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ADIABATIC TEMPERATURE RISE OF MASS CONCRETE IN FLORIDA

PROBLEM STATEMENT

Currently, FDOT mandates contractors to provide an analysis of the anticipated thermal developments in mass concrete elements. Contractors typically use Schmidt's method in conjunction with adiabatic temperature rise curves published by ACI 207 Committee for concrete with different cement types and placement temperatures. These curves were developed a few decades ago by testing concrete mixes made with ASTM approved cements. Currently, FDOT specifies AASHTO approved cements, which have different chemical composition and fineness. In addition, ACI 207 curves should be modified for calculating the heat development when pozzolanic materials such as fly ash or slag are used to replace cement.

OBJECTIVES

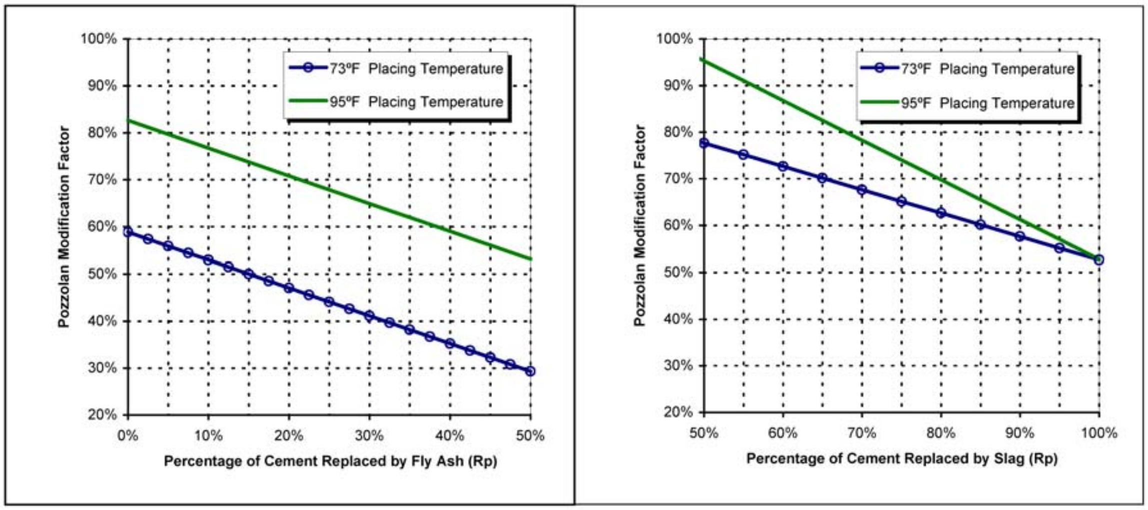
The objective of this project was to develop and recommend a set of adiabatic temperature rise curves for typical mass concretes used in the State of Florida.

FINDINGS AND CONCLUSIONS

Adiabatic temperature-rise tests of concrete made with AASHTO type II cements, pozzolan, and locally available coarse aggregates were performed in the laboratory under conditions that represent those that will occur in the field. A total of 20 mixes with cements from two different sources and various percentages of pozzolanic materials were placed at two different temperatures and tested for adiabatic temperature rise, thermal diffusivity, and compressive strength. The heat of hydration of cement samples and blends of cement and pozzolan were also determined.

The results of this study showed that the reduction of peak temperature due to replacing cement with pozzolan depends on the percentage of pozzolan and concrete placing temperature. For mixes with 73ºF placing temperature, the addition of pozzolan had a larger reducing effect on the peak temperature than those placed at 95ºF. A pozzolan modification factor (α_p) was developed based on the type and percentage of pozzolan in the mix (R_p) and its placing temperature (see figure below). This factor represents the percentage of heat that pozzolan produces compared to the cement that it replaces. It also can be used to calculate equivalent cement content, which is needed to convert the adiabatic temperature rise curve of the base mix (plain cement) into the adiabatic temperature rise curve for a mix with pozzolan.

The average thermal diffusivity for the concrete mixes in this research project was determined to be 0.80 ft^2/day, which is about 35% less than the 1.22 ft^2/day reported in ACI 207. The results also showed that thermal diffusivity of concrete reduces when Portland cement is replaced with high percentage of pozzolans (50% or higher).



Relationship Between α_p and R_p

Comparison between the 28-day compressive strength of concrete samples cured at room temperature and those cured at high temperature (160-190ºF) revealed that high curing temperature reduces compressive strength. For 73ºF placing temperature, this reduction was 20 percent for plain cement concrete. The addition of high percentage of pozzolans reduced the negative effect of high curing temperature on compressive strength.

BENEFITS

The pozzolan modification factor developed and the thermal diffusivity of concrete measured in this study will provide more accurate data that can be used by the FDOT contractors in predicting maximum core temperature of a mass concrete element. Instead of using the rule of thumb suggested by ACI 207 to assume that fly ash produces only about 50 percent (or slag produces 75 percent) as much heat as the cement that it replaces, contractors would have access to more accurate percentages that reflect the type and percentage of pozzolan used and concrete placement temperature. In addition, diffusivity values of typical mass concrete mix designs made with Florida materials will replace the overestimated ACI 207 numbers. A more accurate prediction of anticipated thermal development in the mass concrete element allows the contractor to take the necessary steps in maintaining a temperature differential of maximum 35ºF between the interior and exterior portions of the mass concrete element during curing. Maintaining this differential prevents the formation of thermal cracks, which may cause loss of structural integrity and thus shorten the service life of the concrete element.

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