HKIA

Study Guide for HKIA Professional Assessment

Paper 4

Building Services and Environmental Controls

The Hong Kong Institute of Architects
香港建築師學會

This Study Guide is an online live document prepared by the HKIA Professional Assessment Committee. It will be regularly updated for improvement and refinement due to changes in codes and their interpretation and application.

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HKIA Professional Assessment Committee

Editorial team (HKIA):
John PL Wong, Ming Ho, Tony Ip, Zeth Ko

Vetting advisor:
Benjamín Ho

The Hong Kong Institute of Architects
19/F, 1 Hysan Avenue, Causeway Bay,Hong Kong

TABLE OF CONTENTS

SECTION A – BASIC PRINCIPLES

RECOMMENDED READING

Mechanical and Electrical Equipment for Buildings, 13th Edition; Walter T. Grondzik, Alison G. Kwok; Wiley, October 2017; pp. 115-136, 251-324, 1073-1176.
HKIA PA Paper 4 - Building Services and Environmental Controls, lecture handouts.

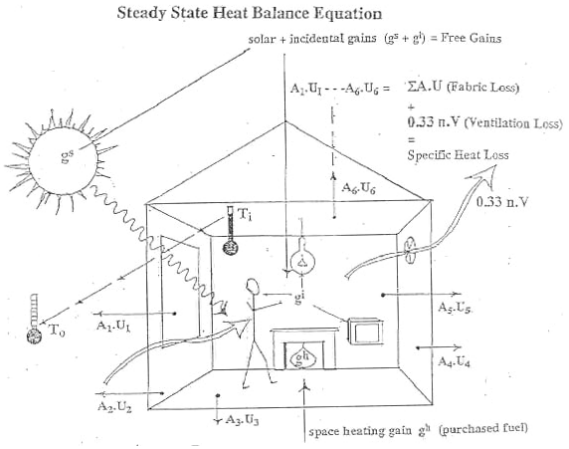
THERMAL COMFORTS & CONTROLS

Normal Human Comfort Levels:
Comfort may be defined as the 'sensation of complete physical and mental well-being'.

Thermal Neutrality – desires neither warmer nor a cooler environment.

ASHRAE – a 7-point scale comfort vote of thermal sensation: hot (+3), warm (+2), slightly warm (+1), neutral (0), slightly cool (-1), cool (-2), cold (-3).

Heat Balance Equation –

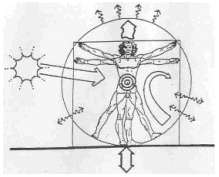


Design Considerations for Mechanical Systems:
Location: Hong Kong 22°18'N, 144°10'E
Outdoor Design Conditions:

Summer	Dry Bulb Temperature:	33°C
	Wet Bulb Temperature:	29°C
Winter	Dry Bulb Temperature:	10°C

FACTORS AFFECTING THERMAL COMFORT

Dry Bub Air Temperature (DBT) –
Indoor Design Conditions
Summer
Dry Bulb Temperature: 23°C ± 1°C
Relative Humidity: 50% nominal
Winter
Dry Bulb Temperature: 20°C ± 1°C



Relative Humidity (RH) – About **50%** is generally satisfactory. If the DBT in the space is optimum, the RH may vary from 30% to 65% without causing too much discomfort.

Sweating normally occurs above 70%; if below 30%, complaints may arise due to excessive drying of the mucous membrane.

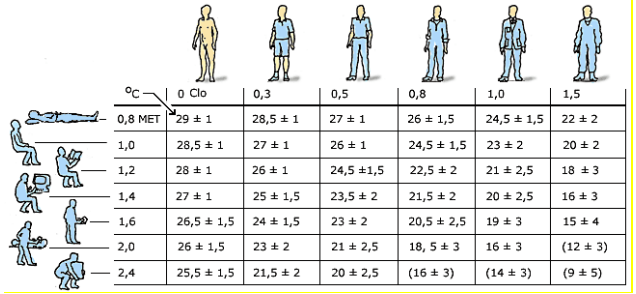
Adequate Air Movement in the vicinity of the occupants is achieved by proper air distribution. Air speed and the individual's activity will have significant impact on the convective heat exchanges and, subsequently, increase evaporation at the surface of the skin.

If air flow is too low, the environment tends to be oppressive, if too high there may be complaints of (cold) drafts.

Mean Radiant Temperature (MRT) is the average temperature of walls surrounding a given space. If the MRT is approximately the same as the indoor dry bulb air temperature (DBT), then the radiation effect on the indoor surfaces has little effect on human comfort.

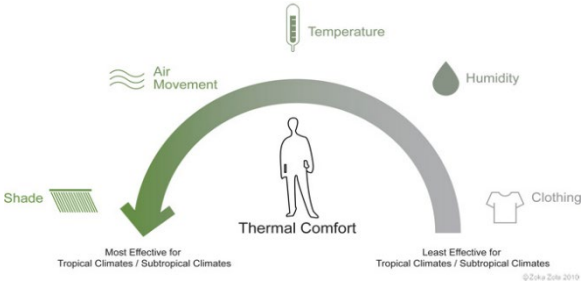
However, if the MRT (surface temperature of window glass and its immediate surroundings) is notably higher than the room air temperature, then radiant heat may result in the greenhouse effect and cause the room temperature to rise especially near to the window areas. This occurs particularly on the surface of the heat-absorbing glass, which can get very hot in summer and cold in winter. These adverse MRT effects can be offset by adjusting the local DBT of the room air at the perimeter of the building by re-zoning and/or realigning the air-conditioning outlets.

Clothing creates a thermal resistance to heat exchanges between the surface of the skin and the surrounding environment (from 0 *clo* without clothes to 3 *clos* in winter clothes, 1 *clo* = 0.155 k m²/W).



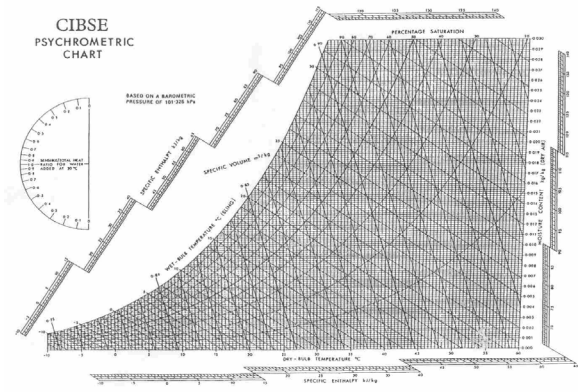
°C	0 Clo	0,3	0,5	0,8	1,0	1,5
0,8 MET	29 ± 1	28,5 ± 1	27 ± 1	26 ± 1,5	24,5 ± 1,5	22 ± 2
1,0	28,5 ± 1	27 ± 1	26 ± 1	24,5 ± 1,5	23 ± 2	20 ± 2
1,2	28 ± 1	26 ± 1	24,5 ±1,5	22,5 ± 2	21 ± 2,5	18 ± 3
1,4	27 ± 1	25 ± 1,5	23,5 ± 2	21,5 ± 2	20 ± 2,5	16 ± 3
1,6	26,5 ± 1,5	24 ± 1,5	23 ± 2	20,5 ± 2,5	19 ± 3	15 ± 4
2,0	26 ± 1,5	23 ± 2	21 ± 2,5	18, 5 ± 3	16 ± 3	(12 ± 3)
2,4	25,5 ± 1,5	21,5 ± 2	20 ± 2,5	(16 ± 3)	(14 ± 3)	(9 ± 5)

The **metabolism** represents the production of internal physical heat necessary to maintain the body at a constant temperature (36.9°C ± 0.5°C) and to compensate for losses to the atmosphere. It varies in accordance with the human activities from a basic metabolism of 45W/m² at rest increasing to 348W/m² when aerobic-dancing.

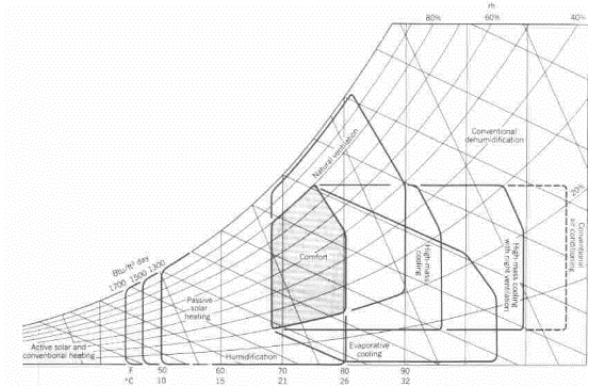


A **Psychrometric Chart** can be used to give a graphical representation of the thermodynamic properties of moist air, and the heat/mass transfer of air-conditioning processes.

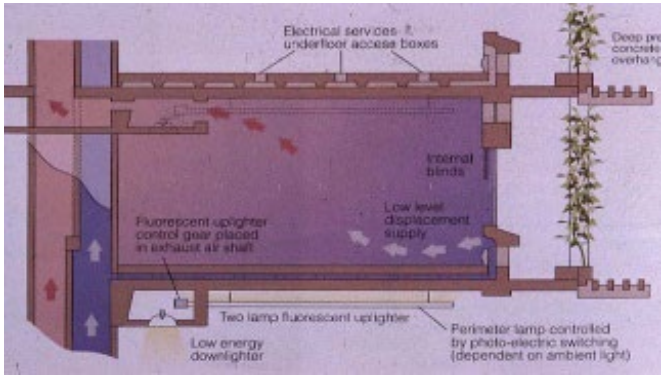
The human body naturally possesses a regulatory mechanism which instinctively adapts its heat losses to the thermal conditions of the atmosphere. These different parameters may be subject to slight variations, but without seriously affecting the degree of thermal comfort of the individual. All these parameters and their respective influences can be represented in a practical way by using the comfort chart which distinguishes the comfort zone and possibly the effects of other factors, such as ventilation or thermal inertia of the building.

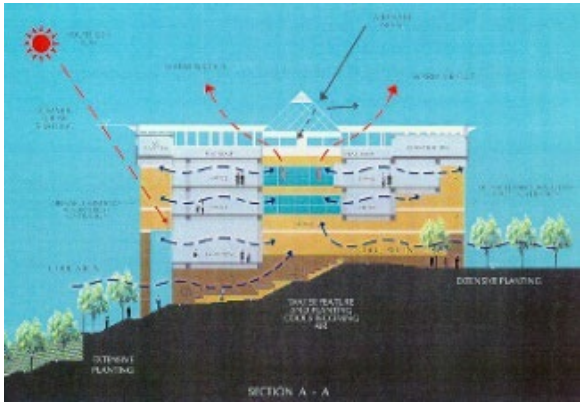


For M&E consultants, psychrometry is essential for air-conditioning design. The Psychrometric Chart, in which properties presented are dry bulb temperature, specific enthalpy, moisture content, wet bulb temperature, specific volume and percentage saturation, provides a graphical representation of the thermodynamic properties of moist air using the data listed in CIBSE Guide C.



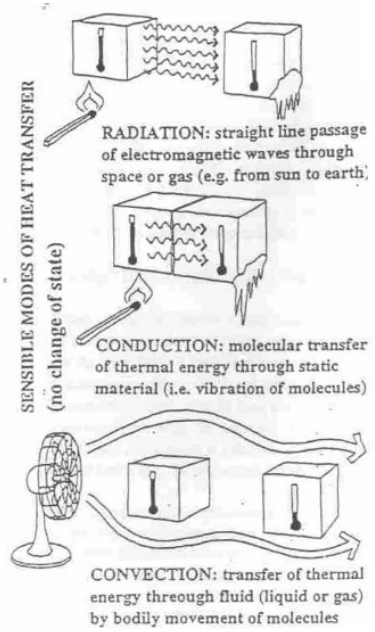
For architects, the **'Building Bio-climatic Chart'** as re-developed by Milne and Givoni (1979) outlines responsive design strategies for various climatic characteristics. For instance, natural ventilation as a passive design strategy can still maintain thermal comfort, even though the room temperature is up to 26°C - provided that relative humidity is kept at no higher than 50%.





BUILDING ENVELOPE PERFORMANCE & ENVIRONMENTAL CONTROLS

Heat transfer via:



Sensible heat is the kind of heat that increases air temperature, for example, heat generated from a light bulb or operating a photocopier.

Latent Heat is the kind of heat that, on top of raising air temperature, also increases the moisture content, e.g., boiling a kettle, taking a shower/bath, audience packed in a pop concert.

U-value (W/m²K) –
Thermal resistance of building materials is the transfer rate of heat through a structure, divided by the difference in temperature across that structure. The structure can be a single or a composite construction. A **lower** U-value represents a **better-insulated** structure – meaning a **higher thermal resistance** of the structure/material. The unit of measurement is W/m²K.

Typical U-value of windows:
6mm-thick clear glass: 4.8 W/m²K;
6+6mm-thick double glazing (air-filled): 3.1 W/m²K; and
6+6mm-thick double glazing (low E, εn = 0.05, argon-filled): 2.3 W/m²K.

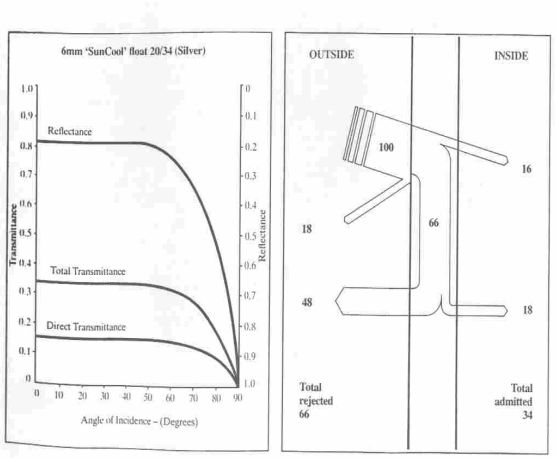
Shading Coefficient of Glass
The shading coefficient of a 6mm-thick single clear glass panel is three times higher than a reflective glass panel – meaning that the latter specification has a much higher capability of reflecting incoming solar radiation energy back into the atmosphere.

Glass Types		U-value (W/m²K)	Shading coefficient	Solar reflectance	Visible transmittance
Single	Clear	6.17	0.95	0.07	0.88
	Tinted	6.17	0.71	0.06	0.75
	Reflective	5.11	0.29	0.27	0.14
	Low-e	4.27	0.84	0.09	0.81

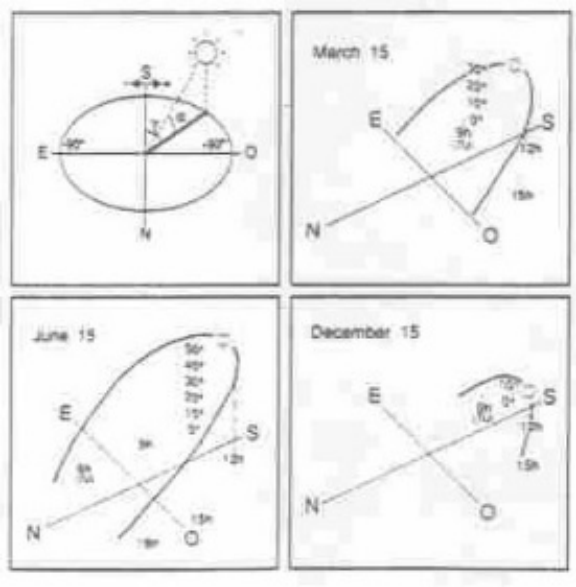
Source:
https://www.pilkington.com/~/media/Pilkington/Site%20Content/UK/Reference/TableofDefaultUValues.pdf

Solar Transmission and Transmittance
The sun's radiation which strikes on the windows of a building can be:

- **reflected** at the glass surface;
- **absorbed** by the glass / shading device (e.g., blinds installed in a double-glazed window); or
- **transmitted** directly into the occupied space.



Angle of Incidence is the angle between a ray incident on a surface and the line perpendicular to the surface at the point of incidence. This angle dictates the amount of solar radiation falling on the surface plane, which would be significantly reduced when the angle is greater than 50 degrees.



It is important for architects to undertake careful consideration of the Wall (window) Orientation factor (Gw) / Roof Orientation Factor (Gs), which measures the amount of solar radiation that is received in a specific orientation.

The table below highlights these factors for Hong Kong's climate over a period from April to October when air-conditioning is typically required.

Wall Orientation Factor (Gw)							
North	NE	East	SE	South	SW	West	NW
0.790	0.924	1.072	1.051	0.975	1.092	1.131	0.965
Roof Orientation Factor (Gs)							
2.16							

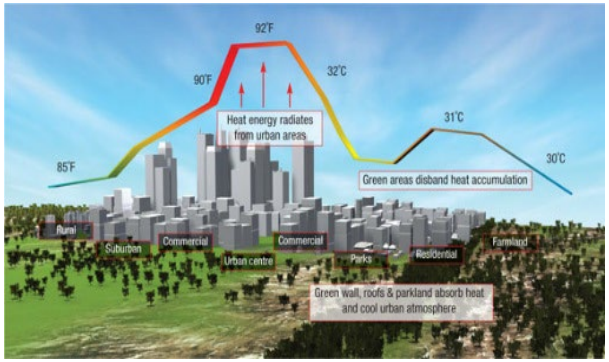
Source:
https://www.bd.gov.hk/doc/en/resources/codes-and-references/code-and-design-manuals/Guidelines_DCREERB2014e.pdf

Design features which include overhangs for the south façade and side-fins for east / west orientations are

effective devices under the external shading multiplier (ESM) in the OTTV computation.
Source:
https://www.bd.gov.hk/doc/en/resources/codes-and-references/code-and-design-manuals/OTTV1995_e.pdf

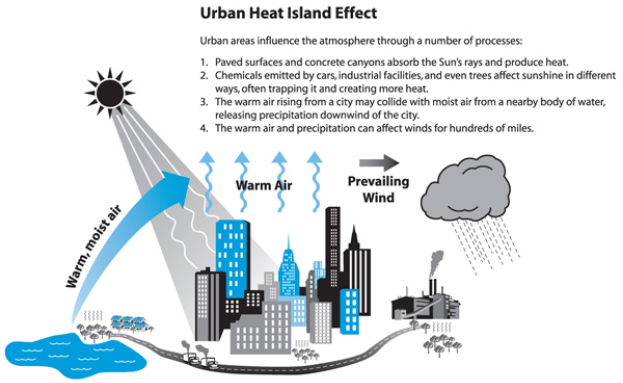
Urban Heat Island Effect occurs in densely populated areas, like Hong Kong and Los Angeles, where the air temperature is higher than the surrounding rural areas. The higher temperature difference in the urban areas is often because of the densely urban development / infrastructure, the change in land use and the anthropogenic heat.

It is often coupled with insufficient design attention to the seasonal urban breezeway and the micro-climate at the master-planning level, as well as the choice of building materials, vegetations (often inadequately provided) and the building massing at the project design stage – usually followed by excessive human development as the city continues to expand.



TOWARDS A CARBON NEUTRAL ENVIRONMENT

The Government launched a 'Green Hong Kong • Carbon

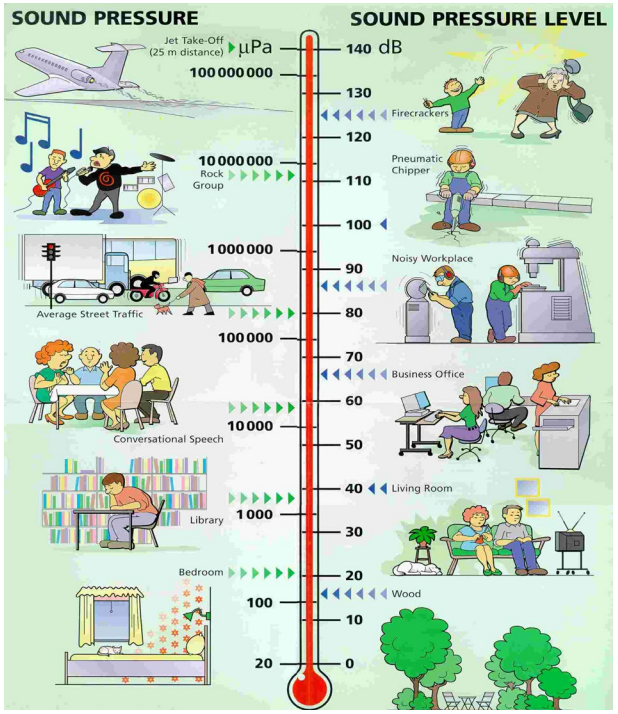


Audit' Campaign in 2018, where over 3,600 organisations have signed up for the 'Carbon Audit • Green Partners' by agreeing to a Carbon Reduction Charter:

- to conduct or to promote carbon auditing practices and
- to implement measures to reduce their carbon emissions for buildings.

Users and managers of buildings can now use the Government's first carbon audit guidelines to assess the carbon emissions from their buildings, explore room for improvement and develop emission reduction measures, so that their buildings can leave a smaller carbon footprint with less operating expenses through improving energy efficiency and waste reduction.

Ecological Footprint is a measure of human demand on the Earth's ecosystems. It compares human demand with Planet Earth's ecological capacity to regenerate. It represents the amount of biologically productive land and sea area required to regenerate the resources that the human population consumes and absorbs/renders harmless the corresponding waste. Using this assessment, it is possible to estimate how much of the Earth (or how many Planet Earths) it may take to support humanity if everybody continues to live in the current lifestyle.



Humanity's total ecological footprint in 2016 was estimated at 1.75 (Planet) Earths in accordance with the World Ecological Footprint Network.

In other words, humanity uses ecological services amounting to 1.75 times as fast as Earth can renew them. Every year, this number is recalculated - with a three-year lag due to the time it takes for the UN to collect and publish all the underlying statistics.

While the term ecological footprint is widely adopted, methods of measurement may vary. However, calculation standards are now emerging to make results more comparable and consistent.

ARCHITECTURAL ACOUSTICS

Decibel System is a sound pressure measurement (power per unit area), from scale zero (threshold of hearing) to 130 (painful sound).

The **inverse-square law** is a scientific law stating that a specified physical quantity (e.g. light and sound) is inversely proportional to the square of the distance from the source of that physical quantity.

In acoustics, the sound pressure of spherical wavefront radiating from a point source decreases by 50% as the distance *r* is doubled (measured in dB).

As the rule of thumb for a single homogeneous partition - Doubling of mass per unit area increases the Sound Transmission Loss (STL) by: *'6 db theoretically but by 5 db in practice'.*

However, the Mass Law does not apply evenly throughout the frequency range. In both high and low frequencies, there are variations due to the degree of stiffness of the partition.

Structure-borne Noise / Noise Criteria
Structure-borne noise is often more difficult to resolve than air-borne noise. In designing for recording studios and television studios, the use of floating slab and an increase of the thickness of the floor slab may usually help to isolate structure-borne noise.

Recommended **Noise Criteria (NC)** range for steady indoor background noise:

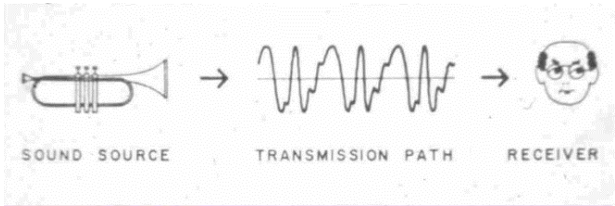
- Living quarters; NC 35-45
- Sleeping quarters; NC 25-35
- Office/classroom; NC 30-35
- Recording studio; NC 15-20

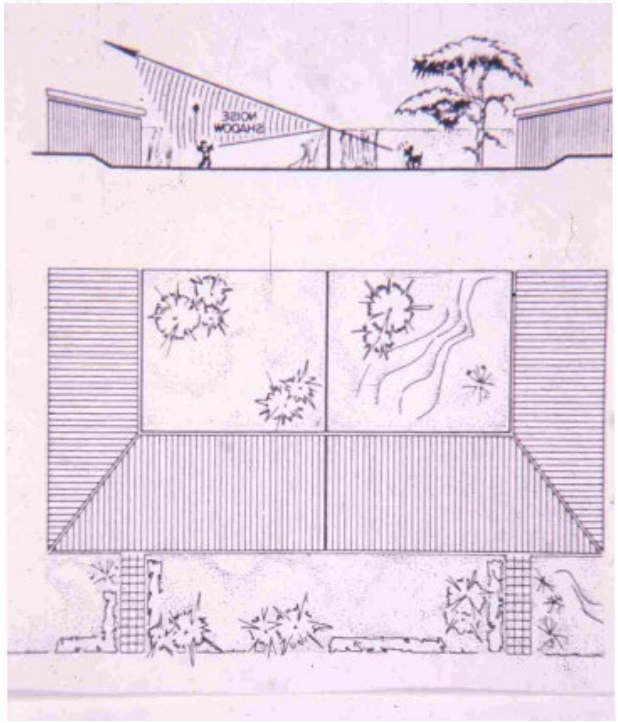
Mass and Stiffness
When a light air molecule strikes a barrier of large mass and rebounds elastically, most of the energy possessed by the molecule is retained by it. The massive wall will usually confine the air-borne sound energy.

Noise Mitigation Projects
In Hong Kong, the MTR (former KCRC) and the Highways Department had commenced many noises mitigation projects along selective railway tracks and highways during the 1990s. These noise barriers aimed to protect the receiver by intercepting the noise transmission path.

Unlike these noises mitigation (barrier) projects, architects are offered an opportunity at an early stage to master-plan the site for a new development by:

1. Distancing the sound source and/or reducing the sound source.
2. Intercepting the transmission path.
3. Selecting an appropriate receiver (space activity facing the sound source) that could tolerate a higher noise level.



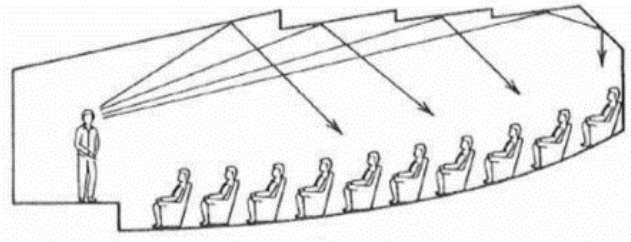


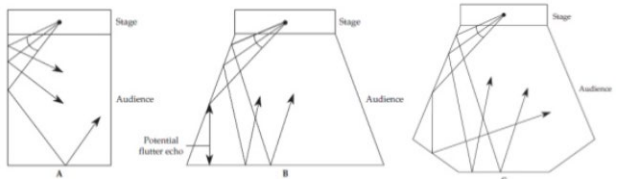
ARCHITECTURAL ROOM ACOUSTICS

This usually requires input from a specialist consultant for the design of concert halls, theatres for performing arts, lecture theatres and particularly multi-purpose auditoriums, in which direct and indirect transmission of sound must be carefully considered.

Sound emitted from a source will be reflected not only once, but several times within a confined space. If the inter-reflections continue for too long, the echo effect described above comes into effect for a multiplicity of reflected paths. Speech intelligibility will then suffer.

Room Acoustics (Geometry) originated from Greek amphitheatres, which were used for staging theatrical performances - enabling speech intelligibility for large audiences. As an evolution, smaller-sized, roofed versions of these theatres, called "Odeons" were subsequently constructed.





When designing for concert halls and large auditoriums, the **Reverberation Time** (RT) is based on the time taken for the sound level in the room to decay by 60 db. RT depends upon the volume of the room, and the amount of sound absorption given by the surfaces (surface/ materials absorption co-efficient).

Sound absorbents perform differently at different frequencies; thus, it is necessary to make separate calculations at the 500, 1000 and 2000 octave bands (in hertz).

Recommendations of reverberation time calculation:

$$\text{Reverberation time} = \frac{0.16 \times \text{volume in m}^3}{\text{total absorption } (\Sigma\ \text{m}^2 \times \text{absorption coefficient})}$$

Architectural acoustics in building design, for instance, should:

- Ensure adequate sound insulation / insulation of mechanical equipment rooms, cushioning the floor, suspending the ceiling, 'isolating' all services.
- Consider "Discontinuous Construction", e.g., floating floor for basketball courts.

CONCLUSION

Candidates should familiarise themselves with the following design aspects:

1. Thermal comfort of occupants – Fanger's model.
2. Six parameters affecting thermal comfort.
3. Mean radiant temperatures and dry bulb air temperatures.
4. Steady state heat balance equation.
5. Building bio-climatic charts and passive solar strategies.
6. Examples of heat transfer via conduction, convection, and radiation.
7. Long-wave and short-wave radiation through glazing.
8. Angle of incidence, long/short wave radiation, greenhouse effect.
9. Thermal resistance of building materials (U-value).
10. OTTV computation – wall orientation factor (Gw), roof orientation factor (Gs), external shading multiplier (ESM), solar factor (orientation).
11. Urban heat island effect and its remedial measures.
12. Ecological footprint and carbon footprint.
13. Decibel system and EPD's benchmark of relative specific construction activities and working hours.
14. Structure-borne, air-borne noise and remedial measures.
15. Inverse-square law (sound and light).
16. Noise criteria for various activities.
17. Noise mitigation strategies.
18. Room acoustics and design criteria for specific activities.
19. Factors affecting the reverberation time.

SAMPLE QUESTIONS

The following sample questions aim to assess candidates' understanding of this Section.
(Please note that these are extracted from *http://hkia.net/en/pdf/PA/Sample_Questions.pdf* and the Professional Assessment Seminars)

1. Which of the following are NOT effective means to reduce solar gain in office buildings in Hong Kong's climate?

(1) using double glazing
(2) reducing the size of the glazing panels
(3) using glazing products of a lower shading coefficient
(4) using glazing products of a higher shading coefficient

A. (1) and (2) only
B. (1) and (3) only
C. (1) and (4) only
D. (2) and (4) only
Ans: C

2. Given the same thickness of typical wall or roof construction, which of the following has the ***lowest*** value of transmission co-efficient (i.e., U value)?

A. concrete with cement sand plaster
B. brick with cement sand plaster
C. timber panel
D. metal panel with fibre glass
Ans: D

3. What is the unit for the thermal transmittance co-efficient, commonly known as U-value?

A. W/m^2
B. m^2K/W
C. W/m^2K
D. $KW/m^2 K$
Ans: C

4. Given concrete walls of the same thickness but different densities, which of the following has the highest value of transmission co-efficient (i.e., U-value)?

A. 2,240 kg/m^3
B. 1,600 kg/m^3
C. 1,300 *kg/m*
D. None of the above answers, as U-value is not related to wall density.
Ans: A

5. Which of the following actions may ***best*** help to maintain human comfort even in an increased indoor temperature?

A. Lowering the humidity
B. Re-circulating the air supply
C. Lowering the lighting intensity
D. Increasing the ventilation rate
Ans: A

6. What does the unit W/m^2K in respect of the performance of building materials refer to?

A. Shading coefficient
B. Energy efficiency ratio
C. Thermal transmittance
D. Life cycle assessment analysis
Ans: C

7. Which of the following can ***only*** generate "sensible heat" (rather than "latent heat") inside a building?

A. Coffee maker
B. Taking a shower
C. Heat generated by light bulb
D. Body heat generated by occupants
Ans: C

8. Which of the following is ***not*** a benchmark for environmental performance assessment?

A. LEED
B. BEAM
C. GBTools
D. Gini coefficient
Ans: D

9. Which of the following is fundamental in preventing the spread of legionnaires' disease in building services installations?

A. Using CFC refrigerants for chiller plants
B. Using single-stack drainage system to avoid cross contamination
C. Using water strainers to filter the incoming water at the supply mains
D. Carrying out regular inspection and maintenance to the water-cooled air-conditioning plants
Ans: D

10. Which of the following statements is ***incorrect*** in respect of Air Ventilation Assessment (AVA) Studies for a new building development?

A. Computational fluid dynamics analysis can check the wind permeabilities at different levels.
B. Wind tunnel test must be carried out on a scaled model in order to get a more accurate result.
C. Pedestrian comfort is the main objective of the AVA study.
D. Landscaping is not taken into account normally.
Ans: D

11. Which of the following is ***not*** conducive to enhancing the sound insulation property of a window?

A. Increasing the U-value of the window assembly.
B. Increasing the air gap width of double-glazed window.
C. Increasing the glass thickness of single-glazed window.
D. Using unequal glass thicknesses for the two glass panes of double-glazed window.
Ans: A

12. When the acoustics in an open office setting are of primary concern, which location of the following building components is a critical factor?

A. the electrical main distribution panel
B. water chillers for air-conditioning
C. the fire alarm annunciator panel
D. the fire protection system riser
Ans: B

13. Structure-borne noise, like the bouncing of a basketball in a ball court, can be most effectively insulated by ...

(1) providing a floating slab to the ball court.
(2) providing acoustic lining to the walls of the ball court.
(3) increasing the thickness of the floor slab of the ball court.
(4) using concrete of a lower density for the floor slab of the ball court.

A. (1) and (2) only
B. (1) and (3) only
C. (1) and (4) only
D. (2) and (4) only
Ans: B

REVISION QUESTIONS

1. What are the key components of the steady state heat balance equation? _____
2. Name the four environmental related factors that affect thermal comfort. _____
3. Name the two non-environmental related factors that affect thermal comfort. _____
4. In the building bio-climatic chart, state the range of room temperatures and relative humidity where passive natural ventilation design strategy is feasible. _____
5. State whether it is the long-wave OR short-wave radiation that has the capacity of penetrating through glass. _____
6. State whether it is the long-wave OR short-wave radiation that has the capacity of heating up the floor and wall after penetrating through glass. _____
7. Explain why the angle of incidence is so critical for the penetration of solar radiant heat through glazing into the interior. _____
8. State three other remedial measures (i.e., avoiding choosing dark paving) to alleviate urban heat island effect. _____
9. What is an ecological footprint? _____
10. What is a carbon footprint? _____
11. What is the inverse-square law and its relevance to the architectural acoustics? _____
12. State the NC for a living room. _____
13. State two methods to reduce structural-borne noise, when designing for a basketball court. _____
14. Which one of the three main design strategies is adopted in the construction of an acoustic noise barrier along railway tracks? _____
15. Explain why inappropriately designed reverberation time would affect the speech intelligibility for a large auditorium? _____

SECTION B – SUSTAINABLE DESIGN AND ENVIRONMENTAL ISSUES

BASIC CONCEPTS

BACKGROUND

Buildings accounts for 90% of energy consumption or 60% of greenhouse gas emissions in Hong Kong in the following context:

- High population density
- 42,000+ buildings in private sector
- 8,000+ high-rise buildings and skyscrapers
- People live and work in 24% of Hong Kong's total land area
- Average population density of built-up areas 27,330 persons/km^2 (Hong Kong's total land area: 1,110 km^2)

HONG KONG'S CLIMATE ACTION PLAN 2030+

Target

- Base year 2005
- 6.2 tonnes in 2014, <4.5 tonnes in 2020, 3.3-3.8 tonnes in 2030
- Absolute carbon emission reduction 20% in 2020, 26-36% in 2030
- Carbon intensity reduction target 50-60% in 2020, 65-70% in 2030

Adaptation - Blue-green Infrastructure

- Severe rainfall
- Sea level rise and coastal protection
- Sponge city
- Integrated drainage and flood management, including green roof, rain garden, retention lake, wetland, bioswale, water harvesting, eco-river channel, porous pavement, retention tank etc.

Adaptation - City Planning

- Strengthening urban fabric: new code of practice on wind effects; urban climatic planning; urban regeneration
- Smart city development

Adaptation - Water Security

- 6-pronged supply structure: local yield, seawater flushing, Dongjiang water, desalinated water, reclaimed water, and recycled greywater and harvested rainwater
- Water conservation

Adaptation - Conservation and Biodiversity

- Implementing Biodiversity Strategy and Action Plan (BSAP)
- Enhancing country parks and special areas
- Promoting sustainable farming and fisheries
- Enhancing biodiversity in urban environment

Resilience

- Preparing for emergencies
- Dealing with extreme heats
- Green finance
- Raising community awareness

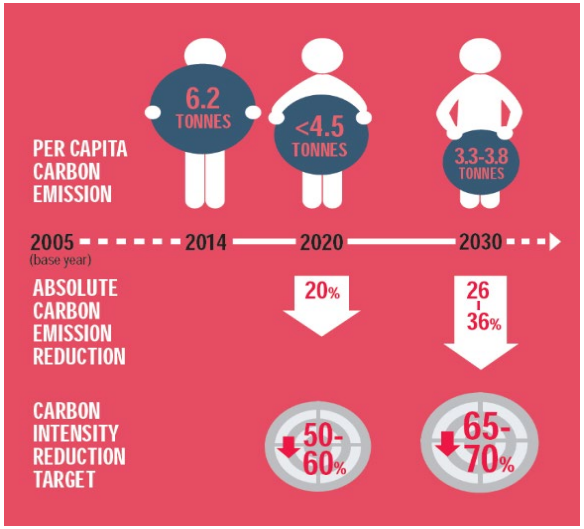
GREEN BUILDING

A **green building** is designed to minimise environmental impact on the ecosystem while achieving the required purposes and comfort levels for building occupants.

- A building that provides the specified building performance requirements while minimising disturbance to and improving the functioning of local, regional, and global ecosystems both during and after its construction and specified service life.
- A building that optimises efficiencies in resource management and operational performance, and minimises risks to human health and the environment, together with social equity and economic viability.
- In the context of HK's sub-tropical climate and dense high-rise development, a sustainable building should be designed to prioritise safety, health, well-being, comfort, functions, and efficiency.

Green Building Performances

- Hygiene, health, comfort, and amenity
- Land use, site impacts and transport
- Use of materials, recycling, and waste management
- Water quality, conservation and recycling
- Energy efficiency, conservation and management



https://www.climateready.gov.hk/files/report/en/HK_Climate_Action_Plan_2030+_booklet_En.pdf

SECTION B – SUSTAINABLE DESIGN AND ENVIRONMENTAL ISSUES

SUSTAINABLE SITE

SITE DESIGN

Sustainable Site Aspects include:
- Site location
- Site planning and design
- Emissions from the site

Site Design Appraisal demonstrates how various site aspects and architectural planning issues contribute collectively to the enhancement of the site and its surrounding neighbourhood.
- Detailed assessment of the climatic and topographic conditions immediate to the site.
- Examination of the orientation of buildings with respect to environmental conditions, overshadowing and views.
- Planning of building form in response to local environmental conditions, such as variation of the height of buildings, distances among and separation between buildings, in order to achieve better natural ventilation and daylighting.

SITE ECOLOGY

Ecological Impact to conserve and enhance the natural environment by protecting the ecological value of the site in terms of habitat and biodiversity and using brownfield sites.

Nature Conservation and Bio-Diversity Assessment Criteria include naturalness, habitat diversity, non-recreatability, species diversity and richness, and species rarity / endemism.

Landscaping and Planting
- Encourage building development to preserve or expand urban greenery to enhance the quality of living environment, reduce surface runoff to drainage systems and minimise impacts on fresh water and ground water systems during building use.

Sustainable Landscaping Strategies
- Enhance a site's microclimate (trees for shade and windbreaks, ponds and fountains, acoustic barriers, podium with gardens, etc.).
- Provide for efficient irrigation (efficient use of direct rainfall, plant selection, water retention, materials in walkways allowing percolation to sub-soil, using well water, drip irrigation systems, etc.).
- Control surface run-off (roof ponds, holding tanks, semi-permeable surfaces in open areas, etc.)

Landscape Treatment of The Development
- Compliance with existing legislation and administrative measures relevant to preservation of vegetation, including the felling of trees;
- Trees retained, replanted or removed, and work undertaken to protect existing trees both during construction and in operation;
- Site formation with specific details of slope treatment;
- Choice of finishes in qualitative terms for all hard landscaping elements, indicating any perceived or quantifiable environmental benefits;
- Planting plans with the character and planting densities for all soft landscaping elements, details of the species used, and assessment of environmental benefits;
- The adequacy of soil depth and drainage for all planted areas;
- The method of irrigation used and source of water supply; and
- Future maintenance provisions.

SITE MICRO-CLIMATE

Urban Microclimate ensures the microclimate around and adjacent to buildings has been considered and, where appropriate, suitable mitigation measures are provided.

Wind Amplification considers that air ventilation at pedestrian zones is desirable at an average 1.5m/s breeze. No pedestrian areas shall be subject to excessive wind velocities caused by amplification due to the site layout and/or building design. Such velocity should not exceed an average "hourly mean wind speed" of 4 m/s.

Elevated Temperatures

- Providing shade of at least 50% of non-roof impervious surfaces on the site (parking, walkways, plazas) using light-coloured, high-albedo materials (albedo of at least 0.4).
- Providing roof material that meets the solar reflectance index (SRI) of 78 or vegetation roof covering at least 50% of the total roof area.

DAYLIGHT & LIGHT POLLUTION

Neighbourhood Daylight Access preserves daylight and views to neighbouring sensitive buildings. Sensitive buildings are defined as follows:

- Residential buildings;
- Premises that require daylight to enhance the lighting environment for the occupants to perform tasks, such as offices and schools;
- Premises that require daylight for energy saving and an improved environment for the transient stage of occupation, such as the circulation area of shopping centres and indoor games halls; and
- Premises that require daylight primarily for view, such as hotels and hospitals.

Change in the access to daylight may be objectively assessed in terms of the change in vertical daylight factor (VDF) [either unchanged or is no less than 12%,] on the façades of sensitive receivers, or change in viewing angle [reduced by less than 5%], whichever is deemed most appropriate.

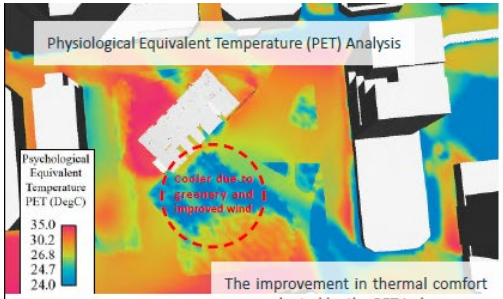
Light Pollution is regarded as waste light from lighting schemes that produces glare, obscures the night sky, affects adversely nocturnal ecosystems and may intrude on neighbouring properties.

Measures are considered to ensure that exterior lighting does not create unwanted and unnecessary light pollution.

HISTORICAL CONTEXTS

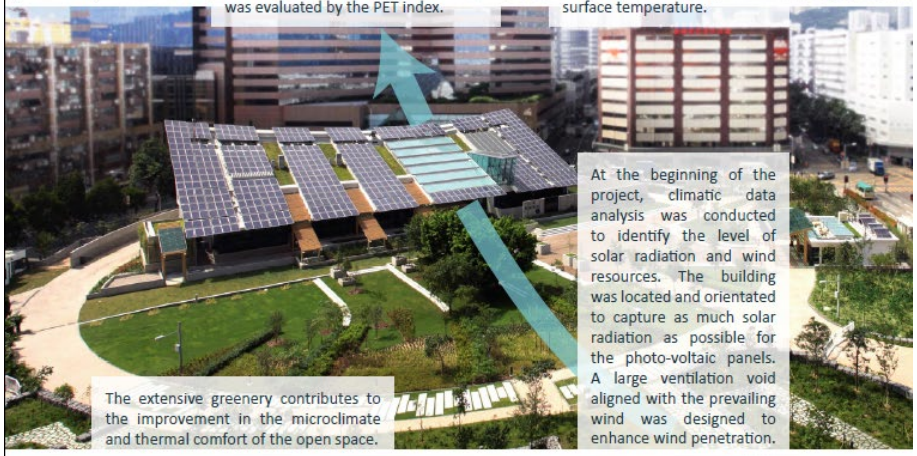
Cultural Assets (Intangible Heritage)
Cultural assets may include practices, places, expressions of community and customs that are passed down from one generation to another. Old trees may also be considered a form of cultural assets.

Cultural Heritage (Tangible Heritage)
The establishment of cultural heritage is to conserve and protect archaeological remains, historic buildings and monuments so as to maintain the local and regional cultural heritage which contains archaeological, historical and religious values. Cultural heritage provides a means of knowing and interpreting social, cultural and economic changes and broadening our understanding of the past. It also provides a focus for community identity, from which a sense of belonging to Hong Kong could be fostered in the communities.



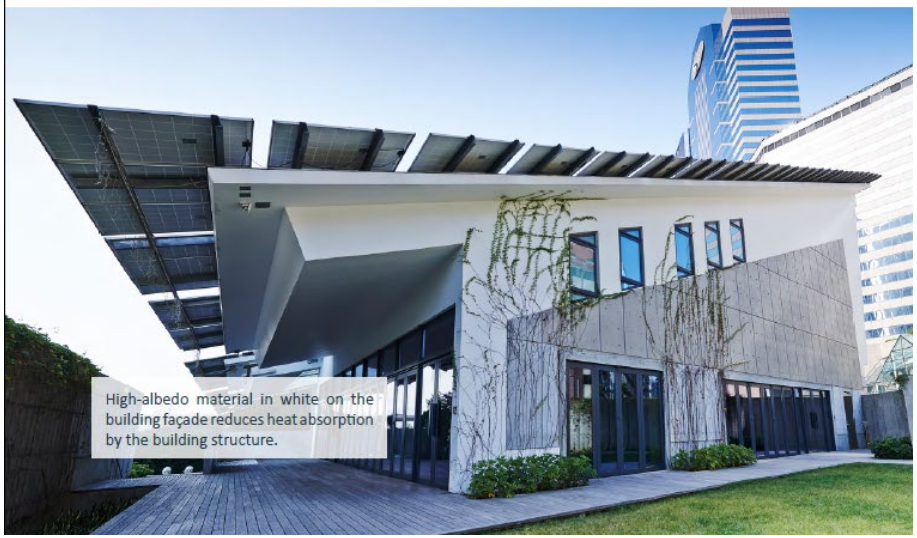
The improvement in thermal comfort was evaluated by the PET index.

Permeable paving helps lower surface temperature.



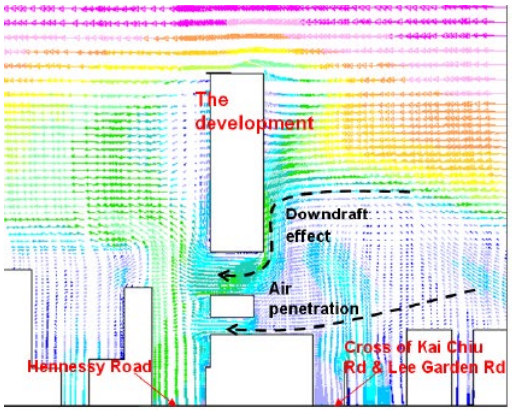
The extensive greenery contributes to the improvement in the microclimate and thermal comfort of the open space.

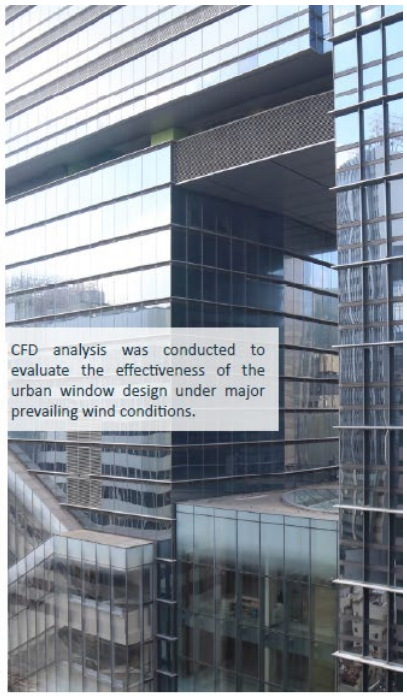
At the beginning of the project, climatic data analysis was conducted to identify the level of solar radiation and wind resources. The building was located and orientated to capture as much solar radiation as possible for the photo-voltaic panels. A large ventilation void aligned with the prevailing wind was designed to enhance wind penetration.



High-albedo material in white on the building façade reduces heat absorption by the building structure.

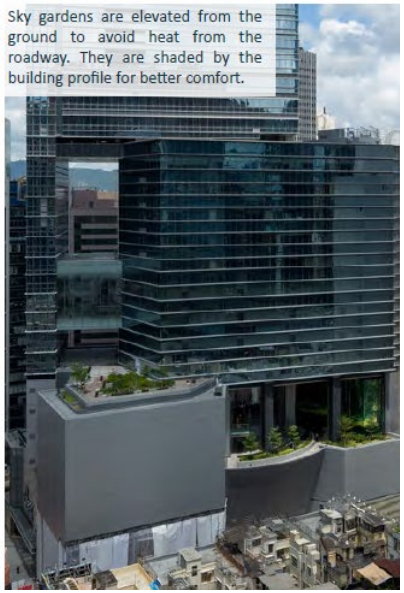
Source: CIC Zero Carbon building – *"HKGBC Guidebook on Urban Microclimate Study" p.88*
https://www.hkgbc.org.hk/eng/engagement/file/UMC_Guidebook_amended_reduced.pdf





CFD analysis was conducted to evaluate the effectiveness of the urban window design under major prevailing wind conditions.

The three openings in the building structure act as urban windows for wind to penetrate high up from the ground.



Sky gardens are elevated from the ground to avoid heat from the roadway. They are shaded by the building profile for better comfort.

Source: Hysan Plan – *"HKGBC Guidebook on Urban Microclimate Study" p.94*
https://www.hkgbc.org.hk/eng/engagement/file/UMC_Guidebook_amended_reduced.pdf

SECTION B – SUSTAINABLE DESIGN AND ENVIRONMENTAL ISSUES

ENERGY CONSERVATION

PRINCIPLES

Passive Design Means should be implemented as the first priority and they include:

- Enhancement of daylight access
- Natural ventilation design
- Behavioural changes

Active Systems with high efficiency should then be specified as a needed supplement to the passive design means. Examples include efficient air-conditioning units, efficient lighting fixtures, low-flow water taps, etc.

Renewables should be considered holistically and prudently. Some renewable energy systems are not energy efficient for the time being because the energy used to manufacture the system is greater than the energy it generates over its lifetime.

PASSIVE DESIGN MEANS

Orientation and Solar Access

- Site planning and building operation
- Envelope heat transfer
- Natural ventilation
- Daylight design
- Glare

Daylight and View

To maximise daylight intake and optimise views, large glazed windows or glass walls could be installed on the north-facing façades of buildings.

Natural Ventilation

To enhance natural ventilation effectiveness, building orientation shall be carefully decided as it affects the amount of prevailing wind passing through.

Solar Heat Gain

Orientating the building's long side to face north and south, while minimising the frontage on the east and west sides, will help minimise solar heat gain by the building.

Glare

Avoid siting skylights and glazed areas to face west will prevent problems caused by glare.

ENERGY EFFICIENT BUILDING LAYOUT

Design Principles include:

- Consideration of built form and building orientation to enhance energy conservation;
- Consideration of optimal spatial planning to enhance energy conservation;
- Consideration of building permeability through provision of building features to enhance the effectiveness of natural ventilation;
- Provision of fixed or movable horizontal/vertical external shading devices; and
- Provision of movable external shading devices for major atrium façade windows and skylights.

Stack Effect

Cool air is denser and hence heavier, while hot air is less dense and thus lighter. The force of air movement is determined by the extent of climate differences and the height of the enclosure.

BUILDING ENVELOPE

Building Envelopes in Hong Kong should be designed to minimise solar heat gain. This reduces summer cooling loads and associated energy consumption.

OVERALL THERMAL TRANSFER VALUE (OTTV)

The OTTV calculation methodology was published in 1995 by the Buildings Department for commercial buildings. It is an indicator of the thermal performance of building envelopes.

OTTV considers the following factors:

- Orientation;
- Window-to-wall ratio;
- Glazing specification (shading coefficient);
- Solar shading;
- Wall configuration (overall u-value, thermal mass and outer absorptivity); and
- Roof configuration (overall u-value, thermal mass and outer absorptivity).

RESIDENTIAL THERMAL TRANSFER VALUE (RTTV)

Energy Efficiency for Residential Buildings
Residential developments should have an average solar irradiation of 395 kWh/m^2 from April to October inclusive. The peak solar irradiation occurs towards the west.

The compliance with the following design and construction requirements is one of the pre-requisites for the granting of GFA concessions under PNAP APP-151:

- $RTTV_{Wall} \leq 14$ W/m^2 and $RTTV_{Roof} \leq 4$ W/m^2;
- $OTTV_{RRF} \leq 24$ W/m^2 (tower) or 56 W/m^2 (podium) as calculated in accordance with the CoP for OTTV in Buildings 1995 and PNAP APP-104;
- The extent of compliance with NVTC requirements (i.e., % of area of habitable space complying with the Guidelines on NV_{TC}) should be submitted to BD; and
- $VLT_{Glass} \geq 50\%$ & $ER_{Glass} \leq 20\%$. The VLT requirement is only applicable to the glass installed in the prescribed windows referred to in B(P)R 30 and 31.

Guidelines on Design and Construction Requirements for Energy Efficiency of Residential Buildings focus on:

- new residential buildings;
- energy efficiency/ use related to design and construction of building fabric; and
- energy efficiency/ use in operational phase.

However, there are several challenges in Hong Kong:

- Rising energy consumption trend in residential sector leading to increased carbon emissions
- The carbon challenge: residential sector accounts for 25% of total electricity consumption (the second largest sector) in Hong Kong
- Humid sub-tropical climate: design for thermal comfort:
  (i) air movement; and
  (ii) solar shading control
- Densely built context: concerns about Environmental Conflicts:
  (i) air quality
  (ii) noise pollution
  (iii) heat emission, etc.

Residential Thermal Transfer Value (RTTV) is the average heat gain per unit façade / roof area:

Key Difference between RTTV and OTTV

- Default operation and occupancy patterns for residential buildings
- Independent suitable values for roof and wall

RTTV Exclusions

- Internal shading devices, such as draperies and blinds;
- Solar reflection or shading from adjacent developments; and
- Use of energy-efficient building services equipment and appliances.

Daylight and Glare Control

- Visible Light Transmittance (VLT) ≥ 50%
- Glass External Reflectance (ER) ≤ 20%

NATURAL VENTILATION FOR THERMAL COMFORT (NV_{TC})

Cross Ventilation Layout
The cross-ventilation path between the primary and secondary ventilation openings should consist of no more than two straight lines (one turn only), from the middle of one window to another. The angle of turn for the cross-ventilation path at the joint of the two lines must be no greater than 90°.

The cross-ventilation path must be less than 12m in length for each habitable space. The total aggregate openable window size should not be less than one-eighth (1/8) of the usable floor area of the room.

Single-Sided Ventilation Layout
The depth of habitable spaces should not be more than 4.5m, measuring from the centre of openable windows. Only windows meeting the 4.5m room depth limit will be counted for the openable area calculation.

The total aggregate openable window size should not be less than one-fifth (1/5) of the usable floor area of the room.

Heat Emission from Air-Conditioners
Heat emissions from air-conditioning units of a residential unit should be at least 1.5m below and horizontally apart from ventilation openings and a common boundary of an adjoining site.

ACTIVE SYSTEMS

Examples of Energy Efficient Active Systems

- High-volume-low-speed (HVLS) Ceiling Fan: a patented air-foil and winglet design that moves a large volume of air at a slow speed. As a result, airflow is increased and discomfort is dismissed as humidity is reduced at a higher rate of evaporation. The acceptable temperature for inhabitants is raised by 2 degrees Celsius with an air flow of 0.5m/s, thus energy saving can be achieved.
- Desiccant Dehumidification: instead of overcooling the supply air to achieve dehumidification, a desiccant wheel handles the dehumidification process separately from the cooling system. Desiccant is dried by recovered heat from the Combined Cooling Heating and Power (CCHP) system.
- Chilled Beams and Under-floor Displacement Cooling: a high temperature cooling system with chilled beams and under-floor displacement cooling is used. In convective cooling, cooled air is distributed from the floor with a higher supply temperature and lower air speed. The system operates at higher chilled water temperatures and avoids another reheating process. For radiant cooling, chilled beams cool and absorb heat from inhabitants and spaces, requiring less pump and fan energy to deliver cooling.

RENEWABLE ENERGY OPPORTUNITIES

Renewable energy resources include biomass, hydro energy, geothermal energy, solar energy, wind energy, ocean thermal energy, wave energy and tidal action.

Solar Energy System

- Photovoltaic (PV) Systems
- Solar Thermal Systems
- Daylight Systems

Photovoltaic Systems

PV systems includes PV panels, thin film photovoltaic (TFPV) panels and building-integrated photovoltaic (BIPV) panels.

Solar Thermal Systems

Solar thermal systems includes solar hot water preheating system that uses vacuum-tube hot water solar panels.

Daylight Systems

Daylight systems includes light pipes which are used for transporting or distributing natural light.

Case study of Zero Carbon Building:

Optimise Window to Wall Ratio (WWR)

To optimise natural ventilation and control of heat gain/glare/daylight, appropriate ratios of window to wall areas are achieved. For north-west and south-east façades of the office area, a high WWR is obtained with fritted glass, external shades, and large operable windows for cross ventilation.

High Performance Glass Wall System

The two main window systems for the office area are a high performance glazing system incorporating low-emissivity coated glass panels, and actuator controlled operable windows. A reduction in energy consumption is expected from lower cooling loads and reliance on artificial lighting due to good thermal and optical performance. Energy use for dehumidification would be reduced by good air-tightness.

External Solar Shading

Vertical shading fins on the north-west façade maximise the penetration of natural daylight and blocks low angled sun in the late afternoon. Solar heat gain is reduced with better glare control.

Figure 3.1.18 Exterior of Zero Carbon Building
(Source: Hong Kong Construction Industry Council)

Case study of Hysan Place:

Solar-shading devices

Angled vertical fins were added to the west façade to block the late afternoon summer sun, and were angled, slightly pointing northwest to better block direct sunlight and avoid blocking views to the harbour. The horizontal fins in addition to the vertical fins were also found to improve the overall shading, especially on summer days. The horizontal fins also added to the internal illumination of the west side, functioning as external light shelves.

Low-emissivity double-glazing

Allows sufficient visible light to enter the building while reducing unwanted solar heat gain and exterior noise at the same time.

Daylighting Glazing	Vision Glazing
CSG-8 FVR 1-59 + 12A + 8C	CSG- 8 CEF 11-38 + 12A + 8C
VLT: 55%	VLT: 42%
Ref: 30%	Ref: 34%
SC: 0.42	SC: 0.35

Figure 3.1.19 Solar-shading devices
(Source: Hysan Development Company Limited)

Case study of Hong Kong Science and Technology Park:

Low Energy Façades

- high performance low-E double glazing allows daylight to enter whilst controlling solar heat gains
- optimise window to wall ratio (40%) to balance views, visibility and daylighting whilst reducing solar gains
- external solar shading devices reduce cooling demand by controlling the penetration of heat from the sun
- highly insulated façades minimise heat gains through walls

Motorised Sun Louvres

- solar tracking louvres automatically adjust to minimise solar gains to the entry lobbies

Figure 3.1.20 Smart louvers
(Source: Hong Kong Science and Technology Parks Corporation)

Case study of Energizing Kowloon East Office:

Window to Wall Ratio

Reduce cooling demand via:

- Optimise window to wall ratio (~20%) to reduce solar heat gain
- Insulate envelope using rock wool (U-value of wall: 0.83 vs EMSD's reference input 3.3, i.e. 75% reduction in thermal transmission)

Figure 3.1.21 Elevation of Energizing Kowloon East Office
(Source: Energizing Kowloon East Office)

Source: *"HKGBC Green Office Guide" p.34-35* *http://hkg-training.hkgbc.org.hk/green_office_guide/eng/files/assets/basic-html/index.html#34-35*

SECTION B – SUSTAINABLE DESIGN AND ENVIRONMENTAL ISSUES

MATERIAL CONSERVATION

PRINCIPLES

Sustainable Material and Waste Aspects include:
- Selection of materials
- Efficient use of materials
- Waste disposal and recycling

Selection of Materials
- Rapidly renewable materials
- Certified sustainable materials
- Recycled materials
- Ozone depleting substances
- Regionally manufactured materials

Efficient Use of Materials
- Building reuse
- Modular and standardised design
- Prefabrication
- Adaptability and deconstruction

Material Selection
- Highest recycled content and minimal virgin materials
- Minimal environmental impact during production and throughout its life
- Not only recycled, but recyclable/ biodegradable at the end
- Durability & low maintenance

Design for Adaptability
- Adjustable
- Versatile
- Refitable
- Convertible
- Scalable
- Movable

Life Cycle Assessment (LCA)
LCA is an environmental evaluation tool in which all impacts arising from the manufacture, use and disposal of a product or service are quantified. These impacts include all extractions from (i.e., resources) and all emissions to (i.e., pollution) the environment throughout the whole life cycle of a product or service.

Life Cycle Costing (LCC)
LCC is an economic evaluation tool in which all costs arising from creating, owning, operating, maintaining, and disposing of a project are quantified.

MATERIALS OF RECYCLED CONTENTS

The **use of recycled materials** aims to reduce the consumption of virgin resources:
- Pre-consumer recycled materials vs post-consumer recycled materials
- Material of recycled contents vs material to be recyclable

Building Façade and Structural Components
- Pulverised Fuel Ash (PFA) as a partial cement replacement in concrete. (PFA content is often no more than 25%)
- Ground Granulated Blast-furnace Slag (GGBS) as a partial cement replacement in concrete (GGBS content is usually no more than 40%)

Non-structural Materials
- Carpet made from old carpet/ recycled-content fibre
- Recycled-content rubber flooring made of plastic bottles & tyres
- Recycled plastic lumber from recycled-plastic and wood chips for outdoor decking
- Floor tiles / paving blocks with recycled glass from disposed bottles

REGIONAL MATERIALS

Use of regional materials will reduce costs, energy use in transportation and the associated pollution, while supporting the local economy.

The point of raw materials and manufacture shall be located:
- within an 800km radius by road transportation;
- within a 1,600km radius by rail transportation; or
- within a 4,000km radius by sea transportation.

RAPIDLY RENEWABLE MATERIALS

Rapidly renewable materials are materials that grow faster than traditional extraction demand (i.e., planted and harvested in less than a 10-year cycle), such as bamboo, cork, natural linoleum, soybean composite, strawboard, sunflower seed and wheatboard, and would not incur significant biodiversity loss, increased erosion, or impact on air quality.

LOW-EMITTING MATERIALS

Harmless Materials

- Use zero and low volatile organic compound (VOC) / formaldehyde (HCHO) products
- Use non-chlorofluorocarbons (non-CFC)/ non-hydrochlorofluorocarbons (non-HCFC) based refrigerants
- Avoid extensive use of granite and marble finishes which emit radon (Rn). Rn is a colourless radioactive gas that increases the risk of lung cancer.

Reduced PVC Content

Polyvinyl chloride (PVC) products can usually be found in electrical cables, furniture components, floor coverings, blinds, finishes etc.

- Its degradation has potential to cause irritating respiratory illness by emitting harmful gases
- Production of PVC may release a toxic chemical, dioxin, into the air, which may pollute water and land.
- Toxic by-products are produced during burning of PVC.
- When PVC reaches the end of its life cycle and is disposed of in a landfill, it again leaks dioxin and heavy metals.

GREENHOUSE GASES

Greenhouse gases are gases (carbon dioxide, water vapour, methane, nitrous oxide, ozone, and various fluorocarbons) that blanket and circle the Earth, preventing solar radiation from being reflected back into the space.

Global warming potential (GWP)

GWP is a relative measure of how much heat a greenhouse gas is trapped in the atmosphere.

Ozone depletion potential (OZP)

OZP is the relative amount of degradation to the ozone layer caused by a chemical compound.

CERTIFIED GREEN PRODUCTS

- **Forest Stewardship Council (FSC)** certification is a certification system for sustainable timber use.
- **CIC Green Product Certification** (HK G-PASS / CIC Carbon Labelling Scheme) refers to locally certified green products for construction. (*http://cicgpc.hkgbc.org.hk/nindex.php?lang=en*)
- **HKGBC – Eco-Product Directory** refers to eco-friendly products with local or overseas certifications. (*http://epdir.hkgbc.org.hk/index.php?lang=en*)

Design for Durability and Resilience

Material selection and adequate protection of exposed building elements aim to minimise the frequency of replacement and maximise materials optimisation.

WASTE DISPOSAL & RECYCLING

Case study of Hong Kong Green Building Council Office:

Materials with High Recycled Content

Figure 3.1.33 Gypsum block wall
(Source: Hong Kong Green Building Council)

Gypsum Block

The gypsum blocks are made from recycled waste from power plants.

In future, when the wall is demolished, the gypsum can also be recycled for other uses.

Figure 3.1.34 Movable partition
(Source: Hong Kong Green Building Council)

High Recycled Content Partition

Movable partitions used in a conference room could contribute to BEAM Plus certification credits. The product contains a high percentage of post-industrial and consumer recycled materials.

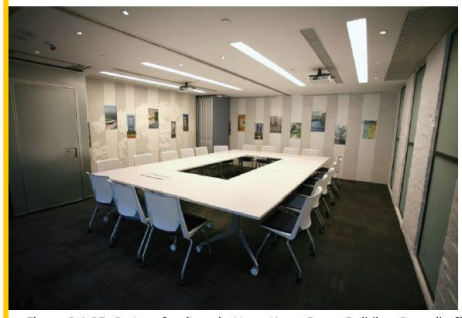


Figure 3.1.35 System furniture in Hong Kong Green Building Council office
(Source: Hong Kong Green Building Council)

System Furniture

System furniture used allows standard size factory built and assembled components to be used. It could also benefit both quality and environmental costs.

Chair with Recycled Content

- 50% recycled contents
- Perforated back, feel cool

Source: *"HKGBC Green Office Guide" p.44*
http://hkg-training.hkgbc.org.hk/green_office_guide/eng/files/assets/basic-html/index.html#44-45

Case study of Jones Lang LaSalle Pacific Place Office:

Renewable Material

Use of green materials e.g., renewable wood materials/FSC certified wood.

Decorative wall of reception counter.

Figure 3.1.38 Decorative Wall of Jones Lang LaSalle Pacific Place Office

Case study of Hong Kong Green Building Council Office:

Renewable Material

Reception counter, pantry cabinets & shelves in the office are made of FSC plywood and covered with bamboo veneer.

Figure 3.1.39 Louvre of Hong Kong Green Building Council
(Source: Hong Kong Green Building Council)

Source: *"HKGBC Green Office Guide" p.46*
http://hkg-training.hkgbc.org.hk/green_office_guide/eng/files/assets/basic-html/index.html#46-47

SECTION B – SUSTAINABLE DESIGN AND ENVIRONMENTAL ISSUES

WATER CONSERVATION

PRINCIPLES

Green Building Systems for Water Use include:
- Water quality for health and wellness
- Water conservation
- Effluent discharges

Water Efficient Devices
- High-efficiency devices include low-flow-rate faucets (water taps) or faucets with aerated flows.
- Automatic shut-off devices are spring-loaded (or push-once) taps, electronic proximity sensors, etc., but excluding timed shut-off devices.
- Use of water efficient facilities and appliances certified under the Water Efficiency Labelling Scheme (WELS).

Grey water
Grey water refers to domestic wastewater generated in households or office buildings from streams without faecal contamination. In a building, grey water is the water leftover from baths, showers, hand basins, kitchen sinks, floor drains, etc.

Black water
Black water is wastewater from toilet and urinal that contains faeces, urine and flushing water, etc. Black water is usually drained using a separate system. It should be treated separately before being discharged.

WATER RECYCLE

Potential end use of treated grey water and rainwater ("reclaimed water"):
- Toilet flushing
- Drip irrigation
- Sprayed irrigation
- Water features
- Car washing
- External cleaning
- Firefighting
- Industrial processes

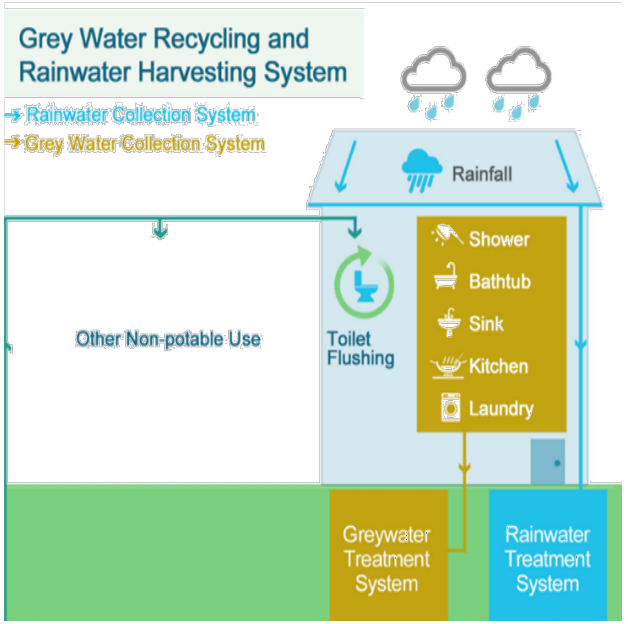
Treated greywater and rainwater ("reclaimed water") shall be **prohibited** from being:
- consumed by humans or animals
- used for bathing or showering
- used to top up swimming pools or spas
- used for food preparation or washing dishes or kitchen appliances
- used for irrigating in any way that will affect edible parts of herbs, fruit, or vegetables
- piped to hot water services

Monitoring & Control for Water Conservation

- Installation of devices to monitor water leakage from the freshwater distribution systems without embedded plumbing pipework
- No water pipe will be embedded in load-bearing structural elements
- Pipework protected by a sleeve and embedded in a non-structural element is acceptable
- Water leakage detectors such as infrared or moisture detector should be provided

WATER-EFFICIENT IRRIGATION

- The use of an irrigation system which does not require the use of municipal fresh water after a period of establishment
- Highly efficient irrigation technology that would incorporate the use of harvested rainwater and recycled grey water to reduce freshwater consumption for irrigation
- Irrigation by lower quality (harvested or recycled) water can be equally effective.
- Native plants can survive without additional watering, and require less fertilisers and pesticides, thereby reducing impacts on local water.



Grey Water Sources	Rainwater Sources	Potential End Use After Treatment
• Wash basins • Baths • Showers • Dishwashers • Laundry machines • Kitchen sinks • Air conditioning condense	• Roofs • Permeable paving • Non-permeable paving • Surface runoff from grass and landscaped areas	• Toilet flushing • Drip irrigation • Sprayed irrigation • Water features • Car washing • External cleaning • Fire fighting • Industrial processes

Case study of Hong Kong Green Building Council

A dual flush sensor promotes best practice in water economy (short or long flush) and hygiene in toilets.

Reduction of water for flushing-20,000m³/year.

Figure 3.3.32 Water saving fixtures in office pantry
(Source: Hong Kong Green Building Council)

Figure 3.3.33 Dual flush sensor
(Source: Hong Kong Green Building Council)

To protect the environment, no bottled water is used.

The selected dispenser has OASIS® Quick Change Filtration and is NSF certified under Standards 42 and 53 with carbon filtration, lead, cyst and Volatile Organic Compound (VOC) reduction media.

Using a water-saver outlet to reduce excessive discharge from the faucet and achieve up to 84% in water savings.

Hand washing sensor reduces potable water for pantry use and hand washing-4,500m³/year.

Figure 3.3.34 Hand Washing Sensor
(Source: Hong Kong Green Building Council)

Water Recycling

Overview for Office Building

To enhance water economy, some of the water discharged by the building can be recycled so that fresh water consumption can be reduced. Water recycling schemes include, but are not limited to, recycling rain water, greywater, condensate water, cooling tower bleed-off water and fire services water.

BEAM Plus NB V1.2 WU 4

Harvesting of rainwater shall lead to a reduction of 5% or more in the consumption of fresh water.

Recycled greywater shall lead to a reduction of 5% or more in the consumption of fresh water.

Figure 3.3.35 Rainwater recycling system

Benefits of Green Office Building

- Reduce water demand on water main
- Reduce cost of water usage
- Reduction in the amount of fresh water needed for sewage conveyance
- Reduction in the total amount of fresh water drawn from natural water bodies
- Similarly a reduction in the volume of sewage entering the public sewage infrastructure

Green Strategies for Office Building

- Recycle rainwater for irrigation or cleansing uses
- Recycle grey water from low contaminated waste water in office
- Recycle air conditioning condensate for flushing use
- Recycle cooling water bleed-off for flushing use
- Recycle waste water during fire services system annual inspection for cleansing

Case study of Hysan Place:

Rainwater Collection System.

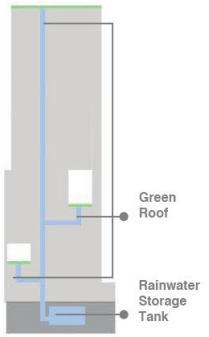
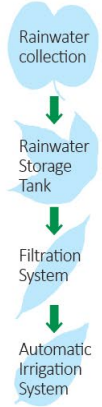


Figure 3.3.36 Rainwater collection system



Rainwater Harvesting System makes use of rainwater collected on green roofs, exterior walls and at ground level for non-potable and safe use purposes. A rainwater harvesting system has a significant effect on the reduction of potable water used for irrigation.

Source: *"HKGBC Green Office Guide" p.98-99* *http://hkg-training.hkgbc.org.hk/green_office_guide/eng/files/assets/basic-html/index.html#98-99*

SECTION B – SUSTAINABLE DESIGN AND ENVIRONMENTAL ISSUES

INDOOR ENVIRONMENTAL QUALITY

PRINCIPLES

Indoor Environmental Quality (IEQ) includes the following aspects:

- Safety
- Hygiene
- Indoor air quality and ventilation
- Thermal comfort
- Lighting
- Acoustics and noise
- Building amenities

Comfort level

Comfort is an expression of satisfaction with the environment in terms of thermal, lighting and acoustic factors.

Thermal comfort

- Environmental factors: air temperature, humidity, air movement, radiant temperature
- Personal factors: activity, clothing

Lighting comfort

- Distribution / uniformity
- Illuminance
- Glare
- Daylight

Acoustics comfort

- Background noise
- Room acoustic
- Noise isolation

ROOM ACOUSTICS

Office type premises

The reverberation time of the "A-weighted" sound pressure level, in modular (private) offices and conference rooms, shall be 0.6s or below. The noise assessment criterion shall be NC 40.

Classrooms and similar premises

The reverberation time of the "A-weighted" sound pressure level in teaching rooms, other than specialist teaching rooms such as laboratories and workshops, shall be 0.6s or below. The noise assessment criterion shall be NC 35.

Residential premises, hotels and apartments

The reverberation time of the "A-weighted" sound pressure level, in bedrooms and living rooms, shall be between 0.4 and 0.6s. The noise assessment criterion shall be NC 30.

Indoor games halls, indoor swimming pools and the like

The reverberation time of the "A-weighted" sound pressure level, in indoor game halls, indoor swimming pools or other recreational premises, shall be 2.0s or below. The noise assessment criterion shall be NC 45.

NOISE ISOLATION

Office premises

- Between two offices Dw = 38 dB minimum
- Where privacy is important: Dw = 48 dB
- Noise Isolation Class (NIC) of at least 40 for cellular offices

Classrooms

Walls between classrooms on the same floor:
≥ **Sound Transmission Class** (STC)-37
Floors between classrooms on adjoining floors:
≥ STC-50 and Impact Insulation Class IIC-46

Residential premises

- Bedroom to living room: STC-46 (same residential unit)
- Bedroom to bedroom: STC-52, IIC-52 (between residential units) and STC-44 (same unit)
- Living room to living room: STC-52, IIC-52 (between residential units)

DAYLIGHT

Daylight factor (DF)

The percentage ratio of the instantaneous illumination level at a reference point in the interior space to that occurring simultaneously outside in an unobstructed position (%).

Average Daylight Factor

<2%	The interior is not well lit by daylight / full electric lighting often needed during daytime.
2%-5%	The windows give a predominantly day-lit appearance but supplementary electric light is needed. This is usually the optimum range for daylight and for overall energy use.
>5%	The interior is sufficiently lit by daylight / daytime electric lighting rarely needed. Major thermal problems may result from large windows.

Case study of Hysan Place:

Light Shelves

Careful considerations were made to obtain a balance between optimal views and best use of natural light on the one hand and to keep energy consumption low on the other, thus it can reduce the HVAC and lighting energy consumption and enhance the thermal comfort level of the occupants in the perimeter zone.

Custom-designed 'Light Shelves' with a profiled reflective ceiling reflect daylight deep into the interior of each office while offering a magnificent panorama of the harbour along the north side of each office floor. The light shelves reduce glare and excessive lighting in the perimeter zone of the office, whilst reducing contrast with the interior.

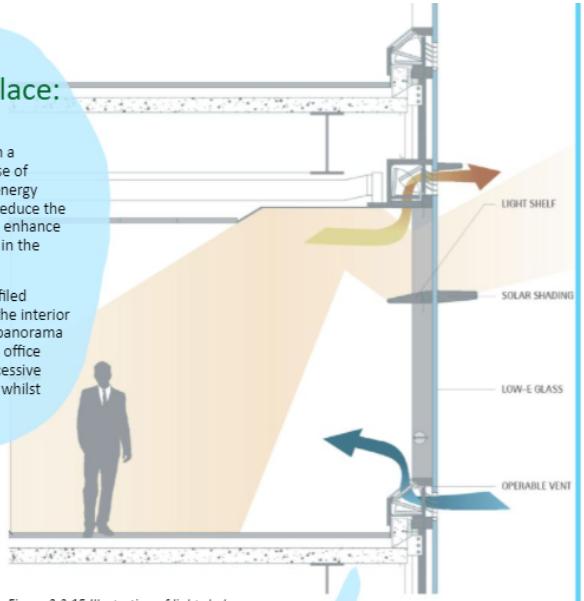


Figure 3.2.15 Illustration of light shelves
(Source: Hysan Development Company Limited)

Case study of 18 King Wah Road:

Sun Shading Device

Sun shading tackles the low angle of the afternoon sun. The sun shade extends outwards but also downwards to help mitigate the effects of the harsh afternoon sun. By bringing the shading device downwards, the maximum amount of surface area can be protected without jeopardising the view. On the other hand, during the morning hours, the sun is at a higher angle in the sky. The sunshade at the southwest corner extends out to block the higher early morning and mid-day sun. The sunshade can also extend in a horizontal direction, which helps to bring indirect lighting into the space, without affecting the view of the outside.

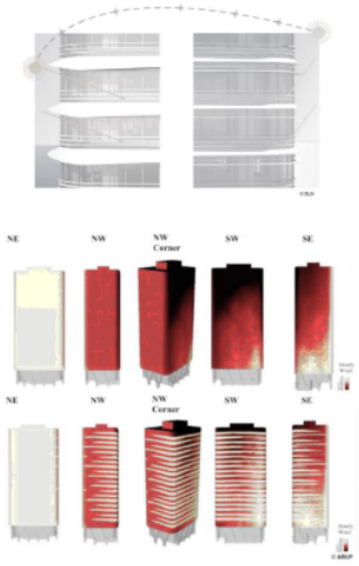


Figure 3.2.16 Effect of façade
(Source: Henderson Land Development Company Limited)

Source: *"HKGBC Green Office Guide" p.66*
http://hkg-training.hkgbc.org.hk/green_office_guide/eng/files/assets/basic-html/index.html#66-67

Case study of Hysan Place:

Operable Vent

In the right external conditions, occupants can open top and bottom operable vents along the perimeter zones of the office floors, then the combined wind and stack effect will enable occupants to enjoy natural ventilation. The vents provide a healthier and more comfortable environment for staff working after-hours or contractors doing fitting out work. Occupants may enjoy natural ventilation during the transition season or non-office hours according to their own comfort and ventilation requirements.

Figure 3.2.8 Perimeter air vent
(Source: Hysan Development Company Limited)

Figure 3.2.9 Illustration of natural ventilation
(Source: Hysan Development Company Limited)

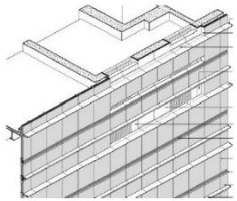
Outdoor Conditions	Operation Mode	Under Automatic Control	
		Operable Vents (except 33/F, 37-38/F)	Air-Handing Units (AHUs)
21°C- 23°C or above	Normal	Close	Normal
16°C- 20°C and Relative Humidity (RH) <75%	Mode 1	Open	• Free Cooling • Variable Air Flow
15°C or below	Mode 2	Open or Partially Open (avoid over-cooling)	• Free Cooling • Variable Air Flow

Mixed Mode Ventilation

Mixed Mode Ventilation combines natural ventilation (via operable vents) and mechanical ventilation/ air conditioning to provide and enhance occupants' comfort on office floors. Once the vents are opened, unnecessary air conditioning to individual perimeter zone will be automatically switched off without wasting energy. The effective area benefiting from natural ventilation would be a 5m deep space behind the façade.

Free Cooling System

Free Cooling System or Economize Cycle uses oversized air handling units and air ducts. Outside fresh air will be used for direct space cooling without using cooling towers during the right outdoor conditions, distributing a higher air volume at faster speed to enhance the thermal comfort level for occupants.



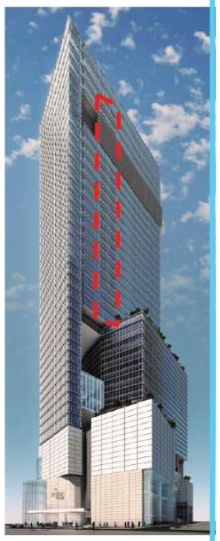


Figure 3.2.10 Mixed mode ventilation
(Source: Hysan Development Company Limited)

Source: *"HKGBC Green Office Guide" p.62*
http://hkg-training.hkgbc.org.hk/green_office_guide/eng/files/assets/basic-html/index.html#62-63

SECTION B – SUSTAINABLE DESIGN AND ENVIRONMENTAL ISSUES

GREEN BUILDING ASSESSMENT SCHEMES

BEAM PLUS

BEAM Plus offers independent assessments of building sustainability performance in Hong Kong. It is recognised and certified by the Hong Kong Green Building Council (HKGBC). It consists of a comprehensive set of performance criteria related to the planning, design, construction, commissioning, fitting out, management, operation and maintenance of a building under the following assessment aspects.

- **Integrated Design and Construction Management** encourages the project team to enhance communication with stakeholders and adopt an integrated design approach throughout green building design and construction stages.
- **Community Aspects** focus on the socio-economic impacts of the development on the neighbourhood to enhance the surrounding built environment, local character and social identity.
- **Sustainable Sites/ Site Aspects** are about the location, design, infrastructural provisions and basic amenities of a building or a development.
- **Green Building Attributes** are about selecting a BEAM Plus certified building or adopting best practices in operations.
- **Management** concerns responsible management practices and provisions to encourage sustainable management of occupied areas.
- **Materials and Waste Aspects** encourage waste reduction and efficient use of materials of lesser environmental impacts.
- **Energy Use** relates to low energy design, energy efficiency practices and adoption of renewable energy.
- **Water Use** emphasises the adoption of water efficient devices and practices, reduction of water uses and quality of potable water.
- **Health and Wellbeing, Indoor/ Outdoor Environmental Quality** encompasses various environmental aspects of indoor/ outdoor environment which have an impact on the health, comfort or well-being of the occupants and neighbours, including daylight access, air quality, ventilation, and thermal comfort.
- **Innovations and Additions** give credits to projects with innovative designs that enhance environmental performance; and projects with superior performance that greatly exceed the prevailing requirements in the assessment.

BEAM PLUS NEW BUILDINGS (NB)

BEAM Plus New Buildings covers the demolition, planning, design, construction, and commissioning of new building projects. It can also be applied to major renovations, alterations, and additions. Based on BEAM Plus NB version 2.0, the assessment of a new building's performance covers:

- Integrated Design and Construction Management
- Sustainable Sites
- Materials and Waste Aspects
- Energy Use
- Water Use
- Health and Wellbeing
- Innovations and Additions

BEAM PLUS EXISTING BUILDINGS (EB)

BEAM Plus Existing Buildings measures the actual performance of a building and evaluates its facility management practices. The assessment covers all aspects of management, operation and maintenance. Based on BEAM Plus EB version 2.0 (Comprehensive Scheme & Selective Scheme), the assessment of an existing building's performance covers:

- Management
- Site Aspects
- Materials and Waste Aspects
- Energy Use
- Water Use
- Indoor Environmental Quality
- Innovations & Additions

BEAM PLUS INTERIORS (BI)

BEAM Plus Interiors covers the design and construction of fit-out, renovation and refurbishment work in non-domestic, occupied spaces. Based on BEAM Plus BI version 1.0, the assessment of an interior's performance covers:

- Green Building Attributes
- Management
- Materials and Waste Aspects
- Energy Use, Water Use
- Indoor Environmental Quality
- Innovations and Additions

BEAM PLUS NEIGHBOURHOOD (ND)

BEAM Plus Neighbourhood is the first tool developed locally to address sustainability issues at the early stage or master planning stage of a project. Based on BEAM Plus ND version 1.0, the assessment of a neighbourhood's performance covers:

- Community Aspects
- Site Aspects
- Material and Waste Aspects
- Energy Use
- Water Use
- Outdoor Environmental Quality
- Innovations and Additions

SECTION B – SUSTAINABLE DESIGN AND ENVIRONMENTAL ISSUES

REFERENCES

Code of Practice for Overall Thermal Transfer Value in Buildings, Buildings Department
(https://www.bd.gov.hk/doc/en/resources/codes-and-references/code-and-design-manuals/OTTV1995_e.pdf)

Green Design Guide for Material Resources Optimisation in Building Life Cycle, Hong Kong Green Building Council
(https://www.hkgbc.org.hk/eng/engagement/guidebooks/green-design-guide/images/Green_Design_Guide_Eng.pdf)

Guidelines on Design and Construction Requirements for Energy Efficiency of Residential Buildings, Buildings Department
(https://www.bd.gov.hk/doc/en/resources/codes-and-references/code-and-design-manuals/Guidelines_DCREERB2014e.pdf)

HKGBC Guidebook on Urban Microclimate Study, Hong Kong Green Building Council
(https://www.hkgbc.org.hk/eng/engagement/file/UMC_Guidebook_amended_reduced.pdf)

Hong Kong's Climate Action Plan 2030+, Environment Bureau
(https://www.enb.gov.hk/sites/default/files/pdf/ClimateActionPlanEng.pdf)

Hong Kong Green Office Guide, Hong Kong Green Building Council
(http://hkg-training.hkgbc.org.hk/green_office_guide/eng/files/assets/basic-html/index.html#1)

Hong Kong Green School Guide, Hong Kong Green Building Council
(https://www2.hkgbc.org.hk/ebook/HKGBC_HKGSG/eng/files/assets/basic-html/index.html#page1)

Hong Kong Green Shop Guide, Hong Kong Green Building Council
(http://greenshopguide.hkgbc.org.hk/eBook/en/files/assets/basic-html/index.html#3)

Latest standards for Building Environmental Assessment Method, "BEAM Plus" for New Buildings and Existing Buildings, published by Hong Kong Green Building Council & BEAM Society
(https://www.hkgbc.org.hk/eng/beam-plus/introduction/index.jsp)

Practice Guidebook on Compliance with Building Safety Requirements for Adaptive Re-use of and Alteration and Additional Work to Heritage Buildings under the Building Ordinance, Buildings Department
(https://www.bd.gov.hk/doc/en/resources/codes-and-references/code-and-design-manuals/heritage_2019.pdf)

Technical Specifications on Grey Water Reuse and Rainwater Harvesting, Water Supplies Department
(https://www.wsd.gov.hk/filemanager/en/content_1874/technical_spec_grey_water_reuse_rainwater_harvest.pdf)

SAMPLE QUESTIONS

The following sample questions aim to assess candidates' understanding of this Section.
(Please note that these are extracted from http://hkia.net/en/pdf/PA/Sample_Questions.pdf and the Professional Assessment Seminars)

1. Which of the following is not an assessment criterion for BEAM Plus?

A. Cost effectiveness
B. Barrier-free access
C. Life Cycle Assessment
D. Daylight access
Ans: A

(i) Which of the following is least effective in reducing "heat island effects" in designing open-air car parking lots?

A. Using natural asphalt for paving
B. Planting trees to provide shading
C. Providing a roof cover of high solar reflectance
D. Laying a lawn with trafficable open-grid paving
Ans: A

3. The glazing that gives the lowest OTTV is

A. skylight with double glazing.
B. west-facing single glazed window
C. east-facing single glazed window
D. south-facing single glazed window
Ans: D

4. Which of the following is not a benchmark for environmental performance assessment?

A. BEAM Plus New Buildings
B. BEAM Plus Interiors
C. BEAM Plus Neighbourhood
D. BEAM Plus Harbourfront
Ans: D

SECTION C – HEATING, VENTILATION AND AIR-CONDITIONING

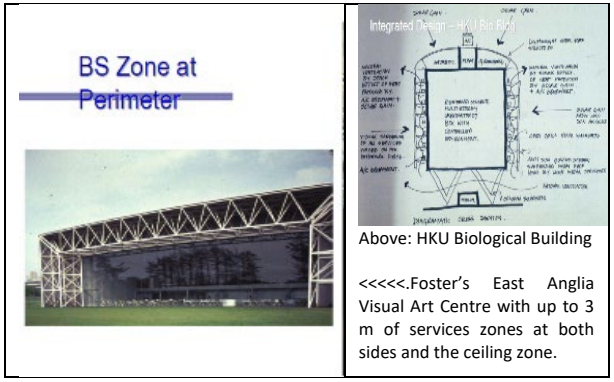
RECOMMENDED READING

Mechanical and Electrical Equipment for Buildings, 13th Edition; Walter T. Grondzik, Alison G. Kwok; Wiley, October 2017; pp. 531-698.
HKIA PA Paper 4 - Building Services and Environmental Controls, lecture handouts.

HEATING, VENTILATION AND AIR CONDITIONING

HVAC system is often described as all the component processes involved in air-conditioning, which is simultaneously a process of controlling air temperature, relative humidity, ventilation, air movement, and air cleanliness of a given space to provide the occupants with a comfortable indoor environment for various activities. Environmentally friendly architects would maximise the natural ventilation for comfort, prior to considering other mechanical systems, especially in the planning design stage.

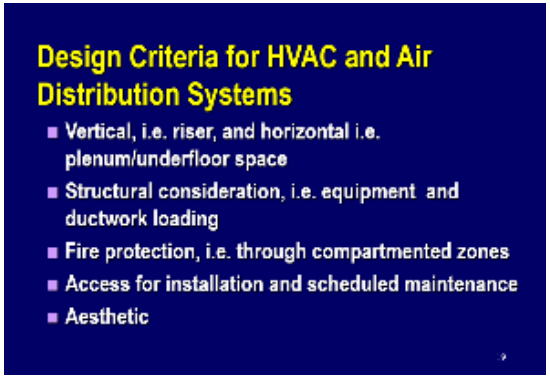
To benefit from the economy of scale, a central system is always preferred for larger buildings in Hong Kong. However, such system would inevitably take up a considerable amount of floor spaces usually at specific locations. Hence, it is essential for architects to have a good grasp of the choice of various HVAC systems, its essential and connecting components, its specific location, its supporting system, and a concept of its capacity relative to the spatial requirements, even at the conceptual stage.



Above: HKU Biological Building

<<<<<.Foster's East Anglia Visual Art Centre with up to 3 m of services zones at both sides and the ceiling zone.

At the early design stage, architects' role is to lead other design team members to consider the choice of various HVAC systems (its system components, approximate riser, and horizontal distribution), its preliminary capacity, appropriate structural supporting system, and budgeting issues relative to the selected system.

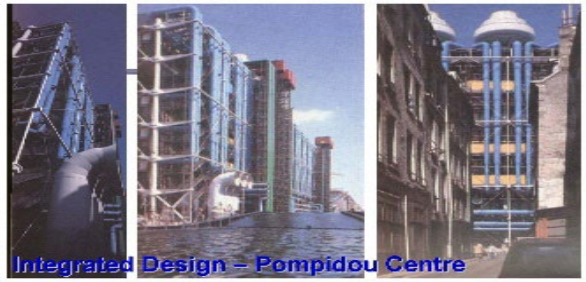


Further considerations of the accommodating space required for each of the (functional) components of the selected HVAC systems are required. This includes 'Spaces for Services' for chillers (air- or water-cooled), fresh air intake/exhaust air, AHU/ PAU, services cores (risers and distributors) and the like, relative to the selected system including plant room requirements.

Architects would be assisted by other design team members when considering structural issues for various essential components of the systems, for instance, structural supports for chillers and other equipment, and sizing/ routing of ductworks, especially through structural openings.

Finally, various issues in the project design, including fire protection (fire protection through compartments and for ductworks), access for installation, and scheduled/ emergency maintenance and repairs would be dealt with throughout the project stage.

HVAC system and its essential components could pose significant impact on the building design. The rear façade of the Pompidou Centre, Paris is a seminal exhibit of these systems, while the front façade is dominated by the escalator system.

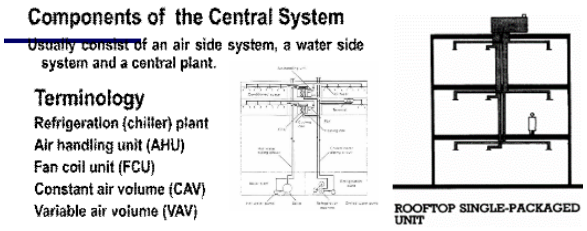


ESSENTIAL COMPONENTS OF A CENTRAL SYSTEM

Water is cooled in the refrigeration (chiller) plant (or heated in the boiler plant) in a central air-conditioning system.

Chilled (and/ or hot) water supplies are pumped to the air handling units (AHU) of designated floors and ultimately to the terminals (e.g., fan coil unit).

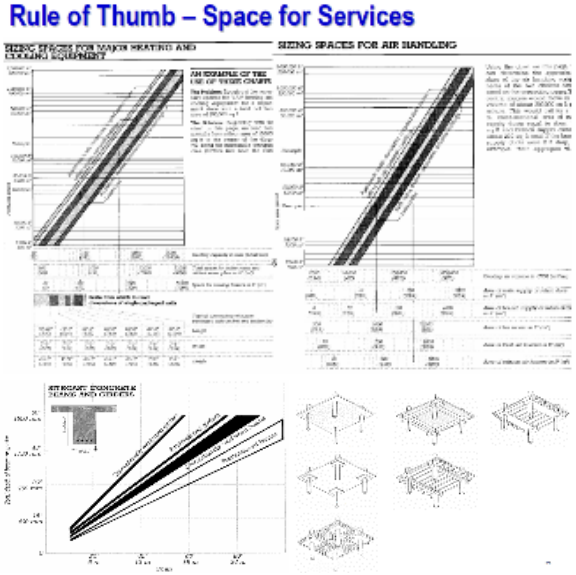
After the air has been cooled (heated), humidified/ dehumidified, and purified in the AHUs or terminals, the conditioned air is then supplied to the designated spaces/ zones through the ductwork to offset the cooling or heating loads to maintain a desirable indoor environment.



By far, the largest and usually the heaviest component of the central chilling system is the air-chilled refrigeration plant as shown on the rooftop (or at the lower floor if for the water-cooled version) of the building. To accommodate the air duct network, chilled water supply and return pipes, the AHU/ PAU rooms are always found in stack at the same location on each floor.

To enable an architect to deliver these scopes of works, a better understanding of the available HVAC systems (its features, components, and its applications) is indispensable – generally in the form of all-water and all-air systems.

- Fan coil unit system (FCU)
- Constant air volume system (CAV)
- Variable air volume system (VAV)
- Packaged unitary system – split unit, window type unit



Extracted from Architects' Studio Companion.

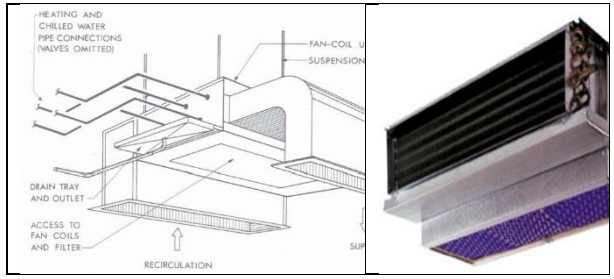
FAN COIL UNIT (WITH OUTSIDE AIR INTAKE)

By far, this is the most common type of installation in commercial buildings. This system typically comprises a series of ceiling mounted fan coil units in each room.

In commercial buildings, the chiller of the central plant supplies chilled water often at below 10°C to the fan coil unit terminus. This requires insulation to protect the supply and return pipes to avoid condensation on the pipe surfaces.

Traditionally, fan coil units are wired to operate with the fan control at high/medium/low settings. Fan coil systems can also be linked to the Building Management System (BMS) via a communication network, and therefore adjustable and controllable from a central control room.

The system usually works together with the ventilation system that not only supplies fresh air, but also extracts air for re-cycling hence energy efficiency.



Typically, in tertiary education buildings, a classroom for 30 - 40 students may require 2 - 3 fan coil units with individual control switches.

Heating in cold weather is possible by installing an additional electric heating coil in the fan coil unit.

Advantages:

- Lower capital cost
- Individual room temperature control
- Minimal floor space needed

Disadvantages:

- Poor humidity control
- Higher maintenance

FCUs are commonly found in office buildings, tertiary education buildings, large restaurants, and small exhibition halls.

CONSTANT AIR VOLUME SYSTEM

CAV systems are commonly found in small catering establishments, such as tea restaurants, small cafés etc., for a single thermal zone often in areas of smaller than 40-50 m² in size. CAV systems can also be used in concert halls or event venues with a predictable occupancy, as the system always operates at rated airflow.

For a CAV system, the supply rate of chilled air (often through a single air duct) is often constant, but the supply air temperature is adjustable. This is based on the pre-set

room temperature to meet the thermal load of the single zone.

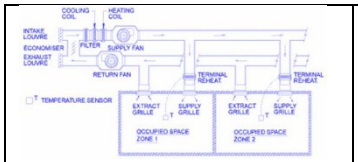
Advantage:

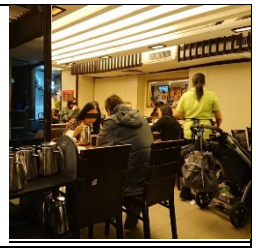
- Relatively inexpensive compared to other central systems due to less sophisticated control without a central plant location

Disadvantages:

- Indoor temperatures difficult to control (usually over-cooling) especially in cafés and tea restaurants
- More duct work (space) compared with other package (window and split) A/C units
- Access to terminal units for maintenance and repair required
- Air balancing work required
- Air distribution may cause draughts
- Inflexible in zoning and control

Commonly found in smaller tea restaurants and cafes where the system's payback period is an essential consideration.





Above: Drexel University
Supply air (constant) duct behind the decorative black strips >>>

VARIABLE AIR VOLUME SYSTEM

Unlike the CAV system, VAV can supply varying airflow but also at variable temperature settings.

The air (treated) is provided through the central duct system, which comes through the control box and then distributes through ductworks to the VAV boxes in accordance with the needs of each thermal zoning of the building – often controlled by occupant-sensors generally known as carbon dioxide sensors for large auditoriums and concert halls.

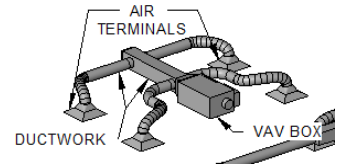
The air is supplied in variable volume until the specific room (usually larger space with higher ceiling) has reached its pre-defined limitation level, then the air supply will be automatically reduced while air supply continues to other thermal zones of the building as required.

Advantages:

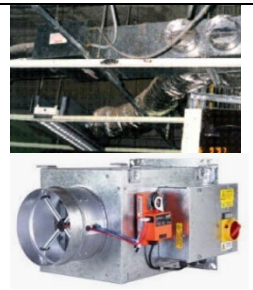
- Central plant location
- More precise temperature control
- Increased dehumidification
- Optimum air distribution to reduce draughts
- Compressor wear and tear reduced due to less stop-go operations
- Lower energy consumption by system fans
- Less fan noise
- Flexible in zoning and control

Disadvantages:

- More duct work (space)
- Air balancing work required
- Access to terminal units for maintenance and repair required
- Higher capital cost and maintenance cost



Source: *https://www.emsd.gov.hk/filemanager/en/content_2/VAV-SPRC.pdf*



PACKAGED UNITARY SYSTEM

Packaged unitary systems are factory-assembled units, in which the components of the air system are either in a single package (window-type) or in two split units.

Although these packaged A/C units are usually inexpensive and easy to install, this somehow creates aesthetic and installation challenges for architects, particularly in the façade design and access for maintenance and repair. This is a common issue in recent years when more residential buildings are installed with extensive glass walls often from just above the floor skirting to the ceiling level.

Window-type and Split-type A/C units are common in residential buildings because of its simple operation and lower cost. Also, plant rooms are not required.

Advantages:

- Individual room temperature control
- Individual air distribution system,
- Quick installation
- Good availability

Disadvantages:

- Poor response to occupancy changes
- Aesthetics in façade design hindered
- Generally poor control over humidity and fresh air intake
- Usually higher cost per BTU

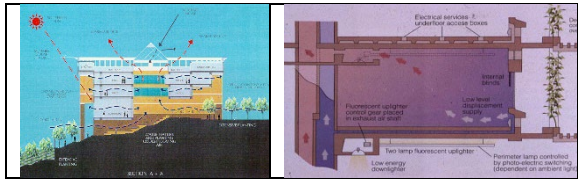
Air Handling Unit (AHU) is a machine that conditions (i.e., heats/cools, cleans, humidifies/ dehumidifies) and circulates air in a building. In other words, it is designed to provide heating/ cooling, ventilation, and air

distribution in buildings. AHU rooms are usually found in stack at the same location of each floor.

Natural ventilation is unpowered airflow through open windows, doors, and other intentional openings of the building envelope.

Natural ventilation through intentional openings can be achieved by differential pressures from wind or indoor-outdoor temperature differences. Airflow through open windows, doors and other design openings can be used to provide adequate ventilation for contaminant dilution and temperature control.

The pressure difference can be effected by **wind pressure,** or **stack effect**, and the combination of **wind and stack** effect.



Natural ventilation plays an important role in the master planning and design of public housing estates since the 1950s, featuring breezeways, ventilated staircases, open-balcony corridors, cross ventilation of the residential units, etc.

Natural ventilation as a passive design strategy can push the thermal comfort zone boundary up to 25 degrees Celsius given that the relative humidity is controlled and maintained at 50-60% with reference to the Bio-climatic Chart.

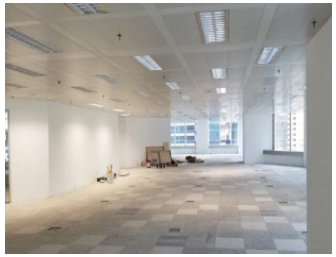
Air Flush Out ensures that the building ventilation system is not being contaminated by the left-over residues from construction activities. In BEAM Plus, one credit is awarded for *'undertaking a building 'flush out' or 'bake out'; and the replacement of all filters prior to occupancy'*.

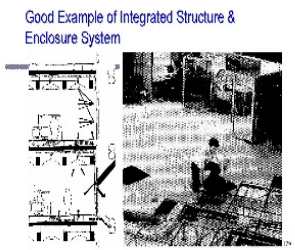
The flushing duration shall be subject to the calculation of fresh air required to attain the 'good' class in the IAQ certification.
Regarding mechanical ventilation, PNAP APP-98 gives favourable consideration to the design of windowless bathrooms in domestic buildings, provided that a system of mechanical ventilation producing **5 air changes per hour** is in operation at any time when the room is in use. This is important in the midst of the COVID-19 in ensuring negative pressure in the bathroom.

Source:
https://www.bd.gov.hk/doc/en/resources/codes-and-references/practice-notes-and-circular-letters/pnap/APP/APP098.pdf

UPWARD AIR-FLOW SYSTEMS

Underfloor Cooling with or without air duct. One of the large-scale applications of this system in Hong Kong is in The Center, where whole-floor plenums (without air ducts) are filled with chilled air.





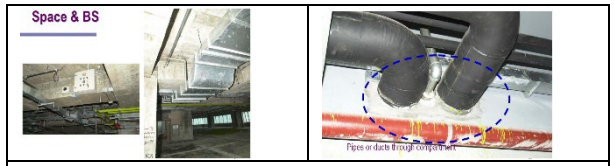
Advantages:
- Upward air flow with extraction at the ceiling plenum
- Easy cleaning and maintenance for the air distribution system
- Improved indoor air quality
- High flexibility to changes

Disadvantages:
- High capital cost prohibiting widespread applications

Air distribution system is the transportation of the conditioned supplied air to the designated zone commonly via a system of ductwork.

An air duct system should be designed to meet the air flow's functional requirement, minimise drop in flow pressure (hence energy loss), minimise air flow noise, and reduce installation and maintenance cost.

Architects must integrate the air distribution system and other M&E services systems with the building structure at ceiling level. Therefore, a combined reflected ceiling plan at an earlier stage would be advantageous.



Primary airduct intersects with structural beam and chilled water pipes (supply and return) through fire compartments.

The number of **HVAC** zones should be as few as possible for cost considerations; however:
- Too few zones will almost result in complaints from the occupants due to excessive differences in temperature throughout the space, while
- Too many zones normally incur a greater capital cost without necessarily providing any additional comfort.

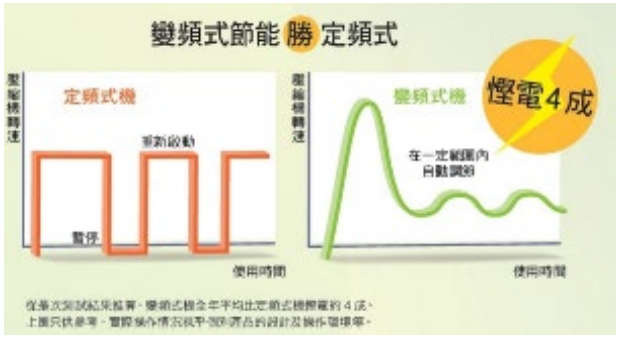
Operational Considerations

- Thermal considerations
- Perimeter and centre zones
- High density population
- Odour
- After-office hours
- Multi-purpose use
- Sub-metering for energy-efficient measures

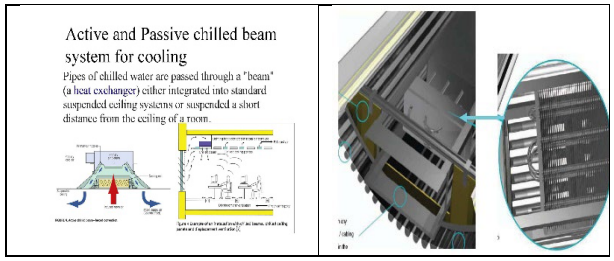
LATEST DEVELOPMENTS

Inverter air-conditioners

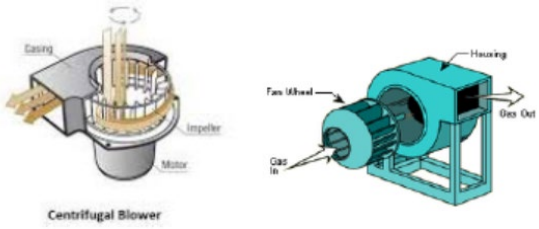
Variable-frequency drives (VFDs) of a packaged air-conditioning unit, in which the compressor can operate in a continuous mode instead of a stop-go operation, can result in energy saving, less wear and tear, and a quieter environment, in comparison with a traditional refrigerant compressor.



Active and Passive Chilled Beam System for Cooling



Air Induction Unit - **Bladeless fan** design for semi-outdoor environment, in sharp contrast with the traditional centrifugal fan in the AHU system for air distribution.



(**Centrifugal fans** in AHU system are used for its high efficiency in air distribution)

GENERAL CONSIDERATIONS IN APPLICATION

Exemplar Rule of Thumb for Cooling Tower Capacity:
For a hotel with an estimated cooling load of 900 TR, optimum cooling would result if **four** units of 300 TR each are used with due consideration for regular maintenance and to cope with the peak loading.

Architects should select refrigerants with no ODP (Ozone Depleting Potential) and minimal GWP (Global Warming Potential).

The ODP of the HCFCs e.g., HCFC-123, HCFC-22, is much smaller than the ODP of the CFCs, but is not negligible.

In contrast, HFCs, e.g., HFC-134a, HFC-410a, have an ODP that is essentially zero, but their GWP is substantially greater than some of the HCFCs, leading directly to global warming when the compound leaks into the atmosphere.

Desiccant Dehumidification in an Air Conditioning System is a process that utilises the desiccant material to absorb moisture or water vapour from the air, thereby keeping the humidity level in the air at the desired range.

Desiccant dehumidification systems work under the following principle - hot and humid air in the ambient condition will be initially dehumidified in the liquid dehumidifier, and then further cooled by the air conditioning system (cooling water, evaporative cooling system, vapour compression system, etc).

In the dehumidifier, the strong solution of liquid desiccant absorbs moisture from the ambient air and thereby becomes a diluted/ weak solution. The weak solution will then be passed through to the regenerator to be re-concentrated.

Desiccant materials used can either be solid (e.g., silica gel, molecular sieve) or liquid (e.g., lithium chloride (LiCl), calcium chloride ($CaCl_2$)).

Desiccants, as an alternative, could dehumidify the air owing to their hygroscopic properties. The ability of the liquid desiccants to hold moisture is normally greater than that of solid desiccants.

Common liquid desiccant materials are in two types:

- Aqueous solution of organic solvents:
  e.g., tri-ethylene glycol, diethylene glycol and ethylene glycol
- Inorganic aqueous salt solutions:
  e.g., calcium chloride, lithium chloride, lithium bromide, and calcium bromide

Liquid desiccant dehumidification and cooling system has the following advantages:

- Energy required for a desiccant dehumidification process is about 30% less when comparing with the conventional vapour compression system.
- Reduced greenhouse gas emissions - carbon reductions of 33.2% with electricity saving up to 18.9% could be achieved by the hybrid liquid desiccant cooling system.
- Desiccant materials are capable of absorbing inorganic and organic contaminants in the air during the dehumidification process. The absorption process has the potential to remove biological pollutants such as bacteria, fungi, and viruses for the improvement of the indoor air quality.

CONCLUSION

Candidates should familiarise themselves with the following design aspects:

1. All air HVAC systems and their components
2. Air & water systems and their components
3. CAV / VAV and their application
4. Underfloor cooling and its application
5. District cooling/heating
6. Stack effects and prevailing wind in natural ventilation
7. AHU and its M&E equipment
8. Application of renewable energies in HVAC
9. Legionnaires' disease in HVAC system
10. Liquid desiccant dehumidification in an air conditioning system

SAMPLE QUESTIONS

The following sample questions aim to assess candidates' understanding of this Section.
(Please note that these are extracted from *http://hkia.net/en/pdf/PA/Sample_Questions.pdf* and the Professional Assessment Seminars)

1. Which of the following statements is true for an underfloor air conditioning system?

A. It uses more fan power.
B. It is not suitable for winter heating.
C. The circulated comfort zone covers the space from the finished floor to the false ceiling.
D. It is more effective than conventional air conditioning systems when used in a computer data centre.

Ans: D

2. The heat rejection capacity of the cooling tower system of a hotel is estimated to be 600 TR. What is the most optimum combination of cooling towers?

A. 1 set of 600 TR package cooling tower
B. 1 set of 900 TR package cooling tower
C. 2 sets of 450 TR package cooling towers
D. 3 sets of 300 TR package cooling towers

Ans: D

3. Which of the following is fundamental in preventing the spread of Legionnaires' disease in building services installations?

A. Using CFC refrigerants for chiller plants
B. Using single-stack drainage system to avoid cross contamination
C. Using water strainers to filter the incoming water at the supply mains
D. Carrying out regular inspection and maintenance for the water-cooled air-conditioning plants

Ans: D

4. Which of the following statements is incorrect in respect of Air Ventilation Assessment (AVA) Studies for a new building development?

A. Computational fluid dynamics analyses can check the wind permeability at different levels.
B. Wind tunnel test must be carried out on a scaled model in order to get a more accurate result.
C. Pedestrian comfort is the main objective of the AVA study.
D. Landscaping is not normally considered.

Ans: D

5. Which of the following actions may best help maintain human comfort even in an increased indoor temperature?

A. Lowering the humidity
B. Re-circulating the air supply
C. Lowering the lighting intensity
D. Increasing the ventilation rate

Ans: A

REVISION QUESTIONS

1. Why is constant air volume system widely used in small tea restaurants of about 25 -75 m² net floor area? _____
2. What are the advantages of inverter air-conditioners? _____
3. How many functional sets of pipework are required to be connected to a fan coil unit? _____
4. State the required minimum distance of fresh air intake/ exhaust air outlet away from the cooling tower. _____
5. Compare the advantages and disadvantages of water-cooled and air-cooled chillers in Hong Kong. _____
6. Draw a refrigeration cycle of a window A/C stating the heat absorbing and heat rejection parts _____
7. State why centrifugal fans are widely used in HVAC system, in comparison with other fan types? _____
8. List the essential components in descending order of the floor area being taken up by a central HVAC system. Sketch a schematic diagram of a typical air-cooled HVAC system. _____
9. List the M&E equipments that are commonly found in the AHU room. _____
10. State the HVAC design criteria for the indoor conditions (temperatures and humidity as adapted by the M&E consultant) in summer and winter, respectively, in Hong Kong. _____
11. Compare and contrast the consequences of a fan coil HVAC system with too few zones, and that with too many zones in a Grade B office building. _____
12. Compare and contrast the conventional stop-go compressor and the variable frequency drive in air-conditioning units. Why is the latter more energy-efficient? _____
13. Describe the principle behind liquid desiccant dehumidification in an air conditioning system. _____
14. Describe the application of the Chilled Beam System. _____
15. Describe the application of the Bladeless Fan in a cooling system. _____
16. Compare and contrast the underfloor cooling system with and without air duct. _____
17. What are the staircase pressurisation requirements in high-rise commercial buildings? _____
18. What are the two forces behind natural ventilation for a building? _____
19. Name the factors affecting air flow inside an air duct system and how the architect together with the M&E consultant could design a better air distribution system. _____
20. What are the specific air changes per hour, as per PNAP APP-98, in respect of windowless bathrooms? _____
21. What is 'Air Flush Out'? _____
22. What is the main purpose of ice storage system, particularly for cities with dual electricity tariff system? _____
23. Which part of the HVAC system is the Legionnaires' Disease usually associated with?

SECTION D – FIRE SERVICES

RECOMMENDED READING

Mechanical and Electrical Equipment for Buildings, 13th Edition; Walter T. Grondzik, Alison G. Kwok; pp.1177-1256.
HKIA PA Paper 4 - Building Services and Environmental Controls, lecture handouts.

PRINCIPLES OF FIRE SAFETY ENGINEERING

Fire can break out at any time, and anywhere inside a building. A **'Fire Plan'** considers the fire risks in the building, its relevant measures to minimise such risks, the consequences of fire, and the actions to be taken if fire occurs.

Architects' primary concerns of fire engineering are for: (a) protection of people; and (b) protection of property. All fire services systems in Hong Kong shall be installed to the satisfaction of the Fire Services Department and to comply with the Codes of Practice, guidance from the Loss Prevention Council and B.S. Standards.

The loss caused by fire can be minimised by incorporating both **passive** and **active** elements into the architectural design.

Performance-based or fire engineering approach is normally adopted to seek exemption for commercial projects by means of an engineering justification report.

For complex and special projects such as main railway terminals, airport concourses and super-tall atriums, fire engineering would be treated as an alternative to achieve fire safety. A Fire Safety Strategy Report is to be submitted.

For architects, passive measures often refer to:	The active F.S. systems
• fire resistant period (FRP) structures / materials • fire protected staircases • exit routes and passageways	• Sprinkler (Pre-action) Systems • Fire Hydrant & Hose Reel System • Deluge System • Drencher System • Water Spray System • Automatically Operated Total Flooding System • Automatic Fire Detection & Alarm System • Hand Appliances • Smoke Control & Extraction Systems • Essential Power Supply for Fire Services • Cabin Concept

FIRE SAFETY IN TALL BUILDING

Architects' roles, in general:

- Coordinates with the fire engineer
- Makes building safer
- Appropriate design of building with adequate active/passive measures for fire extinguishment or control
- Evaluates fire safety and the associated risk
- Improves building safety based on the fire safety engineering approach for tall atriums, main railway terminals, and airport concourses.
- Special considerations for the provision of refuge floor (for domestic building or a composite building exceeding 40 storeys) with no occupied accommodation or accessible mechanical plant rooms; net area for refuge should be not less than 50% of the total gross floor area of the refuge floor; a clear floor height of not less than 2,300mm; a passengers' lift should NOT open onto the refuge floor in normal operation.

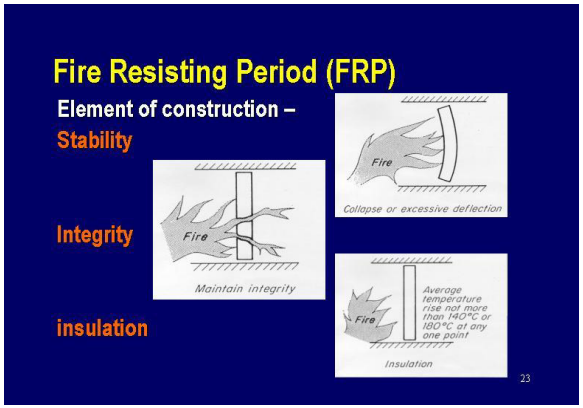
PASSIVE FIRE SERVICE DESIGN

Code of Practice for Fire Safety in Buildings 2011, latest revision - Key Aspects:

- Compartmentation
- Fire Resistant Period (FRP)
- Protection of Adjoining Buildings
- Separation between Uses
- Separation between Occupancies
- Opening through Fire Resisting Walls and Floors
- Vertical Shafts
- Protection against Spread of Fire and Smoke between Floors
- Roofs / Special Hazards / Basement / Bridges & Tunnels / Doors
- Refuge Floors

Prior to considering active fire safety systems, architects must comply with the FRP and material requirements regarding the elements of construction.

The fire resisting period in the element of construction in the event of fire falls into 3 criteria: Stability, Integrity, and Insulation.



Elements of construction – walls, fixed lights, doors, fire shutters or other components – should satisfy these criteria of stability, integrity, or insulation relating to the various methods of exposure (British Standard 476: Parts 20 to 24: 1987). See the latest revision of the Code of Practice for Fire Safety in Buildings 2011.

Stability (load bearing capacity) - The ability of a specimen of a load-bearing element to support its test load, where appropriate, without exceeding the specified criteria with respect to either the extent of, or rate of deformation or both.

The load bearing construction must support its full load during the fire and continue this support for specific hours after the heating period.

Failure of floors, flat roofs and beams is said to occur when deflection reaches more than 1/30 of their span.

Integrity - Failure occurs when cracks or other openings form, through which flame or hot gases leading to combustion can pass to the side of the element remote from the fire.

Insulation - The ability of a separating element to restrict the temperature rise of the unexposed face to the specified level.

Failure occurs when the temperature on the side of the element remote from the fire is increased generally by more than 140 degrees Celsius or at any point by more than 180 degrees Celsius.

ACTIVE FIRE SAFETY SYSTEMS

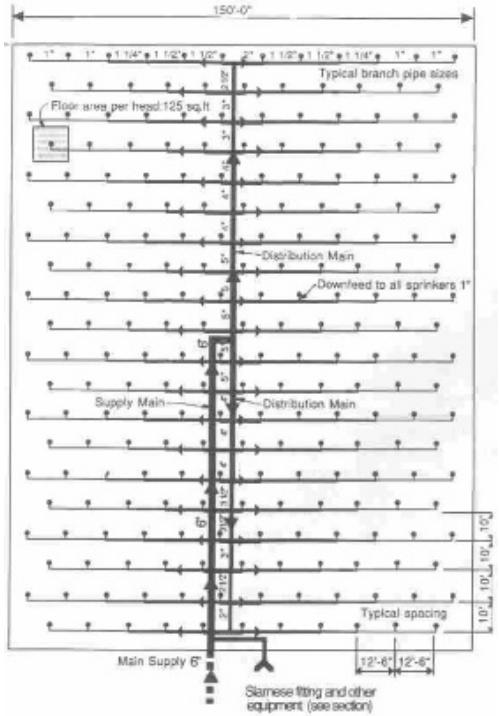
Active Fire Safety Systems are commonly found in commercial buildings to comply with the fire safety requirements.

An **Automatic Sprinkler System** is a firefighting system designed to be triggered by the fire itself to dispense water in the areas to ensure rapid suppression of the fire with the minimum injury to life and damage to the property. Since a sprinkler system is only designed to be an automatic first line of defence for fighting incipient fires, the provision of a sprinkler system cannot entirely obviate the need for other means of fighting fires.

The spacing of the sprinkler heads will depend on the fire hazard rating of the building. In general, the greater the hazard, the closer the heads must be spaced and the larger the anticipated fire area.

For ordinary hazard, which covers such application as in offices, hotels, hospitals, libraries, and restaurants, heads must be spaced not more than 4 m apart. Such layout typically protects 12 m² of an effective floor area (4 m x 3 m or alternatives giving the same cover area).

Supply tank - the minimum effective quantity of water required will depend on the category of fire hazard, the pipework configuration, WSD supply, and other fire considerations.



An architect should consider the following design aspects for the installation of the automatic sprinkler system.

- Location of the plant/ tank room.
- Pump and pump control room (number of pump sets catering for backup and maintenance requirements).
- Running of the service pipes - vertically and horizontally.
- Access requirement for the firemen (sprinkler water inlet and fire engine).
- Sprinkler water supply system, i.e. single end or fed from both ends.
- Volume of sprinkler water tank in respect of the hazard group, zone height and pipe fed (single or double end-fed).
- Coverage of 12m² per sprinkler head for most areas except rooms with electrical services, toilets, M&E plant rooms, etc.
- Sufficient heads for ceiling voids exceeding 800mm.

PRE-ACTION SPRINKLER SYSTEM

This is normally used in rooms containing computers or other sensitive electronic equipment. The water supply valve is only actuated by the automatic fire detection system which senses heat, products of combustion, ultra-violet, or infra-red radiation from a fire.

The designated water pump then draws water rapidly from the pre-action water tank to fill up the sprinkler pipes. However, water flow does not begin to burst out - not until the sprinkler head has been activated by the heat of the fire.

The system is primarily designed to counteract the operational delay of a conventional dry pipe system, and at the same time, to eliminate the danger of water damage from the accidental discharge of automatic sprinklers or piping at the expense of additional pumps and tank.

FIRE HYDRANT, HOSE REEL & OTHER FIREFIGHTING SYSTEMS

The fire hydrant & hose reel system comprises a hydrant outlet, hose reel, supply tank, fire pump, rising main and fire service inlet together to form a wet riser system. A fire hydrant is usually located at / near the fire escape stairs.

The hose reel system, usually in 30mm diameter rubber tube and 30m maximum in length, is intended to be used by the building occupants as the first aid device against fire.

Architects should be aware of the location and FSD requirements for the installation of fire hydrant and hose reel system - the latest edition of the Codes of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment.

Architects should be familiar with the following clauses and design criteria:

Clause 4.2.23.4 - No locking device is fitted to such doors (of hose reel cabinet)

Clause 4.2.24.1 - When not in use the outer face of the reel is flush with the wall.

Spacing between street fire hydrants should be 100 metres staggered on alternative sides of the roadway wherever applicable. Wherever possible, there should be at least two street fire hydrants within the site of the building concerned and they should be fixed not less than 60 metres from the building they are intended to protect.

The street fire hydrant shall be of an accepted standard pattern and, with one 65 mm outlet working, shall be capable of delivering not less than 2,000 litres per minute (33.3 litres/second) with a minimum running pressure of 170 kPa at the outlet. The minimum output should be made available from two 65 mm outlets of a system delivering at the same time, i.e., a total output of not less than 4,000 litres per minute (66.7 litres/second). The minimum delivery time shall be at least 60 minutes. Hydrant body is painted in red for freshwater system and in yellow for sea water system.

Fire hydrants in buildings of about 65mm diameter are intended to be used by firemen – saving their time in running a flexible pipe from the ground floor to the floor on which fire has broken out.

The **Deluge System** is designed to deliver most water in the least time. It wets down an entire fire area by emitting water to the sprinklers or spray nozzles that are open. Deluge system is suitable for extra-hazard occupancies in which flammable liquids are handled or stored, and where fire may flash ahead of the operation of the ordinary automatic sprinklers. Suitable installations for the deluge system are aircraft hangers, airfield oil storage tanks, and petrol filling stations.

The **Drencher System** delivers a curtain spray for the protection against external and internal exposure to fire, and/or the protection of large openings. As prescribed by the Code of Practice (Amended) Minimum Fire Service Installations and Equipment, drencher installations are required for the theatre proscenium openings and places where there is a higher level of fire risks.

The **Water Spray System** is designed to extinguish fires involving oil or similar flammable liquids using water alone. This system is widely used for the protection of

equipment, such as oil filled electrical equipment, lubricating system, governor gear, oil storage, cooling and filtration systems of steam turbo alternator, oil-fired boiler, oil fuel store, oil processing plant, rubber mixing and spreading machinery, paint/varnish manufacturing plant, and petrol filling station.

The extinguishing action is due to the emulsification of oil. Typical water spray system discharges water with considerable force onto the surface of the flammable liquid from the specially designed projectors. The water leaves the projectors in high velocity and evenly distributes over the protective area. It is the impact of the water on to the surface of the flammable liquid that forcefully create a transient aqueous emulsion, which is incapable of burning.

A typical water spray system looks very much like a sprinkler system. The difference is that the water spray system uses nozzles to emit high velocity water streams, while a sprinkler system emits relatively low velocity water sprays.

Independent water tanks is to be provided for the water spray system with the capacity to operate for at least 30 minutes.

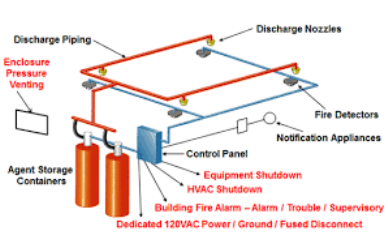
A **foam system** has the major advantage to create a tremendous volume of foam from a limited water supply. The system is also suitable for the application where limited use of water is desirable. Typically, the foam has a maximum expansion ratio of up to 1,000 times for each volume, though low expansion foam usually has a much smaller expansion ratio.

AUTOMATICALLY OPERATED TOTAL FLOODING SYSTEM

FM200, NAFS-III and CF A-410 systems are all common automatic systems. Installation design must be in accordance with NFPA Standard 2001 and UL Standard 1058.

The FM200 system, which has now become the industrial standards, usually covers only the designated core areas, such as telecommunication control rooms, data centres, storages for masterpieces of art, simply because of its high installation and maintenance cost.

Very often, a central plant room is not a must. Instead, a storage cupboard is required to house the cylinders, control panels and the associated fittings.



AUTOMATIC FIRE DETECTION & ALARM SYSTEM

An automatic fire detection system would warn occupants and the Fire Services Department of an outbreak of a fire in a building. An annunciator board pinpoints the location of the actual alarm point. It can normally give off an alarm signal at the very early stage of a fire outbreak. The key element is the detector itself. In Hong Kong, the use of ionisation smoke detectors and heat detectors is more common.

Hand Appliances

There are three types of hand appliances:

- Buckets filled with dry sand or water.
- Portable fire extinguishers.
- Fire blankets.

Nowadays buckets of sand are seldom used as far as aesthetic appearance is concerned. Also sand buckets are often misused as ashtrays or dustbins, while buckets with water would require periodic top-ups. These buckets are painted in red as required by the Code of Practice (Amended) Minimum Fire Service Installations and Equipment.

Fire blankets are mostly used in kitchens. A fire blanket, which is a piece of flame-resistant cloth, is to be covered over a fire to cut off its air supply.

Types of portable fire extinguishers: water, foam, carbon dioxide and chemical powder.

SMOKE CONTROL & EXTRACTION SYSTEM

A survey of fire accidents in the USA by the U.S. Consumer Product Safety Commission has concluded that most fatalities in fire accidents occur due to smoke inhalation rather than the effects of heat or fire. Since smoke is produced very quickly after ignition, it is essential for such smoke control and extraction systems to respond swiftly.

Two types of smoke extraction system:

Static smoke extraction system – This smoke extraction system utilises smoke reservoirs, localised ducting, permanent openings and automatic opening of windows, panels or external louvers actuated by smoke detectors, in order to remove smoke and products of combustion by natural ventilation from the designated fire compartment.

In general, smoke should not travel for more than 30m before entering the nearest point of inlet of the (static) extraction system. At least one extraction point should also be provided for every 500 m² of floor area.

Dynamic smoke extraction system – This is a mechanical ventilation system capable of removing smoke and products of combustion from the designated fire compartment, and supplying fresh air in such a manner as to maintain a smoke-free zone below the smoke layer. Maximum velocities, based on the free area of the grille, shall be:

- At make-up air inlets where not mechanically propelled: **3 m/s**.
- At make-up air inlets where mechanically propelled: **6 m/s**.
- At extract grilles or outlets: **6 m/s**.

Generally, the flow rate of supplied or make-up air should be at least 80% of the extraction rate.

Smoke Discharge System (commonly known as "smoke vents") – This may be permanently open, or opened only when automatically actuated. The free area of the smoke discharge is required to be not less than 2% of the floor area served by the system. Of this, not less than half shall be permanently open or automatically actuated.

If permanent openings are provided, signs shall be displayed on or adjacent to the openings on the inside of the building with the following wording in both English and Chinese:

THIS OPENING IS A SMOKE VENT.
DO NOT COVER OR CLOSE
此乃排煙口
不得遮蓋或關閉

The sections of discharges not required to be operated automatically shall be provided with easily operated, and accessible quick release operating devices to be fixed at a height not exceeding 1.8m AFFL. The minimum possible number of operating devices is desirable. Signs should however be written as the following instead:

THIS OPENING IS A SMOKE VENT.
DO NOT COVER OR OBSTRUCT
此乃排煙口
不得遮蓋或阻塞

Actuation and Operation

Systems with permanently fixed smoke barriers and permanently open discharges require no actuation.

All other systems shall be actuated by smoke detectors installed in accordance with the requirements of the Fire Services Department.

The smoke detector installation may be zoned, at the discretion of the designer, to serve only one smoke compartment or several smoke compartments. However, it is recommended that a cross-zone smoke detector system should be installed to reduce false alarms particularly in industrial buildings.

Smoke Barriers may be operated only when actuated, or permanently fixed.

The smoke barrier shall be constructed of non-combustible materials that can resist the passage of smoke. The barrier should have a fire resistance period of not less than 1 hour when tested to British Standard 476: Parts 20 to 23.

For "below-ground" compartments, the smoke barrier shall extend to a depth of 800 mm below the lowest beam, obstruction, window head or top of vent opening situated in the compartment.

For "above-ground" compartments, the smoke barrier shall extend to a depth of 500 mm below the lowest beam, obstruction, window head or top of vent opening.

The lowest portion of the smoke barrier, when in the fire position, shall be no less than 2m AFFL (above finished floor level).

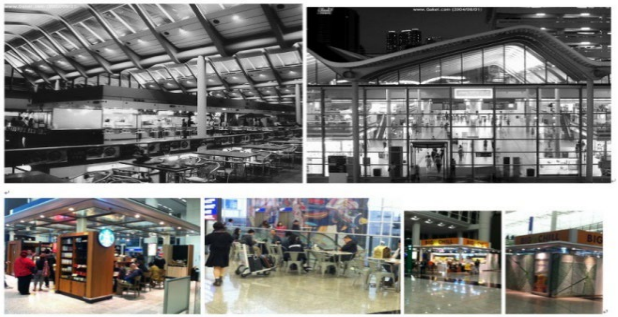
The smoke zone should not exceed 2,000 m² in area.

Very Early Smoke Detection Apparatus (VESDA) – The system works in principle by continuous sampling of the surrounding air into a distributed pipe network via a high-efficiency aspirator. The air sample passes through a dual-stage filter inside the detection chamber and is then exposed to a laser light source for the detection of invisible by-products of degraded materials during the pre-combustion stages of a fire. The system is intended to alarm the occupants of a fire outbreak as early as possible.

CABIN CONCEPT

Movement of smoke and hot gases produced by fires can be a significant part of the fire safety design for the occupants in large buildings. Several computational models have been developed for the calculation of the dynamics. Smoke control and fire safety are commonly attained by means of automatic roof vents, pressurisation, and mechanical smoke extraction.

The 'cabin concept' may be particularly suitable for buildings with large open areas, concourses, or tall atria. For a large airport concourse, the public circulation areas should be kept safe and free from heat and smoke. Although these areas may contain significant amounts of fire load, it is impractical to have physical separation between them. The concourse would also include catering facilities, gift shops, duty-free shops, etc. Such fire and smoke control can be achieved by treating these designated business areas as an open-sided 'cabin' to be fitted with automatic sprinklers and smoke extraction systems.



AUTOMATIC SPRINKLER SYSTEM

Hazard Classification

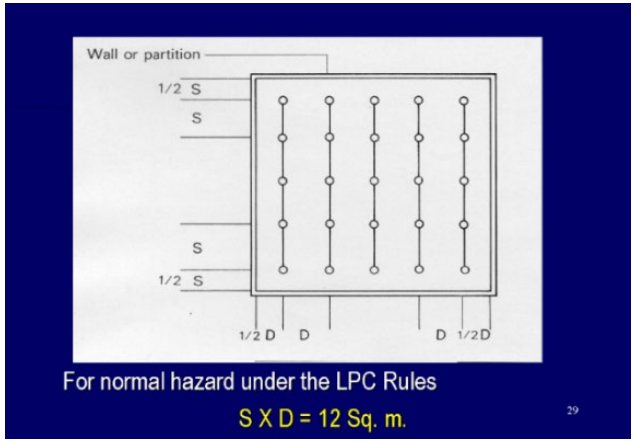
Occupancies shall be classified as:

i) Light Hazard – libraries, offices, hotels, schools of area of not more than 126m².

ii) Ordinary Hazard -

OHI : restaurants, offices etc.
OHII : foods factories, high-rise buildings.
OHIII : car parks, departmental stores.

iii) High hazard - abnormal fire loads are sub-classified as high hazard; potable spirit storage hazard, oil and flammable liquid hazard, etc.



SPACING / LOCATION OF SPRINKLER HEADS

Specific requirements of the coverage area per sprinkler head for various hazard groups of occupancies are summarised as follows:

Hazard	Sprinkler Type	Max. area covered per sprinkler (in m²)	Max distance between adjacent sprinklers (in m)
Light	Non-sidewall	21	4.6
	Sidewall	17	4.6
Ordinary	Non-sidewall	12	4.0
	Sidewall	9	3.4
High	Non-sidewall	9	3.7

F.S. inlet at the main entrance

FIRE SAFETY REQUIREMENTS FOR RESIDENTIAL FLATS WITH OPEN KITCHEN DESIGN IN HONG KONG

Residential units with open kitchens constructed according to approved building plans should be fitted with fire service installations and equipment as specified in the relevant codes of practice, including:

(a) Smoke detector(s) with a sounder base; and
(b) Sprinkler head(s).

Windowless kitchens that employ ventilating systems fitted with fire dampers should also be inspected annually.

For open-kitchen units constructed in accordance with the Code of Practice for Fire Safety in Buildings 2011, there is no specific requirement regarding the types of cooking stoves.

Pursuant to the Building (Ventilating Systems) Regulations, Cap. 123J and Ventilation of Scheduled Premises Regulation, Cap. 132CE, the ventilating systems, governed by respective legislations, must be inspected and certified by a registered specialist contractor (ventilation works category) at intervals not exceeding 12 months. After inspection, the contractor is required to issue a certificate to the system owner, the owner's representative and FSD.

Source:
https://www.hkfsd.gov.hk/eng/news/Residential_Flats_with_Open_Kitchen_Design_eng.pdf

DANGEROUS GOODS STORE

Fire Safety Requirements for Storage of Category 5 Class 3 Dangerous Goods Not Exceeding 2,500 Litres in Aboveground tanks

For indoor storage, the tank is to be placed inside a fire resisting room of at least 2 hours in FRR with a door sill capable of containing 100% of the tank capacity.

The room is to be ventilated to open air, and the door opening is to be fitted with a self-closing door having a FRP of not less than one hour.

An automatic closing device in the form of fire curtains/ dampers/ shutters, equipped with an electro-thermal link, released by a signal from an appropriate type of heat/ smoke detector fixed on the ceiling to actuate the device, shall be provided to the high and low ventilators of the store.

For the heat detectors, the actuation temperature shall be rated at 54°C to 65°C. The control panel of these detectors shall be located outside the store.

Such device shall be installed by a Registered Fire Service Installation Contractor and a copy of the completion certificate issued shall be forwarded to FSD.

Sprinkler heads at the store, if any, shall be blanked off.

One 4.5kg CO_2-type fire extinguisher and two buckets of dry sand shall be provided.

For the outdoor storage, lightning rod and earthing connections shall be provided to the tanks.

Above-ground storages shall be indicated by a standard sign fixed to the external wall adjacent to the lobby window opening of the store. The sign shall not obstruct access or ventilation to the lobby. The sign shall be painted with red-reflective materials on a white background.

A flammable dangerous goods pictorial plate, which may be purchased from the Licensing and Certification Command Headquarters, shall be provided, and fixed at a prominent position of the main entrance to the store. The store shall be kept locked when not being attended.

POTENTIAL FIRE HAZARDS IN MINI-STORAGES AND RELATED ABATEMENT MEASURES

Following the tragic no. 4 alarm fire at Ngau Tau Kok mini-storage on 21 June 2016 which broke out at Amoycan Industrial Centre costing 108 hours of firefighting and the lives of two firefighters, FSD has subsequently issued a practice note regarding the potential fire hazards in mini-storages and related abatement measures, which highlights the following requirements:

- Make sure that all exit doors can be readily and conveniently opened from within the premises without the use of any keys.

- Remove all locking devices on exit doors or modify such locking devices to enable the doors to be readily and conveniently opened from within the premises without the use of any keys.

- The total area of unobstructed and breakable windows (including 'access windows') should not be less than 1/16 (6.25%) of the total floor area of the mini-storage.

- Regarding the provision of 'access windows': -

(a) The total area of 'access windows' should not be less than 1/50 (2%) of the total floor area of the mini-storage.
(b) At least one 'access window' should be provided at an interval of 20 m on each external wall with window(s).
(c) An 'access window' should measure at least 1m high by 0.85m wide.
(d) The sill of any 'access window' should not be higher than 1.1m AFFL.
(e) All 'access windows' should be directly connected to the internal means of escape of the mini-storage.

- Rearrange the mini-storage cubicles into rows/clusters, each occupying an area not exceeding 50 m², and - there should be a separation distance of 2.4 m between rows/clusters; - any side of each row/cluster should not exceed 20 m in length; - the distance between the ceiling and the top of the storage cubicles and/or stored articles should not be less than 1 m; and - the storage cubicles and/or stored articles should not exceed 2.35 m in height. The covered rows/clusters of mini-storage cubicles are to be installed with heat detectors in accordance with British Standard 5839.

- Sufficient provision of exit signs and directional signs, and to maintain such signs in working order.

- Remove/ rearrange the storage facilities or conduct any necessary alteration works to the hose reel system to ensure that the coverage is adequate and to maintain such system in working order.

- Such alteration works are to be undertaken by a Registered Fire Service Installation Contractors, who upon completion of the works will submit a certificate to this effect to FSD; and the covered rows/ clusters of mini-storage cubicles are to be certified by qualified building professionals to the effect that they are structurally sound and with good fire resistance performance.

Source:
https://www.hkfsd.gov.hk/eng/source/safety/mini_storage/MiniStorage_Fire_Hazard_identified_eng.pdf

CONCLUSION

Candidates should familiarise themselves with the following design aspects:

1. Fire hydrant and hose reel requirements.
2. Street fire hydrant (no more than 100m from a building).
3. Escalator smoke baffle.
4. Examples of application of the drencher, water spray, and deluge systems.
5. Requirements and design criteria of emergency generator.
6. Pressurisation of staircase and its design criteria.
7. Design criteria for dangerous goods store and mini storage.
8. Relaxation of 'telecommunications exchange centre' or 'computer/data processing centre' in lower floors of an existing industrial building.
9. FSD Circular Letter No. 2/2019 Fire Safety Requirements for Waivers for Buffer Floor and Lower Floors of an Existing Industrial Building.

SAMPLE QUESTIONS

The following sample questions aim to assess candidates' understanding of this Section.
(Please note that these are extracted from *http://hkia.net/en/pdf/PA/Sample_Questions.pdf* and the Professional Assessment Seminars)

1. Which of the following premises should be provided with a smoke extraction system?

A. Dangerous goods store
B. Double-storey carpark basement
C. Atrium with a compartment volume of 20,000m³
D. Common internal corridor with fixed windows on a typical guestroom floor of a hotel

Ans: D

2. Which of the following are valid benefits of the FM200 system, which is commonly adopted as a fire-fighting provision for computer centres?

(1) Plant room is not a must.
(2) Water is not required for firefighting.
(3) The system is easily reinstated after false alarm.
(4) It is less expensive than pre-action sprinkler system.

A. (1) and (2) only
B. (1) and (4) only
C. (2) and (3) only
D. (3) and (4) only
Ans: A

3. Which of the following does not affect the sizing of sprinkler water tanks in Hong Kong?

A. Type of building
B. Occupancy of building
C. Presence of direct phone link to fire station
D. Amount of water sources or supplies
Ans: B

4. Which of the following firefighting devices can be found in a domestic building?

(1) Sprinkler
(2) Hose reel
(3) Fire hydrant
(4) Extinguisher

A. (1), (2) and (3) only
B. (1), (3) and (4) only
C. (1), (2) and (4) only
D. (2), (3) and (4) only
Ans: D

5. What is the maximum spacing between adjacent sprinklers?

A. Light Hazard - 1.5m, Ordinary Hazard - 1.7m, High Hazard - 2m
B. Light Hazard - 2.3m, Ordinary Hazard - 2m, High Hazard - 1.5m
C. Light Hazard - 2.3m, Ordinary Hazard - 2m, High Hazard - 1.7m
D. Light Hazard - 2.3m, Ordinary Hazard - 2m, High Hazard - 2m
Ans: B

REVISION QUESTIONS

1. What is a Fire Plan? _____
2. What is a performance-based fire engineering approach to fire safety? _____
3. What are the three terms that describe the FRR and represent the make-up of the element of construction? _____
4. What elements of construction are generally acceptable for fire compartmentation other than fire door and fire shutter? _____
5. What are the essential components of an automatic sprinkler system? _____
6. Sketch a schematic diagram of an automatic sprinkler system for a 20-storey office building. _____
7. State the locational requirement of the main F.S. inlet of a commercial building. _____
8. Compare and contrast the single-end and double-end feed in an automatic sprinkler system. _____
9. Under what conditions are sprinkler heads required in the ceiling void? _____
10. In accordance with the BS EN 12845 incorporated in FSD Circular Letter 3/06, what clearance should be maintained below a sprinkler head? _____
11. Fire blanket is the most effective firefighting device to put out _____ in a kitchen fire.
12. Under which fire hazard type is a coverage of 12 m^2 floor area per sprinkler head acceptable? _____
13. Explain why additional pumps and tanks are required for the pre-action sprinkler system to cover part of a building's floor area, e.g., telecommunication control room. Sketch a schematic diagram where appropriate. _____
14. State the locational requirements of the fire hydrant, and the hose reel system respectively. _____
15. What are the operational temperatures of the sprinkler head bulb in a general office and kitchen's cooking area respectively? _____
16. Compare and contrast the STATIC and DYNAMIC smoke extraction systems. _____
17. What are the fire protection requirements (passive and active) for a refuge floor? _____
18. What are the fire protection requirements (passive and active) for a dangerous goods store? _____
19. State the application criteria for an automatically operated total flooding system (e.g. FM200) in a data centre. Sketch a schematic diagram where appropriate. _____
20. State the application criteria for a foam system. _____
21. State the two most common types of automatic fire detection and alarm system. _____
22. What is VESDA and what are its applications? _____
23. Under the Code of Practice of Minimum FSI&E, can the buckets filled with dry sand and water be replaced by portable fire extinguishers? _____
24. What is the underlying principle of the 'cabin concept' for large atria and concourses? Name two common malpractices of retailers and facility managers that cause deviation from the principle. _____

SECTION E – PLUMBING AND DRAINAGE

RECOMMENDED READING

Mechanical and Electrical Equipment for Buildings, 13th Edition; Walter T. Grondzik, Alison G. Kwok; Wiley, October 2017; pp. 855-1072.
HKIA PA Paper 4 - Building Services and Environmental Controls, lecture handouts.

STATUTORY REQUIREMENTS

Water Authority's Regulations / Design Codes of Institute of Plumbing / Building (Standards of Sanitary Fitments, Plumbing, Drainage Works & Latrines) Regulations Cap. 123I

Under section 14(3) of the Waterworks Ordinance (Cap. 102], the Water Authority has the power to prescribe the construction or installation of, or alteration to, a fire service or inside service, and the pipes and fittings used in the construction, installation or alteration must be of the prescribed nature, size, and quality.

All plumbing proposals for water supply service and fire service are therefore subject to the approval of the Water Authority.

The Hong Kong Waterworks Standard Requirements (latest revision) is a set of the normal requirements, which are applicable to the installation of inside service and fire service in addition to the requirements set out in Schedule 2 of the Waterworks Regulations.

WATER SUPPLY SYSTEMS

Water Supply Systems
- Direct
- Indirect (for most high-rise buildings)

DESIGN CONSIDERATIONS

- Street water mains at 300 kPa for fresh water and 150 kPa for seawater whilst in buildings, 150 kPa and 75 kPa respectively, thus affecting the piping materials and their connection methods.

In comparison with other pressure boosting systems, the **gravity tank system** has the advantages of:
- simplicity
- no complicated or sophisticated controls
- high reliability
- the only system which provides a reserve capacity available in the event of power failure or water stoppage
- economical
- operating costs are much lower & capital cost is usually lower than other systems
- minimum maintenance – periodic cleaning and possible repainting of tank
- lower energy use – water pump to replenish the tank (no high power pump is needed)
- minimum pressure variations in the distribution system, hence fewer pressure regulating valves

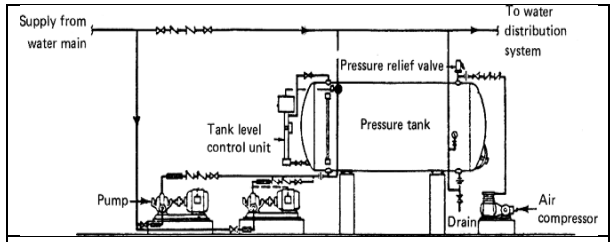
Disadvantages:
- require an elevated tank
- additional structural loading of water and tank
- regular maintenance required for hygiene reason

HYDROPNEUMATIC TANK SYSTEM

A Pneumatic Tank System is a water supply system, in which water is pumped from the supply system into a pressurised tank for storage. Air in the tank is compressed by the water entering the tank. As the pressure in the tank increases, the pressure in the water distribution system also increases since it is fed from the tank.

Advantages of the Pneumatic Tank System:
- no need to have elevated tank
- flexibility in tank location
- space saving
- usually sufficient water pressure

Disadvantages:
- higher initial and operating costs due to the pressure vessel type tank, head pumps and controls
- tank internal corrosion affecting hygiene
- water supply cut-off during cleaning or maintenance works



Pneumatic Tank System

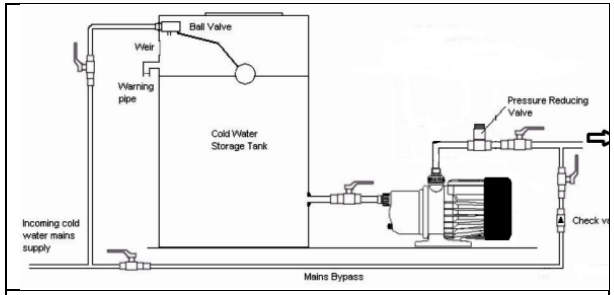
BOOSTER PUMP SYSTEM

A household that suffers from insufficient pressure from the water supply main would benefit from the installation of a booster pump.

The Booster Pump System has the advantages of lower initial cost, and occupies less floor space. However, such system varies from a standalone unit for one apartment

to a complete system to boost water pressure for the whole building.

Disadvantages – sophisticated control, no emergency water reserve, and pump must continue to operate whenever the demand. This may incur possible noise nuisance at night, and higher operating cost.



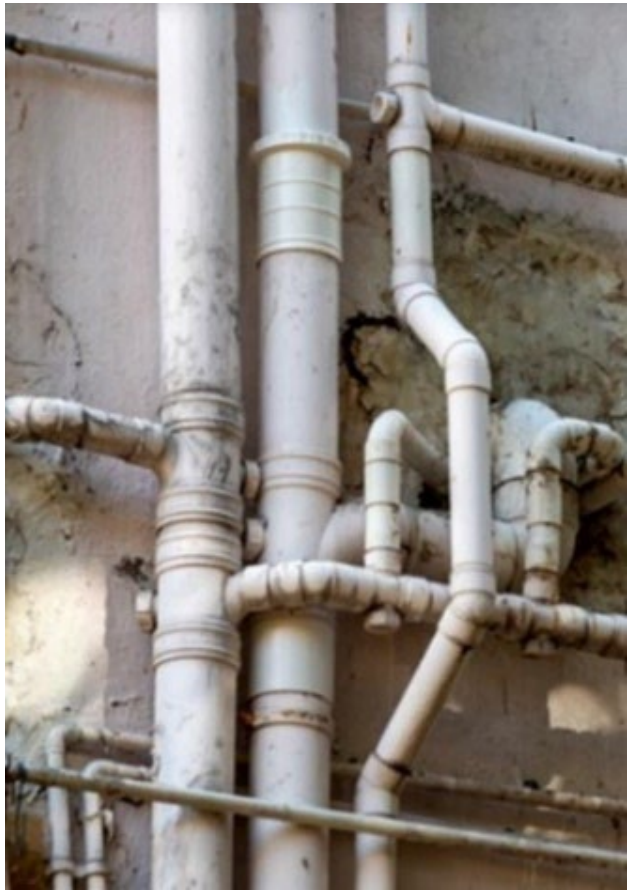
Booster Pump System

Remedial measures to tackle water hammering – First, try to adjust water pressure; Second, check the water pipe wall brackets; but the best way to reduce water hammering is to install relief valve.

Water Regulation 24 governs apparatuses such as water filters that shall not be installed without the permission of WSD. Usually, such water apparatuses shall not be directly connected to the water supply mains so as to avoid the possibility of containment and back flow to the water supply.

GUIDELINES ON INSPECTION AND MAINTENANCE OF DRAINAGE PIPES AND SANITARY FITMENTS OF RESIDENTIAL UNITS

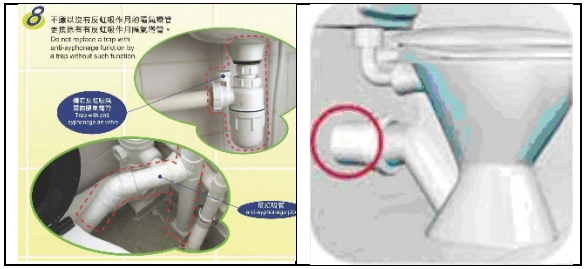
In the midst of COVID-19, it is important that facilities including the water closet, bathtub/ shower tray, floor drain, wash-up sink, and wash basin must be fitted with an effective water seal (a trap with anti-siphonage provision) to prevent foul odour in drainpipes drifting into the premises.



Common renovation works involving repair or replacement of internal branch pipes or sanitary fitments (such as water closets, wash basins or bathtubs) are exempted building works. As a result, in these works are not subject to the Minor Works Control System (MWCS). However, for the repair of external and internal main plumbing and drainage works, suitable contractors registered under the Buildings Ordinance should be appointed in accordance with MWCS.

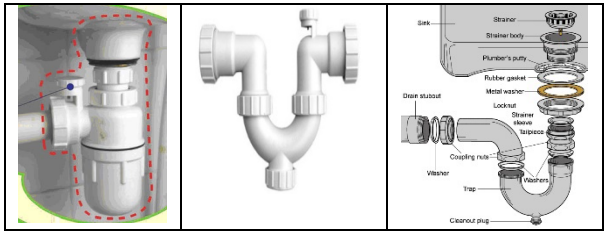
Anti-siphonage valve normalises the pressure inside the pipes to prevent wastewater from back flowing when the occupant turns off the water tap.

The main function of the **anti-siphonage pipe** is to prevent the loss of water seal from the trap of a soil fitment or waste fitment.



P-trap (water closet) retains some water after flushing, thus causing a water seal and preventing sewer gases from entering the building. Flushing water exits at the back of the toilet through a pipe outlet on the wall.

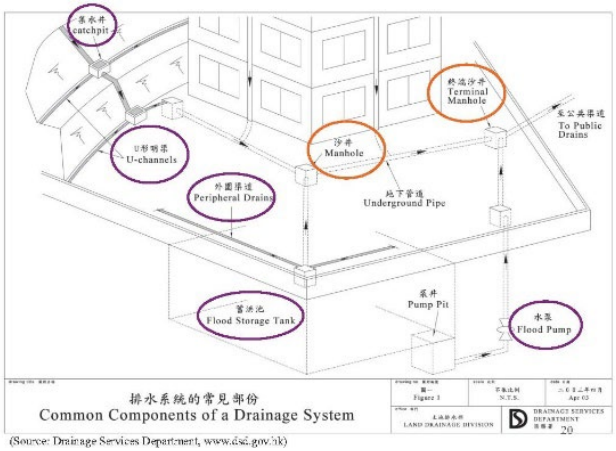
Waste pipe traps – bottle trap, U-shaped trap, P-trap, with cleanout.



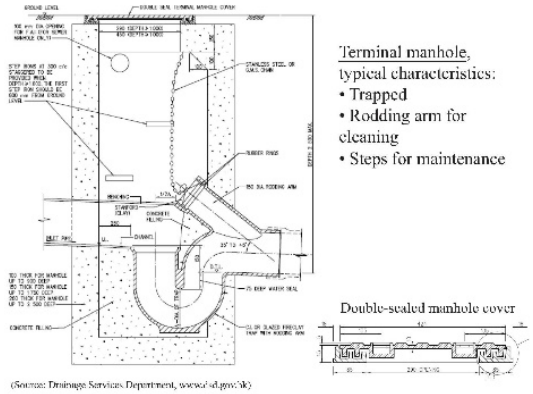
Source:
https://icidportal.ha.org.hk/Home/File?path=/Training%20Calendar/161/Role%20of%20healthy%20drains%20in%20the%20prevention%20of%20spread%20of%20COVID-19.pdf

MANHOLE AND INSPECTION CHAMBER

This refers to a chamber constructed on a drain or sewer to provide access thereto for inspection, testing and the clearance of obstructions. The **Terminal Manhole** prior to its connection to the public drainage system is of importance particularly in determining the invert level, fall, and clearance in the context of its subsequent connections, future maintenance, and repair.



(Source: Drainage Services Department, www.dsd.gov.hk)



(Source: Drainage Services Department, www.dsd.gov.hk)

CONCLUSION

Candidates should familiarise themselves with the following design aspects:

1. Direct and indirect water supply systems for high-rise buildings
2. Design criteria for Gravity Tank System, Pneumatic Tank System, Booster Pump System
3. Water hammering and remedial measures
4. Usage of greywater – disinfecting and filtering
5. Apparatuses governed by Water Regulation 24
6. Guidelines on Inspection and Maintenance of Drainage Pipes and Sanitary Fitments of Residential Units
7. Waste and soil pipes – ventilation pipe at roof level, U-shape trap with cleanout
8. Toilet P-Trap
9. Manhole – last manhole, invert level, fall, rodding eye

SAMPLE QUESTIONS

The following sample questions aim to assess candidates' understanding of this Section.
(Please note that these are extracted from *http://hkia.net/en/pdf/PA/Sample_Questions.pdf* *and* the Professional Assessment Seminars)

1. Which of the following pipes without internal lining is not acceptable to the Water Authority for use as cold/hot/salt water inside service within a building?

A. uPVC pipe
B. Copper pipe
C. Cast iron pipe
D. Galvanised steel pipe
Ans: D

2. Which of the following statements is not correct according to the Water Authority's requirements on water flushing device?

A. Valveless siphonic type is acceptable.
B. Dual-flush may be provided by the valveless-type device.
C. Valve-type flushing devices are acceptable if the flushing volume is kept within 7.5 litres.
D. It is possible to use valve-type flushing devices triggered by an infra-red sensor.
Ans: B

3. Which of the following plumbing installations is not acceptable to the Water Authority?

A. Cast iron pipes in a cold/salt water inside service.
B. Drinking fountain directly connected to the mains water supply system.
C. Branching of water supply pipe downstream of the water meter.
D. Installation of water filters in the water tank at roof with non-return valve upstream of the filter.
Ans: B

4. What is the primary function of a trap in a plumbing drainage system?

A. It catches grease before it clogs the drain.
B. It keeps sewer gas from entering the building.
C. It provides a cleanout when drains become clogged.
D. It catches small items and objects that are accidentally dropped down the drain so they can be retrieved.

Ans: B

5. The Water Authority accepts the minimum volume of flushing cistern to be reduced from 9 litres to

A. 7.5 litres.
B. 6.25 litres.
C. 5 litres.
D. 3.75 litres.

Ans: A

6. Which of the following provisions in a water supply system are not permitted by the Water Authority?

(1) ultra-violet steriliser to ice machines
(2) filtering strainer to drinking fountains
(3) make-up water connection from the kitchen water supply to the kitchen exhaust hood in a restaurant
(4) dedicated potable water tank for restaurants

A. (1) and (4) only
B. (1), (2) and (3) only
C. (2), (3) and (4) only
D. (1), (2), (3) and (4)

Ans: C

7. Which of the followings are current water pipe materials approved by the Water Authority?

(1) lead
(2) uPVC
(3) copper
(4) lined galvanised steel

A. (1) and (4) only
B. (1), (2) and (3) only
C. (2), (3) and (4) only
D. (1), (2), (3) and (4)

Ans: C

8. In a closed re-circulating chilled water system, which of the following control is required?

A. algae control
B. scale control
C. slime control
D. corrosion control

Ans: C

REVISION QUESTIONS

1. Compare and contrast the use of various piping materials for fresh water and seawater. _____
2. What is the major feature affecting the external appearance of a high-rise residential building with a gravity-fed water supply system? Sketch a schematic diagram of such system. _____
3. Why is the gravity-fed water supply system so popular in high-rise residential buildings?
4. List the essential components of the Pneumatic Tank System. Hence, sketch a schematic diagram of the system. _____
5. What is the importance of the last manhole within the development? Sketch a cross section diagram to elaborate on the key parameters. _____
6. What are the functions of U-shape traps in waste pipes? _____
7. What materials are used for the pipework of fresh water and seawater supplies in buildings? _____
8. Why would booster pumps for a small apartment cause public nuisance when in operation after midnight? _____
9. What does Water Regulation 24 stipulate regarding consumers' water apparatuses? _____
10. What is water hammering? How could this be mitigated? _____
11. What is the function of the soil vent pipe? What are the specific installation requirements for the soil vent pipe above roof level? _____
12. What remedial measures can be taken when encountering excessive water pressure? _____
13. What are the general applications of greywater? What is the function of P-Trap in the water closet? _____
14. What are the common methods of treating greywater in urban areas of Hong Kong? _____
15. What are the functions of an anti-siphonage valve and pipe? _____

SECTION F – ELECTRICAL SYSTEMS, LIFTS AND ESCALATORS

RECOMMENDED READING

Mechanical and Electrical Equipment for Buildings, 13th Edition; Walter T. Grondzik, Alison G. Kwok; Wiley, October 2017; pp.699-758; 1257-1422; 1485-1594. and HKIA PA Paper 4 - Building Services and Environmental Controls, lecture handouts.

POWER SUUPLY

Power supplies in Hong Kong – There are two main electricity generation companies in Hong Kong:

- Hongkong Electric Company (HEC), which supplies Hong Kong, Ap Lei Chau and Lamma Islands, and
- China Light & Power Co., Ltd. (CLP), which supplies Kowloon, the New Territories and most of the outlying islands.

SUB-STATION - TRANSFORMER ROOMS

For architects, the design consideration often starts from the transformer sub-station where the incoming high voltage cable from the power company (usually in an underground cable trench) enters the site boundary and subsequently the transformer room.

Transformer design is based on the maximum values of voltage and current during operation. The rating excludes any power factor and hence is not related to the power output (kW). Transformers are rated in terms of kilovolt-amps (kVA).

DISTRIBUTION SYSTEM

Power is distributed to the consumer substations at 11kV. In order to ensure the stability and security of electricity supply to consumers, ring network of electricity supplies is often adopted.

In urban areas, 11kV circuits are usually installed underground, whilst an extensive network of 11kV overhead lines supplies the countryside.

Three main types of incoming supply:

i) Low Voltage Supply Cable

- The L.V. supply is employed when the electricity demand of the building is low and adequate supply can be obtained from L.V. network nearby (below 240kVA, e.g., 400A).

ii) 11kV Incoming High Voltage Cable followed by Low Voltage Supply to Consumer

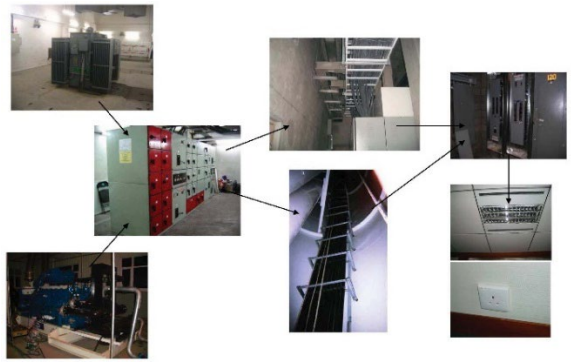
- This is employed when the electricity demand is fairly high.
- For larger buildings, one or more consumer substations (transformer rooms) equipped with 1500kVA 11kV/380V transformers shall be installed.
- No more than 3 transformers can usually be installed inside one consumer substation in accordance with the COP of the two utility companies except with special approval.

iii) 11kV Incoming Supply

- This is required when the electricity consumption is extremely high and/ or a secured supply is desirable, e.g., Tuen Mun Hospital.

DESIGN CRITERIA OF CONSUMER SUBSTATION

When considering the location of the consumer substation (transformer room) in a building, space with less rental value is usually more favourable to clients. However, the following technical requirements, as laid down by the utility companies and government departments, should also be complied with.



General Requirements:

- Proper access of adequate height and width to the sub-station shall be provided.
- Usually, minimum headroom of 3.5m of the substation shall be maintained.
- Fire protection shall be provided for oil-filled transformers (phasing out) and a fire detection system for gas-insulated transformers.
- Consumer main switch room shall be located immediately adjacent to, above or below the substation.
- No expansion joint shall be allowed in the substation.
- Independent ventilation shall be provided in the sub-station.
- Floor level of the substation shall be at least 150mm higher than the outside level to prevent flooding.
- No more than the maximum number of transformers can be housed in one consumer substation except with the utility company's approval.
- Cable trenches, transformer room doors shall be constructed in accordance with the utility company's drawings.

E&M Services required

- Fluorescent fittings & lighting switch
- MCB distribution board c/w MCB
- Socket outlets

- Fire protection/detection systems
- Ventilation system

- Gas leakage alarm system (for SF_6 gas-insulated transformer)
- Equipment bonding and earthing conductor

LANDLORD SUPPLY

Essential: fire protection/ detection system; fireman's lifts; escape stair signage; computer and telecommunication equipment in building management systems; essential lighting. All these essential loads shall be backed up by an **uninterrupted power** (emergency) **supply** (UPS).

Non-essential: plumbing and drainage; passenger lifts; air-conditioning plant; public lighting; general power.

TENANT SUPPLY

Separated meters shall monitor each tenant's electricity consumption for both tariff calculation and energy efficiency purposes.

EMERGENCY GENERATOR

More high-rise buildings were constructed in the 1970's. Since then the FSD's Code of Practice has adopted more stringent fire protective measures. One of the major requirements is the installation of emergency generator. This can provide continuous essential power supply for a certain period of time.

The design should comply with the EPD's Guidelines on Application for Installation of Emergency Generators in respect of:

- 25 litres of conventional liquid fuel
- Minimum distance of 3m above the parapet wall of the podium or the highest point of any structure on the podium/roof
- Positioning of chimneys (exhaust outlets)
- Diesel particulate trap filter (soot trap)

Source:
https://www.epd.gov.hk/epd/sites/default/files/epd/english/environmentinhk/air/guide_ref/files/guidelines_for_e_generator.pdf

PROCEDURE FOR THE DESIGN OF AN ELECTRICAL DISTRIBUTION SYSTEM IN BUILDING

Based on the historical loading data available from the utility company, the M&E consultant can calculate the preliminary total load.

Once most of the loading information of E&M equipment is made available, the consultant can re-estimate the total loading of the whole building and update this figure when necessary.

Based on the equipment loading and the associated fault level, the proper type of over-current protective device and cables for each circuit are selected.

For large voltage supply, bus bars instead of cables are used for the riser. For sensitive telecommunication installations, these bus bars are often protected with steel armour plates to prevent accidental damages or vandalism.

Final Circuits for Lighting and Socket-outlets
13A socket-outlets are extensively used in final circuits. Although 15A socket outlets are still accepted by the electricity companies, each final circuit is restricted to feeding one outlet only.

Using 13A socket-outlets has the advantage of lowering the material/labour costs in wiring and enhancing safety by incorporating a fuse link in the 13A plug.

Residual Current Device (RCD)
The RCD is also known as ELCB (Earth Leakage Circuit Breaker). It is a kind of electric shock protection. If the leakage current is larger than the pre-set value, the corresponding circuit breaker will automatically cut off the power supply from the circuit. Under the current statutory regulation, the ELCB should be used to give protection to every socket outlet, and 30A ELCBs are commonly used.

Conduits and trunking
Conduits, trunking, and cable trays are made of either metal or plastic.

Tubular conduit, which includes a flexible steel draw wire, is commonly set within the concrete slab, or fixed to the slab soffit with access from junction boxes at convenient locations. If additional cabling is required, it can be drawn

through the conduit using the draw wire over a limited distance.

Wall-mounted skirting duct is a convenient way of providing power and telephone terminal around the perimeter of a room. This enhances the flexibility of the floor plan layout.

Floor trunking system can provide electric power outlets at the centre of a large floor. This may be significant in open plan offices where there are no internal partitions, and all skirting ducts are too remote. These may be set flush with the floor surface and covered by tiles or carpets. General-purpose power and telephone sockets can be plugged into the outlets at ease.

Floor-mounted general-purpose outlets are usually installed to suit the office and desk layout with short flexible cables connecting to the desktop computers, table lamps, small power devices, etc. Trunking is generally laid on a plan grid, usually at 3.2/3.6/4.8m centres, to provide the flexibility required.

PERMANENT AND TEMPORARY DISTRIBUTIONS AND CONNECTIONS

The cables supplying electric power within a building may either be of permanent or temporary nature.

Permanent cabling distributions and connections, e.g., for air-conditioning equipment, fans and pumps are rigidly fixed to the building and are more robust. Usually, cable trays or box trunkings are installed for the power distribution.

For general office equipment such as computer terminals, it is advisable to provide greater flexibility in the electrical distribution system, which permits power requirement changes by future tenants. Electric power and telephone cables must be physically separated and protected if carried in the same trunking, since power surges may affect communication signals.

CODES AND REGULATIONS

Electrical installations should be designed in accordance with the following specifications:

- Latest edition of wiring regulations of the Institution of Electrical Engineers
- The CLP Supply Rules/ PAL Supply Rules
- EPD's requirements
- BD/FSD's regulations
- CIBSE design guide

LIGHTING

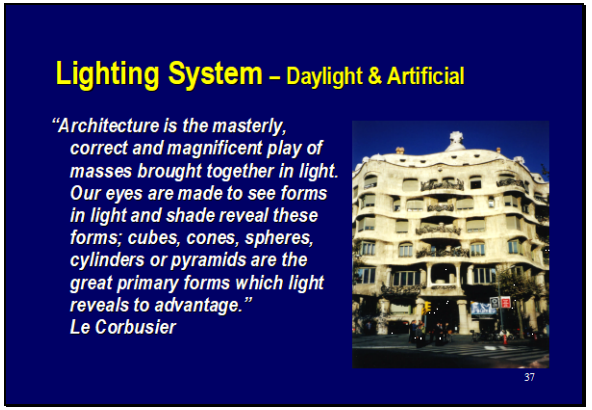
Artificial lighting constitutes a considerable amount of energy use in buildings. A typical building consumes 15% - 25% of the total energy use in artificial lighting.

- Residential 20%
- Industrial 20%
- Stores 20%
- School 15%
- Office 20 - 25%

Reduction in artificial lighting could also contribute to the reduction in sensible heat, resulting in the energy reduction of the air-conditioning system.

Daylighting
Two important aspects to consider:

- light from overcast sky
- direct rays of the sun



As mentioned in Section B of this study guide, daylight factor is the ratio of the illumination received at a point indoor to the illumination received simultaneously by an unobstructed point outdoor.

The factor is made up of three components: -

- The sky component - direct light from the sky falling on the surface in question.
- The externally reflected component - the reflected light from external surfaces.
- The internally reflected component - light received by reflection from the internal surfaces of the room.

The daylight factor for dwellings is based on the following assumptions of the reflection factors:

- Walls 40%
- Floor 15%
- Ceiling 70%

Daylight factor is normally measured or estimated in terms of the light falling on a horizontal plane at 850mm above ground or otherwise at the level of the working plane.

SOLAR HEAT GAIN

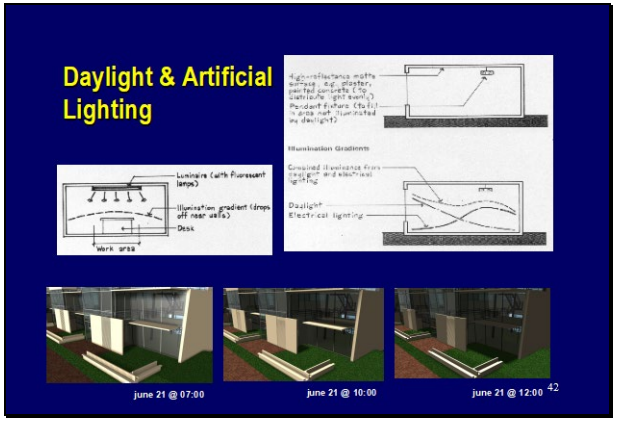
Overheating due to excessive solar gain is a serious design issue in Hong Kong. High window-to-wall ratio, particularly on the east and west facade, coupled with lightweight cladding and construction, tall curtain wall buildings without any shading by fins, vegetations, other buildings (inter-blocks shading), and to a lesser extent, reflected heat from surrounding shiny buildings, are crucial and contributing factors causing overheating inside a building.

In many commercial buildings, ventilation relies solely on the mechanical air-conditioning system, and most windows may not even be operable. Architects must balance the design for the provision of large windows for daylighting, panoramic views, aesthetic considerations, and its possible risks of overheating internally.

DESIGN FOR DAYLIGHTING

- Construct overhang outside window.
- Construct light shelf, splayed head, and sill.
- Screening of the sky by external or internal screens and blinds.
- Use solar control glass.
- Illuminate the window wall (uplight) to reduce luminance contrast at the window wall.
- Use light-coloured finishes for the ceiling and walls, especially for the window wall.

Lighting
Good lighting design in buildings (daylight and artificial) is a matter of both quantity and quality. The architect, in collaboration with the lighting engineer, should consider not only whether there is enough light for the given function of each space, but also the visual efficiency and comfort. Many simulation packages, which can combine natural and artificial lighting, are available in the market to provide cross-checking on the lighting intensity and visual impression of the design in buildings.



Terminology:
Illuminance is the illumination level measured by lux, or lumen per square metre.

Luminance, or brightness of a surface depends both on the incident illumination and on the surface's reflectance. Assuming the surface is matt, the design should avoid direct reflection of the light source.

Luminous efficacy is a measure of how well a light source produces visible light. It is the ratio of luminous flux to power, measured in lumens per watt (lm/W).

Ranging from 65 to 110 lm/W, LED is one of the light sources with highest luminous efficacy. It is more energy efficient than incandescent bulb, compact fluorescent lamp, T5 fluorescent tubes, high intensity discharge lamp, and tungsten halogen lamp.

For comparison of efficacy of different lamps, please refer to this list from EMSD:
Sour*http://www.energyland.emsd.gov.hk/en/appAndEquip/equipment/lighting/tubes.html*

Advantages of LED:
• Long-life – Some high-quality LED luminaries that work properly within its temperature limit will last about 25,000 to 50,000 hours, which is about 3 to 6 times as long as compact fluorescent lamps, and far longer than the typical incandescent lamp with a service life of about 1,000 hours.

• Robust and reliable – LEDs having no filament to break are inherently rugged. They are also difficult to damage with external shock, unlike fluorescent lamp and incandescent bulbs, which are fragile.

• Versatile colour changes – LEDs response quickly to both switching and dimming and it is very suitable for dynamic lighting effects.

Contrast is the eye's perception of the extent of brightness within the visual field i.e., the brightness relative to each other.

Glare occurs whenever one part of an interior is much brighter than the general brightness of the same space. The most common sources of excessive brightness are luminaries and windows as seen directly or by reflection.

Special considerations for hospital and museum design in glare control are usually incorporated.
There are two types of glares:
- Disability glare can cause a reduction of visibility of details in the object.
- Discomfort glare - it can cause visual discomfort.

CIBSE Code for Interior Lighting recommends the following maximum values of glare index for lighting installations.
- Fine processing in watch making 10
- Hospital wards 13
- Drawing Office 16
- Offices 19
- Circulation areas 22
- Hotel food store 25

Methods of reducing glare for electric light.
- Use LED
- Use fluorescent lamp instead of filament lamp

- Replace the bright light source with several weaker sources to give the same luminance if this is practical
- Use opal diffuse or prismatic diffuser
- Increase the general luminance of the interior by using light-coloured finishes

LIGHT SOURCES

Filament (incandescent) lamps: All filament lamps share the characteristic of being able to be instantly relighted following the restoration of an interrupted electricity supply.

A light-emitting diode (LED) is a semiconductor light source which emits light. Electrons in the semiconductor recombine with electron holes - releasing energy in the form of photons. The energy required for electrons to cross the band gap of the semiconductor will determine the colour of the light (corresponding to the energy of the photons). Using multiple semiconductors or a layer of light-emitting phosphor on the semiconductor device, white light is obtained.

GLS: The General Lighting Service lamp refers to the traditional tungsten-filament lamp, available in powers of up to 2000W.

TH: (Linear) The Tungsten-halogen lamp operates at a higher temperature than that of GLS lamps, resulting in higher efficacy, available in powers of up to 2000W.

LVTH: The Low-voltage tungsten-halogen lamp is available in 35, 50, 75, 100 & 150W. Within each wattage above, there are ranges of lamps available, which differ in construction, luminous efficacy, colour properties, cost dimensions, lamp cap type, etc.

HID (High-Intensity Discharge) lamps:

MCF: A low pressure mercury discharge lamp with a linear glass discharge tube within an internal fluorescent coating: a tubular fluorescent lamp (TL), available in up to 125W.

MCFA: An MCF lamp with an external conducting strip connected to both end caps (for quick starting).

MCFE: An MCF lamp with an external water repellent coating.

MCFR: An MCF lamp with an internal reflecting coating on part of the tube (or designated as "reflector TL-F").

MCFB: An MCF lamp with an internal metal starting strip fitted with special single contact caps (reflector TL-X or TL-S).

CF: Compact Fluorescent lamp, with designated Type L (2-pin 2-arm or 4-pin 2-arm) & PLC (2-pin 4 arm), are not self-ballasted. Other CF lamps are usually self-ballasted. They include Type SL (Jam-jar shape), SLD (spherical), and EL (electronic ballasted) lamps. Available in up to 35 W. Families of CF lamps are fast developing; lamps with various shapes, colours, and powers are coming into the market.

MBF: High-pressure mercury discharge lamp, not very popular now, overtaken by SON or MBI lamps. Available in elliptical bulb shape and reflector shape (MBFR). MBFR is an MBF lamp in which part of the outer envelope has an inner reflecting coating. Available in up to 2000W.

MBT or MBFT or MBTF: Mercury-tungsten 'dual' lamp, a tungsten filament that acts as the ballast to a mercury discharge capsule, has already become a museum piece.

MBI: Metal-halide (still using high pressure mercury vapour) lamps, which are increasingly being used in industrial situations. Usually in elliptical envelops, available in up to 2000W.

MBIF: An MBI lamp with a fluorescent coating on the inside of the outer envelope.

MBIL: An MBI lamp in linear double form without an outer envelope.

MBIR: An MBI lamp with reflects form.

CSI or CID: Compact-source metal-halide lamps (CSI = Compact Source Iodide, CID = Compact Iodide Daylight), smaller in size and operates at higher colour temperatures than other metal halide lamps.

HMI: Another type of compact-source metal-halide lamp with double ends and operates with a saturated vapour pressure, it emits strongly in the ultraviolet region.

SOX: Low-pressure sodium-vapour lamp. The emitted light is virtually monochromatic yellow, without colour-rendering property. SOX lamps are extensively used for lighting of main traffic routes, because of their high efficacy and the belief that - yellow light penetrate fog-better. However, they are not recommended for any indoor and industrial outdoor applications. The lamp is usually fitted with a U-shaped arc tube casing.

SLI: An SOX with a linear arc tube which is combined with the outer envelope to form one unit (linear construction).

SON: High-pressure sodium-vapour lamp emits a pleasant golden-hued light of quite good colour-rendering, which is suitable for both indoor and outdoor industrial tasks where fine colour discrimination is not required. The usual form is linear and both single and double-ended lamps (SON-TD or SON-L) are made, and a reflector-bulb version is also available (SONR). Available in up to 1000W.

SONDL: White SON is good for general industrial use and has proved to be most satisfactory source for security lighting installations. A high-output version (SONP) is available. SON lamp family is developing rapidly. As new types of SON lamp are introduced, new suffix letter will be associated with them.

Cold cathode external lighting system in neon tubes that enable the changing of colour by programming via the Building Management System has once been widely adopted in new and retrofitted commercial developments internally and externally. However, with the LED system's rapid development, it is now becoming less attractive in application.

CHOICE OF LAMP

The availability of the range of luminaries significantly affects the choice of lamp, so detailed considerations should be made by the designer to achieve the intended effect particularly for applications in the commercial sector.

The designer should compile a list of suitable lamps by rejecting those, which do not satisfy the design objectives. The availability of suitable luminaries can then be checked, and the economics of the combinations assessed.

Lamps must satisfy their properties in colour rendering. Visual tasks requiring accurate perception of colours are less common than what the public may believe, but there are many merchandising situations where good (and accurate) colour rendering is desirable, such as in the apparel industry.

A warm colour (2500-3500K) appearance tends to be preferred for an informal, cosy and comfortable environment, at lower illuminance, and in cold environments.

A cool colour (4000-6000K) appearance tends to be preferred for formal situations, at higher illuminance, and in hot environments.

It is normally undesirable to illuminate adjacent areas (visibly) with sources of significantly different colour appearance.

Many high-pressure discharge lamps have the deficiency of having longer run-up time. These lamps are unsuitable for areas requiring rapid provision of illumination.

Lamp life affecting its subsequent maintenance requirement must also be considered. Other selection aspects, such as standardisation of lamp types and sizes within a particular site particularly areas with access difficulties, can simplify maintenance.

In rooms where rotating or moving machinery is used, care should be taken to avoid stroboscopic effects.

Lamps are not completely standardised between makers, - lamps from different suppliers having similar general descriptions may not be identical; they may differ, for example, in lumen output, colour property, claimed lifespan or restarting characteristics etc. It is also important to review the performance specifications of the lamp, especially its wattage, voltage, beam spreads, lamp type and colour temperature if required. For detailed information of a specific lamp, for instance, Luminous Intensity Distribution chart illustrating the intensity and distribution angles, the manufacturer's datasheet should always be studied.

A good lighting system not only requires a good design, but also indispensably sound management, good operation, and efficient maintenance in the context of technical performance, energy efficiency, and aesthetic appearance.**Terminology as in EMSD's Code of Practice for Energy Efficiency of Lighting Installations:**
'Lighting Power Density (unit: W/m^2)' refers to the total electric power consumed by the lighting installations per unit floor area of an illuminated space – as a performance indicator of energy efficiency in lighting design.

Table (LG4) : Maximum Allowable Values of Lighting Power Density for Various Types of Space

Space Code	Type of Space	Maximum Allowable Lighting Power Density (W/m^2)
A.	**Spaces for Common Activities**	
A.1	Atrium / Foyer	33
A.2	Carpark (indoor type)	8
A.3	Conference / Seminar Room	25
A.4	Corridor	15
A.5	Data Processing Room	25
A.6	Storeroom	15
A.7	Kitchen / Pantry	22
A.8	Lift Lobby	22
A.9	Machine Room / Switch Room	15
A.10	Reception / Waiting / Queuing Area	22
A.11	Rest / Recreation Room	22
A.12	Staircase	13
A.13	Toilet / Washroom / Shower Room	15
A.14	Vehicle Depot (for maintenance/repair/inspection)	22
B.	**Offices**	
B.1	Open Plan Office / Cellular Office	23
B.2	Drawing Office	28
C	**Hotels**	
C.1	Bedroom	25
C.2	Banquet Room / Function Room / Ball Room	40
D	**Educational Institutions**	
D.1	Classroom / Lecture Theatre / Laboratory	23
D.2	Library (reading area, stack area, audio visual centre)	23
E.	**Mass Assembly Area**	
E.1	Seating Area inside a Theatre / a Cinema / an Auditorium / a Concert Hall	35
E.2	Mass Assembly Area / Assembly Hall	25
E.3	Exhibition Hall / Gallery	25

Source:
https://www.emsd.gov.hk/filemanager/en/content_724/lightingcop.pdf

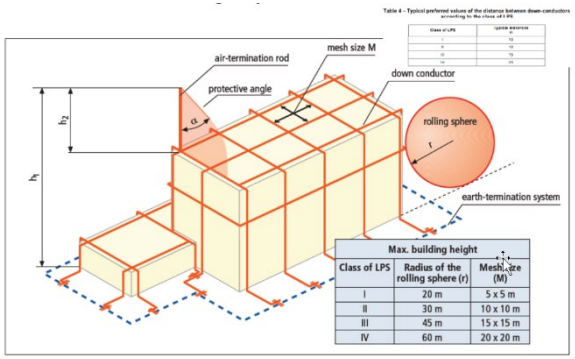
'**Luminaire'** refers to a lighting device, which distributes light from a single lamp or a group of lamps. A luminaire should include control gears and all necessary components for fixing and mechanical protection for lamps.

'**Luminous Flux** (unit : lm)' is a quantitative measure of light emitted by a light source. The quantity is derived

from radiant flux (power in watts) by evaluating the radiation in accordance with the spectral sensitivity of the standard eye as described by the CIE Standard Photometric Observer.

'**Luminous Efficacy** (unit : lm/W)' is defined as a ratio of luminous flux emitted by a single lamp to the power consumed by the lamp. Its numerical value is equal to the lamp's Luminous Flux divided by the Nominal Lamp Wattage.

Lumen Method is commonly adopted to determine the



number of luminaries needed to provide a given illuminance.

LIGHTNING PROTECTION

The safety of any structure and its occupant when exposing to lightning is dependent on the correctly designed, manufactured, and installed lightning protection system in compliance with British Standard EN 62305:2013.

A lightning conductor is incapable of discharging a thunder-cloud's lightning flash. Its main purpose is to divert a lightning discharge, which might otherwise directly strike a vulnerable part of the structure. Such striking energy is required to be confined and conveyed to the earth in a safe manner.

The zone of protection is the volume within which a lightning protection conductor can give protection against a direct lightning strike - by directing the strike to the conductor. The size and shape of the protective zone varies according to the height of the building or the vertical conductor.

Generally, structures not exceeding 20m in height may require a vertical conductor rising from the ground level. The zone has been defined as the cone with its apex at the tip of the conductor and its base discharged to the ground.

For structures taller than 20m, where there is a higher probability for such buildings to be struck from the side, it is recommended that the protected volume should be determined using the **Rolling Sphere Method**.

Since the lightning leader can approach a building from any position, all possible approaching angles can be simulated by rolling an imaginary sphere around and over the building right down to the ground as illustrated in the below diagram. Such a portion of surface may need a lightning conductor.

Source:
https://www.bse.polyu.edu.hk/deptNews/2012/20121206-Lightning_lecture%20note.pdf

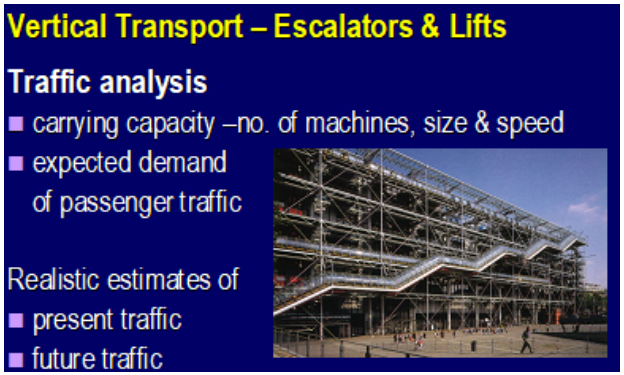
Generally, the smaller the size of the sphere, the greater the protection, but the more costly the installation would become. The British standard BS6651 recommends the rolling sphere with a radius of 20m.

Major Components of the Lighting Protection System
i) Air terminations
ii) Down conductors
iii) Joints and bonds
iv) Test joints
v) Earth terminations
vi) Earth electrodes

LIFTS AND ESCALATORS

Vertical Transportation – lifts, escalators, moving ramps, dumb-waiters, hydraulic platforms, vertical conveyors, and gondolas.

Lifts can be classified in accordance with the usages:
1. Passenger lift/Fireman's lift.
2. Service/Goods Lift.
3. Freight Lift.



Traffic analysis: The carrying capacity of any lifting system must match the expected demand for transportation in the building based on design criteria consistent with the building's quality, e.g., a Class A Office.

A precise calculation of the capacity of the lifting equipment based on the number of machines, sizes and speeds are made possible by computation. Realistic estimates of the present traffic and future traffic over the expected life of the building are required since lift and

escalator systems are very difficult to modify once they have been installed.

Round-Trip Time (RTT) is the time taken for a passenger to complete a lift journey from the main entrance lobby to a particular floor. It may be considered as the summary of the following components. The sequence starts from the instant at which the call button is pressed. Car descends to the main lobby / Doors open / Passengers

enter / Doors close / Car accelerates to maximum speed / Car travels at constant maximum speed / Car decelerates to stop / Doors open / Passengers leave / Doors close (lift car returns to the main lobby if being programmed).

Waiting Interval (WI) is expressed in seconds and represents the round-trip time of one car divided by number of cars in a common group system; it provides a criterion for measuring the quality of service. The average waiting time is sometimes termed as 'qualitative value', as it measures the quality of service offered by the lift system.

Interval (in sec.)	Quality of Service	
35-45		Acceptable for offices
60		Acceptable for hotels
90		Acceptable for residential flats

Rule of Thumb: Values of HC and WI

Building type		HC(%)	WI(sec)
Offices	High cost	13 - 15	25 - 30
	Low cost	12 - 14	30 - 45
Residential	High cost	5 - 7	50 - 60
	Low cost	6 - 8	60 - 70
Hotels	High cost	7 - 8	40 - 60
	Low cost	6 -7	50 - 70
Shops	High cost	8 -9	40 - 60
	Low cost	7 - 8	40 - 60

48

Hoisting Capacity (HC) represents the percentage of the total building population which can be transported by the lift installation within the building in a five-minute peak period. This is a measurement of the system's capacity of filling up passengers within the building at a given time.

Calculated values of HC and WI for a lift installation (comprising several lifts) must match the quality criteria of the building. By itself, the HC is an insufficient parameter for predicting the quality of lifting performance.

In Hong Kong, it is common to find long queues at the G/F lift lobby that extend to the street especially in Class B commercial buildings where WI and HC indexes are less than desirable.

To alleviate the problem, take a scenario of four (18 passengers) lifts that could provide the same HC as three (24 passenger) lifts, but the WI for the three-car group would be almost twice as long.

- large cars tend to improve the HC
- small cars tend to improve the WI

To resolve this design issue for a given lift selection where the HC is better than required and the WI is not good enough, the solution would be to use more smaller cars. Other strategies such as lift zoning and lift calling control systems would also alleviate the problem.

EMSD Code of Practices for Energy Efficiency recommends that the decoration load of a passenger lift is in any case to be limited to 600 kg.

Lift Travel is the number of floors above ground multiplied by the floor height.

ESCALATORS

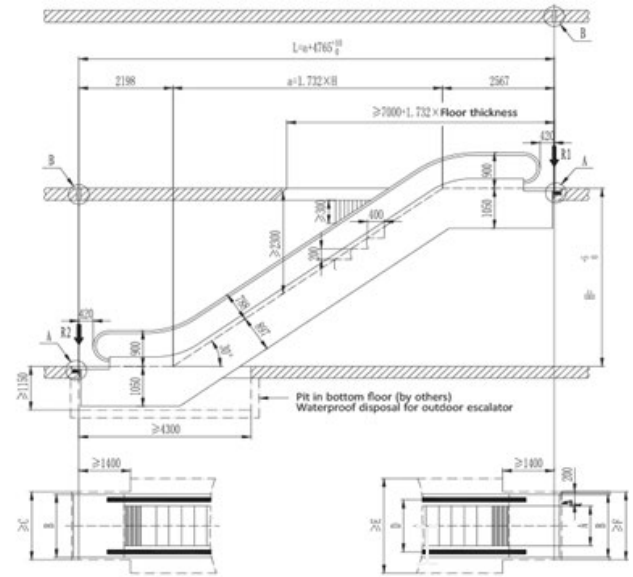
The selection of escalators is based on the maximum number of persons to be transported over a five-minute period. The carrying capacity of an escalator group must match the expected peak demand.

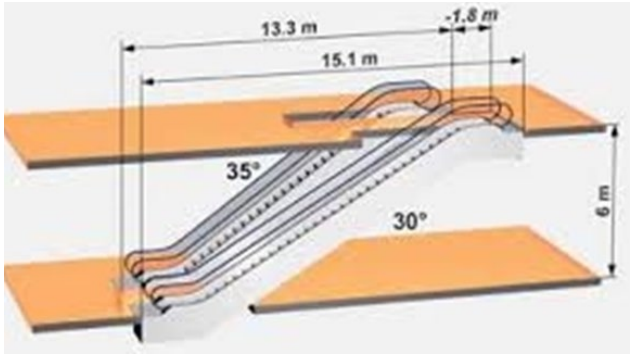
Escalators are powered by constant speed AC motors, with handrails coordinated with the movement at the same speed as the treads.

Widths of the tread are 600 mm, 800 mm and 1000 mm, for 1, 1.5 and 2 persons respectively.

The angle of inclination of an escalator is normally 30 degrees (max. 35 degrees).

The escalator standard speeds are 0.45 to 0.6m/s, although high speed lifts can travel at an amazing speed of 20m/s.





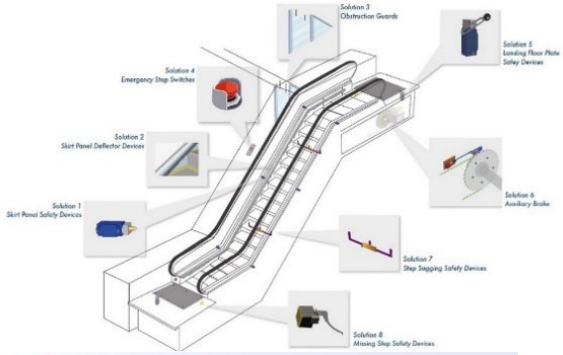
Source:
https://www.emsd.gov.hk/filemanager/en/content_805/CoP%20on%20Lift%20Works%20and%20Escalator%20Works%202018%20Edition%20(Eng).pdf

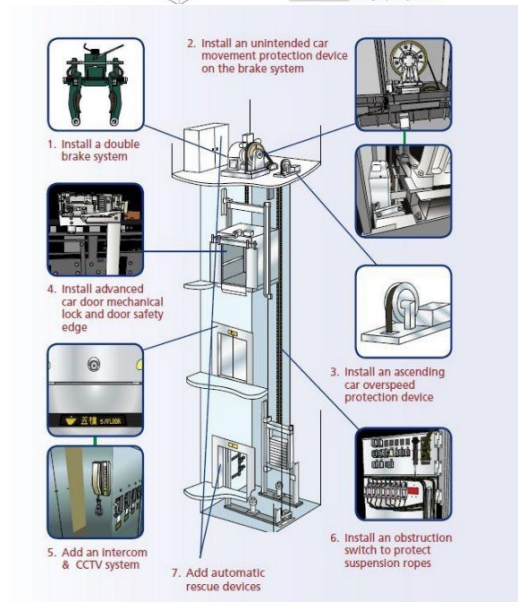
The machine-roomless lift has become rather popular as it saves space and travels faster than the conventional traction lift and hydraulic lift.

With the recent escalators and lift accidents, EMSD have issued the following guidelines, and offered monetary assistance to qualified buildings.

- Applicable Solutions for Enhancing Requirements of Existing Escalators.
- Applicable Solutions for Enhancing Requirements of Existing Lifts.

Financial assistance focuses on the 7 points of enhancing lift safety, for instance, by installing double brake system, and CCTV in lift cars, etc.



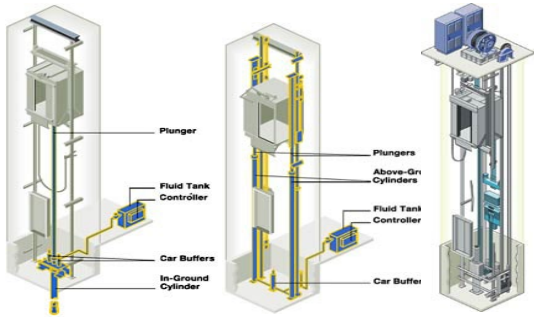


Source:
https://www.emsd.gov.hk/en/lifts_and_escalators_safety/responsible_persons_corner/lift_modernisation_resource_corner/index.html

HYDRAULIC LIFTS AND TRACTION LIFTS

The modern hydraulic lift uses oil pressure from a self-contained power pack driven by an electric motor to drive the plunger supporting the lift car up and down the shaft.

An electric lift with traction drive (gear or gearless) consists of a lift car suspended by steel ropes, which travel over a grooved driving sheave/track.



CONCLUSION

Candidates should familiarise themselves with the following design aspects:

1. Design criteria and application for Transformer Substation, LV Switch Room, Electrical Room, and Emergency Generator Room.
2. Provisions for LV, 11kV/380V, 11kV High Voltage incoming power supply.
3. Earth Leakage Circuit Breaker and MCB.
4. Earthing of all electrical equipment including low-voltage shaver outlets and vanity units.
5. Essential and non-essential power supplies particularly in the context of FS.
6. Device for high voltage distribution, i.e., bus bar.
7. Uninterrupted power supply (UPS) and its typical application.
8. Typical lux levels for usages in CIBSE Guide.
9. Three components of Daylight Factor.
10. Causes of bad lighting design.
11. Measures to obviate discomfort / disability glare.
12. Colour rendering – warm / cool.
13. Maintenance issues for artificial light fittings.
14. Familiar lamp types in respect of performance and energy efficiency - see lamp types underlined.
15. External lighting system - cold cathodes.
16. Latest developments in artificial lighting – LED, fibre optic lighting and metal halide illuminators.
17. Design criteria of Rolling Sphere Principle of 20m radius and components of lightning protection system.
18. Design criteria of vertical transportation.
19. Assessment criteria for quality lift services - WI vs HC.
20. Operational principles of hydraulic lift.
21. Latest developments of lift system - floor-buttonless lift system, high speed lift system.

SAMPLE QUESTIONS

The following sample questions aim to assess candidates' understanding of this Section.
(Please note that these are extracted from *http://hkia.net/en/pdf/PA/Sample_Questions.pdf* and the Professional Assessment Seminars)

1. Which of the following combinations reflects the commonly recommended lighting intensities in line with the design guide of the Chartered Institution of Building Services Engineers (CIBSE)?

Offices and Fire Escape Stairs respectively
A. 200 lux 30 lux.
B. 300 lux 50 lux.
C. 400 lux 80 lux.
D. 500 lux 100 lux.
Ans: D

2. Which of the following provisions is not required for a Main Switch Room?

A. Mechanical ventilation
B. Lighting
C. Gas flooding protection
D. Equipotential bonding
Ans: C

3. A lift machine room shall be designed

A. to be accessible from the common area.
B. with access complying with the minimum standard prescribed under the Code of Practices for Means of Escape.
C. with minimum clear headroom of 2.3m.
D. to be protected by fire sprinklers.
Ans: A

4. What is the minimum clear headroom of an escalator measured at the edge of steps to ceiling above?

A. 2.0 m
B. 2.1 m
C. 2.3 m
D. 2.5 m
Ans: C

5. Which of the following parameters does not affect the lift waiting time?

A. Rated load
B. Number of stops
C. Door closing time
D. Handling capacity
Ans: A

6. What is the normal maximum number of 1500kVA transformers in one transformer room that the power generation companies are prepared to accept?

A. 2
B. 3
C. 4
D. 5
Ans: B

7. Which of the following firefighting systems is usually deployed in an electrical plant room?

A. hose reel
B. pre-action sprinkler
C. 4.5 kg CO_2 fire extinguisher
D. foam-based fire extinguisher
Ans: C

8. What is the typical standard of lighting intensity for an office?

A. 100 - 200 lux at desk level
B. 200 - 300 lux at desk level
C. 300 - 400 lux at desk level
D. 400 - 500 lux at desk level
Ans: D

9. Which of the following safety devices are built into the electricity supply system?

A. circuits, surcharge and insulation
B. fuses, grounding and circuit breaker
C. conduit, short circuit and emergency power
D. capacitor, negative charge and armoured cable
Ans: B

10. Which of the following equipment should be connected to the emergency power supply of a building?

(1) fire pumps
(2) fireman's lift
(3) exit signs
(4) audio advisory system
(5) staircase pressurisation system

A. (1), (2) and (3) only
B. (1), (4) and (5) only
C. (2), (3) and (4) only
D. (1), (2), (3), (4) and (5)
Ans: D

11. Emergency generators are usually placed on the roof so that

(1) valuable lower floor space is not taken up.
(2) structural loading is more evenly distributed.
(3) emergency power can be more evenly distributed.
(4) the exhaust chimney can be located away from other openings.

A. (1) and (2) only
B. (1) and (4) only
C. 2) and (3) only
D. (3) and (4) only
Ans: B

12. Rank the luminous efficacy of the following lamp types in ascending order.

(1) fluorescent
(2) metal halide
(3) tungsten filament
(4) low pressure sodium vapour

A. (1), (3), (2), (4)
B. (1), (3), (4), (2)
C. (3), (1), (2), (4)
D. (3), (1), (4), (2)
Ans: C

13. Which of the following are some of the latest developments in passenger lifts?

(1) the breakthrough in speed of 17m/sec for super high-rise buildings
(2) the hoisting mechanism can be fitted within the confine of the lift shaft
(3) the ropeless self-driven cab which can travel in vertical, horizontal, curved, or branched directions
(4) the floor-button-less lift car allows the passenger to select the destination floor at the lobby and get assigned a specific lift

A. (2) and (4) only
B. (1), (2) and (3) only
C. (1), (3) and (4) only
D. (1), (2), (3) and (4)
Ans: D

REVISION

1. Sub-station usually accommodates _____ transformers.
2. State the general building work requirements of the transformer substation.

   _____
3. State the general M&E requirements of the transformer substation.

   _____
4. L.V. switch rooms are usually found near to _____.
5. Design requirement for not locating transformer substation at G/F with adjacent vehicular access: _____
6. What are the functions of RCD, ELCB, MCB? _____
7. What is the function of bus bar in an electrical room? _____
8. What is three-phase electricity? And why this is important for some economic activities? _____
9. Name the essential electrical systems that would be connected to the diesel emergency generator. And what are design criteria in determining the choice of its location? _____
10. What is Lighting Power Density Index? _____
11. Name the three constituent components of the daylight factor? _____
12. Name the highest reflection element in the daylighting factors for dwellings? _____
13. How is daylight factor calculated/ measured? _____
14. State the relationship between solar heat gain and daylight, and how the architectural design can alleviate this problem. _____
15. Familiarise yourself with these terminologies – Illuminance, Luminance, Lux, Lumen, Contrast, Glare _____
16. Rank in descending order lamp types (referred in this section) in respect of energy efficiency _____
17. What is the colour temperature for (cool) **white** light and **warm** light respectively? Why this is important to the specifications for various building functions/ activities? _____
18. Which of the following lamp types is more suitable for emergency lighting despite not having a high energy efficiency – GLS, SOX or HID? _____
19. What does the Luminous Intensity Distribution chart refer to when selecting a suitable lamp type? _____
20. What are the typical applications of cold cathode lighting system? _____
21. What is the principle behind LED that makes it so popular? _____
22. State the general application of optic fibre in special lighting. _____
23. Name the major components constituting the 20m radius Rolling Sphere Protection Method for buildings above 20 m in height. _____
24. What are the general factors being considered in the lift traffic analysis? _____
25. Compare and contrast the HC and WI, state which one is more important in defining the quality of lift services. _____
26. Elaborate on the HC and WI given that four numbers of 18-passengers lift cars can provide very similar HC as three numbers of 24-passengers bigger lift cars if the HC is better than required. _____
27. What are functions of escalator smoke baffles in respect of location, size, and materials used? _____
28. Describe the lift passenger's step-by-step account experience when entering the lift lobby area of a building that deploys a floor-button-less lift system. _____
29. Compare and contrast the hydraulic lift and electric traction lift in respect of their applications and quality of services. _____
30. What are the relevant applicable solutions for enhancing requirements of existing lifts (7 items) and escalators (8 items) as promoted in EMSD's recent programmes, following several severe related accidents? _____

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