IIB Module 4M19 Coursework **(RETURN TO MRS EVERETT'S OFFICE)**

Detailed notes for task H1 **Temperature profile of a room, in space and time**

Task (as outlined in main handout on Environmental Measurement)

A battery-powered data logger is available with up to 8 thermistor sensors on long leads and a humidity sensor. Set up the equipment to record the distribution of air (not surface) temperature across two orthogonal cross-sections of the room at a chosen time, preferably when the heating has been in operation for a few hours. In each case, note the main heat sources and sinks, ventilation conditions, no. of occupants, etc. Then set up to do a set of readings over 48 hours.

For the 48 hour reading you may wish to use a larger number of sensors by also setting up the 6 thermistor sensors on long leads, and a humidity sensor provided. These can be placed along and across the room and preferably also outside. Set the logger to take readings at say five-minute intervals over a 48-hour period.

Use these graphs to present and analyse the temperature and humidity history of the room. Present your readings in an appropriate form (preferably graphical); and suggest the causes and significance of any deviations from uniform temperature. Comment on the performance of the instruments.

Accompany the transverse profile thermistor measurements with an investigation of the response of the occupants – and also record humidity and 'globe' temperature. Note the occupants' activity, clothing, air movement, etc. – and compare with published standards. An infrared thermometer is available to measure surface temperature – its calibration may need checking.

Equipment : 1206 logger with 8 thermistors (most leads up to 10 m, some up to 20 m) and a humidity probe. 1256 Squirrel logger with 4 thermistors (leads up to 20 m), 2 thermistors with shorter leads and a humidity probe.
Infrared thermometer, Hand-held temperature and humidity meter, Globe device.

References : New Metric Handbook; Planning and Design Data, Butterworths Architectural, 1999 or 1990 edition.
AT Howarth, Prediction of air temperature variation in naturally-ventilated rooms... Building Services Engg. 6, 1985, 169-175.
CIBSE Guide A: Environmental Design of Buildings. Chartered Institution of Building Services Engineers, 2008.

Detailed suggestions

Concentrate on temperature distribution on two suitable vertical planes, running perpendicular to one another, somewhere in the middle, well away from the entrance doors, perhaps best a section through a radiator. Use one selected occasion, preferably with heating in full operation. Take careful note of heat sources (e.g. computers), ventilation, occupancy levels etc., indeed of anything which may affect the temperature distribution. Outside temperature may be useful as well as humidity at a few locations. One member of the trio could use the hand-held thermometer and concentrate on relating occupants' responses to measured parameters. If there is appreciable heat radiation, measure some 'globe' temperatures.

A telescopic pole and base support is available to hold the thermistors at fixed heights from the floor – so that taking the profile should be fairly rapid. Once it is done, set up the equipment to do a profile over a time period of 48 hours, at several positions – say near ceiling, about mid-height and near floor at your chosen cross-section, and near mid-height

one close to the façade and the other at the opposite wall of the LR5 / LR6. It is suggested that you place one of thermistors with the 20 m lead outside by threading the lead through a window. In doing so you should minimize the convective heat transfer through the open window and preferably locate the thermistor as far away from the window as possible and protected from solar radiation. Try to keep the Squirrel data-logger and its leads to one side of the lecture room, so as not to interfere with the occupants. It may be possible to run leads along the floor as long as these are covered with the high visibility mats provided to alert occupants to trip hazards. Readings could be taken automatically, say every 10 minutes.

Equipment : data logger

1206 logger with 8 thermistors (most leads up to 10 m, some up to 20 m) and a humidity probe. 1256 Squirrel logger with 4 thermistors (leads up to 20 m), 2 thermistors with shorter leads and a humidity probe.

(a) Read the instruction manual carefully. The display appears on pressing the left red button A. The instrument has been set to record temperature (using thermistors) on channels 1 to 8, and humidity on channels 15 and 16 (though at first sight the humidity readings may seem unreliable). Channels 13 and 14 give temperature readings at the humidity probes, which incorporate thermistors.

(b) You can monitor channel readings by pressing left button A to get 2 on left, then middle button B to select channel. One way to do the first part would be to use the Squirrel as a meter with a short-term memory, not as a logger which dumps to computer. Use the device with the interval at 3 minutes (as preset). Take a single scan of up to 10 channel readings using function 1.3 (start then stop within 3 minutes). The single set of readings stored in the machine can then be displayed using 3.2 as described on p.10 of the Manual, and taken down in your laboratory book. An alternative, if conditions in the room seem fairly stable, would be to read each channel in turn, sweeping across channels using function 2 and the middle red button.

(c) You are to record air rather than surface temperatures, and will need some means of placing the thermistors at desired positions. A vertical telescopic pole which is moved across the room is provided, but beware of changes in ceiling level. Aim to take some readings quite close to (say within 50 mm of) the floor and ceiling. Try to arrange that the thermistors are held well away from the operator, and the operator's hand is well away from a thermistor so that the readings are not disturbed.

(d) Decide beforehand how long to wait for readings to settle reasonably – you need to take readings as quickly as possible, lest the temperature profile change. The probes (especially the humidity ones) should be checked against each other and against a reliable standard (if possible), and readings adjusted if necessary by simple addition or subtraction to combat any discrepancy.

(e) For the profile over time channels on the data logger are set using function 5. You set the recording interval using function 8, and start recording using function 1.3. Try a test run for a short period, before beginning the main run. Attach a 'Do Not Touch' notice, and return to stop recording about 48 hours later.

You should transfer the data straight away – the next group using the logger may corrupt or erase your readings. Leave the thermistors in place (in case you need to take further readings) and take the logger to Mr. Touhey (Structures Lab) who will download the data and email it to you. Once you have received your data from Mr Touhey and you have ascertained that it is complete, remove the thermistors form the room and return them to Mr. Touhey. There may be other groups using the equipment each week – so please be considerate.

Other equipment

The ST 507 digital thermometer (with probe) comes with an instruction card, and is very straightforward to use. We have an arrangement for measuring the temperature within a small black body – the 'globe temperature' – affected by radiation as well as air temperature. On a sunny day near a window you might find that the globe and air temperatures are different.

There is also a Testo handheld temperature and humidity meter which you may use for spot readings if required.

Temperature records on the roof of the Computer Lab Building located at the West Cambridge site are available on http://www.cl.cam.ac.uk/research/dtg/weather/.

Write-up

You may find the MATLAB software on the DPO computers useful for displaying results on a cross-section of the room, drawing contours automatically etc. It is important to distill the large number of readings down to something easily comprehensible. These will be a particularly useful basis for making your (brief) recommendations on how to improve the performance of the space.

You could present such contoured plots – giving a snapshot of the temperature distribution at one moment – for two or three different occasions in LR5 / LR6, and discuss how they compare with Howarth's predictions, the main features of the plot (max. temperature variation) etc. Comment on the absolute magnitude of any temperature differences noted (since it is difficult to talk sensibly about percentages or ratios). Are these differences significant for subjective response of the occupants?

The Environmental Data Sheet gives information on a proposed 'Corrected Effective Temperature' dependent on globe temperature, air speed, and wet bulb temperature (related to humidity via the psychrometric chart). Does this CET fit reasonably with occupants' responses in the lecture room?

References

(a) New Metric Handbook – pages 384-397 enclosed (especially p.388-9) (folio AH32 in CUED Library).

(b) The prediction of air temperature variations.... A.T. Howarth 1985 (especially Figs 1, 2, 4 and 7) – copy enclosed.

(c) CIBSE Guide A: Environmental Design of Buildings. Chartered Institution of Building Services Engineers, 2008.