IIB Module 4M19 Coursework (RETURN TO 4M19 CUPBOARD)

Detailed notes for task V1 Air velocity around room and occupants

Task (as outlined in main handout on Environmental Measurement)

One blower door kit, one hot-wire and one rotating-fan anemometer are available. The anemometers must first be calibrated (typical speeds less than 1 m/s) by a timed walk in still air over a measured distance (or in some other way you can invent). Means of determining the direction of air flow will also be needed. First use the anemometers to make a rapid survey of air movement in the lecture room. Identify any significant inflows and outflows (e.g. with different combinations of windows and doors open. Attempt to estimate the number of air changes per hour. Then concentrate on a chosen detail – air movement near a window, or near a hot radiator etc. Identify any differences in air velocity with height (e.g. measuring air velocities at ankle height and head height) and note the occupant response. Record your results in appropriate diagrams.
Use the blower door kit to perform the airtightness test at a range of pressures. Plot the pressure difference *vs.* the flow rate on a logarithmic scale and from this obtain values of the flow coefficient and the flow exponent that are particular to the room under test. It will then be possible to quantify Q_{50} (the air flow rate in m^3/h through each m^2 of building fabric at 50Pa) and n_{50} (the number of air changes via the building fabric per hour). Compare airchange measurements with published standards on ventilation. Note that the blower door test will be performed with the demonstrator Miss Alessandra Luna-Navarro (al786@cam.ac.uk), who will be in touch to make the necessary arrangements. Comment on the causes and significance of any noteworthy observations, and on the performance and suitability of the instruments.

Equipment : 1 blower door kit (used under supervision), 1 thermal anemometer, one rotating-fan anemometer, 1 infrared thermometer, 1 handheld temperature and humidity meter (if required).

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

First concentrate on the performance and calibration of the anemometers at low air speeds (< 1.0 m/s, possibly as low as 0.1m/s). Then investigate the broad pattern of air flow in the lecture room during the observation period chosen – through doors, open windows, draughts around ‘closed’ windows etc. What is the ventilation strategy for the lecture room – where does air come in and go out, and which source is fresh? Measure representative velocities, and the direction of flow, and estimate areas. The aim here is to identify all the major contributions to air change in the room, and estimate the number of changes per hour due to each. Averaged over time, the net inflow should of course be zero. (Air changes due to inflow from other parts of the building – e.g. the Baker Building Staircase – will naturally be less valuable than ventilation than fresh air through windows.) You should briefly investigate occupants’ views about the amount of ventilation – and compare with the guidelines given in the New Metric Handbook, CIBSE Guide A etc. You should first attempt this with the doors and windows closed and comment in the suitability of the equipment.

You should follow this with air flow measurements with appropriate combinations of windows / door opened or closed.Then concentrate on some particular flow pattern, e.g. near an open window or above a radiator or other heat source. Determine flow velocities in broad outline, and compare the pattern with those given by Howarth or elsewhere.

Use results from the airtightness test using the door blower test. The blower-door kit is used to either pressurise or depressurise the room with the aim of measuring the fan speed required to maintain a pressure difference (Δp) of 50 Pa between indoors and outdoors. The test is intended to measure the air-tightness of the building envelope, therefore all windows should be shut but not sealed and all inlets / outlets that are not located in the building envelope should be sealed. The measured air flow rates and pressure differentials are related by equation 1.

$q_v = C(\Delta p)^n$ (1)

Where q_v is the volumetric flow rate through the opening ($m^3 s^{-1}$), C is the flow coefficient ($m^3 s^{-1} Pa^{-n}$), · p is the pressure difference across the opening (Pa), and n is the flow exponent (varying from 0.5 for fully turbulent flow to 1.0 from laminar flow). C and n are room characteristics and can be determined from the experimental data.
To achieve accuracy in the airtightness test results, perform the door blower test to at a range of room pressures and record the flow rate required to maintain these pressures. Plot · p *vs.* q_v on a logarithmic scale and find the line of best fit (whilst reporting the goodness of fit). From this determine the flow coefficient C and the flow exponent n from:

$\ln q_v = \ln C + n\ln(\cdot \;\cdot)$ (2)

From your line of best fit, calculate the volumetric flow rate of air passing through each m^2 of the building fabric per hour at 50Pa (q_{50}) and the number of air changes per hour (N_{50}). Compare these values to recommended values for air-tightness and establish whether this is classified as a leaky or air-tight building.

Use the appropriate airtightness correction factor (CIBSE Guide A) to estimate the annual average ventilation in air changes per hour to the expected value during the normal operation of the building. Note this correction factor converts the test conditions of 50 Pa to the real-world conditions. Compare this to the air change estimates made with the anemometers and comment on whether the air change per hour satisfy ventilation requirements.

Equipment

Portable thermal anemometer TA2-15 (also hand-held digital thermometer ST 507 with probe, if required). A second anemometer will be available, and is thought more reliable at low air speeds.

Read the instruction manual for the anemometers carefully. It is up to you to invent a reasonable way of checking calibration at velocities of order 0.3 to 1.0 m/s (or over the range which later proves useful – some velocities in the LR5 / LR6 are very low). A timed steady walk in otherwise still air, keeping the reading constant, might be a possibility, but note how your calibration was done.

When using the anemometer, note direction and sense of flow (into or out of the room) as well as speed. Direction can be found by rotating the sensor to give maximum response. You may need to invent some means of being certain also of the sense of flow – sometimes obvious, but for low velocities not always so.

When considering inflows and outflows, strictly it is the net mass inflow which should be zero on average over time – but the small differences in air densities can be neglected in this case. A greater source of inaccuracy will be caused by occupant, opening and closing of doors, and consequent variations over the time you take the readings. Also, when converting airspeed to volume flow rate through an opening, try to arrive at some effective

area for the opening, rather than just use the total area.
If you consider the air flow near a radiator or a window, it may be worthwhile to measure the air temperature at a few places, as well as its velocity pattern. Since the anemometer is less accurate at low flow velocities, it would be worthwhile to find a flow pattern with some fairly high speeds (say 1 m/s), even if it is not in the lecture room. Some of the older style radiators in the other parts of the Inglis and Baker building are appropriate for this.

References
(a) New Metric Handbook; Planning and Design Data, Butterworths Architectural (pp.384-397 enclosed – see especially p. 384-7). (Folio AH32 in CUED Library.)
(b) CIBSE Guide A: Environmental Design of Buildings. Chartered Institution of Building Services Engineers, 2008.
(c) AT Howarth, Prediction of air temperature variation