PRACTICE *of* Professional Engineering Examination 2025

Information for Applicants

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Professional Engineers Registration Examination
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1 INTRODUCTION

The mission of the Professional Engineers Board is to safeguard life, property, and welfare of the public by setting and maintaining high standards for registering professional engineers and by regulating and advancing the practice of professional engineering.

The Professional Engineers Board registers professional engineers in the branches of civil, electrical, mechanical and chemical engineering. A person applying for registration as a professional engineer to the Professional Engineers Board is required to hold an approved degree or qualification listed in the Professional Engineers (Approved Qualifications) Notification and acquired not less than 4 years of relevant practical experience. He is also required to sit and pass examinations prescribed by the Board. In addition, the applicant is required to attend an interview.

The following sections set out the requirements and details for the Practice of Professional Engineering Examination 2025 while details on other application requirements are available on the PEB website at www.peb.gov.sg.

2 DESCRIPTION OF EXAMINATION

The Practice of Professional Engineering Examination tests the applicant's ability to apply his knowledge and experience in professional engineering practice, and his knowledge of the rules and regulations regulating the practice of professional engineering in civil, electrical, mechanical or chemical engineering.

3 ELIGIBILITY TO SIT FOR EXAMINATION

A person may apply to sit for the Practice of Professional Engineering Examination after he has-

(a) obtained not less than 2 years 6 months of practical experience in engineering work relevant to the branch of engineering that he seeks to be registered in; and

(b) sat for and passed the Fundamentals of Engineering Examination.

4 FEES

The fee for an application to sit for the Practice of Professional Engineering Examination is $450.

5 DATE OF EXAMINATION

The dates for the Practice of Professional of Engineering Examination 2025 are:

a) Chemical Engineering – 10 September 2025
b) Civil Engineering – 10 September 2025
c) Electrical Engineering – 10 September 2025
d) Mechanical Engineering – 10 September 2025

6 VENUE

The venue would be determined by PEB and successful applicants would be informed of the details of the venue.

7 APPLICATION

Application and payment shall be made online at PEB's website by 20 June 2025. Refer to the Application Guide for submission of application. Applicants are advised to send in their applications early to allow time for processing.

8 STRUCTURE OF EXAMINATION

A summary of the structure of the Practice of Professional Engineering Examination 2025 is shown in the table below. The examination is 'open book' and further details are given in **Annex A: Format, Syllabus and Sample Questions.**

Subjects	Time Allocated	Format
PPE Part 1 Common paper	2 hours 10 mins	• Answer 10 compulsory Multiple Choice Questions • Answer 3 out of 5 essay questions
PPE Part 2 Civil/mechanical/ electrical/chemical engineering	4 hours 10 mins	• Answer 1 compulsory question plus 4 out of 7 questions

(Note: For PPE 2025 Part 2 Civil, only answers based on Eurocodes will be accepted. Answers based on Singapore/British Standards will not be accepted.)

9 PASSING REQUIREMENTS, FINAL RESULTS AND NOTIFICATION

(a) A candidate is required to take both Parts 1 and 2 when he sits for the examination unless he qualifies for an exemption as described in (b) below. Examination results will be given to candidates on a Pass/Fail basis and no scores or marks will be given to candidates. To obtain a 'Pass' in the examination, a candidate is required to obtain a pass score in both Parts 1 and 2 respectively.

(b) A candidate who has taken both parts when he sits for the examination and obtains a pass score in only one of the two parts is deemed to have failed the examination. However, if he sits for the examination again, he would be granted an exemption from the part for which he has obtained a pass score. This exemption shall be granted provided the candidate sits for the examination again within a 3-year period from the date of result. With the exemption, he would only need to take the part of the examination for which he did not obtain a pass score. No exemption shall be granted if he sits for the examination again after the exemption period, in which case he is required to take both Parts 1 and 2.

(c) Examination results will be mailed to the candidates around mid-December 2025.

10 EXAMINATION APPEALS

A candidate who has failed the examination may submit a written appeal in hard copy to request a review of his/her performance. The appeal is to be received by PEB within **2 weeks after the date of results notification letter** and late appeals would not be considered. The result of the appeal/review will be sent by written mail to the appeal candidate. The appeal candidate would not be able to review his examination paper.

11 REVIEW COURSES

The Board does not endorse any review course or material provided as study aids.

12 NO REFUND OF FEES FOR ACCEPTED CANDIDATES

The application fee for the examination is non-refundable for candidates who have been accepted to sit for the examination.

13 REQUEST FOR ACCOMODATION

A candidate who has disabilities may submit a written request for accommodation. The request is to be received by PEB not later than 6 weeks before the date of examination and late request would not be considered. PEB's decision will be conveyed to the applicant by written mail not later than one week before the examination date.

Annex A: FORMAT, SYLLABUS AND SAMPLE QUESTIONS

I Practice of Professional Engineering Examination Part 1 (Common)

Professional conduct and ethics are important areas because most of the disciplinary actions taken by the Professional Engineers Board are in the area of ethics and not technical matters. Professionalism and ethics are closely related and inseparably bound as professional status and recognition are based on public interest. A professional engineer's judgment and decisions can have great impact on public health and safety. He is expected to uphold the dignity, standing and reputation of the profession. He shall practise ethically in relation to his clients, employers, fellow professionals and the public at large.

Format

This is a common paper which has two sections on the Professional Engineers Act and Professional Conduct and Ethics. The paper comprises 10 multiple choice questions (MCQs) and 5 essay type questions based on hypothetical case studies. The candidates must answer all the 10 compulsory MCQs (25 marks) and can choose to answer any 3 out of the 5 essay questions (75 marks) during the 2 hours 10 mins examination period.

Syllabus

The paper will focus on the latest revisions of the following Professional Engineers Act and Rules:

- Professional Engineers Act
- Professional Engineers (Code of Professional Conduct and Ethics) Rules
- Professional Engineers Rules

References will also be made to past disciplinary actions taken by the Professional Engineers Board arising from complaints against professional engineers.

Questions will be set to test the candidates' understanding and interpretation of the provisions in the act and rules as well as how they will tackle hypothetical cases involving the clients, the employers, fellow professionals and the public at large.

Sample Questions From Past Year Papers for Practice of Professional Engineering Examination Part 1 (Common)

Section A - Answer 10 Multiple Choice Questions – each at 2.5 marks (COMPULSORY)

1 Under what circumstances shall a professional engineer advise the client to engage the services of experts and specialists?

(a) The professional engineer shall give the advice when in his opinion and judgment such services are in the interest of his client.
(b) The professional engineer shall give the advice when he feels such services will pass the responsibility to others.
(c) The professional engineer shall give the advice when he can indirectly benefit from the appointment of experts and specialists.
(d) The professional engineer shall give the advice when he considers that in doing so the cost input of his company will be reduced.

2 A professional engineer may publicise his practice. However, in doing so, the professional engineer shall ensure that the publicity —

(a) contains information that is related to all the projects undertaken by him or his company but without the consent of the clients.
(b) contains only information beneficial to his business even though it is likely to diminish public confidence in the engineering profession or to otherwise bring the profession into disrepute.
(c) contains only justifiable claims to expertise or specialization; makes no reference to past project information which constitutes a breach of confidentiality to the client; and does not compare or criticise the quality of services provided by any other professional engineer or allied professional.
(d) contains information with material facts even if it may create an unjustified expectation about the results that can be achieved by him.

3 Engineer A provides design, plans and specifications for a commercial building to Developer P who submits them to the authority for approval but fails to pay Engineer A for the work performed. Thereafter, Developer P asks Engineer B to review, endorse and resubmit the plans to the authority for approval. Shall Engineer B agree to undertake the project?

(a) Engineer B shall not agree to undertake the project as he has an ethical obligation to recognise and give credit to the creative works of other engineers.
(b) Engineer B shall agree to undertake the project as long as Engineer A does not complain.
(c) Engineer B shall agree to undertake the project as Engineer A does not know.

(d) Engineer B shall agree to undertake the project as he is employed by the Developer.

4 Engineer C comes from overseas and is not a registered professional engineer in Singapore. If he uses the abbreviation "Er." or "Engr" as a title before his name in Singapore, he is guilty of an offence and will be liable on conviction to —

(a) a fine not exceeding $2,000 and, in the case of a second or subsequent offence, to a fine not exceeding $5,000.
(b) a fine not exceeding $10,000 or to imprisonment for a term not exceeding 6 months or to both.
(c) a fine not exceeding $5,000 and, in the case of a second or subsequent offence, to a fine not exceeding $10,000 or to imprisonment for a term not exceeding 6 months or to both.
(d) a fine not exceeding $10,000 and, in the case of a second or subsequent offence, to a fine not exceeding $20,000.

5 Engineer D is a Professional Engineer specialising in structural engineering design and has just inherited a plot of land from his uncle. He plans to build 6 units of terrace houses on the plot of land and engages an architect to proceed with the design. He intends to play the role of structural engineer himself. Is it in order for Engineer D to provide structural design for his own housing project?

(a) It is in order for Engineer D to provide structural design for the project since he is a qualified structural PE.
(b) It is in order for Engineer D to provide structural design for the project since he can save cost.
(c) It is not in order for Engineer D to provide structural design for the project since other structural engineers will be deprived a chance to get involved.
(d) It is not in order for Engineer D to provide structural design for the project since he is acting as a housing developer as well.

6 Which one of the following categories of engineer is not permitted to supply or offer to supply professional engineering services in Singapore?

(a) A registered professional engineer who has in force a practising certificate authorising him to engage in such profession engineering work.

(b) An engineer under the direction or supervision of a registered professional engineer who has in force a practising certificate.

(c) An engineer authorised by the Professional Engineers Board to work in collaboration with a registered professional engineer who has in force a practising certificate.

(d) Just any registered professional engineer.

7 When the Investigation Committee appointed by the PE Board to investigate a complaint against a registered professional engineer finds that the complaint to be valid, it shall report its findings to the Board and recommend to the Board to order that a formal inquiry be held by a Disciplinary Committee. Under the provisions of the Professional Engineers Act, the Disciplinary Committee shall consist of —

(a) 3 registered professional engineers with at least 10 years' standing who are not the chairman or member of the Investigation Committee and at least 2 shall be members of the Board.

(b) 5 registered professional engineers with at least 15 years' standing who are not the chairman or member of the Investigation Committee and at least 2 shall be members of the Board.

(c) 5 registered professional engineers with at least 10 years' standing who are not the chairman or member of the Investigation Committee and at least 3 shall be members of the Board.

(d) 3 registered professional engineers with at least 15 years' standing who are not the chairman or members of the Investigation Committee and at least 2 shall be members of the Board.

8 A professional engineer whose application for registration as a specialist professional engineer has been refused by the PE Board may appeal to the Minister within —

(a) 60 days after being notified of such refusal.

(b) 30 days after being notified of such refusal.

(c) 20 days after being notified of such refusal.

(d) 50 days after being notified of such refusal.

9 Under the Professional Engineers Act, every registered professional engineer who has in force a practising certificate on the day of election of candidates as members of the Professional Engineers Board must vote for the election of such members at such time and in such manner as prescribed by the Board. Any PE who fails to do so shall face the penalty of

(a) not entitled to apply for a practising certificate unless he has good reason for not voting or pay a fine of $3,000.

(b) not entitled to apply for a practising certificate unless he has good reason for not voting or pay a fine of $300.

(c) not entitled to apply for a practising certificate for one year and pay a fine of $300.

(d) not entitled to apply for a practising certificate for one year.

10 Engineer F, who performed an environmental impact study on a new project for Developer Q, utilised some of the same raw data earlier developed and owned by him for Contractor P at a nearby location. The conclusion of the environmental impact study was essentially the same in both studies. Engineer F billed Developer Q for a complete study but did not inform Developer Q the use of raw data developed for another client and that he invoiced Contractor P for the complete study. Was it ethical for Engineer F to charge Developer Q for the complete environmental impact study and was it ethical for him not to disclose the use of raw data developed for another client?

(a) It was unethical for Engineer F to charge Developer Q for the complete environmental impact study and it was unethical for him not to disclose the use of raw data developed for another client.

(b) It was ethical for Engineer F to charge Developer Q for the complete environmental impact study and it was ethical for him not to disclose the use of raw data developed for another client.

(c) It was ethical for Engineer F to charge Developer Q for the complete environmental impact study and it was unethical for him not to disclose the use of raw data developed for another client.

(d) It was unethical for Engineer F to charge Developer Q for the complete environmental impact study and it was ethical for him not to disclose the use of raw data developed for another client.

Section B - Answer 3 Out Of 5 Essay Questions (each at 25 marks)

Question 1

Engineer A, on behalf of the engineering firm of which he is a principal, submitted a statement of qualifications to a developer for a mega project.

In due course he was notified that his firm was on the "short list" for consideration along with several other firms, but it was indicated to him that his firm did not appear to have qualifications in some specialised aspects of the requirements, and that it might be advisable for the firm to consider a joint venture with another firm with such capabilities.

Engineer A thereupon contacted Engineer B, a principal of a firm with the background required for the specialised requirements, and inquired if Engineer B's firm would be interested in a joint venture if Engineer A was awarded the job. Engineer B's firm responded in the affirmative.

Thereafter, Engineer C, a principal in a firm which was also on the "short list," contacted Engineer B and indicated the same requirement for a joint venture for specialised services, and also asked if B's firm would be willing to engage in a joint venture if the C's firm was selected for the assignment. Engineer B also responded in the affirmative to Engineer C but did not notify Engineer A of his response to Engineer C.

Is it ethical for Engineer B to agree to participate in a joint venture arrangement with more than one of the several since he did not make a full disclosure to all of the firms?

Discuss the issues and comment on Engineer B's conduct with reference to relevant sections of the Professional Conduct and Ethics rules where applicable.

Question 2

Engineer A was retained by an architect to provide mechanical engineering services in connection with the design of an office building. Engineer A performed his services and thereafter a dispute arose between Engineer A and the architect as to Engineer A's compensation for his services. The issue was never resolved.

Several months later, the owner, who retained the architect on the project, requested that Engineer A provide him with a copy of the air-conditioning drawings in order to perform certain work on the building project which did not involve issues of safety or health. The owner offered to pay Engineer A the cost of reproduction and any administrative staff costs and to mediate the dispute between Engineer A and the architect. Engineer A refused to provide the owner with a copy of the drawings and declined owner's offer to mediate the dispute.

Was it ethical for Engineer A to refuse to provide the owner with a copy of the drawings and to decline owner's offer to mediate the dispute between Engineer A and the architect?

Discuss the issues and comment on Engineer A's conduct with reference to relevant sections of the Professional Conduct and Ethics rules where applicable.

Question 3

Engineer A was employed by an transportation agency to supervise and inspect the signals and communication systems of a public transportation system. The systems were supplied and installed by Company B under a design-and-build contract. Close to the completion of the project, in one of his site inspection rounds, Engineer A discovered that part of the signals cables installed were undersized, untidy and would likely lead to failure in the train signals.

He called for a meeting with the agency's management and Company B's representatives. The representatives disputed Engineer A's claim and argued that as the systems were part of a design-and-build package, Engineer A did not have the right to question what Company B did. Engineer A considered that following the discussions at the meeting initiated by him, he had fulfilled his duties in informing the agency's management and Company B's representatives even though his opinions were ignored. He then left the matter as it was and took no further follow-up actions.

Discuss the issues and comment on Engineer A's conduct with reference to relevant sections of the Professional Conduct and Ethics rules where applicable.

Question 4

Code of Professional Conduct and Ethics - Part I

2.- (5) A professional engineer shall —

(a)	exercise due restraint in criticising the work of another professional engineer; and
(b)	not maliciously or recklessly injure or attempt to injure, directly or indirectly, the professional reputation, prospects or business of another professional engineer.

Explain how a professional engineer can exercise restraint in criticising the work of another professional engineer when he is supporting a contractor in a tender bid and proposing an alternative to a design that is already completed and issued by the other professional engineer as part of the tender documents. Please give at least 4 unique points.

When there is an incident, reporters will approach professional engineers to comment on the incident. Highlight the clause in the Code of Professional Conduct and Ethics which these professional engineers should be aware of, when they are not aware of the full facts of the incident.

How then can the professional engineer who was approached provide comments without contravening the above clause. Please give at least 3 unique points.

Question 5

A newly registered professional engineer, Engineer A, currently under employment of a large consulting engineering firm has intention to set up a firm to engage in professional engineering works and provide professional engineering services for submission to public authorities for the purpose of obtaining permit / license / approval. To have a head start while in his current salaried position, Engineer A's strategy is to publicise his service offer to his current firm's business associates for a much lower service fee as his initial startup overhead cost is much lower than his current firm. To further broaden his reach, he also offers to pay his current firm's business associates introduction fees if they help to canvass for jobs on his behalf.

Discuss the issues, comment on Engineer A's conduct, explore any alternate ways Engineer A can consider for his start-up business with reference to relevant applicable sections of the Code of Professional Conduct and Ethics.

II Practice of Professional Engineering Examination Part 2 (Civil)

The paper aims to examine the candidates on their proficiency in the practice of civil/structural engineering at a professional level. Candidates are expected to have a good working knowledge and experience of civil/structural engineering design and practices in Singapore. In particular knowledge is required in the areas of regulatory framework, submission and approval procedures, statutory acts and regulations, practices guidelines and codes of practice.

The examination will place emphasis on the Professional Engineer's role in building projects in the local context either acting as the Qualified Person for the project or Professional Engineer for the civil and structural engineering works.

Format

This is a 4 hours 10 mins paper and a candidate is required to answer 1 compulsory question covering the design of concrete and steel structures and choose 4 out of 7 questions covering areas of design, codes of practice, acts and regulations, submission/approval procedures & site supervision. The candidates may bring along their own reference materials and calculators as necessary.

(Note: For PPE 2025 Part 2 Civil, only answers based on Eurocodes will be accepted. Answers based on Singapore/British Standards will not be accepted.)

Syllabus

The list of reference literature, codes, acts, regulations, etc., appended below is meant as a guide and is not exhaustive. The latest Acts and Regulations, Publications and Civil Engineering Codes /Standards will apply.

- **Acts and Regulations**
  - Professional Engineers Act and Regulations
  - Building Control Act and Regulations
- **Publications**
  - **SCDF**
    - Code of Practice for Fire Precautions in Buildings
    - Handbook on Fire Precautions in Buildings
    - FSSD Fire Safety Handbooks
  - **LTA**
    - Guidelines & Publications on Rapid Transit Systems
    - Building Works & Restricted Activities in Railway Protection Zone
    - Street Proposals
    - Vehicle Parking

- Other Guidelines and Standards

- **NEA**
  - Code of Practice on Environmental Health
  - Code of Practice on Pollution Control

- **PUB**
  - Code of Practice on Surface Water Drainage
  - Standard Specifications for Drainage Works
  - Code of Practice on Sewerage and Sanitary Works
  - Sewerage and Drainage Standard Drawings

- **NParks**
  - Procedures and Guidelines for Plan Submissions

- **MOM**
  - Workplace Safety & Health Act and Subsidiary Legislations

- **BCA**
  - Guidelines and Handbooks on Civil Defence Shelters
  - Code of Practice on Buildable Design

- **Civil Engineering Codes/Standards**
  - Codes and Standards under Building Control Act and Regulations
  - Codes and Standards for Roads and Transit Systems to LTA's Requirements

Sample Questions From Past Year Papers for Practice of Professional Engineering Examination Part 2 (Civil)

Section 1- Question 1 (20 marks) is COMPULSORY

Question 1

A segment of a long pipe rack system is shown in Figure Q1-1. The main structural system comprises portal frames spaced at 6m centre to centre with intermediate pipe support at 3m centre-to-centre and connected with two tie beams. The structural steel beams that support the eight (8) numbers of 8-inch water pipes are spaced at minimum 150mm edge-to-edge. The 8-inch diameter water pipes have a loading of 1.45kN/m run when the pipe rack system is in operation. The frictional force at frame is 15% of the pipe load and the pipes will be operated under an anchor force of 5 kN/m2 at stressed condition at frame only. The maintenance load is 0.75 kN/m2 .

The arrangement of pipe rack system with dimensions is shown in Figure Q1-1. The section of the pipe supporting beams are UB203×165×36 kg/m and columns UC203×203×60 kg/m of 5m height. The columns are pin connected via baseplates to pile caps. The main pipe supporting beams are welded to the column. The intermediate pipe supporting beams are pin-connected to the tie beams. The specification states that the pipe rack system shall be designed to cater for any configurations in the use of the pipes during operation, testing and maintenance periods. All steel sections are grade 355 N/mm2. Steel section properties are provided in Annex.

a) Sketch the ultimate bending moment diagram of the portal frame under operation loading, both in vertical and horizontal action separately.

(2 marks)

b) Calculate the value of sway imperfection due to the combination of vertical action only and determine if the global imperfection is required to be considered in the design.

(6 marks)

c) Check using conservative method for general use, the adequacy of the intermediate beam supporting the water pipes to SS EN 1993 considering the most critical vertical load combination when the pipes are in operation.

(12 marks)

Question 1 *(Cont'd)*

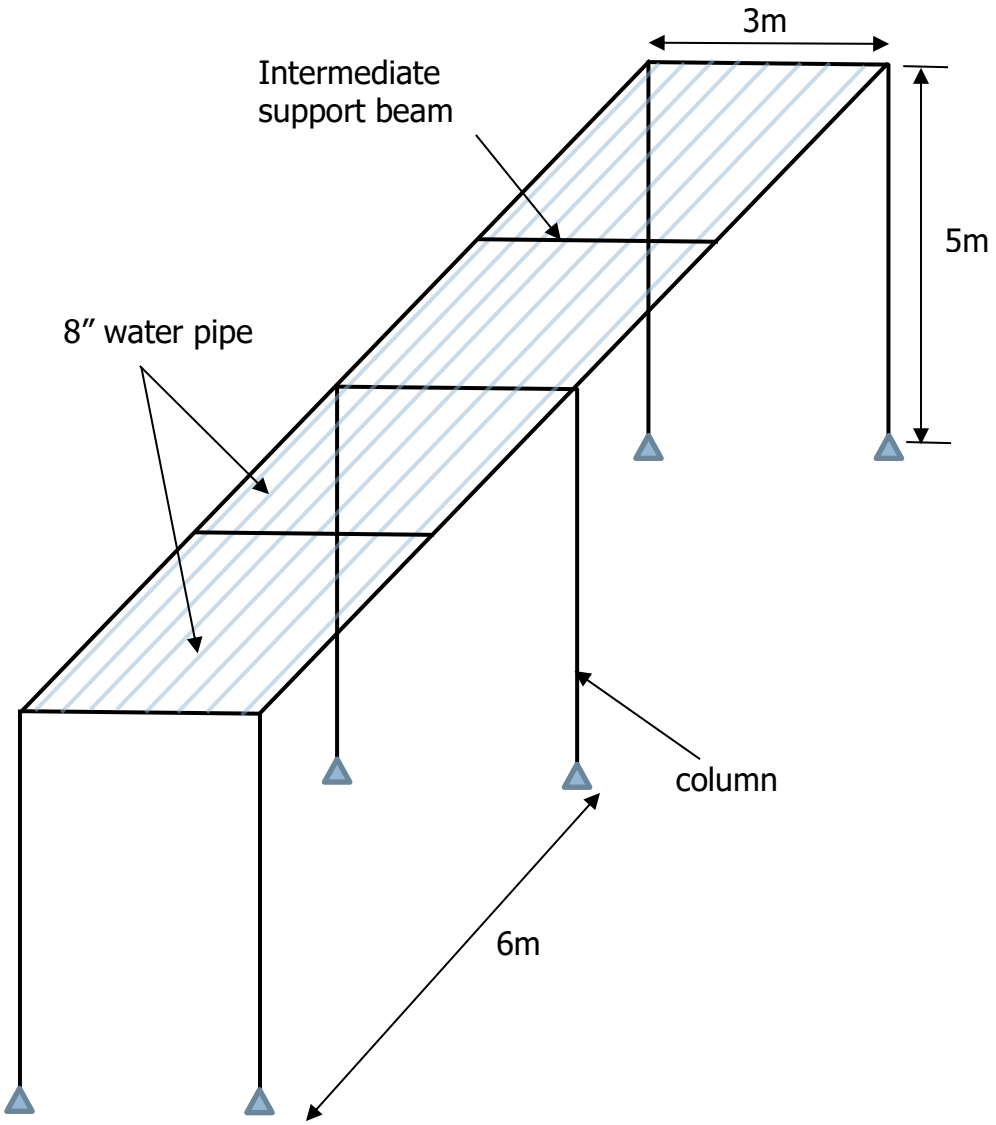


Figure Q1-1

Section 2 – Answer 4 Out Of 7 Questions (each at 20 marks)

Question 2

The existing ground condition at a site that was reclaimed many years ago is shown in Figure Q2-1. The water table is 4m below the ground surface. The marine clay is fully consolidated.

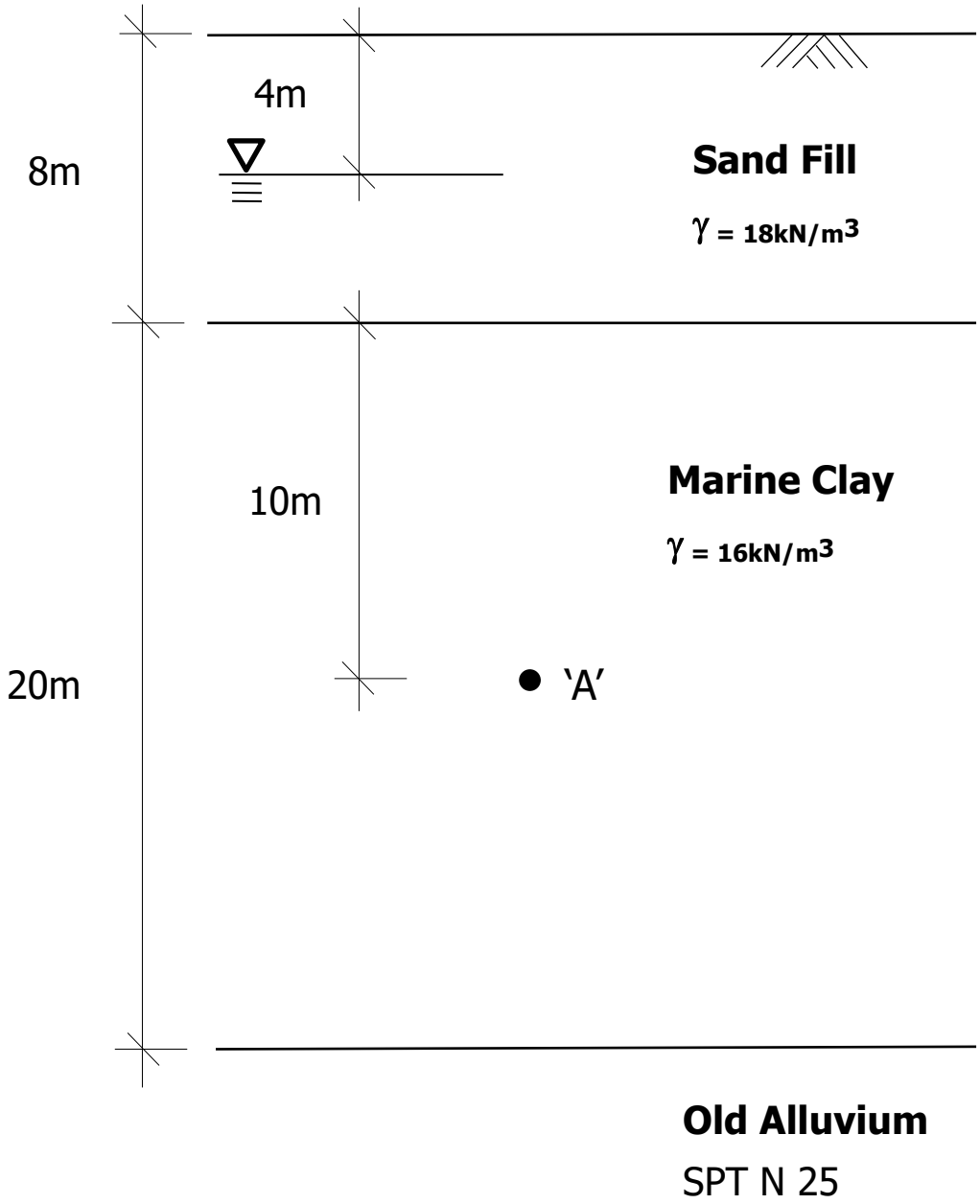


Figure Q2-1

Question 2 *(Cont'd)*

(a) Estimate the total stress, pore-water pressure, effective stress and undrained shear strength at Point 'A' of the marine clay.

(4 marks)

(b) There is a proposal to lower the ground level by 2m for a new development. Estimate the pore-water pressure and undrained shear strength at Point 'A' for the following conditions:

(i) immediately after the lowering of the ground level, and

(ii) in the long-term.

(4 marks)

(c) Due to threats of climate change, the proposal in (b) is aborted. The new proposal is to raise the existing ground level with 2m of fill. The density of the fill material is 18 kN/m^3. Estimate the pore-water pressure and undrained shear strength at Point 'A' for the following conditions:

(i) immediately after raising the ground level, and

(ii) in the long-term.

(4 marks)

Note: You may assume one-dimensional consolidation theory. The proposed lowering and raising of the ground level in (b) and (c) are instantaneous.

A braced excavation was carried out at another site. The typical section of the excavation is illustrated in Figure Q2-2. The marine clay is normally consolidated. A water standpipe is installed into the dense sand layer next to the excavation. The water level in the standpipe is shown in Figure Q2-2.

Question 2 *(Cont'd)*

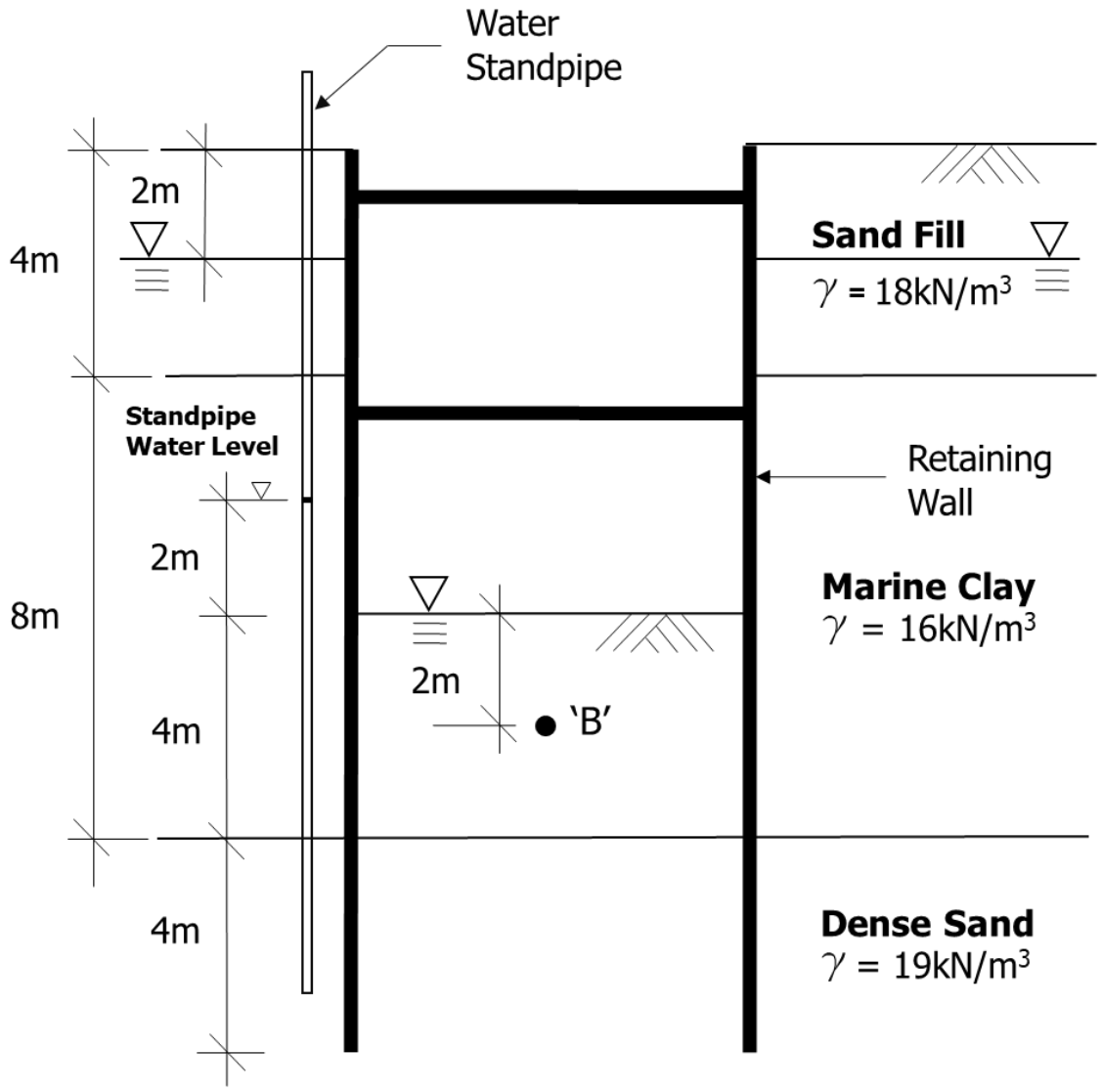


Figure Q2-2

(d) Estimate the water pressures acting on both sides of the retaining wall (earth and excavation faces). Illustrate your answer by plotting the water pressure diagrams with values on both sides of the retaining wall.

(5 marks)

(e) Compute the effective stress at Point 'B' of the Marine Clay. Comment on your answer.

(3 marks)

You may assume steady-state flow condition in your calculations for (d) and (e).

Question 3

a) A building has tilted over time, as it sits on an uneven layer of thick marine clay below the ground surface as shown in Figure Q3-1. The tilt is currently slightly in excess of 1:200.

i) Do you think the building is structurally safe? Substantiate your answer with assumption, if any.

(2 marks)

ii) What are the criteria and measures taken to determine whether the building is structurally safe or unsafe?

(2 marks)

iii) If your study has shown the building is not safe, suggest engineering solutions to make it safe.

(3 marks)

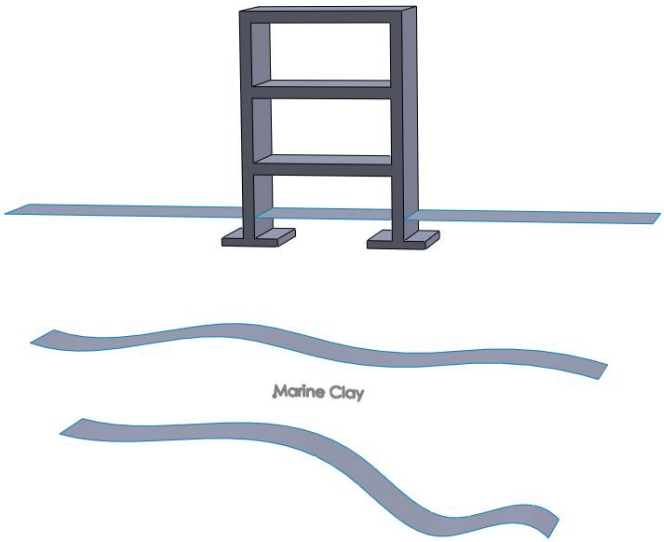


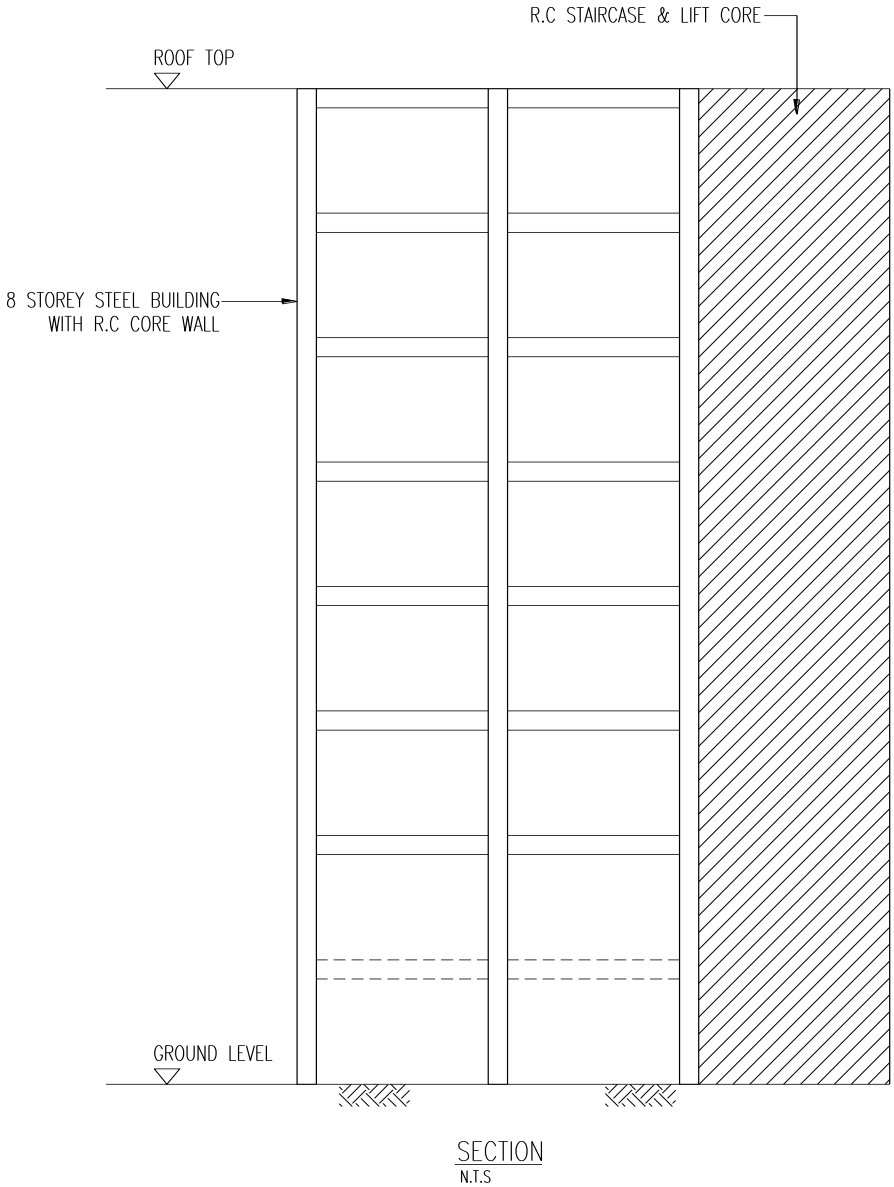
Figure Q3-1

Question 3 *(Cont'd)*

(b) The 2nd storey floor slabs of an 8 storey steel building linked to the lift and staircase RC wall is to be removed for more headroom (See Figure Q3-2).

How will the removal of dead load affect the existing building? Does it make the building safer?

(8 marks)



SECTION
N.T.S

Question 3 *(Cont'd)*

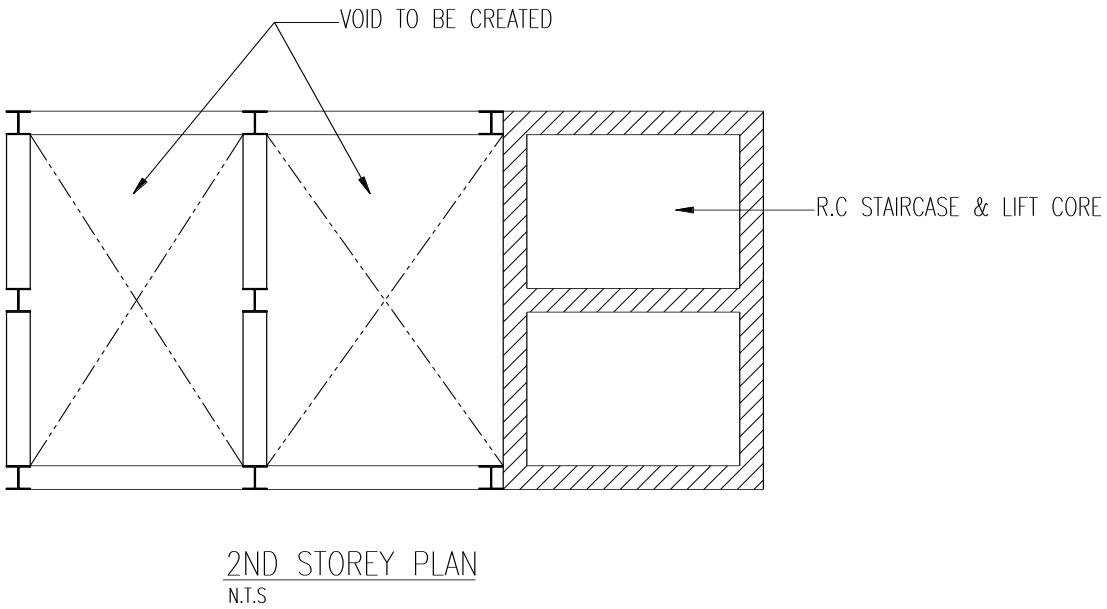


Figure Q3-2

(c) In Singapore's changing landscape, the introduction of complex building is not unexpected. BCA has revised criteria for early pre-consultation of structural concept for complex buildings. The intent is to ensure the structural robustness of complex buildings, where specific considerations need to be given to the design and construction of such complex buildings. In this context, what is deemed to be a complex building?

(5 marks)

Question 4

You have been appointed as the engineer for Project Alpha, a re-development project whereby the existing entrance is to be retained. Refer to Figure Q4-1. The site area is 2,363m^2. The various catchments are shown in Table Q4-1.

Table Q4-1

Catchment	Area (m^2)
Planting strip (through ground)	200
Ramp to carpark	82.5
All other areas (paved)	2,080.5

(a) Calculate the peak runoff for the development at discharge to the roadside drain using Rational Formula (with a weighted runoff coefficient) based on Code of Practice guidelines. Time of concentration is 60 min for a return period of 10 years. Round up to the nearest whole number in m^3/hr.

(5 marks)

(b) Does the development meet the maximum allowable peak runoff based on Code of Practice?

(2 marks)

(c) Compute the maximum allowable peak runoff at discharge to roadside drain based on the Code of Practice. Round up to the nearest whole number in m^3/hr.

(3 marks)

(d) The roadside drain is a box culvert. The clear dimensions of the box culvert are 1.070m depth by 1.5m wide with a gradient of 1:300. Using Manning's equation, does the culvert satisfy the peak runoff computed in Part (a)?

(5 marks)

(e) Sketch the longitudinal section of the box culvert from Chainage 1450 to 1468 with details according to PUB submission standard.

(5 marks)

Question 4 *(Cont'd)*

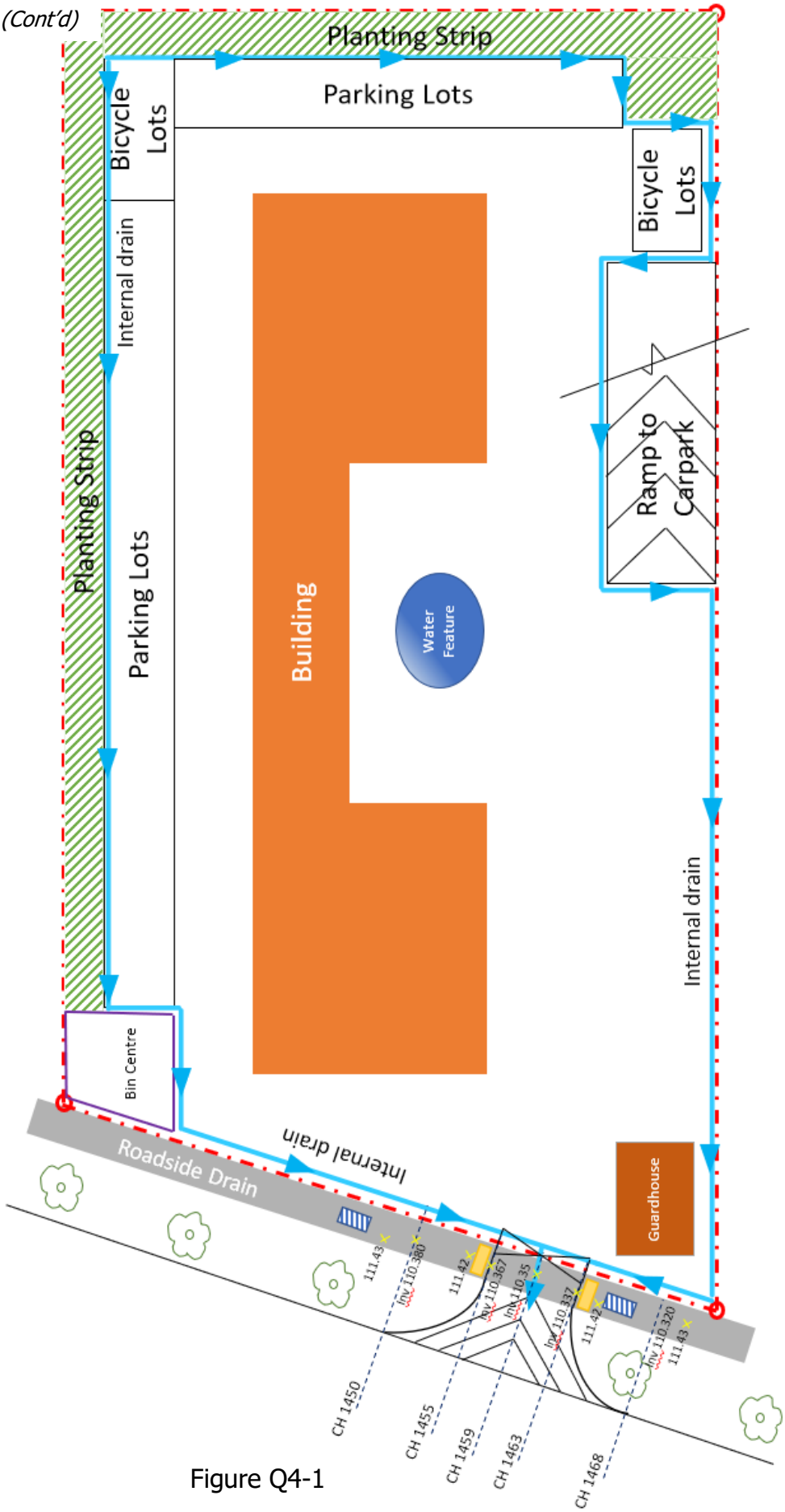
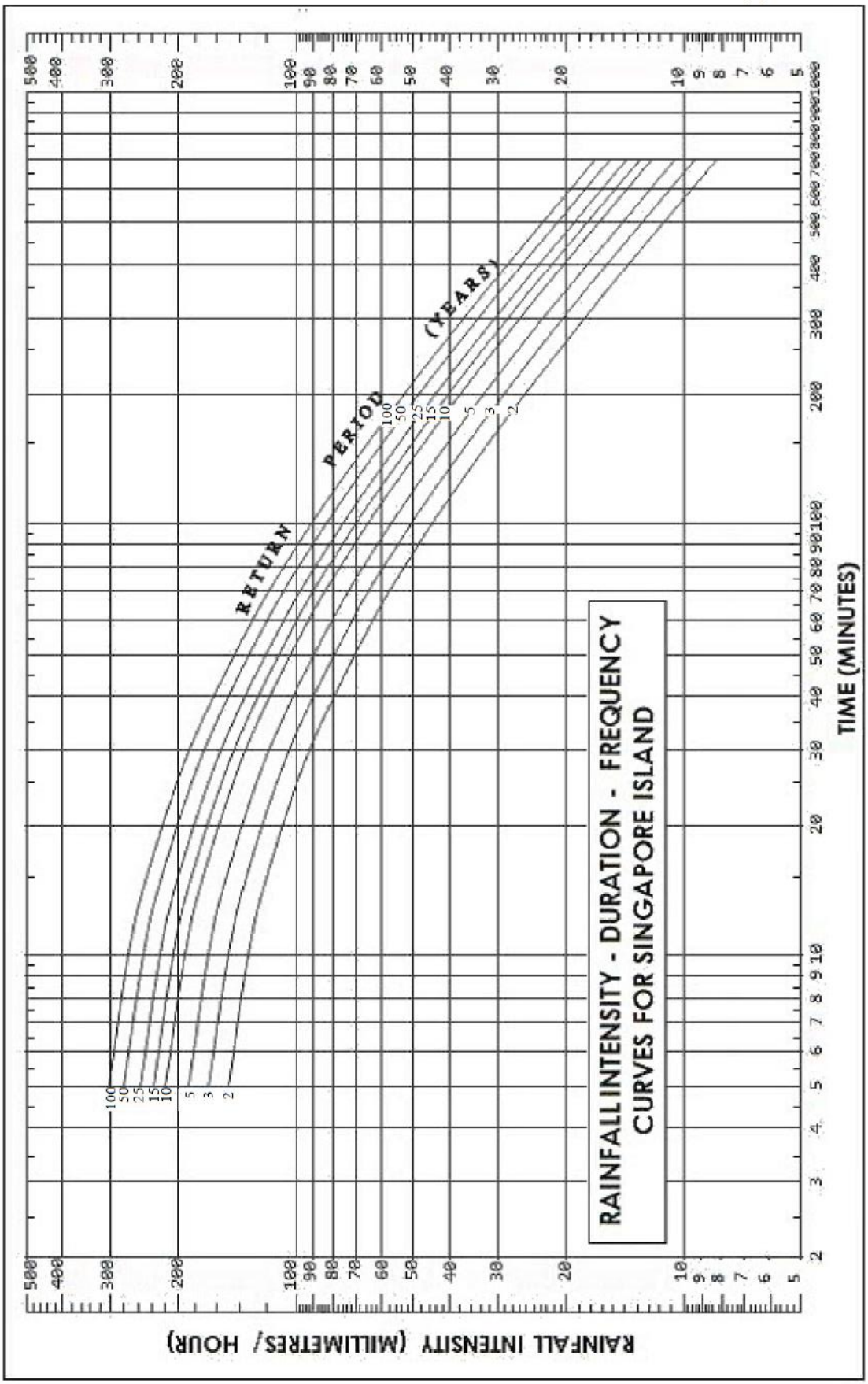


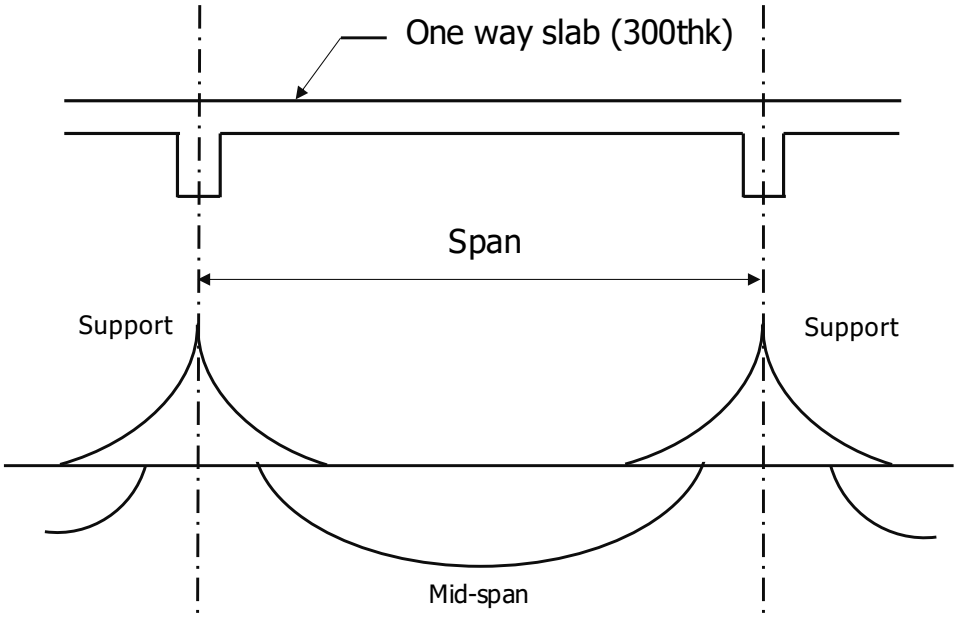
Figure Q4-1

Question 4 *(Cont'd)*



Question 5

Figure Q5-1 illustrates the details of an interior span in a continuous slab design. In the serviceability limit state, the maximum bending moments under gravity loads at the supports and mid-span from the analysis are tabulated.



Bending Moment Envelope

Load Case (Service)	**Bending Moment (kNm / m)**	
	Support	**Mid-span**
Dead Load	100	75
Imposed Load	40	30

Figure Q5-1

(a) Determine the steel reinforcement required to resist the bending moment at the support for the ultimate limit state. The slab is 300 mm thick. The concrete grade is C32/40 and the cover to the centroid of the steel reinforcement is 50 mm. Yield strength of steel reinforcement is 500 N/mm^2.

(3 marks)

Question 5 *(Cont'd)*

(b) Based on the answers in (a), it is decided that the continuous slab will be post-tensioned. List four (4) benefits of post-tensioning.

(2 marks)

(c) Determine the effective prestress force required to balance 75% of the bending moment at the support due to dead load only. The centroid of the tendons is 40 mm from the top of the slab.

(3 marks)

(d) Nominal 12.7 mm diameter strands with a cross sectional area of 100 mm^2 is proposed for the tendons. The yield stress of the strand is 1860 N/mm^2. If the initial prestressing force is 75% of the breaking load and with a long-term prestress loss of 20%, propose a tendon configuration for the slab based on your design in (c). Assume there are 5 strands in one tendon.

(3 marks)

(e) With the tendon configuration proposed in (d), determine the eccentricity of the tendons required at the mid-span to balance 75% of the bending moment due to dead load. Calculate the resulting ultimate bending moment capacity at mid-span and comment on the answer.

(4 marks)

(f) There are some doubts over the tendon stressing records for a localised bay of slab after construction. Explain with reasons the implications if the tendons are not stressed to the specified forces? How would you verify the performance of the as-built slab condition?

(3 marks)

(g) If one of the strands broke during stressing, propose an immediate remedial measure that can be taken on site to mitigate the situation before the ducts are grouted. The broken strand is blocked and is not replaceable.

(2 marks)

Question 6

Referring to a PPVC concrete module of approximately 40 ton as shown in figure Q6a & Q6b.

(a) Propose the number of lifting points required and indicate the proposed location of the lifting points.

(3 marks)

(b) Provide a sketch of the proposed type of lifting points and its anchorage details.

(3 marks)

(c) Provide calculation of the forces on each lifting point for the module and the safety factor required for the lifting point.

(5 marks)

(d) Describe the considerations and give a sketch of the proposed lifting frame used and how to ensure the lateral stability of the module during lifting.

(5 marks)

(e) Describe in detail how to ensure the vertical and horizontal alignment of the modules during installation.

(4 marks)

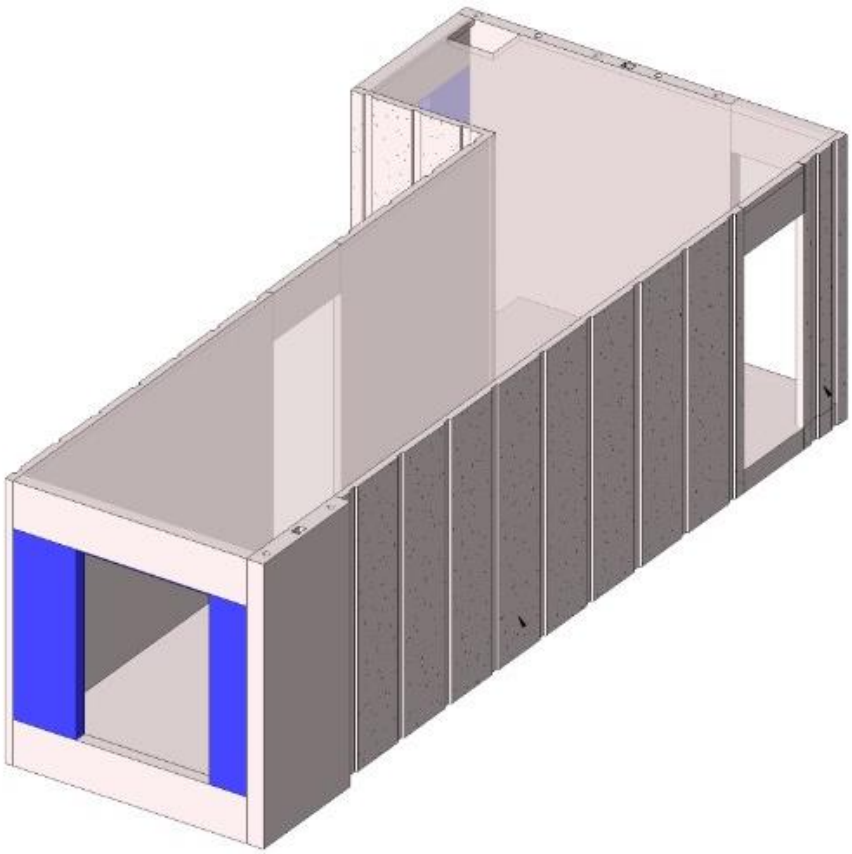


Figure Q6a 3D View of PPVC module

Question 6 *(Cont'd)*

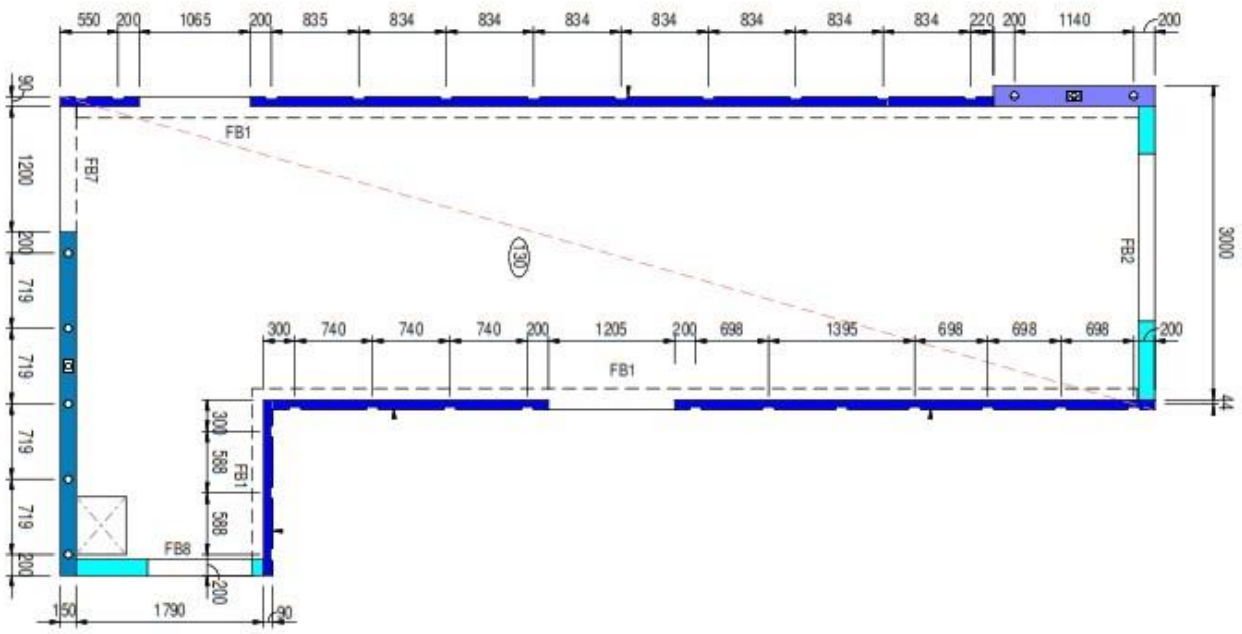


Figure Q6b Plan View of PPVC Module

Question 7

You are appointed as the engineer for the Infrastructure Work by the Land Transport Authority, LTA. The scope of work involves building a cantilever linkway connecting to the existing bus stop and an overhead pedestrian bridge.

(a) The preferred alignment has been determined as shown by the 'green' line in Figure Q7-1. The Work falls within the road reserve. Write a report to the Client, advising on the feasibility of the preferred alignment of the proposed linkway based on the site condition. The 1.8m Reinforced Concrete U-Drain (RCU), Telco manhole and 900mm NEWater pipe are existing services.

(5 marks)

(b) Assuming the final accepted alignment by all agencies has been refined and as shown in Figure Q7-2.

Sketch a typical section of the linkway at Section A-A, reflecting the linkway structure clear height and width as per LTA Architectural Requirement, the existing RCU, NEWater pipe and the Telco manhole.

Asbuilt information on RCU:
Depth, 1500mm
Top slab thickness, 150mm
Wall thickness, 150mm

(5 marks)

(c) Based on the accepted alignment, the linkway is supported on the existing 1.8m RCU.

i) Sketch the bending moment and shear force diagrams at the base of the linkway column due to vertical action.

(2 marks)

ii) Draw the forces that you will consider in order to check the stability of the structure.

(3 marks)

(d) List the procedure and requirement to seek approval from PUB on works near the NEWater pipe.

(5 marks)

Question 7 *(Cont'd)*

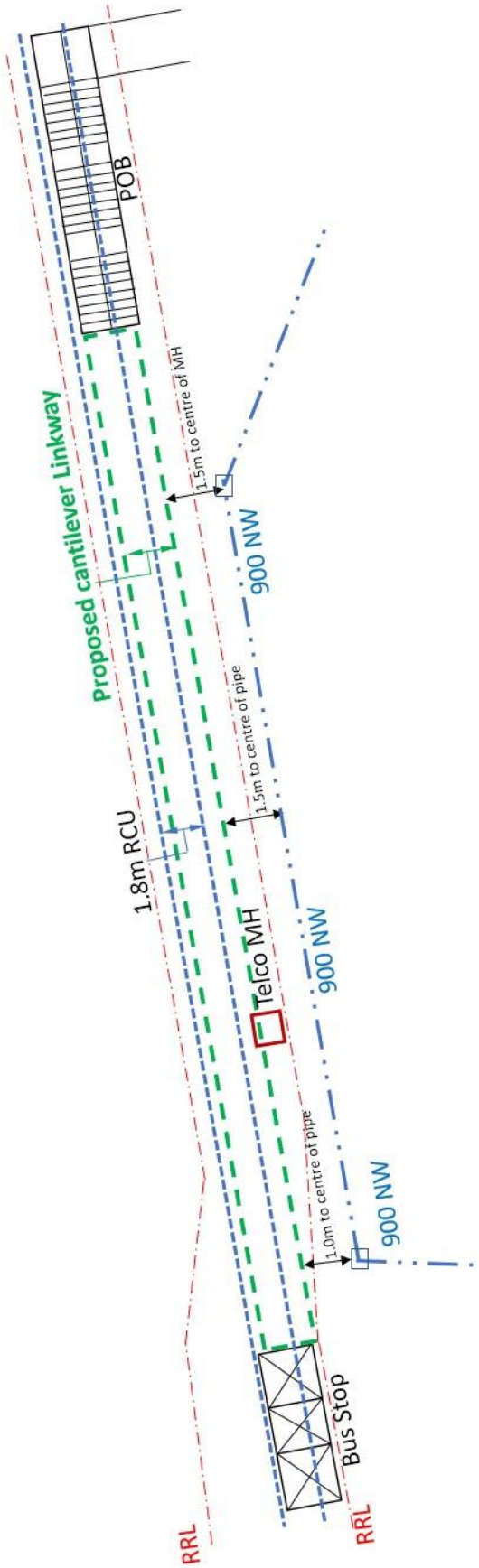


Figure Q7-1
Scale: NTS

Question 7 *(Cont'd)*

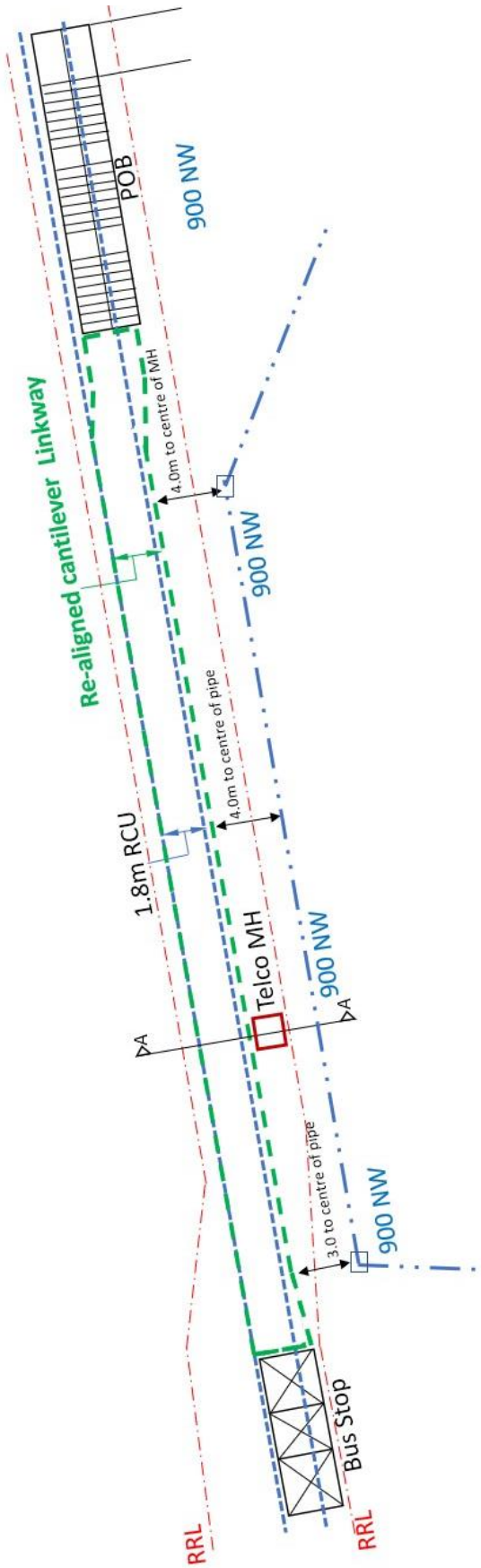


Figure Q7-2
Scale: NTS

III Practice of Professional Engineering Examination Part 2 (Electrical)

The paper aims to examine the candidates on their proficiency in the practice of electrical engineering at a professional level. Candidates are expected to have a good working knowledge and experience of electrical engineering design and practices in Singapore. In particular knowledge is required in the areas of regulatory framework, submission and approval procedures, statutory acts and regulations, practices guidelines and codes of practice.

The examination will place emphasis on the Professional Engineer's role in building projects in the local context in relation to electrical engineering works.

Format

This is a 4 hours 10 mins paper that examines candidates on technical competency and understanding of standards and codes that are applicable in Singapore for the discipline of electrical engineering.

The paper consists of 2 Sections and 8 questions. Candidates must answer questions in both sections (Section 1 and Section 2). Section 1 consists of a compulsory question on SS 638, statutory acts and regulations. Candidate is required to answer this compulsory question. Section 2 consists of 7 questions. Candidates shall choose to answer 4 out of 7 questions. The latest Acts and Regulations, Publications and Engineering Codes /Standards will apply.

Syllabus

- **Codes of Practice**
    - SS 638: Code of practice for electrical installations
    - SS 626: Code of practice for design, installation and maintenance of escalators and moving walks
    - SS 650 - 1 : Code of practice for temporary electrical installations - Construction and building sites
    - SS 650 - 2 : Code of practice for temporary electrical installations - Festive lighting, trade-fairs, mini-fairs and exhibition sites
    - CP 88 - 3 : Code of practice for temporary electrical installations - Shipbuilding and ship-repairing yards
    - SS 530: Code of practice for energy efficiency standard for building services and equipment.
    - SS 531-1: Code of practice for lighting of work places – Indoor.

- SS 531-2: Code of practice for lighting of work places – Outdoor.
- SS 531-3: Code of practice for lighting of work places - Lighting requirements for safety and security of outdoor work places.
- SS 532: Code of practice for the storage of flammable liquids.
- SS 535: Installation, operation, maintenance, performance and construction requirements of mains failure and standby generating system.
- SS 538: Code of practice for maintenance of electrical equipment of electrical installations.
- SS 546: Emergency voice communication system in building.
- SS 550: Installation, operation and maintenance of electric passengers and goods lifts.
- SS 551: Code of practice for earthing.
- SS 555-1 : Code of practice for protection against lightning – General requirement.
- SS 555-2 : Code of practice for protection against lightning – Risk management.
- SS 555-3 : Code of practice for protection against lightning – Physical damage to structures and life hazard.
- SS 555-4 : Code of practice for protection against lightning – Electrical and electronic systems within structures.
- SS 558: Code of practice for construction, installation, operation and maintenance of intruder alarm systems.
- SS 563-1: Code of practice for the design, installation and maintenance of emergency lighting and power supply systems in buildings. Part 1 : Emergency lighting.
- SS 563-2: Code of practice for the design, installation and maintenance of emergency lighting and power supply systems in buildings. Part 2 : Installation requirements and maintenance procedures.
- SS 564-1: Green data centres - Part 1 : Energy and environmental management systems

- SS 564-2: Green data centres - Part 2 : Guidance for energy and environmental management systems
- SS 576: Code of practice for earthworks in the vicinity of electricity cables.
- SS 601: Code of practice for maintenance of grid-tied solar photovoltaic (PV) power supply system
- SS 645: Code of practice for the installation and servicing of electrical fire alarm systems
- TR 25: Technical Reference for electric vehicle charging system
- TR 100: Technical Reference for Floating photovoltaic power plants - Design guidelines and recommendations
- Electricity Act
- Electricity (Electrical Installations) Regulations
- Handbook for Application of Installation Licence, published by EMA
- Fire Code & Fire Code Handbook
- BCA Green Mark Assessment Criteria published by BCA
- Code on Accessibility in the Built Environment published by BCA
- Handbook for solar photovoltaic system (PV) Systems, published by BCA and EMA
- How to Apply for Electricity Connection, published by SP Group
- Code of Practice for Info-communication Facilities in Buildings (COPIF) published by IMDA
- Transmission Code

- **Electrical Power Supplies, Tariffs and Design**
  - Electricity market
  - Generation, transmission and distribution in Singapore
  - Electricity bill calculation for HT and LT consumers

- Design of electrical installations
- Load estimation
- Power factor correction
- Power quality and power system harmonics
- Consumer Substation, Switchboards and Switchgears
- Maintenance of electrical equipment, switchgears and cables
- Design for energy efficiency and sustainability

- **Lighting requirement for workplace, indoor and outdoor**
  - Visual needs for safety and security
  - Determine the lighting requirements for indoor and outdoor work places.

- **Energy efficiency and accessibility requirement for buildings**
  - Minimum energy-efficiency requirements for new installation and replacement of systems and equipment in buildings
  - Replacement of components of systems and equipment in buildings
  - Criteria for determining compliance with energy efficiency in building with regards to air-conditioning and heat rejection equipment, water heaters, motor drives and lighting used in buildings.
  - Requirement and guidelines for buildings to be designed or retrofitted to provide accessibility and safety to persons with disabilities and families with young children.

- **Protection for Safety**
  - Measures in protection against electric shock (basic and fault)
  - Principle of operation of protective devices
  - Maximum demand and diversity factors
  - Protection against over-current and short circuits
  - Protective devices and circuit conductors

- Discrimination in protection of electrical circuits

- **Cables, Busways, and Distribution Boards**
  - Type and characteristic of cables
  - Method of installation
  - Sizing of conduit and trunking
  - Factors affecting the current carrying capacity of cables
  - Sizing of cables and busways for use under different types of conditions
  - Connected load, maximum demands and circuit breakers ratings for a electrical distribution board

- **Earthing**
  - Purpose of earthing
  - Methods of earthing
  - Earth fault loop impedance and earth fault current
  - Suitable sizes of circuit protective conductor
  - Testing of earthing

- **Lightning Protection Systems**
  - Rolling sphere technique of determining zones of protection
  - Spacing of air terminations and types of air termination
  - Down conductors for building below 45 m and those exceeding 45 m
  - Earth electrodes, earth resistance values and hazards of a rise in ground potential caused by lightning strike
  - Selection of appropriate materials and installation methods
  - Prevention of side flashing
  - Design requirement of complete lightning protection system

- Transients and surge suppression
- Effect of lightning on system and structure
- Source and type of damages due to lightning
- Risk assessment aspect in lightning protection

- **Emergency Lighting**
  - Exit and emergency lighting requirements for evacuation of occupants
  - Types of back-up power supplies
  - Exit and directional Signs

- **Standby Power Generator System**
  - Types of essential and critical loads
  - Sizing of generator with considerations for maximum demand of essential load, transient or motor starting loads and voltage dip
  - Voltage regulation and its effects on generator sizing
  - Protection for alternator and prime mover
  - Installation of standby generator system including day-tank, battery and charger, fuel supply, engine cooling system, plant room ventilation, exhaust and fresh air intake, control and instrumentation panel and automatic transfer switch.
  - Underground fuel storage system
  - Grounding/Earthing arrangement
  - Maintenance

- **Automatic Fire Alarm System**
  - Requirement for automatic and manual fire detection system and purpose of compartmentation as required by the Fire Code
  - Interaction with other building services such as emergency voice communication system, lifts, AHUs, pressurization fans and auto-doors during alarm activation

- **Emergency Voice Communication System**
    - Requirements for public address system for building above 24 m but less than 60 m
    - Requirements for emergency voice communication for building above 60 m
    - Requirements for fireman intercom
- **Inspection, Testing and Common Violation In Electrical Installation**
    - Mandatory requirements for inspection and testing of electrical installation prior to energisation of electrical supply
    - Types of test instruments and standard methods of testing

Sample Questions From Past Year Papers for Practice of Professional Engineering Examination Part 2 (Electrical)

Section 1 - Question 1 (28 marks) is COMPULSORY

Question 1

(a) Explain the difference and purpose of bonding and earthing as required for an electrical installation in Singapore.

You are checking the lightning protection system for a building for compliance to the new code, what is the minimum size of stranded copper bonding conductor allowed to connect the non-ferrous connector point to the earth termination system?

(b) You are the LEW responsible for the electrical installation in a newly built mixed development. The main switchboard is ready for turn on. Identify the certificate(s) to be submitted to SP Services Ltd (SPS) when you request for an energisation appointment.

(c) An electrical installation with an approved load of 1000 KVA is taking direct supply from PowerGrid's network. The low voltage main switchboard (MSB) with air circuit breaker (ACB) had passed the factory acceptance test and was delivered to site; feeder cables were laid and terminated to the MSB. Identify the tests to be carried out on site before requesting for the turn-on by SP Services Ltd (SPS).

(d) Explain the purpose of the primary injection test.

(e) Refer to the distribution board shown in Figure Q1(e). A new load, an air handling unit (AHU) rated at 11 kW 3-phase 400V at 0.8 pf, will be added to the distribution board.

(i) Is there a need to upgrade the incoming breaker size and the bus bar ratings of the distribution board? State the reason(s) for your answer.

(ii) Determine the current rating of the MCB and the cable size for the new AHU. Assume that the cable length from the distribution board to the new AHU is 20m and the permitted Line-Line voltage drop is 8V.

(iii) Is there a change in the short-circuit rating of the MCCB in the distribution board when the new load is added? State the reasons for your answer.

Question 1 *(Cont'd)*

(iv) How would the LEW in-charge of the operation and maintenance of the electrical installation isolate the distribution board to make it safe for the modification works to be carried out? Elaborate on the procedures and safety measures to be taken before physical works on the distribution board can commence.

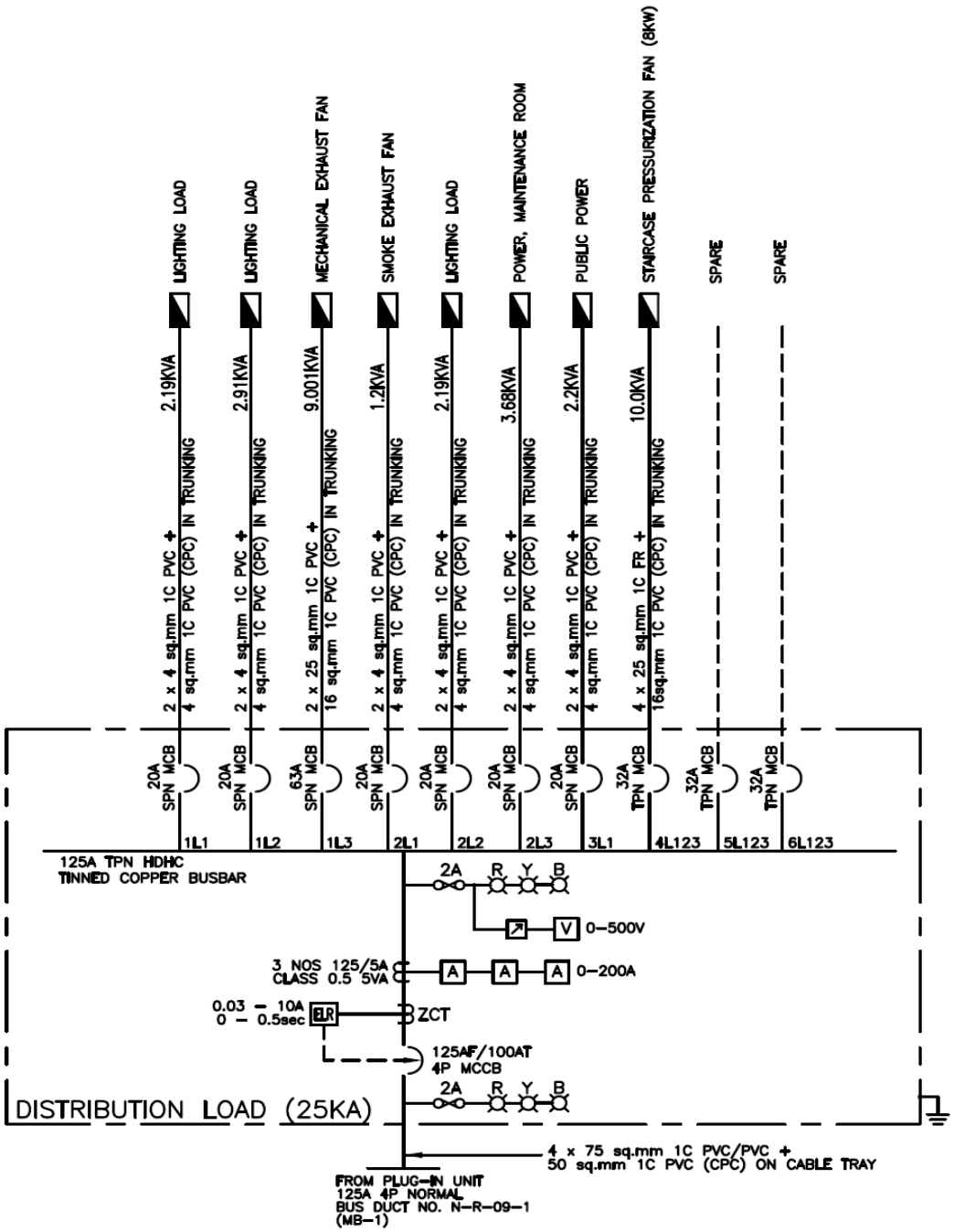


Figure Q1(e)

Section 2 – Answer 4 Out Of 7 Questions (each at 18 marks)

Question 2

(a) You are asked to design an installation where electronic system will be installed and required to comply with electromagnetic compatibility (EMC) requirement. Identify the three criteria for your design?

(b) Figure Q2(b) shows the basic decomposition of a typical EMC coupling problem where EMC is concerned with the generation, transmission and reception of electromagnetic energy. What are the three ways to prevent unintended interference?

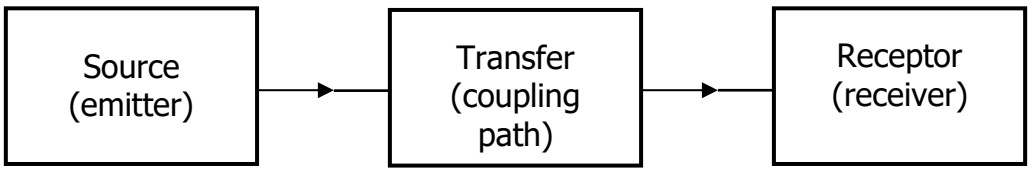


Figure Q2(b)

(c) A vertical electrical riser housed inside an office/commercial complex is radiating electromagnetic field (EMF) as measured and indicated in Figure Q2(c). Explain how to remove or reduce the radiated EMF and to protect the occupants from this exposure?

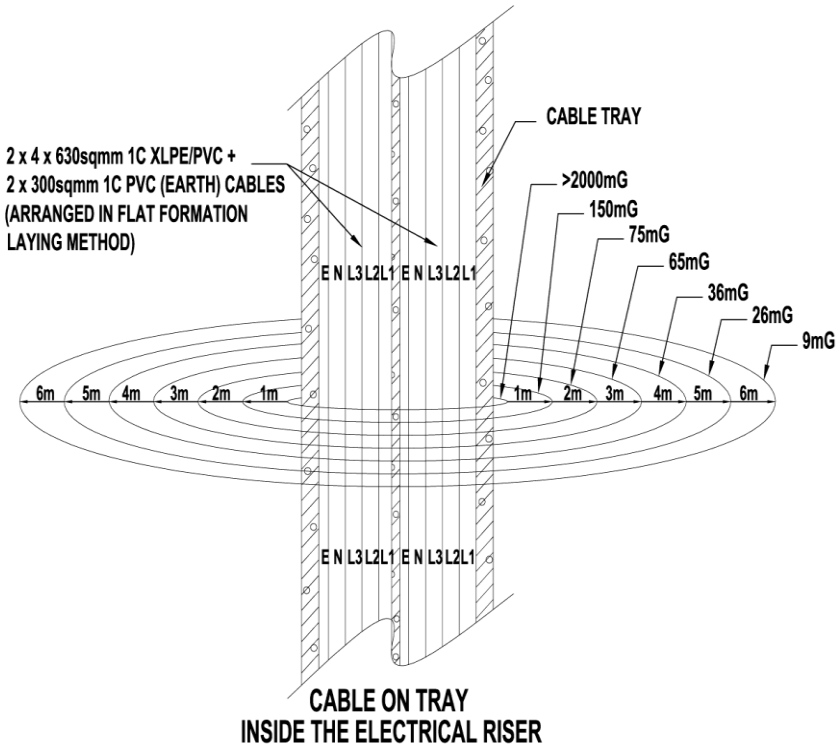


Figure Q2(c)

Question 2 *(Cont'd)*

(d) (i) State the main purpose of the lightning protection system.

(ii) Explain how the main purpose stated in above (i) can be achieved.

(iii) Explain how to reduce the dangerous side-flashes for a building?

Question 3

(a) Before work can commence on a high voltage switchboard, what are the 5 essential steps that need to be carried out to ensure the safety of the workers? Assume that you can only shut down half of the switchboard.

(b) With the aid of a diagram, describe the protection requirements of the incoming panel of a 22 kV supply. You should include the type, rating and accuracy class of various devices where appropriate**.**

(c) A 22kV/400V 2-MVA transformer is connected directly to the "incoming mains" air circuit breaker of a LV switchboard. The 22 kV cable is protected by an IDMTL overcurrent relay R1 which is connected to 100/5A current transformers. R1 is set at 50% plug setting and time multiplier at 0.3. The protection on the LV side is an IDMTL overcurrent relay R2 which is connected to 3000/5A current transformers. Both the relays R1 and R2 have the same time-current characteristic which is given by:

$$\mathbf{t = 0.14/(M^{0.02} - 1)\ secs\ \ (\ for\ Time\ Multiplier = 1\ )}$$

where M = Plug Setting Multiplier

The symmetrical fault current at the 400-V switchboard is 36,000 A. Determine a suitable plug setting and a suitable time multiplier for relay R2 if the time discrimination between the two relays R1 and R2 is 0.4 secs.

Available plug settings for the two IDMTL relays are 50%, 75%, 100%,125%,150%,175% and 200%.

Assume the LV circuit breaker does not have direct-acting element.

Question 4

(a) In your design of the electrical switchroom, you have given thoughts for future maintenance.

(i) State the requirement for earthing resistance and extraneous conductive parts when you are conducting the handover inspection.

(ii) Explain and state the purpose on the requirement expected before the end of defect liability period (DLP) in the interest of your client.

(b) A 630A, 230/400V 50 Hz switchroom distributing energy to a row of shophouses is disgusted with paper boxes and accumulated dirt over prolonged period of 3 years. The owner explained to you that the load is high only during all the festive seasons, such as mid-autumn, Deepavali, Hari Raya, and the like in Singapore. You are asked by the owner to advise the frequency of maintenance and any violation.

(c) During a routine check on a switchboard and the stand-by generator for an electrical installation that is providing supply at 3-phase 4- wire 400/230 V 50 Hz to the mix load of a building. After you have switched over the mix load from the utility supply to the generator supply, you noticed that few lamps could be seen to flicker on its brightness; and decided to measure the voltage. The measured values were:

- L1 to L2 = 406 V
- L2 to L3 = 400 V
- L3 to L1 = 410 V
- L1 to N = 140 V
- L2 to N = 200 V
- L3 to N = 303 V
- N to E = 140 V

You decided to reconnect the mix load back to the utility supply. Those lamps that flickered, do not flicker any more. You measured the voltage again and the values were:

- L1 to L2 = 405 V
- L2 to L3 = 401 V
- L3 to L1 = 408 V
- L1 to N = 234 V
- L2 to N = 230 V
- L3 to N = 238 V
- N to E = 3 V

(i) From the results, explain the phenomenon that the lamp flickers.
(ii) What do you deduce from this result and how would you troubleshoot?

Question 5

(a) You are the designer of a condominium project, and a lift is required to be provided between basement 1 & 2 carparks and the 1st storey of the residential block. The total travel distance of these 3 landings is 6.8m and you have advised the client to install a lift complying with SS 550 instead of a platform lift, as it has safety features that a platform lift does not have. List 6 safety features and explain the purpose of each safety feature.

(b) The Greenmark criteria for new residential buildings require that the energy performance and energy effectiveness of a building be evaluated.

(i) Name 3 systems where energy performance evaluations must be carried out and give a brief description of each evaluation.

(ii) For the effective use of energy assessment criteria, energy efficient features are encouraged. Name any 3 such energy efficient features.

(c) Data centres are typically lightly occupied and notwithstanding that the lighting load is a small portion of the total load of a data centre, propose 2 methods of lighting design that will reduce the lighting energy consumption.

(d) State 2 design considerations for an Emergency Voice Communication System to comply with the SS Code of Practice and the Fire Code with respect to:

(i) audibility, and

(ii) fault monitoring.

Question 6

(a) A 90 sq. m residential unit comprises three bedrooms, one living/dining room and a kitchen. Design the electrical single-line diagram to provide electricity to the whole unit with the incoming supply and meters. Indicate the ratings of the protection devices, cable sizes and circuit labels for each of the outgoing circuits to serve minimally the following:

(i) lighting,

(ii) switched socket outlets,

(iii) cooker units,

(iv) water heaters, and

(v) air-conditioning units.

State all assumptions made.

(b) A data centre has the following energy consumption profile:

- Overall Energy Usage over 1 year is 13,140 MWhr
- The data centre facility has a PUE of 1.4

(i) What is the ICT energy load consumed over the same period of time?

(ii) What is the ICT average load rating in kW?

(c) Based on the Singapore Standard SS 550

(i) Describe two things which will happen when a lift overloading device detected the load exceeds the rated capacity.

(ii) In the absence of standby diesel generator, what is the alternative means of power supply and the requirement for emergency operations of the lift?

(iii) Name two locations where a stopping device shall be provided for stopping, and maintaining the lift out of service, including the power operated doors.

Question 7

(a) Based on the Singapore Civil Defence Force Fire Code, identify 3 building services/ systems in a building where the provisions of secondary power source are required.

(b) What is the maximum delay between the failure of the electrical supply to normal lighting and the energization of the

(i) exit lighting and

(ii) emergency lighting?

For a battery-operated emergency lighting system, what is the minimum back-up period of the battery for continuous operation?

(c) In order to comply with local codes, draw diagrams showing the spacing between detectors and detectors and wall for installation on a flat ceiling in an open space for

(i) heat detectors

(ii) smoke detectors.

(d) How long must the battery be able to support the Emergency Voice Communication (EVC) system in the event of a primary power failure if

(i) no emergency backup generator is provided?

(ii) an emergency backup generator is provided?

(e) Based on the Code of Practice for Info-Communications Facilities in Buildings (COPIF), conduits can be used to distribute cables in parts of a building where usage density is low and flexibility in relocating telecommunication outlets is not required. Name 4 basic considerations for the installation of these conduits.

IV Practice of Professional Engineering Examination Part 2 (Mechanical)

The paper aims to examine the candidates on their proficiency in the practice of mechanical engineering at a professional level. Candidates are expected to have a good working knowledge and experience of mechanical engineering design and practices in Singapore. In particular knowledge is required in the areas of regulatory framework, submission and approval procedures, statutory acts and regulations, practices guidelines and codes of practice.

The examination will place emphasis on the Professional Engineer's role in building projects in the local context in relation to mechanical engineering works.

Format

This is a 4 hours 10 mins paper that examines candidates on technical competency and understanding of the use and application of standards and codes that are applicable to the practice of mechanical engineering at a professional level in Singapore.

The paper consists of 2 Sections comprising a total of 8 questions. Candidates are required to answer questions in both sections (Section 1 and Section 2). Section 1 will consist of a compulsory question on principles, codes, and legislation related to general mechanical engineering practice, safety and environmental protection. Section 2 will consist of a total of 7 optional questions. Candidates may choose to answer any 4 out of the 7 questions.

Syllabus

The scope of professional engineering work covered by Professional Engineers (Mechanical) may include the following fields: -

- **Piped Services**

  Cold and Hot Water Services; Sanitary Plumbing Systems within buildings; Town Gas Incoming Supply and Distribution; Liquefied Petroleum Gas (LPG) Multi-Cylinder Systems; Swimming Pool Filtration System

- **Air Conditioning & Mechanical Ventilation**

  Indoor Air Quality Comfort / Environmental Control / Fire Safety Requirements

- **Fire Safety in Buildings**

  Wet and Dry Rising mains/Hydrant Systems; Fire Hose reel System; Automatic Fire Sprinkler System; Fire Detection and Alarm System; Gas Flooding System

- **Lift and Hoisting Systems**

  Lifting / Hoisting Equipment

- **Other Major Mechanical Systems and Services**

  Boiler Plants, Calorifiers, Pressure Vessels, Pressure Piping

- **Energy Conservation for Mechanical Building Services / Buildings**

- **Relevant Codes of Practices, Standards and Acts (Based on latest applicable Codes of Practices, Standards and Acts)**

  All relevant regulations, by-laws, Acts and accepted codes of practice of:-

  - National Environment Agency
  - Public Utilities Board
  - PowerGas Ltd
  - PowerGrid Ltd
  - Singapore Civil Defence Force
  - Ministry of Manpower
  - Building and Construction Authority
  - Energy Market Authority

- **Singapore Standards – Codes of Practice (Based on latest applicable Codes)**

  - SS 497: Code of practice for design, safe use and maintenance of gantry cranes, overhead travelling cranes and monorail hoists
  - SS 536: Code of Practice for safe use of mobile cranes
  - SS 559: Code of Practice for safe use of tower cranes

- SS 567: Code of Practice for Factory Layout – Safety, Health and Welfare Considerations
- SS 595: Singapore Standard for steel wire ropes for hoisting - Part 3: Code of practice for the care, inspection and maintenance of steel wire ropes for hoisting
- SS 617: Code of practice for the lifting of persons in work platforms suspended from cranes
- SS 532: Code of Practice for the Storage of Flammable Liquids
- SS 597: Code of practice for bulk liquid oxygen storage installations on user premises
- SS 636: Code of Practice for Water Services
- CP 52: Code of Practice for Automatic Fire Sprinkler System
- SS 530: Code of Practice for Energy Efficiency Standard for Building Services and Equipment
- SS 553: Code of Practice For Air-Conditioning And Mechanical Ventilation In Buildings
- SS 554: Code of practice for indoor air quality for air-conditioned buildings
- SS 575: Code of practice for fire hydrant, rising mains and hose reel systems
- SS 578: Code of Practice for Use and Maintenance of Portable Fire Extinguishers
- SS 591: Code of practice for long term measurement of central chilled water system energy efficiency
- SS 608: Code of practice for gas installation
- CP 10: Code of Practice for The Installation and Servicing of Electrical Fire Alarm Systems
- SS 550: Code of Practice for Installation, Operation and Maintenance of Electric Passengers and Goods Lifts.
- SS 626: Code of practice for design, installation and maintenance of escalators and moving walks

- SS 564 - 1: Singapore Standard for Green data centres - Part 1: Energy and environmental management systems

- SS 564 - 2: Singapore Standard for Green data centres - Part 2: Guidance for energy and environmental management systems

- **Other Standards and Codes (Based on latest applicable Standards and Codes)**

  - NFPA 2001: Standard for Clean Agent Fire Extinguishing systems (FM200)

  - American Society of Mechanical Engineers codes on pressure vessels and piping

  - American Petroleum Institute codes on pressure vessels and piping

  - British Standards on pressure vessels and piping

Sample Questions From Past Year Papers for Practice of Professional Engineering Examination Part 2 (Mechanical)

Section 1 (28 marks) - Compulsory

Question 1
(All **TEN** parts in Q1 carry equal marks)

1.1 (a) When is pressurization required for staircases? What are the performance criteria that must be achieved in pressurization?

(b) For duct penetrations, when are fire dampers not permitted?

(c) Describe how you should design a mechanical ventilation system for a smoke free lobby.

1.2 (a) Where passenger lifts are installed in a building with manual or automatic fire alarm system as required in the code, describe how the lifts should function when the fire alarm is activated.

(b) Also describe how the lifts should function in the event of normal power failure or interruption.

(c) In a building without standby generator what should you provide for the safe operation of the passenger lifts in the event of main power failure or interruption?

1.3 Town gas is to be provided for food and beverage outlets in a new commercial building development.

(a) What are the requirements if the gas piping is to be routed through a naturally ventilated basement car park?

(b) Describe the interlocking system to be provided if the kitchen of a food and beverage outlet is not naturally ventilated and is located in the basement.

(c) What are the requirements if the gas piping is routed within the false ceiling of an air conditioned corridor which is 30 m long at storey 1?

1.4 (a) What is hot-tapping as practiced in process plant operation?

(b) Under what considerations can hot tapping technique be used?

1.5 Discuss the purpose of pressure testing? Write short notes on the following pressure testing methods:

(a) Leak testing;

(b) Pneumatic testing; and

(c) Proof testing.

1.6 (a) Explain the meaning of "design point" in the design of an Ordinary Hazard sprinkler system.

(b) A circular duct is located more than 150 mm from the wall. What is the maximum width this can be before a sprinkler must be installed underneath it?

(c) What is the maximum distance below a non-combustible ceiling that a sprinkler may be installed?

1.7 (a) State the density of discharge (mm/min) for OHII design.

(b) Explain briefly the operation of a pre-action sprinkler system.

1.8 In air-conditioning cooling load calculations for the purpose of sizing systems, what are the indoor and outdoor design conditions to be used? Support your answers with recommendations from the relevant code of practice.

1.9 In designing an air-conditioning system to handle out-gassing from furnishings and other works what provisions must be made to the system?

1.10 (a) What is the definition of "Factor of Safety" as associated with the use of steel wire ropes for hoisting?

(b) What are the respective minimum Factor of Safety for stationary and running wire ropes used for winches and cranes?

Section 2 – Answer 4 Out 7 Questions (each at 18 marks)

Question 2

(a) What are the primary objectives in maintaining swimming pool water in a safe and pleasant condition?

(b) Calculate the minimum volume of a storage sump (m^3) and the pump flow rate in l/s for a pumped drainage system with a catchment area of 800m^2. You may use the data in Table 1 below.

Table 1

Duration (hrs)	3	4	5	6	12	24
Total Rainfall (mm)	151.4	210.6	253.4	281.9	376.7	533.2

Question 3

A 9-Storey Commercial Office Development comprises of the following:

- 1st storey retail, restaurants & cafe, toilets and bin centre;
- Typical floor - 2nd to 9th storey office, pantry, toilets and AHU room;
- Roof.

Refer to the answer sheets for 1st storey plan, typical 2nd to 9th storey plan, roof plan, and the typical (enlarged) toilet layout.

The three eateries at the 1st storey shall be designed for independent operation / maintenance from each other. The bin centre and AHU rooms shall be provided with a floor gully / trap each.

Design a sanitary works for the proposed development complying with the relevant Code of Practice on Sewage & Sanitary. Your design shall comprise of

(i) the complete sanitary layout plan on every floor including the typical (enlarged) toilet layout.

(8 marks)

(ii) the schematic diagram tallying with the sanitary layout plans

(6 marks)

(iii) calculation of the estimated sewerage discharge according to the appliances/ fittings provided; the calculation shall base on the tables and formula in the Reference Sheet

(4 marks)

State all your design considerations.

Question 3 *(Cont'd)*

Reference Sheet - tables and formula

Waste water flowrate (Q_{ww})

Q_{ww} is the expected flowrate of waste water in a part or in the whole drainage system where only domestic sanitary appliances (see Table 1) are connected to the system.

$$Q = K\sqrt{(\Sigma DU)}$$

where

Q_{ww} = Waste water flowrate (l/s)

K = Frequency factor

ΣDU = Sum of discharge units

Table 1

Typical Frequency Factors (K)

Usage of appliances	***K***
Intermittent use, e.g. in dwelling, guesthouse, office	0.5
Frequent use, e.g. in hospital, school, restaurant, hotel	0.7
Congested use, e.g. in toilets and/or showers open to public	1.0
Special use, e.g. laboratory	1.2

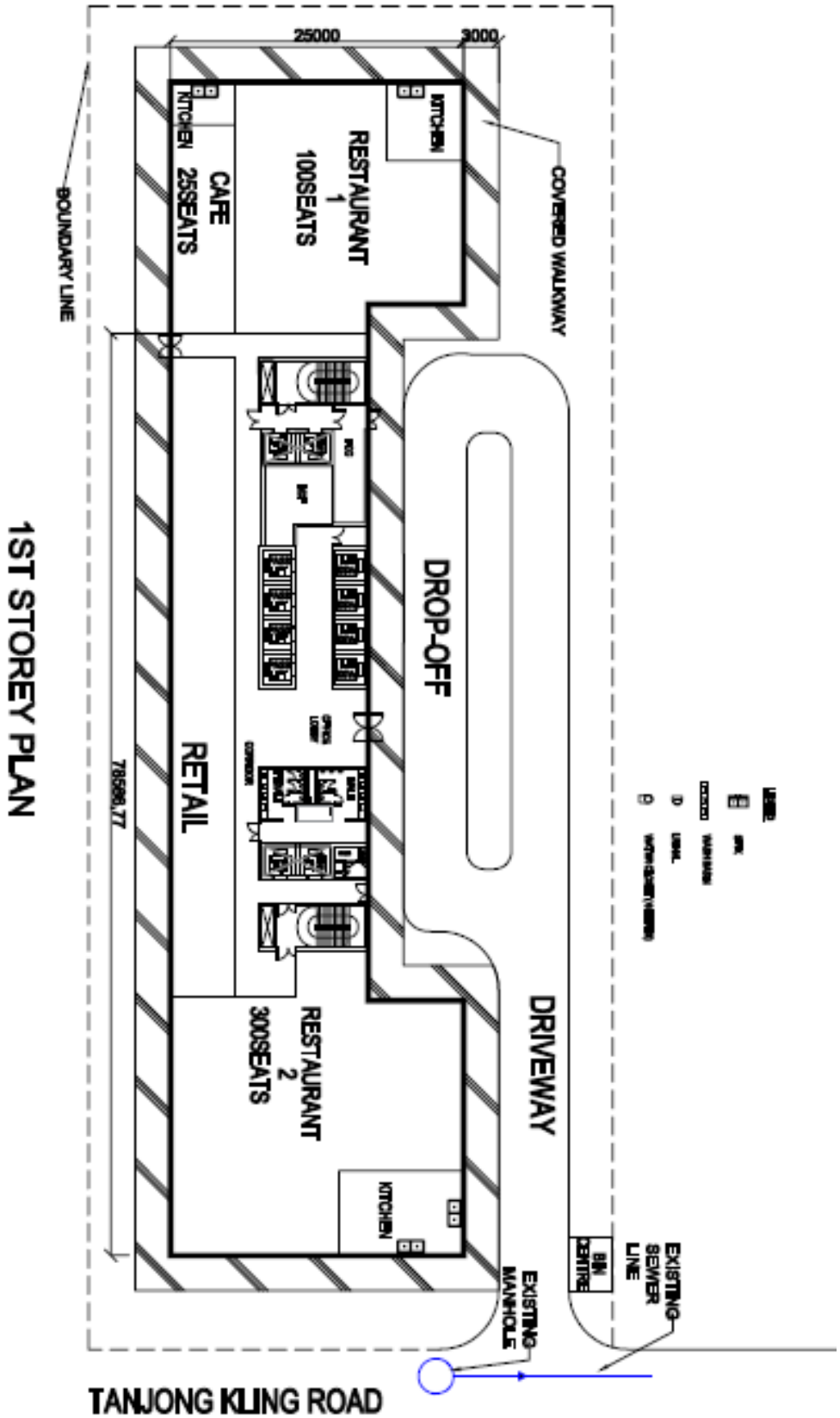
Appliance	**DU** l/s
Wash basin, bidet	0.5
Shower without plug	0.6
Shower with plug	0.8
Single urinal with cistern	0.8
Urinal with flushing valve	0.5
Slab urinal per person	0.2
Bath	0.8
Kitchen sink	0.8
Dishwasher (household)	0.8
Washing machines up to 6 kg	0.8
Washing machine up to 12 kg	1.5
WC with 6.0 l cistern	2.0
WC with 7.5 l cistern	2.0
WC with 9.0 l cistern	2.5
Floor gully DN 50	0.8
Floor gully DN 70	1.5
Floor gully DN 100	2.0

Tabulation of Appliance used in the development

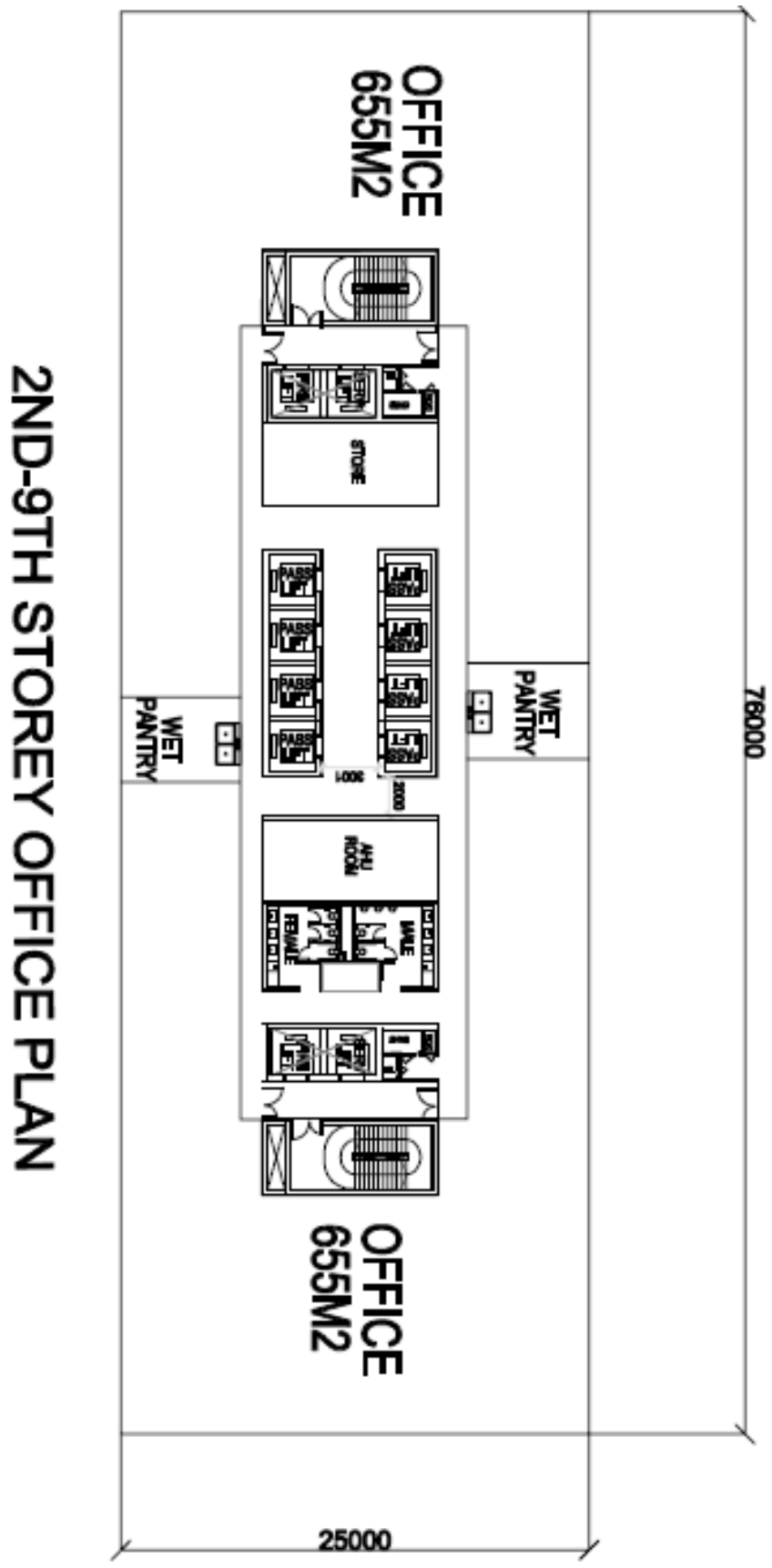
WB: Wash Basin, GT / FT: Floor gully, UR: Urinal w flush valve, KS: Kitchen Sink

APPLIANCE	WB	GT / FT DN 100	WC 7.5l	UR	KS
9th storey Office	6	1	5	3	4
8th storey Office	6	1	5	3	4
7th storey Office	6	1	5	3	4
6th storey Office	6	1	5	3	4
5th storey Office	6	1	5	3	4
4th storey Office	6	1	5	3	4
3rd storey Office	6	1	5	3	4
2nd storey Office	6	1	5	3	4
1st storey Office	6	1	5	3	0
Ist sty Resturant	0	0	0	0	8

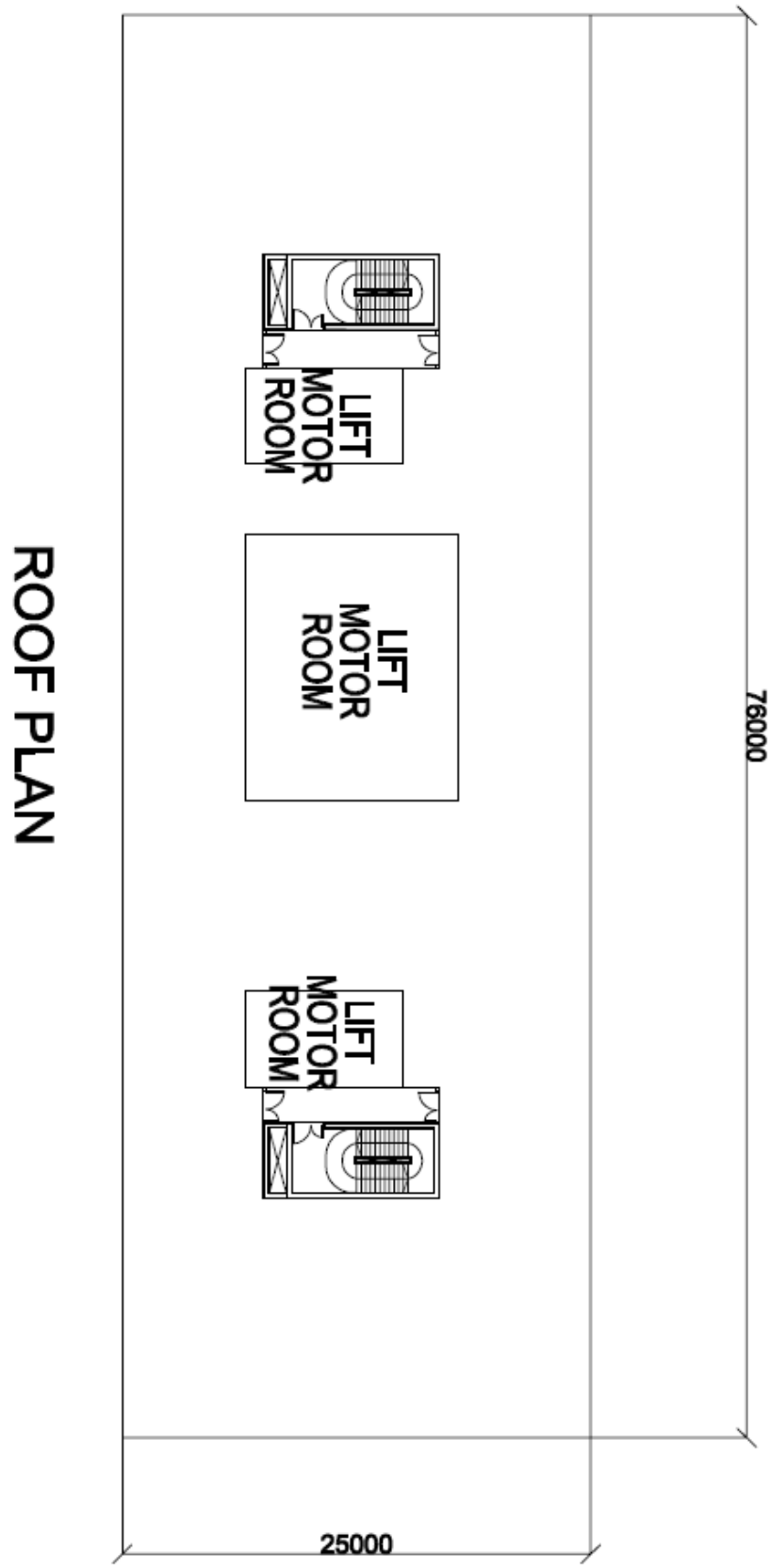
Question 3 *(Cont'd)*



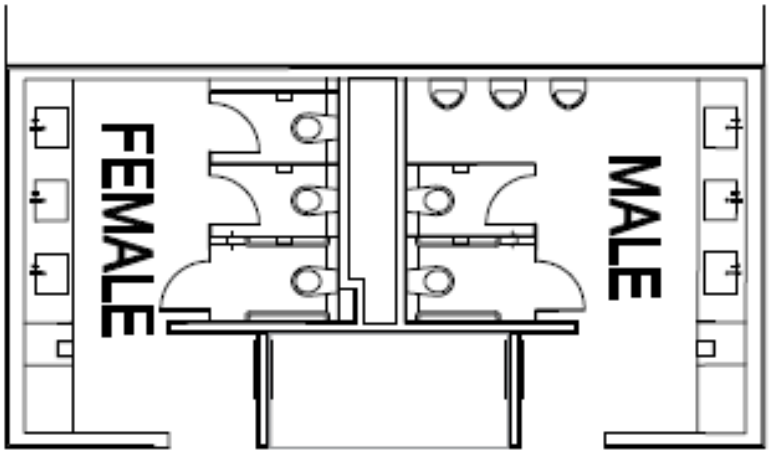
Question 3 *(Cont'd)*



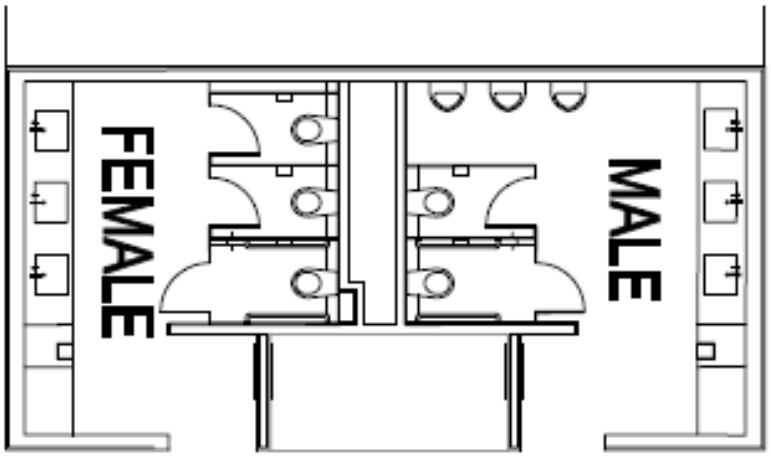
Question 3 *(Cont'd)*



Question 3 *(Cont'd)*



1ST STOREY TOILET



2ND-9TH STOREY TOILET

Question 4

Use the isometric design of an Ordinary Hazard Group II sprinkler system as shown in Figure Q4, to design according to the pre-calculated method.

(a) Determine the water supply requirements and show them on Figure Q4.

(b) Size all range points.

(c) Insert the Design Point.

(d) Size all distribution pipes downstream of the Design Point.

(e) Complete the Statement of Distribution Pipe Losses.

Submit the answer sheets provided with the rest of your answers in the answer book.

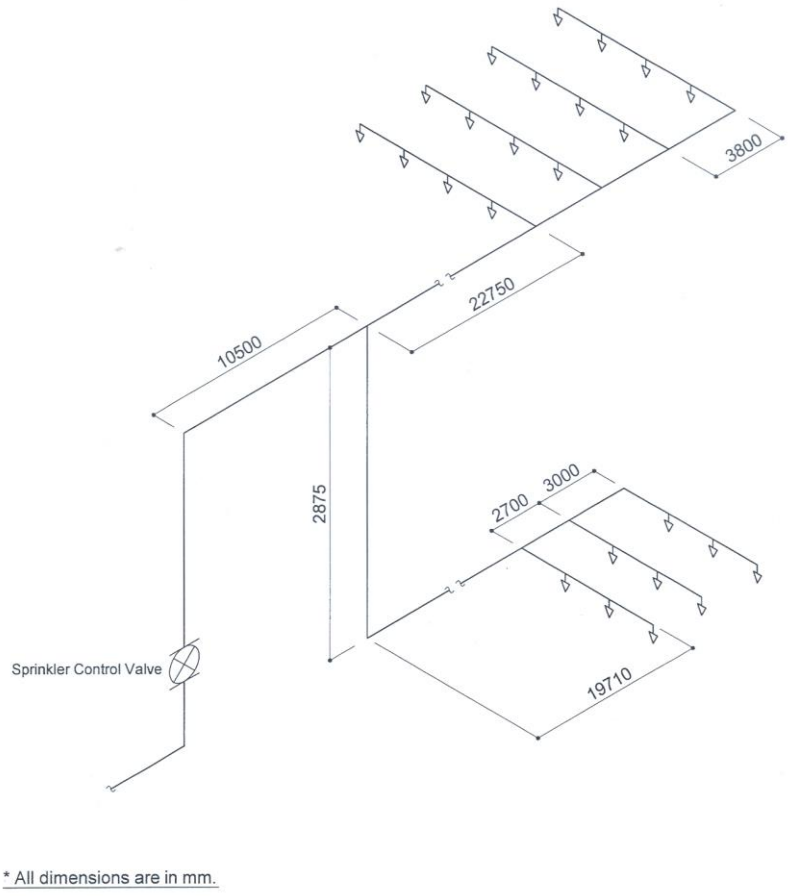


Figure Q4. Isometric design of an Ordinary Hazard Group II sprinkler system

Question 5

A pressure vessel consisting of a shell and two hemispherical heads is constructed from SA 516-70 carbon steel material (Tensile Strength – 70 ksi). The self-reinforced nozzles in the vessel are made from type SA 213-316 stainless steel material (Tensile Strength – 75 ksi). The vessel is shut down eight times a year for maintenance. At start-up, the full pressure of 300 psi and full temperature of 450°F are reached in two hours. The maximum ΔT between any two points during start-up is 300°F. At normal operation, the ΔT is negligible. At shutdown, the maximum ΔT is 100°F. Determine the maximum number of years that this vessel can be operated if a fatigue evaluation is not performed.

You may use the following information:

(i) In accordance with ASME Boiler and Pressure Vessel Code, Section VIII Division 1, paragraph UG-22 or U-2(g), fatigue analysis is not required for materials with a tensile strength of less than 80 ksi when the total number of cycles in (a) through (d) below is less than 1000.

(a) The design number of full range pressure cycles including startup and shutdown.

(b) The number of pressure cycles in which the pressure fluctuation exceeds 20% of the design pressure.

(c) Number of changes in metal temperature between two adjacent points. These changes are multiplied by a factor obtained from Table 2 in order to transform them to equivalent cycle number.

Table 2

Metal Temperature Differential, °F	Factor
50 or less	0
51 to 100	1
101 to 150	2
151 to 250	4
251 to 350	8
351 to 450	12
Higher than 450	20

(d) Number of temperature cycles in components that have two different materials where a difference in the value $(\alpha 1 - \alpha 2) \times \Delta T$ exceeds 0.00034. Where, α is the coefficient of thermal expansion and ΔT is the difference in temperature.

(ii) The coefficient of expansion for carbon steel is 6.5 X 10-6 in./in./°F and that for stainless steel is 9.5 X 10-6 in./in./°F.

Question 6

Figure Q6 below shows a single basement carpark, 60m x 30m, in area. Two void openings, each 10m x 4.5m, are provided at the 1st storey above the car park, and is open to the sky. Two opposite walls in the basement carpark are provided with 1.2m deep openings throughout the length of the wall, as shown.

(a) Calculate the mechanical ventilation requirements for the Basement Carpark.

(b) In what type of buildings would such carpark ventilation system be permitted?

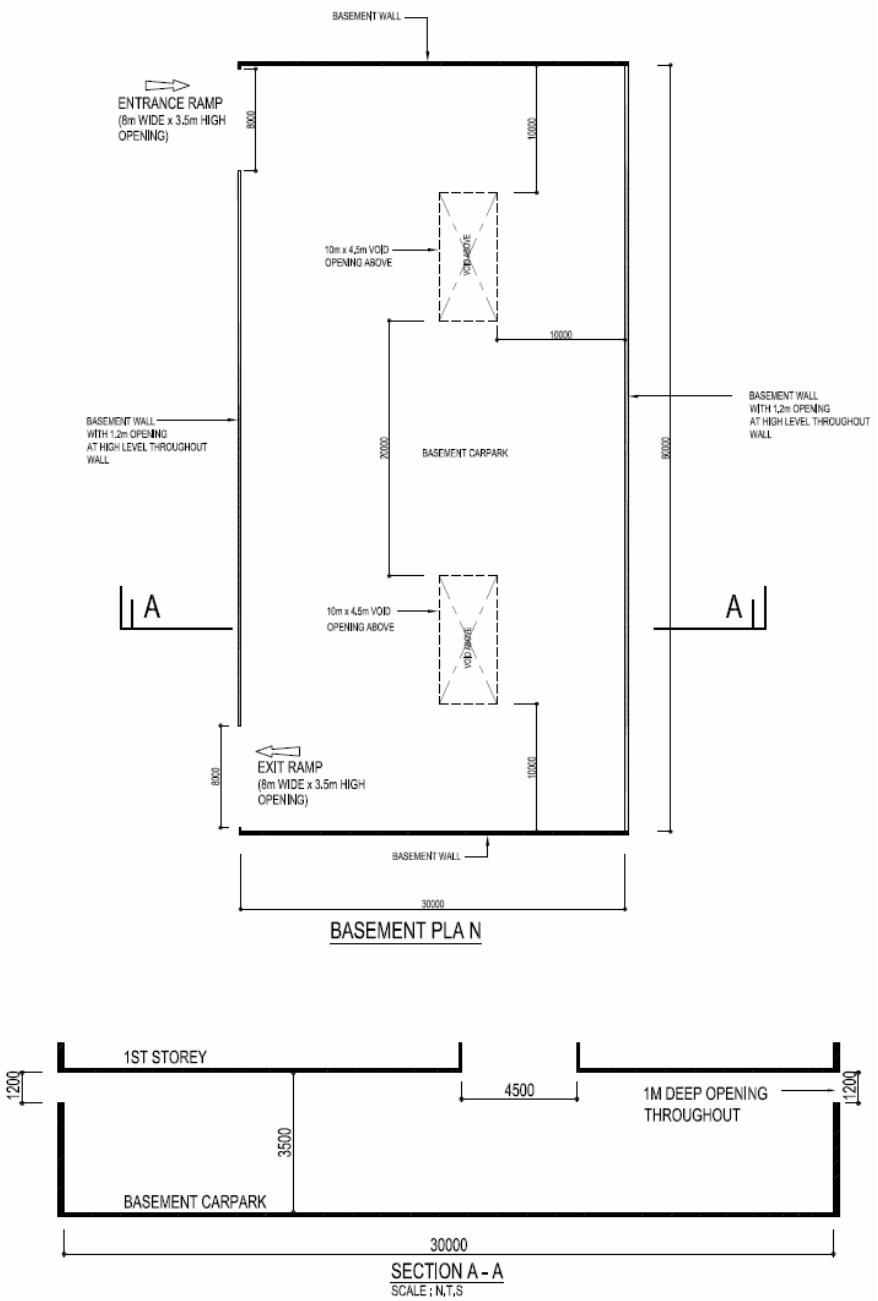


Figure Q6: Single basement carpark

Question 7

The design data from a chilled water plant are as follows:

Chiller cooling capacity Chiller COP	1760 kW 7.0
Chilled water supply temperature Chilled water return temperature	6.5 °C 12.2 °C
Chilled water pump head Chilled water pump efficiency Chilled water pump motor efficiency	300 kPa 75 % 92 %
Condenser water supply temperature Condenser water return temperature	29.5 °C 35.0 °C
Condenser water pump head Condenser water pump efficiency Condenser water pump motor efficiency	200 kPa 75 % 92 %
Cooling Tower fan power	35 kW

(a) Calculate the volume flow rates for chilled and condenser water. Do the pumps meet the power limitation requirements of the code? Suggest a remedy if the conditions are not met.

Show that by the use of variable speed pumping control the pumps will be able to meet the part load performance requirements of the code. Water density and specific heat may be assumed to be 1000 kg/m3 and 4.18 kJ/kg·K, respectively.

(b) What is the overall energy efficiency ratio (EER) of the cooling plant expressed as kW of electric power consumed per kW of cooling?

V Practice of Professional Engineering Examination Part 2 (Chemical)

The paper aims to examine the candidates' proficiency in the practice of chemical engineering at a professional level. Candidates are expected to have a good working knowledge and experience in process safety, process design & operations and related chemical engineering practices in Singapore.

Candidates are also expected to have a good understanding and knowledge of regulatory framework, including safety case regime, statutory acts & regulations and legislative requirements on chemical safety management, fire safety and environmental pollution control.

The examination will place emphasis on the Professional Engineers' roles in the practical application of standards, codes of practice, technical guidance, recommended practices relevant to the chemical & process industries and chemical engineering works to support the industries.

Format

This is a 4 hours 10 mins paper that examines candidates on technical competency and understanding of the use and application of legislation, standards and codes that are relevant to the practice of chemical engineering at a professional level in Singapore.

The paper consists of 2 sections comprising a total of 8 questions. Candidates are required to answer questions in both sections (Section 1 and Section 2). Section 1 will consist of a compulsory question on principles, process safety management, general chemical engineering practices, codes & standards and legislations, including safety case, environmental protection and management. Section 2 will consist of 7 optional questions. Candidates may choose to answer any 4 out of the 7 questions.

Syllabus

The scope of professional engineering work covered by Professional Engineers (Chemical) may include the following fields: -

- **Plant & Process Design**

  Process Design; Process Equipment Sizing and Design; Plot Plan / Equipment Siting; Instrumentation & Control Schemes; Materials of Construction (material properties and selection, corrosion considerations Etc.); Equipment Design Life.

- **Process Safety Management (PSM)**

  Process Safety Management Elements; Process Safety Performance Indicators (CCPS Process Safety Leading and Lagging Metrics); WSH Guidelines on Process Safety Performance Indicators; OSHA 1910.119 Process Safety management of highly hazardous chemicals; Singapore Standard SS 651:2019 Safety and Health Management System for the Chemical Industry; API RP 754 for Process Safety Performance Indicators for the Refining and Petrochemical Industries.

- **Process Hazard Analysis**

  Hazard Identifications and Evaluation Techniques [What-If / HAZOP Terminology and Methodology / Failure Mode Effect Analysis (FEMA)]; Logic Tree - Fault Tree Analysis; Bow-Tie Concept.

- **Functional Safety SIL Classification and Verification**

  Functional Safety (IEC 61508 / IEC 61511 / SIS Safety Life Cycle); Basic Process Control System to HIPS/SIS, SIF, SIL; from HAZOP to Layer of Protection (LOPA); Estimating Consequences & Risk Tolerant Criteria; Failure Types; Hardware Fault Tolerance and Redundancy; Common Cause Failures – ß factor; calculating Probability of Failure on Demand.

- **Fundamental of Hazardous Area Zone Classification**

  Standards for Hazardous Area Zone Classification [IEC System; American System (NEC)]; Principles of Hazardous Area Zone Classification; Explosive Dusts Classification; Material Classification; Temperature Classification; Explosion Protection Type for Electrical Equipment; Equipment Protection Level (EPL) Symbols.

- **Chemical Runaway Reactions and Auto-refrigeration**

  Characteristics of Chemical Runaway Reactions; Hazard Assessment of Chemical Reactions; Selecting and Specifying a Basis of Safety [Factors to be Considered / Preventive Measures (Temperature; Addition; Agitation; Scrubber System / Vents; Safe Time; Instrumentation & Control) / Protective Measures (Emergency Relief System; Inhibiting Runaway Reaction; Quenching & Dumping; Containment)]; Inherent Safer Design (Minimize; Substitute; Moderate / Attenuate; Simplify / Limit Effects – Plant Layout & Equipment Spacing); Auto-refrigeration, controls and materials selection.

- **Pressure Relief System**

  Overpressure Scenarios and Identification; Pressure Relief Valve Type; Effects of Backpressure on Pressure Relief Valve; Pressure Relief Valve Selection; Rupture Disk Devices and Application; ASME Boiler & Pressure Vessel Code Section VIII Requirements [References: Sizing Pressure Relief

Valve Back to Basic; API 520 Sizing, Selection, and Installation of Pressure-relieving Devices in Refineries Part I – Sizing and Selection; API 521 Pressure-relieving and Depressuring Systems; Safety Blowdown and Flare system.

- **Safe Plant Operations**

  Common Hazards Associated with Process Plant to Avoid; Start-up Preparation & Procedures (Elimination of Air / Tightness Testing / Elimination of Water Etc.); Shut Down for Maintenance (De-inventory / Hydrocarbon Freeing / Positive Isolations Etc.); Dust Explosion; Electrical Safety; Management of Change (MOC); Pre-Start-up Safety Review (PSSR); Standard Operating Procedures (SOP); Static-Electricity, Pyrophoric Materials; Auto-ignitions plus control measures; Confined Space safe entry requirements.

- **Quantitative Risk Analysis**

  Consequences estimation for fire, explosion [TNO multi-energy model] and gas dispersion; Source term calculations; Frequency estimation using Event Tree Analysis; Common Preventive and Mitigation Measures to Reduce the Failure Frequencies; Concept of risk calculations [Individual Risk (IR), Location Specific Individual Risk (LSIR), Potential Loss of Life (PLL)] and Risk Criteria.

- **Safety Case**

  Concept of safety case; Identification of major accident hazards; Determination of major accident scenarios and safety critical events; Barrier and mitigation measures; ALARP demonstration.

- **Energy Conservation for Chemical, Process & Utilities Plants**

  Environmental Consideration (Emissions Evaluation and Permitting; Pollution Prevention and Mitigation; Waste Determination and Management); Energy Efficiency Assessment, Evaluation and Mitigation Measures for Carbon Emission Reduction; Process Optimization including Optimal Energy Consumption.

- **Relevant Legislation, Standards, Codes of Practices, Guidelines <u>(Based on latest applicable Legislation, Standards, Codes, Guidelines)</u>**

  - **<u>Legislation</u>**

    - Workplace Safety and Health Act

- Workplace Safety and Health (Major Hazard Installations) Regulations
- Workplace Safety and Health (General Provisions) Regulations
- Environment Protection and Management Act
- Fire Safety Act
- Gas Act

- **Standards and Code of Practices**
  - Singapore Standard CP 75 – Code of Practice for Gas Cylinders – Procedures for change of gas services
  - Singapore Standard SS 532 – Code of Practice for the storage of flammable liquids
  - Singapore Standard SS 537 – Code of Practice for the Safe Use of Machinery
  - Singapore Standard SS 568 – Code of Practice for Confined Spaces
  - Singapore Standard SS 586 – Specification for hazard communication for hazardous chemicals and dangerous goods
  - Singapore Standard SS 634 – Fire Safety for Open Plant Processing Facilities in Oil, Chemical and Process Industries
  - Singapore Standard SS 639-1 – Code of practice for the filling, inspection, testing and maintenance of gas cylinders for the storage and transport of compressed gases – Part 1: Seamless steel and aluminium alloy cylinders (excluding dissolved acetylene) – Inspection at the time of filling, periodic maintenance and testing
  - Singapore Standard SS 639-2 Code of practice for the filling, inspection, testing and maintenance of gas cylinders for the storage and transport of compressed gases – Part 2: Acetylene cylinders – Filling conditions and filling inspection
  - Singapore Standard SS 639-3 Code of practice for the filling, inspection, testing and maintenance of gas cylinders for the

storage and transport of compressed gases – Part 3: Acetylene cylinders – Periodic inspection and maintenance

- Singapore Standard SS 651 – Safety and Health Management System for the Chemical Industry
- Singapore Standard SS 667– Code of Practice for handling, storage and processing of combustible dust
- IP 15 – Hazardous Area Classification Guide
- IEC 61508 – Functional Safety of electrical/electronic/programmable electronic safety-related systems
- IEC 61511 – Functional Safety – Safety Instrumented Systems for the process industry sector
- API RP 505 – Recommended Practice of Classification of Location for Electrical Installations at Petroleum Facilities classified as Class 1, Zone 0, Zone 1 and Zone 2
- API RP 520 Part 1 & 2 - Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries
- API RP 521 - Guide for Pressure-Relieving and – Depressuring Systems
- API 580 - Risk-based Inspection
- API 610 - Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services
- API 617 - Centrifugal Compressor for Petroleum, Chemical and Gas Service Industries
- API 618 - Reciprocating Compressors for Petroleum, Chemical and Gas Industry Services
- API 619 - Rotary type Positive Displacement Compressors for Petroleum, Chemical, and Gas Industry Services
- API 650 - Welded Tanks for Oil Storage
- API RP 751- Recommended Practice for Safe Operation of Hydrofluoric Acid Alkylation Units
- API RP 754 – Recommended Process Safety Performance Indicators for the Refining and Petrochemical Industries

- API RP 2003 - Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents
- API RP 2219 – Safe Operation of Vacuum Trucks in Petroleum Service

- **Guidelines**
  - Safety Case Technical Guide
  - Safety Case Assessment Guide
  - ALARP Demonstration Guidelines: Single Scenario Risk Tolerability and Adequacy of Barriers
  - Guidelines on Safety Instrumented Systems in Major Hazards Installations
  - Guidelines on managing human factors in Major Hazards Installations
  - QRA Criteria Guidelines
  - QRA Technical Guidance
  - WSH Guidelines – Process Safety Performance Indicators

Sample Questions from Past Year Papers for Practice of Professional Engineering Examination Part 2 (Chemical)

Section 1 – Question 1 (28 marks) is COMPULSORY

(a) Safety Case for a Major Hazard Installation (MHI) is regulated under the Workplace Safety and Health (Major Hazard Installations) Regulations.

(i) List two circumstances where the occupier of an MHI is required to review the Safety Case.

(ii) List four minimum information that must be included in a Safety Case.

(iii) A factory stores 40 tonnes of ammonia gas and 10 tonnes of propylene oxide gas. Determine if the factory should be registered as an MHI. Show your working.

(b) The Predictive Aspects of the Safety Case requires the occupier of an MHI to conduct risk assessment and identify the Major Accident Hazards (MAHs) and Major Accident Scenarios (MASs) relevant to the installation and select Safety Critical Events (SCEs) for ALARP demonstration.

(i) Describe the approach to systemically select Safety Critical Events (SCEs) for ALARP demonstration.

(ii) List and explain 4 parameters which will quantitatively affect the consequences of MASs.

(c) The requirement for a pollution control study may be imposed on pollutive industries under the Environmental Protection and Management Act (EPMA).

(i) What are the objectives of carrying out a pollution control study?

(ii) What type of information is required to conduct a pollution control study?

(iii) State two control measures that are widely used by the industries to mitigate each of air, water and noise pollution.

Which Singapore Standard should be used as the reference towards fulfilling the pollution control study requirements?

Section 2 – Answer 4 Out 7 Questions (each at 18 marks)

Question 2

Chlorine is a highly toxic gas, and its release from a containment poses a significant risk of a major accident. Acute exposure to chlorine gas can lead to symptoms such as difficulty breathing (dyspnea), severe coughing, nausea, vomiting, corneal burns, or in severe cases, death.

Chlorine gas is being manufactured in a process plant. During an incident, 100 kg of chlorine is released from a vessel instantaneously. You may assume the release occurred at the ground level. A residential area is located 4 km away from the release source. Answer the following questions. You may refer to the information given below for this question.

(a) Using the probit correlation, determine the concentration of chlorine gas (mg m^{-3}) which could cause 8%, 30%, and 73% probability of death to persons, assuming an exposure duration of 30 minutes. List any other assumptions used. (The probit constants are: a = -6.35, b = 0.5, n = 2.75)

(b) Using an appropriate model, estimate the ground level centreline concentration of chlorine (mg m^{-3}) at the residential area under the worst case weather and stability conditions. Determine the probability of fatality for the residents using the probit correlation in part (a). State any assumptions used.

(c) Determine the maximum distance the gas cloud will travel before the concentration falls below 57 mg m^{-3}. Assume the same conditions as in part (b).

Additional Information

Probit Equation

$$Pr = a + b \times \ln (C^n \times t)$$

Pr = probit corresponding to the probability of death
a, b, n = constants describing the toxicity of a substance
C = concentration (mg m^{-3})
t = exposure time (minutes) (limited to around 30 mins)

Probit Table

P	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0	-	2.67	2.95	3.12	3.25	3.36	3.45	3.52	3.59	3.66
0.1	3.72	3.77	3.82	3.87	3.92	3.96	4.01	4.05	4.08	4.12
0.2	4.16	4.19	4.23	4.26	4.29	4.33	4.36	4.39	4.42	4.45
0.3	4.48	4.50	4.53	4.56	4.59	4.61	4.64	4.67	4.69	4.72
0.4	4.75	4.77	4.80	4.82	4.85	4.87	4.90	4.92	4.95	4.97
0.5	5.00	5.03	5.05	5.08	5.10	5.13	5.15	5.18	5.20	5.23
0.6	5.25	5.28	5.31	5.33	5.36	5.39	5.41	5.44	5.47	5.50
0.7	5.52	5.55	5.58	5.61	5.64	5.67	5.71	5.74	5.77	5.81
0.8	5.84	5.88	5.92	5.95	5.99	6.04	6.08	6.13	6.18	6.23
0.9	6.28	6.34	6.41	6.48	6.55	6.64	6.75	6.88	7.05	7.33

Source: Guideline for Quantitative Risk Assessment, Purple Book, 2005

Pasquill-Gifford Dispersion Model (*Source: Chemical Process Safety, Fundamentals with Applications, 2nd Edition, Daniel A. Crowl, Joseph F. Louvar, 2002*)

Pasquill-Gifford Dispersion Model for Puff with Instantaneous Point Source at Ground Level, Coordinates Fixed at Release Point, Constant Wind Only in x Direction with Constant Velocity u

$$C(x,y,z,t) = \frac{Q_{m^*}}{\sqrt{2}\pi^{\frac{3}{2}}\sigma_x\sigma_y\sigma_z} \exp\{-\frac{1}{2}\left[\left(\frac{x-ut}{\sigma_x}\right)^2 + \left(\frac{y}{\sigma_y}\right)^2 + \left(\frac{z}{\sigma_z}\right)^2\right]\}$$

Where Q_m* is the mass release rate (kg)

Atmospheric Stability Classes

Surface wind speed (m/s)	Daytime insolation[3]			Nighttime conditions[4]	
	Strong	Moderate	Slight	Thin overcast or >4/8 low cloud	≤3/8 cloudiness
<2	A	A–B	B	F[5]	F[5]
2–3	A–B	B	C	E	F
3–4	B	B–C	C	D[6]	E
4–6	C	C–D	D[6]	D[6]	D[6]
>6	C	D[6]	D[6]	D[6]	D[6]

Stability classes:
A, extremely unstable
B, moderately unstable
C, slightly stable
D, neutrally stable
E, slightly stable
F, moderately stable

Recommended Equations for Pasquill-Gifford Dispersion Coefficient for Puff Dispersion (the downwind distance x has units of meters)

Pasquill-Gifford stability class	σ_y (m) or σ_x (m)	σ_z (m)
A	$0.18x^{0.92}$	$0.60x^{0.75}$
B	$0.14x^{0.92}$	$0.53x^{0.73}$
C	$0.10x^{0.92}$	$0.34x^{0.71}$
D	$0.06x^{0.92}$	$0.15x^{0.70}$
E	$0.04x^{0.92}$	$0.10x^{0.65}$
F	$0.02x^{0.89}$	$0.05x^{0.61}$

Question 3

The Feyzin disaster occurred when an operator draining water from a 1,200 m^3 pressurised liquified petroleum gas (LPG) spherical tank, accidentally spilled LPG (taken to be propane). The resultant cloud of propane vapour spread, until it was ignited by a car on an adjoining road. The pool of propane in the bund caused the spherical tank to be engulfed in flames. The fire-fighters arrived on site but did not attempt to cool the burning spherical tank and instead concentrated their hoses on cooling the surrounding tanks. 90 minutes later, the sphere underwent a Boiling Liquid Expanding Vapour Explosion (BLEVE) event.

Properties of propane and other useful information

- Transmissivity, τ_a = 0.812
- Specific weight of propane: 585 kg/m^3
- Heat of combustion of propane, H_c = 46,350 kJ/kg
- Ambient Temperature = 298 K
- Ambient Pressure = 1 atm
- Fraction of the combustion energy radiated = 0.3

Note: Information in Annex may be useful in answering the question, refer to last 2 pages after end of Q8.

(a) Describe how a BLEVE event can occur.

(b) State 3 key hazards posed by a BLEVE event and 3 practical engineering measures that can be taken to minimise the risk of a BLEVE event occurring.

(c) Using the solid plume fire model, estimate the thermal radiation effects (in kW/m2) on the fire-fighters standing 50m away from the LPG sphere arising from the BLEVE fireball.

(d) Determine the percentage lethality for the fire-fighters standing 50m away using the thermal radiation level obtained in (c) and an appropriate probit model.

State all assumptions made clearly in your answers.

Question 4

You are the team leader for a project in your plant expansion and you are required to verify the works performed by your engineer. One of your engineers was given a task to design a wastewater treatment sedimentation system to remove suspended solids from the wastewater and he has 2 sedimentation tank proposals with the following dimensions:

- Rectangular Tank: 22.8 m long, 7.6 m wide and 3.6 m deep
- Circular Tank: 13.7 m diameter, 3.0 m deep
- The average flow rate for each tank is 10,000 m^3/per stream day.

Given terminal velocity equation:

$$v_{TSV} = \frac{(\rho_p - \rho_f) g D_p^2}{18 \mu_f}$$

V_{TSV} = terminal velocity, m/s

ρ_p = density of particle, 1200 kg/m^3

ρ_f = density of fluid, 1000 kg/m^3

μ_f = viscosity of fluid, 0.001 Ns/m^2

D_p = particle size (diameter), m

g = gravity acceleration, m/s^2 (available from handbooks)

(a) Calculate the overflow rate for both tanks (in m/s).

(b) Find the terminal velocity of a suspended solid with a particle size of 80 micron.

(c) If the suspended solid with the smallest particle size of 80 micron is introduced into both sedimentation tanks, based on the overflow rates of both tanks in part (a), discuss briefly which tank is more efficient in removing the suspended solids from water from the terminal velocity standpoint.

(d) Calculate the detention/holding time for both tanks (in hours).

(e) One of the major wastewater streams is collected from scrubbing water of a natural gas processing plant. During the risk assessment exercise of the wastewater sedimentation unit, 2 potential risks were identified, namely "Electric Shock - from the presence of high voltage equipment" and "Presence of Toxic Gases".

(i) Name 2 potential toxic gases present around the sedimentation tanks.

(ii) Describe 3 safety measures you would propose to the management to address each of the 2 risks identified.

Question 5

Businesses continuously evolve and adapt to address various challenges, such as technology advancements, regulatory shifts, or economic factors. Management of Change (MOC) provides a systematic approach to navigate these changes effectively. The primary objective of MOC is to ensure the safety of workers during transition phases.

(a) A disastrous accident at a cyclohexane plant that led to an explosion on 1 June 1974 is often quoted as a watershed event in process safety that has long been held as one of the big events that drove the concept of Management of Change (and Process Safety Management) forward. Briefly describe the incident and the changes that were made leading up to it.

(b) Name three essential elements necessary to support a successful execution of MOC?

(c) Describe in detail each of the three elements in part (b).

(d) Describe the workflow of the MOC process. You may use a flowchart to support your description of the process.

Question 6

Answer all the questions below.

(a) Voting logic for sensor subsystem and final element is used in the SIS design. List the hardware fault tolerances for each of the voting arrangements.

Voting Logic	Hardware Fault Tolerance

(b) A company requires a SIL 3 High Integrity Pressure Protection System (HIPPS) that has a pressure transmitter and a shutdown valve.

The company uses the following elements (sub systems):

Sensor	Transmitter (model X) IEC 61508 type B, Safe Failure Fraction SSF=80%
Logic Solver	SIL 3 rated Logic Solver
Final Element	Air controlled shut down valve (model Z) IEC 61508 type A, Safe Failure Fraction SFF=96%

Assumption: dangerous failure rates of all subsystems justify SIL 3 capability.

1. For the configuration of the SIS system (HIPPS) to comply with IEC 61508 Route 1H:

   (i) What is the required voting logic for sensors to meet SIL3?

   (ii) What is the required voting logic for final elements valve to meet SIL3?

   (iii) Draw the compliant SIF architecture block diagram.

2. For the configuration of the SIS system (HIPPS) to comply with IEC 61508 Route 2H:

   (i) What is the required voting logic for sensors to meet SIL3?

   (ii) What is the required voting logic for final elements valve to meet SIL3?

   (iii) Draw the compliant SIF architecture block diagram.

Tables extracted from IEC 61508 for Route 1H

Table 2 – Hardware Safety Integrity Architectural Constraints for Type A Safety – Related element or subsystem

Safe Failure Fraction	Hardware Fault Tolerance		
	0	1	2
< 60 %	SIL1	SIL2	SIL3
60 % - < 90 %	SIL2	SIL3	SIL4
90 % - < 99 %	SIL3	SIL4	SIL4
> 99 %	SIL3	SIL4	SIL4

Table 3 – Hardware Safety Integrity Architectural Constraints for Type B Safety – Related element or subsystem

Safe Failure Fraction	Hardware Fault Tolerance		
	0	1	2
< 60 %	not allowed	SIL1	SIL2
60 % - < 90 %	SIL1	SIL2	SIL3
90 % - < 99 %	SIL2	SIL3	SIL4
> 99 %	SIL3	SIL4	SIL4

Table for Route 2H (IEC 61508)

SIL		Minimum Hardware Fault Tolerance
1	any mode	0
2	low demand mode	0
2	high demand or continuous mode	1
3	any mode	1
4	any mode	2

Question 7

A spherical tank with a 16 m diameter is to be installed in a refinery tank-farm with the Bottom Tangent Line (BTL) of the tank held at 1.5 m from ground level. The tank is designed to store liquid n-butane (C_4H_{10}) and has a design pressure (DP) of 7 barg. A pressure relief valve (PRV) shall be provided on top of the storage tank for safety relief during fire exposure. The tank is not insulated.

Determine the following:

(i) Estimate the relieving vapour load (kg/h) to the PRV during a fire contingency.

(ii) Select the PRV type and calculate the orifice size (sq. mm) required of the PRV for the fire contingency.

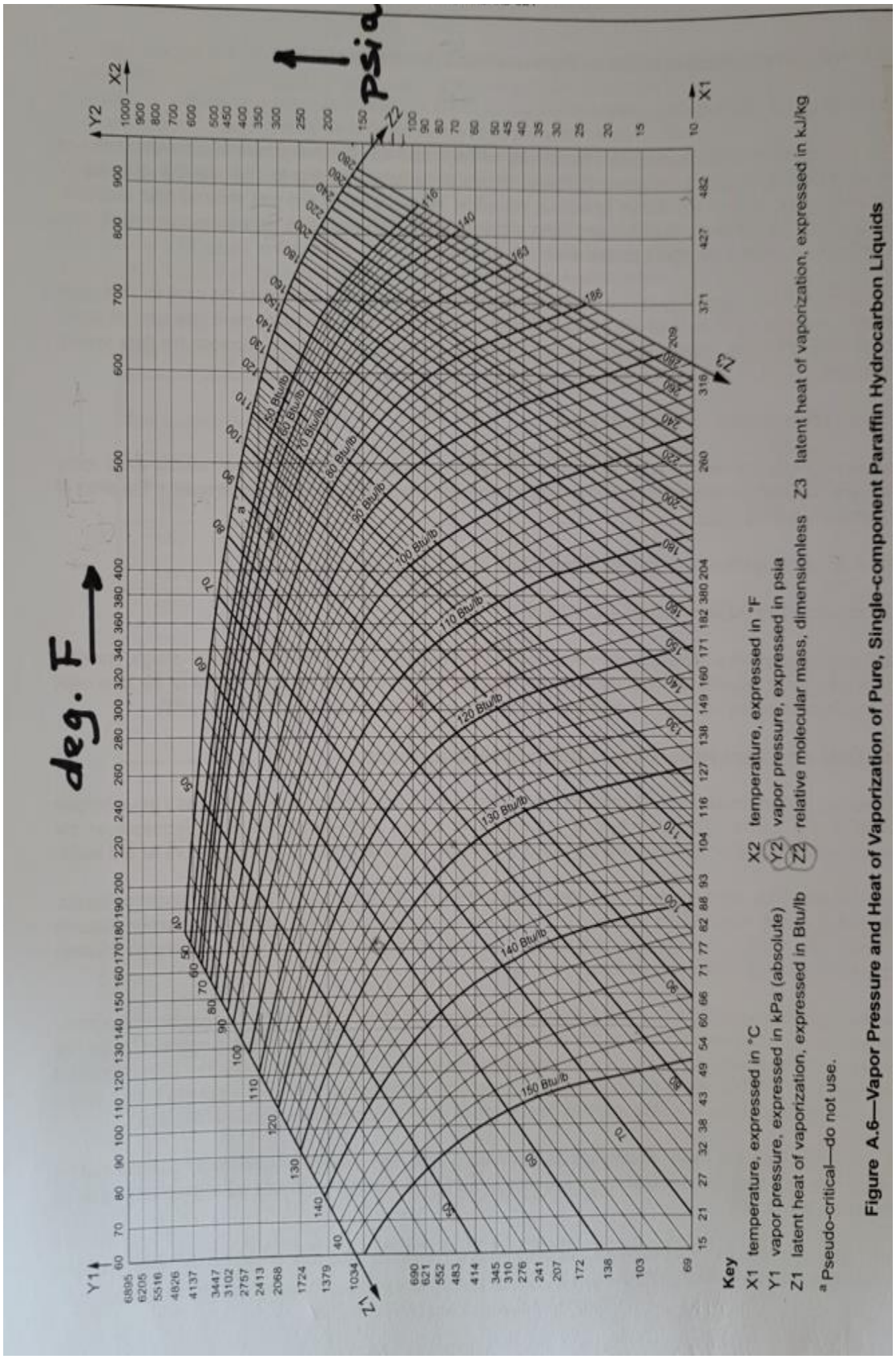
(iii) What maximum pressure drop (kPa) is allowed for the inlet piping to the PRV from the storage tank?

<u>The properties of n-butane are provided below:</u>

C_p/C_v ratio: 1.09
P_{cf}/P_1 ratio: 0.59
Gas compressibility under relieving conditions, Z: 0.80

Notes:

- Candidates can refer to API 520 (Parts I & II) and API 521 to facilitate the calculations.
- The chart for estimating latent heat of vaporisation of C_4H_{10} and the emergency temperature under fire exposure conditions are provided below. Candidates are advised to work using US customary units and convert the results back to metric units.



Key

X1 temperature, expressed in °C
X2 temperature, expressed in °F
Y1 vapor pressure, expressed in kPa (absolute)
Y2 vapor pressure, expressed in psia
Z1 latent heat of vaporization, expressed in Btu/lb
Z2 relative molecular mass, dimensionless
Z3 latent heat of vaporization, expressed in kJ/kg

[a] Pseudo-critical—do not use.

Figure A.6—Vapor Pressure and Heat of Vaporization of Pure, Single-component Paraffin Hydrocarbon Liquids