



Florida Department of Transportation Research

Development of Design Parameters for Mass Concrete
Using Finite Element Analysis
BD545-60

Whenever fresh concrete is used in the construction of large structures, measures must be taken to minimize cracking that may occur due to heat generated as the concrete hardens. Because specifications vary state by state, there is a need to develop a tool to accurately determine temperature and stress development in mass concrete and to predict conditions at which cracking may occur.

Researchers at the Department of Civil and Coastal Engineering, University of Florida have developed a finite element model to analyze the hardening process. They used TNO DIANA software to analyze and model the energy released during mass concrete hydration. First, they analyzed thermal properties of cement and simulated the hydration process to obtain energy and temperature rise using the semi-adiabatic calorimetry test and the isothermal calorimetry. Next, they measured and calculated stresses and strains produced by the thermal gradients in large-scale specimens and computer modeling, respectively, to assess cracking potential.

Researchers produced four different mixes of concrete, typical of mass concrete mixes used in Florida, and made two 3.5x3.5x3.5-foot blocks with each mix. For each mix, researchers applied insulation to all six sides of one block and insulated the other block on all but one side. They placed thermocouples in various locations within the blocks to sense temperature and determine the effectiveness of insulation. Researchers then measured the temperature and strain at predetermined locations until the equilibrium temperature was achieved.

Researchers analyzed insulation amount, mechanical and thermal properties, heat of

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Partially insulated (left) and fully insulated (right) mass concrete block specimens

hydration, and heat capacity. They input the data into the model to determine induced stresses and cracking risk. Researchers determined that heat of hydration energy data obtained from the isothermal calorimetry test should be input into the finite element model to identify the allowable maximum temperatures and stresses that will occur during hydration. They found that adequate insulation should be used in conjunction with formwork material to reduce temperature differentials during the early age hydration of mass concrete to prevent cracking. They also found that to guard against the formation of micro-cracks, a safety factor should be applied to tensile strength values.

Researchers recommend that current restrictions on maximum temperature imposed by state regulating bodies should consider the type of cementitious materials that will be used in the concrete mix. They also recommend that additional research should be conducted on different concrete mixes and larger concrete blocks.