More Information

The Master Builders Solutions brand brings all of BASF’s expertise together to create chemical solutions for new construction, maintenance, repair and renovation of structures. Master Builders Solutions is built on the experience gained from more than a century in the construction industry.

The know-how and experience of a global community of BASF construction experts form the core of Master Builders Solutions. We combine the right elements from our portfolio to solve your specific construction challenges. We collaborate across areas of expertise and regions and draw on the experience gained from countless construction projects worldwide. We leverage global BASF technologies, as well as our in-depth knowledge of local building needs, to develop innovations that help make you more successful and drive sustainable construction.

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Concrete Technology in Focus

Successful Hot Weather Concreting

Introduction

Hot weather can lead to many problems in mixing, placing, and curing of concrete that can have an adverse effect on its properties and service life. This guide has been developed by BASF to assist the entire construction team (owners, specifiers, contractors, and ready-mixed concrete producers) in the design, production, delivery, placement and curing of quality concrete in hot weather.

ACI Committee 305 defines hot weather as any combination of high ambient temperature, high concrete temperature, low relative humidity, wind speed and solar radiation. The effects of high temperature, solar radiation and low relative humidity on concrete may be more pronounced with increases in wind velocity (see Figure 1), and can lead to rapid evaporation of moisture, which is the primary cause of plastic shrinkage cracks in concrete.

Potential Problems

The potential problems of hot weather can occur at any time of the year in warm tropical or arid climates and generally occur during the summer season in other climates. Problems associated with freshly mixed concrete placed during hot weather conditions include increased:

- Water demand (see Figure 2)
- Rate of slump loss and tendency for retempering
- Rate of setting (see Table 1)
- Difficulty in handling, placing, consolidating and finishing
- Occurrence of plastic shrinkage cracking
- Amount of air-entraining admixture to entrain air
- Need for early curing
- Risk of cold joints

Figure 1. Effect of Concrete and Air Temperatures, Relative Humidity and Wind Speed on the Rate of Surface Moisture Evaporation from Concrete

(Source: ACI 305.1 Specification for Hot Weather Concreting)

If the rate of evaporation approaches 0.2 lb/ft²/h (1 Kg/m²/h), precautions against plastic shrinkage cracking are necessary.

Figure 2. Effect of Concrete Mix Temperature on Water Requirement

(Source: PCA, Design and Control of Concrete Mixtures)

Water content, lb/yd³ (kg/m³)

Concrete temperature, ºF (ºC)

Slump: 3 in. (75 mm)

Max. size agg.: 1-1/2 in. (38 mm)
Table 1. Setting Time of Concrete at Various Temperatures

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Setting Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 °F (38 °C)</td>
<td>1-1/2 hours</td>
</tr>
<tr>
<td>90 °F (32 °C)</td>
<td>2-1/2 hours</td>
</tr>
<tr>
<td>80 °F (27 °C)</td>
<td>4 hours</td>
</tr>
<tr>
<td>70 °F (21 °C)</td>
<td>6 hours</td>
</tr>
<tr>
<td>60 °F (16 °C)</td>
<td>8 hours</td>
</tr>
<tr>
<td>50 °F (10 °C)</td>
<td>11 hours</td>
</tr>
<tr>
<td>40 °F (4 °C)</td>
<td>14 hours</td>
</tr>
</tbody>
</table>

In hardened concrete, hot weather can increase:
- Drying shrinkage and differential thermal cracking
- Permeability
- and decrease:
- Compressive and flexural strengths
- Durability
- Water tightness
- Uniformity of surface appearance

ACI 305R Guide to Hot Weather Concrete, states that "Concrete can be produced in hot weather without maximum limits on placing temperature, and perform satisfactorily when proper precautions are observed in proportioning, production, delivery, placing, consolidating, finishing, and curing. As part of these precautions, an effort should be made to keep the temperature of the fresh concrete as low as practical."

Concrete Temperature Control
Concrete temperature at the time of mixing is influenced by temperature, specific heat and quantity of its ingredients. The approximate temperature of freshly mixed concrete can be calculated from the following equation:

\[ T = \frac{0.22(T_c M_c + T_s M_s + T_a M_a + T_w M_w) + T_{c m} M_{cm}}{M_{c} + M_{s} + M_{a} + M_{w}} \]

where:
- \( T \) = final temperature of the concrete mixture
- \( T_c, T_s, T_a, \) and \( T_w \) = temperature of cement, fine aggregate, coarse aggregate and water, respectively
- \( M_c, M_s, M_a, \) and \( M_w \) = mass of cement, saturated surface-dry fine aggregate, saturated surface-dry coarse aggregate, mixing water, free water on fine aggregate and free water on coarse aggregate, respectively.

The temperature of concrete can be reduced by 1 °F (0.5 °C) by reducing:
- Cement temperature by 8 °F (4 °C)
- Water temperature by 4 °F (2 °C) (see Figure 3)
- Aggregate temperature by 2 °F (1 °C)

Of all concrete-making materials, water is the easiest to cool, and using ice as part of the mixing water will help reduce the concrete temperature. The amount of ice used must be included as part of the mix water and should not be more than approximately 75% of the amount of water required to meet the specified water-cementitious materials ratio. ACI 305R has additional guidelines for the use of ice in concrete. As coarse aggregate is the ingredient with greatest mass in concrete, changes in its temperature have a considerable effect on concrete temperature. The following measures will further help to control concrete temperature at the time of batching or during the hydration process:
- Sprinkling and spraying of aggregates with water
- Shaded storage of aggregates
- Use of liquid nitrogen
- Use of fly ash/v slag cement
- Use of chemical admixtures (MasterSet® R, MasterPolyheed®, MasterSet DELVO, MasterSet DELVO ESC)

Concrete & Ambient Temperatures 90 °F (32 °C)

<table>
<thead>
<tr>
<th>Material</th>
<th>Designation</th>
<th>Dosage</th>
<th>Setting Time Retardation vs. Plain Concrete (h/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MasterSet R 100</td>
<td>B &amp; O</td>
<td>2 (130)</td>
<td>+2.30</td>
</tr>
<tr>
<td>MasterSet DELVO</td>
<td>B &amp; O</td>
<td>2 (130)</td>
<td>+0.45</td>
</tr>
<tr>
<td>MasterSet DELVO ESC</td>
<td>B &amp; O</td>
<td>4 (260)</td>
<td>+2.00</td>
</tr>
</tbody>
</table>

Miscellaneous Products
- Synthetic fibers (MasterSet® M or F® Series) reduce the formation of plastic shrinkage cracks.
- The use of an evaporation reducer (MasterKure® ER 50)† will enhance the quality of the concrete. This monomer-free film:
  - Reduces moisture evaporation
  - Reduces crusting, plastic shrinkage cracks
- Note: MasterKure ER 50 is neither a finishing aid, nor a curing compound for concrete

Curing
Curing is the maintenance of satisfactory moisture content and temperature in concrete during its early stages so that desired properties may develop. The minimum recommended curing period is 7 days (see Figure 4). Inadequate curing can cause plastic shrinkage cracking and impair strength development and durability.

Summary
Hot weather difficulties are mainly caused by high concrete temperatures and rapid evaporation of water from concrete. These conditions adversely affect the quality of concrete since the rate of setting is accelerated, strength is reduced and cracks may occur in either the plastic or hardened state. Curing is more critical and air-enforcement more difficult to attain in hot weather. Field strength specimens are affected in the same manner as the concrete in place. If all precautions and recommended ACI 305R guidelines are followed, successful hot weather concrete can be achieved. BASF has the products and technical expertise to assist the entire construction team (owners, specifiers, contractors, and ready-mixed concrete producers) in the design, production, delivery, placement and curing of quality concrete in hot weather.