Discussion

on papers published in the
Magazine of Concrete Research

Volume 35, Number 124 : September 1983

A temperature-matched curing system controlled by microcomputer*

P. J. Wainwright and J. J. A. Tolloczko

Contribution by R. K. Dhir and M. R. Jones

University of Dundee, Department of Civil Engineering

Dr Wainwright and Dr Tolloczko are to be commended for describing a relatively inexpensive but extremely versatile system for both controlling and data-logging the temperature-matched curing of concrete, which for a variety of reasons is assuming an ever-increasing importance⁽¹⁾ as a means of understanding the performance of concrete in a structure.

There are, however, two points which are unclear from the paper. The first is that it is stated on page 166 that the test specimens can be cured both above the water level and below. It would help if the authors would explain how, in the 'above water level position', the curing condition of the test specimens is kept matched to that of the control concrete. The second is that, on page 167, it is stated that the temperature distribution throughout the water in the curing tanks is controlled by regulating the flow rates of heated water via valves. Flow rates are adjusted to the required distribution before an actual measured run. It would appear that the required temperature equilibrium between the control concrete and the curing-tank water could be achieved more simply by having the water input and output positions and a flow rate such that the temperature distribution did not need an adjustment. It would clarify the issue if the authors would state what other alternatives were considered and what advantages the adoption of their method has over others.

We have installed a similar system at Dundee

University in the summer of 1983, closely based on that used at the Cement and Concrete Association. The decision in favour of this system was taken in the autumn of 1982, after examining the various alternatives in consultation with Dr T. A. Harrison, a Principal Research Engineer at the C & C A who had extensive experience in its design and construction. In our system, the proportional-integral-derivative (PID) controller is directly fed with the temperatures of the control concrete and curing-tank water via type T thermocouples. The power need for the heater is then assessed and the two 415 V thyristors operated. An Apple IIe microcomputer is used to record time and temperature at the required interval, which can be varied by programming—say for the first 12 h temperature taken every 15 min, for the next 12 h every 30 min and thereafter every hour, as the temperature gradient flattens. We would like to raise certain points which we think merit consideration in the design and use of this type of system.

(1) The British Standard Draft for Development⁽²⁾ recommends a capability of raising the temperature of the water at a rate of 10°C/h. Our experience has shown that this capacity is required for rich mixes, say with a cement content > 450 kg/m³.

(2) It is normal to bias the heater so that the water lags the control concrete by about 0.3 to 0.5°C⁽³⁾ in order to prevent any leading of the control concrete. Tests carried out by us show that this is readily achieved with the PID type controller, 0.2°C being the closest lag confidently achievable.

*Pages 164 to 169 of *MCR* 124.

(3) The BS Draft⁽²⁾ also suggests that moulds should be covered to allow 'wet curing conditions' and not be completely sealed. This area needs further investigation to see whether a near-adiabatic condition, achievable by sealing the mould with a gasket and bolting on a top plate, or wet curing is the more indicative of an element's curing history. This aspect is presently being studied.

(4) In the choice of microcomputer, an RS 232C address bus may be more advantageous than an IEEE 488 (HPIB). The former has the potential to transmit over much larger distances—certainly 50 m should present no problems in this type of application—whereas the latter ordinarily would require the interface to be no more than 2 m away. In most concrete laboratories and especially on site, remote housing of the computer may be essential. Cabling and peripherals operating the serial line are much less expensive, which helps to keep the cost down even further.

(5) Finally, some consideration must be given to the

microcomputer's tolerances of mains power fluctuations. Whilst complete power failures are comparatively rare events, fluctuations such as power drops are far more common; with tests perhaps running for 5 to 7 days, these events, which can reset the computer, must be taken into account. Complete battery backing is expensive, involving up to a 40% additional cost. However, an on-board auto-boot can automatically load control software after any mains interference or power failure. Thus, together with a battery-backed clock, it can give power failure protection at almost no extra cost.

REFERENCES

1. CONCRETE SOCIETY, THE. Concrete Society scene: Materials Steering Group. *Concrete*. Vol. 17, No. 12. December 1983. pp. 35–37.
2. BRITISH STANDARDS INSTITUTION. *Method for temperature matched curing of concrete*. London, 1984. pp. 4. DD 92 : 1984.
3. HARRISON, T. A. Temperature matched curing. *Civil Engineering*. August 1983. pp. 26–27.

Reply by the authors

We would like to thank Dr Dhir and Mr Jones for their comments and trust that we can clarify the points they mentioned.

With reference to their first point, the equipment described in our paper was designed so that specimens could be cured under various moisture conditions. Although all our work so far has been performed on submerged specimens, the system can be adapted to cure concrete in an unsubmerged state. For the 'above water' curing conditions, we intended that a racking system be built which would allow the control cube and specimens to be placed in the air space between the water and the insulating lids. The water temperature would then be controlled so as to heat the air to follow the temperature of the control cube, thermocouples being located both in the air space and in the water.

With reference to their second point, two curing tanks were used in our system to allow one or both tanks to be used, depending on the number of specimens being cured. Tank No. 2 could be used alone by turning off the flow of water into Tank No. 3.

The amount of water hence needing to be heated would be halved. The reason for regulating flows by a system of valves was purely to achieve a balanced flow of heated water when using both tanks. It was found that, by reducing the flow of water into Tank No. 3, its average temperature lagged behind that of Tank No. 2, i.e. a 'between-tank' temperature variation occurred. It was hence necessary to reduce this variation to a minimum (1.0°C) by regulating water flows.

We also note and agree that some form of 'back-up' power-pack supply would be essential for this type of equipment. This is particularly true if it is to be used under site conditions.

Although our system is capable of producing a maximum temperature rise of only 6°C per hour, it would require a relatively simple modification to increase this to 10°C per hour should the need arise.

With regard to the temperature lag between the water and the concrete, the computer was programmed such that a figure of 0.2°C was achieved.