Modelling the temperature distribution in concrete structures

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These problem were presented by the Cement and Concrete Institute (CCI) this year at the First South African Mathematics in Industry Study Group, held at the University of the Witwatersrand, Johannesburg. The problems concern the use of concrete in large construction projects.

Combining cement and water produces an exothermic reaction. The reaction occurs over a long time period (it is believed that the Hoover dam is still cooling down after its construction from 1933-35, see http://www.usbr.gov/lc/hooverdam/History/damfaqs.html – don't believe them when they say it cooled in March 1935, 2 months before it was finished!). Large concrete structures are therefore produced sequentially in discrete blocks to allow cooling and shrinkage to take place before the next block is poured. To reduce the temperature during the early stages (of the order of weeks) a network of pipes will be incorporated into a block. Chilled water is then pumped through.

There are two main problems to be investigated during the week:
1/ Currently, when modelling the temperature evolution of a concrete block, the CCI will assume the temperature of the block surface is the same as the ambient temperature. This has the advantage that ambient temperatures can be easily obtained from the weather bureau.

However, what is the correct boundary condition and does it have a significant effect on the final results?

2/ How does the pipe network affect the temperature of the concrete and how does the concrete affect the temperature of the water in the pipes? What recommendations can be made to improve the heat removal?

If time permits we can also move on to sequential construction *i.e.* the effect of laying a new block on top of a still cooling one; coupling the thermal model with water flow in a porous media with evaporation at the surface *etc*, *etc*.