UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For the following qualifications :-

M.Sc.

ESGE5: Natural and Mechanical Ventilation in Buildings

COURSE CODE	:	**ENVSGE05**
DATE	:	**20-MAY-02**
TIME	:	**14.30**
TIME ALLOWED	:	**2 hours**

02-C0447-3-40

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UNIVERSITY OF LONDON

MSc DEGREE in SCIENCE in BUILT ENVIRONMENT 2002

for Internal Students of University College London

Module ENVS GE 05: NATURAL AND MECHANICAL VENTILATION IN BUILDINGS

Answer TWO questions only. Answer all parts of the questions chosen.

1. (a) Explain the meaning of thermal mass in the context of buildings, giving examples of low, medium and high thermal mass construction? Discuss the benefits and drawbacks of high thermal mass buildings? *(15 marks)*

   (b) Describe the main factors which lead to overheating in buildings in summer. *(5 marks)*

   (c) Describe the factors in the ***design*** of naturally ventilated buildings which can alleviate overheating in summer? *(5 marks)*

   (d) Describe the factors in the ***operation*** of naturally ventilated buildings which can alleviate overheating in summer? *(5 marks)*

   (e) Taking a naturally ventilated or mixed mode building you know well, or have studied in detail, describe the methods adopted in the design to control summertime overheating. Highlight where the strategy has been particularly successful, or unsuccessful, pointing to any lessons that can be learnt for future designs. *(20 marks)*

2. An architect, designing a naturally ventilated office building with sash windows, wishes to ensure that on calm summer days there will be sufficient natural ventilation, provided by the stack effect, to restrict the internal temperature to no greater than 2°C above the external. The design of the windows allows them to open 0.5 m at the top and 0.5 m at the bottom, with a separation between the mid-points of the openings of 1.5 m and with the full height of the windows being 2.0 m. No decision as yet has been made on the total area of the windows, however, the floor to ceiling height has been fixed at 3.5 m.

   (a) Assuming that computer simulations have shown that the maximum total heat gains are moderate at 40 W/m^2, what would be the required air change rate per hour to maintain the desired temperature difference of 2 K? It can be assumed that the density of air is 1.19 kg/m^3 and the specific heat capacity of air is 1026 J/kgK. If this air change rate is provided in an office with floor dimensions of 24 × 12 m, what would be the volumetric flow rate of air in m^3/s? *(10 marks)*

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(b) Using this air flow rate and the following equation, where the symbols have their usual meaning,

$$Q = C_d A \left(\frac{2\Delta t h g}{\left(\bar{t} + 273 \right)} \right)^{0.5}$$

calculate the equivalent window opening area, A, in m^2, necessary to provide this rate of ventilation. It can be assumed that the discharge coefficient is 0.61 and the outdoor temperature is 26°C. (*5 marks*)

(c) The architect has designed the building to be narrow in plan with windows of equal dimensions on opposite sides of an open plan area. There are no windows in the side walls. Using the equivalent opening area calculated above, estimate the total area of window (including both opening and non-opening parts) required on each wall of the office. (*10 marks*)

(d) Calculate the percentage glazing of the external walls, considered from inside the building? (*5 marks*)

(e) Assuming the building is occupied with 1 person for every 8 m^2, comment on the adequacy of the fresh air ventilation in terms of the likely air quality in the offices on calm summer days. (*10 marks*)

(f) If indeed the building were ultimately designed with this amount of glazing, comment on the potential problems it may have in terms of its environmental comfort in summer. (*10 marks*)

3. It has been decided that a small office building will have a mechanical ventilation system to provide background ventilation and warm air heating in winter, and to assist night ventilation and air movement during the day in summer.

(a) If the building has a total floor area of 1000 m^2 and an occupant density of 1 person per 10 m^2, what fresh air ventilation rate would you recommend for winter? If the floor to ceiling height is 3.5 m, to what air change rate per hour is this equivalent? (*5 marks*)

(b) For night ventilation in summer, it has been determined that a suitable rate should be 8 air changes per hour. It is also believed that this will provide some air movement through the offices on calm days in summer. If the total pressure loss (fan total pressure) in the ductwork system amounts to 325 Pa, what fan power is required to operate the system, assuming the fan to be 75% efficient? (*5 marks*)

(c) For daytime fresh air ventilation and heating in winter, it has been determined that a suitable rate should be 4 air changes per hour, and a two speed fan is to be selected. If the total pressure loss, at this lower air change rate, now amounts to 250 Pa, what fan power is required to operate the system, assuming again a 75% efficient fan? (*5 marks*)

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(d) Describe the processes, which "use up" the "total pressure" in this ductwork system, and how this total pressure loss might be estimated. *(10 marks)*

(e) The architect is dissatisfied with the appearance of the ductwork, and wants to reduce its diameter: the client, however, wants a system which does not use energy wastefully. Explain why reducing the size of the ductwork will increase the energy consumption and running costs of the system. What other problems might arise from reducing the size of the ductwork? Briefly explain any benefits. *(10 marks)*

(f) If the ventilation and heating system runs at 4 changes per hour from 8:00 am until 6:00 pm, five days a week, from the beginning of October to the end of May (35 weeks, say), and at 8 air changes per hour continuously for the rest of the year, and if electricity costs 7 pence per kWh, what will be the approximate annual cost of electricity for the fan? *(5 marks)*

(g) If the fan has been selected to rotate at 8 Hz (cycles per second) when it provides 4 air changes per hour, at what speed would it need to rotate to drive 8 air changes per hour through the ductwork system? *(5 marks)*

(h) Comment on the benefits and drawbacks of the strategy of providing year round mechanical ventilation as a way of maintaining good thermal and air quality conditions in buildings. *(5 marks)*

4. (a) The supply diffusers of cool air in an air conditioned office are to be positioned in a suspended ceiling, flush with its underside. They are to be designed to give effective mixing of the supply air with the room air. Explain the benefits and drawbacks of this type of air conditioning supply arrangement. *(5 marks)*

(b) Explain the role of the Coanda Effect in this context. *(5 marks)*

(c) The air conditioning engineer has been asked to select and lay out the supply diffusers on the suspended ceiling plan. What information would the engineer need to carry out this work and how would the engineer go about deciding the number and position of the diffusers? *(10 marks)*

(d) Explain the consequences for thermal comfort and air quality in the office if i) the "throw", ii) the size and iii) the position of the supply diffusers is wrong for the application? *(15 marks)*

(e) The extract air is to be taken out of the offices through the lighting fittings, which are also mounted in the suspended ceiling. Explain what effect this has on the lamps in the lighting fittings, and what the consequences are for the energy consumed by the lighting and air conditioning overall in the building. What potential problems for air distribution and air quality might this arrangement have? *(10 marks)*

(f) If the air extract points are to be positioned elsewhere, where would you **AVOID** locating them? Why? *(5 marks)*

END OF PAPER