual of Concrete Practice, Part 2. American Concrete Institute, P.O. Box 19150, Detroit, Michigan 48219.*
2. *IS 7861(Part I) – 1975 (Reaffirmed 1997) - Code of Practice for Extreme Weather Concreting PART 1 Recommended Practice for Hot Weather concreting*
3. *CIP – 12 Hot Weather Concreting – National Ready Mixed Concrete Association, 900 Spring Street, Silver Spring MD 20910*
4. *CCA –Data Sheet - Nov 2004, Cement Concrete & Aggregates, Australia*

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