SCA SLAG CEMENT ASSOCIATION

Information Sheets

9: Reducing Thermal Stress in Mass Concrete

According to ACI 2071, "Mass concrete is any large volume of concrete with dimensions large enough to require that measures be taken to cope with the generation of heat and attendant volume change to minimize cracking." Cement hydration generates heat. Heat dissipates from concrete slowly; the thicker the section, the longer it will take the interior to cool. This can result in large temperature differentials between the concrete surface and its interior. The concrete is then subject to high thermal stresses, which can result in cracking and loss of structural integrity.

Reducing Thermal Stress

There are three generally accepted strategies for reducing thermal stress in concrete:

- Reduce the total cementitious content.
- Reduce the portland cement content.
- Slow down the hydration process using various admixtures or cooling the concrete.

How Does Slag Cement Help?

When slag cement is incorporated in a concrete mixture, less heat is generated and thermal stress is reduced:

- Portland cement content is reduced by the percentage of slag cement used.
- Due to increased strength with slag cement, the total cementitious content can be reduced.
- Hydration characteristics of slag cement are such that the early rate of heat generation and peak temperature of the concrete are reduced.

Slag Replacement Levels

Generally, 65 to 80% is considered an optimum replacement range for mass concrete applications. These levels typically provide significant heat reduction while achieving desired strengths. Levels from 50 to 65% have been used successfully in smaller mass concrete placements. Mixtures should be tested with job materials to ensure required thermal and strength characteristics.

Figure 1: The I-70 Stan Musial Veterans Memorial Bridge (opened 2014) pylons used 70% slag cement in the mass concrete mix, which also was used in other concrete classes of the structures

Figure 2 shows the effect of slag cement on temperature rise in mass concrete specimens cast in warm and cool weather. The 4.9 ft (1.5 m) cube-shaped concrete specimens were insulated with expanded polystyrene sheets on all but one of the faces. The graphs illustrate a reduction in peak temperature of concrete made using 50 percent slag cement (GGBS) as compared to concrete using all portland cement (OPC). They also indicate a delay in time to peak temperature with use of slag cement. These differences were more pronounced in cool weather as compared to specimens cast in warm weather.

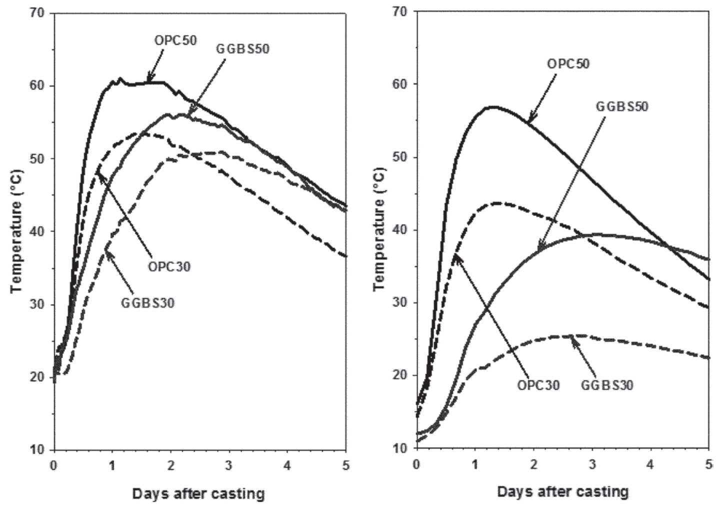

Figure 2: Temperature rise of concrete specimens cast in warm (left) and cool (right) weather with 0 and 50 percent slag cement (adapted from Soutsos et al.3). Note: 30 and 50 refer to the concrete design strengths in MPa (4350 and 7250 psi); degrees Fahrenheit = (degrees Celcius × 1.8) + 32.

References

1. ACI PRC-207.1-21: Mass Concrete—Guide," American Concrete Institute, Farmington Hills, MI, 2021.

2. Photo (Stan Musial Bridge) By Mitchell Schultheis - Own work, CC BY-SA 4.0.

3. Soutsos, M.; Hatzitheodorou, A.; Kwasny, J.; and Kanavaris, F., 2016, "Effect of In Situ Temperature on the Early Age Strength Development of Concretes with Supplementary Cementitious Materials," C*onstruction & Building Materials*, V. 103, pp. 105-116.

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