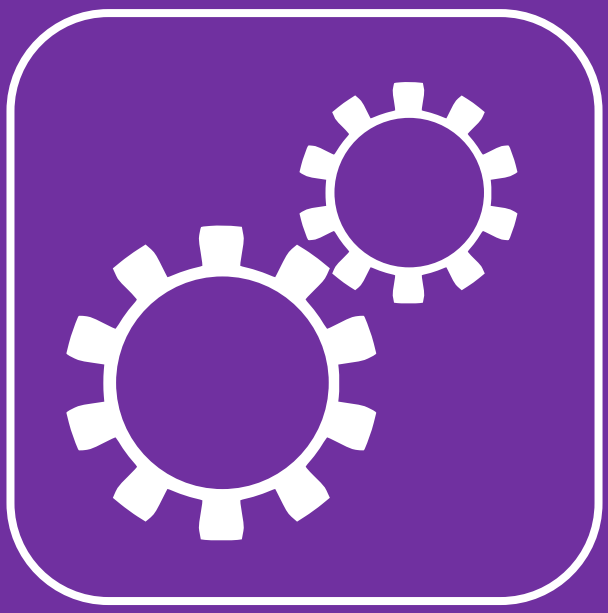

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EXISTING BUILDINGS TECHNICAL GUIDE

Acknowledgements:

Mr. Deva Lutchia	Building and Construction Authority
Mr. Ho Weng Kin	Building and Construction Authority
Ar. Jacelyn Loi	Building and Construction Authority
Ms. Tan Li Sirh	Building and Construction Authority
Ar. Tan Jwu Yih	Building and Construction Authority
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Maintainability Technical Guide (Existing Building) Revision Log

S/N	Brief description of changes	Effective date
01	First issue	01 Nov 2021
02	Second issue with minor updates (Version 1.1)	01 Nov 2021
03	Third issue with minor updates (Version 1.2)	01 Nov 2021
04	Fourth issue (Version 2.0) • Editorial changes across the framework for improved clarity. • Addition of criteria/ / revision to existing criteria i) 2.3.3b (50mm raised partition) ii) 2.3.6c (open ceiling) iii) 3.1.2b (permanent sleeve to mount davit arm) iv) 3.6.2b (weatherproof fire-rated material) v) 5.1.1a (20m radius water points) vi) 5.2.1aii (shallow water body) • Deletion of former criteria i) 1.4.1a (efflorescence) ii) 2.2 (walls and partitions) iii) 2..5 (basement) iv) 3.5.1a (cleaning eyes with viewing panel) v) 3.6.1a (access to fire detectors) vi) 4.1.1a (access to light fixtures) vii) 5.5.1c (water absorption rate of engineered wood)	01 Jan 2024
05	Fifth issue with minor edits (Version 2.1)	01 Jan 2024

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CHAPTER 1: PRINCIPLES & ASSESSMENT APPROACH

Principles

1. Design for Maintainability

Maintainability is a measure of the ease and ability with which maintenance actions or activities can be carried out. A lack of maintainability considerations at the onset of project often creates avoidable maintenance demands which can lead to higher upkeep costs and manpower needs.

"*Design for Maintainability (DfM)*" encompasses the specific measures taken during planning and design to minimise the occurrence of building defects and the expenditure of man-hours and materials to fulfil the maintenance needs in the building lifecycle.

Four important principles are identified, which can be coined as the F.A.M.E principle:

(a) *Forecast maintenance* – Designers should understand the impact of their designs and the expected downstream maintenance works, thereby making necessary upstream design provisions.

(b) *Access for maintenance* – Designers should give due considerations for all areas requiring access for inspection and maintenance, thereby making necessary design provisions.

(c) *Minimise defects* - Designers should give adequate attention to materials performance and detailing to minimise common and critical defects.

(d) *Enable simple maintenance* – Designers should consciously consider standardisation and prefabricated components to facilitate easy inspection and productive maintenance.

2. Maintainability Section (EB)

The Maintainability Section (EB) highlights the importance of DfM and allows cross-functional stakeholders across the value chain - including developers, designers, and FM practitioners – to understand DfM considerations.

It presents a systematic structure and set of design strategies / solutions to weave in DfM considerations into the project at the onset. The Maintainability Section (EB) is performance-based, i.e. it is the intent or objective that is most important and needs to be achieved. The design strategies / solutions suggested therein are in no way exhaustive and alternative approaches would be considered so long as the intent is achieved.

It is worth emphasising that when it comes to access for maintenance, care must be taken that it does not require passing through private or tenanted spaces.

Assessment

1. Assessment approach

i. Scope of common areas

The Maintainability Section (EB) is serves to evaluate a building's maintainability holistically. However, for the purposes of assessment, the focus will be on areas which are either '***common areas' or*** '***developer-owned'*** spaces. In the context of this assessment, the definition of the 2 spaces are as such:

'***common areas'*** – spaces accessible by the public and often experience high footfall

'***developer owned'*** – spaces which fall within the purview and control of the building's developer / owner

The worked examples within this technical guide can be used as a reference to aid in categorising whether areas should or should be considered for assessment.

ii. Tenant spaces

The assessment only covers common areas within the project. However, exceptions are made to access for Condenser Units as these are within designer's control.

iii. Systems for Standby or Night-load

For buildings that are served by chiller, VRF systems used for standby or night-load will not be assessed. The Maintainability Section (EB) does not assess standby systems.

iv. SMART FM

Smart FM solutions presented in the Maintainability Section (EB) zooms in specifically on those that improve cost effectiveness and manpower efficiency of downstream maintenance regimes, such as:

☑ Predictive maintenance of chiller plant
☒ Using AI for chiller plant energy efficiency optimization

2. Allocation of points

Category 1 (Cat 1)
Assessment: Full points for solutions only with 100% applicability in area of application or number of instances.
Category 2 (Cat 2)
Assessment: a. Apportioned points for solutions with 15% to 85% coverage in area of application or number of instances. b. Full points for solutions with >85% coverage in area of application or number of instances. c. No points for solutions with <15% coverage in area of application or number of instances.

3. Documentation Requirements

As part of the assessment, project parties are required to submit the necessary supporting documents at both the design and verification stage assessment. In the case of an existing building, there are a few scenarios – a building (i) without upgrading, (ii) undergoing partial upgrading or (iii) undergoing major A&A.

As such, in applying the Maintainability Section (EB), areas with existing conditions only require verification* stage assessment, while areas undergoing upgrading works will be required to abide by both the design and verification stage assessment.

** Existing parts of a building would comply with the requirements in the verification stage except the following*

- *Delivery orders*
- *Test reports*

Documentation requirements*:*

APPLICABILITY	Areas not undergoing A&A	Areas undergoing A&A
STATUS	Existing	Upgrading
DESIGN STAGE ASSESSMENT	N.A.	All Requirements under design stage
VERIFICATION STAGE ASSESSMENT	All requirements under verification stage, except for delivery orders and test reports	All requirements under verification stage

4. Pro-rating of points

The scoring adopts a pro-rating approach for criteria that are not applicable for any particular project, e.g. a project using VRF system will see the points allocated for chiller plant being not applicable and the points will be prorated using the formula below. This allows projects to be evaluated on a fair and equitable basis despite differences in typologies, adopted systems, or scale.

$$Points\ scored\ after\ proration = (Points\ scored) \times \frac{(Total\ number\ of\ points)}{(Total\ number\ of\ points) - (Total\ points\ which\ are\ not\ applicable)}$$

CHAPTER 2: LCC METHODOLOGY AND BMS UPGRADE CASE STUDY

LCC METHODOLOGY

1. Introduction

Life cycle cost (LCC) analysis is a method of economic analysis that includes costs related to procurement, construction, operation, and maintenance over a defined period. The key emphasis of LCC in the Maintainability Section (EB) is to ascertain the operations and maintenance cost savings of the alternative good practice, especially the saving due to improvement in productivity as well as manpower reduction, over the current industry baseline. To achieve holistic sustainability, it is strongly recommended to integrate life cycle cost approach in the early design stage considering both sustainability and maintainability benefits of the proposed design alternative.

The LCC study for the Maintainability Section (EB) refers to the methodology set in

- **ISO15686-5: 2017**, Building and constructed assets – Service life planning, part 5, Life-cycle costing.
- **NIST Handbook 135**, Life-cycle Costing Manual by U.S. Department of Commerce, Technology Administration and National Institute of Standards and Technology. Comply with ASTM Standard E917.

2. LCC Analysis Vs Simple Payback Method

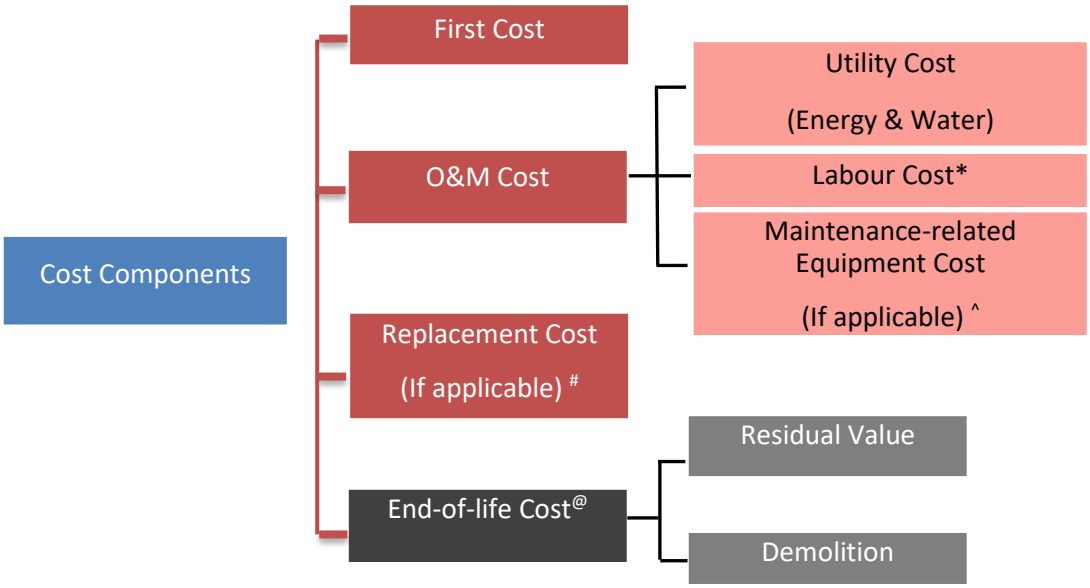
The Maintainability Section (EB) employs an LCC study to evaluate the design with maintenance in mind. The Maintainability Section (EB) promotes holistic sustainability in terms of long term economic and social impact through greater cost savings and reduced reliance on manual labour.

While simple payback is a quick way to assess the return on capital investment, it does not consider the total cost of ownership, including the labour intensity of operations and maintenance. Simple payback is widely used to assess the systems associated with energy consumption but less prevalent for passive system such as architecture, landscape, building interiors etc. wherein much of the costs are associated with labour spent on system/equipment maintenance throughout its life cycle.

LCC analysis provides better insights on all costs associated with the entire life span of the system/equipment, including operations and maintenance cost, manpower savings, replacement cost etc. As such, LCC analysis provides a clear differentiation on project alternatives having different useful lives.

3. LCC input

The LCC study in the Maintainability Section (EB) includes the following inputs:



Note:

** Labour cost must be included as part of the operation and maintenance cost in the LCC study.*

^ Maintenance-related equipment cost refers to use of equipment to facilitate maintenance. For example, the rental cost for scaffoldings for cooling tower maintenance.

 # Replacement cost in the Maintainability Section (EB) only occurs when baseline and alternative solutions have different life spans.

@ End of life cost varies from building to building and is difficult to estimate with reasonable accuracy without site context. Therefore, it is not included in the Maintainability Section (EB) LCC study. However, design team is recommended to assess the end of life cost on project to project basis as it might be a significant part of cost for certain building.

4. Study period

The study period for an LCC is the time over which the costs and benefits related to a capital investment decision is calculated. In the Maintainability Section (EB), the study period is set to the lifespan of the presented solutions with the longest expected lifespan not exceeding 30 years.

Setting the length of study period

In the Maintainability Section (EB), the study period is guided by the following two assumptions*:

- The study period is the same as the life span of the system/equipment's for either the baseline or alternative solutions, whichever is longer. For example: cooling tower's service life is about 15 years. The study period for cooling tower-related LCC is set at 15 years for both baseline and alternative solution.
- If the life span of certain system/equipment is more than 30 years, then the study period is capped at 30 years. For example, a building façade's life span can more than 30 years. In carrying out the LCC study for building façade access system in the Maintainability Section (EB), the study period is limited to maximum of 30 years.

**Note: Study period can also be defined by owner's time horizon, i.e. the interested study period by the building owner. Project team shall evaluate and choose the most appropriate study period to suit their purpose.*

5. Labour rate

As mentioned in the earlier section, labour savings represents a crucial outcome of the LCC study in the Maintainability Section (EB). The labour rate is referenced from NTUC's published rate in 2019[1] and standard schedule of rates (SOR) observed during the data collection.

Table 1. NTUC published labour rates

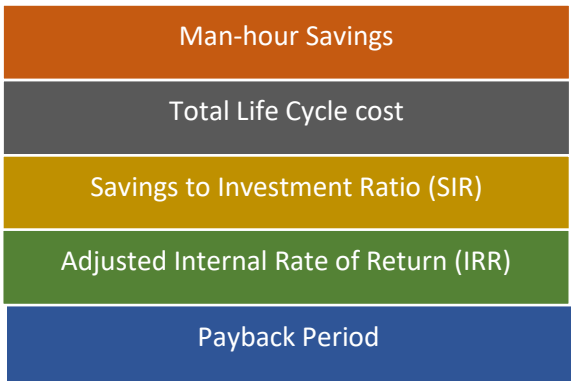
Type of worker	Wage/hr	Monthly Wage
General indoor cleaner	$6.9	1,200
General outdoor cleaner	$8.1	1,400
Multi-skilled cleaners/machine operators	$9.2	1,600

Table 2. SOR for specialised (e.g. M&E) works*

Type of worker	Rates
Semi-skilled worker	$20/ hr/ ppl
Skilled worker	$40/ hr/ ppl
Specialist	$80/ hr/ ppl

**The SOR is based on local data collected in 2019 when the Maintainability Section (EB) LCC exercise was conducted and is only for reference. Project team shall use the project specific SOR for LCC study.*

6. LCC output



- Man-hour Saving is the man-hour saving per year for the proposed solution as compared to baseline. Although, man-hour savings is not a direct output from LCC analysis, rather it is instrumental to reduce the operations and maintenance cost which is included in the LCC analysis. The man-hour savings is indicated separately in the Technical guide to better illustrate the productivity gains by adopting the better practice solution.

[1] https://ntuc.org.sg/wps/wcm/connect/b30e4bd7-aea9-4c4b-9ed9-5b6202a70d67/Tripartite+Cluster+for+Cleaners+Report_Dec+2016.pdf?MOD=AJPERES

- Total life cycle cost is the future Net Saving (NS) amount, in present value, it is what the project alternative is expected to save over the study period. An investment is cost effective if the NS is positive.

- SIR is a measure of economic performance for a project alternative that expresses the relationship between its savings and its increased investment cost (in present value terms) as a ratio. An investment is cost effective if SIR is greater than 1.0.

- AIRR is a measure of annual percentage yield from a project investment over the study period. AIRR is compared against the investor's minimum rate of return which is generally equal to discount rate uses in the LCC study.

- Payback Period is the time required to recover incremental (premium) investment cost.

Table 3. LCC Analysis methodology and data input

Approach	
Evaluation Method	Life-cycle cost analysis
Discounting Approach	Present Value (PV) at the base date
Cost Measurement Basis	Constant dollars as of the base date
Cash-Flow Convention	End-of-year cash flows
Evaluation Criteria	Lowest life-cycle cost Highest net saving SIR > 1 AIRR > discount rate
Data and Parameters	
Base Date (year)*	Beginning of study period
Service Date (year)*	Beginning of service period of the system/equipment
Study Period	System life span and maximum to 30-year service period
Discount Rate**	3%
Rate of Increase (Labour and material) **	0.1%

**For the Maintainability Section (EB) LCC, base date/year is set as 2019. The first cost is accounted in 2019. It is assumed that the service date/year starts from next year, i.e. 2020. O&M cost is accounted at the end of one-year operation.*

***The discount rate and rate of increase in labour and material is based on local (Singapore) data in 2019.*
Key assumptions in adopting the discount rate and rate of Increase (Labour and material):

a. *Considering the guaranteed interest rates offered by local bonds offerings and banks, which is the range of 0.17% to 1.13% (from 2010 to 2019) and ISO15686-5, 2017 which suggests a discount rate between 0-4%, a discount rate of 3% is adopted for the Maintainability Section (EB) LCC study.*

b. *The "Rate of Increase" in LCC study is the combined rate of increase for inflation rate (building maintenance related materials/equipment replacement), escalation rate of FM-related labour cost and electricity cost. Locally, we note a downward trend in the electricality prices and SOR rates for materials/ equipment replacement have remained largely unchanged over the past 10 years (2010-2019). To represent a long-term trend of rate of increase, a conservative value of 0.1% is used for LCC study.*

7. Notional building

The Maintainability Section (EB) adopts a notional building to compare the initial capital cost and O&M cost of baseline and best practice solutions for the LCC study. The notional building is taken as a typical class-A office building (see Figure 1 & 2 and Table 4 for more information).

Figure 1. Notional building perspective

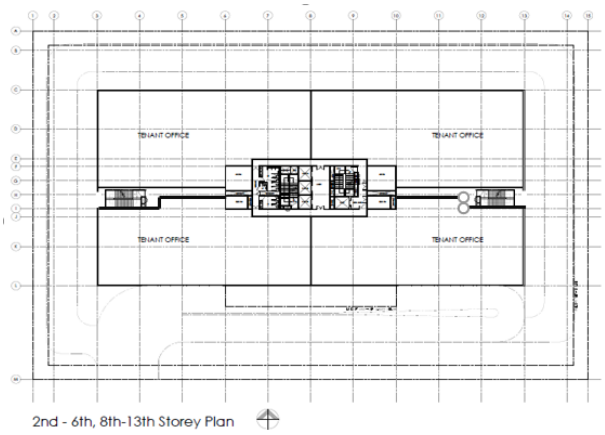


Figure 2. Typical floor plan

Table 4. Notional building information

S/N	Key Design Criteria	Description
1	Site Area	8,246 sqm
2	No. of Floors	14 +2basements
3	Total GFA	49,824 sqm
4	Floor Plate (Typical)	3,466 sqm
5	Air-Conditioning Area	42,990 sqm
6	Construction Cost	$3,500/m^2 GFA ($2,800/m^2 CFA) *

* https://www.arcadis.com/en/knowledge-hub/perspectives/asia/research-and-publications/quarterly-construction-cost

8. Tool Used for the Maintainability Section (EB) LCC Study

The NIST "Building Life Cycle Cost" (BLCC) software tool is adopted in the Maintainability Section (EB) to perform LCC analysis of building systems or solutions. More details on the BLCC software, assumptions and methodology can be accessed here: *https://www.energy.gov/eere/femp/building-life-cycle-cost-programs*

9. LCC Approach for Existing Building compared to New Building

The methodology adopted to derive the LCC analysis is the same for both new building and existing building. However, few inputs/assumptions are tailored to suit the existing building context considering the practical constraints of integrating the better practice solution for an existing building. These include installation works beyond office hours (extended working hours), additional efforts in carrying out addition and alteration to existing building works in order to integrate the new solution, and change in energy efficiency benchmarking for baseline case (where applicable). To account for the latter, in a simplistic manner:

- The initial cost for existing building is amplified by 20% over that of a new non-residential development
- Baseline efficiency to match existing building code compliance, where applicable (e.g. chiller plant efficiency, AHU fan efficiency)

The following inputs remain unchanged in both existing and new non-residential building LCC analysis:

- Number of equipment's for notional building. For example, same number of AHU's is considered for both baseline and proposed solutions
- Operating hours
- System/ equipment replacement schedule
- Labour cost
- Maintenance frequency

10. LCC Example

This segment provides an example of the LCC analysis for one the Key Maintenance Issue (KMI) stipulated in the Maintainability Section (EB). The objective of this example is to illustrate the key inputs and outputs associated with the LCC study. On the data inputs, this LCC example captures the key assumptions including number of equipment, operating schedule, first cost, and operations & maintenance cost. In terms of LCC output, the LCC study demonstrate some of the key outputs which are necessary for stakeholders to make informed decision; such as total life cycle cost, labour savings, and simple payback.

- Baseline solution: Belt Driven DIDW (Double inlet Double width) centrifugal fan used in typical AHU's. The number of AHUs is derived based on the assumed cooling required in the notional building.
    - Baseline AHU fan efficiency is 0.28 kW/RT
    - Proposed AHU fan efficiency is 0.16 kW/RT
- Proposed solution: Direct drive fan system (i.e. EC fans, plug fans, Axial flow fans etc.). The direct drive fans are considered efficient both in terms of energy efficiency and long-term maintainability. The LCC study captures both the energy savings and man-hour savings associated with direct drive fan system.

- Maintenance issues due to belt driven fans: Frequent alignment/ failure of fan parts i.e. pulley, bearing and belts resulting in downtime and frequent replacement of fan components.
- Intent: Use of a fan system with less moving parts (e.g. fans with direct drive motors) for enhanced reliability and reduced downtime
- Study period: 15 years (the usual life span of fan system)

A detailed breakdown of the assumptions, initial cost, operating and maintenance cost (both tangible and intangible) are be found in Table 5 below.

Table 5: LCC Inputs

AHU Fans	Baseline: AHU/FCU fans with **Belt Driven**	Best Practice: AHU/FCU fans with **Direct Driven** (i.e., EC, axial flow, plug fans)
Assumptions	Notional building: 49 nos of AHU with Belt Driven *(cooling capacity 25RT, motor input power 7 kW, i.e. fan efficiency 0.28kW/Ton)* Operating hours: 55 hours /week x 52 weeks **Belt alignment** should be check **monthly** **Belt tension** should be adjusted **quarterly** **Belt must be replaced** periodically (Approx. **every 3 years** with VSD)	Notional Building: 49 nos of AHU with Direct Driven EC fans *(cooling capacity 25RT, motor input power 4 kW, fan efficiency 0.16 kW/RT)* Operating hours: same as baseline **No alignment** required Low maintenance, require very little **relubrication every 5 years**
First Cost	$20k per fans * 49 nos of fans = $980k	$28k per fan * 49 nos of fans = $1.372mil
Operation & Maintenance Cost	• **Utility Cost** AHU energy consumption = 7 x49 x 55 x 52 = 980,980 MWh Electricity cost =980,980 * $0.2/kWh = $196.196k • **Belt Alignment (monthly)** 2 skilled technicians ($80/hr) x 1/6 hrs (~10 mins/AHU) x 49 nos x 12 times/ year Yearly cost = $15,680 Total manhours: 196 • **Belt Tension (quarterly)** 2 skilled technicians ($80/hr) x 24 hrs (~30 mins/ AHU) x 4 times a year Yearly cost = $15,680 Total manhours: 196 • **Belt Replacement (every 3 years)** Equipment Cost for three years: $150 each belt x 49 no's = 7,350 Labour Cost for 3 years: 2 skilled workers x 2hr per belt x 49 no's = 2 x 2 x $80 x 49 =$15,680 Annualized belt replacement cost=($7,350+$15,680)/3= $7,677 Annualized manhours : 196/3=65 **Total maintenance cost /year: $235,233** **Total man-hours spent/year: 457**	**Utility Cost** AHU energy consumption = 4 x49 x 55 x 52 = 560.56 MWH Electricity cost =560.56 * $0.2/kWh = $112.112k **Relubrication** (Every 5 years) 2 skilled technicians ($80/hr) x 1/6 hrs (~10 minutes/AHU) x 49 nos/ 5 years =$261.3 **Total maintenance cost/year: $112,373** **Total man-hours spent/year: 4**
Saving on Man-hour/year	-N/A	453
Environmental Friendliness	-	Quiet operation, lower noise level throughout the entire fan performance Less CO_2 emission with high efficiency motor
Safety	-	Reduced hazard associated with handling the fan during its operational periods All control components and protection electronics are integrated with the motor, easy connection

Table 6: Summary of cost/savings

Input	Baseline Solutions (Belt Driven)	Proposed Solution (Direct Drive Fans)
Initial Cost	$1,176,000	$1,646,400
Operation & Maintenance /Year	$235,233	$112,373
Man-hour/ Year (Man-days/ year)	457 (57.1)	4 (0.5)

Table 7: LCC output example

	Baseline solution AHU/Fans with belt driven	Best Practice Solution AHU/FCU fans with direct drive motors	Savings from Proposed Solution
Initial Investment Cost (S$)	1,176,000	1,646,400	-470,400
Annual O&M Cost (S$)	235,233	112,373	122,860
O&M Cost – Present Value (S$)	2,600,783	1,242,419	1,358,364
Total Life Cycle Cost (Present Value) (S$)	3,776,783	2,888,819	887,964
Labour Saving (Man hour/year)	453		
Simple Payback Period (year)	3.82		

Figure 3: 40% higher on initial investment

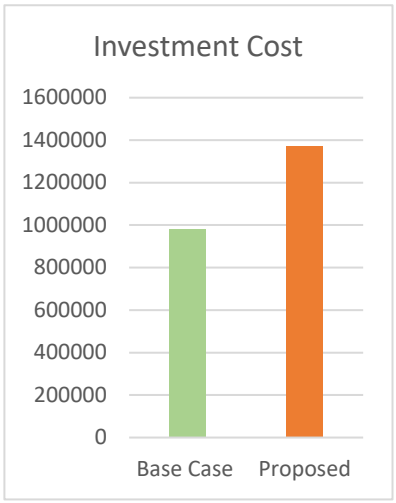


Figure 4: 52% reduction on annual O&M cost

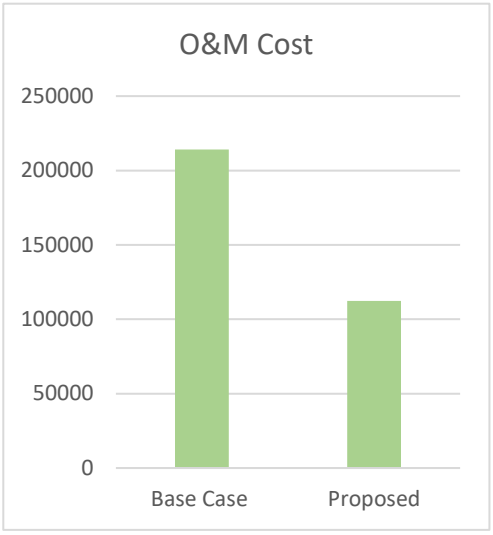


Figure 5: 23% reduction on total life cycle cost

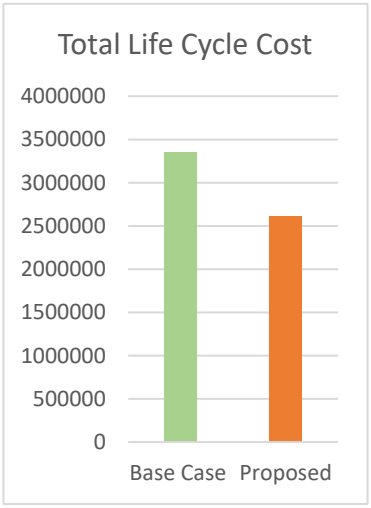
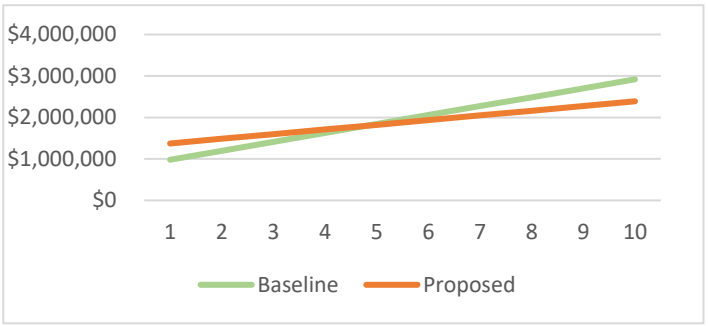


Figure 6: Payback period



CASE STUDY ON UPGRADE OF BMS IN PHASES

Worked Example: Phase-wise BMS upgrade

Introduction:

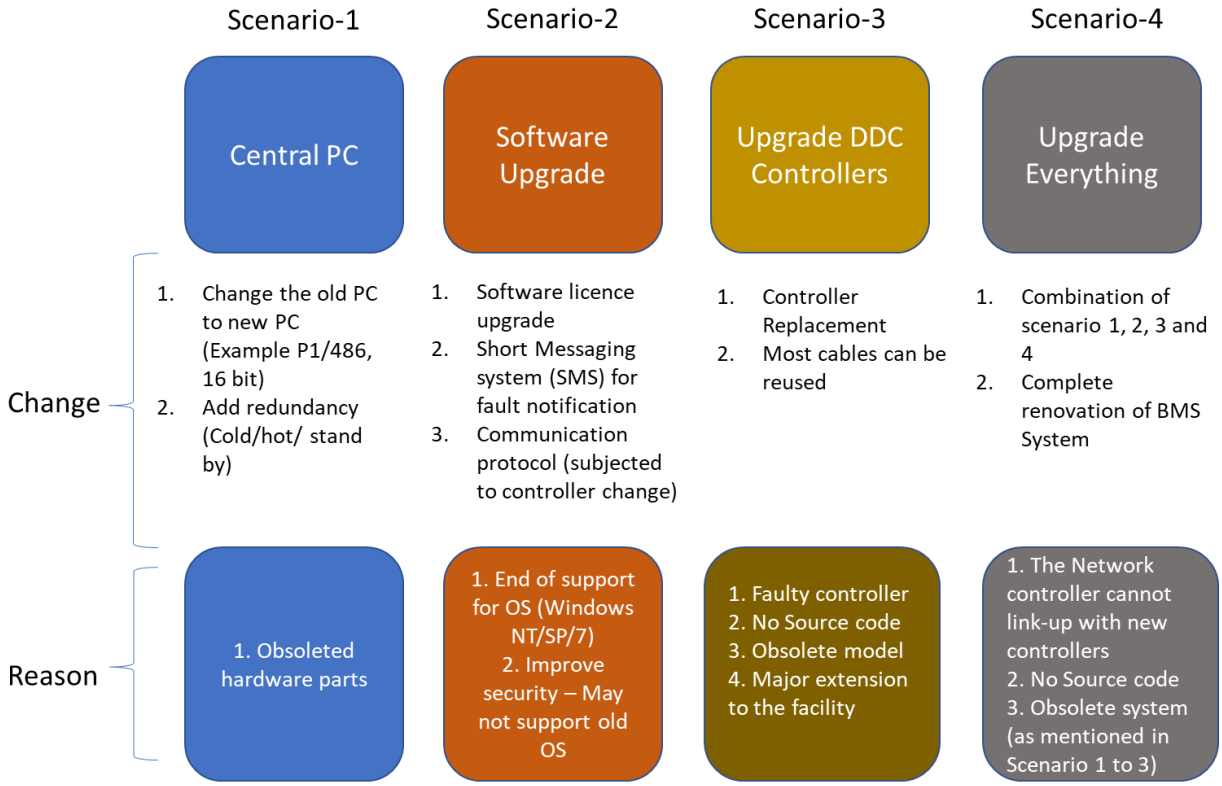
This case study illustrates how a typical BMS system in a building can be upgraded in a phased manner without disrupting the building operations. There are two main approaches to the upgrading of BMS system. The first approach is the complete replacement of existing BMS system. Alternatively, the second is a phase-wise retrofit.

The first approach, which is complete replacing the existing BMS system, a company will benefit from the flexibility of being able to create a fully customized and smart BMS system. Although, this is a more expensive option, and not always feasible due to the risk of disruption to operations.

The challenge of retrofitting an existing BMS system is to identify the potential gaps and prioritize system replacement such that to allow a systematic and phased retrofit to take place over time. Validating the capabilities of existing BMS infrastructure is vital before identifying the systems (either hardware, software and field devices) to be replaced with considerations to be made on the project budget and timescale. The building owner's overall objectives also need to be considered in terms of cost-effectiveness, project duration, operational disruption, and importantly Smart FM objectives.

With complete BMS system replacement being a capital-intensive approach, which may not be feasible for many organisations, this framework proposes more of an incremental process which will assist the building owners to integrate the legacy system/equipment's with open API and smarter systems. By adopting stepwise retrofit of BMS system will not only provide better insights on operational requirements but also facilitates enough lead time for building owners to accrue the budget and becomes an easier process to justify.

Below is the four-step notional approach which can be adopted by any existing buildings to retrofit their existing BMS system;



Sample case study:

The case study uses the same notional building elaborated under the LCC Methodology segment. The notional building serves as a base to derive the Mechanical and Electrical equipment list for BMS integration, I/O point summary, capital cost, list of field devices and sensors etc. To recap, the notional building is taken as a typical class-A existing non-residential office building.

The notional building info is summarised as follows:

S/N	Key Design Criteria	Description
1	Site Area	8,246 sqm
2	No. of Floors	14 +2basements
3	Total GFA	49,825 sq.m
4	Floor Plate (Typical)	3,466 sq.m
5	Air-Conditioning Area	42,990 sq.m
6	Green Mark Rating	Gold Plus (NRB2015)
7	Window to Wall Ratio	60%

Key Equipment Information:

S/N	Equipment / System	Quantity
1	Total Cooling Load	1,220 RT
2	Chiller configuration	3 x 650 RT, (2 Duty, 1 Standby)
3	CHWP, CWP and cooling Tower	3 No's (2 Duty, 1 Standby)
4	AHU	Total 49 no's
5	FCU	Total 18 no's
6	Mechanical Fans	Total 56 no's
7	Transformers	Total 4 no's
8	Genset	Total 2 no's

Input and output (I/O) point summary:

I/O point summary is calculated based on the integration of following services with BMS;

S/N	Equipment/ System	Sub-system	Mode of Integration
1	Chiller plant	Chiller, pumps and cooling towers	Low Level Interface
2	Air Distribution (AHU, FCU)	AHU, FCU, CSU etc.	Low Level Interface
3	Mechanical Ventilation	Toilet, Kitchen, pressurisation, Fresh air etc.	Low Level Interface
4	Carpark Ventilation	Smoke extract fans, Jet fans	Low Level Interface
5	Electrical	HT Switch board, LT switch board, Transformer, Lighting DB, Genset, Surge protection, Chiller MCC etc.	Low Level Interface
6	ELV System	CTTV, Access control etc.	High Leve Interface
7	Domestic water	Tank & Pump (PUB, NEWater, Make-up)	Low Level Interface
8	Fire protection system	Fire Alarm panel	Low and High Level Interface
9	Vertical Transportation	Lift and Escalators	High Leve Interface
10	Miscellaneous	Solar Panel, Energy monitoring system	High Leve Interface

HLI refers to “High Level Interface”, which allows monitoring and control of equipment’s directly via the BMS communications network BACnet, Lon works.

Low level interface uses dry contacts for monitoring or other electrical parameters such as volts and /or current. For example, if a device is operating a relay wired in parallel with the device operates, the BMS sees the contacts closure and logs or monitors the point. the point has changed from a “0” of off to a “1” or on when the contacts on the relay close.

Four step costing Summary:

As mentioned in the earlier sections, the Maintainability Section (EB) smart FM framework proposes a sample cost breakdown to systematically upgrade the BMS system in a phased manner. The notional building is used as a base to come-up with equipment sizing, I/O points system and key bill of quantities. Please note that the below mentioned cost breakdown is strictly for reference only and building owners to evaluate the gap analysis and cost computation based of their respective building scale, usage and importantly the existing condition of the BMS system. For the proposed five step costing summary, the notional building is considered around 8 to 10 years old with no retrofit conducted for BMS system since inception. The cost of upgrade will vary for different buildings.

Description		Scenario 1		Scenario 2		Scenario 3		Scenario 4
		Central PC (S$)		Software Upgrade (S$)		Controller (S$)		**Total Upgrading (S$)**
1	**Central Equipment**	Item cost	Total Cost	Item cost	Total Cost	Item cost	Total Cost	
a.	Hardware X 02	5,500	6,250					**6,250**
	Workstation/Server c/w Monitor & Accessories including UPS to support central for 30min.	750						
b.	Software			53,000	69,000			**69,000**
	Central SCADA Software							
	SMS System including modem							
c.	Provision of high and/or low level interface with other systems which includes Modbus, TCP/IP, RTU, BACnet, OPC for communication to other M&E systems							
	Air conditioning and Mechanical Ventilation System							
	Electrical System							
	Plumbing and Sanitary System							
	Fire Alarm System							
	Chiller plant Management System							
	Lift System							
	Lighting System							
	Others							
d.	All Engineering/Programming work for the central workstation including graphic creation.			16,000				

Description		Scenario 1		Scenario 2		Scenario 3		Scenario 4
		Central PC (S$)		Software Upgrade (S$)		Controller (S$)		Total Upgrading (S$)
2	**DDC Controller (est. 1650 LL point and 900 HL point)**					105,000	185,000	**185,000**
	DDC controller c/w panel and 15 minutes UPS backup					60,000		
	Labour Works (replace DDC only)					20,000		
3	**Field Sensors/Devices**							
	Field Sensor and Devices (refer to BOQ below)							**165,000**
4	**Installation**							
	All cable installation work including, cable support, mounting, termination etc.							**275,000**
5	**Labour Works**							
	Project management, engineering, testing and commissioning (replace field devices)							**40,000**
6	**Any other works**							
	Please state other works needed to complete the work (switch/rack/etc base on the I/O point stated in item 2)							**8,000**
						Total Cost (S$)		**748,250**

CHAPTER 3: TECHNICAL GUIDE

CRITERIA			Points Allocation
Section 0 – GENERAL			
0	General Project Requirement		8.5
	Sub-total score for Section 0		8.5
Section 1 – ARCHITECTURAL EXTERIOR			
1.1	General Façade	Part A	2
	Part A: Subtotal of 1.1		*2*
1.2	Cladding – Tile / Stone / Metal / Others	Part B: Façade System	4
1.3	Curtain Wall		4
1.4	Masonry, Lightweight Concrete Panels, and Precast components		4
	Part B: Subtotal of 1.2 to 1.4		*4 (Max)*
1.5	Façade Features	Part C: Façade Ancillaries	3.5
1.6	Entrance lobby		3
1.7	Roof		2
	Part C: Subtotal of 1.6 to 1.7		8.5
	Sub-total score for Section 1 (Part A + Part B+ Part C)		14.5
Section 2 – ARCHITECTURAL INTERIOR			
2.1	Floors		2.5
2.2	Ceilings		5.5
2.3	Wet Rooms and Storage		8
2.5	Loading Bay/ Back of House Service Areas		3
	Sub-total score for Section 2		19
Section 3 – MECHANICAL			
3.1	Chiller Plant		13.5

3.2	Unitary Air Conditioning System – VRF System	Part A: Air Conditioning Plant Systems	1.5
	Part A: Subtotal for cooling systems (subtotal of apportioned 3.1 and 3.2)		13.5 (Max)
3.3	Air Distribution System	Part B	8
3.4	Domestic Water Supply		0.5
3.5	Sanitary System		1.5
3.6	Fire Protection System		3.5
	Part B: Subtotal of 3.3 to 3.6		13.5
	Sub-total score for Section 3 (Part A + Part B)		27
Section 4 – ELECTRICAL			
4.1	Lighting System		2
4.2	Power Distribution System		2.5
4.3	Extra Low Voltage (ELV) System		3.5
4.4	Lightning Protection System		1
4.5	Vertical Transportation System		1.5
	Sub-total score for Section 4		10.5
Section 5 – LANDSCAPE			
5.1	Softscape		2
5.2	Hardscape		3
5.3	Vertical Greenery		0.5
5.4	Roof, Sky Terraces, Planter boxes on building edge/facade		3
5.5	Standalone Structures		2
	Sub-total score for Section 5		10.5
Section 6 – SMART FM – Innovative Solutions			
6.1	Cybersecurity		1
6.2	Adoption of Smart FM solutions		10
	Sub-total score for Section 6		11

Section 7 – SMART FM – Building Management Systems			
7.1	Central Computer		2
7.2	Software Integration		4
7.3	Controllers		2.5
7.4	Integration with M&E systems		2
	Sub-total score for Section 7		10.5
Section 8 – SMART FM – FACILITIES MANAGEMENT SYSTEM			
8.1	Failure Analysis	Part A: Asset Management	1.5
8.2	Life Cycle Management		1.5
	Part A: Subtotal of 8.1 to 8.2		3
8.3	Service Management	Part B: Operations Management and Supply Chain Management	2.5
8.4	Maintenance Management		1.5
8.5	Other General Services		1
8.6	Supply Chain Management		4.5
	Part B: Subtotal of 8.3 to 8.7		9.5
	Sub-total score for Section 8 (Part A + Part B)		12.5
	Overall Maintainability Points		**124**

SECTION 0 – GENERAL

0. GENERAL REQUIREMENTS (UP TO TOTAL 8.5 POINTS)

Promote inclusion of Design for Maintainability (DfM) during AEI stage

Intent

To maximise opportunities for integrated, cost effective adoption of good design and construction strategies. Emphasising maintainability as a fundamental evaluative criterion for building design, construction and operations.

Design Strategy and assessment: (2.5 points)

a. Promote integrated design approach and stakeholder engagement at planning and key design stages.

i) Conduct at least 3 design charrettes during the concept/ detail design stage involving minimally 3 stakeholders from the following group (0.5 Point):

- **Building owner/ representative**
- **Facilities manager (FM)/operator**
- **Design consultants (minimally one representative each from the various disciplines – architecture, civil & structural, mechanical, and electrical, landscape, quantity surveyor, etc.)**
- **Other specialist consultant / supplier (i.e. environmentally sustainable design, lighting specialist, material specialists, façade access consultant, etc.)**

As early as practicable during the design stage, conduct at least 3 design charrettes to optimise integration of design for maintainability upstream, drawing inputs from stakeholders across the value chain

The design charrette should accomplish the following:

- To draw design team members' attention on design for maintainability
- To share the background of design for maintainability framework
- To identify potential downstream maintenance issues due to the proposed design/ nature of project
- To identify the desired certification level and points targeted
- To generate potential solutions and maintenance strategies that improve the maintenance regimes

ii) Use of 5-step SMART process to evaluate building's potential to implement Smart FM, and to identify suitable solutions that will streamline FM maintenance process, improve productivity and service delivery. (1 Point)

The 5-step SMART FM process is described in the "Guide to Smart FM" which is available on BCA's website.

The project team (including developer and facilities manager) must collaborate closely on this write up. To facilitate the process, the project team may refer to the guiding questions below.

5 Step Smart Process	Guiding Questions
Step 1 – Set business objectives and outcomes	• What do I want to achieve and set as my FM outcomes? • What KPIs can I set to monitor these outcomes? • How will these KPIs be tracked? • What FM services should I prioritize to meet these outcomes?
Step 2 – Map out Smart FM solutions as enablers	• What are the smart fm solutions that can help me achieve the outcomes? • What level of "smartness"? Type 1, 2 or 3? • How are these multiple smart fm solutions integrated? • Is there a system architecture diagram that explains how data would flow across the smart fm solutions?
Step 3 – Adopt suitable implementation model	• What solutions will be owned the building owner? • What solutions will be owned by the FM company or service provider? • Will the building owner own all the data regardless of the implementation model?
Step 4 – Review procurement contract	• What is the contract period? • Can outcome-based contracts be adopted with these smart fm solutions? • Can Integrated FM contracts be adopted with these smart fm solutions?
Step 5 – Track outcomes and review for continuous improvement	• How will these KPIs be tracked? • When will the KPIs be reviewed?

iii) Design for maintainability report, as part of the O&M manual, outlining the key maintainability considerations and provisions. (1 Point)

The DfM report should be led by the design consultants with inputs from the contractor.

It must be handed over to the eventual owner/user who will maintain the development.

It should state the designers' proposed maintenance considerations and strategies which typically include, but not limited to the following:

- unique requirements of the project
- areas requiring maintenance access (including spatial and structural requirements, etc.)
- anticipated maintenance tasks and frequency
- materials / equipment that have specific maintenance requirements
- proposed/ assumed maintenance methodology (equipment, methods, etc.)

Documentation requirements

Design Stage

- Stakeholders involved in the discussion on Design for maintainability.
- Documents demonstrating the integrative design process via correspondences, meeting agenda, minutes of meeting etc. recorded during the design charrettes.
- 5-step smart FM process report signed by developer and facilities manager

Verification Stage

- Design for maintainability report.
- Submit as-built drawings, photographs, and/or O&M manuals highlighting the maintainability features installed on site.
- Updated 5-step smart FM report signed by developer and facilities manager

Design strategy and assessment: (up to 2 points)

b. Use of life cycle cost (LCC) approach[2,3] to identify solutions with better economic and maintainability benefit throughout the building life span.

i) Undertake project-specific LCC analysis on adopted LCC-related solutions listed in this appraisal system for. (0.5 points per LCC, up to 2 points)

Documentation requirements

Design Stage

- Life cycle cost analysis report for selected items (pls refer to the LCC chapter).

Verification Stage

- NA

Design strategy and assessment: (Up to 4 points)

c. Maintenance contract

Use of performance-based contracts and integrated facilities management (IFM) contracts to improve labour efficiency.

i) Projects demonstrating performance-based / outcome-based maintenance contract for the following services:
(1 point for each item, up to 2 points)

- **Chiller plant**
- **Air distribution**
- **Cleaning (toilets, waste management, etc.)**
- **Landscape**
- **Security**

ii) Projects demonstrating integrated facilities management (IFM) contracts for the following maintenance services:
(1 point for 2 maintenance services, up to 2 points)

- **Building maintenance services**
- **Mechanical and Electrical maintenance services**
- **Security services**
- **Cleaning services**
- **Landscape services**

[2] NIST Handbook 135, Life-cycle Costing Manual for the Federal Energy Management Program
[3] ISO 15686-5, Building and Constructed Assets – Service Life Planning, Part 5: Life-cycle costing, 2nd edition. 2017

- **Pest control services**

Performance-based/outcome-based service does not prescribe the required headcount/ frequency of maintenance to deliver quality services; instead performance-based/outcome-based service specifies the desired service outcome. It enables service providers to adopt innovative technology, enhance processes, and offer better solutions to improve productivity and deliver quality service. An early decision on performance-based service during design stage enables designers to provide necessary design provision/ detailing to allow performance-based/outcome-based contracting during building operations.

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
100% (No provision for baseline)	Up to 5%	Up to 5%	5 -6

Baseline design strategy: No performance contract
Proposed design strategy: Chiller plant with performance contract
Study period: 15 years
Yearly labour saving: 15%-20% Man-hour

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
100% (No provision for baseline)	5%-10%	Up to 5%	3 - 4

Baseline design strategy: No performance contract
Proposed design strategy: Chiller plant + AHU with performance contract
Study period: 15 years
Yearly labour saving: 15%-20% Man-hour

Documentation requirements

Design Stage

- Meeting notes from the design charrette highlighting the systems shortlisted for performance-based/ outcome-based contracting and the design provisions.
- Tender Specification showing the requirement on performance-based maintenance contract and integrated FM contract.
  OR
- Contract clauses highlighting the performance-based maintenance and integrated FM contract.

Verification Stage

- Performance-based and integrated FM contracts.

SECTION 1 – ARCHITECTURAL EXTERIOR

Part A: SECTION 1.1

1.1. GENERAL FAÇADE (3 points)

1.1.1. Reduce risk of water ingress and streaking on façade (1 point)

Intent

External façade cladding of various materials (e.g. metal, glazing, stone or tile, and masonry wall) and façade features (e.g. canopies, sunshades, niches, fins, ledges, BIPV, etc.) require regular cleaning maintenance or repair at façade joints to ensure water tightness. Frequency of cleaning or repair on façades as well as risk of water ingress and streaking can be reduced with optimal façade design and detailing.

Design strategy and assessment: (0.5 point)

a. **Design for drip edges/grooves to mitigate streaking on exterior soffits and vertical façade surfaces e.g. leading edge of flashing, sills, overhangs or other horizontal projecting façade elements.**

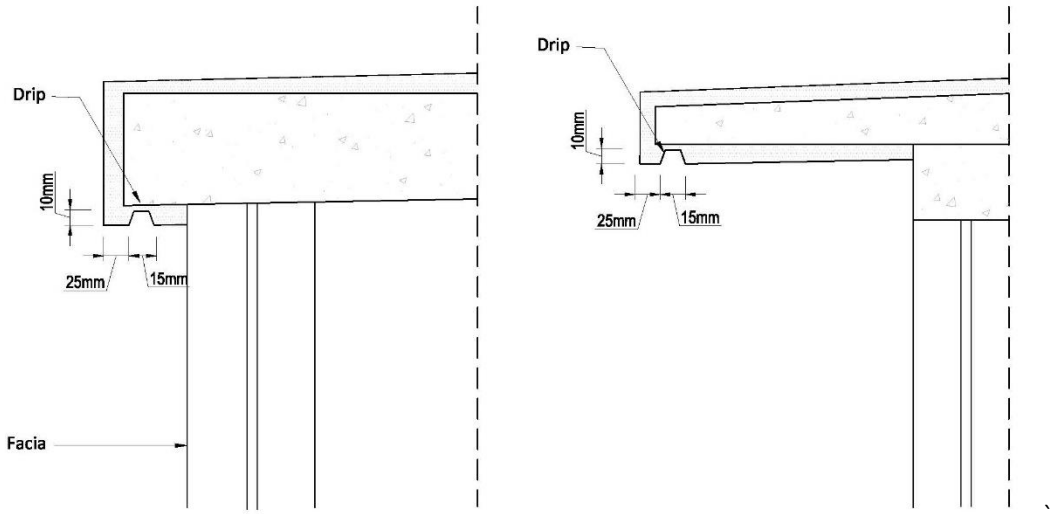


Figure 7: Typical drip edge detail on projected façade elements. Image on the left illustrates detail on recessed window and image on right illustrates detail on sunshades.

Documentation requirements

Design stage

- Plan/elevation drawings locating drip edge detail on the façade surfaces.
- Detail drawings showing façade drip edge detail.

Verification stage

- As-built drawings/shop drawings of façade indicating drip edge detail.
- Photographs of incorporated drip edge detail after implementation.

Design strategy and assessment: (0.5 point)

b. Design all top surface of walls to slope away from the external face of façade.

Note: Top surface of wall or coping must have overhang on the rear side with drip control to mitigate streaks on the back walls (OR) equivalent measures.

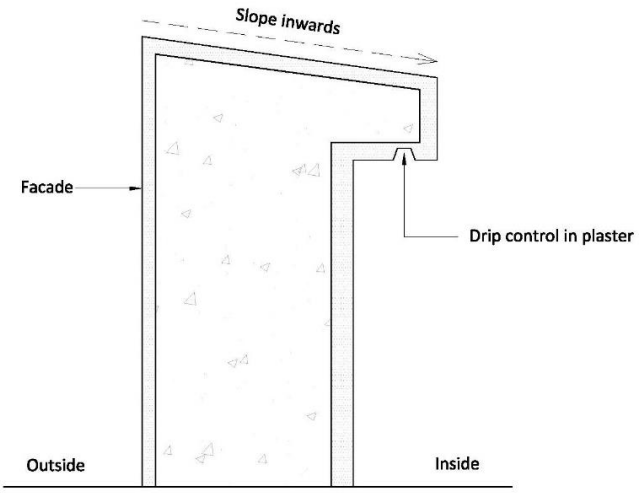


Figure 8: Drawing illustrating slope gradient on top surface of external wall.

Documentation requirements

Design stage

- Plan drawings locating all relevant top surface of wall that slope away from exterior face of façade.
- Detail section drawings showing slope.

Verification stage

- As-built drawings/shop drawings showing slope incorporated on top of wall surfaces.
- Photographs of incorporated slope after implementation.

1.1.2. Access for maintenance of façade (1.5 point)

Intent

To ensure safe and efficient access to facilitate cleaning, repair & replacement, , and inspection of façade.

Design strategy and assessment: (0.5 point)

a. Ensure entire façade is accessible for maintenance.

Note:

- *Façade includes wall, cladding (stone, tile, metal, and glazing), openings, structural members, railings, façade features (sun-shading devices), and M&E systems (façade lighting, media walls, solar panels [BIPV])*
- *Sole use of rope access is deemed unacceptable unless proven otherwise.*

Access for façade maintenance, if accessible from within the building, must not be via tenanted/leased out spaces. *Life cycle cost analysis: baseline design strategy vs proposed design strategy*

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
6.8X- 6.9X	75% - 80%	15% - 20%	14 - 15

Baseline design strategy: Davit arm (gondola) for cleaning and glass replacement
Proposed design strategy: Automated BMU for cleaning and glass replacement
Study period: 30 years
Yearly labour savings: 70-80% man-hour

Documentation requirements

Design stage

- Plan/elevation/schematic drawings indicating entire façade is 100 % accessible through one or a combination of façade access systems. Please refer to BCA's façade access design guide[4] for more details on the submittals.

Verification stage

- Maintenance strategy report for façade access.

1.1.3. Access for maintenance of façade, soffit, and roof of enclosed sky bridges (0.5 point)

Intent

To ensure safe and efficient access to facilitate cleaning, maintenance, and of façade and roof of enclosed sky bridges.

Design strategy and assessment: (0.5 point)

a. Ensure the roof, façade and soffit of skybridge are accessible for maintenance.

Note: Sole use of rope access is deemed unacceptable unless proven otherwise.

Documentation requirements

Design stage

- Plan/elevation/schematic drawings demonstrating entire roof and façade of skybridge is 100 % accessible through one or a combination of access systems. Please refer to BCA's façade access design guide[5] for more details on the submittals.

Verification stage

- Maintenance strategy report for skybridge's roof and façade access.

[4] Refer to BCA Façade Access Design Guide to provide required details on Façade access strategy, façade features etc. https://www1.bca.gov.sg/docs/default-source/docs-corp-buildsg/sustainability/dm_fadg_2017.pdf
[5] Refer to BCA Façade Access Design Guide to provide required details on Façade access strategy, façade features etc. https://www1.bca.gov.sg/docs/default-source/docs-corp-buildsg/sustainability/dm_fadg_2017.pdf

Part B: Façade Systems - Section 1.2 to 1.4

(*For singular façade system, points can be scored for 1.2, 1.3 or 1.4. In case project comprises multiple façade systems, points will be apportioned on an area basis*)

1.2 CLADDING - TILE / STONE / METAL / OTHERS (4 POINTS)

1.2.1. Reduce risk of water ingress and streaking on façade (up to 4 points)

Intent

To ensure water tightness and minimise façade streaking through optimal design detailing and choice of materials to reduce the frequency of repair and maintenance.

Design strategy and assessment: (0.5 point)

a. **For streaking:**
   Specify metals of similar properties or separators between different metal components on the exposed face of the façade to mitigate risk of bi-metallic corrosion.

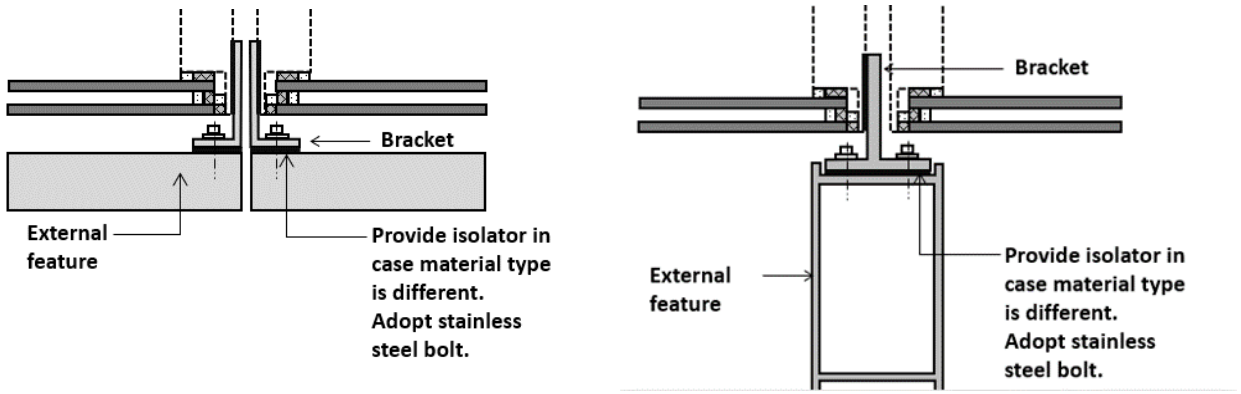


Figure 9: Example - plan drawing (detail) on left and right illustrating connection between curtain wall and metal external feature on the exposed face of the facade. Providing metals of similar metal properties or separator/isolator helps to mitigate risk of bi-metallic corrosion.

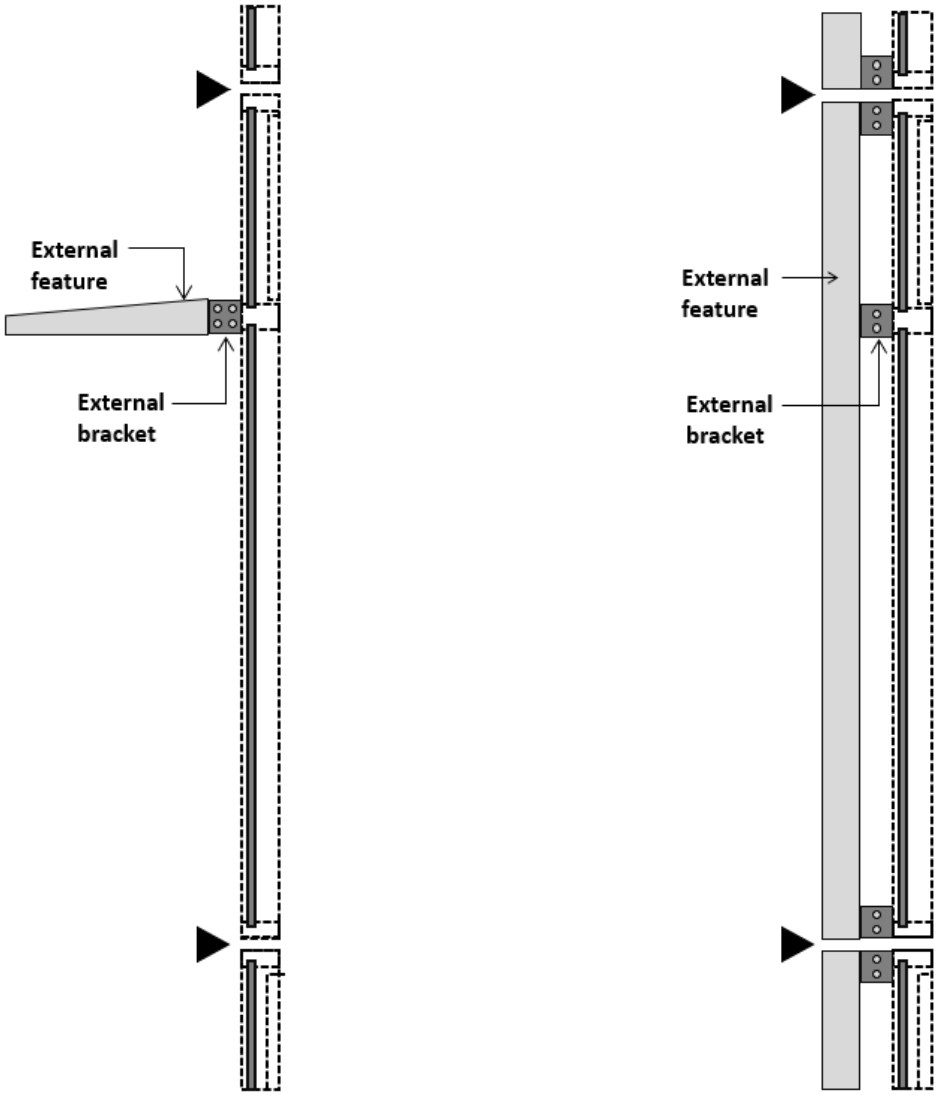


Figure 10: Example - section drawing (detail) on left and right illustrating connection between curtain wall and metal external feature on the exposed face of the facade. Providing metals of similar metal properties or separator/isolator helps to mitigate risk of bi-metallic corrosion.

Credits: YKK AP FAÇADE

Documentation requirements

Design stage

- Tender specification indicating metals of similar properties or separators between different metal components on the exposed face of the façade.
- Plan /elevation/section and detail drawings indicating metals of similar properties or separators between different metal components.

Verification stage

- As-built (façade shop drawings) to show implementation.
- Product specification indicating the properties of the metal components.

Design strategy and assessment: (2.5 points)

b. For water ingress – design for pressure -equalised (rain-screen) system, comprising of:

i) Ventilation openings of adequate dimensions to ensure pressure-equalisation of the cladding cavity

ii) Drainage system to positively drain out water

iii) Air cavity with a fully sealed internal backing wall behind the cladding.

Note:

- *Pressure Equalised System acts like a typical cavity wall to allow rainwater discharge and moisture ventilation (like breathable façades) to reduce risk of water ingress through external walls. Water ingress is reduced by 'equalisation' of internal and external pressures (pressure moderated system).*
- *The table below shows the solution permutation feasibility under section 1.2 for PES and Non - PES façade systems.*

Solutions under 1.2	*PES system*	*Non - PES system*
1.2.1a	*yes*	*yes*
1.2.1b	*yes*	*No*
1.2.1c	*NA*	*yes*
1.2.1d	*NA*	*yes*
1.2.1e	*yes*	*NA*
1.2.1f	*yes*	*yes*
Advanced effort	*yes*	*yes*

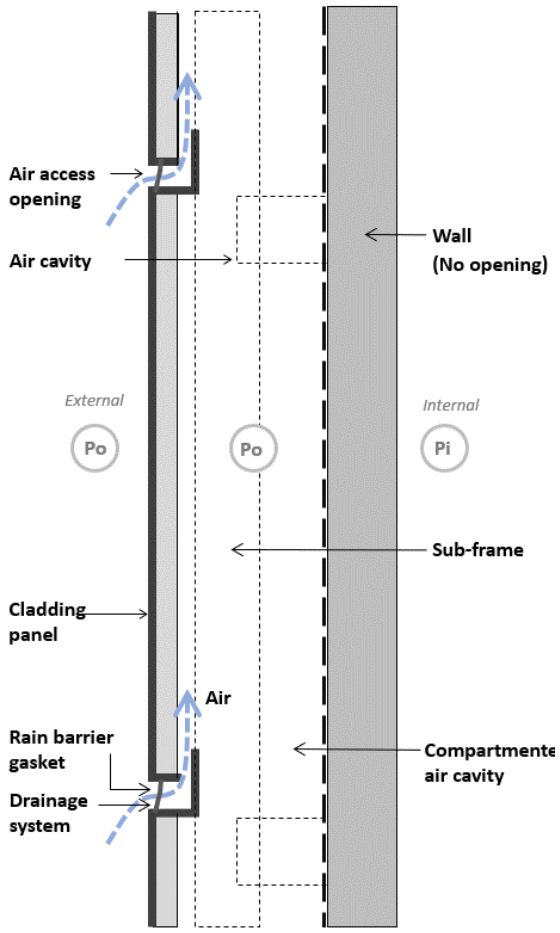


Figure 11: Drawing illustrating pressure equalised metal cladding system.

Credits: YKK AP FACADE

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
20% - 25%	70% - 75%	Up to 5%	25 - 30

Baseline design strategy: Non-pressure equalised system
Proposed design strategy: Pressure equalised system
Study period: 30 years
Yearly labour savings: 60-70% man-hour.

Documentation requirements

Design stage

- Plan/elevation drawings indicating open joint, pressure equalised stone/tile cladding system and extent, in case of different cladding system.
- Detail drawings of open joint, pressure equalised stone/tile cladding system.

Verification stage

- As-built (façade shop drawings) to show implementation.

Design strategy and assessment: (1 point)

c. For water ingress - In face-sealed cladding: specify silicone or modified silicone sealant that is compatible and with adequate adhesion properties to the substrate.

Note:

- *Silicone: 100% Silicone is an inorganic substance with outstanding UV resistance and thermal stability.*
- *Modified Silicone (MS): is an organic substance which is hybrid between Silicone and Urethane. MS in its chemical formulation, provides the properties that 100% Silicone has and is paintable because of the Urethane polymer in it.*
- *Proposed silicone or modified silicone for stone/tile cladding has to be tested to Adhesion-in-Peel in compliance to ASTM C794[1][6]. The test should include – but not limited to – various primer solutions and testing without primer.*
- *Proposed silicone or modified silicone is recommended to have minimum properties of +50% movement capability, tested in compliance with ASTM C920[2][7] for Class 50.*
- *External application must be conducted in dry weather condition as sealant does not adhere well on wet, damp surface. Ensure the joint is dry, clean and free from contaminants.*

Documentation requirements

Design stage

- Plan/elevation drawings indicating all tile and stone façades using sealants.
- Tender specification indicating sealant type as silicone or modified silicone.
- Tender specification indicating proposed silicone or modified silicone for stone/tile cladding to be tested to Adhesion-in-Peel in compliance to ASTM C794[1]. The test should include but not limited to various primer solutions and testing without primer.

Verification stage

- Test reports showing Adhesion-in-Peel results.
- Product specification and delivery orders of the sealant used and primer, if any.

Design strategy and assessment: (0.5 point)

d. For streaking – specify sealant type with non-stain, non-bleed properties.

Note:

- *Sealant may cause stain on a porous substrate such as tile or stone. The non-stain and non-bleed properties reduce exudation from the sealant, thus minimising staining.*
- *In Metal cladding - sealant on the facade may cause streaking due to bleeding of oil which grab dust particles. The latter forms streaks during rain. Sealant with non-stain and non-bleed properties to be used to reduce dust deposition and resultant streaking.*

[6] ASTM C794-18, Standard Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants, ASTM International, West Conshohocken, PA, 2018, www.astm.org

[7] ASTM C920-18, Standard Specification for Elastomeric Joint Sealants, ASTM International, West Conshohocken, PA, 2018, www.astm.org

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
5% - 10%	40% - 45%	Up to 5%	5 - 6

Baseline design strategy: PU sealant
Proposed design strategy: Sealant with non-bleed, non-stain properties
Study period: 10 years
Yearly labour savings: 50% - 60% man-hour.

Documentation requirements

Design stage

- Plan/elevation drawings locating all tile and stone façades using sealants.
- Tender specification indicating sealant type with non-stain and non- bleed properties and in compliance with ASTM C1248 standards[8].

Verification stage

- Product specification showing the non-stain and non-bleed property for the sealant type used and delivery orders of the specified sealant.
- Test reports showing compliance of standards.

Design Strategy and assessment: (1 point)

e. For water ingress - specify gasket type EPDM or TPE.

Documentation requirements

Design stage

- Plan/elevation drawings indicating all tile and stone façades using gaskets.
- Tender specification indicating gasket type as EPDM or TPE complying to ASTM C864-05 standards[9].

Verification stage

- Product specification of the gasket type used to show compliance of standards and delivery orders.

[8] ASTM C1248-06, Standard Test Method for Staining of Porous Substrate by Joint Sealants, ASTM International, West Conshohocken, PA, 2006, www.astm.org
[9] Refer to ASTM C864-05(2019), Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers, ASTM International, West Conshohocken, PA, 2019, www.astm.org.

Design strategy and assessment: (0.5 point)

f. For water ingress - design for double layer protection at façade interfaces, coping, etc.

Note:

- *A double layer protection reduces risk of water ingress even in case of damaged or peeled primary layer of protection (e.g. Sealant). Façade interfaces, façade copings, and flashing areas that are vulnerable and at risk of failure of 1st layer of protection (e.g. Sealant) can incorporate double layer protection for better protection.*
- *In case of sealant, external application must be conducted in dry weather condition as sealant does not adhere well on wet, damp or frozen surface. Ensure the joint is dry, clean and free from contaminants.*

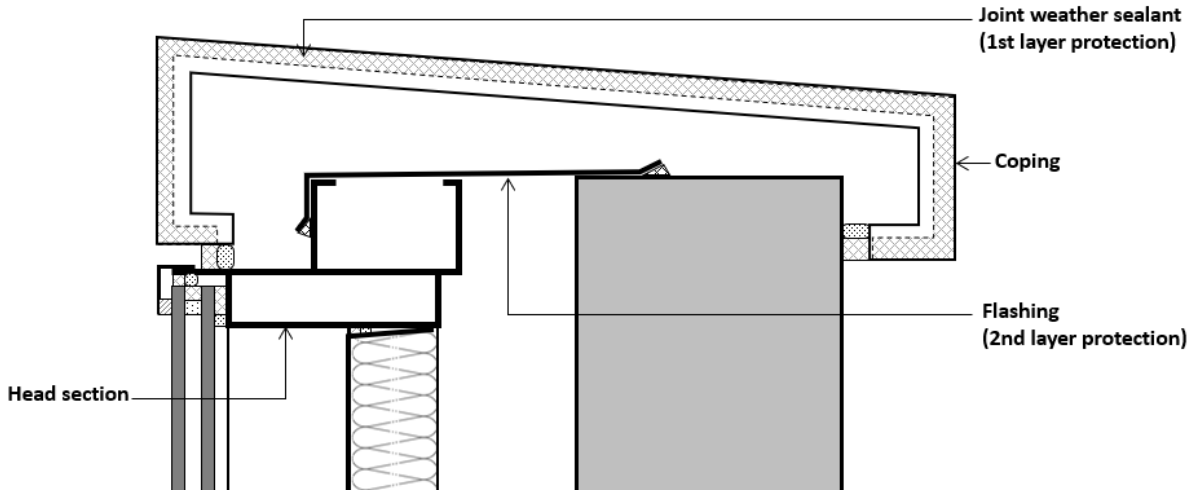


Figure 12: Drawing illustrating double layer protection at façade coping, in this case sealant (1st layer of protection) and flashing (2nd layer of protection).

Credits: YKK AP FAÇADE

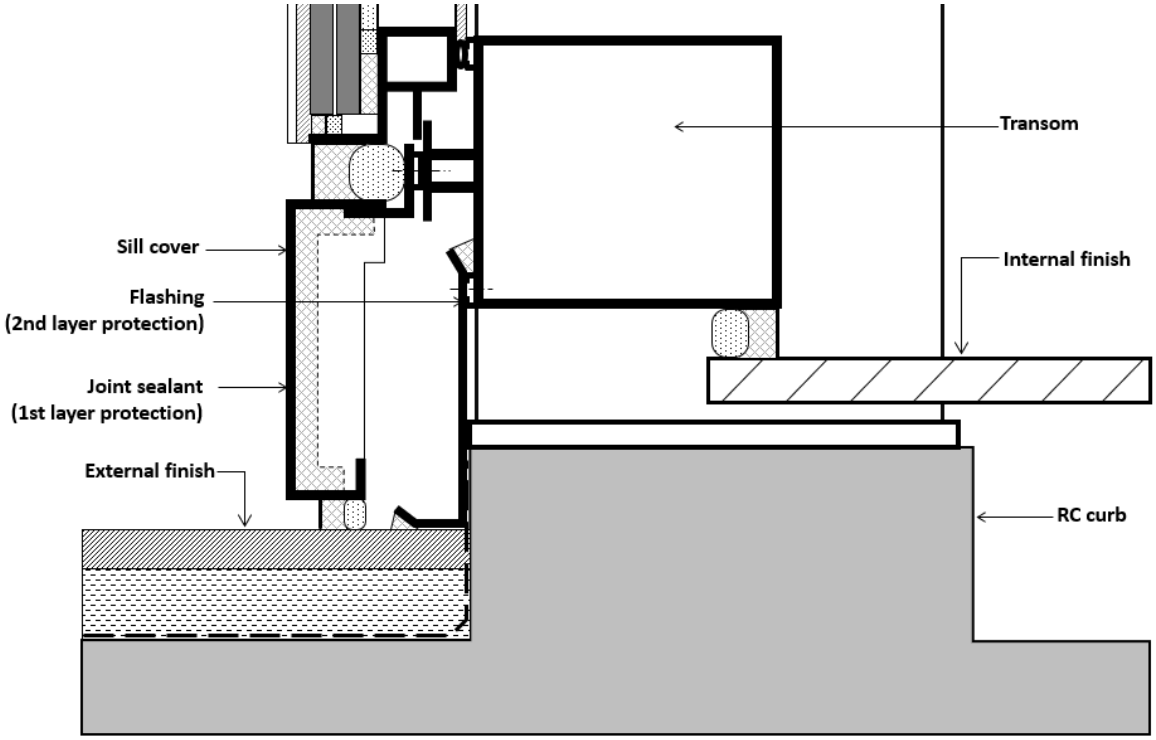


Figure 13: Drawing illustrating double layer protection at bottom flashing, in this case sealant (1st layer of protection) and flashing (2nd layer of protection).

Credits: YKK AP FAÇADE

Documentation requirements

Design stage

- Plan/elevation drawings indicating double layer protection on the façade.
- Typical detail drawings of double layer protection.

Verification stage

As-built drawings (façade shop drawings) to show implementation.

Advanced effort: (Bonus 1 point)

For water ingress: Specify anti-carbonation coating or waterproofing layer onto the backing wall behind the cladding.

Documentation requirements

Design stage

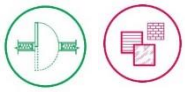
- Plan drawing locating anti – carbonation coating or waterproofing layer on the backing wall behind the cladding.
- Tender specification indicating anti – carbonation coating or waterproofing layer on the backing wall.

Verification stage

- Delivery orders of product.
- Photographs showing implementation.

1.3 CURTAIN WALL (4 points)

1.3.1 Reduce risk of water ingress and streaking on façade (Up to 4 points)



Intent

To ensure water tightness and minimise façade streaking through optimal design detailing and choice of materials to reduce the frequency of repair and maintenance.

Design strategy and assessment: (0.5 point)

a. For streaking - Specify metals of similar properties or separators between different metal components on the exposed face of the façade to mitigate risk of bi-metallic corrosion.

Documentation requirements

Design stage

- Tender specification indicating metals of similar properties or separators between different metal components on the exposed face of the façade. Plan /elevation/section and detail drawings indicating metals of similar properties or separators between different metal components.

Verification stage

- As-built drawings (façade shop drawings) to show implementation.
- Product specification indicating the properties of the metal components.

Design strategy and assessment: (2 points)

b. For water ingress - design for pressure-equalised system comprising of:

i) Ventilation openings of adequate dimensions to ensure pressure-equalisation of the cavities

ii) Drainage system to positively drain out water

iii) Internal air-seal layer to pressurise internal cavities and minimise risk of water penetration.

Note:

- *Pressure Equalised System acts like a typical cavity wall to allow rainwater discharge and moisture ventilation (like breathable façades) to reduce risk of water ingress through external walls. Water ingress is reduced by 'equalisation' of internal and external pressures (pressure moderated system).*
- *For mixed developments, where the non-residential component does not have a façade system but consist of only full height glass walls for their shopfronts, these glass walls will not be considered for assessment.*
- *The table below shows the solution permutation feasibility under section 1.3 for PES, Non - PES façade systems and full height glass walls for shopfronts.*

Solutions under 1.3	*PES system*	*Non - PES system*	*Full Height Glass Walls for Shopfronts*
1.3.1a	*yes*	*yes*	*NA*
1.3.1b	*yes*	*No*	*NA*
1.3.1c	*yes*	*yes*	*NA*
1.3.1d	*yes*	*yes*	*NA*
1.3.1e	*yes*	*NA*	*NA*
1.3.1f	*yes*	*yes*	*NA*

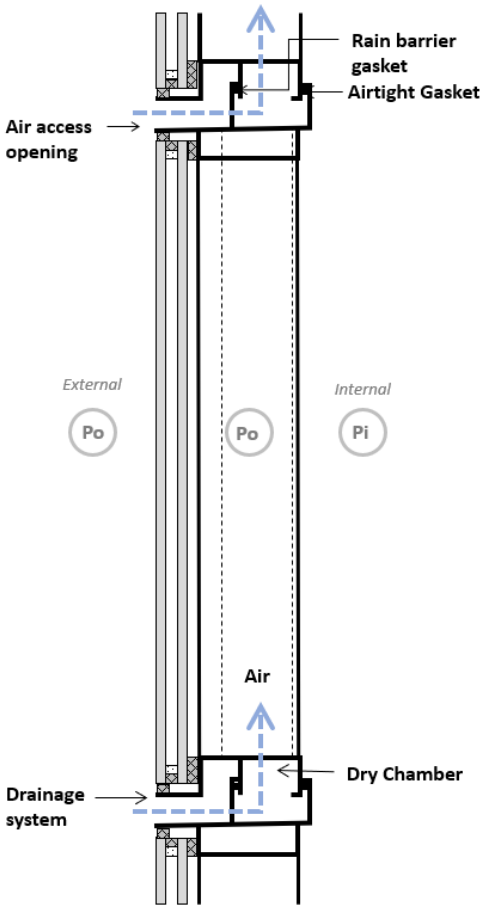


Figure 14: Drawing illustrating pressure equalised system.

Credits: YKK AP FAÇADE

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
20% - 25%	70% - 75%	Up to 5%	25 - 30

Baseline design strategy: Non-pressure equalised system
Proposed design strategy: Pressure equalised system
Study period: 30 years
Yearly labour savings: 60-70% man-hour.

Documentation requirements

Design stage

- Plan/ elevation drawings indicating open joint, pressure equalised glazing system and extent, in case of different cladding system
- Detail drawings of open joint, pressure equalised glazing system.

Verification stage

- As-built (façade shop drawings) to show implementation.

Design strategy and assessment: (1 point)

c. For water ingress - specify silicone sealant that is compatible and with adequate adhesion properties to the substrate.

Note:

- *Silicone: 100% Silicone is an inorganic substance with outstanding UV resistance and thermal stability.*
- *Proposed silicone for glazing has to be tested to Adhesion-in-Peel in compliance to ASTM C794[1]10. The test should include but not limited to various primer solutions and testing without primer.*
- *Proposed silicone is recommended to have minimum properties of +50% movement capability, tested in compliance with ASTM C920[2][11] for Class 50.*
- *External application must be conducted in dry weather condition as sealant does not adhere well on wet, damp or frozen surface. Ensure the joint is dry, clean and free from contaminants.*

Documentation requirements

Design stage

- Plan/elevation drawings indicating all glazing façades using sealants.
- Tender specification indicating proposed silicone to be tested to Adhesion-in-Peel in compliance to ASTM C794[1]. The test should include but not limited to various primer solutions and testing without primer.

Verification stage

- Test reports showing Adhesion- in Peel test results.
- Product specification and delivery orders sealant used and primer, if any.

[10] ASTM C794-18, Standard Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants, ASTM International, West Conshohocken, PA, 2018, www.astm.org

[11] ASTM C920-18, Standard Specification for Elastomeric Joint Sealants, ASTM International, West Conshohocken, PA, 2018, www.astm.org

Design strategy and assessment: (0.5 point)

d. For streaking - specify sealant type with non-stain, non-bleed properties.

Note: Sealant may cause stain on a porous substrate such as tile or stone. The non-stain and non-bleed property reduce exudation from the sealant thus minimising the stain.

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
5 - 10%	40% - 45%	Up to 5%	5 - 6

Baseline design strategy: PU Sealant
Proposed design strategy: Sealant with non-bleed, non-stain properties
Study period: 10 years
Yearly labour savings: 50% - 60% man-hour.

Documentation requirements

Design stage

- Plan/elevation drawings indicating all glazing façades using sealants.
- Tender specification indicating sealant type with non-stain and non-bleed properties and in compliance with ASTM 1248 standards[12]

Verification stage

- Product specification indicating the non-stain and non-bleed property for the sealant type used and delivery orders of the specified sealant.
- As-built drawings/shop drawings showing use of specified sealant type.

Design strategy and assessment: (1 point)

e. For water ingress - specify gasket type EPDM or TPE that is compatible with the substrate.

Documentation requirements

Design stage

- Plan/elevation drawings indicating all metal cladded façades using gaskets.
- Tender specification indicating gasket type as EPDM or TPE complying to ASTM C864-05(2019)[13].

Verification stage

- Product specification of the gasket type used to show compliance of standards and delivery orders.

[12] ASTM C510-16, Standard Test Method for Staining and Color Change of Single- or Multicomponent Joint Sealants, ASTM International, West Conshohocken, PA, 2016, www.astm.org
[13] Refer to ASTM C864-05(2019), Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers, ASTM International, West Conshohocken, PA, 2019, www.astm.org.

Design strategy and assessment: (0.5 point)

f. For water ingress - design for double layer protection at façade interface, coping, etc.

Note:

- *A double layer protection reduces risk of water ingress even in case of damaged or peeled primary layer of protection (e.g. Sealant). Façade interfaces, façade copings, and flashing areas that are vulnerable and at risk of failure of 1st layer of protection (e.g. Sealant) can incorporate double layer protection for better protection.*
- *In case of sealant, external application must be conducted in dry weather condition as sealant does not adhere well on wet, damp or frozen surface. Ensure the joint is dry, clean and free from contaminants.*

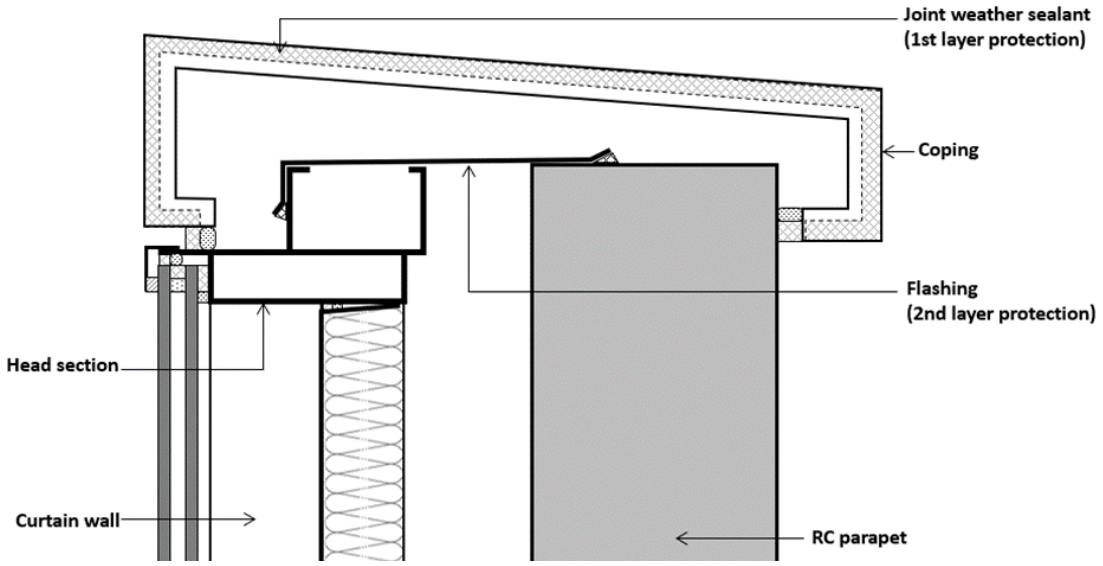


Figure 15: Drawing illustrating double layer protection at façade copping, in this case sealant (1st layer of protection) and flashing (2nd layer of protection).

Credits: YKK AP FAÇADE

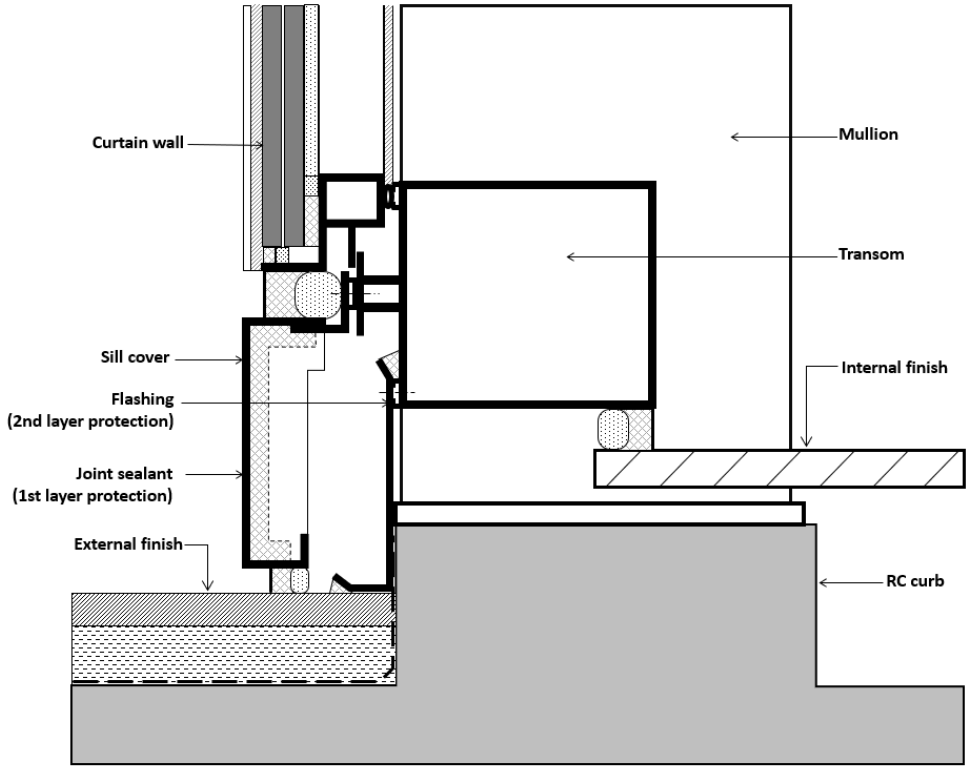


Figure 16: Drawing illustrating double layer protection at bottom flashing, in this case sealant (1st layer of protection) and flashing (2nd layer of protection).

Credits: YKK AP FAÇADE

Documentation requirements

Design stage

- Plan drawings indicating double layer protection on the façade.
- Typical detail drawings of double layer protection.

Verification stage

- As-built (façade shop drawings) to show implementation.

1.4. MASONRY AND LIGHTWEIGHT CONCRETE PANELS (4 points)

1.4.1. Reduce risk of water ingress and efflorescence formation (3 points)

Intent

To ensure water tightness and minimise façade streaking to reduce the frequency of repair and maintenance through optimal design detailing and choice of materials.

Design strategy and assessment: (0.5 point)

a. **For water ingress: design movement joints in large continuous areas, or between adjacent/different building components, to minimise the risk of damage to façade, weather seal, and waterproofing joints.**

Note: In a continuous cladded surface, movement joints intervals should not be more than 6 m. Minimum width to be ½ inch, to accommodate shrinkage after expansion.

Documentation requirements

Design stage

- Plan drawings indicating all masonry and light weight concrete panel façades.
- Elevation drawings showing movement joints indicating width of movement joints and intervals.

Verification stage

- As-built drawings/shop drawings to show implementation.

Design strategy and assessment: (1 point)

c. For water ingress in pre-cast joints – specify silicone or modified silicone sealant on exterior exposed joints, that is compatible and with non-detachment properties to the substrate.

Note:

- Silicone: 100% Silicone is an inorganic substance with outstanding UV resistance and thermal stability.

- Modified Silicone (MS): is an organic substance which is hybrid between Silicone and Urethane. Silicone in its chemical formulation, provides the properties that 100% Silicone has and is paintable because of the Urethane polymer in it.

- Proposed silicone or modified silicone for pre-cast joints must be tested to Adhesion-in-Peel in compliance to ASTM C794[1]. The test should include but not limited to various primer solutions and testing without primer.

- Proposed silicone or modified silicone is recommended to have minimum properties of +50% movement capability, tested in compliance with ASTM C920[2] for Class 50.

- External application must be conducted in dry weather condition as sealant does not adhere well on wet, damp or frozen surface. Ensure the joint is dry, clean and free from contaminants.

Documentation requirements

Design stage

- Plan/elevation drawings indicating all precast façades using sealants.
- Tender specification indicating sealant type as silicone or modified silicone.
- Tender specification indicating proposed silicone or modified silicone for precast to be tested for Adhesion-in-Peel in compliance to ASTM C794[1]. The test should include but not limited to various primer solutions and testing without primer.

Verification stage

- Test reports showing Adhesion- in Peel results.
- Product specification and delivery orders of the sealant used and primer, if any.

Design strategy and assessment: (1 point)

d. For efflorescence:

i. Specify clear coat, with good resistance to water absorption on façade surface. e.g. for fair-faced or pigmented concrete.

(OR)

ii. Specify paint with good resistance to water absorption, complying with SS500 or equivalent

Note: Surface coatings that are water repellent reduce the occurrence of efflorescence.

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
Up to 5%	75% - 80%	15% – 20%	1 - 2

Baseline design strategy: only standard paint SS345
Proposed design strategy: Paint with good resistance to water absorption, complying to SS500
Study period: 10 years
Yearly labour savings: 60% - 70% man-hour savings

Documentation requirements

Design stage

- Plan drawings indicating façade with coatings / paint with good resistance to water absorption.
- Tender specification indicating clear coat with good resistance to water absorption or paint finish with good resistance to water absorption complying to SS 500 or equivalent.
- Tender specification indicating proposed clear coat or paint finish to be tested for water absorption complying to SS500 requirements or equivalent.

Verification stage

- Test reports showing water absorption results complying to SS 500 or equivalent.
- Product specification and delivery orders of the product.

1.4.2. Reduce risk of façade from flaking/peeling/cracking/blistering (Up to 1 point)

Intent
To minimise flaking, peeling, cracking, and blistering due to humidity and dampness through optimal choice of materials so as to reduce the frequency of repainting and maintenance.

Design strategy and assessment: (1 point)

a. Specify paint finish[14]:

Top coat:

Paint with good resistance to water absorption complying with SS500 or equivalent.

(OR)

Mineral paint

Note:
- *The appropriate primer coat and undercoat to be recommended by the manufacturer for the specified top coat, taking into consideration the condition of the substrate. The various coats must be compatible.*
- *Proper preparation of surface for paint is mandatory. Ensure that paint selection is suitable for substrate.*

Life cycle cost analysis: baseline design strategy vs proposed design strategy

[14] Codes + Regulations: SS 542:2008 Code of practice for painting of buildings mentioned "weathering resistant grade synthetic resin emulsion" paint.

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
Up to 5 %	45% - 50%	25% - 30%	1 - 2

Baseline design strategy: standard paint SS345 with primer (water-based)
Proposed design strategy: Paint with good resistance to water absorption, complying to SS500
Study period: 10 years
Yearly labour savings: 10-20% man-hour savings

Documentation requirements

Design stage

- Plan drawings indicating all external surfaces with paint finish.
- Tender specification indicating use of selected paint finish.
- Tender specification indicating proposed paint finish to be tested for water absorption complying to SS500 requirements or equivalent (if non-mineral paint).

Verification stage

- As-built drawings to show implementation.
- Test reports showing water absorption results complying to SS 500 or equivalent (if non-mineral paint).
- Product specification and delivery orders of applicable products.

Worked Example 1:

A mid-rise office building of 30 years was initially designed with a combination of 3 façade systems - masonry wall with plaster & paint, a curtain wall system, and a tile cladding. It is currently undergoing a façade facelift and the tile cladding is being replaced with a more durable metal cladding system. The total area of the façade systems is 5,000m^2, comprising:

- 900m^2 of metal cladding
- 2,100m^2 of curtain wall glazing
- 2,000m^2 of masonry wall with plaster & paint

The breakdown of the new façade is shown in Area Table I below:

	Metal Cladding (m^2)	Curtain Wall Glazing (m^2)	Masonry wall with plaster & paint (m^2)	Total (m^2)
Facade	900	2100	2000	5000

Area Table I : Breakdown of Façade System

Documentation requirements*:*

APPLICABILITY	Masonry wall
STATUS	Existing
DESIGN STAGE ASSESSMENT	N.A.
VERIFICATION STAGE ASSESSMENT	<u>1.41 Reduce risk of water ingress and efflorescence formation</u> a. For efflorescence: specify mortar materials that are salt-free • Test report showing salt-free sand – for onsite mortar and grout • Product specification indicating salt-free or chloride-free - for premix mortar or grout • Delivery orders of the specified mortar materials b. For water ingress: design movement joints in large continuous areas, or between adjacent/different building components, to minimise the risk of damage to façade, weather seal, and waterproofing joints. • As-built drawings/shop drawings to show implementation. c. For water ingress in pre-cast joints – specify silicone or modified silicone sealant on weather-exposed joints, that is compatible and with adequate adhesion properties to the substrate. N.A. *(Masonry wall does not meet solution (c), hence there will be no documentation requirement.)* d. For efflorescence: specify clear coat with good resistance to water absorption on façade surface. E.g. in the case of exposed or pigmented concrete surfaces (OR) specify paint with good resistance to water absorption complying to SS500 or equivalent. N.A. *(Masonry wall does not meet solution (d), hence there will be no documentation requirement.)* <u>1.4.2 Reduce risk of façade from flaking/peeling/cracking/blistering</u> a. Specify paint finish: Top coat – paint with good resistance to water absorption complying with SS500 (OR) Mineral Paint • As-built drawings to show implementation. • Test reports showing water absorption results complying to SS 500 or equivalent (if non-mineral paint). • Product specification and delivery orders of applicable products.

Documentation requirements*:*

APPLICABILITY	Metal cladding
STATUS	Upgrading
DESIGN STAGE ASSESSMENT	<u>1.2.1 Reduce risk of water ingress and streaking on facade</u> a. For streaking: Specify metals of similar properties or separators between different metal components on the exposed face of the façade to mitigate risk of bi-metallic corrosion efflorescence. • Tender specification indicating metals of similar properties or separators between different metal components on the exposed face of the façade. • Plan /elevation/section and detail drawings indicating metals of similar properties or separators between different metal components b. For water ingress – design for pressure-equalised (rain-screen) system, comprising: • Ventilation openings of adequate dimensions to ensure pressure-equalisation of the cladding cavity • Drainage system to positively drain out water • Air cavity with a full sealed internal backing wall behind the cladding N.A. *(Metal cladding does not meet solution (b), hence there will be no documentation requirement)* c. For water ingress - In face-sealed cladding: specify silicone or modified silicone sealant that is compatible and with adequate adhesion properties to the substrate. • Plan/elevation drawings indicating all tile and stone façades using sealants. • Tender specification indicating sealant type as silicone or modified silicone. • Tender specification indicating proposed silicone or modified silicone for stone/tile cladding to be tested to Adhesion-in-Peel in compliance to ASTM C794[1]. The test should include but not limited to various primer solutions and testing without primer. d. For streaking – specify sealant type that has non-stain, non-bleed properties. • Plan/elevation drawings locating all tile and stone façades using sealants. • Tender specification indicating sealant type with non-stain and non- bleed properties and in compliance with ASTM C1248 standards e. For water ingress – specify gasket type EPDM or TPE N.A. *(Metal cladding does not meet solution (e), hence there will be no documentation requirement)*

	f. For water ingress - design for double layer protection at façade interfaces, coping and bottom flashing. • Plan/elevation drawings indicating double layer protection on the façade. • Typical detail drawings of double layer protection Advanced Effort – For water ingress: Specify anti-carbonation coating or waterproofing layer onto the backing wall behind the cladding • Plan drawing locating anti – carbonation coating or waterproofing layer on the backing wall behind the cladding. • Tender specification indicating anti – carbonation coating or waterproofing layer on the backing wall.
VERIFICATION STAGE ASSESSMENT	<u>1.2.1 Reduce risk of water ingress and streaking on facade</u> a. For streaking: Specify metals of similar properties or separators between different metal components on the exposed face of the façade to mitigate risk of bi-metallic corrosion efflorescence. • As-built (façade shop drawings) to show implementation. • Product specification indicating the properties of the metal components. b. For water ingress – design for pressure-equalised (rain-screen) system. • As-built drawings (façade shop drawings) to show implementation. c. For water ingress - In face-sealed cladding: specify silicone or modified silicone sealant that is compatible and with adequate adhesion properties to the substrate. • Test reports showing Adhesion-in-Peel results • Product specification and delivery orders of the sealant used and primer, if any. d. For streaking – specify sealant type that has non-staining, non-bleeding properties. • Product specification showing the non-stain and non-bleed property for the sealant type used and delivery orders of the specified sealant. • Test reports showing compliance of standards. e. For water ingress - specify gasket type EPDM or TPE • Product specification of the gasket type used to show compliance of standards and delivery orders. f. For water ingress - design for double layer protection at façade interfaces, coping and bottom flashing. • As-built drawings (façade shop drawings) to show implementation. Advanced Effort – For water ingress: Specify anti-carbonation coating or waterproofing layer onto the backing wall behind the cladding. • Delivery orders of product. • Photographs showing implementation.

- Proportion of Metal Cladding
  = 900m^2 / 5,000 m^2 = 18% (≥15%)

- Proportion of Curtain Wall Glazing system
  = 2,100m^2 / 5,000 m^2 = 42% (≥15%)

- Proportion of Lightweight concrete panel
  = 2,000m^2 / 5,000m^2 = 40% (≥15%)

NOTE: *The maximum points available for Façade Systems - Section 1.2 to 1.4 = 4pts*

(For singular façade system, points can be scored for 1.2, 1.3, or 1.4. In this case as the project comprises multiple façades, systems points will be apportioned across the various systems on an area basis)

1.2 Cladding – Tile / Stone / Metal / Others

NOTE: *The maximum points available under 1.2 is 18% * 4pts = 0.72pts*

1.2.1 Reduce risk of water ingress and streaking on façade (Up to 4 points)	Points	Assessment category	**Used in Project**	**Points Scored**
a. For streaking: Specify metals of similar properties or separators between different metal components on the exposed face of the façade to mitigate risk of bi-metallic corrosion.	0.5	Cat 1	√	18% * 0.5 = 0.09
b. For water ingress: Design for pressure-equalised (rain-screen) system, comprising of: i) Ventilation openings of adequate dimensions to ensure pressure-equalisation of the cladding cavity ii) Drainage system to positively drain out water iii) Air cavity with a fully sealed internal backing wall behind the cladding.	2.5	Cat 1	×	0
c. For water ingress – In face-sealed cladding: specify silicone or modified silicone sealant that is compatible and with adequate adhesion properties to the substrate.	1	Cat 1	√	18% * 1 = 0.18
d. For streaking – specify sealant type with non-staining, non-bleeding properties.	0.5	Cat 1	√	18% * 0.5 = 0.09

e. For water ingress – specify gasket type EPDM or TPE.	1	Cat 1	×	0
f. For water ingress - design for double layer protection at façade interfaces, copings, and bottom flashings.	0.5	Cat 2	√	18% * 0.5 = 0.09
Score for *1.2 Cladding System*				0.09 + 0.18 + 0.09 + 0.09 = 0.45
BONUS: For water ingress: Specify anti-carbonation coating or waterproofing layer onto the backing wall behind the cladding.	1	Cat 1	√	18% * 1 = 0.18

1.3 Curtain Wall

NOTE: *The maximum points available under 1.3 is 42% * 4pts = 1.68pts*

1.3.1 Reduce risk of water ingress and streaking on façade (Up to 4 points)	Points	Assessment Category	**Used in Project**	**Points Scored**
a. For streaking: Specify metals of similar properties or separators between different metal components on the external face of façade to mitigate risk of bi-metallic corrosion.	0.5	Cat 1	√	42% * 0.5 = 0.21
b. For water ingress – design for pressure-equalised system comprising of: i) Ventilation openings of adequate dimensions to ensure pressure-equalisation of the cavities ii) Drainage system to positively drain out water iii) Internal air-seal layer to pressurise internal cavities and minimise risk of water penetration	2	Cat 1	√	42% * 2 = 0.84
c. For water ingress - specify silicone sealant that is compatible and with adequate adhesion properties to the substrate.	1	Cat 1	√	42% * 1 = 0.42
d. For streaking – specify sealant type with non-staining, non-bleeding properties.	0.5	Cat 1	√	42% * 0.5 = 0.21
e. For water ingress – specify gasket type EPDM or TPE that is compatible with the substrate.	1	Cat 1	√	42% * 1 = 0.42

f. For water ingress – design for double layer protection at façade interfaces, copings, etc..	0.5	Cat 2	×	0
Score for *1.3 Curtain Wall*				0.21 + 0.84 + 0.42 + 0.21 + 0.42 = 2.1 1.68 (max)

1.4 Masonry and Lightweight Concrete Panels

NOTE: *The maximum points available under 1.4 is 40% * 4pts = 1.6pts*

1.4.1 Reduce risk of water ingress and efflorescence formation (3 points)	Points	Assessment Category	**Used in Project**	**Points Scored**
a. For water ingress: design movement joints in large continuous areas, or between adjacent/different building components, to minimise the risk of damage to façade, weather seal, and waterproofing joints.	0.5	Cat 1	√	40% * 0.5 = 0.2
b. For water ingress in precast joints – specify silicone or modified silicone sealant on exterior exposed joints, that is compatible and with adequate adhesion properties to the substrate.	1	Cat 1	×	0
c. For efflorescence: Specify clear coat with good resistance to water absorption on façade surface. E.g. fair-faced or pigmented concrete (OR) Specify paint with good resistance to water absorption complying to SS500 or equivalent.	1	Cat 2	×	0
1.4.2 Reduce risk of façade flaking/peeling/cracking/blistering (Up to 1 points)	Points	Assessment Category	**Used in Project**	**Points Scored**
a. Specify paint finish: Top coat: paint with good resistance to water absorption complying with SS500 or equivalent *(1 point)* *(OR)* Mineral paint *(1 point)*	1	Cat 2	√	40% * 0.5 = 0.21
Score for *1.4 Masonry and Lightweight Concrete Panels*				0.2 + 0.2 + 0.21 = 0.61

As such, the final points for the entire Part B : ***Façade System (Metal Cladding + Curtain wall glazing + Masonry and light weight concrete panels)*** = 0.45 + 1.68 + 0.61 = **2.74 pts + 0.18 pts (bonus*)**

The bonus points of **0.18 is not be limited by the maximum cap under 1.2 Cladding and can be considered as additional points.*

Part C: Façade Systems - Section 1.5 to 1.7

1.5. FAÇADE FEATURES (3.5 points)

1.5.1. Direct access to all protruding façade features, e.g. canopies, sunshades, niches, fins, ledges, BIPV, façade screens, etc. (0.5 point)

Intent

To ensure safe and efficient access to facilitate cleaning, maintenance, and inspection of all façade features e.g. canopies, sunshade, niches, fins, ledges, photovoltaic panels, BIPV etc.

Design strategy and assessment: (0.5 point)

a. Ensure every part of all façade features is accessible for maintenance.

Note: Sole use of rope access is deemed unacceptable unless proven otherwise.

Documentation requirements

Design stage

- Plan/elevation/schematic drawings demonstrating all façade features is 100 % accessible through one or a combination of access systems. Please refer to BCA's façade access design guide[15] for more details on the submittals.

Verification stage

- Maintenance strategy report for façade access indicating access to façade features.

1.5.2. Reduce risk of corrosion of exposed supporting steel structures.(1 point)

Intent

To reduce the frequency of maintenance and repair of steel structures exposed to natural surrounding environment through optimal detailing.

Design strategy and assessment: (1 point)

a. Design to avoid direct contact of a steel base with the ground (raise at least 100 mm) to mitigate corrosion and entrapment of moisture and dirt.[16]

For example - Protect steel bases at ground by providing conical concrete upstand in water ponding areas.

[15] Refer to BCA Façade Access Design Guide to provide required details on Façade access strategy, façade features etc. https://www1.bca.gov.sg/docs/default-source/docs-corp-buildsg/sustainability/dm_fadg_2017.pdf

[16] Reference BS EN 12944-3, www.steelconstruction.info

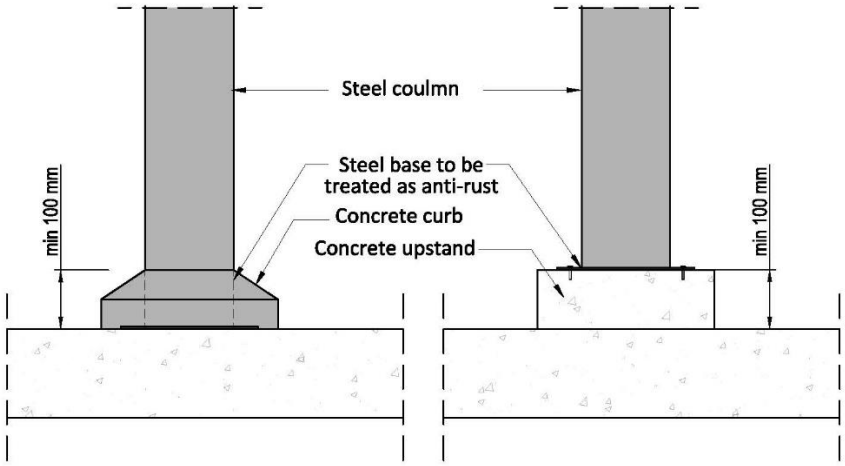


Figure 17: Concrete protection for steel base.

Documentation requirements

Design stage

- Plan drawings locating all steel structures with steel base protection.
- Detail drawings for steel base protection (minimum 100 mm above ground).

Verification stage

- As-built drawings/shop drawings to show implementation.
- Photographs of the concrete upstand or concrete curb after implementation.

1.5.3 Reduce risk of water ingress in open joint cladding (i.e. cladding serving as a decorative feature and not as a water barrier). (1 point)

Intent

To reduce the frequency of maintenance and repair of exposed steel features – such as open joint cladding – by improving its durability through optimal design detailing.

Design strategy and assessment: (1 point)

a. For features such as open-joint cladding: provide flashings at regular intervals (not exceeding 3 floors) to positively drain out the cladding cavities and prevent the accumulation of water.

Documentation requirements

Design stage

- Plan/elevation drawings open joint cladding on the façade.
- Tender specification indicating use of flashings at regular intervals (not exceeding 3 floors) to drain out cladding cavities and prevent the accumulation of water.
- Detail drawings illustrating use of flashings on the cladding.

Verification stage

- As-built drawings/shop drawings to show implementation.
- Photographs of flashings on the open joint cladding after implementation.

1.5.4 Reduce risk of tile/stone from detaching off façade (1 point)

Intent

To enhance public safety by minimising the incidence of dislodged tile and stone cladding through optimal detailing; and hence reducing the frequency of maintenance and repair.

Design strategy and assessment: (1 point)

a. Design for mechanically-fixed individual tile/stone panels with stainless steel fixings.

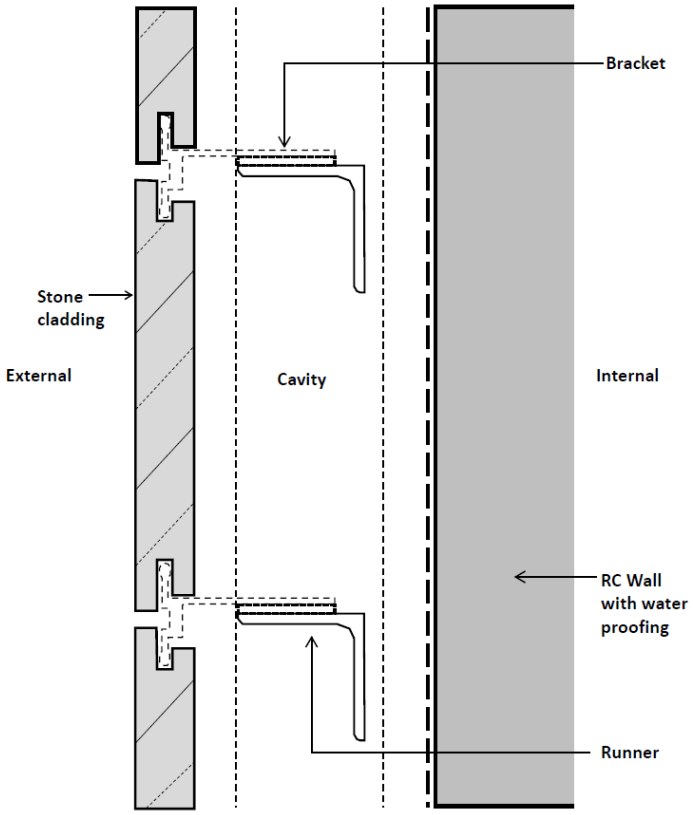


Figure 18: Illustration of mechanically fixed stone cladding.

Documentation requirements

Design stage

- Plan/elevation drawings locating the tile and stone cladding façades using mechanically mounted panels.
- Tender specification indicating mechanically mounted, individual tile/stone panels with stainless steel fixings.
- Plan/elevation/section and detail drawings of mechanically mounted individual tile/stone panels with stainless steel fixings.

Verification stage

- As-built drawings (façade shop drawings) to show implementation.
- Product specification and delivery orders of the product.

1.6. ENTRANCE LOBBY (3 points)

1.6.1. Reduce risk of water ingress at entrances. (Up to 3 points)

Intent

To minimise water ingress at entrances caused by wind driven rains, through optimal design detailing to reduce the frequency of maintenance.

Design strategy and assessment: (2 points)

a. Design canopy/overhang (with minimum 1:50 slope) to shelter against wind-driven rain with canopy angled at maximum 45° to the entrance line and with drop a panel if canopy/overhang does not shelter to entrance line.

Note: The above gradient of 1:50 is indicative. Designers may propose alternative gradients to meet the intent of effective water drainage.

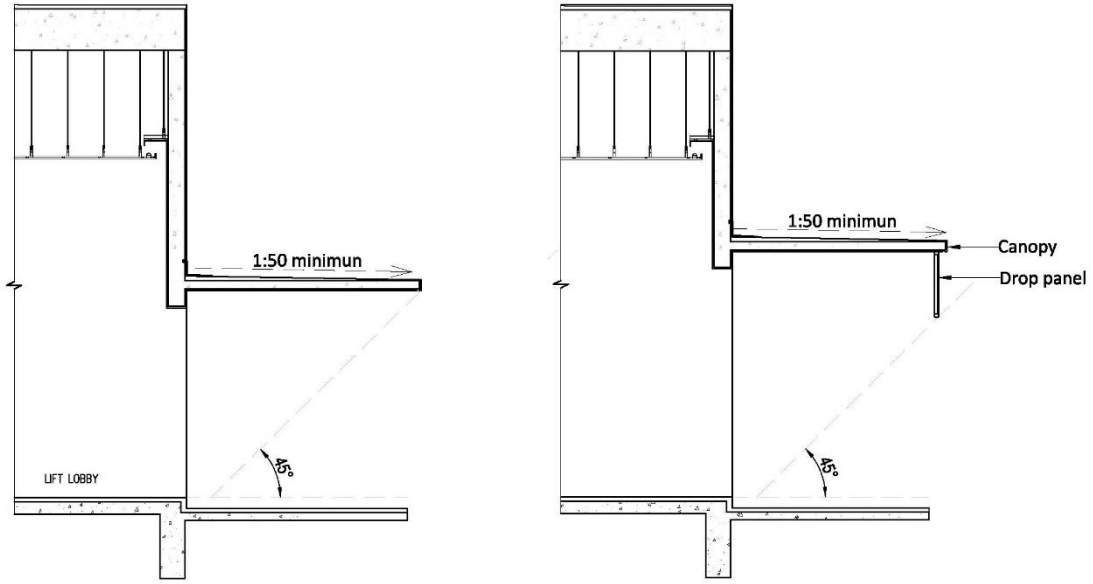


Figure 19: Design of canopy overhang (left), Design of canopy overhang with drop panel (right)

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
1X - 1.1X	65% - 70%	10% - 15%	13 - 14

Baseline design strategy: Poorly designed canopy without brush mats
Proposed design strategy: Canopy (adequately designed to prevent wind driven rain)
Study period: 30 years
Yearly labour savings: 60-70% man-hour.

Advanced efforts: Numerical simulation (wind-driven rain penetration) studies specific to location, context of surroundings of entrances (+1 bonus point)

Documentation requirements

Design stage

- Plan drawings locating the canopy/overhang at proposed building entrances.

- Plan/section/elevation showing canopy/overhang design and slope to fall at proposed entrance locations.
- Simulation studies and reports conducted for design improvement for advanced efforts.

Verification stage

- As-built drawings/shop drawings to show implementation.

Design strategy and assessment: (2 points)

b. Design entrances with transition/buffer zone, e.g. vestibule design
(Solution b & c work as an integrated system and are not mutually exclusive, i.e. both must be scored.)

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
1.3X - 1.4X	40% - 50%	10% - 20%	Up to 25

Baseline design strategy: Poorly designed canopy without brush mats
Proposed design strategy: Entrance with vestibule design
Study period: 30 years
Yearly labour savings: 60-70% man-hour.

Design stage

- Plan drawings locating transition/buffer zone.
- Section/elevation drawings showing transition/buffer zone with drain pans, brush mat gratings, and walk-off mats at proposed building entrances.

Verification stage

- As-built drawings/shop drawings to show implementation.
- Photographs illustrating the buffer zone.

Design strategy and assessment: (1 point)

c. Design for aluminium drain pan with walk-off mat.
(Solution c must be integrated with solution a or b to be eligible for scoring.)

Note:
- *By understanding factors such as traffic type, flow and environment entrance matting specification can be determined.*
- *Length of matting considered should be based on the number of people entering a premises per hour or per day.*

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
5% - 10%	25% - 30%	10% - 20%	3 - 4

Baseline design strategy: Poorly designed canopy without brush mats
Proposed design strategy: Poorly designed canopy with aluminium brush mats
Study period: 30 years
Yearly labour savings: 50-60% man-hour savings

Documentation requirements

Design stage

- Plan drawings locating aluminium drain pans with brush mat gratings and walk-off mats at proposed building entrances.
- Section/elevation drawings showing aluminium drain pans with brush mat gratings and walk-off mats at proposed building entrances.

Verification stage

- Photographs showing aluminium drain pan.

1.7. ROOF (2 Points)

(*For roof waterproofing, points can be scored for either 1.8.2, 1.8.3, or 1.8.4. Points will be prorated for projects having multiple types of roofs system)*

1.7.1. Reduce risk of water ponding on roofs. (up to 1 point)

Intent

To reduce frequency of maintenance and repair of roof due to damage caused by water ponding, through optimal choice of material and detailing.

Design strategy and assessment: (0.5 point)

a. For concrete flat roofs - design slope not gentler than 1:150 and with scupper drains/gutter.

Note:

- *Consider siphonic drainage system for quick and efficient water drainage.*
- *The above gradient of 1:150 is indicative. Designers may propose alternative gradients to meet the intent of effective water drainage.*

Documentation requirements

Design stage

- Plan drawings indicating minimum 1:150 slope with scupper drains/gutter for concrete roofs.

Verification stage

As-built drawings/shop drawings to show implementation.

Design strategy and assessment: (0.5 point)

b. For metal sheet profiles:
Design slope to manufacturer's specification

(OR)
Design slope for different sheet profiles based on the roof pitch table.

(OR)
Design slope for different sheet profiles determined by rainwater drainage capacity calculation.

Note: Minimum pitch has an important influence on the life expectancy of the product.

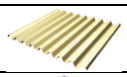
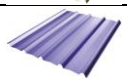
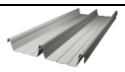
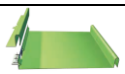
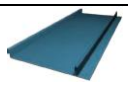
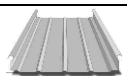
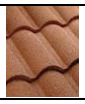
Metal Roofing Profile	Image	Minimum Rib to Rib Distance (mm)	Minimum Rib Height (mm)	Minimum Roof Pitch without end-lap (degree)	Minimum Roof Pitch with end-lap (degree)
Pierce-Fixed Profile		87.5	24	3	5
		190.0	29	3	5
Concealed-Fixed Profile		203.0	41	2	3
		300.0	27	7.5	7.5
		320.0	25	7.5	7.5
		290.0	25	3	5
Standing Seam Profile		315	32	3	5
		415	65	2	3
Shingle Profile		N.A.	N.A.	15	15

Table 8- Roof pitch values

Documentation requirements

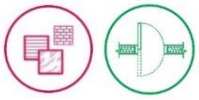
Design stage

- Plan drawing locating metal roofs.
- Tender specification indicating the slope of metal sheet profile based on manufacturer's specification (OR) roof pitch values (OR) determined by rainwater drainage capacity calculation.
- Plan/section drawings indicating the slope.

Verification stage

- As-built drawings/shop drawings to show implementation.

1.7.2. Reduce risk of waterproofing failure/decay on concrete roofs. (0.5point)



Intent

To reduce the frequency of maintenance and repair of concrete roofs through optimal choice of materials and design detailing.

Design strategy and assessment: (0.5 point)

a. **Specify bitumen/polymer elastomer preformed waterproofing membrane *(design for overlap and proper termination of waterproofing membrane)***

   (OR)

   Specify water-based/solvent-based liquid applied waterproofing membrane.

   Note: Choice of preformed waterproofing membrane or liquid applied waterproofing membrane can be based on complexity of roof profile and ease of application.

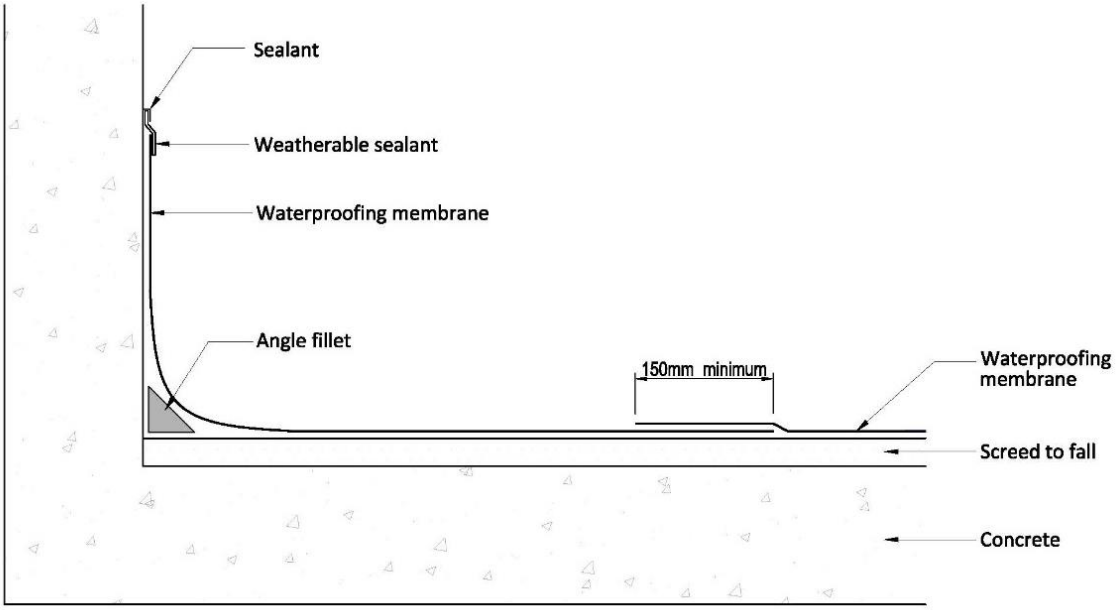


Figure 20: waterproofing termination and overlapping detail

Documentation requirements

Design stage

- Plan drawing locating concrete roofs with waterproofing membrane.
- Tender specification indicating bitumen/polymer elastomer preformed waterproofing membrane (OR) water based/solvent based liquid applied waterproofing membrane.
- Detail drawings illustrating overlap and termination of waterproofing details (if using waterproofing membrane).

Verification stage

- Delivery orders of product.
- Photographs showing implementation.

1.7.3. Reduce risk of corrosion on metal roofs (0.5 point)

Intent

To reduce the frequency of maintenance and repair of metal roof structures by improving its durability through optimal choice of materials.

Design strategy and assessment: (0.5 point)

a. **Specify metal of similar properties or separators between different materials to mitigate risk of bi-metallic corrosion between roof and other metal components or accessories.**

Note: Refer to the table below for compatibility of metal with other metal accessory and materials.

Material	Accessory or Fastener Material					
	Zn-coated steel & zinc	Stainless Steel (300series)	AM-coated steel	Aluminium	Copper, Brass, Lead & Monel	Carbon Black ^
steel†	Yes*	No	Yes	Yes	No	No
Stainless steel	No	Yes	No	No	No	No
AM-coated steel	Yes*	No	Yes	Yes	No	No
Zn-coated steel & zinc	Yes	No	Yes*	Yes*	No	No

* Inert catchment (occurs where rainwater or condensation falls on materials that do not affect its corrosive properties in any way) situation may apply
† Includes all prepainted products on an aluminium/zinc/magnesium alloy-coated steel or zinc-coated steel base
AM-coated steel = aluminium / zinc / magnesium alloy-coated steel
Zn-coated steel = zinc-coated steel
^ As found in some washers, roof penetration flashings and black "lead" pencils etc.

Table 9 - Compatibility of direct contact between metals or alloys

Note: Careful prevention of swarf (steel debris arising from cutting or piercing operations when using friction saws, abrasive discs, drills, etc) staining (elaborate) is necessary during installation. Swarf particles, if left on the surface, will corrode and cause rust stains which will detract from the finished appearance of the product.

Documentation requirements

Design stage

- Tender specification indicating use of metal components with similar properties on the roof system based on manufacturer's recommendation or based on compatibility of direct contact of metal and alloys.

Verification stage

- Product specification showing the properties of the metal components or accessories of the metal roof system.
- Delivery orders of product.

SECTION 2 – ARCHITECTURAL INTERIOR

2.1 FLOORS (2.5 points)

2.1.1 Reduce risk of damage to floors in common areas within the building (1.5 points)

Intent

To reduce the frequency of repair and replacement to floorings due to wear and tear, though optimal selection of materials.

Design strategy and assessment: (1.5 points)

a. Specify flooring materials with minimum Mohs[17] hardness value of 7, in areas of high pedestrian traffic such as main entrances, lobbies, corridors and connecting walkways.

Note: Mohs scale represents the mineral hardness of a material surface. The tile's surface resistance to wear and tear helps in reduced repair and replacement. The selected tile should comply with ASTM C1895 for Mohs hardness value.

-Spaces with specific acoustic requirements maybe exempted despite being under the influence of the developer (ie. Auditorium, classrooms, cinemas etc.)Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental Cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
5% - 10%	75% - 80%	10% - 15%	3 - 4

Baseline design strategy: Ceramic tiles
Proposed design strategy: Full body porcelain tiles with Mohs value of minimum 7
Study period: 10 Years
Yearly labour savings: 70 - 80% man-hour savings.

Documentation requirements

Design stage

- Tender specification indicating the type of flooring material and the minimum Mohs hardness value.
- Plan drawing showing the location and extent of application of the specified floor finish.

Verification stage

- As-built (interior) drawings to show the extent of implementation.
- Relevant technical material specification or product performance test results indicating the specified Mohs hardness value.
- Delivery order for the specified product.

[17] BCA – Good Industry Practices - Tiles with hardness value of 7 or higher are normally acceptable for most commercial applications or heavy traffic areas.

Worked Example 2a:

Hotel Hibiscus is an 18-storey 3-star hotel with 600 guest rooms, built 10 years ago. It has a main reception lobby to welcome guests, 3 ballrooms and a few large meeting rooms and executive lounges that are available for corporate and public booking.

The hotel is undergoing upgrading with partial A&A works in the common areas by replacing the carpets in the entrance lobby and lift lobbies into fully homogenous tiles. The flooring currently has a total area of 4,000m^2, comprising:

- 400m^2 of entrance lobby
- 2,500m^2 ballrooms
- 150m^2 of lift lobbies
- 450m^2 of common corridors
- 500m^2 meeting rooms and executive lounges

The breakdown of the newly renovated hotel is shown in Area Table II below:

NOTE: *Though meetings rooms & executive lounges and common corridors would fall under the influence of the developer, the use of carpets in these areas are necessary for its acoustic property in this context. As such, it is not considered for assessment.*

	Carpet (m^2)	Homo. Tiles (m^2)	Total (m^2)
Entrance Lobby	0	400	400
Ballrooms	2500	0	NA
Lift lobbies	0	150	150
Common Corridors	450	0	NA
Meeting Rooms & Exec. Lounges	500	0	NA
TOTAL (AREA FOR ASSESSMENT)			550

Area Table II : Breakdown of Flooring System

Hotel Hibiscus is an existing building with alteration works done, as such it will be required to submit documents at both stages in design and verification.

Documentation requirements*:*

APPLICABILITY	NIL	Homogenous tiles at i) entrance lobby, ii) lift lobbies
STATUS	Existing	Upgrading
DESIGN STAGE ASSESSMENT	N.A.	2.1.1a. Specify flooring materials with minimum Mohs hardness value of 7, at areas of high pedestrian traffic such as main entrances, lobbies, corridors and connecting walkways. • Tender specification of homogenous tiles with minimum Mohs hardness value • Plan drawing highlighting extent and area of homogenous tiles used
VERIFICATION STAGE ASSESSMENT	N.A.	2.1.1a. Specify flooring materials with minimum Mohs hardness value of 7, at areas of high pedestrian traffic such as main entrances, lobbies, corridors and connecting walkways. • As built (interior) drawings highlighting extent and area use of homogenous tiles • Technical material specification showing homogenous tiles' performance results for Mohs hardness value • Delivery order for the homogenous tiles used in the project

- Total applicable floor area for assessment
  = 550m^2

- Proportion of homogenous tiles to floor area
  = 550m^2 / 550m^2 = 100% (≥15%)

2.1.1 Reduce risk of damage to floors in areas of high pedestrian traffic

2.1.1 Reduce risk of damage to floors in areas of high pedestrian traffic (1.5 points)	Points	Assessment Category	**Used in Project**	**Points Scored**
a. Specify flooring materials with minimum Mohs hardness value of 7, at areas of high pedestrian traffic such as main entrances, lobbies, corridors and connecting walkways.	1.5	Cat 2	√	100% * 1.5 = 1.5

**carpet does not meet the criteria of Mohs hardness value and hence does not score under this*

2.1.2 Reduce maintenance works for floors in common areas within the building (1 point)

Intent

To reduce the frequency of maintenance of floorings due to stains through optimal selection of materials.

Design strategy and assessment: (1 point)

a. Specify flooring material – e.g. homogenous tiles[18] – with water absorption rate not exceeding 0.5 % to reduce settling of stains[19] in areas of high pedestrian traffic such as entrances, lobbies, corridors and connecting walkways

Note: Water absorption rate indicates how much moisture a specific material is likely to absorb. Tiles with lower water absorption rate absorbs lesser stains and makes it easier for maintenance. The selected tile should comply with ASTM C373 for the water absorption test.

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental Cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
10% - 15%	15% - 20%	15% - 20%	5 - 6

Baseline design strategy: Carpet
Proposed design strategy: Vinyl Floor
Study period: 10 Years
Yearly labour savings: 20 - 30% man-hour savings.

Documentation requirements

Design stage

- Tender specification indicating the flooring materials with maximum water absorption rate.
- Plan drawing showing the location and extent of the application.

[18] BCA – Good Industry Practices - Homogeneous tile is a form of ceramic tile composed of fine porcelain clays but fired at much higher temperatures than ceramic tile. This process makes homogeneous tiles denser, harder, less porous and therefore less prone to moisture and stain absorption than ceramic tiles.
[19] BCA – Good Industry Practices - Impervious tiles – Absorbs water between 0 and 0.5% –Suitable for both indoor and exterior use.

Verification stage

- As-built (interior) drawings to show the extent of implementation.
- Relevant technical material specifications or product performance test results indicating the water absorption value of not more than 0.5%.
- Delivery order for the specified product.

Worked Example 2b:

Hotel Hibiscus' spaces that have been designed with homogenous floor tiles can also score for 2.1.2.

Hotel Hibiscus is an existing building with alteration works done, as such it will be required to submit documents at both stages in design and verification.

Documentation requirements*:*

APPLICABILITY	NIL	Homogenous tiles at i) entrance lobby, ii) lift lobbies
STATUS	Existing	Upgrading
DESIGN STAGE ASSESSMENT	N.A.	2.1.2a. Specify flooring material – e.g. homogenous tiles – with water absorption rate note exceeding 0.5% to reduce settling of stains • Tender specification of homogenous tiles with maximum water absorption rate • Plan drawing highlighting location and extent of homogenous tiles used
VERIFICATION STAGE ASSESSMENT	N.A.	2.1.2a. Specify flooring material – e.g. homogenous tiles – with water absorption rate note exceeding 0.5% to reduce settling of stains • As built drawings highlighting location and extent of homogenous tiles used • Technical material specification showing homogenous tiles' performance results indicating water absorption value of not more than 0.5% • Delivery order for the homogenous tiles used in the project

**The carpet does not meet any solution in 2.1 Floors, hence there will be no documentation requirement*

2.1.2 Reduce maintenance works for floors in common areas within the building

2.1.2 Reduce maintenance works for floors in areas of high pedestrian traffic (1 point)	Points	Assessment Category	**Used in Project**	**Points Scored**
a. Specify flooring material – e.g. homogenous tiles – with water absorption rate not exceeding 0.5 % to reduce settling of stains at areas of high pedestrian traffic such as entrances, corridors and lift lobbies.	1	Cat 2	√	18% * 1 = 0.18

** carpet does not meet the criteria of water absorption rate, hence does not score under this.*

The total points for ***2.1 Floors*** (2.1.1 + 2.1.2) = 0.27 + 0.18 = 0.45 points

2.2 CEILINGS (5.5 points)

2.2.1 Access to services within double slab areas for maintenance purposes (up to 2 points)

Intent

To ensure ease of access within double slabs for safe, efficient maintenance of services and equipment therein.

Design strategy and assessment: (1 point)

a. Provide double slabs with minimum clear headroom of 1.8 m.

Note:

- *Avoid using the area as storage which becomes obstacles for maintenance workers.*
- *Adequate lighting should be provided within double slab*
- *Consider adequate fall and drainage to avoid risk of water ponding from possible leakages.*

Documentation requirements

Design stage

- Tender drawings (plan and section) highlighting the clear headroom space of 1.8m for areas with double slab.

Verification stage

- As-built drawings to show the double slab and the clear headroom space.

Design strategy and assessment: (2 points)

b. Provide double slabs with minimum clear headroom of 2 m.

Note:

- *Avoid using the area as storage which becomes obstacles for maintenance workers.*
- *Adequate lighting should be provided within double slab*
- *Consider adequate fall and drainage to avoid risk of water ponding from possible leakages.*

Documentation requirements

Design stage

- Tender drawings (plan and section) highlighting the clear headroom space for areas of double slab.

Verification stage

- As-built drawings to show the double slab and the clear headroom space.

2.2.2 Access to services within the ceiling in non-tenanted indoor spaces (up to 1 point)

Intent

To ensure ease of access within the ceiling for efficient maintenance of services and equipment therein.

Design strategy and assessment: (1 point)

a. Specify open ceiling design.

Documentation requirements

Design stage

- Tender specification indicating the open ceiling plan for the selected areas.
- Reflected ceiling plans showing the extent of open ceiling plan layout.

Verification stage

- As-built (interior) drawings to show implementation.
- Photographs of completed works highlighting the open ceiling.

Design strategy and assessment: (0.5 point)

b. Specify suspended modular ceiling system that is easily demountable.

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental Cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
10% - 15%	95% - 100%	Up to 5%	9 - 10

Baseline design strategy: Monolithic plaster ceiling
Proposed design strategy: Suspended mineral fibre grid ceiling
Study period: 10 Years
Yearly labour savings: 90 - 100% man-hour savings.

Documentation requirements

Design stage

- Tender specification indicating type of false ceiling panel.
- Reflected ceiling plans showing the extent of the false ceiling and typical sectional drawing highlighting the demountable fixture details.

Verification stage

- As-built (interior) drawings to show implementation.
- Photographs of completed works showing the modular ceiling panel.

Worked Example 4a:

Rosebay Towers is a building of 20 years. It is a 15-storey office building with a GFA of 25,000 m^2 with multi-tenanted office spaces, a main reception, and a drop-off porch for guests. It also has several accompanying facilities such as meeting rooms, a F&B area as well as sky terraces on the 4th, 8th and 14th storey.

Most of the office spaces in Rosebay Towers are tenanted except for the top 2 floors, the 14th and 15th storey, which are owned by the developer. The building will be undergoing upgrading works and the developer has decided to replace all the existing suspended modular ceiling panels to new ones with improved acoustic properties. The monolithic ceiling in lift lobbies & corridors will also be changed to suspended modular ceiling. The design of the common areas and top 2 floors of interior ceiling has:

- A total ceiling area of 3,000m^2
- 3,000 m^2 of office spaces in a mix of suspended modular ceiling and open ceiling
- 200 m^2 of meeting room in suspended modular ceiling
- 300m^2 of main reception in monolithic ceiling
- 500m^2 of common lift lobbies & corridors in monolithic ceiling

The breakdown of which is shown in Area Table III below:

NOTE: *The spaces below are within the scope of common areas as they fall under the influence of the developer.*

	Monolithic Ceiling (m^2)	Suspended Modular Ceiling (m^2)	Open Ceiling (m^2)	Total (m^2)
Office Spaces (Developer-owned)	0	1000	2000	3000
Meeting rooms (Developer-owned)	0	200	0	200
Main Reception	300	0	0	300
Lift Lobbies & Corridors	0	500	0	500
TOTAL	300	1700	2000	4000

Area Table III : Breakdown of Ceiling Systems in indoor spaces

Rosebay Towers is an existing building with alteration works done, as such it will be required to submit documents at both stages of design and verification.

Documentation requirements*:*

APPLICABILITY	Open ceiling office spaces Monolithic ceiling* at main reception	Suspended modular ceiling system at i) office spaces, ii) meeting rooms, iii) lift lobbies & corridors
STATUS	Existing	Upgrading
DESIGN STAGE ASSESSMENT	N.A.	2.2.2b. Specify suspended modular ceiling system that is easily demountable. • Tender specification indicating type of false ceiling panel • Reflected ceiling plan showing the extent of the false ceiling and typical sectional drawing highlighting the demountable fixture details.
VERIFICATION STAGE ASSESSMENT	2.3.1a. Specify open ceiling design • As-built (interior) drawings to show implementation. • Photographs of completed works highlighting the open ceiling.	2.2.2b. Specify suspended modular ceiling system that is easily demountable. • As built interior drawings showing implementation • Photographs of completed works showing the suspended modular ceiling panel

**Monolithic ceiling at the i) main reception, ii) lift lobbies & corridors does not meet the criteria.*

- Total interior ceiling area for common areas
  = 3,000m^2 + 200m^2 + 300m^2 + 500m^2 = 4,000m^2
- Proportion of open ceiling
  = 2,000m^2 / 4,000m^2 = 50% (≥15%)
- Proportion of suspended modular ceiling
  = 1,200m^2 / 4,000m^2 = 30% (≥15%)

2.2.1 Access to services within the ceiling in indoor spaces

2.2.1 Access to services within the ceiling in non-tenanted indoor spaces (up to 1 point)	Points	Assessment Category	**Used in Project**	**Points Scored**
a. Specify open ceiling design	1	Cat 2	√	50% * 1 = 0.50
b. Specify suspended modular ceiling system that is easily demountable.	0.5	Cat 2	√	30% * 0.5 = 0.15
		Score for 2.3.2		0.5 + 0.15 = 0.65

**Monolithic ceiling does not meet the criteria and not able to achieve points.*

2.2.3 Access to ceiling for maintenance (1 point)

Intent

To ensure ease of access to ceiling for safe and efficient maintenance.

Design strategy and assessment: (1 point)

a. **Provide access to all parts of ceilings** *(including weather-exposed ceilings)* or exposed soffit (where there are no ceilings) **for general maintenance.**

Note:

- *Avoid use of scaffolding as an access strategy.*
- *Ceilings using mobile elevated working platform (MEWP), must ensure obstruction-free access to all parts of the ceiling.*
- *Areas with permanent tiered seatings may be excluded for assessment (eg. auditoriums, concert halls.)*
- *Access to Lightings and smoke detectors will be assessed here.*

Documentation requirements

Design stage

- Schematic drawings (plan/elevation/section) demonstrating entire false ceiling system is 100% accessible through one or combination of access systems.

Verification stage

- Extract from maintenance strategy report indicating the provision of access.

2.2.4 Reduce risk of warping / deterioration of ceiling panel systems that are weather-exposed, e.g. sky terraces, entry porches, corridors, and canopies (up to 1 point)

Intent

To reduce frequency of repair and replacement of weather-exposed ceiling panels through optimal selection of materials.

Design strategy and assessment: (1 point)

a. Specify suspended metal panel modular ceiling system, e.g. baffle metal panels and metal mesh panels.

Note:

- *Panels should be designed to prevent sagging and withstand wind loads.*
- *Panels should be sized such that they can be easily handled by one person.*

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental Cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
40% - 45%	75% - 80%	Up to 5%	8 - 9

Baseline design strategy: moisture-resistant monolithic plaster ceiling *(Calcium Silicate)*
Proposed design strategy: Metal Panel Modular Suspended Grid ceiling
Study period: 10 Years
Yearly labour savings: 90 - 100% man-hour savings.

Documentation requirements

Design stage

- Tender specification indicating the type of metal suspended modular ceiling panel.
- Reflected ceiling plans showing the extent of metal false ceiling plan layout.

Verification stage

- As-built (interior) drawings showing the extent of implementation.
- Relevant technical material specification for the selected metal panel ceiling and the anticorrosion property of the material.
- Delivery order for the selected ceiling panels.
- Photographs of completed works.

Design strategy and assessment: (1 point)

b. Specify moisture-resistant suspended non-metallic modular ceiling panels with water absorption rate not exceeding 5 %.

Note: Water absorption rate indicates how much moisture a specific material is likely to absorb. Ceiling panels with lower water absorption rate absorbs less moisture and are less prone to deterioration. The selected ceiling panel should comply with ASTM C473 for the water absorption test.

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental Cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
15% - 20%	55% - 60%	10% - 15%	4 - 5

Baseline design strategy: Moisture Resistant monolithic plaster ceiling (gypsum board)
Proposed design strategy: Moisture resistant suspended grid ceiling (calcium silicate)
Study period: 10 Years
Yearly labour savings: 90% - 100% man-hour savings

Documentation requirements

Design stage

- Tender specification indicating the moisture resistant material and maximum water absorption rate for suspended ceiling panel.
- Reflected ceiling plans showing the extent of the moisture-resistant false ceiling.

Verification stage

- As-built (interior) drawings to show the extent of implementation.
- Relevant technical material specification or product performance test results for the moisture resistant property of the ceiling panel for the water absorption rate.
- Photographs of completed works.

Design strategy and assessment: (1 point)

c. Specify for open ceiling design.

Documentation requirements

Design stage

- Tender specification indicating the open ceiling system for the selected areas.
- Reflected ceiling plans showing the extent of open ceiling plan layout.

Verification stage

- As-built (interior) drawings to show implementation.
- Photographs of completed works showing the open ceiling spaces.

Worked Example 4b:

Rosebay Towers has a link bridge that connects the 2 blocks of the office units. The office building has 500m^2 of ceiling area that are weather exposed and are managed by the owner. The sky terraces of the office units had been designed with monolithic ceiling. With the recent upgrading works in the building, the modular metal panels in the drop-off porch are also replaced. The newly designed ceiling areas comprise of:

- 360m^2 of sky terraces designed with open ceiling, located on the 4th, 8th and 14th storey
- 80 m^2 of drop-off porch in modular metal panels
- 60m^2 of link bridge in open ceiling

The breakdown is shown in Area Table IVArea Table III below:

	Modular Metal Panel (m^2)	Open Ceiling (m^2)	Total (m^2)
Sky Terraces	0	360	360
Drop-off porch	80	0	80
Link Bridge	0	60	60
TOTAL	80	420	500

Area Table IV : Breakdown of Ceiling Systems in weather exposed spaces

Rosebay Towers is an existing building with alteration works done, as such it will be required to submit documents at both stages of design and verification.

Documentation requirements*:*

APPLICABILITY	Open ceiling at: i) sky terraces, ii) link bridge	Suspended modular metal panel at: i) drop-off porch
STATUS	Existing	Upgrading
DESIGN STAGE ASSESSMENT	N.A.	2.2.4a Specify suspended metal panel modular ceiling system, e.g. baffle metal panels and metal mesh panels. • Tender specification indicating the type of metal suspended modular ceiling panel. • Reflected ceiling plans showing the extent of metal false ceiling.
VERIFICATION STAGE ASSESSMENT	2.3.3c. Specify for open ceiling design. • As-built (interior) drawings to show implementation. • Photographs of completed works showing the open ceiling spaces.	2.2.4a. Specify suspended metal panel modular ceiling system, e.g. baffle metal panels and metal mesh panels. • As-built (interior) drawings showing the extent of implementation. • Relevant technical material specification for the selected metal panel ceiling and the anti-corrosion property of the material. • Delivery order for the selected ceiling panels. • Photographs of completed works.

- Proportion of modular metal panel
  = 80m^2 / 500m^2 = 16% (≥15%)

- Proportion of open ceiling
  = 420m^2 / 500m^2 = 84% (≥15%)

2.2.4 Reduce risk of warping / deterioration of ceiling panel systems that are weather-exposed

2.2.4 Reduce risk of warping/deterioration of ceiling panel system that are weather-exposed, e.g. sky terraces, entry porches, corridors and canopies. (up to 1 point)	Points	Assessment Category	**Used in Project**	**Points Scored**
a. Specify suspended metal panel modular ceiling system, e.g. baffle metal panels and metal mesh panels.	1	Cat 2	√	16% * 1 = 0.16
b. Specify moisture-resistant suspended non-metallic modular ceiling panels with water absorption rate not exceeding 5 %.	1	Cat 2	×	0
c. Specify open ceiling design.	1	Cat 2	√	84% * 1 = 0.84
Score for 2.3.4 ceiling panel systems				0.16 + 0.84 = 1

As such, the total score for ***2.3 Ceilings*** (2.3.1 + 2.3.3) = 0.65 + 1 = 1.65 points

2.3 WET ROOMS AND STORAGE (8 points)

2.3.1 Provide permanent space to store cleaning tools and toilet supplies (up to 1 point)

Intent

To improve maintenance efficiency through provision of storage by adopting appropriate design & detailing.

Design strategy and assessment: (1 point)

a. **Design for storage rooms for cleaning tools, carts, and supplies such as tissue rolls and soap refill for every male and female toilet cluster.**

Documentation requirements

Design stage

- Tender drawings (plan and elevation) showing the location of storage rooms for every male and female toilet clusters.

Verification stage

- As-built (interior) drawings to show implementation.
- Photographs showing the dedicated rooms for storage.

Design strategy and assessment: (0.5 point)

b. **Design for at least one storage space within the male or female toilet clusters to store supplies such as tissue rolls and soap refill.** (*Point cannot be scored if already scored for solution a)*

Documentation requirements

Design stage

- Tender drawings (plan) showing the location of storage space within every male and female toilet clusters for store supplies.

Verification stage

- As-built (interior) drawings to show implementation.
- Photographs of completed works showing the dedicated storage space.

2.3.2 Reduce risk of mould and fungus formation on walls in wet rooms (up to 1 point)

Intent

To reduce the frequency of repair and replacement of wall surfaces due to mould and algae formation, through optimal selection of materials.

Design strategy and assessment: (1 point)

a. Specify wall finishes with tiles e.g. glazed ceramic tiles and homogenous tiles.[20] [21] .

Note: Water absorption measures how much moisture a specific material is likely to absorb. Wall finishes with low water absorption rate helps in reducing the formation of mould and fungus and reduce repair and replacement. The selected tile should comply with ASTM C373 for the water absorption test.

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental Cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
2.1X - 2.2X	95% - 100%	15 – 20%	6 - 7

Baseline design strategy: Standard paint with primer
Proposed design strategy: Tiled wall cladding
Study period: 10 Years
Yearly labour savings: 80 - 90% man-hour savings.

Documentation requirements

[20] Guide to Better Public Toilet Design and Maintenance, 1.3. Wall and floor tiles of large surface areas are encouraged for easy maintenance. The tile size should be at least 100mm by 200mm. Part III Maintenance Strategy Report, F2.1, "Use moisture impervious, durable and cleanable materials for toilet floor and wall surfaces, to facilitate cleaning and resource conservation.

[21] BCA – Good Industry Practices - Impervious tiles – Absorbs water between 0 and 0.5% of its weight.

Design stage

- Tender specification indicating tile
- Plan and section drawings showing the extent of wall finish.

Verification stage

- As-built (interior) drawings to show extent of implementation.
- Relevant technical material specification or product performance test results for the water absorption rate for the selected material.

Design strategy and assessment: (0.5 point)

b. Specify wall finishes with anti-mould top coat.

Note: The surface preparation for the top coat must follow the method statement mentioned inSS542.

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental Cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
Up to 5%	55% - 60%	40% - 40%	1 - 2

Baseline design strategy: Standard paint with primer
Proposed design strategy: Anti-mould paint
Study period: 10 Years
Yearly labour savings: 20 - 30% man-hour savings.

Documentation requirements

Design stage

- Tender specification indicating anti-mould paint finish as top coat.
- Plan and typical sectional drawings showing the extent of application.

Verification stage

- As-built (interior) drawings to show extent of implementation.
- Relevant technical material specification on anti-mould property of the selected paint finish.
- Delivery order for the specified paint finish.

Worked Example 5:

A 7-storey primary school has staff and student toilets with a wall height of 2.5m, measured from the finished floor level to the false ceiling, and is coated in typical plaster and paint. However, upgrading works are planned after 10 years to renovate 5 out of the 7 total clusters of toilets on the school. In all these 5 clusters, the walls will be undergoing upgrade with wall tiles up to 2.0 m above floor level while the remaining wall area is coated with plaster and paint with anti-mould properties.

The primary school wall area is designed with:

- A total wall area of 1,100m^2
- 300 m^2 of male and female staff, student toilets (2 clusters, at level 6,7)
- 750 m^2 of male and female staff, student toilets (5 clusters at level 1-5)
- 50m^2 of accessible toilet

The breakdown of all the toilets are shown in Area Table IVArea Table III below:

	Typical plaster and paint (m^2)	Plaster and paint with anti-mould (m^2)	Wall tiles (m^2)	Total (m^2)
Lvl 6,7 Male and female staff, student toilets (2 clusters, existing)	300	0	0	300
Lvl 1-5 Male and female staff, student toilets (5 clusters, upgraded)	0	150	600	750
Lvl 1-7 Accessible toilet	50	0	0	50
TOTAL	350	150	600	1100

Area Table V : Breakdown of Ceiling Systems in weather exposed spaces

The primary school is an existing building with alteration works done, as such it will be required to submit documents at both stages of design and verification.

Documentation requirements*:*

APPLICABILITY	Typical plaster and paint at i) lvl 6,7 male and female student toilets, ii) lvl 1-7 accessible toilet	Wall tiles at i) lvl 1-5 male and female student toilets, Plaster and paint with anti mould at i) lvl 1-5 male and female student toilets
STATUS	Existing	Upgrading
DESIGN STAGE ASSESSMENT	N.A.	2.3.2a. Specify wall finishes with tiles e.g. glazed ceramic tiles and homogenous tiles. • Tender specification indicating the type of tile material used • Plan and section drawings showing the extent of wall finish. 2.3.2b. For painted surfaces specify for anti-mould top coat • Tender specification indicating anti-mould paint finish as top coat. • Plan and typical sectional drawings showing the extent of application.
VERIFICATION STAGE ASSESSMENT	N.A. (*Typical plaster and paint do not meet the solution 2.4.2(a), there will be no documentation requirement)*	2.3.2a. Specify wall with tiles e.g. glazed ceramic tiles and homogenous tiles. • As-built (interior) drawings to show extent of implementation. • Photographs of completed works
	2.3.2b. For painted surfaces specify for anti-mould topcoat. 0. As-built (interior) drawings to show extent of implementation. • Relevant technical material specification on anti-mould property of the selected paint finish. • Delivery order for the specified paint finish (only for upgrading).	

NOTE: *The total wall area of 1,100m² are assessed. As only wall tiles, plaster and paint with anti-mould properties meet the criteria below, the upgraded toilet clusters at lvl 1-5 can score, while the remaining toilets including the accessible toilet is unable to score.*

- Proportion of wall tiles
  = 600m²/1,100m² = 56% (≥15%)

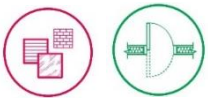
- Proportion of plaster and paint with anti-mould
  = 150m² / 1,100m² = 14% (≤15%)
-

2.3.2 Reduce risk of mould and fungus formation on walls in wet rooms

2.3.2. Reduce risk of mould and fungus formation on walls in wet rooms (up to 1 point)	Points	Assessment Category	**Used in Project**	**Points Scored**
a. Specify wall with tiles e.g. glazed ceramic tiles and homogenous tiles.	1	Cat 2	√	56% * 1 = 0.56
b. Specify wall finishes with anti-mould top-coat	0.5	Cat 2	√ (≤15%)	0
Score for 2.4.3 walls in wet rooms				0.56

The total sub-points for *2.4.3 under Wet Rooms & Storage* is = 0.56 point

2.3.3 Reduce risk of damage to toilet cubicle partitions and enable ease of cleaning (1 point)



Intent

To reduce the frequency of repair and replacement of toilet partitions due to damage, through optimal selection of materials and design & detailing.

Design strategy and assessment: (0.5 point)

a. Specify water-resistant, partition panels with water absorption rate not exceeding 5%, e.g. phenolic panels.[22]

[22] Guide to Better Public Toilet Design and Maintenance, 1.3 Materials, "Materials used should be durable, easy to maintain and resistant to vandalism and neglect. For all wall finishes, it must be of materials which are impervious, durable such as ceramic tiles and phenolic panels etc which can facilitate cleaning and resource conservation (such as minimising the use of water and cleaning agents). This also applies to floors, which must be constructed of waterproof non-slip surfaces like ceramic tiles, natural stone, homogeneous tiles, terrazzo or other impervious materials, to facilitate cleaning and resource conservation."

Documentation requirements

Design stage

- Tender specification indicating the maximum water absorption rate of the material.
- Plan and sectional drawings showing the location of application.

Verification stage

- As-built (interior) drawings to show implementation.
- Relevant technical material specification or product performance test results for the rate of water absorption for the selected product.

Design strategy and assessment: (0.5 point)

b. Design for raised partition walls with minimum of 50 mm gap[23] from the finished floor level.

Documentation requirements

Design stage

- Tender drawings (plan and section) indicating the raised partition walls with at least 50 mm gap from the finished floor level.

Verification stage

- As-built (interior) drawings to show implementation.
- Photographs highlighting the implemented raised partition panels.

2.3.4 Reduce risk of water spill, and splashing and soap dripping on the counter and floor (up to 3.5 points)

Intent

To reduce the frequency of maintenance due to wet floors and counters, through appropriate design & detailing.

Design strategy and assessment: (1.5 points)

a. Water spill on floor - Design for full vanity washbasin to slope away from the user[24].

Documentation requirements

Design stage

- Tender specification indicating vanity wash basin.
- Plan, elevation, and sectional drawings showing full vanity washbasin set that meets the requirements.

[23] Guide to Better Public Toilet Design and Maintenance, 1.5 Water Closets (WCs), "Cubicle partitions must be of rigid design and wall or ceiling hung, where practical, without leg support for easy cleaning of the floor."

[24] Guide to Better Public Toilet Design and Maintenance, 1.6 Wash Basins, "All wash basins should be installed into vanity tops, and located beneath the vanity. Vanity tops should have backsplash and apron edges"

Verification stage

- As-built (interior) drawings to show the implementation.
- Photographs of completed works.

Design strategy and assessment: (0.5 point)

b. Water spill on floor – Design for soap and tissue dispenser within arm's reach of each faucet[25].
(Points can be scored only after scoring solution (a))

Documentation requirements

Design stage

- Tender drawings (plan and typical sections) indicating the location of soap and tissue dispenser.

Verification stage

- As-built (interior) drawings to show implementation.
- Photographs of completed works.

Design strategy and assessment: (1 point)

c. Soap dripping on counter/floor – Design of soap dispenser location to be vertically mounted directly above basin or integrated bin.

Note: Soap dispensers fixed above the counter are easier to identify and refill.

[25] Guide to Better Public Toilet Design and Maintenance, 1.7 Provision of Facilities, "A one-stop provision of auto sensor tap, auto sensor soap dispenser, litter bin and hand-dryer or paper towel dispenser at wash basin area is strongly recommended to minimise wetting of floors and provide the ease of keeping the toilet clean and dry."

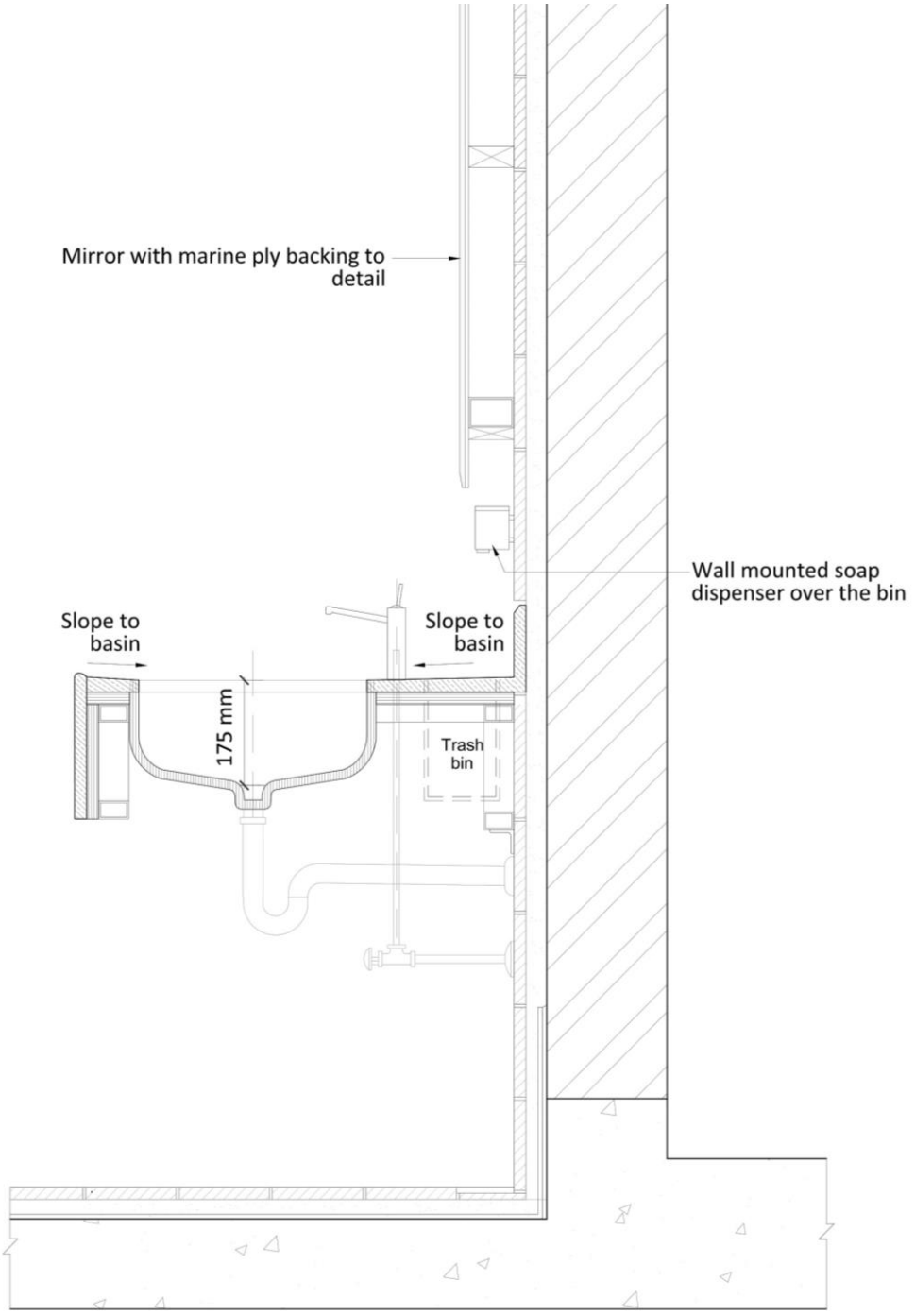


Figure 21 - Schematic sectional drawing with vanity basin

Documentation requirements

Design stage

- Tender drawings (plan, elevation, and typical sections) showing soap dispenser vertically mounted above the bin or basin.

Verification stage

- As-built (interior) drawings to show implementation.
- Photographs of completed works.

Design strategy and assessment: (0.5 point)

d. Water splash on counter/floor - Specify depth of basins to be minimally 175 mm to avoid excessive splashing.

Note: The use of flat bottom wash basins is not recommended[26].

Documentation requirements

Design stage

- Tender drawings (plan and typical section) indicating the wash basin counter design with the depth of the basin.

Verification stage

- As-built (interior) drawings to show implementation.
- Relevant technical specification showing the depth of the basin.

2.3.5 Reduce the need to replace entire mirror glass pane when damaged (0.5 point)

Intent

To ensure ease of replacement of damaged mirror glass panes, through appropriate design & detailing.

Design strategy and assessment: (0.5 point)

a. Design for individual, modular mirror panes with standard sizes that are easy to replace.

Documentation requirements

Design stage

- Tender drawings (elevation) showing individual, modular mirror panes.

Verification stage

- As-built (interior) drawings to show implementation.
- Photographs showing the mirrors in the toilet.

[26] Guide to better Public Toilet Design and Maintenance – Restroom Association (Singapore) 2018 - Section 1.6 Wash Basins and Shower taps. "The use of flat bottom wash basins is not recommended. Such wash basins do not effectively allow dirt and debris to be washed into the drain pipes."

2.3.6 Reduce degradation of false ceiling system in wet rooms (up to 1 point)

Intent

To reduce the frequency of repair and replacement of moisture-exposed ceiling panels through optimal selection of materials.

Design strategy and assessment: (1 point)

a. **Specify moisture-resistant, suspended non-metallic modular ceiling panels with water absorption rate not exceeding 5%.**

Note: Ceiling panels with lower water absorption rate absorbs less moisture and reduces deterioration. The selected ceiling panel should comply with ASTM C473 for the water absorption test.

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental Cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
15% - 20%	85% - 90%	5% - 10%	5 - 6

Baseline design strategy: Moisture resistant monolithic plaster ceiling
Proposed design strategy: moisture resistant suspended modular ceiling (Calcium Silicate)
Study period: 10 Years
Yearly labour savings: 90 - 100% man-hour savings.

Documentation requirements

Design stage

- Tender specification indicating the moisture resistant material and maximum water absorption rate for suspended ceiling panel.
- Reflected ceiling plan showing the extent of the moisture-resistant false ceiling plan layout.

Verification stage

- As-built (interior) drawings to show extent of implementation.
- Relevant technical material specification or product performance test results for the moisture resistance property of the ceiling panel with water absorption rate of 5% or lower.
- Photographs of completed works.

Design strategy and assessment: (1 point)

b. **Specify suspended metal panel modular ceiling system, e.g. baffle metal panels, aluminium trellis, and metal mesh.**

Documentation requirements

Design stage

- Tender specification indicating the type of metal suspended ceiling panel.
- Reflected ceiling plan showing the metal modular ceiling.

Verification stage

- As-built (interior) drawings to show extent of implementation.
- Photographs of completed works.

Design strategy and assessment: (1 point)

c. Specify for open ceiling design.

Documentation requirements

Design stage

- Tender specification indicating the open ceiling system for the selected areas.
- Reflected ceiling plans showing the extent of open ceiling.

Verification stage

- As-built (interior) drawings to show implementation.
- Photographs of completed works showing the open ceiling spaces.

Worked Example 6:

A 5-storey shopping mall has toilets on every floor of the building. There are 10 clusters of toilets in the shopping mall, 2 on each floor. The toilets were all initially designed with monolithic panels. However, the mall is undergoing upgrading works that affected only the first 3 floors of the building. Toilets on this floor will replace the monolithic panels with suspended metal modular ceiling structures, leaving the top 2 floors untouched. The ceiling area of the wet rooms and storage has a total ceiling area of 2500m^2, and is now comprised of:

- 240m^2 within each cluster of male, female toilets and an accessible toilet,
- 1,440m^2 for the 6 clusters of toilets on the level 1-3, newly designed with metal mesh ceiling structures
- 960m^2 for the 4 clusters of toilets on level 4-5, designed with monolithic ceiling
- 10m^2 of janitor stores located adjacent to each cluster with a total of 100m^2, designed with moisture resistant ceiling panel in the shopping mall.

The breakdown of the new wet rooms in the mall is shown in Area Table VI below:

	Suspended metal modular ceiling (metal mesh) (m^2)	Monolithic ceiling (m^2)	Moisture resistant modular ceiling panel (m^2)	Total (m^2)
Lvl 1-3 Male, Female & Accessible Toilet	1440	0	0	1440
Lvl 4-5 Male, Female & Accessible Toilet	0	960	0	960
Janitor Store	0	0	100	100
	1440	960	100	**2500**

Area Table VI : Breakdown of Ceiling Systems in the toilets

The shopping mall is an existing building with alteration works done, as such it will be required to provide documents during design and verification stage.

- Proportion of suspended metal modular ceiling (metal mesh)
  = 1,440m^2 / 2,500m^2 = 58% (≥15%)
- Proportion of moisture resistant modular ceiling panel to total ceiling area in wet rooms
  = 100m^2 / 2,500m^2 = 4% (<15% of total ceiling area, it will not score any points.)

Documentation requirements*:*

APPLICABILITY	Moisture resistant modular ceiling panel* at i) janitor stores Monolithic ceiling** at lvl 4,5 toilets	Suspended metal modular ceiling metal mesh at lvl 1-3 upgraded toilets
STATUS	Existing	Upgrading
DESIGN STAGE ASSESSMENT	N.A. *(Monolithic ceiling does not meet any of the solutions 2.4.6(a) and (b), hence no documents are required.)* *(Under the assessment category (Cat 2), no assessment is required if the area is <15%. As such, since the moisture resistant modular ceiling is only 4% of total ceiling area, it will not be considered for assessment.)*	2.3.6.b. Specify suspended metal panel modular ceiling system, e.g. baffle metal panels, aluminium trellis, and metal mesh. • Tender specification indicating the type of metal suspended ceiling panel. • Reflected ceiling plans showing the modular metal ceiling .
VERIFICATION STAGE ASSESSMENT	N.A. *(Under the assessment category (Cat 2), no assessment is required if the area is <15%. As such, since the moisture resistant modular ceiling is only 4% of total ceiling area, it will not be considered for assessment.)*	2.3.6.b. Specify suspended metal panel modular ceiling system, e.g. baffle metal panels, aluminium trellis, and metal mesh. • As-built (interior) drawings to show extent of implementation. • Photographs of completed works.

NOTE: *Under the assessment category of Cat 2, full points can be scored when proportion is >85%. Hence, the moisture resistant ceiling panel, which is 96% of total ceiling area, will score for 100% of the points.*

2.3.6 Reduce degradation of false ceiling systems in wet rooms

2.3.6 Reduce degradation of false ceiling system in wet rooms (up to 1 point)	Points	Assessment category	**Used in Project**	**Points Scored**
a. Specify moisture-resistant suspended non-metallic modular ceiling panels with water absorption rate not exceeding 5%.	1	Cat 2	√ (<15%)	0
b. Specify suspended metal panel modular ceiling system, e.g. baffle metal panels, aluminium trellis, and metal mesh.	1	Cat 2	√	58% * 1 = 0.58
c. Specify open ceiling design	1	Cat 2	ξ	0
Score for 2.4.9 walls in wet rooms				0.58

The total sub-points for 2.3.6 *under Wet Rooms & Storage* is = 0.58 point

2.4 LOADING BAY/ BACK OF HOUSE SERVICE AREAS (3.5 points)

2.4.1 Reduce damage caused by impact on walls and columns in vehicular ramps and loading bay areas (up to 1.5 point)

Intent

To reduce the frequency of repair and maintenance of damaged building elements, through optimal selection of materials.

Design strategy and assessment: (1.5 point)

a. Specify :
- **i) wall bumpers (0.375 point),**
- **ii) column guards (0.375 point)**
- **iii) wheel stoppers (0.375 point),**
- **iv) bollards (0.375 point).**

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental Cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
100% (No provision for Baseline	90% - 95%	75% - 80%	4 - 5

Baseline design strategy: No column guard and wall bumper
Proposed design strategy: With column guard and wall bumper
Study period: 30 Years
Yearly labour savings: 90 - 100% man-hour savings.

Documentation requirements

Design stage

- Tender specifications indicating the protection layer for walls, columns, wheel stoppers, bollards.
- Plan and typical sectional drawings showing the location of protective measures for loading bay/back of house service areas.

Verification stage

- As-built (construction) drawings to show implementation.
- Photographs of completed works.

2.4.2 Reduce damage to walls, columns, and floors at back of house traffic delivery areas (up to 2 points)

Intent

To reduce the frequency of repair and maintenance of damaged building elements, through optimal selection of materials.

Design strategy and assessment: (0.5 point)

a. Specify column guards in service delivery areas.

Incremental Cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
100% (No provision for Baseline)	95% - 100%	5% - 10%	9 - 10

Baseline design strategy: Concrete Block Wall with no additional protection
Proposed design strategy: Wall bumper and column guard
Study period: 10 Years
Yearly labour savings: 90 - 100% man-hour savings.

Documentation requirements

Design stage

- Tender specifications indicating the protective layer for columns.
- Plan drawing showing the location of protective measures for columns in back of house area.

Verification stage

- As-built (construction) drawings to show implementation.
- Photographs of completed works.

Design strategy and assessment: (1.5 point)

b. Specify protective materials:

i) For walls, e.g. chequered plate on walls (0.5 point)

ii) For floors, e.g. epoxy flooring (0.5 point)

iii) For doors, e.g. kickboards on doors (0.5 point)

Documentation requirements

Design stage

- Tender specifications indicating the protective materials for walls, floor and doors.
- Tender drawings (plan and typical sections) showing the location of protective measures for walls, floors, and doors.

Verification stage

- As-built (construction) drawings to show implementation.
- Photographs of completed works highlighting the protective measures.

SECTION 3 – MECHANICAL SYSTEM

PART A: COOLING SYSTEMS – SECTION 3.1 to 3.2

(Points in 3.1 or 3.2 will be apportioned based on the installed capacity of chillers and VRF condenser units. Points will be prorated for projects served by District Cooling system.)

3.1 CHILLER PLANT (13.5 points)

This section addresses the design solutions with respect to chiller plant main equipment such as chillers, pumps, cooling towers, and ancillary systems (e.g. sensors and actuators, water treatment system, ventilation provisions, and general pipe works). Access space provision must include routine inspection, cleaning, calibration, and possible future replacement.

Chiller plant equipment which shares common space for access and maintenance must comply with the following:

- Shared maintenance space is applicable if the adjacent equipment is not maintained simultaneously.
- The shared clearance must be equal or greater than the larger of those required.

The typical chiller plant room layout is shown in Figure 22.

Note:

- *The access space provisions stated in Figure 22 are applicable for commonly available equipment in the ACMV industry. However, designers should follow manufacturer's specified space requirement if the minimum access space is greater than the values stated in relevant sections.*
- *The pipe routing shown below is only indicative and designers must follow the least resistance path for optimal performance.*

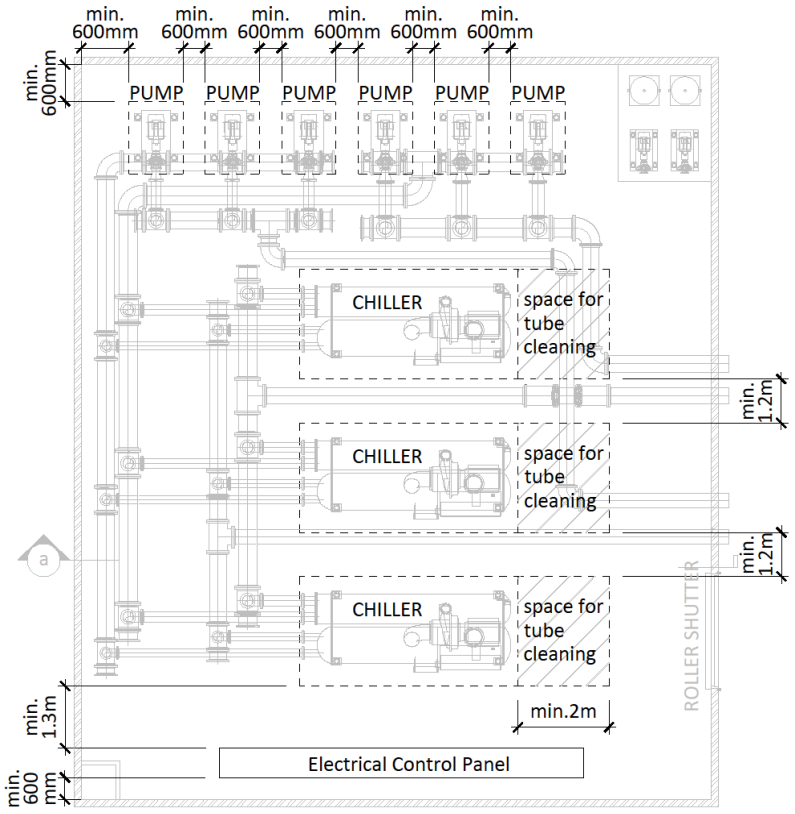


Figure 22: Typical chiller plant room layout and space provision

3.1.1 Access space for chiller plant equipment maintenance (1.5 points)

Intent

To provide adequate space for chiller plant equipment which requires frequent maintenance and thus improve maintainability of the equipment and labour efficiency.

Design strategy and assessment: (0.5 point)

a) Chiller

i) Provide minimum 1.5 m clear space to the back of the chiller to facilitate tube cleaning and general maintenance.
(OR)

Provide operable opening (i.e. roller shutter) to the back of chiller with minimum 2 m clear space upon opening of operable opening. The dimension of the operable opening must be greater than the width and height of the chiller.

ii) Provide minimum 1.2 m between the chillers (measured from plinth to plinth) for regular maintenance.

iii) Provide minimum 1.5 m clear space above the chiller for overhaul or replacement.
(OR)

Provide minimum 1m clear space above the chiller if the chiller plant has I-Beam to hoist heavy equipment's such as compressor.

Note: Designers should follow manufacturer's specified requirement if the minimum access space is greater than the above stated access requirements.

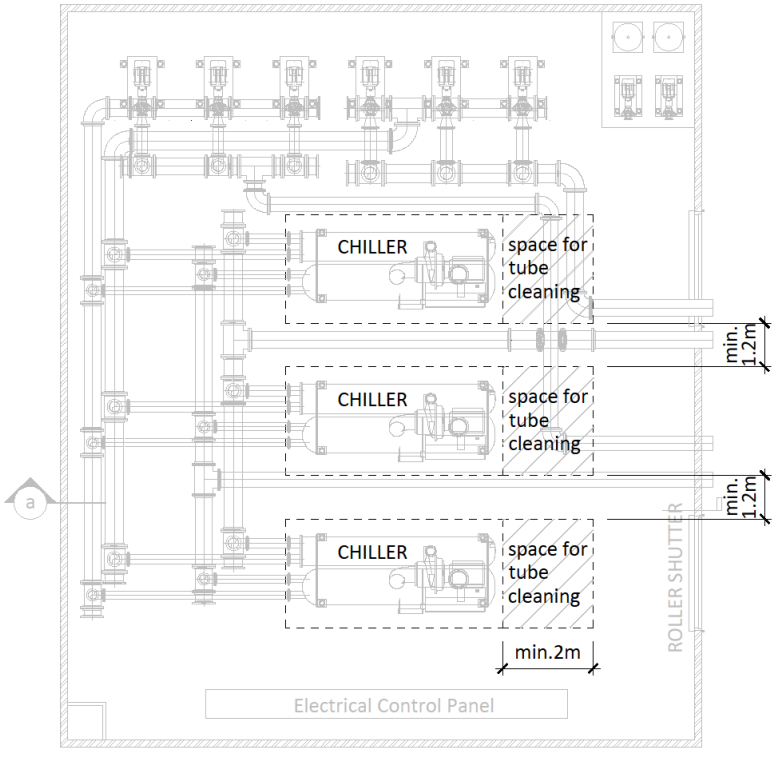


Figure 23: Access space for chiller

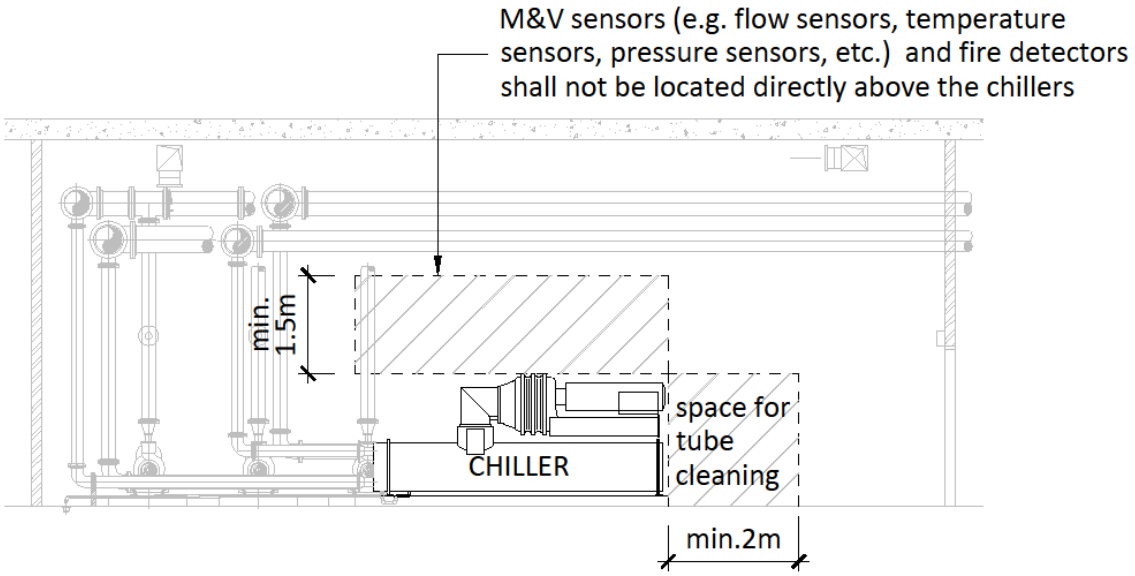


Figure 24: Headroom requirement for chiller

Documentation requirements

Design Stage

- Architectural/mechanical plan drawings indicating the chiller plant location.
- ACMV chiller plant layout drawing showing the access provision or tender specifications indicating the exact access requirement.

Verification Stage

- Shop drawing/as-built chiller plant layout and sectional drawing indicating the access provisions as per the actual equipment selection.
- Shop drawing/as-built drawing/roller shutter detail drawings showing the dimension and indicating the access space for chiller.
- Photographs showing the clear access provision to chiller plant equipment including M&V sensors and fire detectors.

Design strategy and assessment: (0.5 point)

b) Pump

i) Provide minimum 600 mm* clear space around the pump for regular maintenance.

ii) Provide minimum 1 m clear headroom above the pump and motor to facilitate overhaul maintenance/replacement.

iii) Provide clear and unobstructed access to chilled water pump for regular maintenance and replacement.

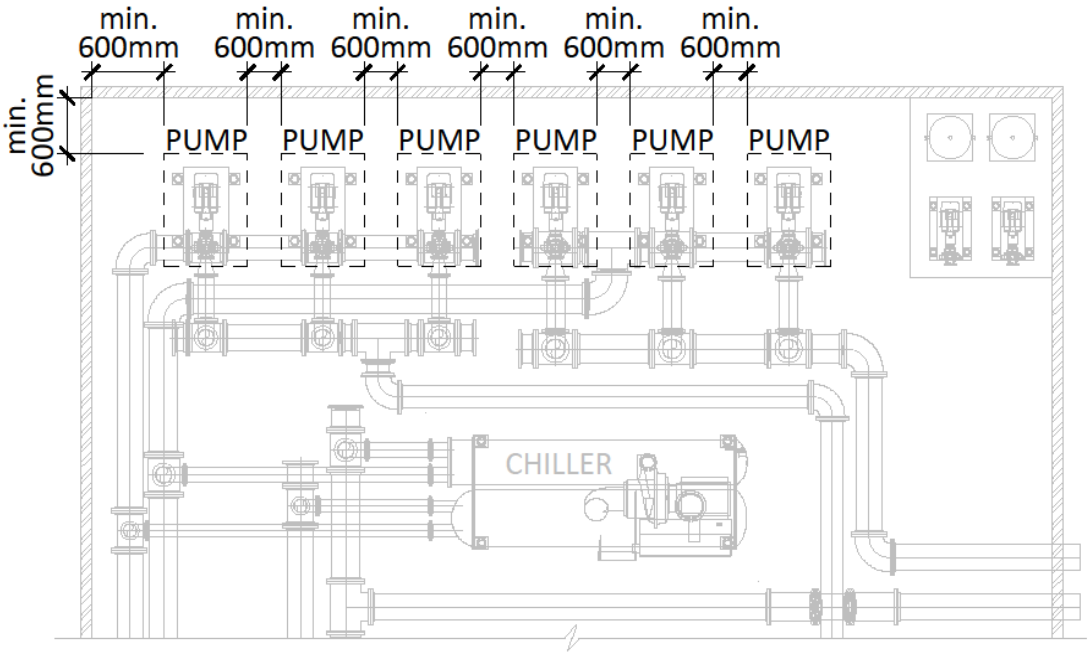


Figure 25: Access space requirement for pump (part plan)

Note:

** excluding the pipe connection.*
Designers should follow manufacturer's specified requirement if the minimum access space is greater than the above stated access requirements.

Documentation requirements

Design Stage

- Chiller plant layout drawing with access provision and headroom requirement.
- Tender specifications indicating the exact access requirement for chilled water pumps and condenser water pumps.

Verification Stage

- Shop drawings/as-built drawings highlighting the space and headroom provision for pumps with dimensions as per the actual equipment selection.
- Photographs showing the provision of access space and headroom.

Design strategy and assessment: (0.5 point)

c) **Locate all the measurement and verification (M&V) sensors < 3.0 m height from finished floor level (FFL).**
(AND)
Provide unobstructed access to the M&V sensors for maintenance.
M&V sensors includes:
- Chilled water supply and return temperature sensors
- Chiller water flow meters
- Condenser water supply and return temperature sensors
- Condenser water flow meters

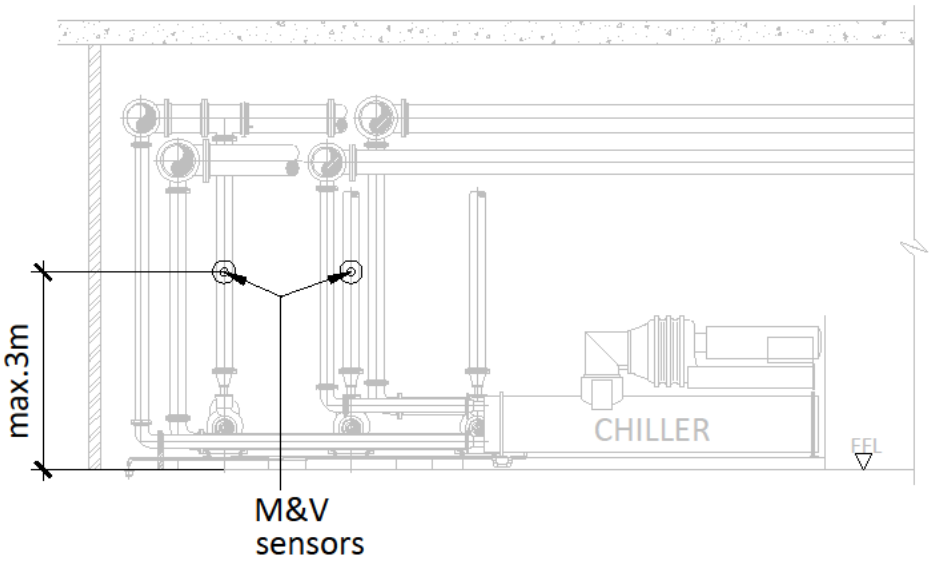


Figure 26: Location requirement for M&V sensors (part plan)

Documentation requirements

Design Stage

- Tender drawing/specification indicating the M&V sensor mounting height and access requirement.

Verification Stage

- Shop drawing/as-built chiller plant sectional drawing indicating the installation height of M&V sensors.
- Chiller plant sectional drawings showing the vertical height of the sensors.
- Photographs showing the implementation.

3.1.2 Access to equipment requiring frequent maintenance (5 points)

Intent

To improve maintainability of the equipment and labour efficiency. To avoid safety hazard without proper access.

Design strategy and assessment: (2 points)

a. **Provide permanent stairs and catwalks around the cooling towers to access water basin and fill media. The clear width of the catwalks must not be less than 600 mm. (2 points)**

(OR)

Provide Catwalk to access cooling tower fill area (1 point)

Note: All catwalks must be provided with handrail of minimum 1m height.

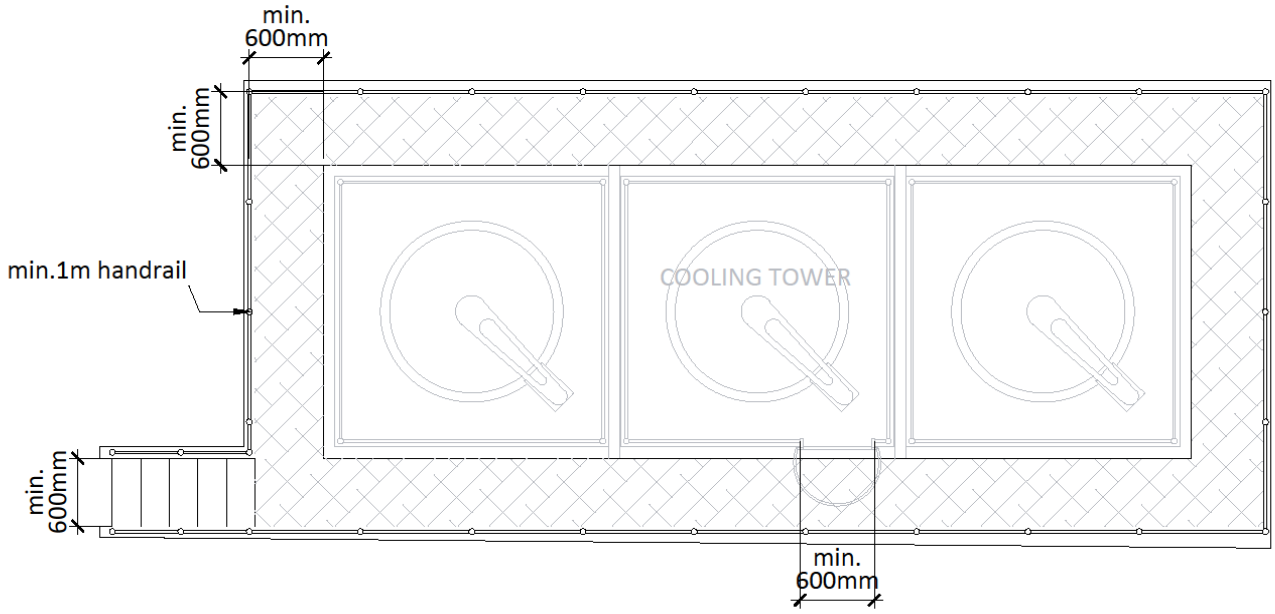


Figure 27: Cooling tower with catwalk (4 sides)

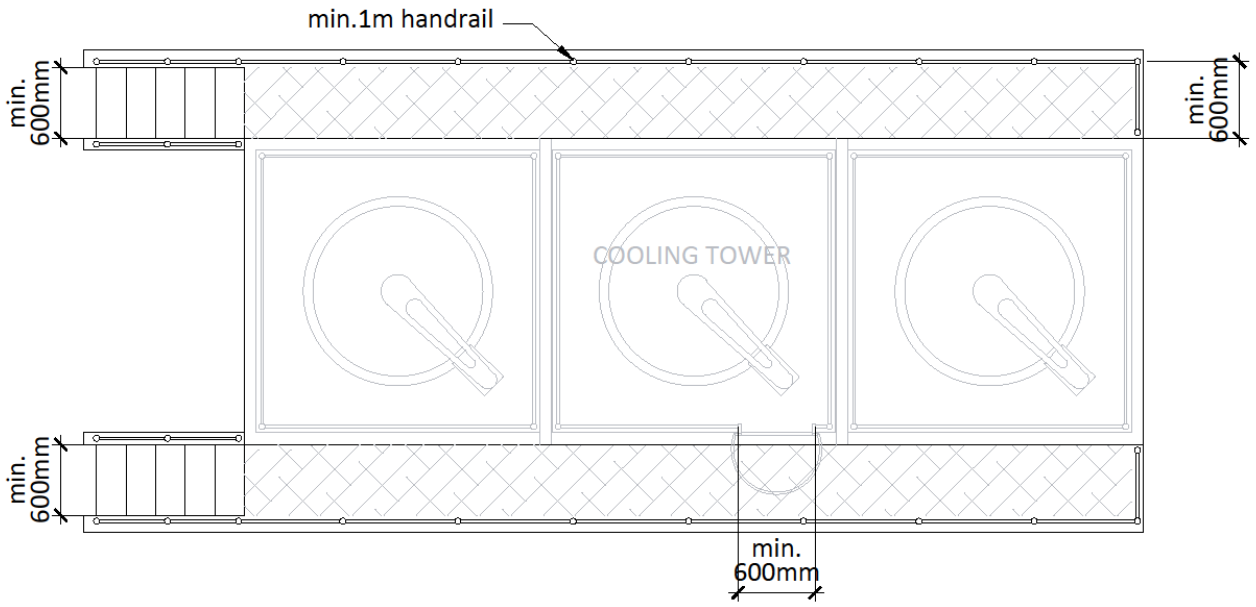


Figure 28: Cooling tower with catwalk (2 sides)

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
100% (No provision for baseline)	55%-60%	20%-25%	4-5

Baseline design strategy: no provision of cooling tower maintenance platform
Proposed design strategy: provision of cooling tower maintenance platform
Study period: 15 years
Yearly labour saving: 20%-30% man-hour.

Documentation requirements

Design Stage

- ACMV plan drawing showing the requirement on the maintenance platform.
- Tender specifications capturing the maintenance platform requirements.

Verification Stage

- ACMV shop drawing/as-built drawings indicating the permanent stairs and catwalk around the cooling tower.
- Photographs showing the catwalk and maintenance platform.

Design strategy and assessment: (1 point)

Davit arm provision at the top of cooling tower for repair and replacement of heavy components i.e. motor, fans etc.

b. Provide permanent sleeve to mount davit arm for all cooling towers and hand over of 1 davit arm for each cooling tower model to building owner

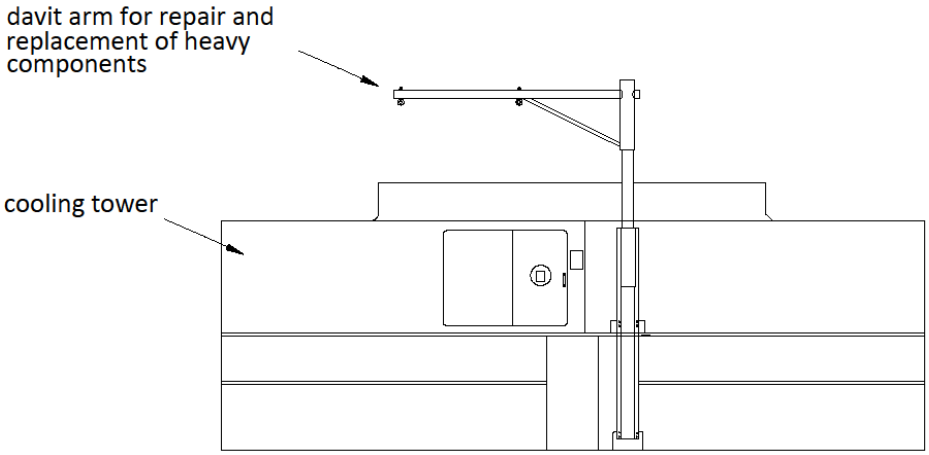


Figure 29: davit arm at top of cooling tower

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
100% (No provision for baseline)	95%-100%	35%-40%	6-7

Baseline design strategy: no provision of motor davit at fan side
Proposed design strategy: provision of motor davit at fan side
Study period: 15 years
Yearly labour saving: 80%-90%

Documentation requirements

Design Stage

- Tender specifications showing a permanent sleeve to mount davit arm for all cooling towers
- Tender specifications on handover of 1 davit arm for each cooling tower model to building owner

Verification Stage

- As-built cooling tower detail drawing or photographs showing the permanent sleeve to mount davit arm.
- Handover documents for 1 davit arm for each cooling tower model to building owner.

Design strategy and assessment: (0.5 point)

a. **Provide cat ladder with metal enclosure (cage) to access top of the equipment i.e. cooling tower etc.**

Documentation requirements

Design Stage

- Tender specifications showing the requirement on cat ladder with metal enclosure.

Verification Stage

- As-built drawings/shop drawings showing the cat ladder with metal enclosure.
- Photographs showing the actual provision of cat ladder access.

Design strategy and assessment: (0.5 point)

b. **Provide metal step-over platform at the main access leading to the plant rooms to avoid stepping on rooftop services (i.e. major ductwork, pipes above 100 mm diameter, trunking exceeding 200 mm in width etc.).**
The stepover platform must have minimum width of 600 mm with both sides protected by a handrail with a vertical height of at least 1 m.

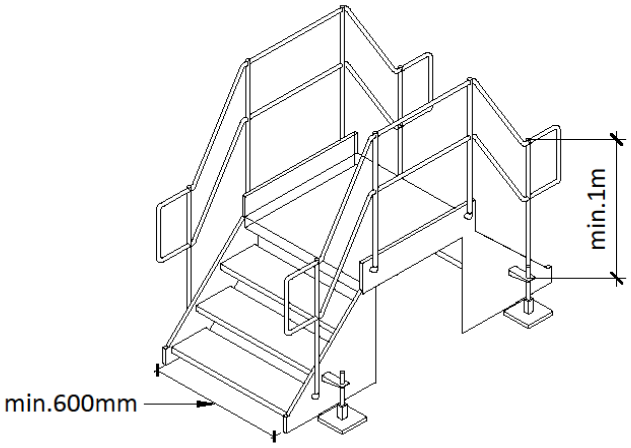


Figure 30: Step-over

Documentation requirements

Design Stage

- Tender specifications showing the requirement for metal step-over platform.

Verification Stage

- ACMV shop drawing/as-built drawing indicating the provision for metal step-over platform.
- Photographs showing the provision of metal step-over platform.

Design strategy and assessment: (0.5 point)

c. **Provide minimum 1.2 m wide clear access route from the nearest lift lobby or staircase to the M&E plant rooms for regular maintenance (i.e. pump room, chiller plant room including cooling tower etc.).**
The access/egress route must be sufficient in terms of space provision and loading capacity to allow safe movement of maintenance staff, the handling of major plant items, and the use of mechanical lifting devices where necessary[27].

Note: Designers should follow manufacturer's specified requirement or specialist's recommendation if the minimum access space is greater than the above stated access requirements.

Documentation requirements

Design Stage

- ACMV tender drawing/specifications capturing the access path requirement.

Verification Stage

- As-built service drawings/shop drawings indicating the access route provision from roof entrance to the M&E plantroom/equipment.
- Photographs showing the access route provision.

[27] Defense Works Functional Standard, Design and Maintenance Guide 08, Space requirement for plant access, operation and maintenance

Design strategy and assessment: (0.5 point)

f. Provide minimum 2m headroom from the top of cooling tower to objects such as trellis.

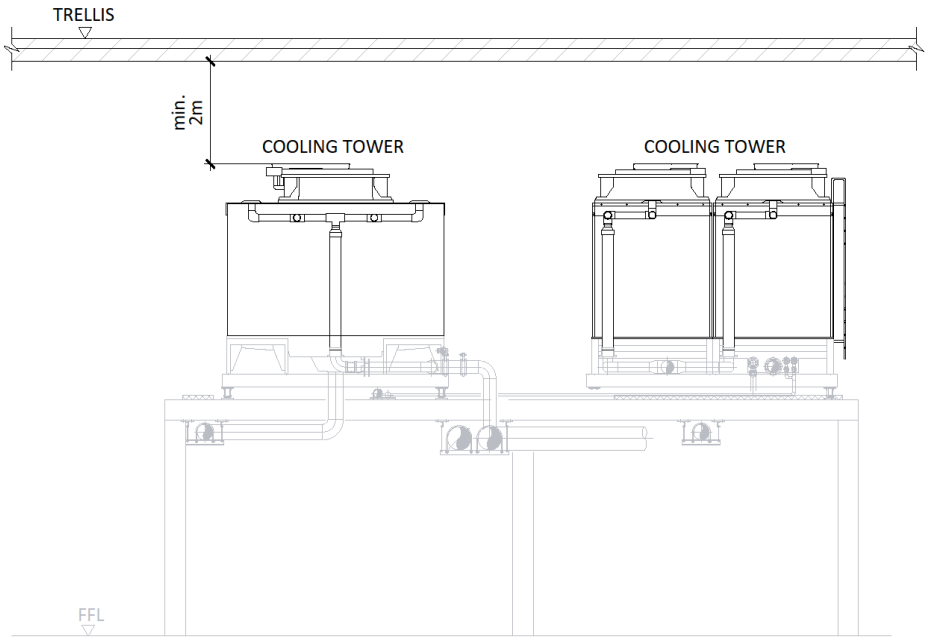


Figure 31: Headroom requirement for cooling tower with trellis

Documentation Requirements

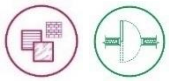
Design Stage

- Tender specifications indicating the cooling tower headroom access requirement.

Verification Stage

- Shop drawing/as-built cooling tower detailed drawing indicating the minimum 2 m headroom requirement.
- Photographs showing the access provision on top of cooling tower.

3.1.3 Reduce risk of corrosion and dust invasion in cooling tower (up to 1.5 points)



Intent

To improve cooling tower maintainability and avoid corrosion and dust invasion.

Note: Points can be scored for either 3.1.6b or 3.1.6c. Points will be apportioned for projects having both cross flow and counter flow cooling towers.

Design strategy and assessment: (1 point)

a. All components in contact with condenser water or air stream must be corrosion-protected. The construction material must be either:

i) FRP (fiberglass reinforced polyester with UV inhibitors).

ii) 304 stainless steel.

iii) For galvanized steel cooling tower, the zinc coating must comply with the following:

- **Hot-dip galvanized steel must comply with ASTM A123 (OR) G235 (OR) JIS H 8641 coating standards.**
- **Continuous steel sheet must comply with ASTM A653 zinc coating thickness.**

Note: General requirement – applicable to both cross and counter flow cooling tower.

Components in contact with condenser water or air stream include cold water basin, hot water basin (for cross flow cooling tower) and structural framework.

Documentation requirements

Design Stage

- Tender specifications capturing the cooling tower construction material requirements (including support structures frames and accessories).

Verification Stage

- Cooling tower technical data sheet/as-built drawing/factory certificates, and any relevant third-party certificate on the material properties and coatings.

Design strategy and assessment: (0.5 point)

b. For cross flow cooling tower, provide basin cover to mitigate dust invasion and algae growth in the upper water basin.

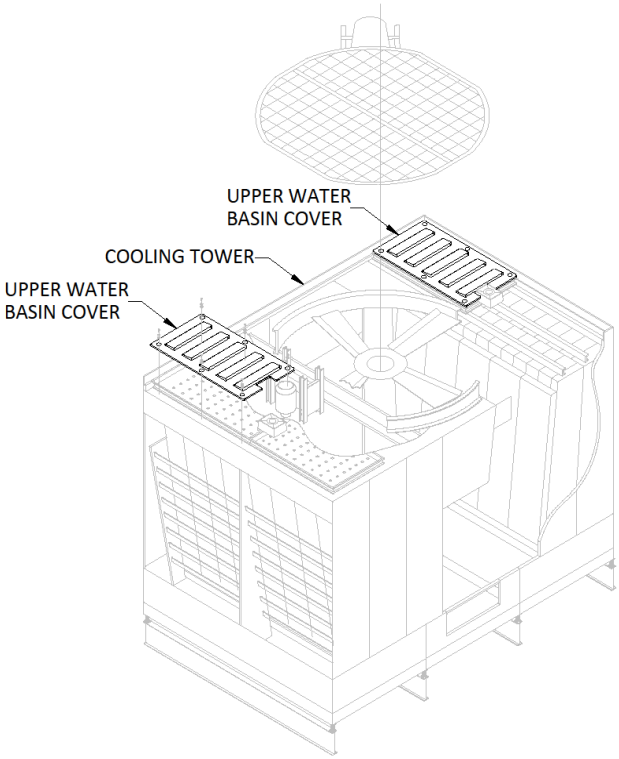


Figure 32: Cross flow cooling tower with upper water basin cover

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
100% (No provision for baseline)	65%-70%	30%-35%	5-6

Baseline design strategy: no provision of cooling tower upper basin cover
Proposed design strategy: provision of cooling tower upper basin cover
Study period: 15 years
Yearly labour saving: 60%-70% man-hour

Documentation requirements

Design Stage

- Tender specifications capturing the requirement for additional cover for cooling tower upper water basin.
- ACMV tender drawing showing the details on cooling tower upper water basin with cover.

Verification Stage

- Shop/as-built drawing showing the cover for upper water basin. Submit relevant technical data sheet from the suppliers highlighting the cover arrangement.
- Photographs showing the provision of upper water basin cover.

Design strategy and assessment: (0.5 point)

c. For counter flow cooling tower, provide air intake louvres to avoid sun light from entering the cooling tower basin and thus reducing algae formation.

Note: the air intake louvres must avoid direct sunlight penetration to the cooling tower water basin. The length, depth, and angle of the louvre is subject to supplier's recommendation.

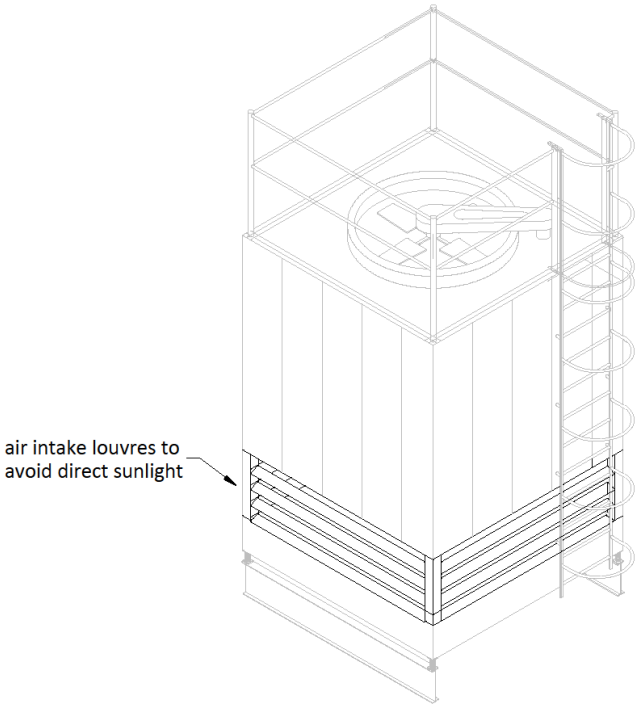


Figure 33: Counter flow cooling tower with air intake louvres

Documentation requirements

Design Stage

- Tender specifications showing the requirement of air intake louvres for cooling tower.

Verification Stage

- Catalogues/technical data sheet showing the details of air intake louvres or supplier's letter showing that the intake louvers will prevent sunlight penetration.
- Photographs of the louvres showing the implementation.

3.1.4 Reduce risk of oil/grease deposit on the cooling tower fins (1.5 point)

Intent

Enhance maintainability by preventing the grease deposit on the cooling tower fins.

Design strategy and assessment: (0.5 point)

a. **The kitchen exhaust outlet must be at least 5 m away from cooling tower air intake.**
(AND)
The kitchen exhaust must be directed either perpendicular or opposite to the cooling tower air intake.

Note: Projects deviating from the above requirement must adopt performance driven approach (such as using CFD) to prove that kitchen exhaust is not directed towards the cooling towers.

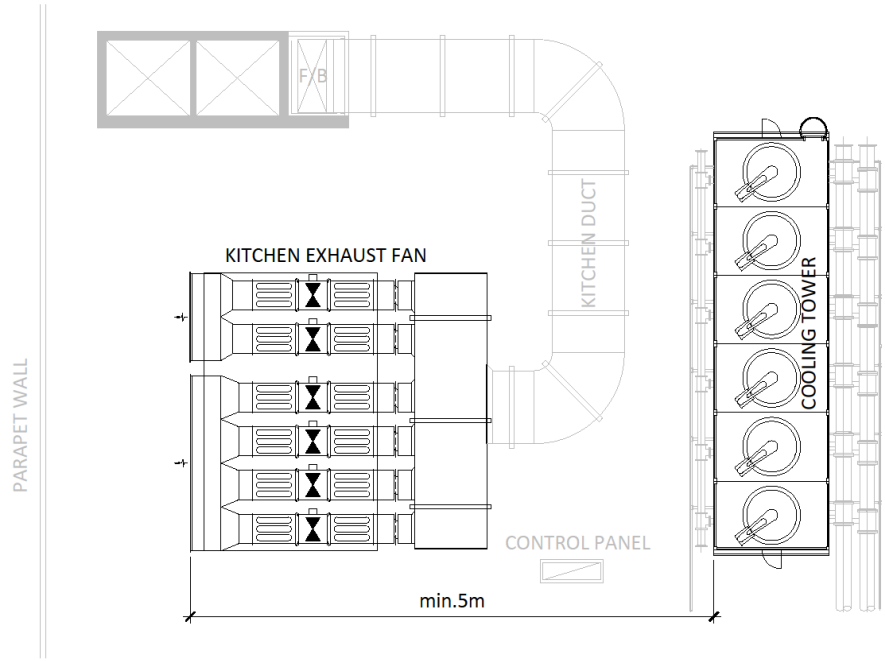


Figure 34: Roof with cooling tower and kitchen exhaust fan

Documentation requirements

Design stage

- Tender specifications highlighting the requirement for kitchen exhaust termination.
- ACMV plan drawing showing the kitchen exhaust duct termination and distance from cooling tower.

Verification Stage

- Shop drawing/as-built drawings showing the direction of kitchen exhaust discharge and distance to the cooling tower intake.
- Photographs of actual installation showing the compliance.

Design strategy and assessment: (1 point)

b. Provide kitchen air cleaning system (i.e. air scrubber, electrostatic precipitator filters etc.) to avoid grease deposit on the cooling towers.

Documentation requirements

Design stage

- Tender specifications capturing the kitchen air cleaning system requirement.
- ACMV tender drawings showing the requirement of the kitchen exhaust air cleaning system.

Verification Stage

- Shop drawing/as-built drawing/detail drawing showing the kitchen exhaust air cleaning system.
- Catalogue or technical data sheet showing the details of kitchen air cleaning system.

3.1.5 Reduce risk of fouling issue and improve condenser water quality (2.5 points)

Intent

Enhance maintainability and performance of the cooling towers and chillers.

Design strategy and assessment: (1.5 points)

a. Provide microprocessor based, automatic water quality monitoring and control system linked to Building Management System (BMS).
The critical parameters must be monitored by BMS. Auto monitoring and control is applicable to both chemical-based and non-chemical based/chemical-free water treatment system.
The critical parameters include the following:

i) Conductivity
ii) Temperature
iii) pH value
iv) Total dissolved solids (TDS)
v) Hardness
vi) Salinity
vii) Oxidation reduction potential (ORP)

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
45%-50%	45%-50%	30%-35%	3-4

Baseline design strategy: conventional chemical water treatment
Proposed design strategy: real-time monitoring and auto-dosing according to the water quality for chemical water treatment
Study period: 10 years
Yearly labour saving: 50-60% man-hour

Documentation requirements

Design stage

- Tender specifications showing the requirement for cooling tower water treatment with automatic monitoring and control system.

Verification Stage

- Technical data sheet/cut sheet showing the parameters monitored for water treatment system.
- BMS I/O point schedule highlighting the points monitored/controlled for water treatment system.
- Photographs of actual installation showing the compliance.

Design strategy and assessment: (1 point)

b. Provide auto-tube cleaning for water cooled chillers.

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
100% (No provision for baseline)	85%-90%	10%-15%	3-4

Baseline design strategy: no provision of auto-tube cleaning system
Proposed design strategy: provision of auto-tube cleaning system (Ball type)
Study period: 5 years
Yearly labour saving: 30%-40% man-hour

Documentation requirements

Design stage

- Tender specifications showing the requirement for auto tube cleaning system.
- ACMV schematic drawing showing the provision of auto-tube cleaning system.

Verification Stage

- Technical data sheet/catalogue of auto tube cleaning system.
- Shop drawing/as-built chiller plant drawing highlighting the integration of auto-tube cleaning system.

3.1.6 Reduce risk of dust and debris settlement inside the cooling tower basin (up to 1.5 points)

Intent

To enhance the maintainability of the cooling towers and overall performance of the chiller plant.

Note: Project can score either for 3.1.9.a or 3.1.9.b. Total scores for 3.1.9 is capped at 1.5 points.

Design strategy and assessment: (1.5 points)

a. **Provide basin sweeper system (including side stream separator) to remove coarse to fine particles and silt deposit in the cooling tower basin.**

Note: The basin sweeper system must be provided for each cooling tower.

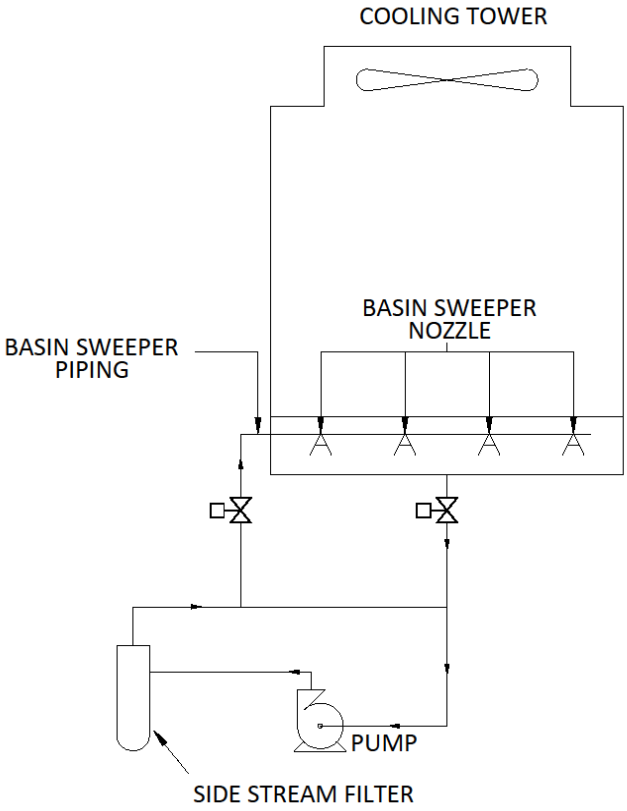


Figure 35: Cooling tower basin sweeper system

Documentation requirements

Design Stage

- Tender specifications showing the requirement on basin sweeper system and side stream separator.
- ACMV tender schematic drawings showing the details of basin sweeper and side stream separator system.

Verification Stage

- As-built drawings/shop drawings showing the adoption of basin sweeper system.
- Photographs showing the provision of basin sweeper system and side stream separator.

Design strategy and assessment: (1 point)

b. Provide side stream centrifugal separator or equivalent in condenser water loop to mitigate debris and dust accumulation.

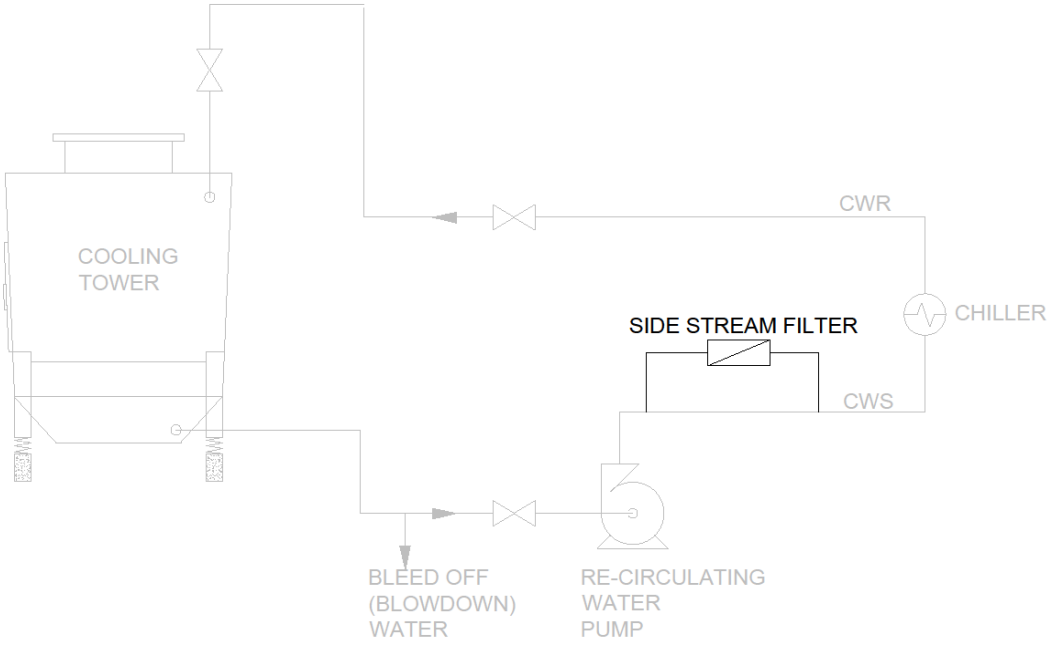


Figure 36: Schematic diagram for side stream filtration system

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
100% (No provision for baseline)	80%-85%	35%-40%	6-7

Baseline design strategy: no provision of filtration system for cooling towers
Proposed design strategy: provision of side stream filtration system for cooling towers
Study period: 15 years
Yearly labour saving: 20%-30% man-hour

Documentation requirements

Design Stage

- Tender specifications showing the requirement on side stream centrifugal separator system.
- ACMV tender schematic drawing showing the details of side stream filtration system.

Verification Stage

- As-built drawings showing the adoption of side stream filtration system.
- Photographs showing the provision of side stream filtration system.

3.2 UNITARY AIR CONDITIONING SYSTEM – VARIABLE REFRIGERANT FLOW (VRF) (1.5 points)

3.2.1 Access to VRF outdoor units (up to 0.5 point)

Intent

Provide adequate access space for VRF maintenance.

Design strategy and assessment: (0.5 point)

a. For single VRF outdoor unit installation:

Top Discharge:

i) Provide minimum 500 mm to the front for refrigerant piping and maintenance access.

ii) Provide minimum 300 mm to the suction side for air intake.

Note: The above-mentioned access requirements is based on:

- *Front/side: Wall equal to the height of the condenser unit (CU).*
- *Back: Wall Up to 500mm from the unit bottom.*

Side Discharge:

i) The outdoor units must not be stacked.

ii) Provide minimum 500 mm to the front for maintenance access.

iii) Provide minimum 150 mm to the suction side for air intake.

iv) Provide minimum 350mm on the side with refrigerant piping for maintenance

Note: The above-mentioned access requirements is based on obstacle on both suction and discharge side. For outdoor units which are obstructed by walls on multiple sides, follow manufacturer specified access provisions.

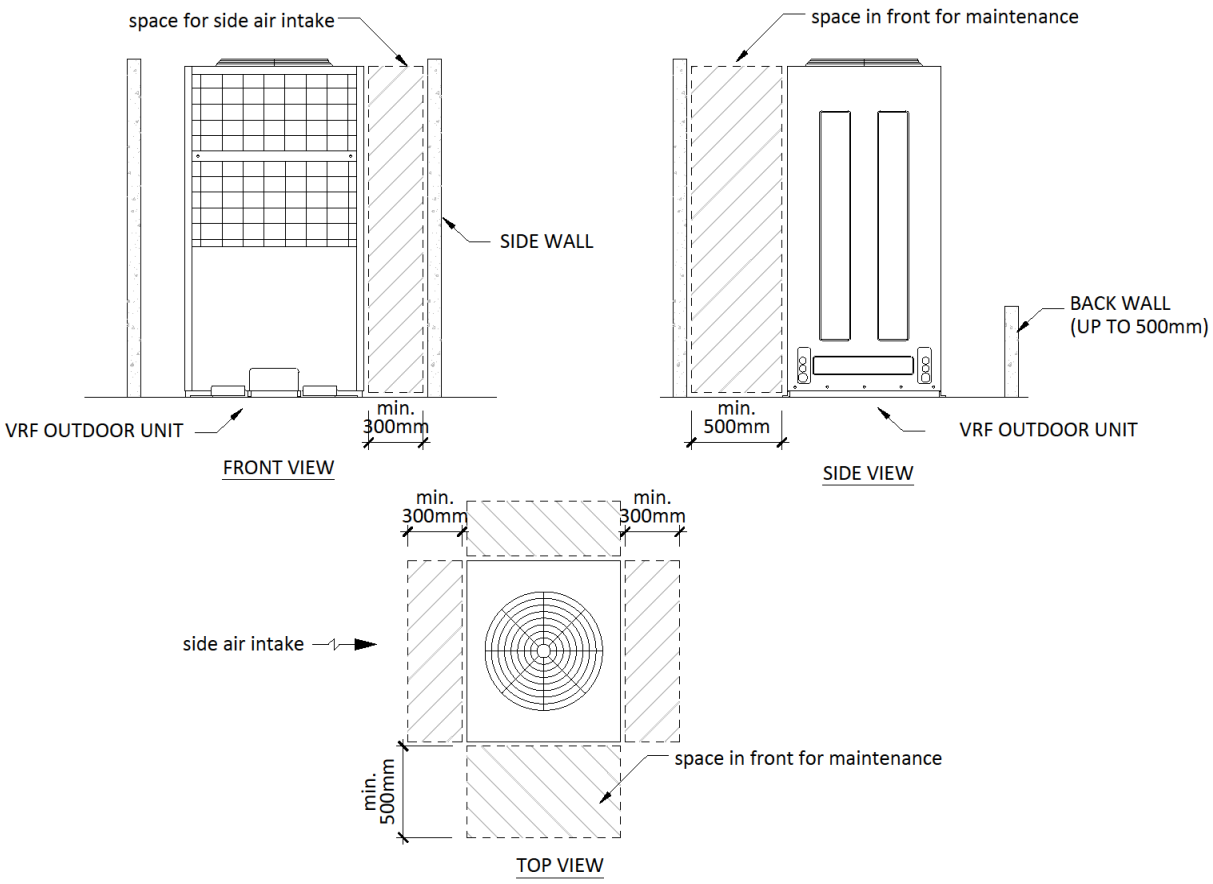


Figure 37: Space requirement for single VRF outdoor installation (top discharge)

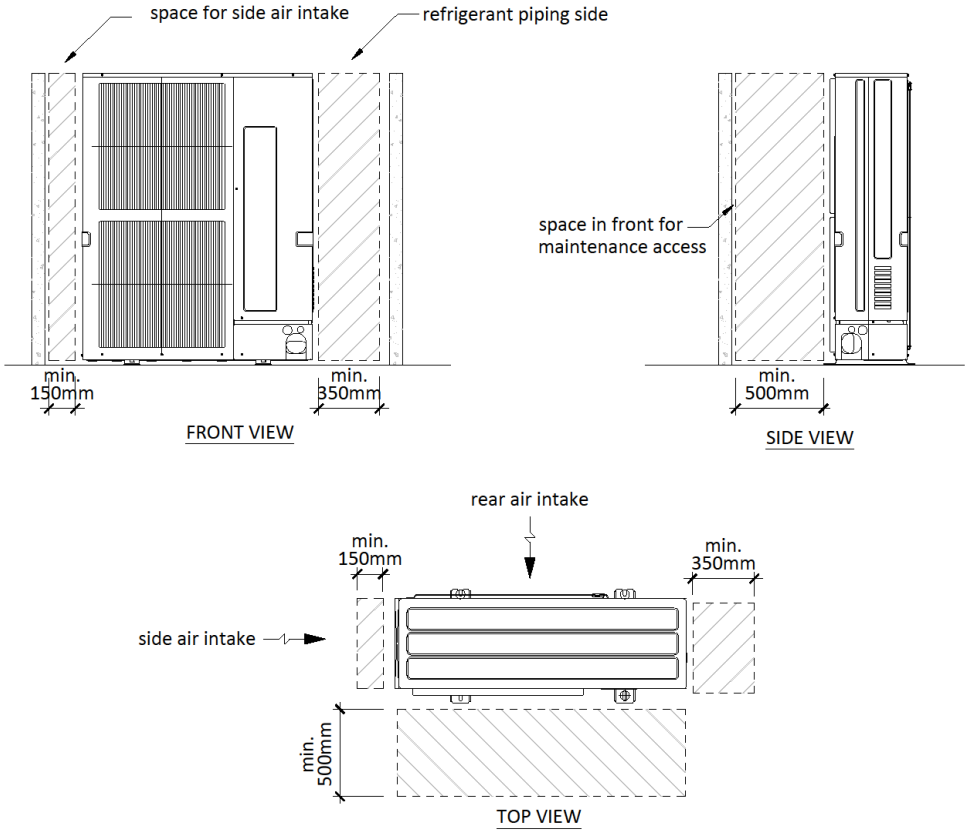


Figure 38: Space requirement for single VRF outdoor installation (side discharge)

Documentation requirements

Design Stage

- Tender specifications indicating the exact access requirement.

Verification Stage

- Shop drawing/as-built VRF layout and sectional drawings indicating the access provisions as per the actual equipment selection.
- Photographs of actual installation and access requirement.

Design strategy and assessment: (0.5 point)

b. For collective VRF outdoor unit installation:

Top Discharge:

i) Provide minimum 500 mm to the front for refrigerant piping and maintenance access.

ii) Provide minimum 300 mm to the suction side for air intake.

iii) If there is a wall at both front and back of the unit, provide minimum 1 m access space for each unit.

Note: For outdoor units which are obstructed by walls on multiple sides, follow manufacturer specified access provisions.

Side Discharge:

i) The outdoor units must not be stacked.

ii) Provide minimum 500 mm to the front for maintenance access.

iii) Provide minimum 300 mm to the suction side for air intake.

iv) Provide minimum 350mm on the side with refrigerant piping for maintenance If there is a wall on both sides, provide minimum 1 m clear access space for at least one side of the unit.

Note: For outdoor units which are obstructed by walls on multiple sides, follow manufacturer specified access provisions.

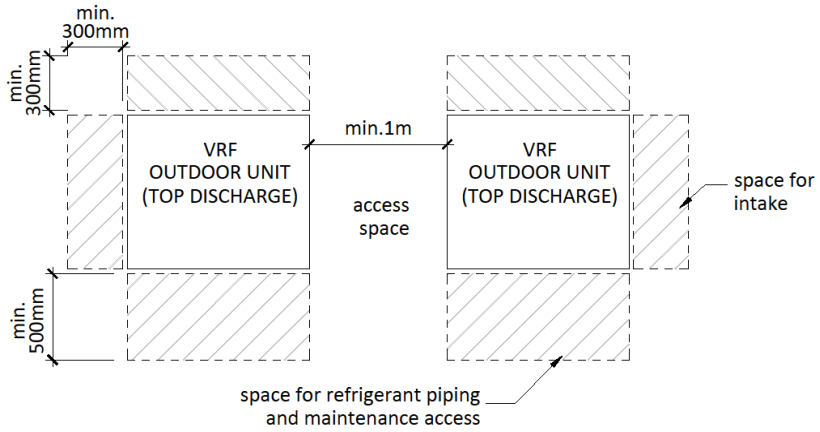


Figure 39: Space requirement for collective VRF outdoor unit (top discharge) – top view

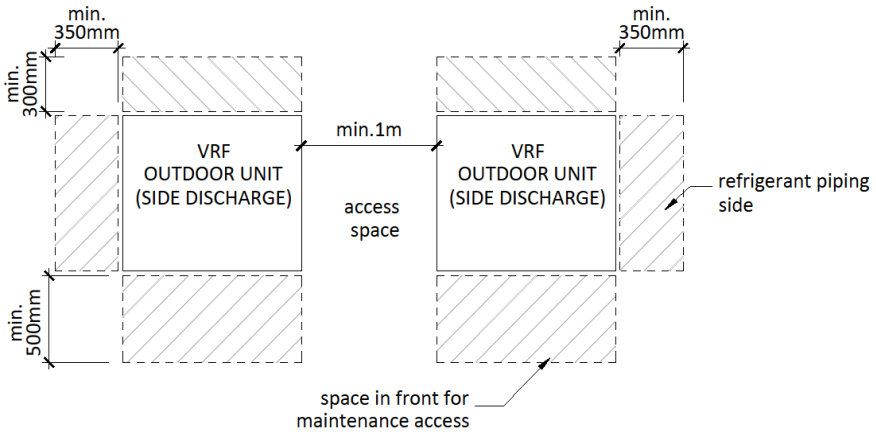


Figure 40: Space requirement for collective VRF outdoor unit (side discharge) - top view

Documentation requirements

Design Stage

- Tender specifications indicating the exact access requirement.

Verification Stage

- Shop drawing/as-built VRF layout and sectional drawings indicating the access provisions as per the actual equipment selection.

Design strategy and assessment: (0.5 point)

c. For floor-by-floor VRF outdoor unit installation :

Top Discharge:

i) Provide minimum 500 mm to the front for refrigerant piping and maintenance access.

ii) Provide minimum 300 mm to the suction side for air intake.

iii) Avoid air short-circuiting, connect the air outlet via ducting to the outside wherever required.

iv) If the duct is terminated against the louvre, the louvre angle should be ≤20° from horizontal. The free opening for louvre screen should be minimum 70 %.

Side Discharge:

i) The outdoor units must not be stacked.

ii) Provide minimum 500mm to the front for maintenance access.

iii) Provide minimum 300 mm to the suction side for air intake.

iv) Provide minimum 350mm on the side with refrigerant piping for maintenance

Note: The above-mentioned access requirements is specific to outdoor units located at the service corridor facing the building exterior. For any other site-specific space constraints, refer to manufacturer's recommendations for access space requirements.

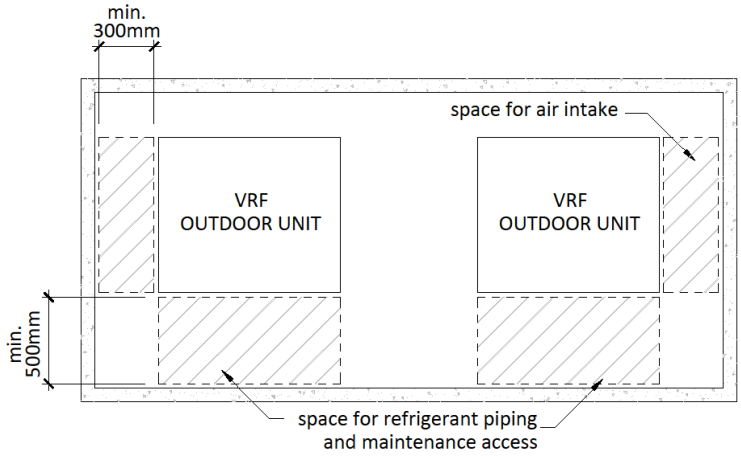


Figure 41 Space requirement for VRF outdoor installation (top discharge) – top view

Documentation requirements

Design Stage

- Tender specifications indicating the access requirement.

Verification Stage

- Shop drawing/as-built drawing (including plan and sectional drawing) indicating the access provisions as per the actual equipment selection.

3.2.2 Avoid damage to the refrigerant pipe and insulation (1 point)

Intent

To avoid damage to refrigerant pipe with proper installation.

Design strategy and assessment: (1 point)

a. **Refrigerant pipe mounted outdoor (e.g. at roof level) must be mounted on inside raised trunking to avoid water ingress and damage to stepping/lateral impact.**

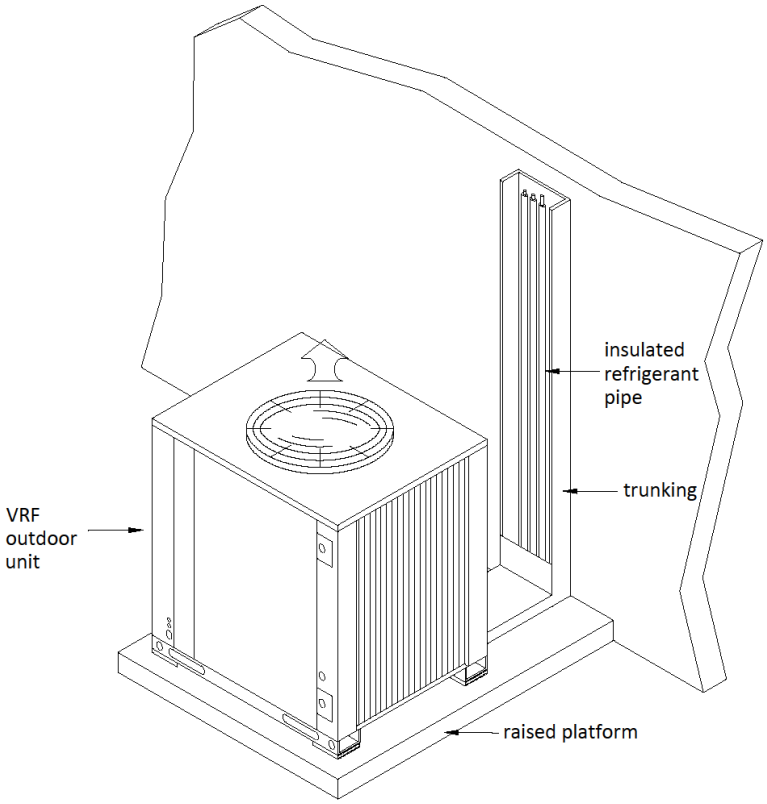


Figure 42: Trucking for refrigerant pipe

Documentation requirements

Design Stage

- Tender specification showing the requirement for raised platform with trunking.

Verification Stage

- Shop drawing/as-built VRF drawing showing the compliance for installation details.
- Photographs showing the installation.

Worked Example 7:

A mid-rise office building has been designed with two type of cooling system- chiller plant and Variable Refrigerant Flow (VRF) system. The total operating peak cooling load for chiller plant and VRF system is 4000kW and 1000kW, respectively.

- Proportion of cooling load of Chiller Plant system $= \frac{4000}{4000+1000} = 80\%$
- Proportion of cooling load of VRF system $= \frac{1000}{4000+1000} = 20\%$

3.1 Chiller Plant

Scoring for chiller plant system is shown in table below. Total points scored for this building under Chiller Plant is 10 points.

		Points	Assessment category	Used in project	Points Scored
3.1.1	Access to chiller plant room for equipment replacement	1.5	-	✔	1
3.1.2	Access to equipment requiring frequent maintenance	5	-	✔	5
3.1.3	Reduce risk of corrosion and dust invasion in cooling tower	1.5	-	✔	1
3.1.4	Reduce risk of oil/grease deposit on the cooling tower fins	1.5	-	✔	1
3.1.5	Reduce risk of fouling issue and improve condenser water quality	2.5	-	✔	1
3.1.6	Reduce risk of dust and debris settlement inside the cooling tower basin	1.5	-	✔	1

3.2 UNITARY AIR CONDITIONING SYSTEM – VARIABLE REFRIGERANT FLOW (VRF)

Scoring for VRF system is shown in table below. Total points scored for this building under VRF is 1 point.

		Points	Assessment category	Used in project	Points Scored
3.2.1	Access to VRF outdoor units	1	-	✗	0
3.2.2	Avoid damage to the refrigerant pipe and insulation	1	-	✓	1

The total score after apportioning $= \mathbf{80\%} \times \mathbf{10} + \mathbf{20\%} \times \mathbf{1} = \mathbf{8.2}$ points

Note:
Apportionment of points will only apply if the building is served by both chiller plant and VRF systems. And the cooing capacity of each cooling system must not be less than 15% of cooling load otherwise apportionment would not apply as show in worked example 7.

Worked Example 8:

A mid-rise office building has been designed with two type of cooling system- chiller plant and Variable Refrigerant Flow (VRF) system. The total operating peak cooling load for chiller plant and VRF system is 4000kW and 500kW, respectively.

Proportion of cooling load of VRF system $= \frac{500}{4000+500} = 11.1\% < 15\%$

Scoring for cooling system is the same as Worked Examples 7 which is 10 points. Scoring for VRF is also 1 point.

In this scenario, 10 points will be scored for 3.1 & 3.2 as apportioning will not apply because the cooling capacity of VRF is less than 15% of the total cooling capacity.

PART B: SECTION 3.3 TO 3.7

3.3 AIR DISTRIBUTION SYSTEM (8 points)

3.3.1 Access space for maintenance of air distribution system (Up to 1 points)

Intent

To provide efficient and safe maintenance access around the air handing units for regular maintenance.

Design strategy and assessment: (1 point)

Minimum 75% of the AHUs comply to below solutions = 0.5 point
All AHUs (100%) comply to below solutions = 1 point

a. Floor mounted air handling unit (AHU)

i) AHU access – Provide minimum 1 m clear space from the AHU room door entrance to the AHU for general maintenance.

ii) Cooling coil pipe and filter access – Provide minimum 800 mm clear space after pipe connection to facilitate cooling coil cleaning and filter access.

iii) Fan access – Provide minimum 800 mm clear space for fan/motor access and maintenance (if the access is not from cooling coil connection side).

iv) Provide minimum 600 mm clear space to the side of AHU and 450mm to the back of AHU.

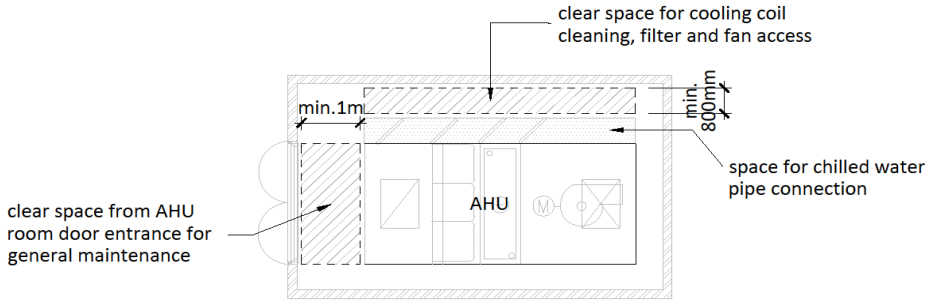


Figure 43: AHU room plan drawing

Note: Designers should follow the manufacturer's specified space requirement if the minimum access space is greater than the above stated values.

Documentation requirements

Design Stage

- Tender specifications indicating the access requirement.

Verification stage

- As-built drawings/shop drawings (including plan drawing/section) highlighting the AHU room access provision.
- Photographs showing implementation.
- O&M manual indicating the AHU maintenance strategy report.

Design strategy and assessment:

Minimum 75% of the ceiling mounted AHUs comply to below solutions = 0.5 point
All ceiling mounted AHUs (100%) comply to below solutions = 1 point

b. Ceiling mounted air handling units (AHU)

i) Cooling coil, filter and fan access – Provide minimum 600 mm clear space after pipe connection for cooling coil cleaning, filter access, and fan/motor access and maintenance.

ii) AHU side and back clearance - Provide minimum 300 mm clear space to back of the AHU for general access.

iii) For AHU's suspended at heights (≤ 3 m) – Provide minimum ground clearance of 1.5 m x 2.5 m to the mount scaffold.

iv) For AHU's suspended at heights (> 3 m) – Provide permanent catwalk with structural platform (with handrails) around the AHU for periodic maintenance. The clear width of the catwalks must not be less than 600 mm.

Note: Air handling units of cooling capacity greater than 35 kW must be floor-mounted [28]

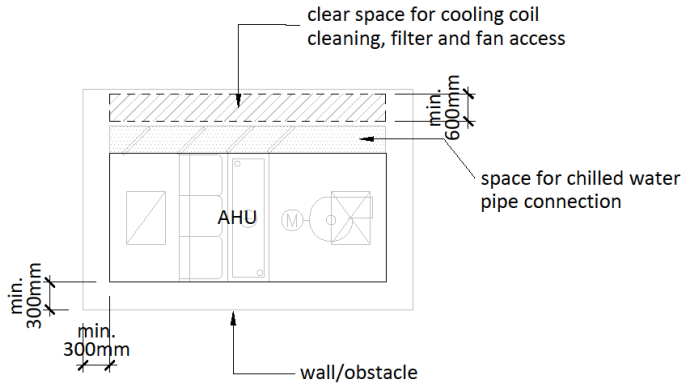


Figure 44: Typical access provision for ceiling suspended AHU

[28] *Refer SS 553:2016 Code of practice for air-conditioning and mechanical ventilation in buildings, section 9.1.1 under Air Handling Units*

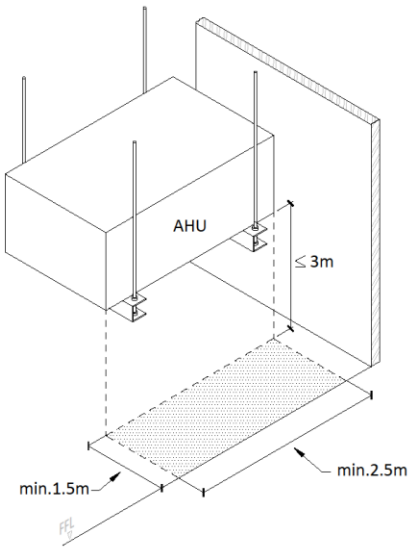


Figure 45: Ground clearance to mount scaffold for AHU located ≤ 3 m

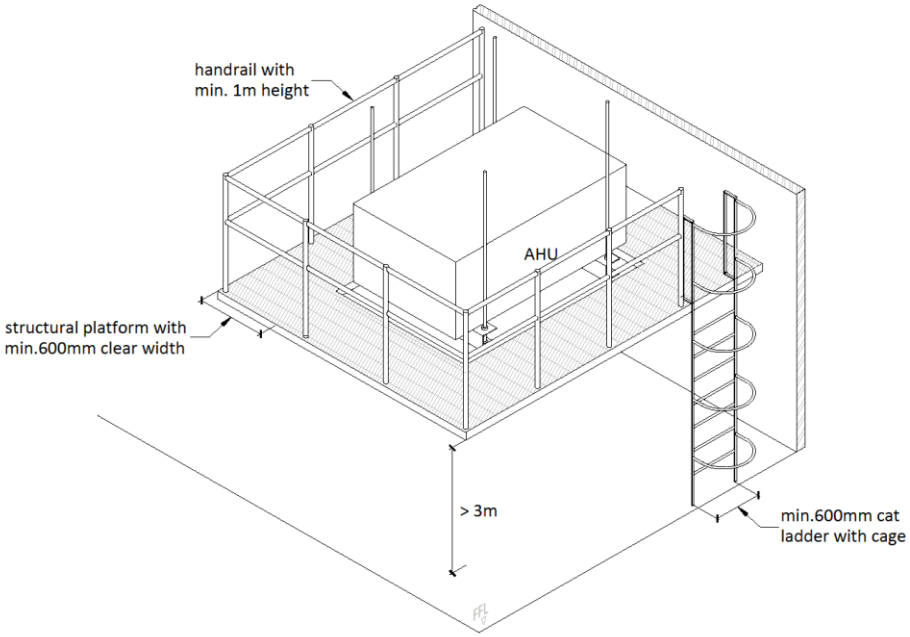


Figure 46: Cat ladder with structural platform to access AHU located > 3m

Note: Designers should follow the manufacturer's specified space requirement if the minimum access space is greater than the above stated values.

Documentation requirements

Design Stage

- Tender specifications indicating the access requirement.

Verification stage

- As-built drawings/shop drawings (including plan drawing/section) highlighting the AHU room access provision.
- Photographs showing implementation.
- O&M manual indicating the AHU maintenance strategy report.

Design strategy and assessment: (1 points)

Minimum 75% of the FCUs comply to below solutions = 0.5 point
All FCUs (100%) comply to below solutions = 1 point

c. Fan coil units (FCU)

i) Provide ceiling access panel with minimum 600 mm x 600 mm to access filter, cooling coil, and fan section for regular maintenance and replacement.

ii) Cooling coil pipe connection access – Provide minimum 450 mm clear space after pipe connection from any obstacle.

iii) FCU side clearance - Provide minimum 200 mm access space from any obstacle.

iv) FCU and key components such as actuator control valve, local control panel (LCP) must be directly accessible and within maximum 600mm from the access panel.

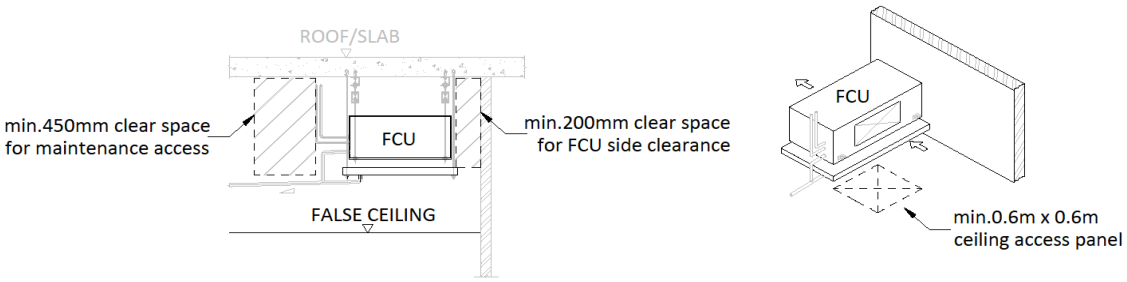


Figure 47: Typical access provision for FCU

Note: Designers should follow the manufacturer's specified space requirement if the minimum access space is greater than the above stated values. This item is not applicable to projects without fan coil units.

Documentation requirements

Design Stage

- Tender specifications indicating the access requirement.

Verification stage

- As-built drawings/shop drawings (including plan drawing/section) at appropriate scale highlighting the FCU access provision.
- Photographs showing implementation.
- O&M manual indicating the FCU maintenance strategy report.

Note: The typical detailing should match the shop drawing/as-built drawing layout.

Design strategy and assessment:

d. Access to FCU mounted at heights (i.e. atrium, lobby space)

i) Access requirements stated in 3.3.1c.

(AND) either (dii), (diii) or (div)

ii) Provide clear access route for Mobile Elevated Work Platforms (MEWP) to reach the lobby, atrium space from the nearest door entrance.

- **Provide clear access with entrance door/ opening of 1.8 m width x 2.4 m height and working base of 1.8 m width x 2 m length if the mounting height is less than or equal to 10.5 m.**
- **Provide clear access with entrance door/ opening of 2 m width x 2.8 m height and working base of 2 m width x 2 m length if the mounting height is greater than 10.5 m.**

Clear and unobstructed access must be provided from the entrance to the location directly below the FCUs. This must include the height and width of entrance door, the clearance along the MEWP access path as well as the working base for MEWP to carry out the maintenance work. The floor (loading and finishes) must be able to withstand the MEWP to be deployed for maintenance work. The deployment and operation of MEWP must comply with authority requirements. The actual clear access must depend on the proposed type of MEWP to be used and the manufacturer's recommended clearances through the access way.

iii) Provide alternative access (e.g. maintenance platform, access from top floors etc.) without having to access from the atrium floor.

iv) Locate FCU less than 3 m from FFL for easy access and maintenance.

Note: This item is not applicable to projects without fan coil units mounted at heights.

Documentation requirements:

Design Stage

- Plan drawing(s) showing the access route for MEWP movement to the atrium/lobby space.
- ACMV plan drawing/section at appropriate scale showing the alternative access provisions (OR) tender specifications indicating the access provisions (i.e. maintenance platform etc.).
- Tender specifications indicating the access requirement.

Verification Stage

- As-built drawings/shop drawings with actual access route marking from building entrance to the atrium/lobby space.
- As-built drawings/shop drawings (including plan drawing/section) showing the alternative access provisions (i.e. maintenance platform, access from mezzanine floor etc.).
- As-built drawings/shop drawings (including plan drawing/section) indicating the mounting height ≤ 3 m.
- Photographs showing implementation.

Worked Example 9a:

A mid-rise office building has been designed with the following air distribution system with the access provision compliance.

Description	Type of air distribution system	Number of AHU/FCU	Compliance
3.3.1 Access space for maintenance of air distribution system	AHU (Floor mounted)	10	Yes

- Proportion of AHU access compliance for 3.3.1.a = 100%

In this scenario, 1 point will be scored for 3.3.1 as all AHU comply with 3.3.1.a.

Worked Example 9b:

A mid-rise office building has been designed with the following air distribution system with the access provision compliance.

Description	Type of air distribution system	Number of AHU/FCU	Compliance
3.3.1 Access space for maintenance of air distribution system	AHU (Floor mounted)	8	Yes
	AHU (Floor mounted)	2	No

- Proportion of AHU access compliance for 3.3.1.a $= \frac{8}{10} = 80\% > 75\%$

In this scenario, 0.5 point will be scored for 3.3.1 as >75% of AHU complies with 3.3.1.a.

Worked Example 9c:

A mid-rise office building has been designed with the following air distribution system with the access provision compliance.

Description	Type of air distribution system	Number of AHU/FCU	Compliance
3.3.1 Access space for maintenance of air distribution system	AHU (Floor mounted)	7	Yes
	AHU (Floor mounted)	3	No

- Proportion of AHU access compliance for 3.3.1.a $= \frac{7}{10} = 70\% < 75\%$

In this scenario, no point will be scored for 3.3.1 as <75% of AHU complies with 3.3.1.a.

Worked Example 9d:

A mid-rise office building has been designed with the following air distribution system with the access provision compliance.

Description	Type of air distribution system	Number of AHU/FCU	Compliance
3.3.1 Access space for maintenance of air distribution system	AHU (Floor mounted)	10	Yes
	AHU (Ceiling suspended)	1	No

- Points scored for 3.3.1.a is 1 point as all AHU (floor mounted) comply with access provision
- No point for 3.3.1.b as the assess provision does not comply with the requirement

In this scenario, 0.5 point will be scored for 3.3.1 as there is 90.9% compliance.

3.3.2 Reduce risk of water ponding and algae growth in the AHU room (1 point)

Intent

Improve maintainability by providing proper termination of the AHU drain pipe and adequate floor treatment.

Design strategy and assessment: (0.5 point)

a. AHU drain pipe must be terminated directly above the floor trap to avoid any water spillage.

Note: The drain pipe must have minimum 1:100 slope to avoid any water choke. This item is not applicable to projects without AHUs.

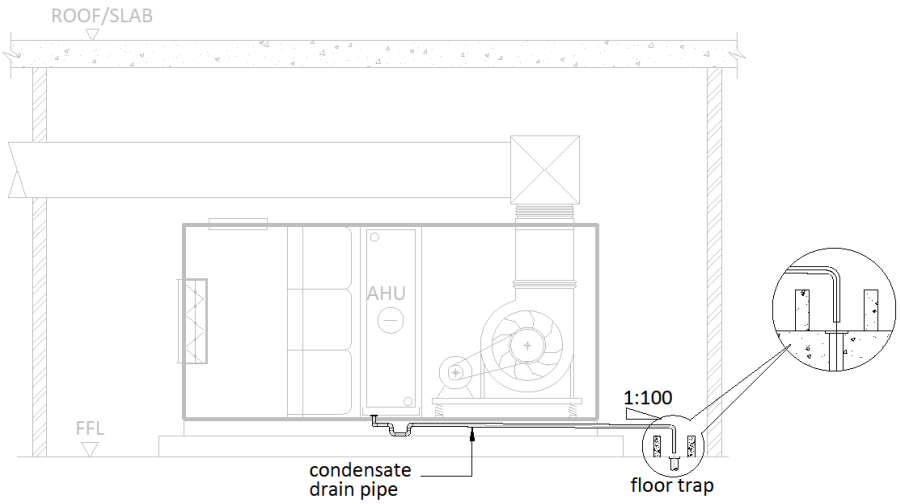


Figure 48: Typical AHU condensate drain termination

Documentation requirements:

Design Stage

- ACMV plan /section / typical detail drawings at appropriate scale showing the typical drain termination and slope requirement.
- Tender specifications indicating the AHU condensate drain pipe must be at least 1:100 gradient and terminated directly above the floor trap.

Verification stage

- As-built drawings/shop drawings (including plan drawing/section) showing the typical drain termination and slope requirement.
- Photographs showing implementation.

Design strategy and assessment: (0.5 point)

b. AHU room floor to be provided with epoxy coating to avoid algae and mould growth.

Note: The epoxy coating must be applied in strict accordance with the manufacturer's instructions, by an applicator trained and approved by the manufacturer. The key performance properties such as tensile strength, hardness, abrasion resistance etc. must comply with ASTM or equivalent standards. This item is not applicable to projects without AHUs or when AHUs are not located in rooms.

Documentation requirements:

Design Stage

- Tender specifications indicating the AHU room floor epoxy coating requirement.

Verification stage

- Product specifications/catalogue highlighting the epoxy coating and applicable performance properties.
- Photographs showing implementation.

3.3.3 Reduce risk of choke of condensate drain pipes (1 point)

Intent

Prevent choking of condensate drainpipe, thus avoiding frequent maintenance calls. To avoid operational issues to tenant and landlord ACMV equipment.

Design strategy and assessment: (0.5 point each)

a. The horizontal drain pipes must have minimum slope of 1:100 for easy flow of condensate drain.

b. Provide T-joint before terminating the individual drain pipe from AHU to the main drain stack for periodic cleaning.

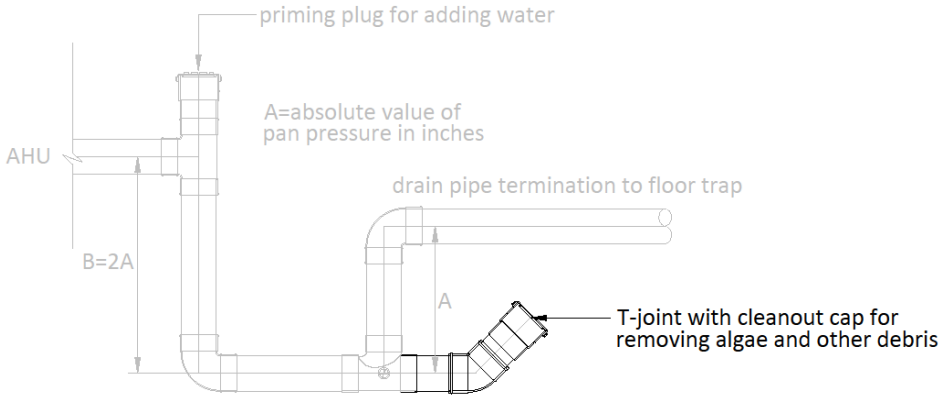


Figure 49: Typical detail for AHU drain termination

Note: This solution is only applicable when the condensate drain pipe for more than 1 AHU is connected to the same condensate stack. This will not be applicable if individual AHU discharges to floor trap.

Documentation requirements:

Design Stage

- Tender specifications indicating the condensate drain pipe slope requirement.
- ACMV typical detail drawing showing the drain termination and T-joint arrangement.

Verification stage

- As-built drawings/shop drawings showing the condensate drain pipe gradient
- Photographs showing the T-joint

3.3.4 Reduce frequency of replacement for AHU filters (2 points)

Intent

Prevent frequent replacement of filters and achieve operational cost savings.

Design strategy and assessment: (2 points)

a. **Provide differential pressure switch linked to BMS for real-time monitoring of filter choke condition. (0.5 point)**

Note: Differential pressure switch must be provided for both primary and secondary filter for PAHUs and AHUs. Items a to c will not be applicable to projects without AHUs.

b. **Specify fibre glass filter media with average initial resistance not greater than 90 Pa for primary filter (MERV 8 and ISO ePM10 50%) and 145 Pa (MERV 14 and ISO ePM1 80%) for secondary filter. (0.5 Point)**

Note: Synthetic media with initial static charge is not acceptable.

c. **Specify filters with better Life Cycle Cost for increased service life and lower cost of ownership. LCC should capture the key parameters such as "Total cost of ownership, service life, Energy consumption details and Indoor Air Quality performance". (1 Point)**

Note:

i. Total cost of ownership should be in Singapore dollars
ii. Energy consumption is based on 0.2 S$/KWH
iii. Indoor Air Quality must be complaint to ISO 16890/ ASHRAE 52.2:2017

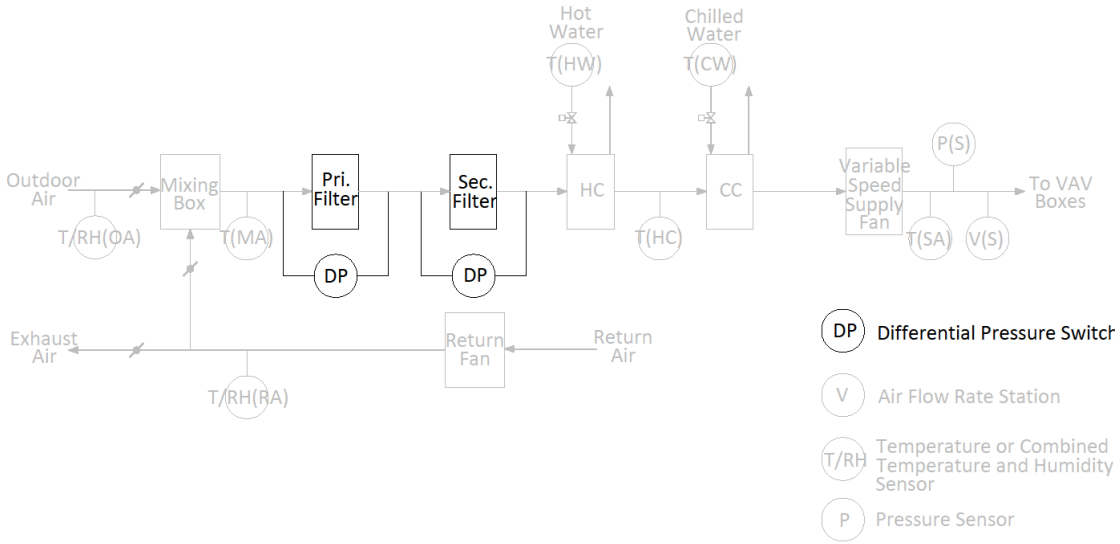


Figure 50: AHU diagram showing the differential pressure switch

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
1.5X-2X	40%-50%	40%-50%	1 year

Baseline design strategy: Conventional filters
Proposed design strategy: Filters with better LCC
Study period: 5 years
Yearly labour saving: 20-30% man-hour

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
3X	45%-50%	40%-45%	1 year

Baseline design strategy: AHU with periodic filter replacement
Proposed design strategy: AHU with filter replacement frequency based on pressure differential sensor
Study period: 10 years
Yearly labour saving: 20-30% man-hour

Documentation requirements:

Design Stage

- Tender specifications/ drawings indicating the filter type, initial resistance for primary and secondary filter.
- Typical filter selection with LCC computation
- Typical detail drawing/BMS point schedule showing the showing the provision of differential pressure switch.
- Tender specifications indicating the differential pressure switch requirement.

Verification stage

- Technical data sheet/ drawing showing the filter type, initial resistance for primary and secondary filter
- BMS point schedule showing the provision of differential pressure switch.
- Photographs showing the implementation.
- BMS screenshot showing the integration for real-time monitoring of the filter condition.

3.3.5 Avoid frequent re-alignment of fan parts i.e. pulley, bearings, and belts (2 points)

Intent

To avoid frequent alignment/failure of fan parts i.e. pully, bearings, and belts. To improve maintainability and reliability of the air handling unit.

Design strategy and assessment: (2 points)

a. **Specify AHU fan system with less moving parts (i.e. fans with direct drive system) for enhanced reliability and reduced downtime.**

Note: Points will be prorated for buildings with more than 75% of cooling capacity served only by FCUs. Spaces that are served by FCUs with pre-cooled fresh air from PAUs are not considered as spaces served only by FCUs.

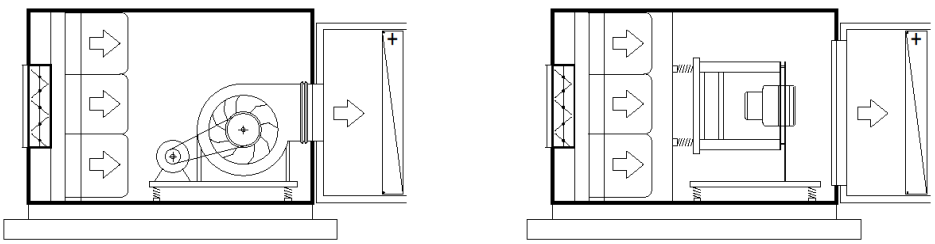


Figure 51: Conventional (left) and Direct Drive Fan system (right)

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
40%-45%	45%-50%	15%-20%	3-4

Baseline design strategy: AHU fans with belt driven
Design strategy: AHU fans with direct driven
Study period: 15 years
Yearly labour saving: 80%-90% man-hour

Documentation requirements:

Design Stage

- Tender specifications indicating the direct drive fans.
  Note: Applicable to all AHU's.

Verification stage

- Technical data sheet/catalogue showing the direct drive fan system which includes general arrangement (GA) drawing indicating the fan arrangement, number of fans etc.
- As-built equipment schedule indicating the direct drive fan system.
- O&M manual indicating the fan maintenance strategy report.

Worked Example 9:

A low-rise commercial building has been designed with air handling units (AHUs) serving the common areas and fan coil units (FCU) serving the retail units. Pre-cooled air from PAU is also provided to the retail units. The AHUs and PAU have direct drive fans.

Equipment capacity

Air Handling Units (AHUs)	200 kW
Pre-cooled Air Handling Unit (PAU)	150 kW
Fan Coil Units (FCUs)	550 kW

As the retail units are served by both FCUs and pre-cooled air from PAUs, they are not classified as spaces only served by FCUs.

In this case, the project will score **2 points** as direct drive fans are provided for the AHUs and PAU.

Worked Example 10:

A low-rise commercial building has been designed with air handling units (AHUs) serving the common areas and fan coil units (FCU) serving the retail units. Pre-cooled air is not provided to the retail units. The AHUs have direct drive fans.

Equipment capacity

Air Handling Units (AHUs)	200 kW
Fan Coil Units (FCUs)	700 kW

Proportion of cooling capacity served only by FCUs $= \frac{700}{700+200} = 77.8\%$

In this case, this item will be not applicable (NA) and the points would be prorated as the proportion exceeds 75%.

3.4 DOMESTIC WATER SUPPLY (0.5 point)

3.4.1 Access space for maintenance of water tank (0.5 point)

Intent

To provide adequate space for the safe and efficient maintenance of the water tank.

Design strategy and assessment: (0.5 point)

a. **Provide minimum clear width of 1.2 m access walkway to water tank from the nearest entrance.**

Documentation requirements

Design Stage

- Plumbing drawing/C&S drawing/specifications capturing the access space.

Verification Stage

- Shop/as-built drawing indicting the actual access space provisions.
- Photographs showing the space provision.

3.5 SANITARY SYSTEM (1.5 points)

3.5.1 Access provision to sanitary pipes and design detailing for ease of maintenance (1 point)

Intent

Good design practices that minimize the chance of choked sanitary pipe.

Design strategy and assessment: (1 point)

a. Specify hubless elbows for sanitary stacks with horizontal transfers.

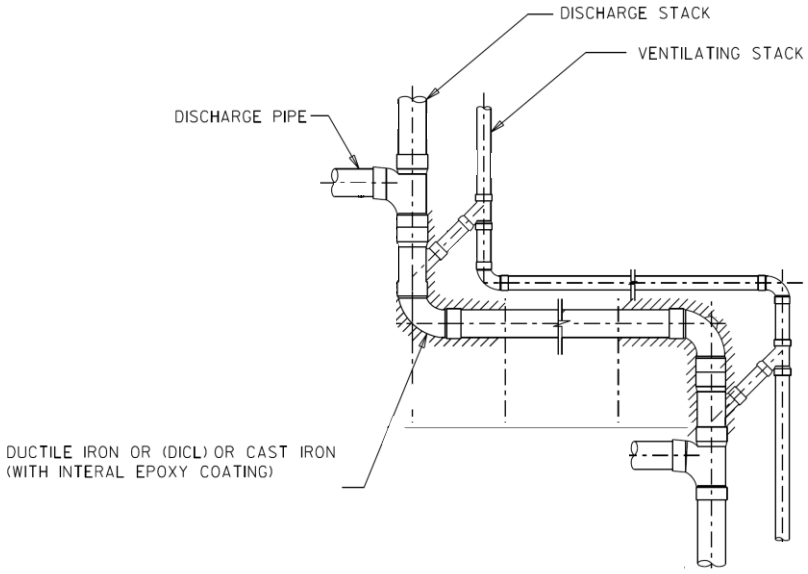


Figure 52: Hubless elbows for sanitary stacks with horizontal transfers

Documentation requirements

Design Stage

- Sanitary drawings showing the details of ductile iron or cast-iron elbows that are used for UPVC sanitary stacks with transfers.

Verification Stage

- As-built sanitary drawings showing the details of ductile iron or cast iron elbows that are used for UPVC sanitary stacks with transfers.

3.5.2 Reduce risk of chokes in the sanitary pipe (0.5 point)

Intent

To prevent chokes in the sanitary pipe.

Design strategy and assessment: (0.5 points)

a. **For buildings with food and beverage (F&B) units, the AHU condensate drain must not be linked to kitchen waste discharge pipes.**

Documentation requirements

Design Stage

- Sanitary tender drawings/specifications showing AHU condensate drain requirements.

Verification Stage

- Sanitary shop/as-built drawings showing the AHU condensate drain requirements.

3.6 Fire Protection System (3.5 points)

3.6.1 Prevent the lack of flexibility for maintenance and testing of sprinkler system (1.5 point)

Intent

To ease the maintenance and general testing of fire sprinkler system.

Design strategy and assessment: (0.5 point)

a. Locate the flow switch drain valve in rooms with floor trap (i.e. toilet, AHU room etc.).

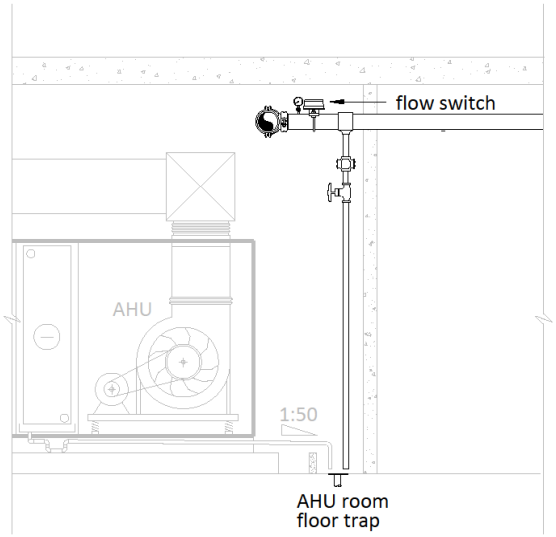


Figure 53: Flow switch drain valve in rooms with floor trap

Note: Items a and b will not be applicable to projects without sprinkle system.

Documentation requirements

Design Stage

- Fire protection system tender drawing/specifications showing the flow switch drain valve in rooms with floor trap.

Verification Stage

- Fire protection system as-built drawing showing the drainage arrangement.
- Photographs showing the implementation.

Design strategy and assessment: (1 point)

b. Provide smart feature such as the automatic flow switch testing system to automate the functional test for the fire sprinkler system.

Periodic inspection, testing, and maintenance of sprinkler system are essential for proper sprinkler function. A timely basis flow switch test is a requirement stipulated in CP52[29]. Conventionally during a routine test, water is discharged from the downstream end of the pipe, causing a drop in the pressure. This pressure difference across the flow switch generates a water flow causing the flow switch to operate. The conventional approach is labour intensive and costly. This solution recommends a simplified and automatic flow switch testing.

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
5X to 6X	95%-100%	55%-60%	6-7

Baseline design strategy: conventional flow switch testing system
Proposed design strategy: automatic flow switch testing system
Study period: 25

Documentation requirements

Design Stage

- Tech specifications showing the requirement on automatic flow switch testing system.

Verification Stage

- As-built fire sprinkler schematic drawing showing the details of automatic flow switch testing system.
- Photographs showing the implementation.

[29] CP 52: 2004 Singapore Standard, Code of Practice for Automatic Fire Sprinkler System

3.6.2 Reduce risk of damage and periodic replacement of fire-rated boards due to exposure to high humidity and water (2 points)

Intent

To prevent the damage and prolong the lifespan of fire-rated materials.

Design Strategy and assessment: (2 Points)

a. **Specify the use of weatherproof fire-rated materials for Fire Protection services such as wet/dry riser and hydrant pipes etc. (1 point)**
b. **Specify the use of weatherproof fire-rated materials for Mechanical Ventilation services such as kitchen exhaust ducts etc. (1 point)**

Note:

Item (a) is not applicable to projects where fire-rated materials are not used for fire protection services. Similarly, item (b) is not applicable to projects where fire-rated materials are not used for mechanical ventilation service.

This criterion applies to both indoor and outdoor fire-rated materials.

Documentation requirements

Design Stage

- Tender specifications showing the requirement on weatherproof fire-rated materials.
- Tender drawings indicating the location of weatherproof fire-rated materials

Verification Stage

- Product catalogue of weatherproof fire-rated materials
- As-built drawings indicating the location of weatherproof fire-rated materials
- Photographs of implementation
- PO/DO for the weatherproof fire-rated materials.

SECTION 4 - ELECTRICAL

4.1 LIGHTING SYSTEM (2 points)

4.1.1 Reduce frequency of light replacement (1 point)

Intent

To select more reliable light fittings for less frequent replacement.

Design strategy and assessment: (1 point)

a. **Use reliable light fixtures such as LED light (LM-80[30] B30 L70 @ L50,000) which requires less maintenance.**
LED life time (L value): the lifetime of LED module is defined as the time it takes until its light output, or lumen maintenance, reaches certain percentage of the initial output. L70 at 50,000 indicated 70% of the initial lumens that remains after end-of-life of 50,000 hours.
B value: The failure fraction for B_y expresses only the gradual light output degradation as a percentage y of a number of LED modules of the same type that at their rated lift designates the percentage (fraction) of failures. The value B30 indicates that the declared L-value will be achieved by minimum 70% of the LED modules and that the remaining 30% may have a lower lumen value.

LM-80 is the test standards which specified how LED manufacturer LED components to determine their performance over time.

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
45%-55%	20%-25%	5%-10%	2-3

Baseline design strategy: not reliable lighting at height
Proposed design strategy: LED with reliable drivers at height
Study period: 5 years
Yearly labour saving: 40%-50% man-hour

Note:

Points scored for 4.1.1b can be apportioned.

Documentation requirements

Design Stage

- Drawings/lighting specifications showing the light fixture specifications.

Verification Stage

- Technical data sheet and cut-sheet showing the light fixture specifications.

[30] IESNA-LM-80: IES approved method: measuring lumen maintenance of LED light sources

Worked Example 10:

A mid-rise office building has been designed with the following light fittings. Only 5W LED downlight selected comply with 4.1.1.b requirement.

Description	Type of lighting	Number of light fittings	Compliance
4.1.1b - Use reliable light fixtures such as LED light (LM80 B30 L70@ L50,000) which requires less maintenance.	3W LED downlight	300	No
	5W LED downlight	300	Yes
	10W LED downlight	400	No

- Total number of Light Fixtures = 1000 no's
- Total number of Light Fixtures comply with the solution= 300 no's

- Proportion of Light Fixtures comply with the solution $= \frac{300}{1000} = 30\%$

Total points scores = 0.3 x 1 = 0.3 point

Therefore, the final score after apportioning for section 4.1.1.b will be 0.3 point.

4.1.2 Reduce the risk of light flickering (0.5 point)

Intent

To use reliable electronic ballast/LED control gear to prevent premature failure which lead to light flickering.

Design strategy and assessment: (0.5 point)

a. **Specify constant DC output type LED driver complying with the following IEC standards to minimise flickering:**

   i) **IEC 62384**[31]

   Note: The standard specifies performance requirements for electronic control gear, the control gear modules specified in this standard are designed to provide constant voltage or current.

   ii) **IEC 61347 Part 1 and Part 2-13**[32]

   Note: The standard specifies general and safety requirements of LED driver which provides safety to the driver user.

b. **For non-LED light fixtures, use electronic ballast to cut off power supply to prevent flickering due to lamp failure.**

Note: The electronic ballast will cut off power to failed fluorescent tube which prevents flickering as in the case of magnetic ballast.

Worked Example 11:

A mid-rise office building has been designed with the following light fittings. Only 3W LED downlight and 12W fluorescent light selected comply with 4.1.2 requirement.

Description	Type of lighting	Number of light fittings	Compliance
4.1.2.a - Specify constant DC output type LED driver complying with IEC standards.	3W LED downlight	500	Yes
	10W LED downlight	400	No
4.1.2.a – For non-LED light fixtures, use electronic ballast to cut off power supply to prevent flickering due to lamp failure	12W T5 fluorescent light	100	Yes

- Total number of Light Fixtures = 1000 no's
- Total number of Light Fixtures comply with the solution= 600 no's
- Proportion of Light Fixtures comply with the solution $= \frac{600}{1000} = 60\%$

Total points scores = 0.6 x 0.5 = 0.3 point

Therefore, the final score after apportioning for section 4.1.2 will be 0.3 point.

[31] IEC 62384, DC or AC supplied electronic control gear for LED modules – performance requirement
[32] IEC 61347-1:2015, Lamp Control Gear –Part 1: General and Safety Requirements
IEC 61347-2-13: 2014, Lamp Control Gear: Part 2-13, Particular Requirements for d.c or a.c. Supplied Control Gear for LED Modules

Documentation requirements

Design Stage

- Tender drawings/specifications highlighting the compliance to IEC standards for LED light fittings and provisions of electronic ballast for non-LED light fittings.

Verification Stage

- Technical data sheet of LED light fittings stating the compliance to IEC standards and third-party test certificates. Technical data sheet of electronic ballast for non-LED light fittings.

4.1.3 Reduce the risk of LED light colour shift (0.5 point)

Intent

To use quality LED luminaire and light source to prevent LED premature failure/degrading.

Design strategy and assessment: (0.5 point)

a. **Specify LEDs tested to ANSI/IES LM-79-19 and LM-80-15 to ensure LED Performance.** [33,34] LED light sources are required designed and certified to meet specified operating hours and the LED performance when it is used in a luminaire. Colour shift often happens when the light output deteriorates. The colour shift is recommended to be less than 2-step MacAdam Ellipses across the lift time of the LED light fixtures.

Note:

Points scored for 4.1.3 can be apportioned.

Worked Example 12:

A mid-rise office building has been designed with the following light fittings. Only 3W LED downlight and 5W LED downlight selected comply with 4.1.3 requirement.

Description	Type of lighting	Number of light fittings	Compliance
4.1.3 - Specify LEDs tested to ANSI/IES LM-79-19 and LM-80-15 to ensure the LED performance.	3W LED downlight	300	Yes
	5W LED downlight	300	Yes
	10W LED downlight	400	No

- Total number of Light Fixtures = 1000 no's
- Total number of Light Fixtures comply with the solution= 600 no's
- Proportion of Light Fixtures comply with the solution $= \frac{600}{1000} = 60\%$

Total points scores = 0.6 x 0.5 = 0.3 point

Therefore, the final score after apportioning for section 4.1.3 will be 0.3 point.

[33] ANSI/IES-LM-79-19: Approved Method: Optical and Electrical Measurement of Solid-state Lighting Products
[34] ANSI/IES LM-80-15: Approved Method: Measuring luminous Flux and Color Maintenance of LED Packages, Arrays and Modules

Documentation requirements

Design Stage

- Tender drawings/specifications highlighting the requirements including the test standards IESNA LM-79-19 and LM-80-15.

Verification Stage

- Technical data sheet, cut-sheet and third-party test certificates indicated with the compliance with the specified standards/requirements.

4.2 POWER DISTRIBUTION (2.5 points)

4.2.1 Reduce risk of water Ingress into electrical room (0.5 points)

Intent

To prevent damage to electrical equipment inside the electrical room.

Design strategy and assessment: (0.5 point)

a. Electrical room must be raised by minimum 100 mm against the outside passageway.

Raising the switch room floor level against its external passage way will prevent water ingress and avoid severe damage to electrical panels. The water can come from regular washing of passage-way or rain if the switch room is facing external of a building.

(OR)

Provide minimum 100 mm plinth for floor mounted electrical switchboard.

Alternatively, to provide plinth for floor mounted switchboard if the switch room floor cannot be raised due to building design.

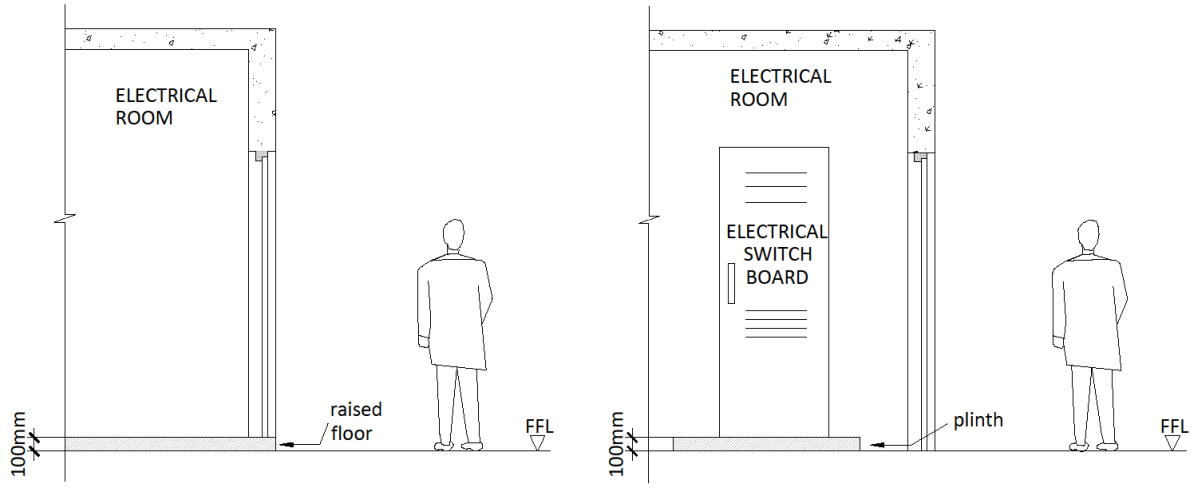


Figure 54: Raised electrical room (left) and switchboard plinth (right)

Documentation requirements

Design stage

- Tender specifications indicating the requirement.
- Drawings indicating the electrical room location and level with respect to passage-way.

Verification Stage

- Shop drawings/as-built section drawings indicating the electrical room location and level with respect to passage way.
- Photographs showing implementation.

4.2.2 Reduce risk of unnoticed failure of surge arrestor located in the LT main switchboard (1 point)

Intent

To prevent failure to equipment due to lightning surge.

Design strategy and assessment: (0.5 point for each item)

a. **Use of surge arrestor with discharge indicator.**
Surge arrestor must be provided for sensitive equipment to protect against voltage surges i.e. servers, digital measuring devices, and other electronic devices etc. Lightning surge can cause damage to sensitive equipment especially electronics. Using surge arrestor with discharge indicator makes it easier to be identified if it is discharged and required for replacement to ensure the equipment is protected against surge at all times. Refer to Figure 55 below for surge arrestor with indicators.

b. **Provide BMS monitoring for surge arrestor status.**
By connecting the surge arrestor with remote monitoring to the building BMS system, timely notification could be provided to user when the arrestor is discharged. Therefore, the replacement can be done quickly to ensure the equipment are always protected against surge. Refer to Figure 55 below for surge arrestor with remote monitoring for linking to BMS system.

Note: Item b will not be applicable to projects without BMS.

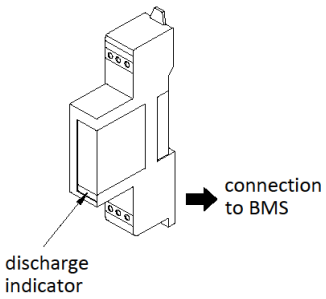


Figure 55: Surge arrestor with discharge indicator and remote monitoring

Documentation requirements

Design stage

- Tender specifications/drawings showing the discharge indicator requirement.
- BMS points schedule indicating the connection to BMS system.

Verification Stage

- As-built single line drawing and BMS points schedule showing the connection to BMS system.
- Photographs showing the discharge indicator and BMS configuration.

4.2.3 Reduce risk of failure of main LT switchboard due to overheating (1 point)

Intent

To prevent damage to switchboard due to overheating.

Design strategy and assessment: (0.5 point for each item)

a. **Install heat sensor in the main LT switchboard to alert any abnormal rise in temperature with audible/visual alarm.**

   Loose electrical connection will cause temperature at the connection to rise beyond normal operation temperature and if not rectify timely will cause damage to the equipment e.g. circuit breaker, cable etc. and may even cause fire if it is not detected early and rectified. Installing heat sensor in the switchboard with audio/visual alarm will provide timely alert whenever the temperature is risen beyond normal operating temperature. Such automatic alert system also eliminates the need for regular visual check and enhance FM productivity.

b. **Integrate sensor to building BMS system for online monitoring of temperature data.**

   Connecting the temperature sensor to BMS system must provide immediate notification of any abnormal increase in temperature and help in predicative maintenance. It improves FM productivity by reducing the regular physical checks.

   Note: Item b will not be applicable to projects without BMS.

Documentation requirements

Design Stage

- Tender specifications/drawings showing the heat sensor requirement.
  Tender specifications/drawings/BMS IO summary indicating the connection to BMS system.

Verification Stage

- Electrical panel technical data sheet/as-built single-line drawing indicating the heat sensor location.
- BMS points schedule indicating the temperature sensor connection to BMS system.

4.3 EXTRA LOW VOLTAGE SYSTEM (3.5 points)

4.3.1 Provide access space for CCTV camera located at heights (1 point)

Intent

To provide ease of access to camera for maintenance.

Design strategy and assessment: (1 point)

a. Provide access to cameras located at heights (≥ 3 m) i.e. foldable poles/arms

Safe and easy maintenance access must be provided for CCTV cameras located at heights. Traditionally, a high ladder is used to access the CCTV cameras which are manpower intensive and pose safety hazard. Instead, use of alternative maintenance provision such as foldable pole which can be lowered to a reachable height during maintenance. This will help to enhance FM productivity and manpower savings. Refer to Figure 56 for foldable pole and arm.

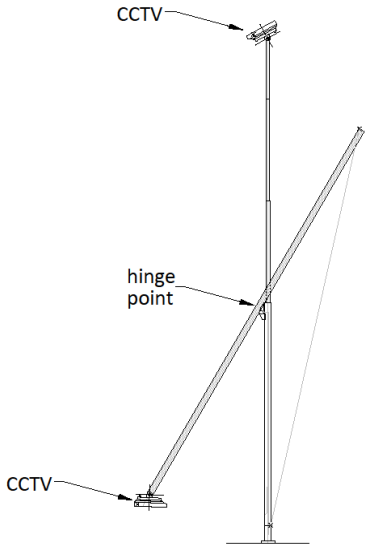


Figure 56: CCTV with foldable pole and arm

(OR)

b. Provide clear access route for mobile elevated work platforms (MEWP) to reach the camera for maintenance.

Clear and unobstructed access must be provided from the entrance to the location directly below the cameras. This clearance must include the height and width of entrance door as well as the clearance along the MEWP access path. The floor (loading and finishes) must be able to withstand the required MEWP to be deployed for the maintenance work. The deployment and operation of MEWP must comply with authority requirements. Refer to Figure 57 below for recommended clear access.

To provide clear access route of 1.8m width x 2m height and working base of 1.8 m width x 2 m length if the mounting height is less than or equal to 10.5 m. The actual clear access will depend on the proposed MEWP to be used and the manufacturer's recommended clearances through the access way.

To provide clear access route of 2 m wide x 2.8 m height and working base of 2 m width x 2 m length if the mounting height is greater than 10.5 m. The actual clear access will depend on the proposed MEWP to be used and the manufacturer's recommended clearances through the access way.

Note: Items a and b will not be applicable to projects without CCTV system.

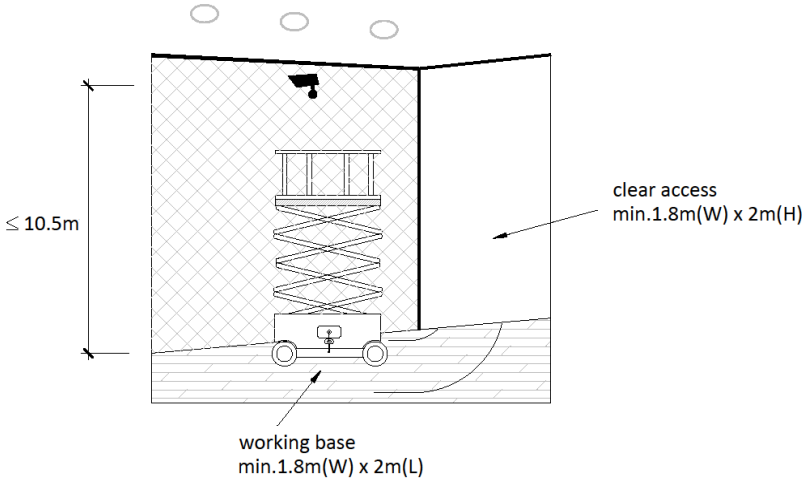


Figure 57: Clear access for CCTV with mounting height ≤10.5m

Documentation requirements

Design Stage

- Electrical layout plan showing the alternative access provisions.
- Tender specifications indicating the access provisions (i.e. foldable poles/arms etc.) or MEWP clear access route from entrance door.

Verification Stage

- As-built drawings/shop drawings showing the access provisions.
- Technical data sheet/cut sheet of foldable poles/arms highlighting the key maintainability features.
- Technical data sheet/cut sheet of MEWP with access route marking.
- Photographs showing implementation.

4.3.2 Provide flexibility for future expansion for CCTV system (1.5 point)

Intent

To make provision for ease of future expansion.

Design strategy and assessment: (0.5 point)

a. **Provide minimum 20% spare capacity in network switch to cater for future expansion.**

It is common to add new cameras while the building in operation over its life span. Lack of spare capacity in network switch may end up adding or replacing existing equipment in order to cater for the expansion. Hence it is recommended to provide at least 20% spare capacity in network switch to facilitate future addition of cameras without having to replace the existing equipment.

Note: Items a and b will not be applicable to projects without CCTV system.

Documentation requirements

Design Stage

- Tender specifications/drawings indicating the spare capacity requirement.

Verification Stage

- Shop drawing /as-built drawing indicating 20% spare capacity in the network switch for future expansion.

Design strategy and assessment: (1 point)

b. **Design that allows for future addition of data storage (either local or cloud base data storage)**

Addition of new cameras would lead to more data storage required, hence the system must have the flexibility to add more data storage to cater for future expansion. Alternatively, additional storage can be cloud base depending on the security policy. Such provision for future storage expansion would eliminate the need to replace the existing equipment due to expansion requirements.

Documentation requirements

Design Stage

- Tender specifications/drawings showing the requirement of future addition of data storage.

Verification Stage

- As-built drawings/shop drawings, technical data sheet, T&C forms etc. showing the implementation.

4.3.3 Reduce risk of damage to outdoor camera and other equipment due to lightning surge (1 point)

Intent

To prevent damage to equipment due to lightning surge.

Design strategy and assessment: (1 point)

a. **Provide surge arrestor to all outdoor cameras**
CCTV cameras installed outdoor for external surveillance are subjected to lightning surge damaging the CCTV system leading to maintenance and safety issues. By adding lightning surge arrestor to the equipment, it will protect the camera from damaged by lightning surge.

Note: The surge protection must be provided at power source and/or network switch. This item will not be applicable to projects without CCTV system.

Documentation requirements

Design Stage

- Tender specifications showing the surge arrestor requirement.

Verification Stage

- As-built schematic drawing showing the surge arrestor requirement.

4.4 LIGHTNING PROTECTION SYSTEM (1 point)

4.4.1 Reduce risk of damage of air termination tape at roof parapet wall due to operation of facade maintenance systems such as gondola (1 point)

Intent

To prevent damage to lightning tape at roof top parapet wall.

Design strategy and assessment: (1 point)

a. **Avoid damage to the lightning protection system by proper design and installation of facade maintenance system.**

   The design of gondola system which will prevent its parts (be it fix structure or suspension steel rope) from damaging the lightning tape which is mounted on the parapet wall. It is recommended to provide sufficient if any of the gondola structure or supporting system is to be installed over the lightning tape.

Documentation requirements

Design Stage

- Tender specifications/façade access system drawings showing the requirement.

Verification Stage

- As-built lightning protection system and façade access system drawings indicating the lightning protection strip interfacing with façade access systems.
- Photographs showing the implementation.

4.5 VERTICAL TRANSPORTATION (1.5 point)

4.5.1 Access to lift motor room for maintenance (0.5 point)

Intent

To provide adequate access for safe and efficient lift maintenance.

Design strategy and assessment: (0.5 point)

a. Provide permanent access (staircase with handrail) to the lift motor room

Access to the lift motor room must be considered during building design stage and unobstructed access way must be provided to the motor room for regular maintenance and repair.

Typically, the entrance to a lift motor room is via service corridor or direct access from roof level. In special cases while there is height difference (>350 mm) from the finished floor level of the corridor to the entrance of the lift motor room, permanent stairs must be provided to the lift motor room. The design must ensure the access path is not obstructed by other services.

Note: This item will not be applicable to projects without lift motor rooms.

Documentation requirements

Design Stage

- Tender specifications/drawings showing the location of lift motor room and access provision from the nearest corridor/access stairs.

Verification Stage

- As-built drawings/shop drawings indicating the access provisions.
- Photographs showing the implementation.

4.5.2 Reduce lift downtime and enhance reliability (1 point)

Intent

To provide predictive maintenance for lift, improve the efficiency, and reduce the manpower requirement for lift maintenance.

Design strategy and assessment: (1 point)

a. Provide lift predictive maintenance.

Provide for real time monitoring of the lift operation and parts/components status to predict if any components would eventually lead to breakdown. Monitor key parameters such as vibration, acceleration, levelling, door jams, gaps, noise, jerk etc.

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
100% (No provision for baseline)	50%-55%	Up to 5%	13-14

Baseline design strategy: reactive maintenance for lift
Proposed design strategy: predictive maintenance for lift
Study period: 15 years
Yearly labour saving: 40%-50% man-hour

Documentation requirements

Design Stage

- Tender specifications/drawings showing the requirement for the provision of IoT-based infrastructure and lift predictive maintenance.

Verification Stage

- Lift maintenance contract showing the IoT based predictive maintenance.
- System architecture showing the integration of IoT based infrastructure and real-time monitoring.

SECTION 5 – LANDSCAPE

5.1 SOFTSCAPE (2 points)

5.1.1 Reduce labour-intensive irrigation for landscape (2 points)

Intent

To improve the operational efficiency of landscape irrigation, through optimal selection of systems and materials.

Design strategy and assessment: (0.5 point)

a. Design for water points with maximum 20 m radius from each point.

Note: This is for back up if auto-irrigation fails or is undergoing maintenance. Maximum radius of water point helps in managing weight of hose better.

Documentation requirements

Design stage

- Tender drawings (plan) indicating the location of water points with coverage radius for all landscape areas.

Verification stage

- As-built (construction) drawings to show implementation.
- Photographs showing the tap points in the landscape area.

Design strategy and assessment: (1.5 points)

b. Specify rain sensor and auto-irrigation with timers.

Note: Scheduled auto-irrigation systems provide precise coverage, eliminating concerns of over or underwatering the landscape and thereby reducing the manhour required for irrigation.

Documentation requirements

Design stage

- Tender specification indicating auto irrigation system (surface/sub-surface) along with timers.
- Plan drawing showing overall landscape area along with the type of irrigation system.
- Calculation showing the percentage of the landscape area that would be served using the system.

Verification stage

- As-built (irrigation shop drawings) showing the extent of the irrigation systems.
- Photographs of completed works highlighting auto irrigation systems (implementation photographs for sub-surface irrigation systems).

Design strategy and assessment: (1 point)

c. Specify auto-irrigation with timers.
(Points cannot be scored if project has already scored for solution (b))

Note:

- *Once the rain sensor activates due to sufficient rainfall, the selected zones of auto irrigation system with timers, will remain inactive until the hygroscopic discs inside the sensor have dried out. This dry out rate will be about the same as the soil drying rate and re-activated once the disc is dry again. The dry out rate can be set to different levels. After the rain sensor dries out, the controller will resume its normal watering schedule.*[35]

- *The rain sensors must be exposed to unobstructed rainfall as per the PUB water efficiency guidebook.*

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental Cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
2.4X - 2.5X	65% - 70%	Up to 5%	4 - 5

Baseline design strategy: Manual irrigation
Proposed Design strategy: Surface drip-tubing auto irrigation with timers
Study period: 5 Years
Yearly labour savings: 80% - 90% man-hour savings

Documentation requirements

Design stage

- Tender specification indicating rain sensor and auto irrigation system (surface/sub-surface) along with timers.
- Plan drawing showing overall landscape area along with the type of irrigation system.
- Calculation showing the percentage of the landscape area that would be served using the system.

Verification stage

- As-built (irrigation shop drawings) showing the extent of the irrigation systems.
- Photographs of completed works highlighting auto irrigation systems (implementation photographs for sub-surface irrigation systems).

[35] PUB, Best practice guide in water efficiency – Buildings

Design strategy and assessment: (+1 bonus point)

Advanced effort: Implement remote monitoring system for landscape irrigation along with water metering for irrigation (+1 bonus point)

Note:

- *Irrigation system must be linked to BMS for remote monitoring of water consumption, leak detection and system status (i.e. system on/off, trip status, auto/manual status).*
- *Remote monitoring helps in efficient facility management with reduced manpower.*

Documentation requirements

Design stage

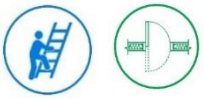
- Tender specification/BMS I-O summary indicating the integration of auto irrigation system and remote monitoring capabilities.

Verification stage

- Shop drawing/ final I-O summary indicating the integration of irrigation system with the BMS along with separate water metering for irrigation.
- Screenshot indicating the BMS dashboard that includes water consumption and schedule for irrigation.

5.2 HARDSCAPE (3 points)

5.2.1 Access for maintenance of underwater lighting systems (1 point)



Intent

To ensure ease of access for maintenance of underwater lighting systems through appropriate design & detailing.

Design strategy and assessment: (1/0.5 point)

a. For shallow water bodies, design for easily replaceable lighting system along the inside perimeter of the structure, and

i. above the water line. (1point)

Note: Consider lighting fixture to be within arm's length from the point of access for ease of maintenance.

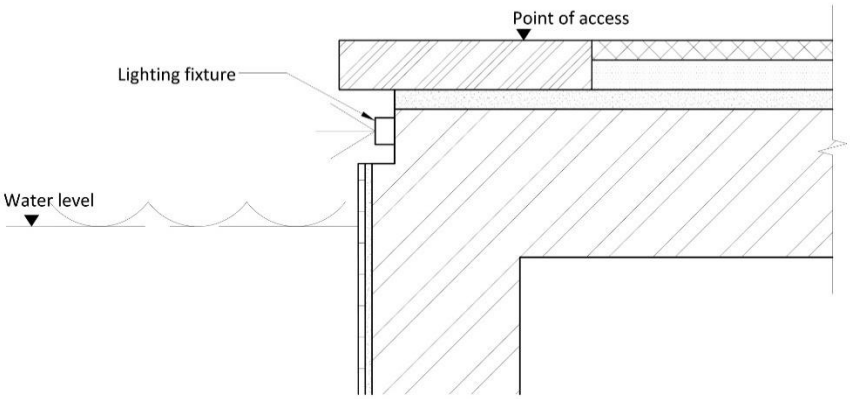


Figure 58 – Section showing example of lighting system located outside the water

ii. within a depth of 500mm below the waterline (calculated from base of light to finished floor level for in-ground water bodies/ to point of access for above-ground water bodies) (0.5 point)

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental Cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
90% – 100%	60% - 65%	Up to 5%	7 - 8

Baseline design strategy: Lighting fixture with integrated driver submerged within water (installed within 500mm depth along the perimeter of water body)
Proposed design strategy: Lighting fixture with integrated driver above water line
Study period: 10 Years
Yearly labour savings: 30% - 40% man-hour savings

Documentation requirements

Design stage

- Tender drawings (plan and section) indicating the location of the lighting fixtures.

Verification stage

- As-built (construction) drawings to show the implementation.
- Photographs of completed works.

5.2.2 Reduce risk of damage/degradation to outdoor landscape furniture (up to 1 point)

Intent

To reduce the frequency of repair and replacement of weather-exposed furniture, through optimal selection of materials.

Design strategy and assessment: (1 point)

a. Specify for engineered wood with water absorption rate not exceeding 0.5%.

Note:

- *As an alternative to natural wood, engineered wood offers a practical middle ground and can be used to replace timber in outdoor applications. Due to its inherent characteristics such as resistant to weather, moisture and termites and low maintenance, they are used widely as a substitute for natural wood.*[36]
- *The selected engineered wood should comply with ASTM D1037-93.*
- *This criterion assesses outdoor decking and fixed furniture, including those within standalone structures.*

Documentation requirements

Design stage

- Tender specification indicating engineered wood along with maximum water absorption rate.
- Plan drawing highlighting the location of application.

Verification stage

- As-built (landscape) drawings to show implementation.
- Relevant technical specification on the maximum water absorption property of the material.
- Delivery order for the selected material.

Design strategy and assessment: (1 point)

b. Specify for anti-corrosion coating or aluminium or stainless steel for metal selections.

Note:

- The selected anti-corrosion coating should comply with ISO 12944-2018 Corrosivity Category C3 , Durability High

- *Stainless Steel Grade should minimally be SS 304*

Documentation requirements

Design stage

- Tender specification indicating the type of metal and/or anti-corrosion coating complying with Iso 12944 corrosivity category 3.
- Plan drawing showing the location of application.

[36] BCA Good industry practices, Composite fibre plastic material chapter 11, Page 82

Verification stage

- As-built (shop drawings) to show implementation.
- Relevant technical specification of the selected anti-corrosion coating complying with ISO 12944 corrosivity category 3.
- Delivery order of the selected metal selections.

Worked Example 13:

A hospital has an outdoor healing park that is opened to the public, patients and staff. A total of 20 wooden benches made of balau wood have been provided as part of the landscape design and is placed at various spots in the park. As part of the overall park upgrade, 18 of these benches placed at resting spots would be undergoing upgrading works to replace them with benches made of reconstituted wood. The remaining 2 of such existing benches located near the water fountain would instead be retained.

The hospital development is an existing building with alteration works done, as such it will be required to submit documents at both stages of design and verification.

Documentation requirements*:*

APPLICABILITY	Balau wood benches*	Engineered wood benches
STATUS	Existing	Upgrading
DESIGN STAGE	N.A.	5.2.2a. Specify for engineered wood with water absorption rate not exceeding 0.5%. • Tender specifications of engineered wood benches and its maximum water absorption rate • Plan drawing highlighting the location of application 5.2.2b. Specify for anti-corrosion coating or stainless steel or aluminium for metal selections** • Tender specification indicating the type of metal and/or anti-corrosion coating. • Plan drawing showing the location of application.
VERIFICATION STAGE	5.2.2a. Specify for engineered wood with water absorption rate not exceeding 0.5%. • As built (landscape) drawings showing implementation of the engineered wood benches • Technical material specification showing the maximum absorption property of the engineered wood • Delivery order for the used engineered wood benches 5.2.2b. Specify for anti-corrosion coating or stainless steel for metal selections N.A. *(The benches do not meet the solution (b), hence there will be no documentation requirement)*	

** Under the assessment category of Cat 2, no assessment is required if the proportion is <15%. As such, since the existing benches made of balau wood is only 10% of all outdoor benches, it will not be considered for assessment.*

Proportion of outdoor benches made of reconstituted wood
= 100% (≥15%)

NOTE: *Under the assessment category of Cat 2, full points will be scored when the proportion of one item is >85%. Hence, the use of benches made of reconstituted wood, which is 90% of all outdoor benches, will score 100% of the points.*

5.2.2 Reduce risk of damage/degradation to outdoor landscape furniture (up to 0.5 point)	Points	Assessment category	**Used in Project**	**Points Scored**
a. Specify for engineered wood with water absorption rate not exceeding 0.5%.	1	Cat 2	√	100% * 1 = 1
b. Specify for anti-corrosion coating or stainless steel for metal selections.	1	Cat 2	×	0
Score for 5.2.2 in hardscape =				1

The total sub-points for ***5.2.2 under Hardscape*** = 1 point

5.2.3 Ensure access for maintenance beneath decking (1 point)

Intent

To ensure ease of access for maintenance of services beneath deck, through appropriate design & detailing.

***Eligibility criteria**: The outdoor deck area for assessment must be minimally 30sqm within the project boundary to be considered for evaluation.*

Design strategy and assessment: (1 point)

a. Design decks with demountable fixture system for maintenance of services beneath and for general cleaning.

Note: The entire deck area must be demountable for maintenance.

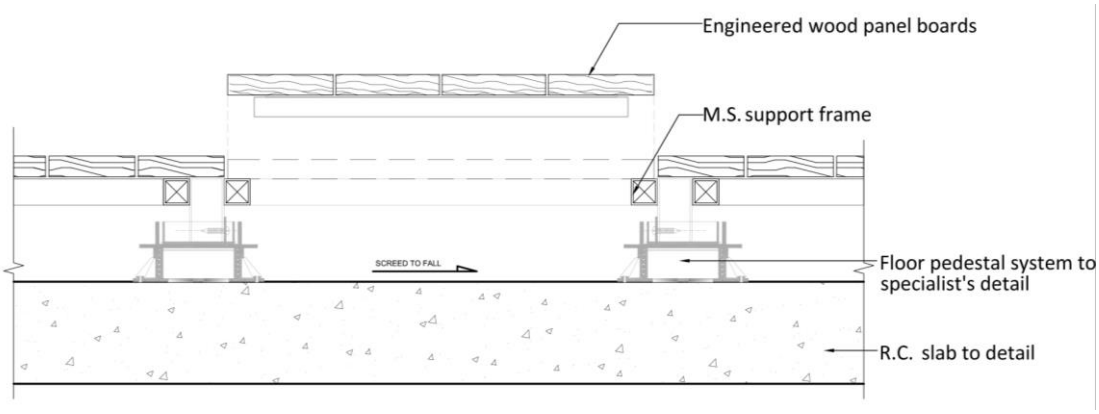


Figure 59 - Typical section showing demountable fixture deck system

Documentation requirements

Design stage

- Tender drawings (plan and section) indicating the decking system along with fixing methodology for demountable strategies.

Verification stage

- As-built (shop drawings) to show implementation.
- Photographs showing sample of the deck in demountable position.

5.3 VERTICAL GREENERY (0.5 point)

5.3.1 Access to all parts of vertical greenery for maintenance and replacement of perished plants (0.5 point)

Intent

To ensure ease of access for safe and efficient maintenance of vertical greenery.

Design strategy and assessment: (0.5 point)

a. Provide maintenance access to all vertical greenery both indoor and outdoor, e.g. catwalk, ladder, access corridor, MEWP, etc.

Note:

- *Landing surface/space must be level, stable and dimensionally adequate for safe, and effective deployment of equipment[37].*
- *The frequency of maintenance tasks as well as the need for safety features – such as maintenance access, anchorage points and safety lines – should be considered in the façade greenery design.*
- *For maintenance walkways, consider a minimum width of 600mm.*
- *Avoid use of scaffolding as an access strategy.*

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental Cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
45% - 50%	85% - 90%	45% - 50%	5 - 6

Baseline design strategy: Green wall access through MEWP
Proposed design strategy: Green wall access using permanently installed metal catwalk
Study period: 30 Years
Yearly labour savings: 60% - 70% man-hour savings

Documentation requirements

Design stage

- Plan/elevation/schematic drawings demonstrating access and working clearance for MEWP at the location. Please refer to BCA's façade access design guide for more details on the submittals.

Verification stage

- Extract from maintenance strategy report indicating MEWP's access and working clearance.

[37] CS E11:2014 Guidelines on Design for Safety of Skyrise Greenery, NParks Centre for Urban Greenery & Ecology, 2014

5.4 ROOF AND SKY TERRACCES, PLANTER BOXES ON BUILDING EDGE/FACADE (2.5 points)

5.4.1 Access for landscape on roof and sky terraces (2 points)

Intent

To ensure ease of access for safe and efficient maintenance of landscape on roof top and sky terraces.

Design strategy and assessment: (0.5 point)

a. Provide direct maintenance access to landscape on all roof and sky terraces.

Note:

- *Direct maintenance access refers to lift access with or without last-mile stairs to roof/sky terrace.*
- *Service lift to roof/sky terrace floors, should be designed with spatial and loading capacity to facilitate transport of access equipment and other materials for maintenance.*[38]

Documentation requirements

Design stage

- Tender drawings (plan and section) showing the access to roof for landscape maintenance.

Verification stage

- As-built drawings to highlight the maintenance access.

Design strategy and assessment: (0.5 point)

b. For planters more than 1.8m wide, provide minimally 300 mm obstruction free maintenance pathway inside the planter box.

Note: Avoid loose stones or pebbles for the pathways as it may pose safety hazard.

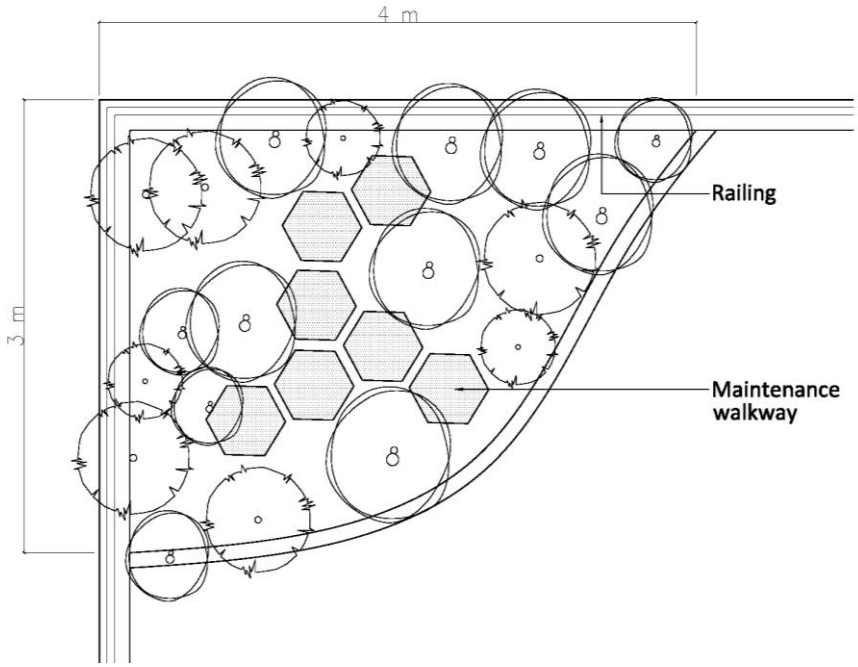


Figure 60 - Maintenance walkway for planter box more than 1m wide

[38] BCA Façade access design guide, 4.1 Roof Access, 4.1.1 Vertical access to roof

Documentation requirements

Design stage

- Tender drawings (plan and section) showing extent of planter box and obstruction free maintenance pathway.

Verification stage

- Photographs showing the path inside the planter box.

Design strategy and assessment: (1 point)

c. For trees: Provide 5 m clear pathway from building edge to tree trunk.[39]

Note: For infant trees, the expected height is to be mentioned in the design stage.

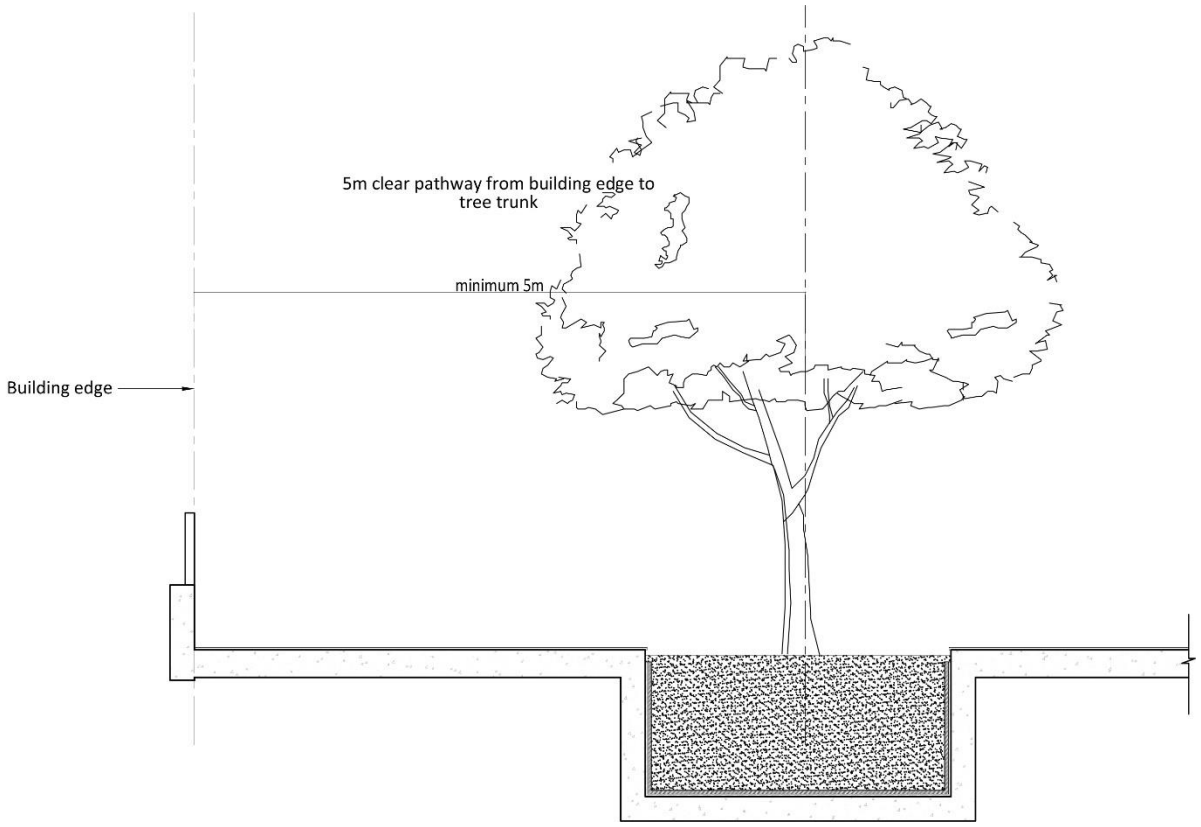


Figure 61 - Typical section showing buffer zone required for trees

Documentation requirements

Design stage

- Tender drawings (plan and section) showing the clear maintenance pathway of 5m for trees from the inner side of the building edge.

Verification stage

- As-built drawings showing the maintenance pathway.
- Photographs highlighting the distance from the tree trunk to the building edge.

[39] Handbook on developing sustainable high-rise gardens – Safe design of trees on rooftop. pg24
CS E09:2012 Guidelines on Planting of Trees, Palms and Tall Shrubs on Rooftop, 2.2.1

5.4.2 Access to planter boxes on building edge (Up to 1 point)

Intent

To ensure ease of access for safe and efficient maintenance of landscape on building edges.

Design strategy and assessment: (1 point)

a. **Provide minimally 600 mm access walkway to planter boxes for maintenance (1 point)**
(OR)
Provide minimally 450 mm access walkway to planter boxes for maintenance (0.5 point)

Note:
- *Consider providing access from non-tenanted spaces.*
- *Safety line and guard rail must be provided as per guideline.*[40]

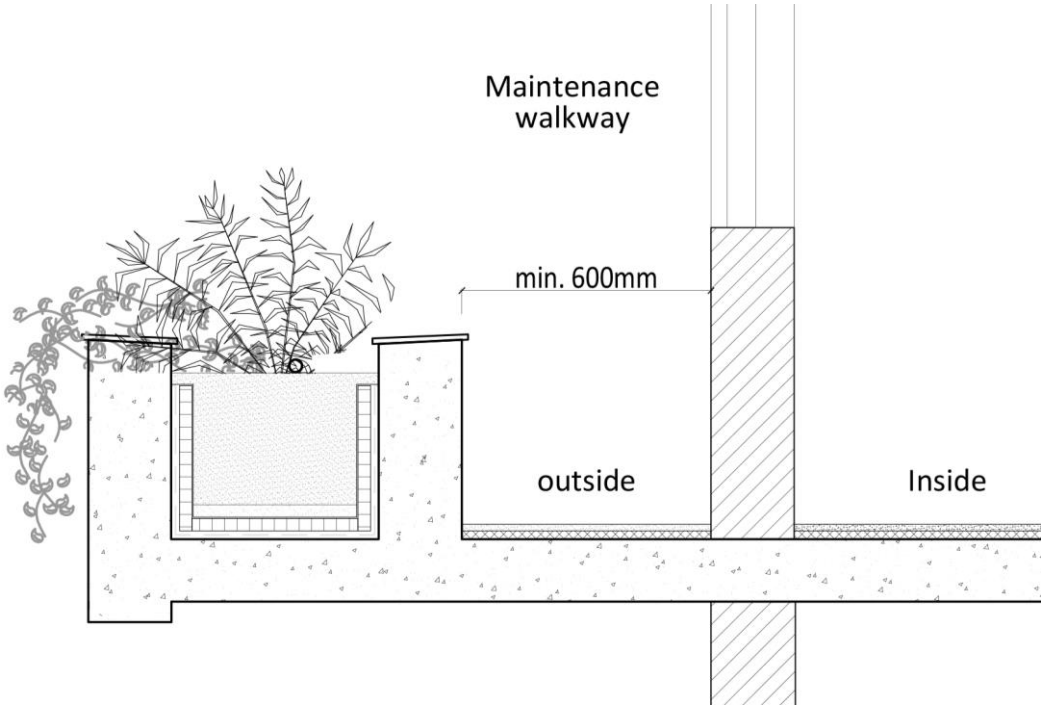


Figure 62- Planter box with maintenance walkway

Documentation requirements

Design stage

- Tender drawings (plan and section) showing the planter box and the provision of accessibility pathway for landscape maintenance.

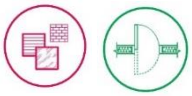
Verification stage

- As-built drawings to show implementation.
- Photographs of the completed works indicating the maintenance access.

[40] Workplace Safety and Health Guidelines

5.5 Standalone Structure (2 points)

5.5.1 Reduce water ponding and degradation of outdoor standalone structures, e.g. pavilions (up to 1 point)



Intent

To reduce the frequency of repair and replacement of outdoor standalone structures through optimal selection of materials and appropriate design & detailing.

Design strategy and assessment: (0.5 point)

a. **Design for outdoor standalone structure's roof slope to be gentler than 15 degrees for efficient water run-off.**

Note: The above gradient of 15 degrees is indicative. Designers may propose alternative gradients to meet the intent of effective water drainage.

Documentation requirements

Design stage

- Tender drawings (plan and section) showing the location of the outdoor standalone structure and slope of the roof.

Verification stage

- As-built drawings to show implementation.
- Photographs of completed works.

Design strategy and assessment: (0.5 point)

b. **Design to avoid direct contact of steel base with the ground (raised by at least 100 mm) to prevent corrosion and entrapment of moisture and dirt.**[41]
Example - Protect steel bases at ground by providing conical concrete upstand in water ponding areas.
(Point cannot be scored if already scored in solution 1.5.2)

[41] Reference BS EN 12944-3, www.steelconstruction.info

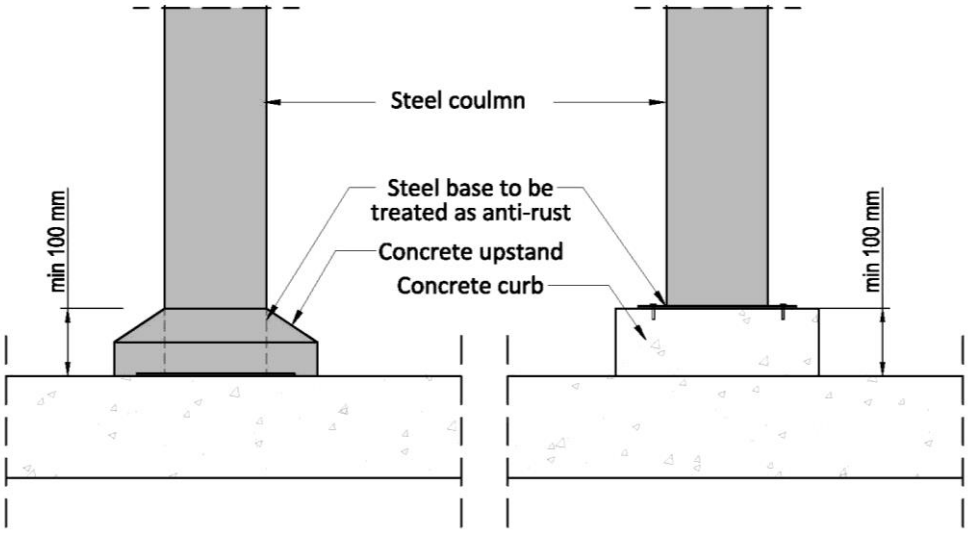


Figure 63 - Concrete upstand protection for steel base

Documentation requirements

Design stage

- Tender drawings (plan and section) showing the location of the vertical structural support and the weather protection detailing.

Verification stage

- As-built drawings to show implementation.
- Photographs of completed works.

5.5.2 Reduce risk of warping / deterioration of ceiling panel systems on standalone structure (up to 1 point)

Intent

To reduce frequency of repair and replacement of weather-exposed ceiling panels on standalone structure through optimal selection of materials.

Design strategy and assessment: (1 point)

a. Specify suspended metal panel modular ceiling system, e.g. baffle metal panels and metal mesh panels.

Note:

- Panels should be designed to prevent sagging and withstand wind loads.
- Panels should be sized such that they can be easily handled by one person.

Life cycle cost analysis: baseline design strategy vs proposed design strategy

Incremental Cost	Yearly operation and maintenance cost saving	Total life cycle cost saving	Simple payback (years)
45% - 50%	75% - 80%	Up to 5%	8 - 9

Baseline: Moisture resistant monolithic gypsum ceiling board
Design strategy: Metal panel suspended modular ceiling
Manpower savings: 90 - 100% man-hour savings

Documentation requirements

Design stage

- Tender specification indicating the type of metal suspended modular ceiling panel.
- Reflected ceiling plans showing the extent of metal false ceiling.

Verification stage

- As-built drawings showing the extent of implementation.
- Relevant technical material specification for the selected metal panel ceiling and the anticorrosion property of the material.
- Delivery order for the selected ceiling panels.
- Photographs of completed works.

Design strategy and assessment: (1 point)

b. Specify moisture-resistant suspended non-metallic modular ceiling panels with water absorption rate not exceeding 5%.

Note: Water absorption rate indicates how much moisture a specific material is likely to absorb. Ceiling panels with lower water absorption rate absorbs less moisture and are less prone to deterioration. The selected ceiling panel should comply with ASTM C473 for the water absorption test.

Documentation requirements

Design stage

- Tender specification indicating the moisture resistant material and maximum water absorption rate for suspended ceiling panel.
- Reflected ceiling plans showing the extent of the moisture-resistant false ceiling.

Verification stage

- As-built drawings to show the extent of implementation.
- Relevant technical material specification or product performance test results for the moisture resistant property of the ceiling panel for the water absorption rate.
- Photographs of completed works.

Design strategy and assessment: (1 point)

c. Specify for open ceiling design.

Documentation requirements

Design stage

- Tender specification indicating the open ceiling system for the selected areas.
- Reflected ceiling plans showing the extent of open ceiling.

Verification stage

- As-built drawings to show implementation.
- Photographs of completed works showing the open ceiling spaces.

SECTION 6 – SMART FM – Innovative Solutions

6.1 CYBER SECURITY (APPLICABLE TO BOTH BMS AND FMS SYSTEM) (up to 1 point)

6.1.1 Lack of Cyber security leading to data theft and economic impact (up to 1 point)

Intent

To provide enhanced protection to internet-connected system and protect organisations against cyber threats

Design strategy and assessment: (0.5 point)

a. Implement a risk-based cyber security assessment conducted by building owner's IT department/cyber security consultant

Building OT system i.e., BMS and FMS system must be governed by Information Security Management System ("ISMS"). These are some basic cyber security requirements that should be included in the ISMS;

i) Minimum of two network tiers for BMS and FMS – web/application tier ("demilitarised zone or DMZ") and data tier separated by firewall that appropriately configured to block direct access to database from external network.

ii) Up-to-date anti-virus software in all machines.

iii) Firewalls to assess communication with 3rd-party services.

iv) Encryption of critical data at rest (stored data) and data in transit (transmitted data);

v) User access must have Individual user authentication and multi-level grouping to regulate the access. The login authentication to be password protected.

vi) Conducting of regular Vulnerability Assessment & Penetration Testing ("VAPT") and remediation of all critical, high and medium security issues; VAPT should minimally cover the latest OWASP Top 10 vulnerabilities.

vii) System audit log or audit trail to record data changes and system access.

viii) Install two-factor Authentication.

Note:

i) Risk assessment involves taking steps to understand any flaws or vulnerabilities in the network and steps taken to remediate the threat. The above-mentioned list of key cyber security provisions is non-exhaustive. Building owner/cyber security consultant to evaluate the building specific cyber security requirements.

Documentation requirements

Design Stage

- Company's IT policy capturing the risk-based cyber security assessment requirement for BMS AND/OR FMS system.

Verification Stage

- Risk-based cyber security assessment report highlighting the key risks, proposed cyber security framework and formulate remediation steps.

Additional recommendation for guidance:
The typical cyber security risk assessment report should include following steps;

i) **Take inventory of systems and devices** – *the report should document all device that are connected to the network i.e., computers, servers, routers, printers, API's etc. Any hardware that is linked to the data network can potentially become the source of a cyber intrusion.*

ii) **Identify potential weaknesses and threats –** *Assessing the different cyber-attacks that potentially target the system network must be thoroughly validated. Potential threats include:*
- *Unauthorized access to your network*
- *Misuse of information or data leakage*
- *Failed processes*
- *Data loss*
- *Disruption of service*

iii) Determine the risk impact - List all potential risks and rate them on a scale of low, medium, and high risk.
- Low-risk items might include servers that contain public information but no private data and where such servers are connected to an in-house network.
- Medium-risks items might be related to offline data storage at a specific physical location.
- High-risk items might include payment or customers' personal information stored in cloud software

iv) Develop and set cybersecurity controls – With the understanding of the potential risk, set-up security controls and protocols which can greatly reduce risks and improve compliance. The security controls include some of the solutions listed above.

v) Evaluate the effectiveness and repeat – Conduct the cybersecurity risk analysis at least annually to ensure that the cyber security controls are Upto date. Also, it is recommended to conduct regular Vulnerability Assessment & Penetration Testing ("VAPT") and remediation of all potential threats; VA to minimally cover the latest OWASP Top 10 vulnerabilities

Additional resources: https://securityscorecard.com/blog/how-to-perform-a-cyber-security-risk-analysis

Design strategy and assessment: (1 point)

b. The organisation is assessed by an independent party and certified to comply with 1 of the following certifications;

a. **ISO 27001**, the International Information Security Standard
b. **SOC 2** certification, American Institute of Certified Public Accountants.
c. **IEC 62443**, Industrial communication networks - IT security for networks and systems.

Documentation requirements

Verification Stage

- Certificate issued by the independent party.

6.2 Adoption of Smart FM Solutions (10 Points)

6.2.1 Adopt innovative technologies that improve FM labour efficiency and service delivery (up to 3 points)

Intent

To use innovative technologies to improve operational efficiency and reduce maintenance cost. Solution scored for should be supported by measurable improvement in FM process (e.g., in productivity, cost and manpower savings, customer satisfaction, service delivery etc).

Design strategy and assessment: (up to 3 points)

a. Type 1 – Use of digitised workflow automation to streamline the workflow, productivity and service delivery (1 point each):

Digitalized Workflow Automation: When triggered by a feedback or incident, automatically initiates a process that tracks, monitors, and closes the feedback or incident.

Example applications are as follows:

1. Remote monitoring systems with sensors that which will alert FM team on soft FM (e.g. cleaning, pest control, etc.)
2. Video analytics with incident detection that would alert security team of any abnormalities
3. Application that allows for automated temperature adjustment in accordance to user feedback
4. Smart toilets
5. Smart bins
6. Smart monitoring system for fire extinguishers
7. Smart exit lights
8. Software platform for defects management
9. Software platform for handover of as-built drawings

Documentation requirements

Design Stage

- Tender specifications / tender drawings for Type 1 Smart FM solutions
- Developer's project brief for Type 1 Smart FM solutions that are not finalised during design stage

Verification Stage

- System write up for the Type 1 Smart FM solutions implemented
- Photos, screenshots and as-built drawing showing the extent of implementation

b. Type 2 – Use of data analytics and artificial intelligence for system optimization and predictive maintenance (1 point each):

i) Diagnostics AI: Able to identify system deviations and diagnose potential causes.

ii) Predictive AI: Able to diagnose problems and predict future states of assets and systems.

Example applications are as follows:

1. M&E equipment condition monitoring with sensors and analytics for preventive/conditional-based maintenance (e.g. monitoring of embedded sensors in chiller or VRF CU to predict mechanical wear and failure)
2. Fault detection diagnostics to find failed or improperly operating equipment (e.g. using abnormalities in IAQ readings or deviation from set points to relate equipment faults)

Documentation requirements

Design Stage

- Tender specifications / tender drawings for Type 2 Smart FM solutions
- Developer's project brief for Type 2 Smart FM solutions that are not finalised during design stage

Verification Stage

- System write up for the Type 2 Smart FM solutions implemented
- Photos, screenshots and as-built drawing showing the extent of implementation

6.2.2 Advanced Smart FM - Integrated and aggregated Smart FM solutions that improve FM labour efficiency and service delivery (up to 4 points)

Intent

To deploy smart design solutions via integrated platform to Improve operations efficiency

Design strategy and assessment: (up to 3 points)

a. Type 3 – Integration across systems (1 point each):

Integration across multiple systems/FM services to optimize resource deployment and utilization across multiple systems/FM services

Example applications are as follows:

1. Use of lift traffic and carpark gantry data to forecast and streamline cleaning regimes
2. Integration of CCTV with access control system for intrusion detection
3. Integration between CCTV system and Fire Alarm System to promptly identify occurrences of false alarms

Documentation requirements

Design Stage

- Tender specifications / tender drawings for Type 3 Smart FM solutions

Verification Stage

- System write up for the Type 3 Smart FM solutions implemented
- Photos, screenshots and as-built drawing showing the extent of implementation

Design strategy and assessment: (1 point)

b. Aggregated Smart FM Solution

Building owners can explore areas where economies of scale can be achieved through aggregation of FM solutions.

Example applications are as follows:

1. For building owners with a portfolio of buildings, Smart FM solutions or FM functions such as cleaning and security can be aggregated across the portfolio of buildings for a better overview and management of resources.
2. Building owners with a single development may explore aggregation through FM companies and solution providers through outcome-based contracts. FM companies and solution providers can better manage resources to meet service demands through the aggregation of buildings in a district.

Documentation requirements

Design Stage

- Tender specifications / Developer's project brief highlighting the aggregation of Smart FM solutions or FM functions across a portfolio of buildings
- Tender specifications / Developer's project brief highlighting the aggregation of FM services within a district through outcome-based contracts.

Verification Stage

- Documentary evidence extracted from relevant FM contracts

6.2.3 Design for Robotics and Automation (R&A) (up to 3 points)

Intent

Design buildings to facilitate the deployment of robotics to carry out building maintenance works for labour efficiency

Design strategy and assessment: (0.5 point for each R&A solution, up to 3 points)

a. Design for Robotics and Automation

Building infrastructures should be designed to optimise robot capabilities such as their range of mobility, ease of completing tasks, and ability to navigate its work environment.

Identifying the robots of interest to be deployed and recognising their corresponding level of autonomy is important in planning for suitable infrastructure that would cater to the robots.

Example use of FM robots could include the following:

- Cleaning robot e.g. façade, floor, window, toilet
- Concierge robot
- Façade inspection robot/drone
- Landscape management robot e.g. lawn mowers
- Pest management robot e.g. detection, monitoring, extermination
- Security robot
- Waste management robot

Note: Robot-inclusive design principles can be categorised into the following 5 principles:

1. **Activity**
   Optimise traffic flow involving people, goods, and robots through the selection of best mechanisms suited for deployment, operation, and storage.

   Examples include:
   - Designate and design docking points for easy deployment and storage of robot
   - Demarcate clear robot-only zones where the robot and human's workspaces are not intended to overlap

2. **Accessibility**

Provide infrastructure for safe navigation, good connectivity between areas and access for the robot within its work zone.

Examples include:

- Provide sufficient clearance (width and height) for movement of robot to, during and from its operation
- Minimise obstructions such as uneven surfaces or bumps along robot's pathway
- Provide slopes with appropriate gradient for robot movement instead of steps to remove barriers to movement

3. **Observability**
   Provide infrastructure that allows for good visibility of environment for robot perception, navigation, and localisation.

   Examples include:
   - Utilise high-contrast materials to aid robots in analysing relevant data and discerning boundaries
   - Implement location-tagging technologies (e.g., QR codes, barcodes, symbols) to assist in robot localisation within its work environment
   - Select appropriate building materials and finishes to minimise glare or excessive reflection of light which may disrupt robot sensors

4. **Manipulability**
   Design for the robot ability's to move or rearrange objects in the environment by grasping, carrying, pushing, dropping, or lifting them using its end effectors / grippers

   Examples include:
   - Design appropriate devices such as handles or buttons on objects that requires robot manipulation (e.g., provide handles for better grip)

5. **Safety**
   Ensure the safety of both humans and robots operating in the same workspace

   Examples include:
   - Design features that demarcate no-entry zones for robots (e.g. detection markers at stairs, steep slopes or escalators etc.)
   - Select appropriate floor finishes to prevent slippage

Credits for robot-inclusive design principles: SUTD

Documentation requirements

Design Stage

- Developer's design brief indicating on the type of robotics and the extent of implementation
- Design report (Architectural, Structural, Mechanical & Electrical, Façade and etc) highlighting the key features of the building which would facilitate the implementation of robotics

Verification Stage

- Screenshots / photos showing the actual implementation.

SECTION 7 – BUILDING MANAGEMENT SYSTEM

7.1 CENTRAL COMPUTER (UP TO 2 POINTS)

7.1.1 Avoid data loss due to lack of redundancy (up to 2 points)

Intent

To provide enhanced service reliability and improved system performance by minimizing the downtime.

Design strategy and assessment: (0.5 point)

a. Provide cloned hard drive to backup data points

Note: Manual Backup is a non-automated process of copying and storing data. In order to comply with the requirement, backup BMS data points for minimum two times a year. The stored data can be used to manually restore the system at any time. The back-up must include Operation software (i.e., GUI, trend log), operation system (OS) and associated data points.

Documentation requirements

Design Stage

- BMS Tender specification capturing the BMS data backup requirements

Verification Stage

- BMS maintenance checklist indicating the back-up date, data size and schedule for the next back-up
- Backup files must have proper labelling (I.e., folder structure indicating the month and year) inside the external HDD.

Design strategy and assessment: (1 point)

b. Provide cold stand-by as a back-up for primary server

Note: A cold standby is a redundancy method that involves having one system as a backup for another identical primary system. The cold standby system is called upon only on failure of the primary system.

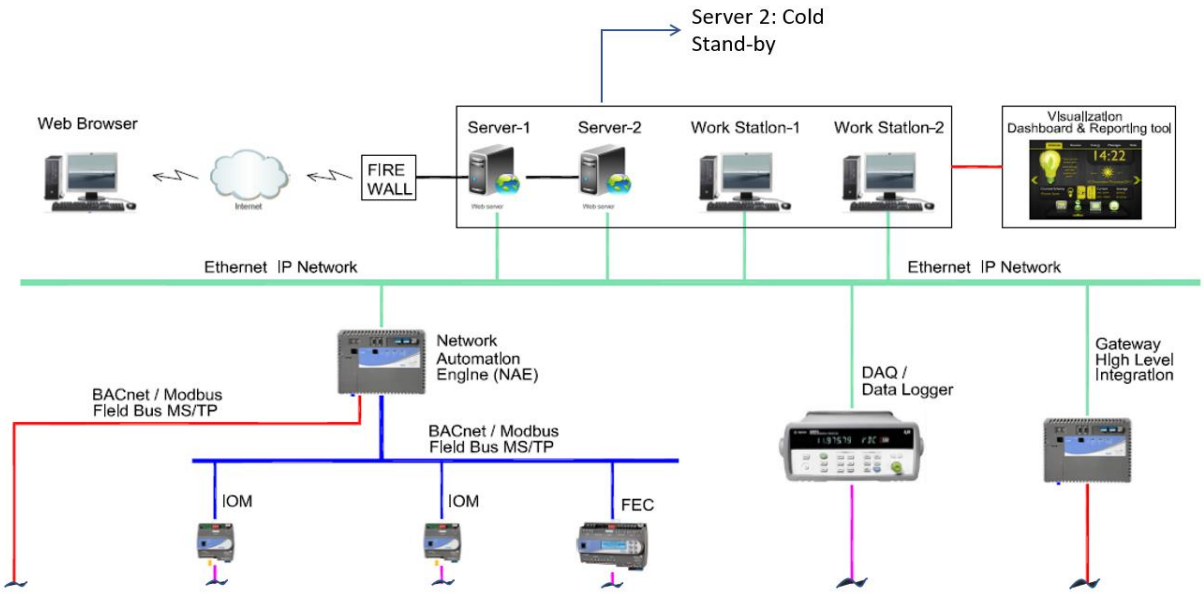


Figure 64: Typical BMS System Architecture with cold stand-by arrangement

Documentation requirements

Design Stage

- BMS Tender specification capturing the cold Stand-by requirements

Verification Stage

- BMS system architecture indicating the cold stand-by arrangement.

Design strategy and assessment: (1.5 point)

c. Provide hot stand-by for automatic switch-over from primary to back-up server

(OR)

Adopt Cloud-Based Building Management Technology for Over-the-cloud redundancy/high availability.

- Minimum uptime 99% - 1.5 point

Note: Hot stand-by uses a backup server that receives regular updates and is standing by ready (on hot standby) to take over immediately in the event of a server failure.

Example: A typical BMS server has run for 1 year (525,600 minute) and the down time within the year is 68 minutes.
Uptime = [Uptime / (Uptime +Downtime)] x 100%
= [525600/ (525600+68)] x 100%
= 99.98%

Documentation requirements

Design Stage

- BMS Tender specification capturing the data backup requirements
- BMS Tender specification capturing the uptime requirements.

Verification Stage

- BMS system architecture indicating the hot stand-by arrangement.
- Uptime calculation for the recent one year.

Design strategy and assessment: (0.5 point)

d. Provide minimum 30 minutes UPS power back-up for central PC/ server

Additional Recommendations:

- Specify UPS with Surge Protection and Automatic Voltage Regulation (AVR) to maintain safe voltage conditions.
- When the power goes out, the UPS must provide battery backup with surge protection for computers, external hard-drives and other electronics, including wireless router (if any)
- Specify UPS with Intelligent battery management: Maximizes battery performance, life, and reliability through intelligent, precision charging.

Documentation requirements

Design Stage

- BMS Tender specification/ schematic capturing the UPS power back-up, capacity and location.

Verification Stage

- BMS System Architecture indicating the UPS power back-up.
- Technical data sheet highlighting the UPS capacity and minimum back-up time.

7.2 SOFTWARE INTEGRATION (TOTAL 4 POINTS)

7.2.1 Integration issues due to proprietary communication Protocol (0.5 point)

Intent

To provide open communication protocol for ease of integration among third party systems.

Design strategy and assessment: (0.5 point)

a. Use open communication protocol (i.e. BACnet , Modbus, etc.)

An open communication protocol allows vendors' equipment to interoperate without the need for proprietary interfaces or gateways. The main advantage of using open protocols is ease of expansion and integration with third-party software for user interface, trend reports, alarming, and other applications. They facilitate easier communication with subsystems such as lighting and chiller controllers.

i) Example for wired Open communication protocols:

- BACnet, LonWorks, KNX, DALI, Modbus, M-bus, OPC etc.

ii) Example for wireless Open communication protocols:

- EnOcean, ZigBee etc

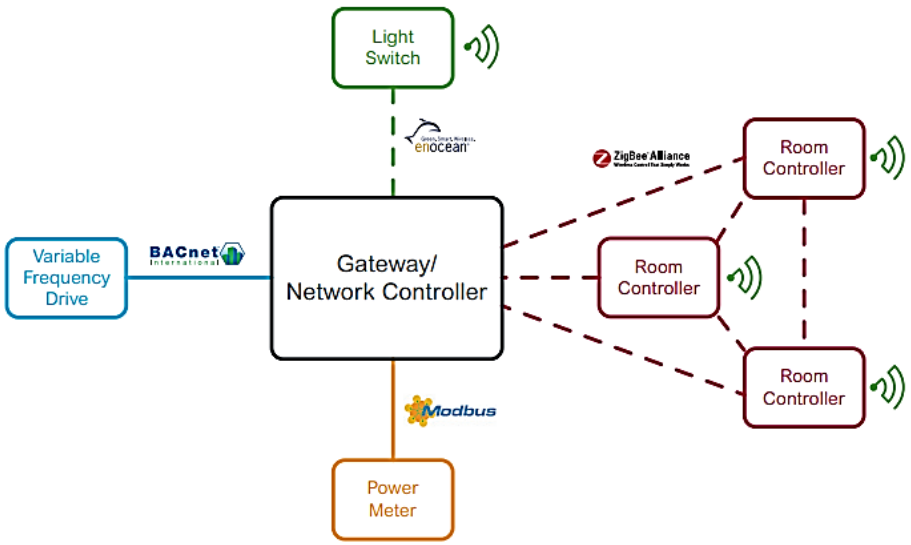


Image credit: Schneider Electric

Figure 65: Example of various connected devices via multiple protocols.

Documentation requirements

Design Stage

- BMS Tender specification/ system Architecture capturing the communication protocol requirements

Verification Stage

- BMS as-built drawing/ system Architecture capturing open communication protocol

7.2.2 Outdated operating system and lack of web access (up to 2 points)

Intent

To provide reliable operating system to enhance performance and security features

Design strategy and assessment: (up to 1 point)

a. Operating system

i) Windows 10 (0.5 point)

ii) Windows Server 2019/ Linux Ubuntu server 20.04.2.0 LTS (1 point)

(or)

iii) Cloud/Virtual computing services (i.e. Microsoft Windows Azure, Google Chrome OS)
Note: For cloud computing services, execution and processes of virtual machines / servers and virtual infrastructure, as well as the back-end hardware and software resources and security patches

Documentation requirements

Design Stage

- BMS Tender specification highlighting the operating system and key specifications

Verification Stage

- BMS System Architecture/ write-up highlighting the version of operating system implemented in the project

Design strategy and assessment: (1 point)

b. Web access

i) Internet Service Provider (ISP)/Mobile Data link-up
(Example: Remote access, live viewing etc.)

Documentation requirements

Design Stage

- BMS Tender specification/ system Architecture capturing the web access

Verification Stage

- BMS as-built drawing/ system Architecture/ write-up capturing the type of ISP/mobile data link-up

7.2.3 Lack of interface with other services (1 point)

Intent

To provide reliable IT infrastructure to facilitate seamless interface and future expansion

Design strategy and assessment: (1 point)

a. Provide IT infrastructure provision for high level integration with other services

i. Provide minimum 20% spare IT port at individual switch level.

ii. Provide minimum 20% spare band width for future expansion.
Note: The normal usage should not exceed the cable limit (Ex: For a 10GB fiber optic cable, the usage should not exceed 8 GB).

Additional Recommendation: Provide minimum 20% spare IT backbone for future expansion (Ex: For a two Cat6A/ fiber optic cable in use, provide one Cat6A/ duplex fiber optic cable spare for future expansion).

Note: IT network must adhere to industry standards for ease of integration and future scalability

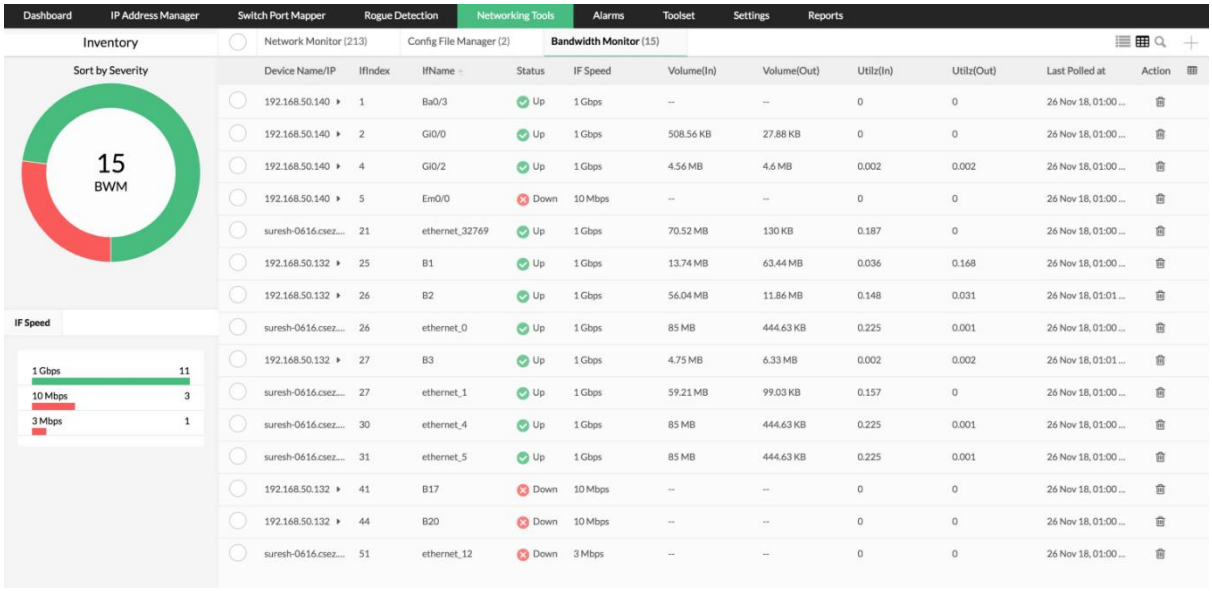
Documentation requirements

Design Stage

- BMS Tender specification, drawing capturing the 20% spare IT ports at individual switch level.
- BMS Tender specification, drawing capturing the 20% band width requirements.

Verification Stage

- As-built BMS schematics, photos highlighting the 20% spare IT ports at individual switch level.
- Computer screenshot indicating the 20% spare bandwidth after the building is fully operational.



7.2.4 Lack of notification system resulting in increased downtime (0.5 point)

Intent

To provide reliable messaging and notification system to enhance service levels and avoid downtime.

Design strategy and assessment: (0.5 point)

a. Provide Short Messaging System (SMS) system
(OR)
Use of applications such as WhatsApp, Telegram, WeChat, etc. to notify the fault
Example: Short messaging system to send message using local telco line to individual (operator or management)

(OR)
Provide email system.
Example: Email system to send alarm notification in email

(OR)
Provide voice call system
Example: Voice call system will call a direct number to notification the operator

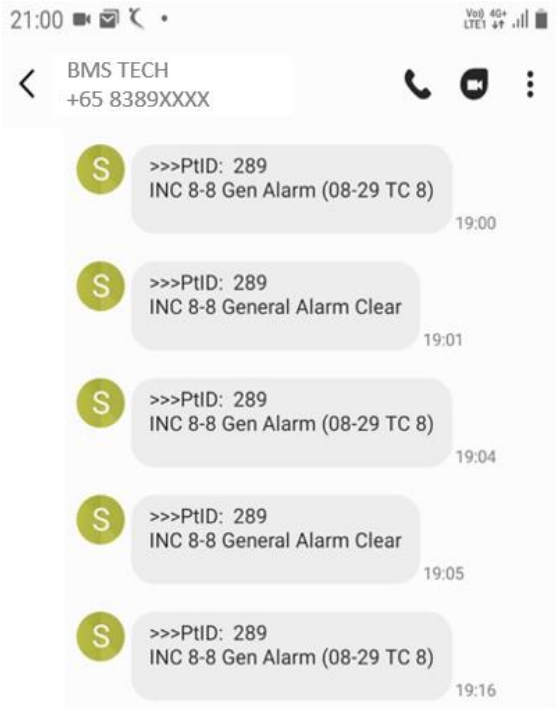


Figure 66: Example: Short messaging system delivered to phone.

Documentation requirements

Design Stage

- BMS Tender specifications capturing the notification system related requirements.

Verification Stage

- BMS write-up highlighting the notification system adopted in the project.
- BMS/mobile screenshot indicating the message/ notification received by the concerned facility manager/ service provider.

7.3 CONTROLLERS (TOTAL 2.5 POINTS)

7.3.1 Lack of Termination List (0.5 point)

Intent

To provide accurate DDC termination points to facilitate future Asset enhancement initiatives and upgrades.

Design strategy and assessment: (0.5 point)

a. Provide full terminal list (naming and tagging).

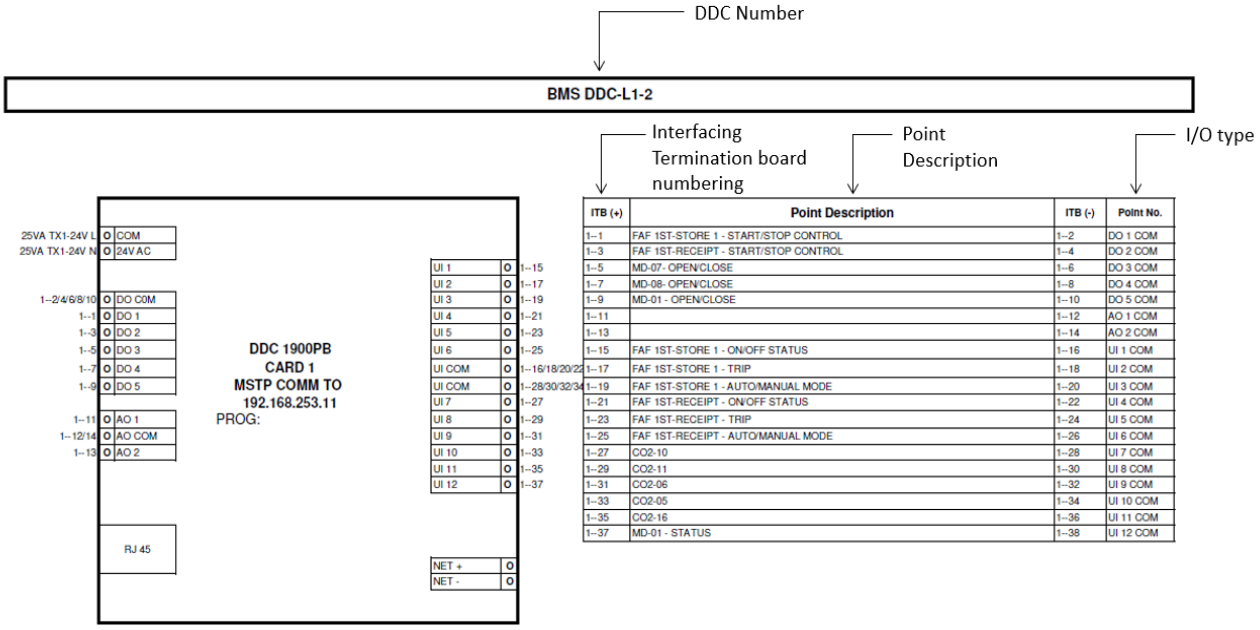
Note:

i) To be updated when building undertake A&A.

ii) The termination list to have proper point description (equipment naming) and corresponding I/O points type and Interfacing Termination board (ITB) numbering.

iii) Terminal list to be maintained in both hardcopy and softcopy to ensure up-to-date knowledge of system set-up.

Additional Recommendation:
FM team to maintain the updated wiring diagram to facilitate future expansion and BMS upgrades.



ITB (+)	Point Description	ITB (-)	Point No.
1--1	FAF 1ST-STORE 1 - START/STOP CONTROL	1--2	DO 1 COM
1--3	FAF 1ST-RECEIPT - START/STOP CONTROL	1--4	DO 2 COM
1--5	MD-07- OPEN/CLOSE	1--6	DO 3 COM
1--7	MD-08- OPEN/CLOSE	1--8	DO 4 COM
1--9	MD-01 - OPEN/CLOSE	1--10	DO 5 COM
1--11		1--12	AO 1 COM
1--13		1--14	AO 2 COM
1--15	FAF 1ST-STORE 1 - ON/OFF STATUS	1--16	UI 1 COM
1--17	FAF 1ST-STORE 1 - TRIP	1--18	UI 2 COM
1--19	FAF 1ST-STORE 1 - AUTO/MANUAL MODE	1--20	UI 3 COM
1--21	FAF 1ST-RECEIPT - ON/OFF STATUS	1--22	UI 4 COM
1--23	FAF 1ST-RECEIPT - TRIP	1--24	UI 5 COM
1--25	FAF 1ST-RECEIPT - AUTO/MANUAL MODE	1--26	UI 6 COM
1--27	CO2-10	1--28	UI 7 COM
1--29	CO2-11	1--30	UI 8 COM
1--31	CO2-06	1--32	UI 9 COM
1--33	CO2-05	1--34	UI 10 COM
1--35	CO2-16	1--36	UI 11 COM
1--37	MD-01 - STATUS	1--38	UI 12 COM

Figure 67: Typical Termination list example

Documentation requirements

Design Stage

- BMS Tender specifications capturing the handover of as-built BMS DDC termination list to FM.

Verification Stage

- Updated DDC termination list in both hard and soft copy format.

7.3.2 Lack of access to DDC panels (0.5 point)

Intent

To provide clear access to DDC panels to facilitate regular maintenance

Design strategy and assessment: (0.5 point)

a. **The top of the control panels must be maximum 1.8m from the finished floor level (FFL) to facilitate direct access.**

   (OR)

b. **The control panels located at heights must have direct access from scaffolding, ladders etc. Provide minimum 800mm clear access space in front of the control panels.**

Documentation requirements

Design stage

- Tender specifications/drawings highlighting the control panel access requirements

Verification Stage

- ACMV/BMS shop/as-built drawings showing the mount height of the control panel.
- ACMV/BMS shop/as-built drawing highlighting the access space provision in front of the control panel.
- Photographs showing the access provision.

7.3.3 Lack of reliable power supply to DDC controllers (up to 1.5 point)

Intent

To avoid reconfiguration of the control parameters due to power loss

Design strategy and assessment: (up to 1.5 point)

a. **Power Supply (Maximum points for section 7.3.3 a i) & ii) is 1 point)**

   i) Provide minimum 30 minutes UPS power back-up for controllers serving critical infrastructure (i.e. Chiller plant, AHU's, PAHU's, HT/LT switch board) – 0.5 point

   ii) Provide minimum 30 minutes UPS power back-up for all controllers – 1 point

   iii) Provide BMS monitoring for incoming power supply for UPS system to facilitate continuous operation – 0.5 point

Note: When the power supply is lost, the controller should be designed to perform an automatic backup of all control parameters into the non-volatile memory storage inside the device. Upon resumption of power, all control settings should be automatically restored.

Documentation requirements

Design stage

- Electrical/BMS tender specifications/drawings highlighting the requirement for UPS power supply.
- Electrical/BMS tender specifications/drawings highlighting the requirement to monitor the incoming power supply to the UPS system

Verification Stage

- Electrical/BMS single line shop/as-built drawing indicating the UPS power supply for controllers serving critical infrastructure.
- Electrical/BMS single line shop/as-built drawing indicating the UPS power supply for all controllers.
- UPS catalogues, specifications and photos etc. capturing the monitoring of incoming power supply to the UPS system.

7.4 Integration with M&E systems (2 POINTS)

7.4.1 Lack of integration with Mechanical & Electrical systems (1.5 point)

Intent

To provide better control and monitoring of Mechanical and Electrical Systems using BMS platform

Design strategy and assessment: (1.5 point)

a. ACMV system

i) Monitor and control of chiller plant equipment's including chillers, cooling towers, chilled water pumps and condenser water pumps – 0.5 point

Note: For buildings served by VRF, monitoring of VRF system is required.

(AND/OR)

ii) Monitor and control of Air distribution system including AHU, FCU and PAHU, main mechanical ventilation fans serving the common areas – 0.5 point

b. Electrical systems

i) Lighting system – 0.5 point

Note: Lighting system monitor and control for the building common areas such as corridors, carpark and external lighting.

Documentation requirements

Design stage

- ACMV/BMS tender specifications/drawings highlighting the requirement to monitor and control of chiller plant equipment or monitor the VRF system
- ACMV/BMS tender specifications/drawings highlighting the requirement to monitor and control of Air distribution system
- Electrical/BMS tender specifications/drawings highlighting the requirement to monitor and control of lighting system.

Verification Stage

- As-built BMS drawing / BMS screenshot indicating the monitor and control of chiller plant equipment's, VRF system.
- As-built BMS drawing / BMS screenshot indicating the monitor and control of air distribution system.
- As-built BMS drawing / BMS screenshot indicating the monitor and control of lighting system.

7.4.2 Lack of integration with Solar PV systems (0.5 point)

Intent

To provide better insights and visualization of Solar PV system operations.

Design strategy and assessment: (0.5 point)

a. Solar PV system Integration

i) High level Integration of solar PV system with BMS for continued monitoring.

Note: The monitoring should include energy yield, Panel temperature, current, voltage, Error messages etc.
The data logger must be pre-programmed and should be able to seamlessly integrate with the Building Automation System via OPC industrial protocol such as Modbus. BACnet etc.

Documentation requirements

Design Stage

- PV tender drawing/specification indicating the requirement for open communication protocol and seamless integration with BMS system.

Verification Stage

- Screenshot of BMS showing the monitoring of PV panels.

SECTION 8 – FACILITY MANAGEMENT SYSTEM

8.1 ASSEST MANAGEMENT – Failure Analysis (1.5 POINTS)

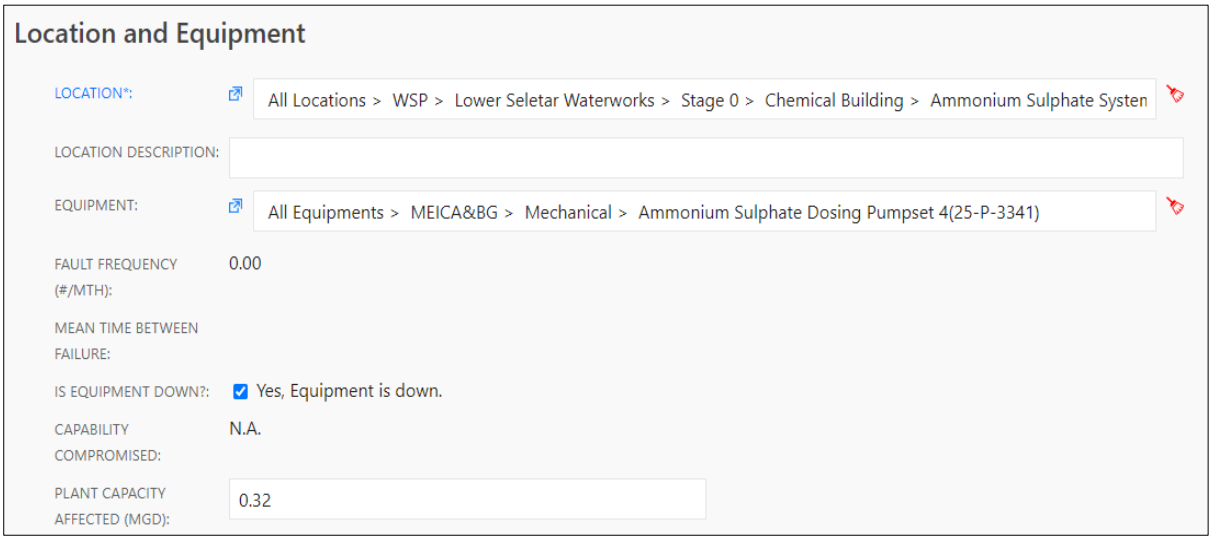
8.1.1 Failure analysis not performed (1.5 point)

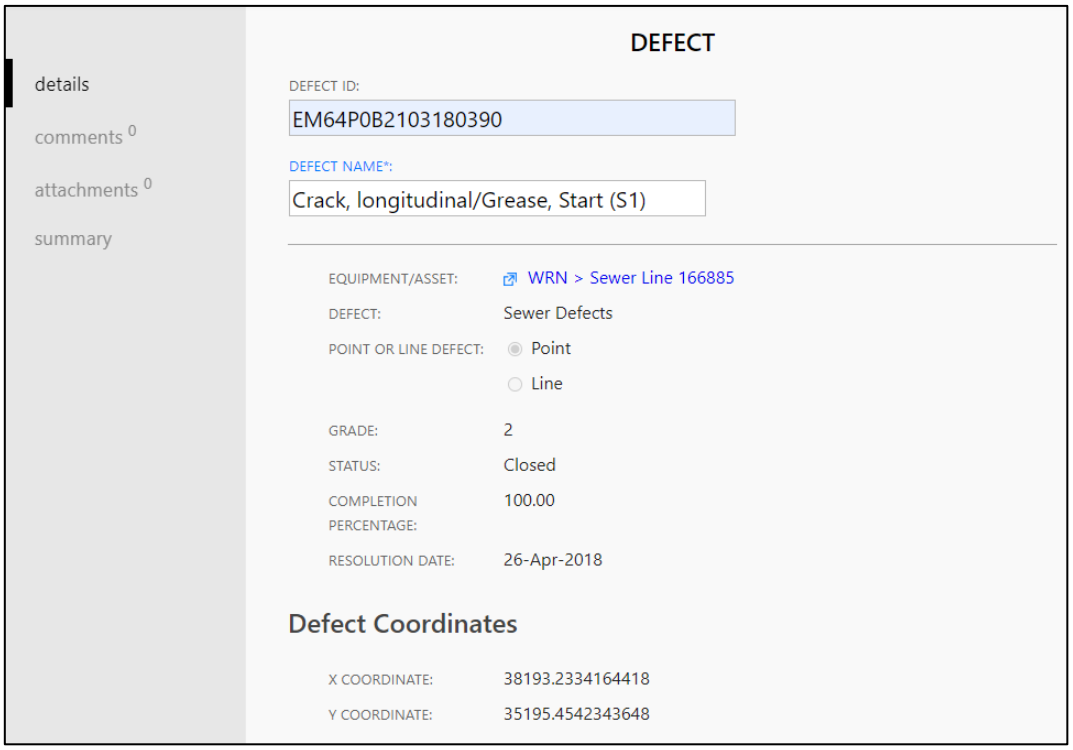
Intent

To predict equipment failure patterns and improve equipment reliability.

Design strategy and assessment: (0.5 point)

a. **Record all equipment or system failure, including downtime and description of fault.**
Note: The record should be in digital form.





Documentation requirements

Design Stage

- Tender Specifications capturing the requirements to create digitalized records of equipment/ system failure.

Verification Stage

- Photo screenshot showing digitalized simple history records i.e., equipment/ system failure, downtime, and fault description etc.
- Photo/ screenshot showing the actual implementation.

Design strategy and assessment: (1 point)

b. Define failure modes or fault codes and perform "Root Cause Failure Analysis (RCFA). Implement failure modelling (e.g. Weibull) for failure rate projection or perform reliability centred maintenance (RCM).

Note: Fault codes allow you to perform analysis on occurrences of problems or defects in your building systems. Failure modelling allows you to model the failure patterns and predict future asset lifespan as well as failure rate.

Documentation requirements

Design Stage

- Tender specification highlighting the requirements to implement RCFA, failure analysis modelling/ predictive maintenance etc.
- Tender specification to include the list of proposed equipment's/systems which must be part of the analysis.

Verification Stage

- Detailed write-up showing how analysis was performed to log faults and predict failure rate based on collected data.
- Detailed write-up on how manpower savings and reliability was improved by adopting failure analysis modelling.

8.2 ASSEST MANAGEMENT – LIFE CYCLE MANGEMENT (1.5 POINTS)

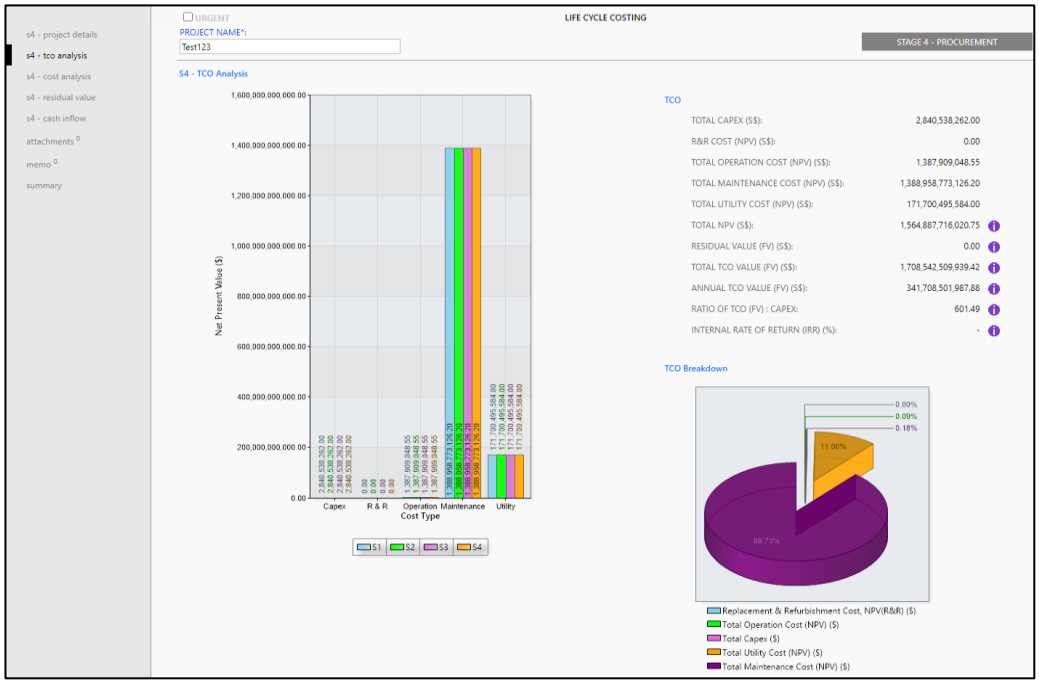
8.2.1 Life cycle management not performed (1.5 point)

Intent

To allow stakeholders (i.e., Facilities managers, consultants etc.) make informed decisions considering whole life cycle cost review.

Design strategy and assessment: (1.5 point)

a. Track life cycle cost (LCC) items (labour/ material, external services) including construction/ acquisition, operations, and maintenance, and perform LCC analysis, such as repair/ overhaul/ replace analysis.



For example, Asset lifecycle should able to capture or provide the following information;

i) Asset location, warranty information or replacement items
ii) Technical and economic life span parameters
iii) Linking business assets to suppliers, users or maintenance teams,
iv) Store inventory and stock information in a single database and automate the sourcing and stock management process.
v) Record expenses incurred like costs by labour, materials, regular services.

Documentation requirements

Design Stage

- Tender specifications indicating the key equipment's/ systems which are included in Life cycle cost analysis.

Verification Stage

- Software tool indicating the LCC features included in the FMS module.
- Demonstrate how LCC is used by facilities managers/ operations team to make procurement and maintenance decisions.

8.3 OPERATIONS MANAGEMENT – SERVICE MANAGEMENT (2 .5 POINTS)

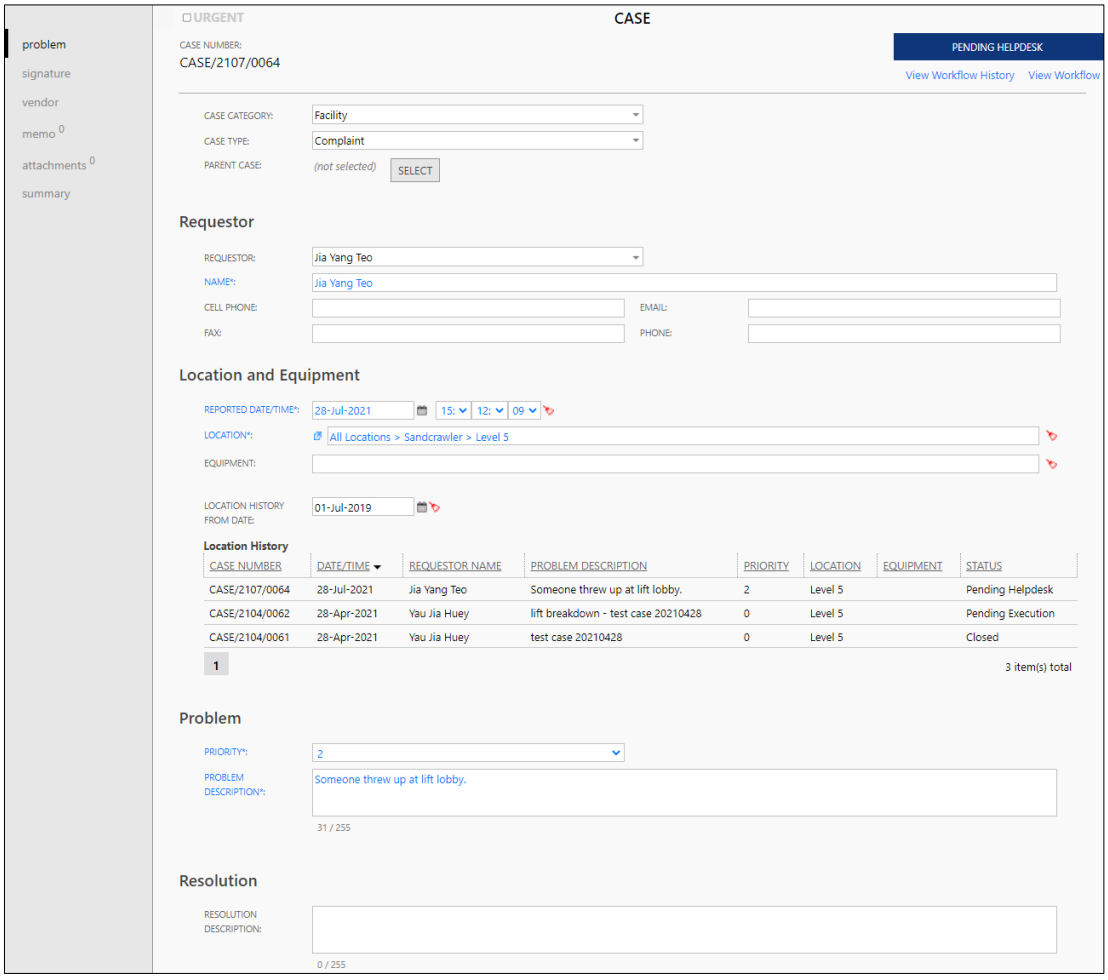
8.3.1 Case management process is manually tracked or not tracked (2 points)

Intent

To provide efficient and timely alerts on each case in order to reduce longer downtime.

Design strategy and assessment: (1 point)

a. **Case management process (logging of new cases, dispatching cases, monitoring progress of case resolutions, closure of completed cases) is automated.**



Documentation requirements

Design Stage

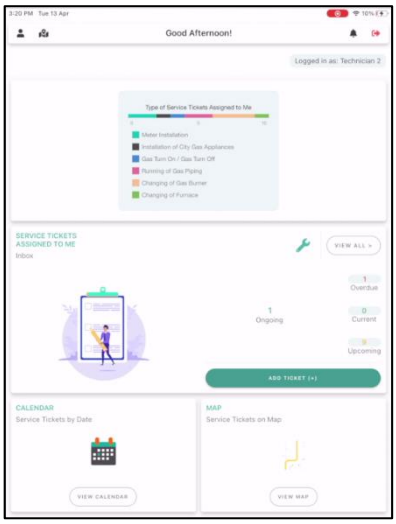
- Tender specifications capturing the requirements to implement automated case management process using FMS software.

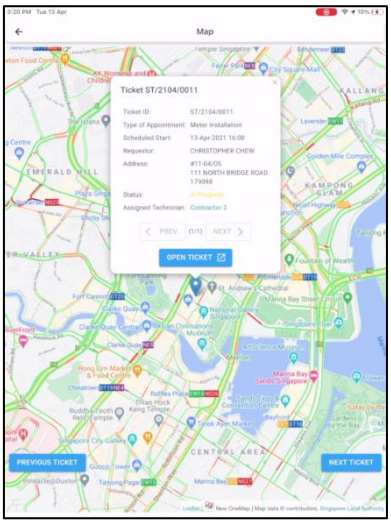
Verification Stage

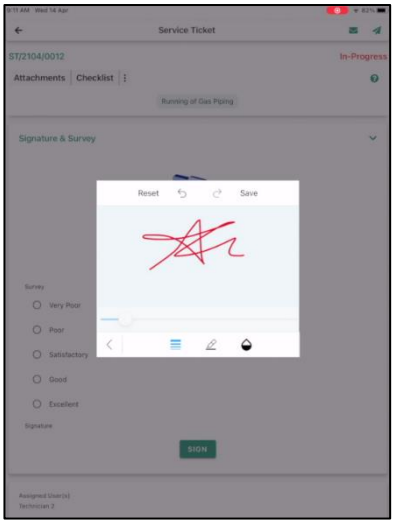
- Detailed write-up/ Illustration showing how cases are logged and automated from the software.

Design strategy and assessment: (1 point)

b. Automated real-time dispatching of cases using SMS, mobile apps or other wireless mechanisms to field staff for acknowledgment and follow up







Documentation requirements

Design Stage

- Tender specifications capturing the requirements to implement automated and real-time crease management process using wireless mechanisms

Verification Stage

- Detailed write-up/ Illustration showing how cases are automatically logged, dispatched and follow-up actions were taken using the FMS software tool.

8.3.2 No customer care or self-service web portal or mobile app (0.5 point)

Intent

To provide efficient customer service and reduce manpower cost.

Design strategy and assessment: (0.5 point)

a. **Customer care or self-service web portal and / or mobile app available for customers to log new cases or review status of existing cases.**

Documentation requirements

Design Stage

- Tender specifications highlighting the implementation of customer care self-service web portal/ mobile app for customer to log / review cases.

Verification Stage

- Detailed write-up/ Illustration showing the key features of customer care self-service web portal.
- Photos/screenshot of actual implementation.

8.4 OPERATIONS MANAGEMENT – MAINTENANCE MANAGEMENT (1.5 POINTS)

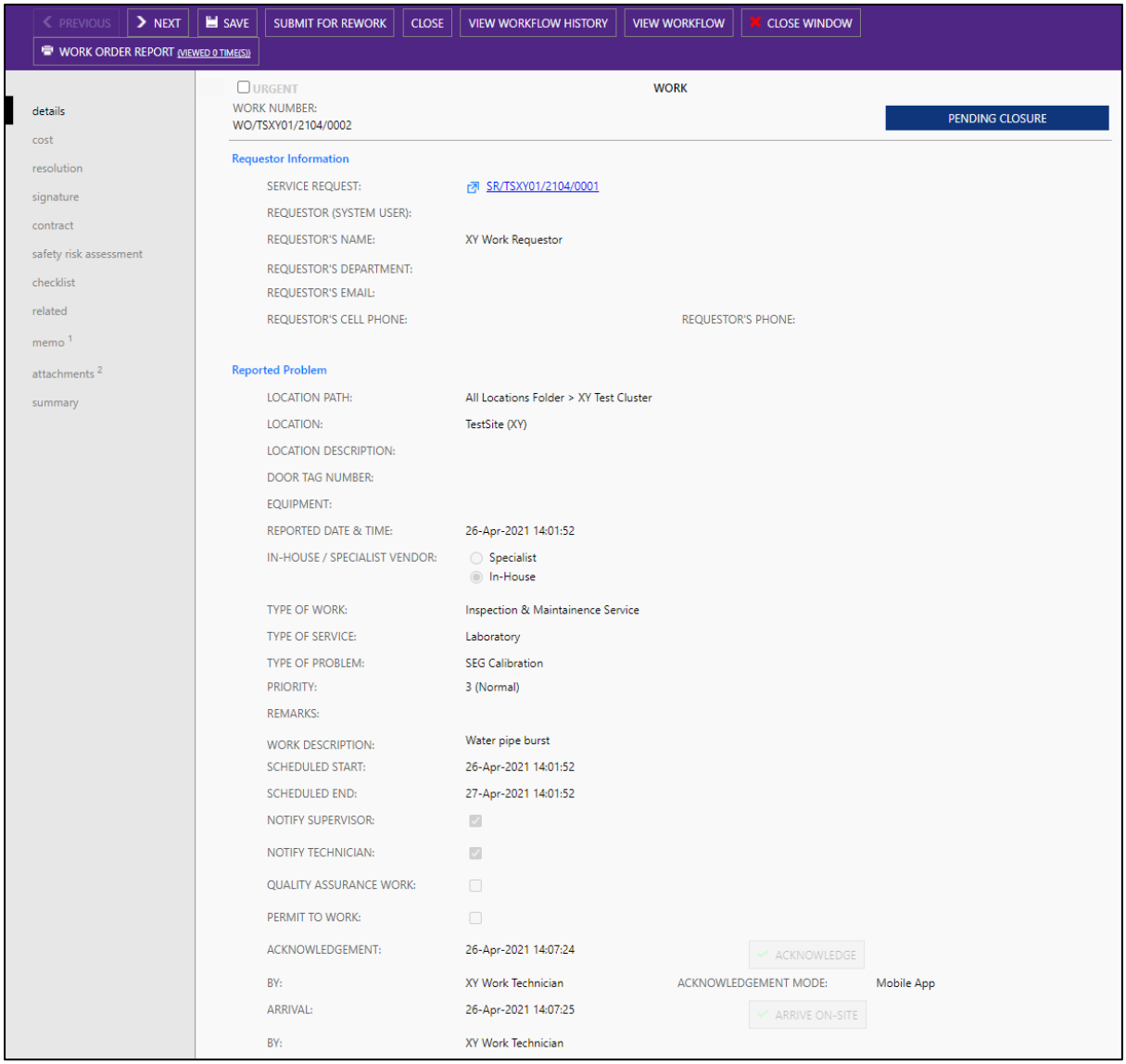
8.4.1 Work order process is ill-defined, manually tracked or not tracked (1 point)

Intent

To promote efficient work order management and improve tracking mechanism

Design strategy and assessment: (0.5 point)

a. **Work order process including application of permit to work for ad-hoc maintenance and scheduled work (e.g. corrective maintenance and preventive maintenance) are automated with FM software.**



Documentation requirements

Design Stage

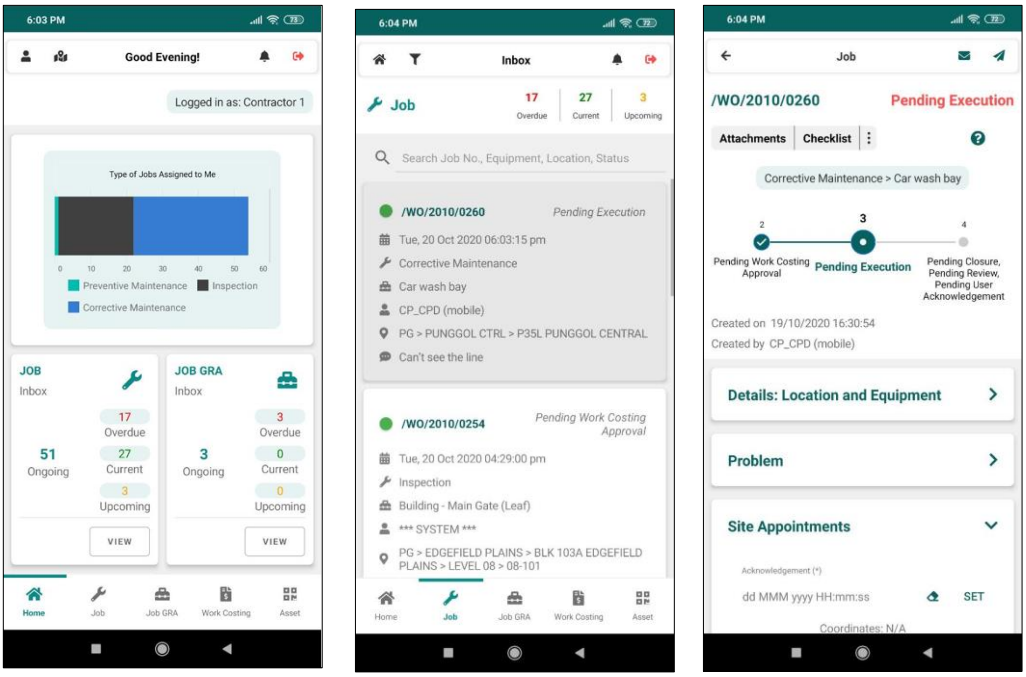
- Tender specifications capturing the requirements pertaining to automated work order process mechanism using FMS software.

Verification Stage

- Detailed write-up/ Illustration showing the implementation of work order process.
- Photos/screenshot of actual implementation

Design strategy and assessment: (0.5 point)

b. Mobile devices and mobile apps are extensively used for work order management processes.



Documentation requirements

Design Stage

- Tender specifications capturing the requirements for deploying mobile devices /apps to automate work order process mechanism. The mobile devices/apps must be integrated with FMS software platform.

Verification Stage

- Detailed write-up/ Illustration showing the implementation and integration of mobile devices/applications.
- Photos/screenshot of actual implementation

8.4.2 Work plans and checklists are not in digitalized format (0.5 point)

Intent

To digitalize work plans for cost effective storage of data and easy access.

Design strategy and assessment: (0.5 point)

a. **Work plans and checklist in digitalized format (e.g. each checklist item is a record), e.g. in a spreadsheet or in a computer database (such as FMS system).**

Note: Checklist items must contain additional technical or other information on a maintenance activity. The information is intended for a tradesperson carrying out the maintenance. When maintenance orders are generated in work orders, the checklist information can be included in a ticket or report for the person carrying out the maintenance.

AHU Monthly Servicing

STEP	DESCRIPTION	
1	Clean plant room floor, door, door frame, and AHU housing, ensure they are free of dust and no items are store in the plant room.	○ Yes ○ No
2	Inspect and replace faulty lighting and power points.	○ Yes ○ No
3	Inspect and report water leakage and cracks on floor, wall and ceilings.	○ Yes ○ No
4	Replace Air Filter	○ Yes ○ No
5	Check cooling coil condition, clean and comb all dented fin of coils	○ Yes ○ No
6	Check and clean condensate drain pan with water hose and vacuum drain pipe, ensure water flow properly and no chokage	○ Yes ○ No
7	Check condition of fan belt for cracks or fraying, adjust belt tension and alignment, replace as required.	○ Yes ○ No
8	Check fan motor for excessive heat and vibration, lubricate motor bearing as required.	○ Yes ○ No
9	Check blower for unbalance, excessive noise and vibration. Lubricate bearing as required.	○ Yes ○ No
10	Check and clean blower fan and fan housing with wire brush.	○ Yes ○ No
11	Check insulation if condensation occur, re-insulate as required.	○ Yes ○ No
12	Inspect wiring and electrical controls for loose connections, charred, broken, or wet insulation, evidence of short circuiting, wrong size fuses	○ Yes ○ No
13	Check and functional test Chilled water actuator motor and valve operation (manually command valves open and closed from the building automation system)	○ Yes ○ No
14	Visual check on U/V lights and report any faulty light.	○ Yes ○ No ○ NA
15	Check all vibration isolator for deterioration of rubber and spring.	○ Yes ○ No
16	Inspect for rust and corrosion. Remove rust and corrosion and apply paint where applicable.	○ Yes ○ No
17	Check and record off coil temperature readings with digital Thermometer.	
18	Check and record AHU Motor RLA with Ampere Clamp Meter.	
19	Remarks	

Documentation requirements

Design Stage

- Tender specifications capturing the sample workplans and checklist in digital format.

Verification Stage

- As-built work plans and checklist in digitalized format for all key equipment's/ systems.

8.5 OPERATIONS MANAGEMENT – OTHER GENERAL SERVICES (1 POINT)

8.5.1 Service request forms and processes are managed manually (1 point)

Intent

To streamline FM services and better utilization of spaces and assets.

Design strategy and assessment: (0.5 point)

a. **Service request forms and processes are digitalized and automated using FM or CRM software.**

   Note: Examples of services are air-con or chilled water extension, meeting room booking, VIP visit arrangements, etc. Usually performed manually by a concierge.

Documentation requirements

Design Stage

- Tender specifications capturing the requirement for implementing automated service request mechanism using FMS software

Verification Stage

- FMS software portal capturing the digitalized service offerings
- Photos/ screenshot capturing the actual implementation.

Design strategy and assessment: (0.5 point)

b. **Customer care or self-service web portal available for customers to submit new service requests or review status of existing requests.**

Documentation requirements

Design Stage

- Tender specifications capturing the requirement for implementing customer care or self-service web portal able to submit new service requests

- Verification Stage
- As built write-up or illustration of customer care web portal highlighting the key features and services description.
- Photos/ screenshot capturing the actual implementation.

8.6 SUPPLY CHAIN MANAGEMENT – INVENTORY, PROCUREMENT & CONTRACT MANAGEMENT (UP TO 4.5 POINTS)

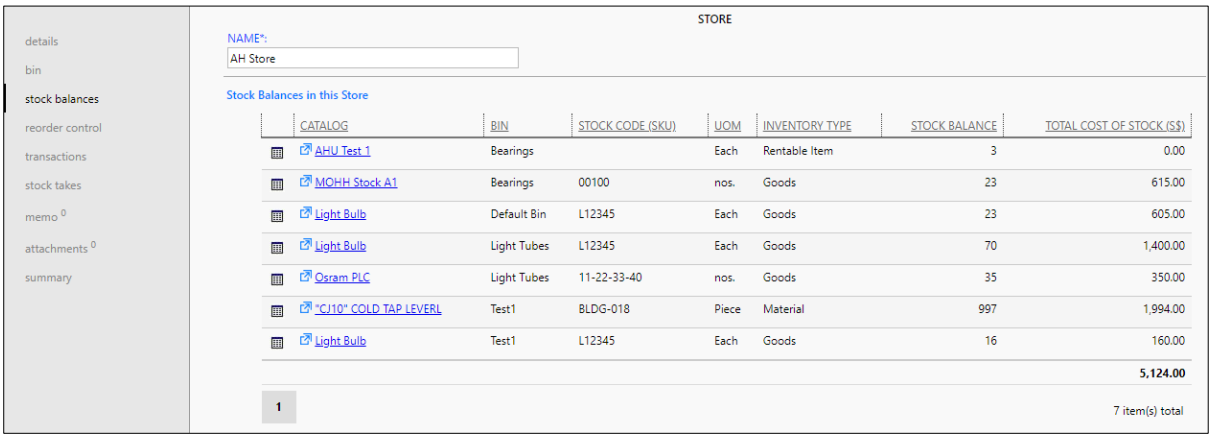
8.6.1 Inventory tracked manually (or FM staff has no access to Finance Department Inventory Management System) (0.5 point)

Intent

To provide digitalized inventory management system for enhanced tracking and labour savings

Design strategy and assessment: (0.5 point)

a. Keep an accurate inventory control register in a database.



Documentation requirements

Design Stage

- Tender specifications capturing the implementation of digitalized inventory management system

Verification Stage

- FMS software system capturing digitalized inventory control register.
- Photos/ screenshot capturing the actual implementation.

8.6.2 Procurement process tracked manually (or FM staff has no access to Finance Department Procurement Management System) – Sourcing, purchasing, goods receipt. (0.5 point)

Intent

To facilitate transparent and efficient procurement process

Design strategy and assessment: (0.5 point)

a. **Purchasing process (purchase order issuance) is automated including following key functions.**
   i) **Sourcing process (tendering, requesting for quotation) is automated with funds availability check.**
   ii) **Progress claims, goods receipt and invoicing processes are automated.**

Documentation requirements

Design Stage

- Tender specifications capturing the requirements for automated purchasing process. The purchasing process must include the key requirements stated in the solution.

Verification Stage

- FMS report capturing the automated purchasing process and associated key requirements stated in the solution.

8.6.3 Expense budget management process tracked manually (or FM staff has no access to Finance Department Budget Management System). (0.5 point)

Intent

To streamline procurement and budgeting activities to achieve resilient supply chain.

Design strategy and assessment: (0.5 point)

a. **Expense budget management processes (new budget approval, budget adjustment, budget reallocation/ virement) are automated.**

Documentation requirements

Design Stage

- Tender specifications capturing the requirements for automated expense budget management process including key features listed in the solution.

Verification Stage

- FMS report capturing the automated purchasing process and associated key requirements stated in the solution.

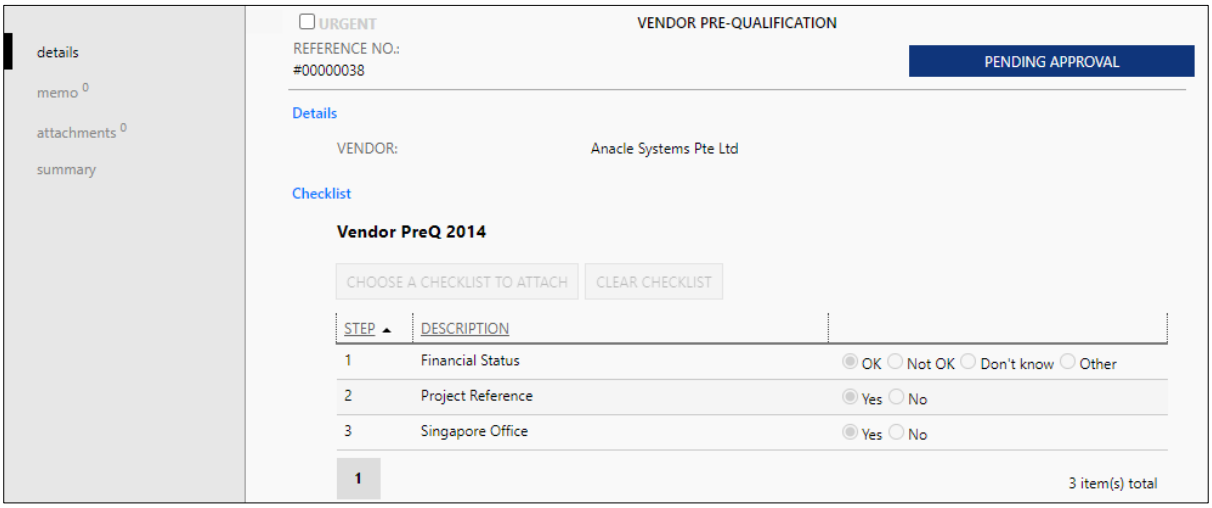
8.6.4 Vendor pre-qualification and regular grading reviews performed manually or not performed (0.5 point)

Intent

To implement automated vendor processing mechanism for improved operations efficiency.

Design strategy and assessment: (0.5 point)

a. Automate vendor pre-qualification and regular grading reviews.



Documentation requirements

Design Stage

- Tender specifications capturing the requirements for automated vendor pre-qualification system.

Verification Stage

- FMS report showing the vendor pre-qualification and regular grading reviews

8.6.5 No vendor self-service web portal (1 point)

Intent

To facilitate transparent and efficient vendor management system to achieve greater operations efficiency

Design strategy and assessment: (1 point)

a. **Implement vendor self-service web portal with following functionality;**
   - i) Vendor portal for self-registration / pre-qualification.
   - ii) Vendor portal for viewing procurement opportunities such as tenders.
   - iii) Vendor portal for submission of bids proposals and receipt of Purchase Orders.
   - iv) Vendor portal for submission of progress claims/ goods delivery or invoices.

Documentation requirements

Design Stage

- Tender specifications capturing the requirements for automated vendor self-service web portal. The portal must include key functionalities list in the solution.

Verification Stage

- FMS report validating the implementation of vendor self-service web portal including key functionality
- Photos/screenshot of actual implementation

8.6.6 Contracts are tracked manually (1 point)

Intent

To streamline contracts and achieve greater operations efficiency.

Design strategy and assessment: (1 point)

a. **Contracts are in digitalized format and kept in central database (AND)**
b. **Pro-active reminders or alerts on key contractual milestones (e.g. reminder for renewal).**

Documentation requirements

Design Stage

- Tender specifications capturing the requirements for digitalized contract documents.

Verification Stage

- Photos/screenshot of digitalized database for storing contracts.
- Photos/screenshot of reminders pertaining to key contractual milestone.

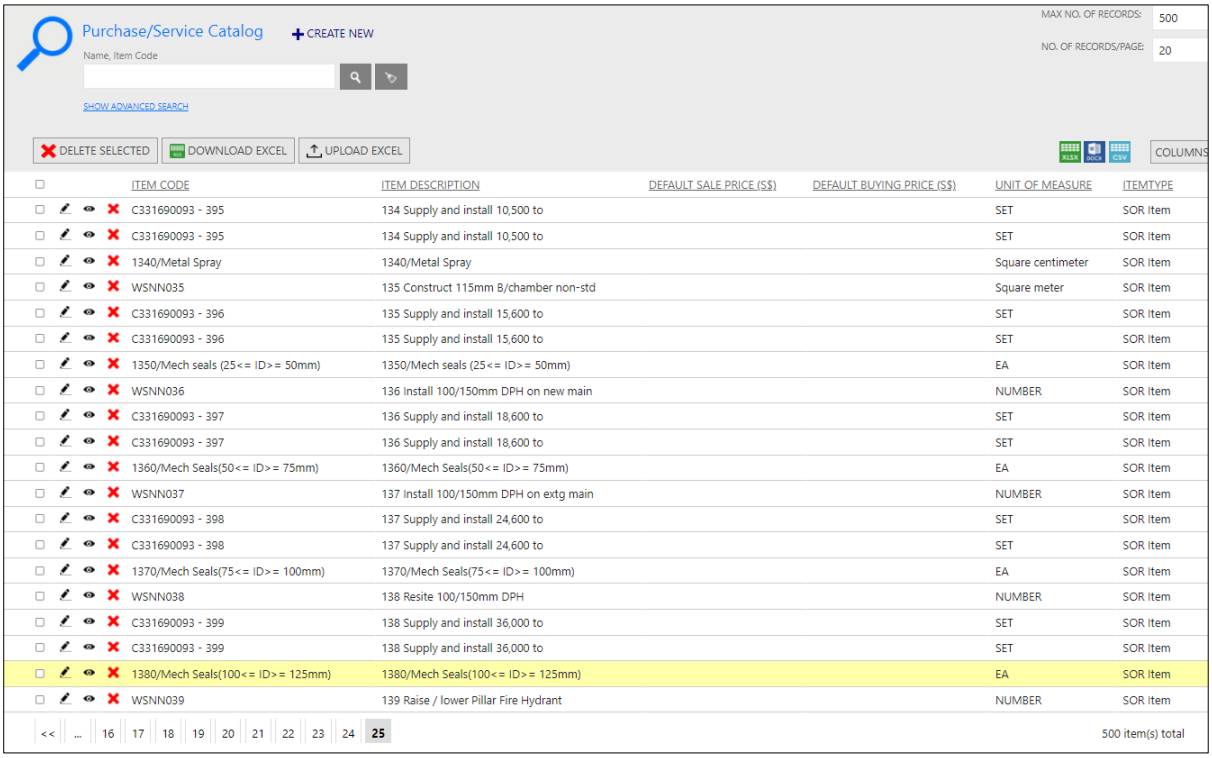
8.6.7 Schedule of rates not in digitalized format (0.5 point)

Intent

To promote better documentation and operations efficiency.

Design strategy and assessment: (0.5 point)

a. Schedule of rates for services in digitalized format and kept in central database.



ITEM CODE	ITEM DESCRIPTION	DEFAULT SALE PRICE (S$)	DEFAULT BUYING PRICE (S$)	UNIT OF MEASURE	ITEMTYPE
C331690093 - 395	134 Supply and install 10,500 to			SET	SOR Item
C331690093 - 395	134 Supply and install 10,500 to			SET	SOR Item
1340/Metal Spray	1340/Metal Spray			Square centimeter	SOR Item
WSNN035	135 Construct 115mm B/chamber non-std			Square meter	SOR Item
C331690093 - 396	135 Supply and install 15,600 to			SET	SOR Item
C331690093 - 396	135 Supply and install 15,600 to			SET	SOR Item
1350/Mech seals (25<= ID>= 50mm)	1350/Mech seals (25<= ID>= 50mm)			EA	SOR Item
WSNN036	136 Install 100/150mm DPH on new main			NUMBER	SOR Item
C331690093 - 397	136 Supply and install 18,600 to			SET	SOR Item
C331690093 - 397	136 Supply and install 18,600 to			SET	SOR Item
1360/Mech Seals(50<= ID>= 75mm)	1360/Mech Seals(50<= ID>= 75mm)			EA	SOR Item
WSNN037	137 Install 100/150mm DPH on extg main			NUMBER	SOR Item
C331690093 - 398	137 Supply and install 24,600 to			SET	SOR Item
C331690093 - 398	137 Supply and install 24,600 to			SET	SOR Item
1370/Mech Seals(75<= ID>= 100mm)	1370/Mech Seals(75<= ID>= 100mm)			EA	SOR Item
WSNN038	138 Resite 100/150mm DPH			NUMBER	SOR Item
C331690093 - 399	138 Supply and install 36,000 to			SET	SOR Item
C331690093 - 399	138 Supply and install 36,000 to			SET	SOR Item
1380/Mech Seals(100<= ID>= 125mm)	1380/Mech Seals(100<= ID>= 125mm)			EA	SOR Item
WSNN039	139 Raise / lower Pillar Fire Hydrant			NUMBER	SOR Item

Documentation requirements

Design Stage

- Tender specifications capturing the requirements for digitalized SOR stored in central database.

Verification Stage

- Screenshot/photos of central database indicating the SOR in digital format. The central database must include last updated and renewal date.

CHAPTER 4: RESPONSIBLE PARTIES FOR KEY MAINTENANCE ITEMS

The table below outlines the primary responsible parties for each Key Maintenance Items (KMIs). The Developer / Building Owner must direct the various responsible parties (where applicable to the project) to collaborate and comply with the KMIs.

KEY MAINTAINENCE ITEMS (Existing Non – Residential Building)	Responsible parties
SECTION 0 – ARCHITECTURAL EXTERIOR	
Promote inclusion of Design for Maintainability (DfM) during AEI stage	Client / Facility Manager / Architect / M&E Consultant/ BIM manager / Other specialists
SECTION 1 – ARCHITECTURAL EXTERIOR	
1.1 General Façade	
1.1.1 Reduce risk of water ingress and streaking on façade	Architect / Façade consultant
1.1.2 Access for maintenance of façade	Architect / Façade consultant
1.1.3 Access for maintenance to façade, soffit, and roof of enclosed sky bridges	Architect / Façade consultant
1.2 Cladding – Tile / Stone / Metal / Others	
1.2.1 Reduce risk of water ingress and streaking on façade	Architect / Façade consultant
1.3 Curtain Wall	
1.3.1 Reduce risk of water ingress and streaking on façade	Architect / Façade consultant
1.4 Masonry and Lightweight Concrete Panels	
1.4.1 Reduce risk of water ingress and efflorescence formation	Architect / Façade consultant
1.4.2 Reduce risk of façade flaking / peeling / cracking / blistering	Architect / Façade consultant
1.5 Façade Features / other façade considerations	
1.5.1 Direct access to all protruding façade features, e.g. canopies, sunshade, niches, fins, ledges, photovoltaic panels, BIPV, etc.	Architect / Façade consultant
1.5.2 Reduce risk of corrosion of exposed steel structures	Architect / Façade consultant

1.5.3	Reduce risk of water ingress in open joint cladding (cladding serving as a decorative feature and not as a water barrier)	Architect / Façade consultant
1.5.4	Reduce risk of tile/stone from detaching off façade	Architect / Façade consultant
1.6	Entrance Lobby	
1.6.1	Reduce risk of water ingress at entrances	Architect
1.7	Roof	
1.7.1	Reduce risk of water ponding on roofs	Architect
1.7.2	Reduce risk of waterproofing failure/decay on concrete roofs	Architect / Water proofing specialist
1.7.3	Reduce risk of corrosion on metal roofs	Architect / Metal roof specialist
SECTION 2 – ARCHITECTURAL INTERIOR		
2.1	Floors	
2.1.1	Reduce risk of damage to floors in common areas within the building	Architect / Interior consultant
2.1.2	Reduce maintenance works for floors in common areas within the building	Architect / Interior consultant
2.2	**Ceilings**	
2.2.1	Access to services within double slab areas for maintenance purpose	Architect / Interior consultant
2.2.2	Access to services within the ceiling in non-tenanted indoor spaces	Architect / Interior consultant
2.2.3	Access to ceiling for maintenance	Architect / Interior consultant
2.2.4	Reduce risk of warping/deterioration of ceiling panel system that are weather-exposed, e.g. sky terraces, entrance porches, corridors and canopies	Architect / Interior consultant
2.3	Wet Rooms and Storage	
2.3.1	Provide permanent space to store cleaning tools and toilet supplies	Architect
2.3.2	Reduce risk of mould and fungus formation on walls in wet rooms	Architect / Interior consultant
2.3.3	Reduce risk of damage to toilet cubicle partitions and enable ease of cleaning	Architect / Interior consultant

2.3.4	Reduce risk of water spill, and splashing and soap dripping on the counter and floor	Architect / Interior consultant
2.3.5	Reduce the need to replace entire mirror glass pane when damaged	Architect / Interior consultant
2.3.6	Reduce degradation of false ceiling system in wet rooms	Architect / Interior consultant
2.4	Loading Bay/Back of House Service Areas	
2.4.1	Reduce damage caused by impact on walls and columns in vehicular ramps, and loading bay areas	Architect
2.4.2	Reduce damage to walls, columns, and floors at back of house traffic delivery areas	Architect
SECTION 3 - MECHANICAL		
3.1	Chiller Plant	
3.1.1	Access to chiller plant room for equipment replacement	Architect/ M&E Consultant
3.1.2	Access to equipment requiring frequent maintenance	Architect / M&E consultant
3.1.3	Reduce risk of corrosion and dust invasion in cooling tower	M&E consultant
3.1.4	Reduce risk of oil/grease deposit on the cooling tower fins	Architect / M&E consultant
3.1.5	Reduce risk of fouling issue and improve condenser water quality	M&E consultant
3.1.6	Reduce risk of dust and debris settlement inside the cooling tower basin	M&E consultant
3.2	Unitary Air Conditioning System – Variable Refrigerant Flow (VRF)	
3.2.1	Access to VRF outdoor units	Architect / M&E consultant
3.2.2	Avoid damage to the refrigerant pipe and insulation	M&E consultant
3.3	Air Distribution System	
3.3.1	Access space for maintenance of air distribution system	Architect /M&E consultant/ Interior consultant
3.3.2	Reduce risk of water ponding and algae growth in the AHU room	Architect / M&E consultant
3.3.3	Reduce risk of choke of condensate drain pipes	M&E consultant
3.3.4	Reduce frequency of replacement for AHU filters	M&E consultant

3.3.5	Avoid frequent re-alignment of fan parts i.e. pulley, bearings and belts	M&E consultant
3.4	Domestic Water Supply	
3.4.1	Access space for maintenance of water tank	Architect / M&E consultant
3.5	Sanitary System	
3.5.1	Access provision and design detailing for sanitary pipes for ease of maintenance	M&E consultant
3.5.2	Reduce risk of chokes in the sanitary pipe	Architect / M&E consultant
3.6	Fire Protection System	
3.6.1	Prevent the lack of flexibility for maintenance and testing of sprinkler system	M&E consultant
3.6.2	Reduce risk of damage and periodic replacement of fire-rated boards due to exposure to high humidity and water	M&E consultant
SECTION 4 - ELECTRICAL		
4.1	Lighting System	
4.1.1	Reduce frequency of light replacement	M&E consultant / Architect / Interior Design consultant / Lighting Consultant
4.1.2	Reduce risk of light flickering	M&E consultant / Architect / Interior Design consultant / Lighting Consultant
4.1.3	Reduce risk of LED light colour shift	M&E consultant / Architect / Interior Design consultant / Lighting Consultant
4.2	Power Distribution	
4.2.1	Reduce risk of water Ingress into electrical room	Architect/ M&E consultant
4.2.2	Reduce risk of unnoticed failure of surge arrestor located in the LT main switchboard	M&E consultant
4.2.3	Reduce risk of failure of main LT switchboard due to overheating	M&E consultant
4.3	Extra Low Voltage System	
4.3.1	Provide access for CCTV camera located at heights	M&E consultant / Architect / Interior Design consultant
4.3.2	Provide flexibility for future expansion for CCTV system	M&E consultant

4.3.3 Reduce risk of damage to outdoor camera and other equipment due to lightning surge	M&E consultant
4.4 Lightning Protection System	
4.4.1 Reduce risk of damage of air termination tape at roof parapet wall due to operation of façade maintenance systems such as gondola	M&E consultant / Architect / Façade consultant
4.5 Vertical Transportation	
4.5.1 Access to lift motor room for maintenance	M&E consultant / Architect
4.5.2 Reduce lift downtime and enhance reliability	M&E consultant
SECTION 5 - LANDSCAPE	
5.1 Softscape	
5.1.1 Reduce labour-intensive irrigation for landscape	Landscape Architect
5.2 Hardscape	
5.2.1 Access for maintenance of underwater lighting systems	Architect / Landscape Architect
5.2.2 Reduce risk of damage/degradation to outdoor fixed landscape furniture	Landscape Architect
5.2.3 Ensure access for maintenance beneath decking	Landscape Architect
5.3 Vertical Greenery	
5.3.1 Access to all parts of vertical greenery for maintenance and replacement of perished plants	Architect / Landscape Architect/ Façade consultant
5.4 Roof, Sky Terraces, Planter boxes on building edge/facade	
5.4.1 Access for landscape on roof and sky terraces	Architect / Landscape Architect
5.4.2 Access to planter boxes on building edge	Architect / Landscape Architect
5.5 Standalone structures	
5.5.1 Reduce water ponding and degradation of outdoor standalone structures	Architect / C&S consultant
5.5.2 Reduce risk of warping/deterioration of ceiling panel system on standalone structure	Architect
SECTION 6 – SMART FM – Innovative Solutions	
6.1 Cybersecurity (Applicable to both BMS and FMS System)	
6.1.1 Lack of cyber security leading to data theft and economic impact	Client / Facility Manager

6.2	Adoption of Smart FM Solutions	
6.2.1	Adopt innovative technologies that improve FM labour efficiency and service delivery.	Client/ Architect/ M&E consultant/ Facility Manager
6.2.2	Advanced Smart FM – Integrated and aggregated Smart FM solutions that improve FM labour efficiency and service delivery	Client/ Architect/ M&E consultant/ Facility Manager
6.2.3	Design for Robotics and Automation (R&A)	Client/ Architect/ M&E consultant/ Facility Manager
SECTION 7 – SMART FM – Building Management System		
7.1	Central Computer	
7.1.1	Avoid data loss due to lack of redundancy	Client / Facility Manager
7.2	Software Integration	
7.2.1	Integration issues due to proprietary communication Protocol	M&E consultant / BMS vendor
7.2.2	Outdated operating system and lack of security features	M&E consultant / BMS vendor
7.2.3	Lack of interface with other services	M&E consultant / BMS vendor
7.2.4	Lack of notification system resulting in increased downtime	M&E consultant / BMS vendor
7.3	Controllers	
7.3.1	Lack of termination list	M&E consultant / BMS vendor
7.3.2	Lack of access to DDC panels	M&E consultant / BMS vendor
7.3.3	Lack of reliable power supply to DDC controllers	M&E consultant / BMS vendor
7.4	Integration with M&E Systems	
7.4.1	Lack of integration with Mechanical & Electrical systems	M&E consultant / BMS vendor
7.4.2	Lack of integration with Solar PV systems	M&E consultant / BMS vendor
SECTION 8 – Facility Management System		
8.1	Asset Management – Failure Analysis	
8.1.1	Failure analysis not performed	Client / FMS vendor / Facility Manager

8.2	Asset Management – Lifecycle Management	
8.2.1	Lifecycle analysis not performed	Client / FMS vendor / Facility Manager
8.3	Operations Management – Service Management	
8.3.1	Case management process is manually tracked or not tracked	Client / FMS vendor / Facility Manager
8.3.2	No customer care or self-service web portal or mobile app	Client / FMS vendor / Facility Manager
8.4	Operations Management – Maintenance Management	
8.4.1	Work order process is ill-defined, manually tracked or not tracked	Client / FMS vendor / Facility Manager
8.4.2	Work plans and checklists are not in digitalized format	Client / FMS vendor / Facility Manager
8.5	Operations Management – Other General Services	
8.5.1	Service request forms and processes are managed manually	Client / FMS vendor / Facility Manager
8.6	Supply Chain Management – Inventory, Procurement & Contract Management	
8.6.1	Inventory tracked manually (or FM staff has no access to Finance Department Inventory Management System)	Client / FMS vendor / Facility Manager
8.6.2	Procurement process tracked manually (or FM staff has no access to Finance Department Procurement Management System) – Sourcing, purchasing, goods receipt	Client / FMS vendor / Facility Manager
8.6.3	Expense budget management process tracked manually (or FM staff has no access to Finance Department Budget Management System).	Client / FMS vendor / Facility Manager
8.6.4	Vendor pre-qualification and regular grading reviews performed manually or not performed	Client / FMS vendor / Facility Manager
8.6.5	No vendor self-service web portal	Client / FMS vendor / Facility Manager
8.6.6	Contracts are tracked manually	Client / FMS vendor / Facility Manager
8.6.7	Schedule of rates not in digitalized format	Client / FMS vendor / Facility Manager