

National Exams December 2010

07-Bld-B5, Fire and Smoke Control in Buildings

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an OPEN BOOK EXAM.
Any non-communicating calculator is permitted.
3. FIVE (5) questions constitute a complete exam paper.
4. Each question is of equal value.
5. Most questions require an answer in essay format. Clarity and organization of the answer are important.

Question 1 (20 marks)

Give scientific explanation for five of the following concepts or terms (each is of 4 marks). If more than five questions are answered, the first five answers as they appear in the answer book will be marked.

- (1.a) Fire triangle
- (1.b) OBC
- (1.c) Ventilation controlled fire
- (1.d) Fuel controlled fire
- (1.e) HRR (Heat Release Rate)
- (1.f) FRR (Fire Resistance Rating)
- (1.g) NPP (Neutral Pressure Plane)
- (1.h) Smoke Reservoir
- (1.i) Request Egress Time
- (1.j) Fire separator

Question 2 (20 marks)

Pressurization and depressurization are two active strategies commonly employed to control the spread of fire and smoke in buildings. Draw diagrams to illustrate how they work. Explain the theory, system structure and major equipments, and typical applications.

- (2.a) Pressurization (10 marks)
- (2.b) Depressurization (10 marks)

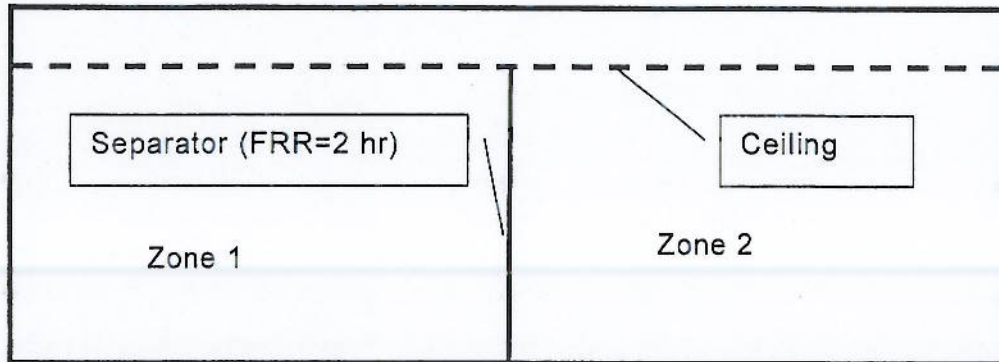
Question 3 (20 marks)

Four questions about sprinkler systems:

- (3.a) Based on the principle of Fire Triangle, explain how a sprinkler system works (5 marks).
- (3.b) Draw a diagram to illustrate the structure of a dry sprinkler system. Explain how a dry sprinkler system works (5 marks).
- (3.c) Draw a diagram to illustrate the structure of a wet sprinkler system. Explain how a wet sprinkler system works (5 marks).
- (3.d) Explain two adverse impacts that a sprinkler system may develop on the fire safety of buildings (5 marks).

Question 4 (20 marks)

Big buildings are normally designed to contain a number of zones that are separated by fire resistive structure assemblies. Figure below shows two zones in one building that are separated by an assembly with FRR of 2 hours.



- (4.a) Explain what is wrong with the figure and how the problem should be fixed (5 marks)
- (4.b) If fire is started from Zone 1, explain the procedure of fire development in the building (7 marks). In your explanation, you should use appropriate terminology.
- (4.c) Draw diagrams to illustrate how you understand the following section of OBC (8 marks)

[The following is from OBC 2006]

3.1.10.3. Continuity of Firewalls

(1) [Ignored]

(2) A firewall is permitted to terminate on the underside of a reinforced concrete roof slab provided,

(a) the roof slab on both sides of the firewall has a fire-resistance rating not less than,

(i) 1 h if the firewall is required to have a fire-resistance rating not less than 2 h, or

(ii) 2 h if the firewall is required to have a fire-resistance rating not less than 4 h, and

(b) there are no concealed spaces within the roof slab in that portion immediately above the firewall.

Question 5 (20 marks)

There are two calculation questions. Please show step-by-step procedure.

(5.a) Fire growth (10 marks)

Assume that the occurrence of fire should be detected before the fire size reaches 100 kW in order to safely evacuate the building and to effectively attack the fire. For a fire described as follows, what is the time (counted from the moment when the fire is started) available for the fire detection system to react?

It takes 40 seconds for the fire to develop from 0 kW to 4 kW. Assume the fire growth is governed by the T-Square Law:

$$Q = q_0 \tau^2$$

where: Q = fire size measured in kW, q_0 is a constant that reflects the rate of fire growth (kW/s^2), τ is time counting from the moment when the fire is started (second)

(5.b) Smoke control (10 marks)

A fire is burning on the floor of a large room that has a ceiling height (ceiling to floor) of 6 meters. It is known that the convective heat release rate from the fire is 5MW. A ventilation system is used to control the height of the smoke layer underneath the ceiling. What is the mass flow rate of smoke removed by the ventilation system and the temperature of the smoke when the height of the smoke layer is controlled at 1.5 meter? How will the height and temperature of the smoke layer change if the ventilation system is operated at a lower speed? Ambient Temperature is 20 °C.

Hint:

$$m_f = 0.071 \cdot Q_c^{1/3} \cdot Y^{5/3} \cdot [1 + 0.026 \cdot Q_c^{2/3} \cdot Y^{-5/3}]$$

$$T_f = T_0 + \frac{Q_c}{m_f c}$$

Where:

m_f = mass flow rate of smoke (kg/s)

Q_c = convective heat release rate from the fire: kW

Y = ceiling height – height of smoke layer (m)

T_f = temperature of the smoke layer (°C)

T_0 = Ambient temperature (°C)

C = specific heat of smoke (kJ/kg.°C)