Green Mark 2021

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RESIDENTIAL BUILDINGS TECHNICAL GUIDE

# Acknowledgements:

| | |
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**Maintainability Technical Reference (Residential 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)<br>• Editorial changes across the framework for improved clarity.<br>• Addition of criteria/ / revision to existing criteria<br>i) 2.4.2b (50mm raised partition)<br>ii) 2.4.5c (open ceiling)<br>iii) 3.3.1c (access panel for ducted FCU)<br>iv) 3.6.1b (weatherproof fire-rated material)<br>v) 5.1.1a (20m radius water points)<br>vi) 5.2.1aii (shallow water body)<br>• Deletion of former criteria<br>i) 1.4.1a (efflorescence)<br>ii) 2.5.1d (basement- negative side waterproofing)<br>iii) 3.5.1a (cleaning eyes with viewing panel)<br>iv) 3.6.1a (access to fire detectors)<br>v) 4.1.1a (access to light fixtures)<br>vi) 5.6.1c (water absorption rate of engineered wood) | 01 Jan 2024 |
| 05 | Fifth issue with minor updates (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 (RB)

The Maintainability Section (RB) 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 (RB) 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. <u>Scope of common areas</u>

The Maintainability Section (RB) 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. <u>Tenant spaces and residential units</u>

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. <u>Systems for Standby or Night-load</u>

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

iv. <u>SMART FM</u>

Smart FM solutions presented in the Maintainability Section (RB) 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:<br><br>**a.** Apportioned points for solutions with 15% to 85% coverage (partial or apportioning) in area of application or number of instances.<br><br>**b.** Full points for solutions with >85% coverage in area of application or number of instances.<br><br>**c.** No points for solutions with <15% coverage in area of application or number of instances. |

## 3. 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

## 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 (RB) 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 (RB) 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

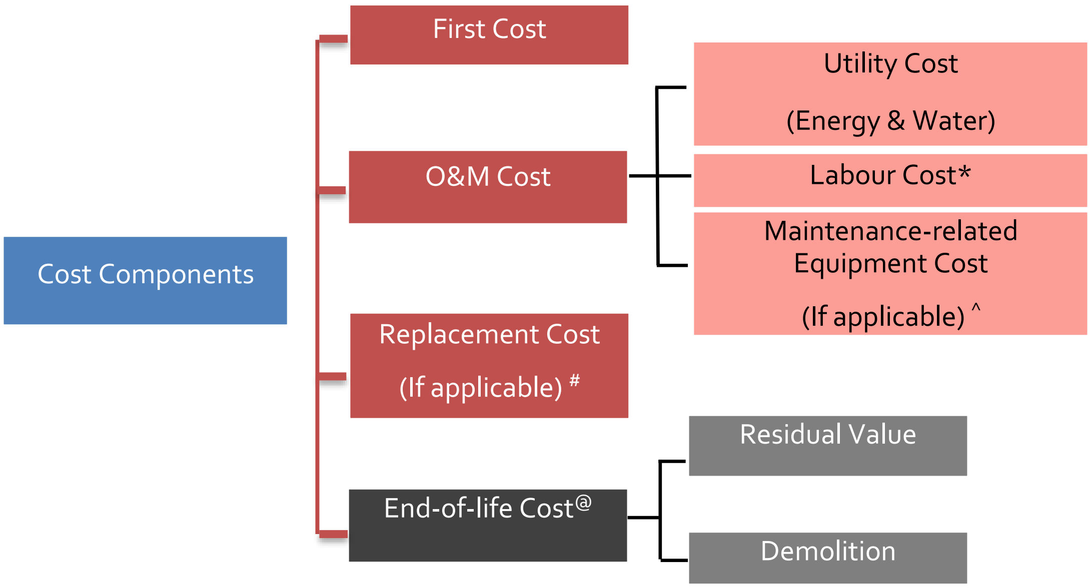
The Maintainability Section (RB) employs an LCC study to evaluate the design with maintenance in mind. The Maintainability Section (RB) promotes holistic sustainability in terms of long term economic and social impact through greater cost savings and reduced reliance on manual labour.

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 (RB) 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 (RB) 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 (RB) 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 (RB), the study period is set to the lifespan of the presented solutions with the longest expected lifespan not exceeding 30 years.

<u>Setting the length of study period</u>

In the Maintainability Section (RB), 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, service life of false ceilings is about 10 years. The study period for LCCs related to LCCs is set at 10 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 (RB), 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 (RB). 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 (RB) LCC exercise was conducted and is only for reference. Project team shall use the project specific SOR for LCC study.*

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

## 6. LCC output

Man-hour Savings

Total Life Cycle cost

Savings to Investment Ratio (SIR)

Adjusted Internal Rate of Return (IRR)

Payback Period

- 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.

- 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<br>Highest net saving<br>SIR > 1<br>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 (RB) 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 (RB) 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 (RB) 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 and Table 4 for more information).

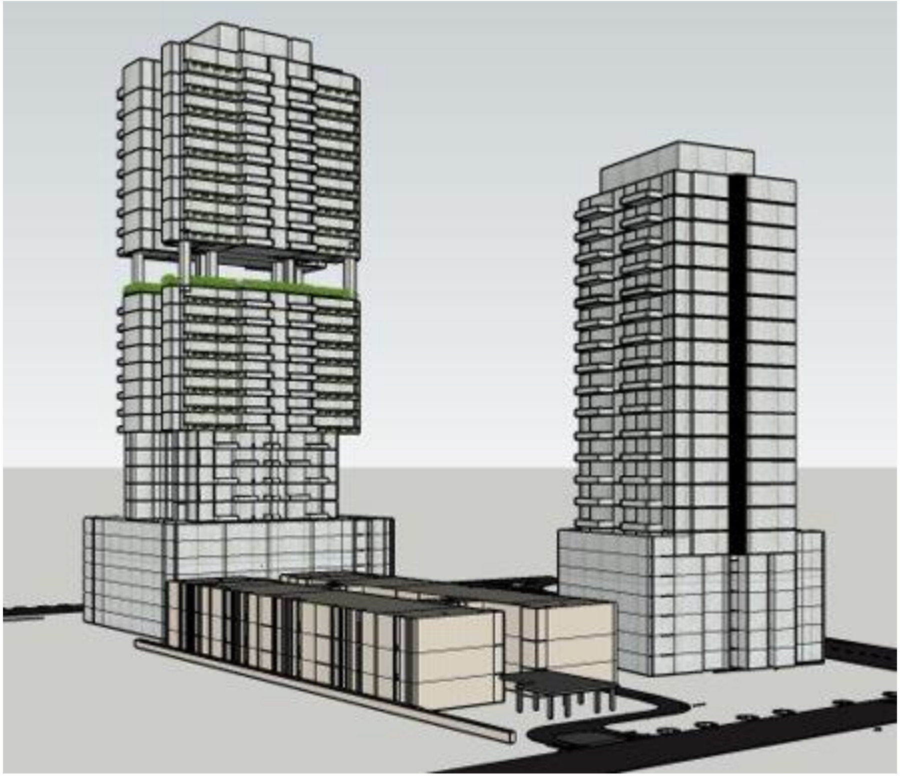


*Figure 1. Notional building perspective*

*Table 4. Notional building information*

| S/N | Key Design Criteria | Description |
|---|---|---|
| **1** | Site Area | 11,540 sqm |
| **2** | Development | ▪ Block 1: 28 storeys<br>▪ Block 2: 21 storeys<br>▪ Terrace houses – 3-storey<br>▪ Facilities: Club house, pool, tennis court, carparks |
| **3** | Total GFA | 25,525 sqm |
| **4** | No. of units | 320 |
| **5** | Construction Cost | $2,500/m$^2$ GFA (~$3,000/m$^2$ CFA) * |

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

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

The NIST "Building Life Cycle Cost" (BLCC) software tool is adopted in the Maintainability Section (RB) 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 Example

This segment provides an example of the LCC analysis for one the Key Maintenance Issue (KMI) stipulated in the Maintainability Section (RB). 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: Monolithic plaster ceiling (Gypsum ceiling). The area of common area ceiling is derived from the notional building.
- Proposed solution: Suspended Grid Ceiling (Mineral Fibre). Suspended Grid ceilings are considered efficient both in terms of access to maintenance as well as replacement damaged panels. The LCC study captures both the ad hoc repair.
- Maintenance issues due to monolithic plaster ceiling: Frequent access to services above ceiling require cutting of ceiling panel and labour-intensive replacement work.
- Intent: Use of suspended grid ceiling panels reduce time and effort taken to access the services and perform maintenance works.
- Study period: 10 years (the average lifespan before complete overhaul is carried out).

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

| Input | Baseline Solution | Best Practice Solution |
|---|---|---|
| Ceiling | Monolithic Plaster Ceiling (Gypsum Ceiling) | Suspended Grid Ceiling (Mineral Fibre) |
| Assumptions | **Notional building**: 2800sqm of common area ceiling<br>First Cost: $35/sqm<br>**Ad hoc Repair:** $500 per repair works for cutting plaster and putting back of monolithic plaster ceiling board when the access panel is not sufficient<br>**Full Replacement:** Assume to have no full replacement of ceiling within the study period but repainting cost is included.<br>Repainting works happen once every 4 years. Cost of repainting works at $2.6/sqm<br>Unit Rate: 10 Days, 7 Men, 8hrs to paint all the monolithic plaster ceiling | **Notional Building:** 2800sqm of common area ceiling<br>**First Cost:** $40/sqm (Mineral Fibre) ($60/sqm for Metal Ceiling)<br>**Ad hoc Repair:** Assumption of mineral fibre ceiling board damaged by regular maintenance, change up to 1% of board per year for a lump sum cost of $300 per trip to replace the board<br>**Full Replacement:** Assume to have no full replacement of ceiling within the study period. Repainting is not required for Mineral Fibre Board<br>LCC to use mineral fibre ceiling board instead of metal ceiling |
| First Cost | 2800sqm x $35/sqm= $98,000 | 2800sqm x $40/sqm = $112,000 |
| Operation & Maintenance Cost | • **Ad hoc Repair Cost**<br>$500/ Repair / Year<br>*2 construction worker x 8 hrs x 2 days = 32 Man Hour*<br>*Full Replacement*<br>*Once every 4 years*<br>*0.25 x $2.6 x 2800sqm = $1820*<br>*0.25 x 7 Construction Worker x 10 Days x 8 Hr= 140 Man Hour*<br>**Total maintenance cost /year: $2320**<br>**Total man-hours spent/year: 140 + 32= 172** | • **Ad hoc Repair Cost**<br>*$300/ Repair / Year*<br>*1 construction worker x 2 hrs x 1 days = 2 Man Hour*<br>**Total maintenance cost /year: $300**<br>**Total man-hours spent/year: 2** |
| Saving on Man-hour/year | -N/A | 170 |

Table 6: Summary of cost/savings

| Input | Baseline Solution<br>Monolithic Plaster Ceiling | Proposed Solution<br>Suspended Grid Ceiling |
|---|---|---|
| Initial Cost | $98,000 | $112,000 |
| Operation & Maintenance /Year | $2320 | $300 |
| Man-hour/ Year<br>(Man-days/ year) | 172<br>(57.1) | 2<br>(0.085) |

Table 7 LCC output example

| | Baseline solution<br>(Monolithic Plaster Ceiling) | Best Practice Solution<br>(Suspended Grid Ceiling) | Savings from Proposed Solution |
|---|---|---|---|
| Initial Investment Cost (S$) | 98,000 | 112,000 | -14,000 |
| Annual O&M Cost (S$) | 2320 | 300 | 2020 |
| O&M Cost – Present Value (S$) | 113,321 | 113,981 | 660 |
| Total Life Cycle Cost (Present Value) (S$) | 115,641 | 114,281 | 1360 |
| Labour Saving<br>(Man hour/year) | 170 | | |
| Simple Payback Period (year) | 6.93 | | |

Figure 2: 14% higher on initial investment

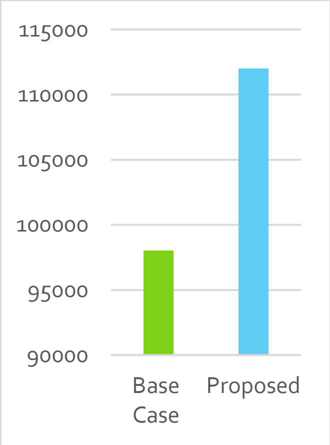



Figure 3: 87% reduction in annual O&M cost

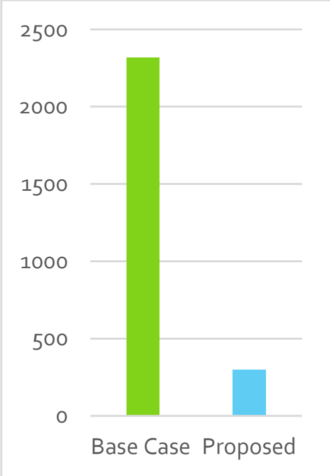



Figure 4: 12% reduction in total life cycle cost

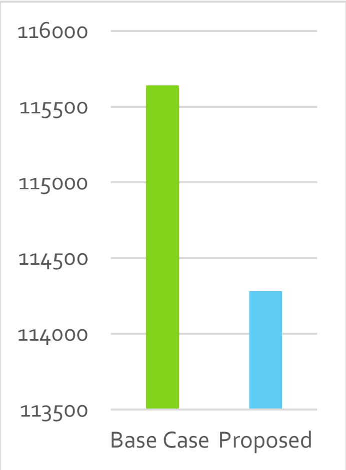
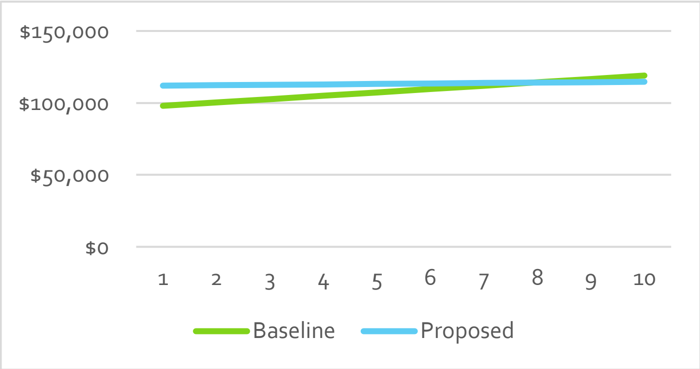



Figure 5: Payback Period




## 10. Maintainability premium

- While the term "Maintainability Premium" is used – drawing semblance to Green Premium – the actual consideration here is an adjustment in first cost for under-investment in maintainability, rather than a premium of sort. The idea here is that Maintainability is part of sensible design to ensure downstream maintainability regimes remain resource-efficient over the life span of a building. Hence, any increase in first cost to enhance maintainability is a must-have investment rather than seen as premium. Notwithstanding, for convenience, we are using the term "premium".
- The Maintainability Section (RB) comprises around 100 better practice solutions. While the intent is to undertake LCC analysis on all solutions, this is however not feasible for the following reasons:

- For the purposes of LCC computations, solutions need to comprise quantitative elements
- Spatial-related solutions for ease of maintenance are considered as a basic design responsibility and not included in the LCC analysis, e.g. access within pump rooms
- Few design and detailing related solutions such as plant room ventilation, slope for condensate drain, roof slope, and waterproofing for retaining walls are deemed essential enough to be addressed in the base design and excluded in the LCC analysis

- Notwithstanding the above, LCC analysis was undertaken on access provisions which reduces significant man-hours and incur considerable efforts to implement the solution, e.g. cooling tower maintenance platform and façade access system. Overall, the LCC study was carried out on 22 architecturally-related LCCs and 6 M&E-related LCC studies.

- Since the LCC studies are based on the notional building, **it is important that project parties undertake project-specific LCC studies to accurately capture the adjustment in the first cost for their respective projects and estimate their potential savings**.

- In deriving the maintainability premium, it is important to exclude the cost associated with solutions included in the Green premium, to avoid double accounting of the capital cost and overall life cycle cost. The focus of maintainability premium is different from that of the green premium typically considered for Green Mark cost benefit analysis. While the Green premium focuses on utility cost savings, the maintainability premium focuses on cost and labour saving arising from improved productivity and ease of maintenance. However, some solutions may include both man-hour savings and utility cost savings due to better maintainability provisions, e.g. reliable lighting which has both maintainability benefits and utilities cost savings due to its better efficiency.

- The LCC study for the Maintainability section was aimed at understanding the maintainability premium for obtaining the Maintainability Badge *(i.e. attaining at least 10 out of the available 15 points under the Maintainability section)* for a residential development, using the notional building. The approach was to aggregate the costs associated in adopting the better practice solutions. The range of solutions adopted was based on a balance of cost, design strategy, and impact for a project aiming for the Maintainability badge. The payback was estimated to take up to 3 years, with an aggregated potential annual labour savings of up to 400 man-days/year.

## CHAPTER 3: TECHNICAL GUIDE

| **CRITERIA** | | | **Points Allocation** |
|---|---|---|---|
| Section 0 – GENERAL | | | |
| 0.1 | General Project Requirement | | 3 |
| | *Sub-total score for Section 0* | | 3 |
| Section 1 – ARCHITECTURAL EXTERIOR | | | |
| 1.1 | General Façade | Part A | 0.5 |
| | *Part A: Subtotal of 1.1* | | 0.5 |
| 1.2 | Cladding system: Tile / Stone / Metal / Others | Part B: Façade System | 4 |
| 1.3 | Curtain Wall: Glazing / Others | | 4 |
| 1.4 | Masonry, Lightweight Concrete Panels, and Precast Components | | 4 |
| | *Part B: Subtotal of 1.2 to 1.4, including pro-ration)* | | 4 (Max) |
| 1.5 | Façade Features / other façade considerations | Part C: Façade Ancillaries | 3 |
| 1.6 | Entrance lift lobby / integrated drop-off points at blocks | | 2 |
| 1.7 | Exposed corridors, lift lobbies, and Link Bridges | | 2 |
| 1.8 | Roof | | - |
| | *Part C: Subtotal of 1.5 to 1.8* | | 7 |
| | *Sub-total score for Section 1 (Part A + Part B+ Part C)* | | 11.5 |
| Section 2 – ARCHITECTURAL INTERIOR | | | |
| 2.1 | Floors | | 2.5 |
| 2.2 | Walls and Partitions | | 1 |
| 2.3 | Ceilings | | 4 |
| 2.4 | Common toilets | | 7 |
| 2.5 | Basement | | 4 |
| | *Sub-total score for Section 2* | | 18.5 |
| Section 3- MECHANICAL | | | |
| 3.1 | Air Conditioning System-Direct Expansion System (DX Units) | | 2 |

| | | |
|---|---|---|
| 3.2 | Air Conditioning System - Variable Refrigerant Flow (VRF) System | - |
| 3.3 | Air Distribution System | 1 |
| 3.4 | Domestic Water Supply | - |
| 3.5 | Sanitary System | 2 |
| 3.6 | Fire Protection System | 2 |
| 3.7 | Swimming Pool System | 3 |
| | *Sub-total score for Section 3* | 10 |
| **Section 4 - ELECTRICAL** | | |
| 4.1 | Lighting System | 1.5 |
| 4.2 | Power Distribution System | 3 |
| 4.3 | Extra Low Voltage (ELV) System | 3 |
| 4.4 | Lightning Protection System | 1 |
| 4.5 | Vertical Transportation System | 2 |
| 4.6 | Carpark Entry System | - |
| | *Sub-total score for Section 4* | 10.5 |
| **Section 5 - LANDSCAPE** | | |
| 5.1 | Softscape | 1 |
| 5.2 | Hardscape | 4 |
| 5.3 | Vertical Greenery | - |
| 5.4 | Roof and Sky Terraces | 1 |
| 5.5 | Water Retaining Structure | 3 |
| 5.6 | Standalone Structures | 1.5 |
| | *Sub-total score for Section 5* | 10.5 |
| Section 6 - FACILITIES | | |
| 6.1 | Outdoor games court | 2 |
| | *Sub-total score for Section 6* | 2 |
| **Section 7 – SMART FM** | | |
| 7.1 | Innovation features in labour-saving/maintenance-free | 5 |
| | *Sub-total score for Section 7* | 5 |
| | ***Overall Maintainability Points*** | **71** |

**SECTION 0 – GENERAL**

## 0. GENERAL REQUIREMENTS (UP TO TOTAL 3 POINTS)

**Promote inclusion of Design for Maintainability (DfM) at planning and design 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: (prerequisite & 1 point)**

**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 (prerequisite) :**

- **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) 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 .
- Demonstrating the integrative design process via correspondences, meeting agenda, minutes of meeting etc. recorded during the design charrettes.

**Verification Stage**

- Design for maintainability report.
- Submit as-built drawings, photographs, and/or O&M manuals highlighting the maintainability features installed on site.

**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. (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

[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

## SECTION 1 – ARCHITECTURAL EXTERIOR

### Part A: SECTION 1.1

## 1.1. GENERAL FAÇADE (0.5 points)

### 1.1.1. Reduce risk of water ingress and streaking on façade (0.5 points)

**Intent**

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

**Design strategy and assessment: (prerequisite)**

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.**

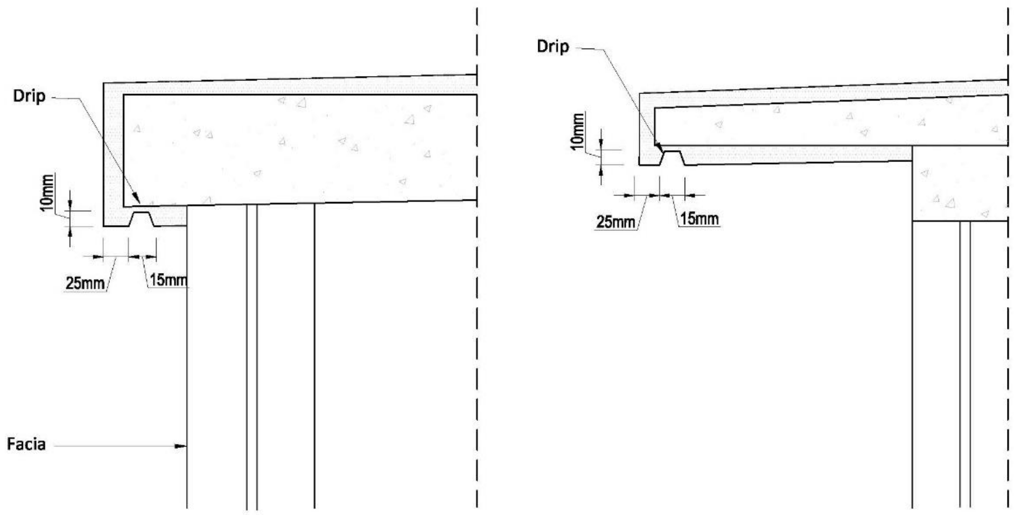



*Figure 6: Typical drip edge detail on projected façade elements. Image on the left illustrates detail on recessed window and image on right illustrates detail on sunshades.*

### 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.*

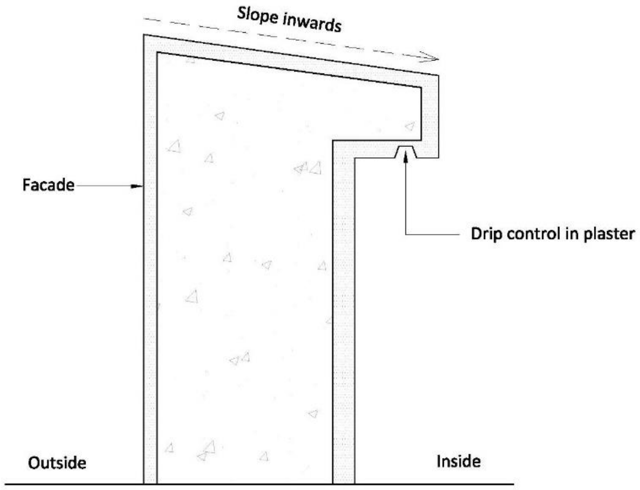



*Figure 7: Drawing illustrating slope gradient on top surface of external wall.*

## 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 (prerequisite)

**Intent**

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

**Design strategy and assessment: (prerequisite)**

**a. Ensure entire façade is accessible for maintenance.**

*Note:*

- *Façade: including 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.*

### 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 to façade, soffit, and roof of sky bridges (prerequisite)

**Intent**

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

**Design strategy and assessment: (prerequisite)**

**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**

*(Points can be scored for 1.2, 1.3, or 1.4; points will be apportioned for projects having multiple types of façade systems)*

## 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: (prerequisite)**

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.**

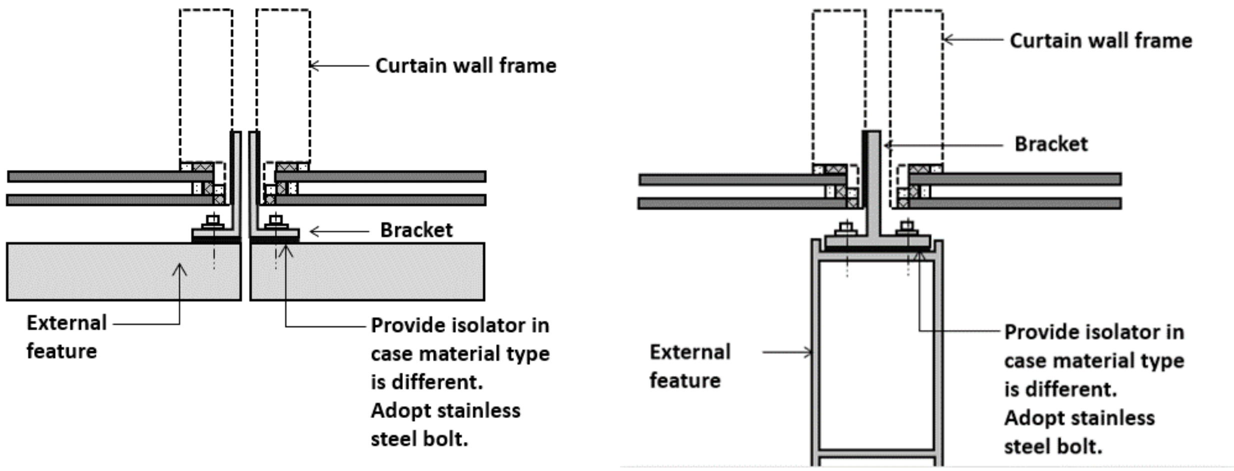



*Figure 8: Example – plan drawing (detail) on left and right illustration connection between curtain wall and metal external feature on the exposed face of the facade. Providing metals of similar properties or separator/isolator helps to mitigate risk of bi-metallic corrosion.*

***Credits: YKK AP FAÇADE***

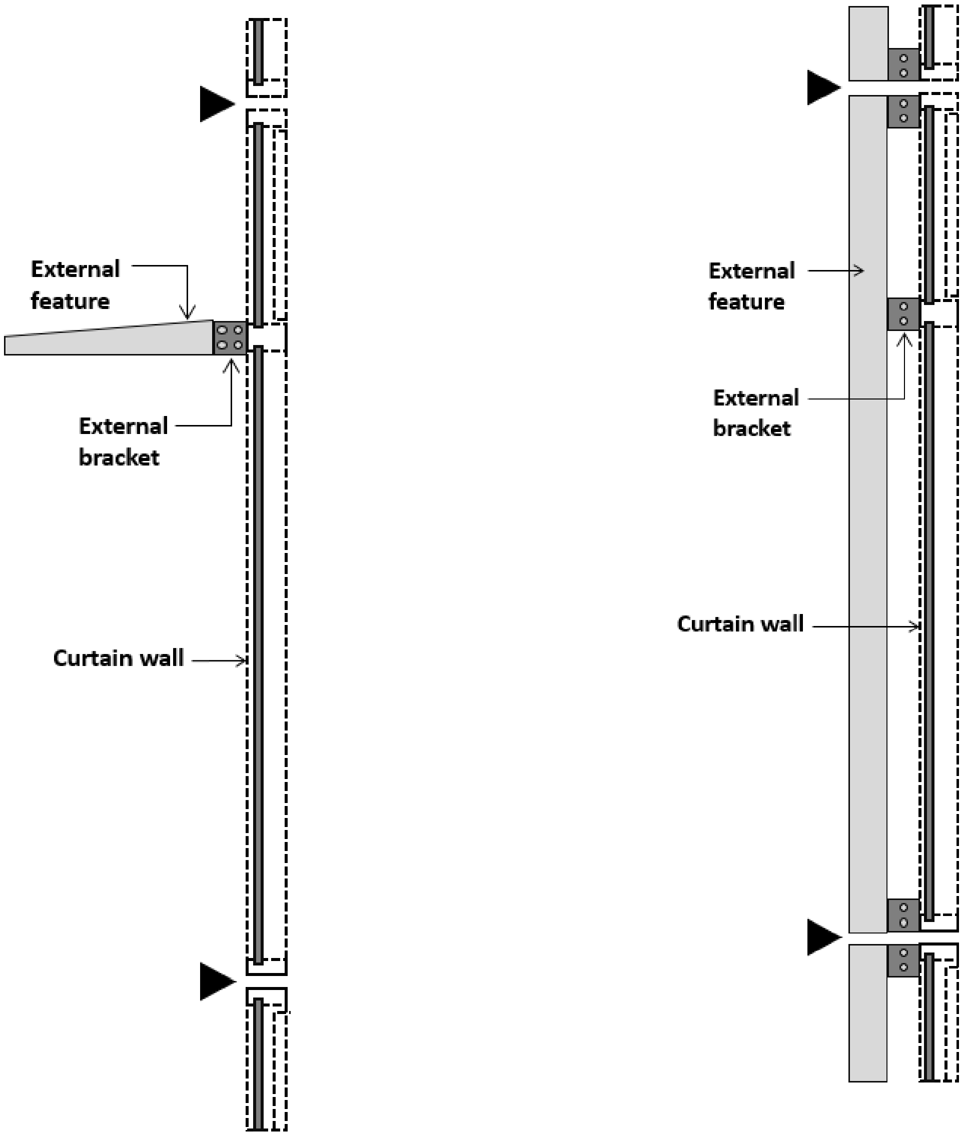



*Figure 9: Example – section drawing (detail) on left and right illustration connection between curtain wall and metal external feature on the exposed face of the façade. Providing metals of similar metal properties or separator/isolator helps to mitigate risk of bi-metallic corrosion.*

***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:**

**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 Systems act 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* |

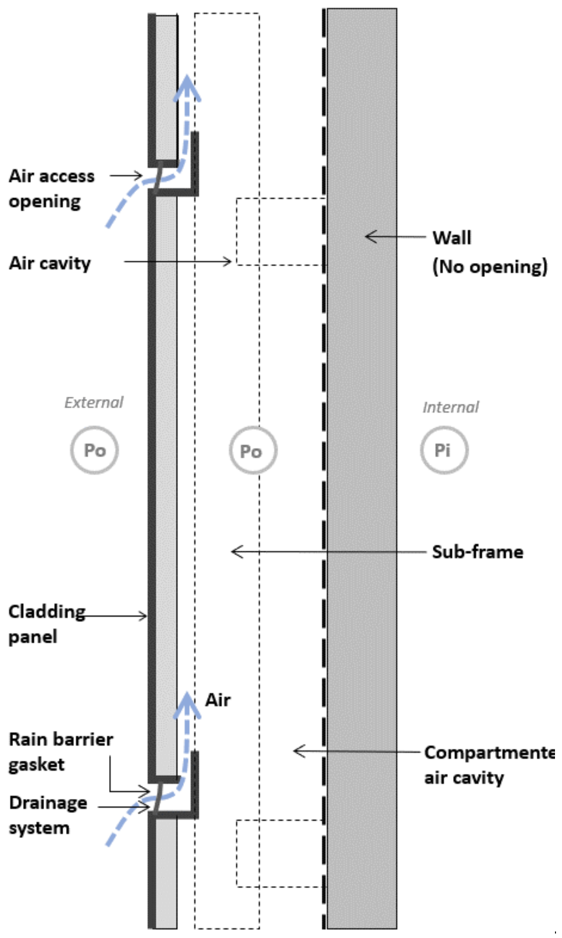



*Figure 10: Drawing illustrating pressure equalised system.*

***Credits: YKK AP FAÇADE***

*Life cycle cost analysis: baseline vs design strategy*

| Incremental cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 20% - 25% | 75% - 80% | 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:*

- *Silicon: 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. Silicon 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 or frozen 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) |
|---|---|---|---|
| Up to 5% | 25% - 30% | Up to 5% | 9 - 10 |

*Baseline design strategy: Sealant without non-bleed, non-stain properties*
*Proposed design strategy: Sealant with non-bleed, non-stain properties*
*Study period: 10 years*
*Yearly labour savings: 40-50% 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 1248 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, copings 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.*

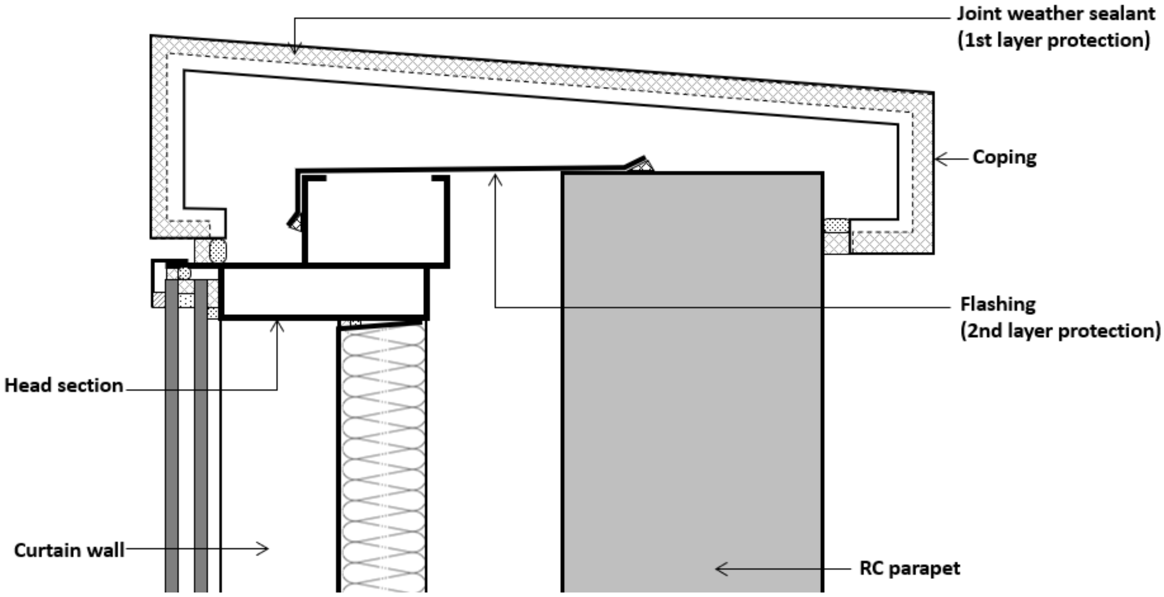



*Figure 11: Drawing illustrating double layer protection at façade copping, in this case sealant (1st layer of protection) and flashing (2nd layer of protection).*

***Credits: YKK AP FAÇADE***

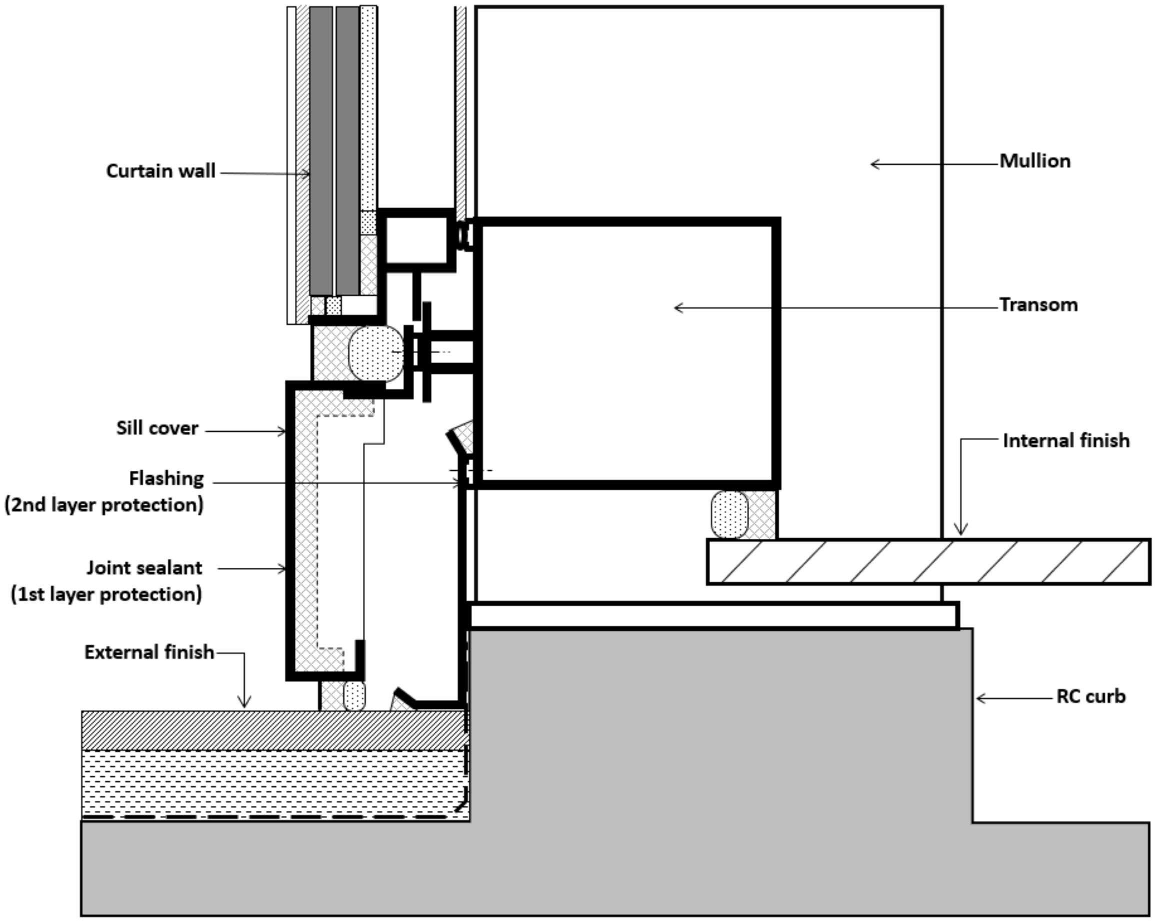



*Figure 12: Drawing illustrating double layer protection at bottom flashing, in this case sealant (1st layer of protection) and flashing (2nd layer of protection).*

***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)**

**Advanced effort: For water ingress: Specify anti-carbonation coating or waterproofing layer onto the backing wall behind the cladding (+1 bonus point)**

### 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: (prerequisite)**

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

#### Verification stage

- As-built (facade 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:**

**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 Systems act 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 1.3 for PES and Non - PES façade systems*

| *Solutions under 1.3* | *PES system* | *Non - PES system* |
|---|---|---|
| *1.2.1a* | *yes* | *yes* |
| *1.2.1b* | *yes* | *No* |
| *1.2.1c* | *yes* | *yes* |
| *1.2.1d* | *yes* | *yes* |
| *1.2.1e* | *yes* | *NA* |
| *1.2.1f* | *yes* | *yes* |

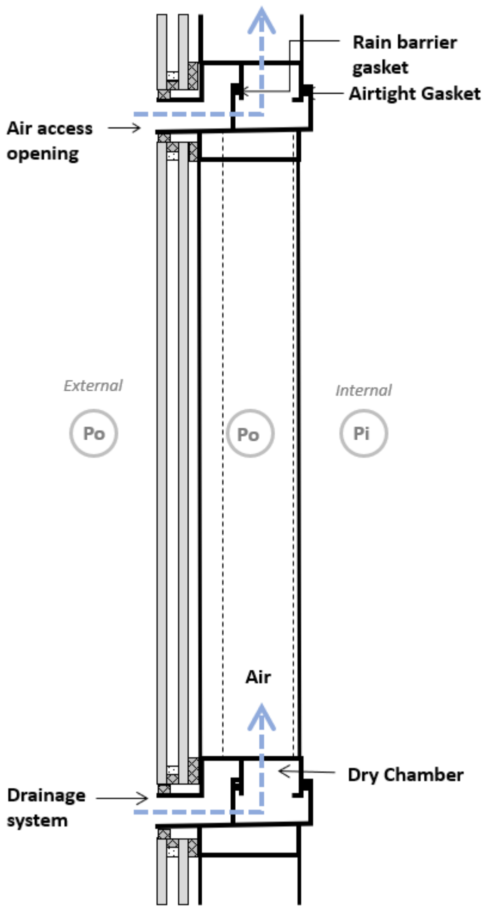



*Figure 13: Drawing illustrating pressure equalised system.*

***Credits: YKK AP FAÇADE***

*Life cycle cost analysis: baseline vs design strategy*

| Incremental cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 20% - 25% | 75% - 80% | 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 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 strategies 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 must be tested to Adhesion-in-Peel in compliance to ASTM C794[1]10. The test should include but not be 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 be 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 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) |
|---|---|---|---|
| Up to 5% | 25% - 30% | Up to 5% | 9 - 10 |

*Baseline design strategy: Sealant without non-bleed, non-stain properties*
*Proposed design strategy: Sealant with non-bleed, non-stain properties*
*Study period: 10 years*
*Yearly labour savings: 40-50 % man-hour*

[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

### 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 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.**

### Documentation requirements

#### Design stage

- Plan/elevation drawings indicating all glazing 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.

**Design strategy and assessment: (0.5 point)**

**f. For water ingress - design for double layer protection at façade interfaces, copings, 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.*
- *Incase 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.*

[12] ASTM C1248-06, Standard Test Method for Staining of Porous Substrate by Joint Sealants, ASTM International, West Conshohocken, PA, 2006, 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.

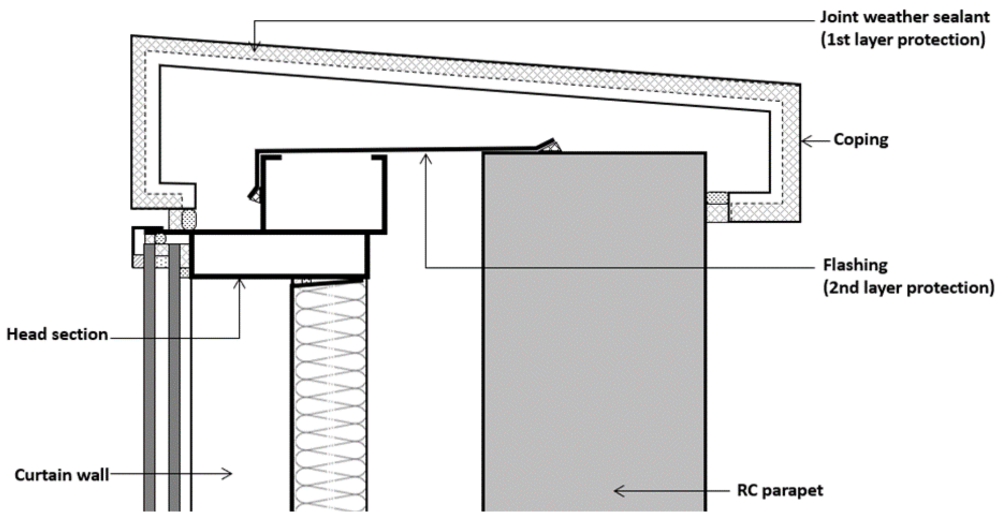



*Figure 14: Drawing illustrating double layer protection at façade copping, in this case sealant (1st layer of protection) and flashing (2nd layer of protection).*

***Credits: YKK AP FAÇADE***

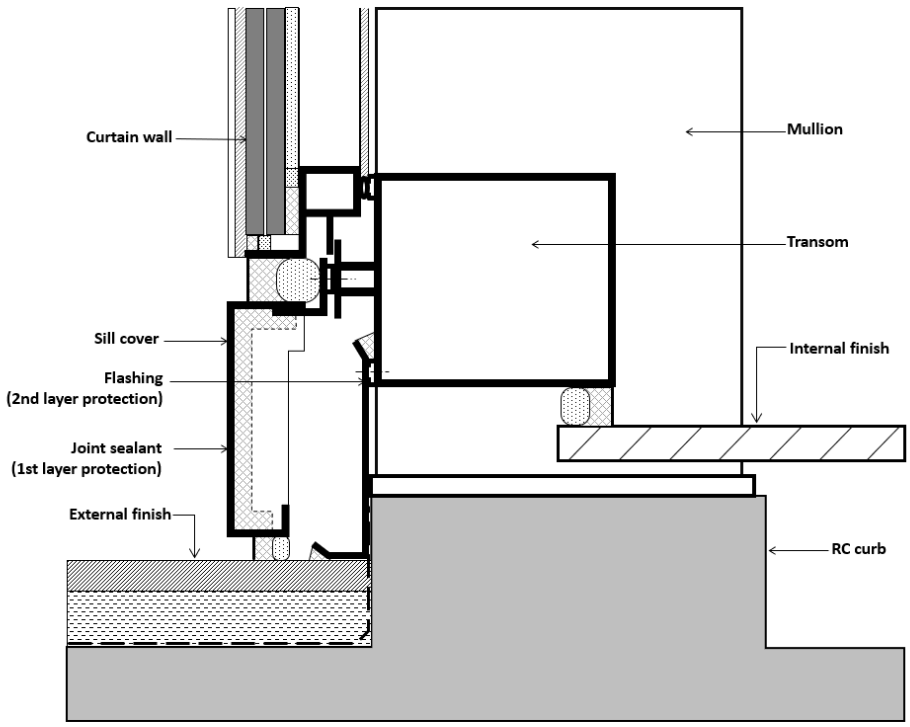



*Figure 15: Drawing illustrating double layer protection at bottom flashing, in this case sealant (1st layer of protection) and flashing (2nd layer of protection).*

***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 drawings (facade shop drawings) to show implementation.

## 1.4. MASONRY, LIGHTWEIGHT CONCRETE PANELS, AND PRECAST ELEMENTS (4 points)

### 1.4.1. Reduce risk of water ingress and efflorescence formation (2 points)

**Intent**

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

**Design strategy and assessment: prerequisite**

**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)**

**b. For water ingress in pre-cast components joints – specify silicone or modified silicone sealant on weather-exposed joints, that is compatible and with adequate adhesion properties to the substrate.**

*Note:*

*- Silicon: 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. Silicon 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 has 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.*

*- 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 facades using sealants.
- Tender specification indicating sealant type as silicon or modified silicon.
- 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)**

**c. For efflorescence: specify**

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

***(OR)***

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

*Note: Surface coatings that have good resistance to water absorption reduce the occurrence of efflorescence.*

*Life cycle cost analysis: Baseline vs Design strategy*

| Incremental cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| Up to 5% | 75% - 80% | 10 - 15% | 1 - 2 |

*Baseline design strategy: only standard paint SS345*
*Proposed design strategy: Paint with good resistance to water absorption complying with SS500*
*Study period: 7 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 flaking/peeling/cracking/blistering (Up to 2 points)

**Intent**

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

**Design strategy and assessment: (2 points)**

a. **Specify for integral colours (i.e. directly mixed into the cement) or post-applied stains (impregnator) with inorganic pigments for surfaces which do not require painting.**

*Note: Integral colours are admixtures (powder or liquid)/iron oxide pigments infused in concrete, while stains are compounds that when applied react with the chemical present in the concrete to create permanent colours.*

### Documentation requirements

#### Design stage

- Plan drawings indicating all surfaces with integral colours in concrete mix or stain on concrete surface.
- Tender specification indicating integral colours in concrete mix or stain on concrete surface.

#### Verification stage

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

**Design strategy and assessment: (1 point)**

**b. 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*

| Incremental cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| Up to 5% | 85% - 90% | 40 - 45% | 1 - 2 |

*Baseline design strategy: standard paint SS345 with primer (water-based)*
*Proposed design strategy: Paint with good resistance to water absorption complying with SS500*
*Study period: 7 years*
*Yearly labour savings: 50-60% man-hour savings*

## Documentation requirements

### Design stage

- Plan drawings indicating all external surfaces with paint finish.
- Tender specification indicating use of selected paint finish and composition.
- 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.

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

**Worked Example 1:**

Springdays Condominium has five 20-storey residential blocks. It has several on-site common facilities such as 2 function rooms, a gym, a club room, swimming pool, a sky terrace on the 6th storey, some outdoor function spaces, and the roof garden. The lift lobbies and corridors serving residents on every floor are naturally ventilated. There is a drop-off porch on the ground floor.

The total façade area for the Springdays Condominium is 50,000 $m^2$, comprising:

- 2,500$m^2$ of stone cladding
- 10,000$m^2$ of metal cladding
- 37,500$m^2$ of glazing

The curtain wall glazing is a pressure-equalised system (PES) while both the stone and metal cladding system are a non-PES system. See breakdown in Area Table I below:

| | Glazing ($m^2$) | Stone Cladding ($m^2$) | Metal Cladding ($m^2$) | Total ($m^2$) |
|---|---|---|---|---|
| Facade | 37500 | 2500 | 10000 | 50000 |

*Area Table I : Breakdown of Façade Systems*

- Proportion of curtain wall glazing system
  = 37,500$m^2$ / 50,000$m^2$ = 75% (≥15%)

- Area of Cladding System (stone + metal)
  = 2,500$m^2$ + 10,000$m^2$ = 12,500$m^2$

- Proportion Cladding System (stone + metal)
  = 12,500$m^2$ / 50,000$m^2$ = 25% (≥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 case project comprises multiple façade systems, points will be apportioned on an area basis)*

***NOTE:** The maximum points available for 1.2 Cladding System is 25% * 4pts = 1pt*

*As both the stone and metal cladding system are designed as a non- PES system with other similar specifications (silicone sealant, waterproofing on the backing wall and double layer protection), they are assessed together under the cladding section.*

## 1.2 Cladding – Tile / Stone / Metal / Others

| 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:<br>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. | Prerequisite | NA | √ | Complied |
| b. For water ingress:<br>Design as pressure-equalised (rain-screen) system, comprising of:<br>i) Ventilation openings of adequate dimensions to ensure pressure-equalisation of the cladding cavity<br>ii) Drainage system to positively drain out water<br>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 | √ | 25% * 1 = 0.25 |
| d. For streaking – specify sealant type with non-stain, non-bleed properties. | 0.5 | Cat 1 | √ | 25% * 0.5 = 0.125 |
| 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, etc. | 0.5 | Cat 2 | √ | 25% * 0.5 = 0.125 |
| Score for *1.2 Cladding System* | | | | 0.25 + 0.125 + 0.125 = 0.5<br>1 (max) |

| | | | | |
|---|---|---|---|---|
| ***BONUS:*** For water ingress: Specify anti-carbonation coating or waterproofing layer onto the backing wall behind the cladding. | 1 | Cat 1 | √ | 25% * 1 = 0.25 |

## 1.3 Curtain Wall

***NOTE:*** *The maximum points available for 1.3 Curtain Wall is 75% * 4pts = 3pts*

| 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:<br>Specify metals of similar properties or separators between different metal components on the external face of façade to mitigate risk of bi-metallic corrosion. | Pre-requisite | NA | √ | Complied |
| b. For water ingress – design for pressure-equalised system comprising of:<br>i) Ventilation openings of adequate dimensions to ensure pressure-equalisation of the cavities<br>ii) Drainage system to positively drain out water<br>iii) Internal air-seal layer to pressurise internal cavities and minimise risk of water penetration | 2 | Cat 1 | √ | 75% * 2 = <u>1.5</u> |
| c. For water ingress - specify silicone sealant that is compatible and with adequate adhesion properties to the substrate. | 1 | Cat 1 | √ | 75% * 1 = <u>0.75</u> |
| d. For streaking – specify sealant type with non-stain, non-bleed properties. | 0.5 | Cat 1 | √ | 75% * 0.5 = <u>0.375</u> |
| e. For water ingress – specify gasket type EPDM or TPE. | 1 | Cat 1 | √ | 75% * 1 = <u>0.75</u> |
| f. For water ingress – design for double layer protection at façade interfaces, copings etc. | 0.5 | Cat 2 | √ | 75% * 0.5 = <u>0.375</u> |
| Score for *1.4 Glazing System* | | | | 1.5 + 0.75 + 0.375 + 0.75 + 0.375 = 3.75<br><u>3 (max)</u> |

As such, the final points for the entire Part B : ***Façade System (Stone & Metal Cladding System + Glazing System)*** = 0.5 + 3 = **<u>3.5 points</u>** + **<u>0.25 (bonus*)</u>**

**The bonus points of **<u>0.25</u>** will 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 1.8

## 1.5. FAÇADE FEATURES / OTHER FAÇADE CONSIDERATIONS (3 points)

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

**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: (prerequisite)**

**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.

**Design strategy and assessment: (prerequisite)**

**b. Ensure all glass features and their structures (e.g. glazed canopies) can withstand maintenance-related loads.**

*Note: provide fall and drainage to mitigate water ponding and stagnation of dirt.*

**Documentation requirements**

Design stage

- PE declaration indicating maintenance load has been accounted for in structural design.

Verification stage

- PE declaration form.

[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

## 1.5.2. Reduce risk of corrosion of exposed 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 (raised by 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.

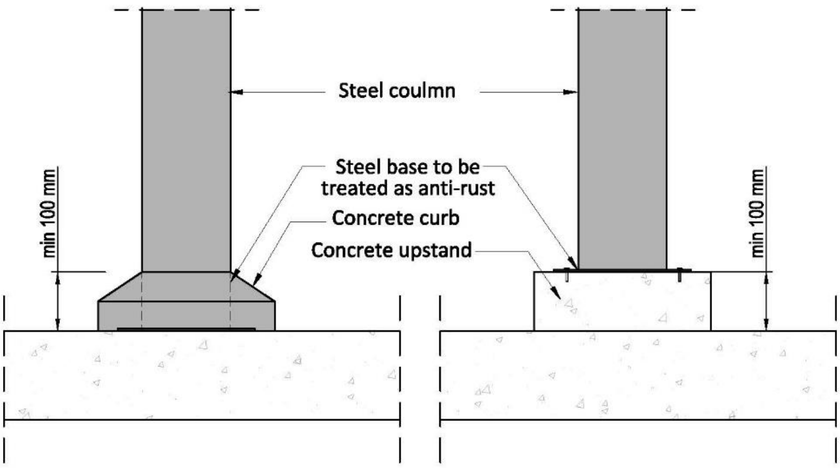



*Figure 16: Concrete upstand protection for steel base.*

### 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.

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

### 1.5.3. Reduce risk of water ingress in open joint cladding (cladding *(i.e. cladding serving as a decorative feature, 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 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.**

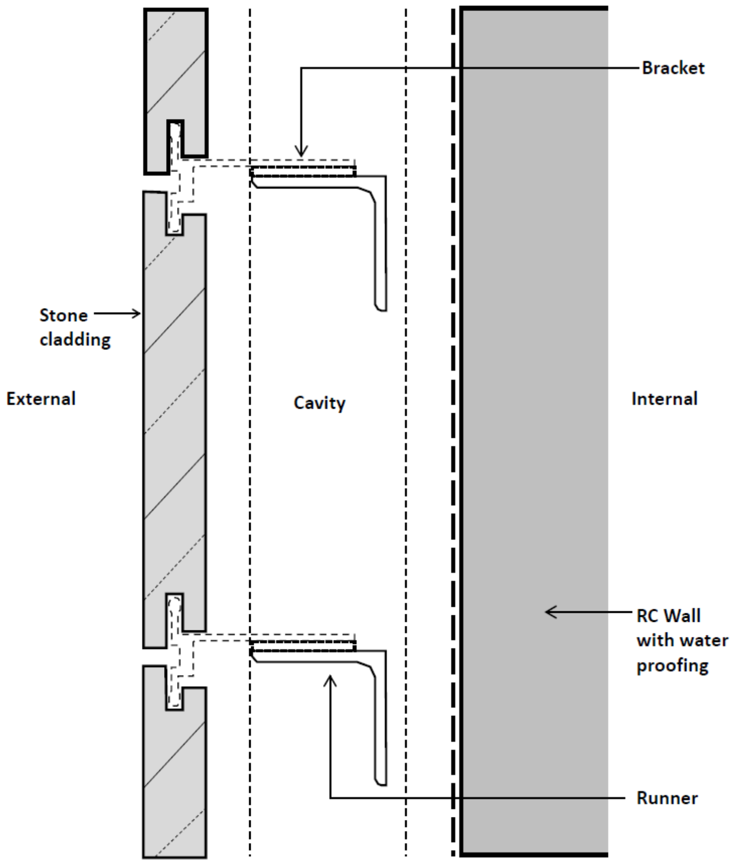



*Figure 17: Illustration of mechanically fixed stone cladding.*

## 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 LIFT LOBBY/INTEGRATED DROP-OFF POINT AT BLOCKS (2 points)

### 1.6.1. Reduce risk of water ingress at entrances. (2 points)

**Intent**

To minimise water ingress at lift lobby entrances / lift lobbies integrated with drop-off points caused by wind-driven rains, through optimal design detailing to reduce the frequency of maintenance.

**Design strategy and assessment: (prerequisite)**

**a. Design to raise internal level by at least 100 mm from the external datum.**

*Note: Use of ramps is encouraged for those who are differently-abled and delivery; with appropriately designed slope adhering to BCA guidelines on accessibility [17].*

*The external datum refers to a point-immediately adjacent to the internal level- t that is exposed to rain and where runoff could accumulate and potentially flow into the building.*

**Documentation requirements**

Design stage

- Plan drawings showing level changes at all building entrances from external datum.
- Detail section drawings indicating the level change (minimum 100 mm) at all building entrances.

Verification stage

- As-built drawings to show implementation.

**Design strategy and assessment: (2 points)**

**b. Design canopy/overhang (minimally 1:50 slope) to shelter against wind-driven rain with canopy angled at maximum 45 degrees to the entrance line and with drop 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.*

[17] Refer to ramp gradients stated in BCA Accessibility Code

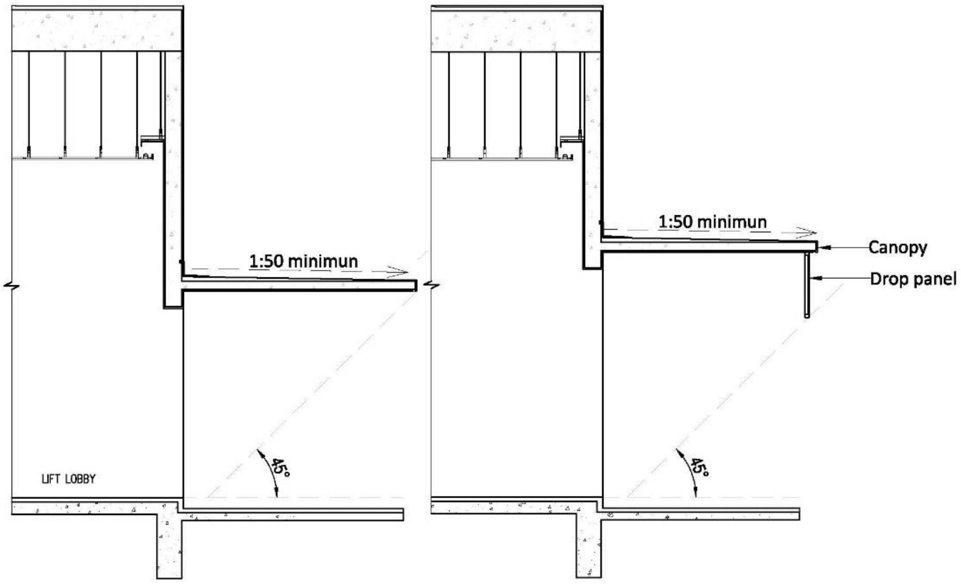



*Figure 18: Design of canopy overhang (left), Design of canopy overhang with drop panel (right)*

*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% | 15% - 20% | 10 - 12 |

*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 effort: (1 bonus point)**

**Advanced efforts: Numerical simulation studies (wind-driven rain penetration) studies specific to location, context of surroundings for 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.

## 1.7. EXPOSED ABOVE-GROUND CORRIDORS, LIFT LOBBIES AND LINK BRIDGES (2 points)

### 1.7.1. Reduce water ponding in above-ground exposed corridors, lift lobbies and link bridges caused by wind driven rain (1.5points)

**Intent**

To reduce the frequency of maintenance in exposed corridors and link bridges due to wet floors caused by wind driven rain, through optimal design detailing.

**Design strategy and assessment: (prerequisite)**

**a. Design for corridor slope to nearest drain outlet to be not gentler than 1:80.**

*Note: The above gradient of 1:80 is indicative. Designers may propose alternative gradients to meet the intent of effective water drainage.*

**Documentation requirements**

Design stage

- Plan drawings indicating the slope.

Verification stage

- As- built drawings showing the implementation

**Design strategy and assessment: (1.5 points)**

**b. Design for vertical rain protection louvres along the corridor and link bridges.**

*Note:*

- *Class C effectiveness rating should be the minimum standard adopted for Ventilation Performance Louvres in Residential developments. The ventilation rate adopted to be 1.5 to 2.5 m/s.*
- *The louvre specification can adopt test standard such as BS EN13030:2001 or equivalent that tests for "water penetration effectiveness": the ability to prevent rain penetrating the louvre; and "Pressure Drop (Entry Loss Coefficient): how freely the louvre allows air to pass through.*

**Advanced efforts: (1 bonus point)**

**Advanced efforts: Simulation studies specific to location, context of surroundings for corridors/entrances *(+1 Bonus point)***

**Documentation requirements**

Design stage

- Plan/section/elevation drawings (detail drawings) locating the vertical rain protection louvers in corridors AND/OR link bridges.
- Tender specification indicating rain protection louvers to comply to a minimum standard of class C effectiveness rating.
- Simulation studies and reports conducted for design improvement for advanced efforts.

Verification stage

- As-built drawings showing the implementation
- Technical specifications of the louvers showing the compliance to class C effectiveness.
- Photographs of vertical rain protection louvers after implementation.

### 1.7.2. Reduce risk of water ingress into lift shaft (0.5 point)

**Intent**

To reduce the frequency of maintenance and repair caused due to water ingress in lift shafts, through optimal design detailing.

**Design strategy and assessment: (0.5 point)**

**a. Design for floor to slope up at threshold of lift door openings.**

**Documentation requirements**

Design stage

- Plan drawings indicating upward slope towards lift door openings.

Verification stage

- As- built drawings showing the implementation

## 1.8. ROOF (PREREQUISITE)

### 1.8.1. Reduce risk of water ponding on roofs (Prerequisite)

**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: (Prerequisite)**

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

*Note:*

- *Consider siphonic / hydraulic drainage system with drains for quick and efficient water draining.*
- *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 the slope with scupper drains/gutter for concrete roofs.

#### Verification stage

- As- built drawings to show implementation.

### Design strategy and assessment: (prerequisite)

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.*

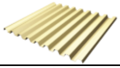
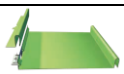
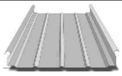
| Metal Roofing Profile | Image | Minimum Rib to Rib Distance (mm) | Minimum Rib Height (mm) | Minimum Roof Pitch without end-lap (degree) | Minimum Roof Pitch with end-lap (degree) |
|---|---|---|---|---|---|
| **Pierce-Fixed Profile** |  | 87.5 | 24 | 3 | 5 |
| |  | 190.0 | 29 | 3 | 5 |
| **Concealed-Fixed 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

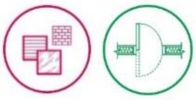
#### Design stage

- 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.

## 1.8.2. Reduce risk of waterproofing failure/decay for waterproofing of concrete roofs. (prerequisite)



### Intent

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

### Design strategy and assessment: (prerequisite)

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.**

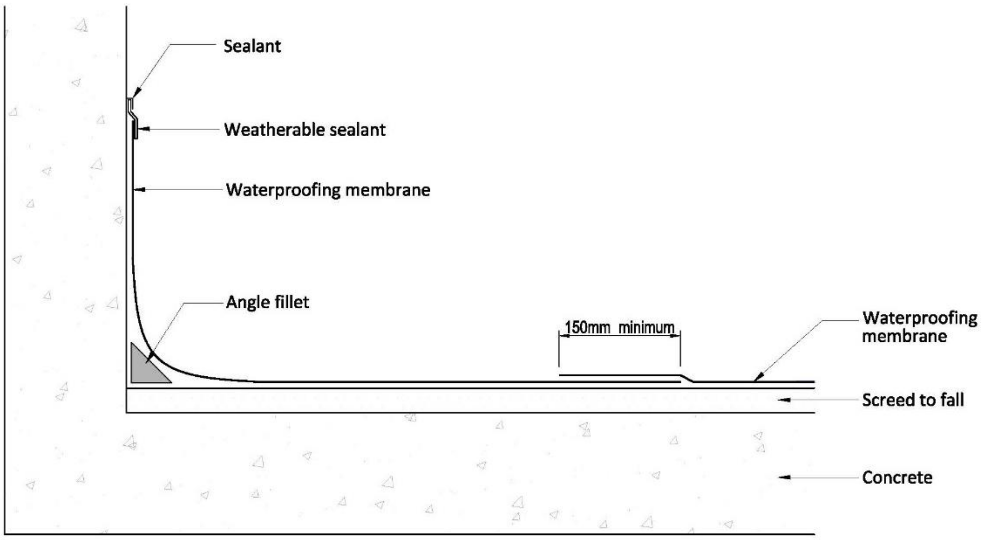



*Figure 19: waterproofing termination and overlapping detail*

### Documentation requirements

#### Design stage

- Plan drawings with indication of all concrete roofs with exposed waterproofing.
- 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.

#### Verification stage

- Photographs showing implementation.

## 1.8.3. Reduce risk of corrosion on metal roofs (prerequisite)

**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: (prerequisite)**

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 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 & COMMON AREAS

## 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[18] hardness value of 7 in areas of high pedestrian traffic such as 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 may be exempted despite being under the influence of the developer (ie. gymnasium, studio spaces etc.)*

*Life cycle cost analysis: baseline vs design strategy*

| Incremental Cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 10% - 15% | 75% - 80% | 15% - 20% | 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**

***The first step to be assessed for this criterion is to scope up the spaces that constitute common areas. This would differ from buildings to buildings. As a rule of thumb, common areas refer to spaces that are within the influence of developers/owners. In the residential context, common areas would refer to all covered spaces (corridors, gym, clubhouse, etc.) that are meant for residents' use.***

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 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.

[18] 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 2:**

Summerville Estate is a cluster of 15-storey HDB comprising 4 residential blocks, with a standalone drop-off porch and no linkways. The common areas include lift lobbies and common corridors on every floor of the blocks.

The corridors are finished with cement screed with hardener and the lift lobbies are designed with tiles. Summerville's total common floor area is 2,100m$^2$, comprising of:

- 375m$^2$ of common corridors in each block, with the total of 1,500m$^2$ across the 4 blocks
- 150m$^2$of lift lobbies in each block, with the total of 600m$^2$ across the 4 blocks

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

***NOTE:** The spaces below are within the scope of common areas as they are areas owned by HDB.*

| | Cement Screed (m$^2$) | Tiles (m$^2$) | Total (m$^2$) |
|---|---|---|---|
| Common Corridors | 1500 | 0 | 1500 |
| Lift Lobbies | 0 | 600 | 600 |
| TOTAL | 1500 | 600 | 2100 |

*Area Table II : Breakdown of Flooring Systems*

- Proportion of all tiles to total floor area
  = 600m$^2$/ 2,100m$^2$ = 28.6% (≥15%)

- Proportion of cement screed to total floor area
  = 1,500m$^2$ / 2,100m$^2$ = 71.4% (≥15%)

| 2.1.1 Reduce risk of damage to floors in common areas within the building (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 | √ | 28.6% * 1.5 = 0.43 |

***NOTE:** Cement screed with hardener is taken to meet the criteria of Mohs hardness value. However, cement screed alone without any hardener would not be able to meet the criteria.*

## 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[19] – with water absorption rate not exceeding 0.5 % to reduce settling of stains[20] in areas of high pedestrian traffic such as entrances, corridors, lift lobbies, 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 vs design strategy*

| Incremental Cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 5% - 10% | 60% - 65% | Up to 5% | 5 - 6 |

*Baseline design Strategy: Tile with absorption rate exceeding 0.5%*
*Proposed design strategy: Impervious tile with absorption rate not exceeding 0.5%*
*Study period: 10 Years*
*Yearly labour savings: 60 - 70% man-hour savings.*

**Documentation requirements**

***The first step to be assessed for this criterion is to scope up the spaces that constitute common areas. This would differ from buildings to buildings. As a rule of thumb, common areas refer to spaces that are within the influence of developers/owners. In the residential context, common areas would refer to all covered spaces (corridors, gym, clubhouse, etc.) that are meant for residents' use.***

### Design stage

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

### Verification stage

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

[19] 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.
[20] BCA – Good Industry Practices - Impervious tiles – Absorbs water between 0 and 0.5% –Suitable for both indoor and exterior use.

## 2.2 WALLS AND PARTITIONS (1 point)

### 2.2.1 Reduce risk of stains on wall surfaces in common areas (up to 1 point)

**Intent**

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

**Design strategy and assessment: (1 point)**

**Specify for finishing to be:**

**i. water-resistant wall materials, e.g. laminate, vinyl, and tile (1 point); or.**

*Life cycle cost analysis: baseline vs design strategy*

| Incremental Cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 2.1X - 2.2X | 95% - 100% | Up to 5% | 7 - 8 |

*Baseline design strategy: Standard Paint with Primer*
*Proposed design strategy: Tile Wall Cladding*
*Study period: 10 Years*
*Yearly labour savings: 20-30% man-hour*

**Documentation requirements**

***The first step to be assessed for this criterion is to scope up the spaces that constitute common areas. This would differ from buildings to buildings. As a rule of thumb, common areas refer to spaces that are within the influence of developers/owners. In the residential context, common areas would refer to all covered spaces (corridors, gym, clubhouse, etc.) that are meant for residents' use.***

Design stage

- Tender specifications indicating the type of water-resistant wall material finish.
- Plan drawings showing the extent of application of the wall finish.

Verification stage

- Relevant technical material specifications for the water-resistant property of the material.
- Delivery order for the specified material.

**Design strategy and assessment: (0.5 point)**

**Specify for finishing to be:**

**ii. Stain-resistant paint or hydrophobic paint (0.5 point)**

*Note:*

- *The water-repellent property of hydrophobic and stain resistant paint, aids lower water absorption and helps in ease of cleaning.*
- *The top coat must be minimally 1.5m from finished floor level*
- *The surface preparation for the top coat must follow the method statement, as mentioned in SS542.*

*The scope of application of this criteria is for common corridors, lift lobbies, and void decks (HDB)*

*Life cycle cost analysis: baseline vs design strategy*

| Incremental Cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| Up to 5% | 35% - 40% | 25% - 30% | 1 - 2 |

*Baseline design strategy: Standard paint with primer*
*Proposed design strategy: Stain Resistant paint*
*Study period: 10 Years*

### Documentation requirements

***The first step to be assessed for this criterion is to scope up the spaces that constitute common areas. This would differ from buildings to buildings. As a rule of thumb, common areas refer to spaces that are within the influence of developers/owners.***

#### Design stage

- Tender specifications indicating the stain resistant/hydrophobic paint finish as top coat.
- Plan and typical sectional drawings showing location of coating application.

#### Verification stage

- Relevant technical material specifications or product performance test results for the stain resistant/hydrophobic property of the selected paint finish.
- Delivery order for the specified paint finish.

**Worked Example 3:**

In Springdays Condominium, all spaces have a typical wall height of 3.6m. The development has a total wall area of 5,000$m^2$ in the common areas, comprising of:

- 600$m^2$ of lift lobbies, fully tiled
- 2,000$m^2$ of common corridors in plaster and stain resistant paint

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

***NOTE:*** *The spaces below are within the scope of common areas as they are under the influence of the owner/developer and are used and accessible by the residents of the condominium.*

*Area Table III : Breakdown of Wall Systems*

| | Laminate ($m^2$) | Tiles ($m^2$) | Plaster & Stain Paint ($m^2$) | Plaster & Paint ($m^2$) | Total ($m^2$) |
|---|---|---|---|---|---|
| Lift Lobbies | 0 | 600 | 0 | 0 | 600 |
| Common corridors | 0 | 0 | 2000 | 0 | 2000 |
| TOTAL | 0 | 600 | 2000 | 0 | 2600 |

***NOTE: The contact zone for staining is taken as*** *up to 1.5m from the FFL. Therefore the area of assessment for stains on wall surfaces will be limited to +1.5 from the finished floor level.*

- Wall area considered for assessment
  = (1.5m / 3.6m) x 2,600$m^2$ = 1,083$m^2$

- Area of water resistant wall material (tiles + laminate) used within assessed wall area
  = (1.5m / 3.6m) x ( 600$m^2$ ) = 250$m^2$

- Proportion of water-resistant wall material (tiles + laminate) to assessed wall area
  = 250$m^2$ / 1,083$m^2$ = 23% (≥15%)

- Area of stain resistant paint (in common corridors) used within assessed wall area
  = (1.5m / 3.6m) x 2,000$m^2$ = 833$m^2$
  **Only the common corridors utilize plaster and paint with stain resistant properties, while the gym and club rooms use only plaster and paint (not stain resistant).*

- Proportion of stain resistant paint to assessed wall area
  = 833$m^2$ / 1,083$m^2$ = 77% (≥15%)

## 2.2.1 Reduce risk of stains on wall surfaces in areas of high pedestrian traffic

| 2.2.1 Reduce risk of stains on wall surfaces in common areas (1 point) | Points | Assessment Category | **Used in Project** | **Points Scored** |
|---|---|---|---|---|
| a. Specify finishing to be water-resistant wall materials, e.g. laminate, vinyl and tile. | 1 | Cat 2 | √ | 23% * 1 = 0.23 |
| b. Specify for finishing to be :<br>Stain-resistant paint<br>(*OR*)<br>Hydrophobic paint | 0.5 | Cat 2 | √ | 77% * 0.5 = 0.385 |
| Score for 2.2.1 | | | | 0.23 + 0.385 = 0.615 |

The total points for ***2.2.1 under Walls and Partitions*** = 0.615 points.

## 2.3 CEILINGS (4 points)

### 2.3.1 Access to services within double slab areas for maintenance purposes (2 points)

**Intent**

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

**Design strategy and assessment: (prerequisite)**

**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 for areas of 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.

**Worked Example 4:**

On the 5th floor of Springdays Condominium, in the area below the sky terrace, the ceiling has been designed with double slabs. It has a total ceiling area of $150m^2$, and out of this, only $30m^2$ of ceiling area has double slab with a clear headroom of 2.0m, while the remaining 120 $m^2$ has a clear headroom of 1.8m. This is part of provision by the developer due to code requirement. All the other parts of the ceiling has been provided with access for general maintenance.

- Proportion of double slabs with 2m clear headroom
  $= 30m^2 / 150m^2 = 20\% \ (\geq 15\%)$

2.3.1 Access to services within double slab areas for maintenance purposes

| 2.3.1 Access to services within double slab areas for maintenance purposes. (2 points) | Points | Assessment Category | **Used in Project** | **Points Scored** |
|---|---|---|---|---|
| a. Provide double slabs with minimum clear headroom of 1.8m. | Prerequisite | - | √ | Complied |
| b. Provide double slabs with minimum clear headroom of 2 m | 2 | Cat 2 | √ | 20% * 2 = 0.4 |
| Score for 2.3.1 for double slab areas | | | | 0.4 |

## 2.3.2 Access to services within the ceiling in common spaces such as clubhouse, function rooms and lobbies (up to 1 point)

**Intent**

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

**Design strategy and assessment: (1 point)**

a. **Specify open ceiling design.**

**Documentation requirements**

***The first step to be assessed for this criterion is to scope up the ceiling spaces in common areas housing services.***

Design stage

- Tender specification indicating the open ceiling plan 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 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 vs design strategy*

| Incremental Cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 10% - 15% | 85% - 90% | Up to 5% | 7 - 8 |

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

### Documentation requirements

***The first step to be assessed for this criterion is to scope up the ceiling spaces in common areas housing services.***

### Design stage

- Tender specification indicating the 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 5:**

Springdays Condominium's common areas constitute a total ceiling area of 800m$^2$, comprising:

- 500m$^2$ of the 2 function rooms in suspended modular ceiling
- 150m$^2$ of club room in monolithic ceiling
- 150m$^2$ of gym designed with open ceiling

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

***NOTE:*** *The common spaces below are within the scope of assessment as they fall under the influence of the developer, unlike the retail amenities which are tenant-owned.*

| | Monolithic Ceiling (m$^2$) | Suspended Modular Ceiling (m$^2$) | Open Ceiling (m$^2$) | Total (m$^2$) |
|---|---|---|---|---|
| Function rooms | 0 | 500 | 0 | 500 |
| Gym | 0 | 0 | 150 | 150 |
| Club Room | 150 | 0 | 0 | 150 |
| TOTAL | 150 | 500 | 150 | 800 |

*Area Table IV : Breakdown of Ceiling Systems in the indoor spaces*

- Proportion of suspended modular ceiling
  = 500m$^2$ / 800m$^2$ = 62.5% (≥15%)

- Proportion of open ceiling
  = 150m$^2$ / 800m$^2$ = 18.8% (≥15%)

2.3.2 Access to services within the within the ceiling in common areas

| 2.3.2 Access to services within the ceiling in common areas such as clubhouse, function rooms, common corridor and lobbies (up to 1 point) | Points | Assessment Category | **Used in Project** | **Points Scored** |
|---|---|---|---|---|
| a. Specify for open ceiling design. | 1 | Cat 2 | √ | 18.8% * 1 = 0.19 |
| b. Specify for suspended modular ceiling system that is easily demountable. | 0.5 | Cat 2 | √ | 62.5% * 0.5 = 0.31 |
| Score for 2.3.2 | | | | 0.19 + 0.31 = 0.50 |

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

## 2.3.3 Access to ceiling for maintenance (prerequisite)

**Intent**

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

**Design strategy and assessment: (prerequisite)**

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.*
   - *Access to Lightings and smoke detectors will be assessed here.*

**Documentation requirements**

Design stage

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

Verification stage

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

## 2.3.4 Reduce risk of warping /deterioration of ceiling panel system that are weather-exposed, at locations such as sky terraces, drop-off porches, corridors, and lobbies. (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 vs design strategy*

| Incremental Cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 40% - 45% | 95% - 100% | 15 - 20% | 5 - 6 |

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

### Documentation requirements

***The first step to be assessed for this criterion is to scope up the ceiling spaces in weather-exposed areas.***

#### Design stage

- Tender specification indicating the type of metal suspended modular ceiling panel.
- Reflected ceiling plans showing the extent of metal panel 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 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% | 90% - 95%% | 25% - 30% | 2 - 3 |

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

### Documentation requirements

***The first step to be assessed for this criterion is to scope up the ceiling spaces in weather-exposed areas.***

### 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 resistance 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**

***The first step to be assessed for this criterion is to scope up the ceiling spaces in weather-exposed areas.***

### 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.

**Worked Example 6:**

Springdays Condominium has 2,500m$^2$ of ceiling area that are weather exposed. These areas comprise:

- 300m$^2$ of sky terrace, designed as open ceiling, located on the 6$^{th}$ storey
- 600 m$^2$ of lift lobbies, also designed as exposed open ceiling
- 1,500m$^2$ of common corridors in typical monolithic ceiling
- 100m$^2$ of drop-off porch, designed as a glass canopy structure, located on the ground floor

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

| | Monolithic Ceiling (m$^2$) | Open Ceiling (m$^2$) | Total (m$^2$) |
|---|---|---|---|
| Sky terrace | 0 | 300 | 300 |
| Common Corridors | 1500 | 0 | 1500 |
| Lift Lobbies | 0 | 600 | 600 |
| Drop Off Porch | 0 | 100 | 100 |
| TOTAL | 1500 | 1000 | 2,500 |

**The glass canopy at the drop-off porch is considered as open ceiling*

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

- Proportion of monolithic ceiling
  = 1,500 $m^2$ / 2,500$m^2$ = 60% (≥15%)

- Proportion of open ceiling
  = 1,000 $m^2$ / 2,500$m^2$ = 40% (≥15%)

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

| 2.3.4 Reduce risk of warping/deterioration of ceiling panel system that are weather-exposed, at locations such as sky terraces, drop-off porches, corridors, and lobbies (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 | × | 0 |
| b. Specify moisture-resistant suspended non-metallic modular ceiling panels with water absorption rate not exceeding 5 %. | 1 | Cat 2 | × | 0 |
| c. Specify for open ceiling design. | 1 | Cat 2 | √ | 40% * 1 = 0.40 |
| Score for 2.3.4 ceiling panel systems | | | | 0.40 |

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

As such, the total score for ***2.3 Ceilings*** (2.3.1 + 2.3.2 + 2.3.4) = 0.4 + 0.5 + 0.4 = 1.3 points

## 2.4 COMMON TOILETS (7 points)

### 2.4.1 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 or homogenous tiles[21] [22].**

*Note: The tiles considered are manufactured tiles, not natural stones.*

[21] 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 (e.g. ceramic tiles and phenolic panels) and cleanable materials for toilet floor and wall surfaces, to facilitate cleaning and resource conservation.

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

*Life cycle cost analysis: baseline vs design strategy*

| Incremental Cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 2.1X - 2.2X | 90% - 95% | 15 - 20% | 1 - 2 |

*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

#### Design stage

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

#### Verification stage

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

**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, as mentioned in SS542.*

*Life cycle cost analysis: baseline vs design strategy*

| Incremental Cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| Up to 5% | 50% - 55% | 45% - 50% | 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 7:**

The common toilets at Springdays Condominium has a total wall area of 600m$^2$. The height of the toilet wall is 2.4m and the walls have been designed 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. Details of the toilets wall area are:

- 290m$^2$ within each cluster of male, female toilet, with a total of 580m$^2$ for the 2 clusters combined across the development
- 20m$^2$ of a unit of accessible toilet

As such,

- Area of wall tiles in the common toilets
  = (2.0m/2.4m) x 600m$^2$ = 500m$^2$
- Proportion of wall tiles
  = 500m$^2$ / 600m$^2$ = 83% (≥15%)
- Area of plaster and paint with anti-mould
  = 600m$^2$ – 500m$^2$ = 100m$^2$
- Proportion of plaster and paint with anti-mould
  = 100m$^2$ / 600m$^2$ = 17% (≥15%)

2.4.1 Reduce risk of mould and fungus formation on walls in toilets

| 2.4.1 Reduce risk of mould and fungus formation on walls in toilets (up to 1 point) | Points | Assessment Category | **Used in Project** | **Points Scored** |
|---|---|---|---|---|
| a. Specify wall finishes with tiles e.g. glazed ceramic tiles and homogenous tiles. | 1 | Cat 2 | √ | 83% * 1 = 0.83 |
| b. Specify wall finishes with anti-mould top coat. | 0.5 | Cat 2 | √ | 17% * 0.5 = 0.09 |
| Score for 2.4.3 walls in wet rooms | | | | 0.83 + 0.09 = 0.92 |

The total points for ***2.4.1 under Ceilings*** is = 0.92 point

## 2.4.2 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.**[23]

### 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**[24] **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.

[23] 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."

[24] 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."

### 2.4.3 Reduce risk of water spill on floor, and splashing and soap dripping on the counter and floor (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[25].**

**Documentation requirements**

Design stage

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

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[26].**
(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.

[25] 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"

[26] 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."

**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 is easier to identify and refill.*

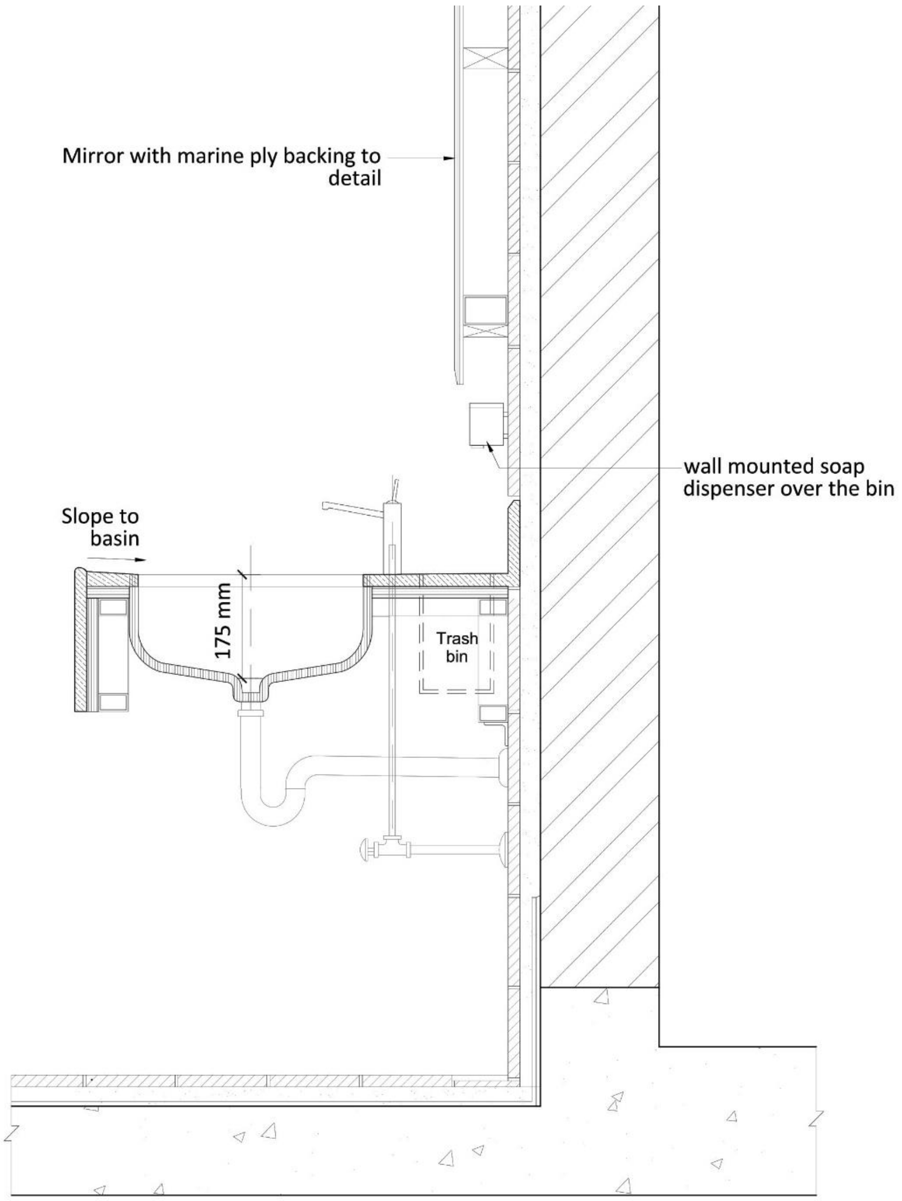



*Figure 20 - Schematic sectional drawing with vanity basin*

### 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*[27]*.*

### 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.

## 2.4.4 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.**

[27] 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."

**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.

## 2.4.5 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 be in compliance with ASTM C473 for the water absorption test.*

*Life cycle cost analysis: baseline vs design strategy*

| Incremental Cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 15% - 20% | 90% - 95% | 35% - 40% | 2 - 3 |

*Baseline design strategy: Moisture resistant monolithic plaster ceiling (Calcium Silicate)*
*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.
- Plan drawing 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 plans showing the false 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.

## 2.5 BASEMENT (4 points)

### 2.5.1 Reduce risk of water ingress/seepage in basement (up to 4 points)

**Intent**

To reduce the frequency of repair and maintenance of basement structures due to water ingress, through optimal selection of materials and design & detailing.

**Design strategy and assessment: (prerequisite)**

a. **Specify for positive side waterproofing on the retaining wall, e.g. sheet-membrane systems, or vapour barriers.**

### Documentation requirements

#### Design stage

- Tender specification indicating water proofing on positive side.
- Plan and sectional drawings showing the location of application.

#### Verification stage

- As-built (construction) drawings to show the extent of implementation.
- Delivery order for the specified waterproofing system.
- Photographs taken during implementation

## Design strategy and assessment: (2 points)

**b. Design for cavity wall with raised kerb of minimally 200mm and with water and mould-resistant wall layer on the inside, e.g. moisture-resistant calcium silicate board.**

*Note:*

- *The inside wall layer should possess water absorption rate not exceeding 5% and should be in compliance with ASTM C473 standards for water absorption test.*
- *Access panel to be provided for periodic maintenance.*
- *Provision of drainage/weep hole along the wall is required as per consultant specification*[28]

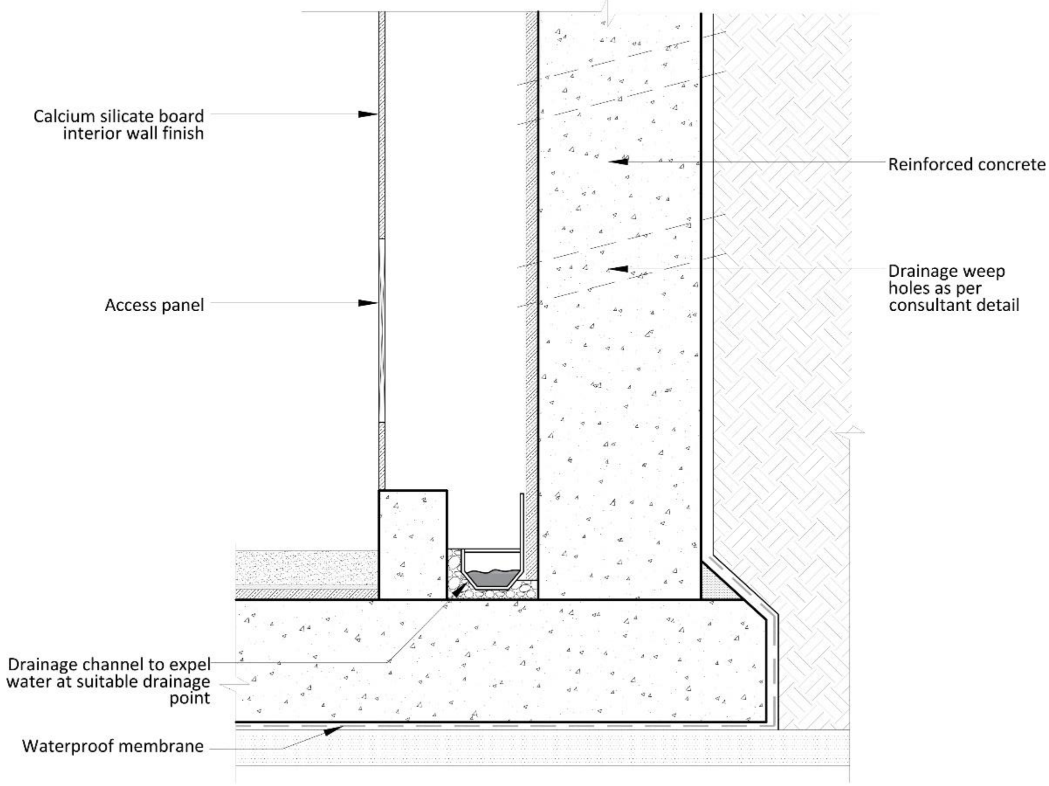



*Figure 21 - Typical section of cavity wall with waterproofing*

*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) |
|---|---|---|---|
| 3.6X – 3.7X | 95% - 100% | 45% - 50% | 9 - 10 |

*Baseline design strategy: RCC wall with positive side waterproofing*
*Proposed design strategy: Cavity wall with raised kerb*

[28] SS 637 :2018 Code of practice for waterproofing of reinforced concrete buildings, "three methods for water tightness, a) tanked protection – the protection depends on the application of a continuous waterproofing barrier system applied to the structure, b) structurally integral waterproofing – the protection depends on the ability of the concrete structure to minimize/ prevent water penetration, and c) drained protection – the protection depends on the provision of floor and wall cavity to collect and channel water out of basement" Depending on which system the Structural Engineer chooses, there are different design details to consider.

*Study period: 30 Years*
*Yearly labour savings: 80 - 90% man-hour savings.*

### Documentation requirements

#### Design stage

- Tender specification indicating the type of water-resistant internal wall.
- Plan and sectional drawings showing the location and extent of application.

#### Verification stage

- As-built drawings to show extent of implementation.
- Relevant technical specification for the water-resistance property and water absorption rate for the selected internal wall.
- Photographs of completed works showing the basement cavity wall with access panel.

**Design strategy and assessment: (1 point)**

**c. Specify for positive side waterproofing for the base slab, e.g. sheet-membrane systems, vapour barriers.**

### Documentation requirements

#### Design stage

- Tender specification indicating water proofing on positive side of slab.
- Plan and sectional drawings showing the type of waterproofing system.

#### Verification stage

- As-built (construction) drawings to show implementation.
- Delivery order for the specified waterproofing system.
- Photographs taken during implementation.

**Design strategy and assessment: (1 point)**
**Design strategy and assessment: (1 point)**

**d. Specify integral liquid water proofing admixture in the concrete.**

### Documentation requirements

#### Design stage

- Tender specification indicating integral waterproofing admixture system.
- Plan and sectional drawings showing location of application.

#### Verification stage

- As-built drawings to show extent of implementation.
- Relevant technical specifications for the selected water proofing system.
- Delivery order for the specified water proofing admixture.

## SECTION 3 – MECHANICAL SYSTEM

## 3.1 AIR CONDITIONING SYSTEM – DIRECT EXPANSION SYSTEM (DX UNITS) (2 points)

### 3.1.1 Access to AC ledge for Condenser Unit (CU) maintenance (pre-requisite)

**Intent**

To provide adequate access from operable windows/opening to the condenser unit thus improving maintainability of the equipment and labour efficiency.

**Design strategy and assessment: (prerequisite)**

a. **Provide operable windows/opening with minimum opening size of 900 mm (H) x 600 mm (W).**
b. **The bottom of the windows/opening for CU access should be located no higher than 1.1 meter from the finished floor level within the unit.**

#### Documentation requirements

Design Stage

- Tender drawing showing the access provision or tender specifications indicating the exact requirement for operable windows/opening access to condensing unit.

Verification Stage

- Shop drawing/as-built drawing showing the dimension of access windows/opening to the condensing unit.
- Photographs showing the implementation

### 3.1.2 Access space around the AC ledge for maintenance of condenser unit (1 point)

**Intent**

To provide adequate maintenance space for condenser unit thus improving maintainability of the equipment and labour efficiency.

**Design strategy and assessment: (prerequisite)**

a. **The safety barrier (such as railing) must be provided around the service ledge with minimum height of 1 meter.**
b. **Adequate working space must be provided for service and maintenance**
   - **i) The outdoor units must not be stacked**
   - **ii) Min clear space in front of the CU: 350 mm**
   - **iii) Min clear space at the back of CU: 200 mm**
   - **iv) Min clear space to the side of CU with control panel: 350 mm**
   - **v) Min clear space to the side of CU without control panel: 100mm**

**Design strategy and assessment: (1 point)**

c. **Provide minimum 600mm by 600mm clear landing space for maintenance crew.**

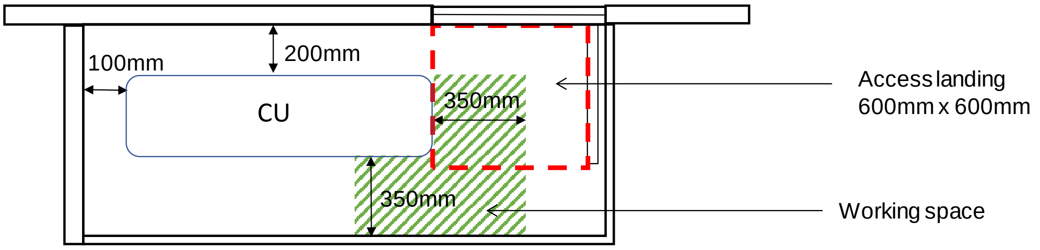



*Figure 22. Adequate working space required and 600mm by 600mm landing space for 1 Condensing Unit*

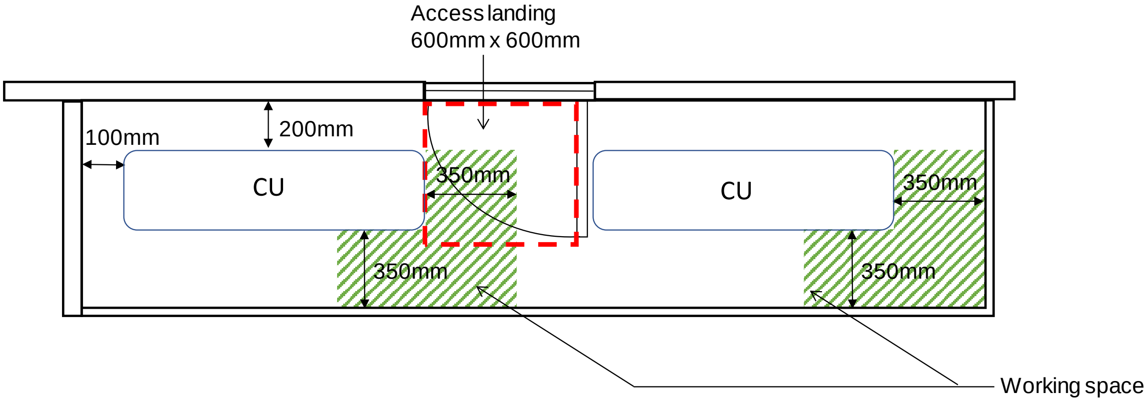



*Figure 23. Adequate working space required and 600mm by 600mm landing space for 2 Condensing Units*

## Documentation requirements

### Design Stage

- Tender drawing showing the access provision or tender specifications indicating the access provision.

### Verification Stage

- Shop drawing/as-built drawing showing the compliance of height requirement for the safety barrier provided around the service ledge.
- Shop drawing/as-built drawing showing the dimensions and indicating the maintenance space for condensing unit.

## 3.1.3 Reduce risk of air short circuit due to the poor location of AC ledge /condenser unit (1 point)

**Intent**

To reduce the risk of air short circuit and thus the frequency of failure of condenser unit.

**Design strategy and assessment: (prerequisite)**

**a. AC ledge must be in a well-ventilated space for effective flow of air (CFD simulation is required if CU is facing enclosed space such as air well).**

### Documentation requirements

#### Design Stage

- Tender drawing showing that the AC ledge is not located in fully enclosed space.
- CFD simulation study showing no air short circuit if CU is facing enclosed space.

#### Verification Stage

- Shop drawing/as-built drawing showing the location of AC ledge with compliance.
- Photographs of showing the implementation

**Design strategy and assessment: (1 point)**

**b. The free opening for louver screens or railings must be minimum 70% with louver angle not more than 30 degrees.**

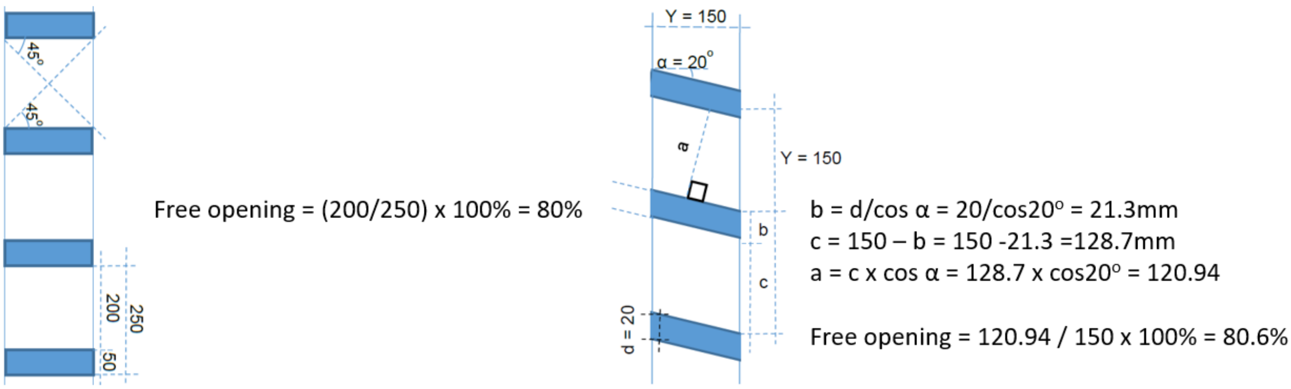



*Figure 24. Free Opening for Louver Screening with 0 degree inclination (left) and 20 degree inclination (right)*

### Documentation requirements

#### Design Stage

- Tender specifications indicating the condenser unit location and louver screening arrangement.

#### Verification Stage

- Shop drawing/as-built drawing showing the louver details.
- Calculation showing the percentage of free opening area.
- Photographs showing the implementation.

## 3.2 AIR CONDITIONING SYSTEM - VARIABLE REFRIGERANT FLOW (VRF)

### 3.2.1 Access to VRF outdoor units (prerequisite)

**Intent**

Provide adequate access space for VRF maintenance.

**Design strategy and assessment: (prerequisite)**

**a. For single VRF outdoor unit installation:**

*Note: This item is not applicable to projects without VRF systems.*

**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 condensing 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.*

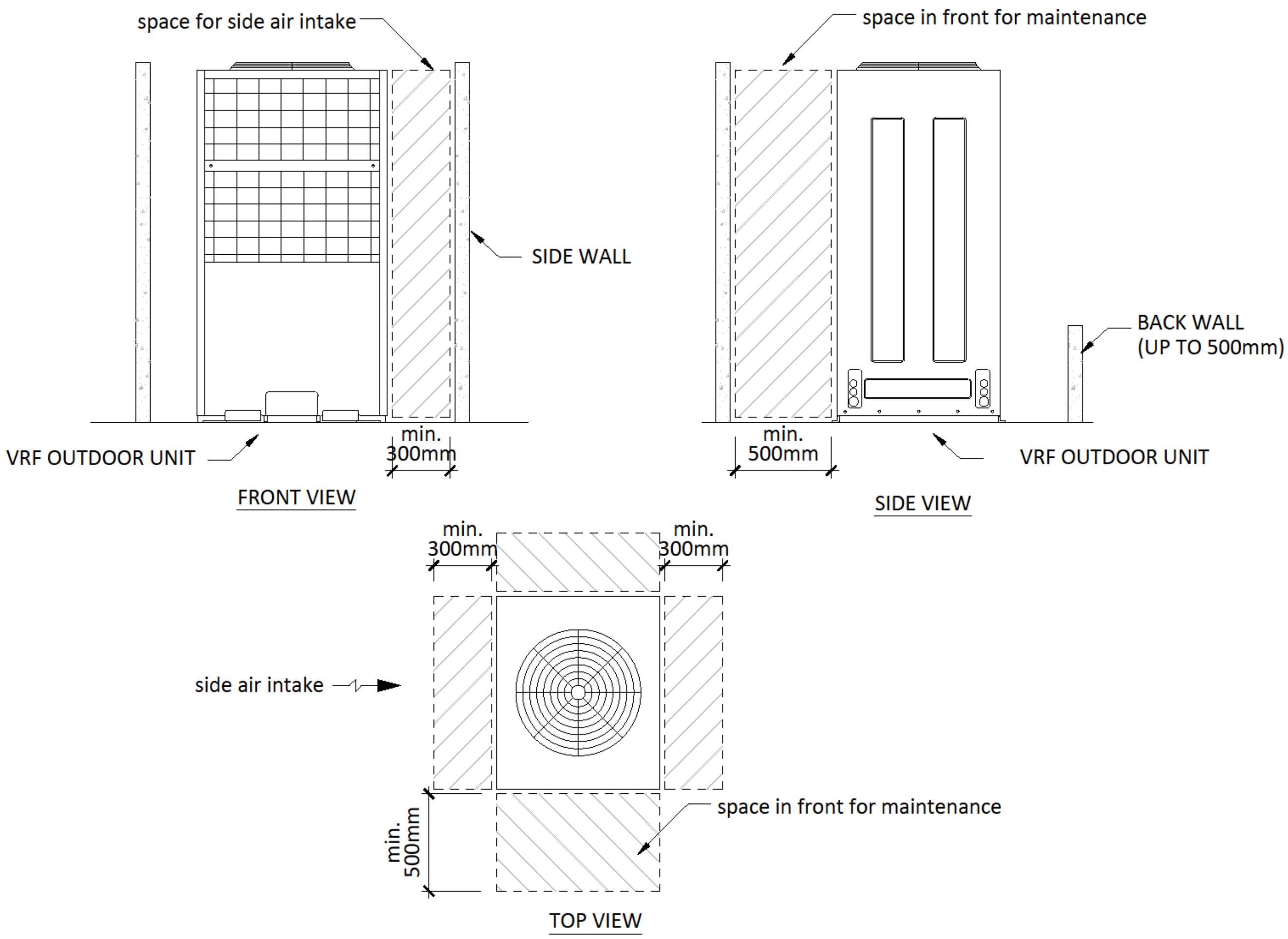



*Figure 25: Space requirement for single VRF outdoor installation (top discharge)*

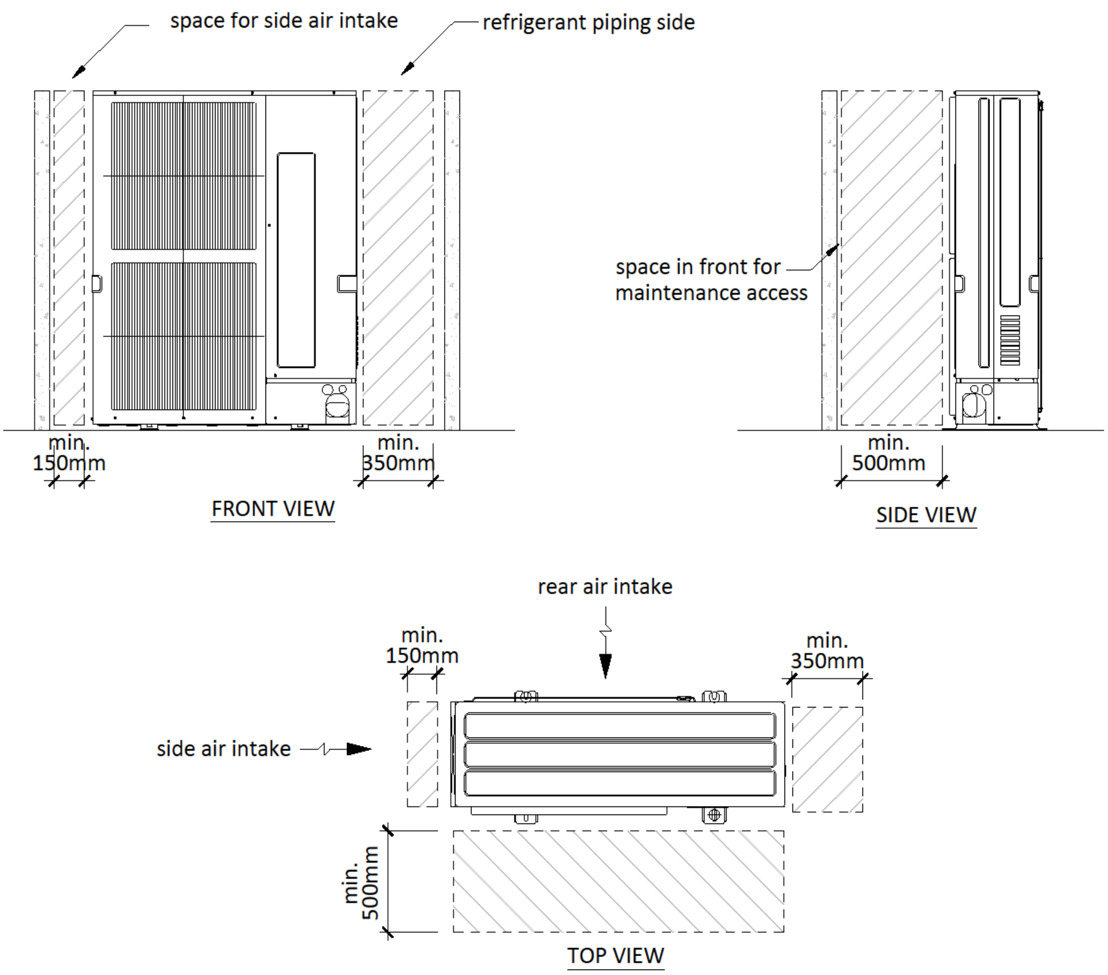



*Figure 26: Space requirement for single VRF outdoor installation (side discharge)*

## 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: (prerequisite)**

**b. For collective VRF outdoor unit installation:**

*Note: This item is not applicable to projects without VRF systems.*

**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.*

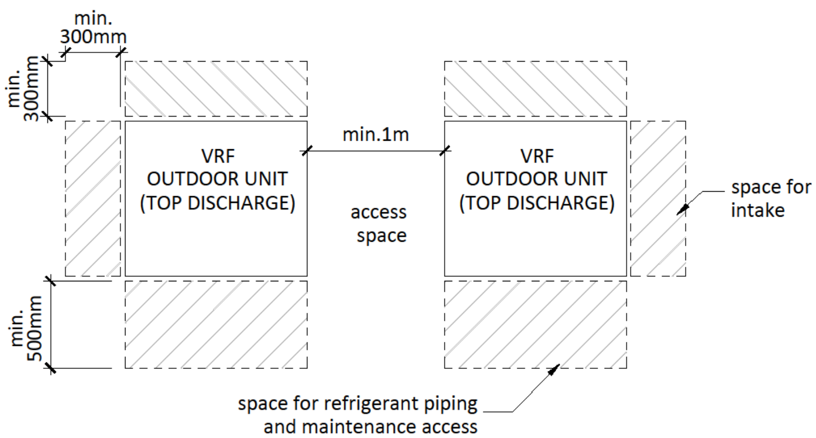



*Figure 27: Space requirement for collective VRF outdoor unit (top discharge) – top view*

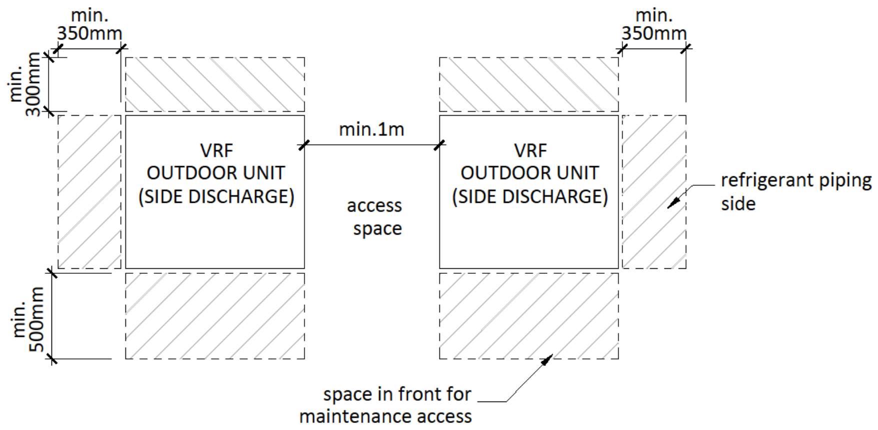



*Figure 28: Space requirement for collective VRF outdoor unit (side discharge) - top view*

### 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: (prerequisite)**

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

*Note: This item is not applicable to projects without VRF systems.*

**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 %.**

*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 manufacture recommendations for access space requirements.*

**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.*

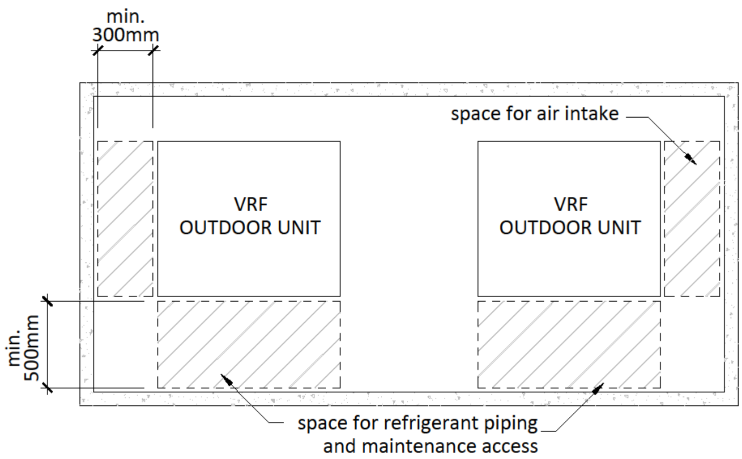



*Figure 29. Space requirement for VRF outdoor installation (top discharge) – top view*

### 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.

## 3.3 AIR DISTRIBUTION SYSTEM (1 point)

### 3.3.1 Access to FCU mounted at heights (i.e. lobby space, clubhouse) (1 point)

**Intent**

To provide efficient and safe maintenance access around the FCU for regular maintenance.

**Design strategy and assessment: (1 point)**

**a. Locate FCU less than 3m from FFL for easy access and maintenance.**

***(OR)***

**b. 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.

***(OR)***

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

**c. For ducted fan coil units installed above ceiling, provide 600mm by 600mm access panel for regular maintenance works.**

*Note: Items a, b and c are not applicable to projects without air conditioning in common areas.*

**Documentation requirements:**

Design Stage

- Plan drawing(s) showing the access route for MEWP movement to the atrium/lobby space.
- Plan/section drawing at appropriate scale showing the alternative access provisions (i.e. maintenance platform etc.).
- Plan drawing indicating provision of 600mm by 600mm access panels
- Tender specifications indicating the access requirement.

Verification Stage

- As-built drawings/shop drawings with actual access route marking from building entrance to the area with FCU mounted at height exceeding 3m.
- 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.
- As-built drawings/shop drawings indicating location of 600mm by 600m access panels
- Photographs showing implementation.

## 3.4 DOMESTIC WATER SUPPLY

### 3.4.1 Access space for maintenance of water tank (prerequisite)

**Intent**

To provide adequate space for the safe and efficient maintenance of the water tank.

**Design strategy and assessment: (prerequisite)**

a. **Provide minimum clear width of 1.2 m access walkway to water tank from the nearest staircase or lift.**

#### Documentation requirements

Design Stage

- Plumbing drawing/plan drawing/specifications capturing the access space requirements.

Verification Stage

- Shop/as-built drawing indicting the actual access space provisions.
- Photographs showing the space provision.

## 3.5 SANITARY SYSTEM (2 points)

### 3.5.1 Access provision and design detailing for sanitary pipes for ease of maintenance (1 points)

**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.**

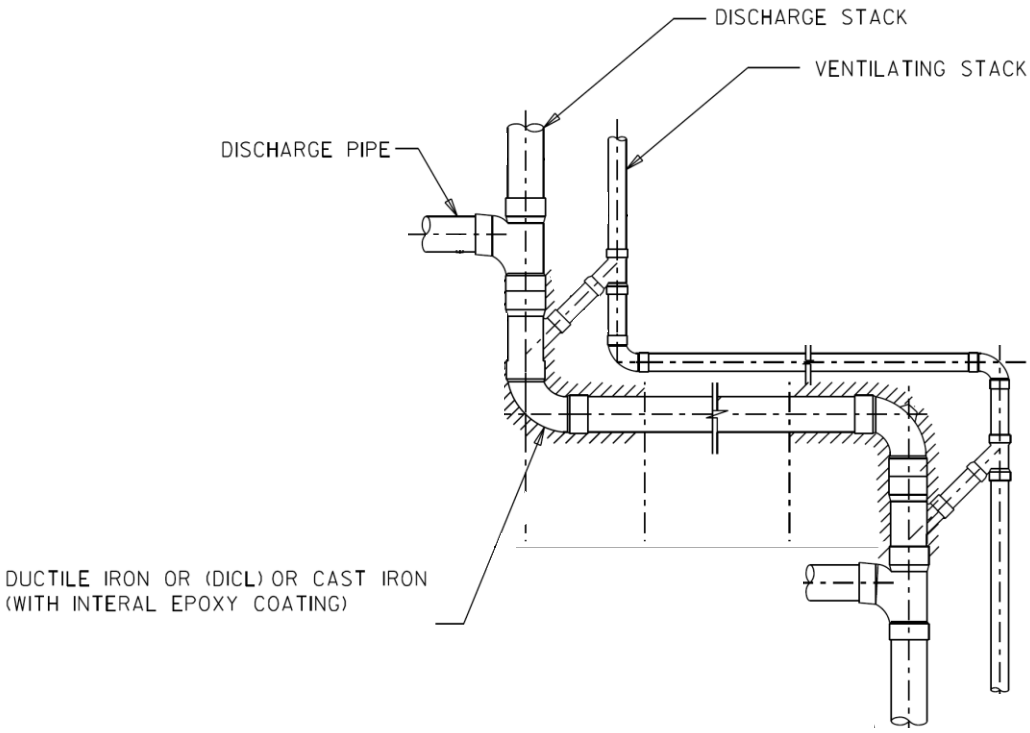



*Figure 30: Hubless elbows for sanitary stacks with horizontal transfers[29]*

### 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.

[29] Code of Practice on Sewage and Sanitary Works, 2019

## 3.5.2 Provide adequate access space for maintenance of ejector pump (Pre-requisite)

**Intent**

To provide adequate space for the safe and efficient maintenance of ejector pumps.

**Design strategy and assessment: (prerequisite)**

a. **Provide minimum 600mm clear space on 1 side of the ejector pumps for regular maintenance.**
b. **Provide minimum 1.5m clear headroom above finished floor level at the top of ejector pit to facilitate overhaul maintenance or replacement.**

*Note: Items a and b are not applicable to projects without ejector pumps.*

### Documentation requirements

Design Stage

- Sanitary drawing/specifications capturing the access space and headroom requirement.

Verification Stage

- Shop/as-built drawing indicating the actual access space provisions.
- Photographs showing the space provision.

### 3.5.3 Reduce risk of chokes in the sanitary pipe (1 point)

**Intent**

To prevent chokes in the sanitary pipe.

**Design strategy and assessment: (1 point)**

a. **Provide at least 75% of the risers with continuous vertical run without any offsets to reduce the additional bends/joints.**
   *Note: Above requirement is applicable only to all typical floors in building.*

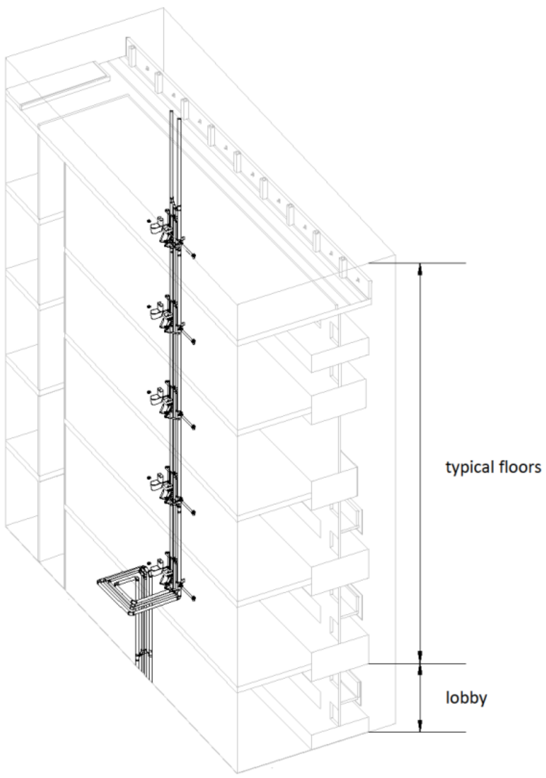



*Figure 31: Risers with continuous vertical run without any offsets for typical floors*

#### Documentation requirements

##### Design Stage

- Sanitary tender drawings/specifications capturing the vertical runs requirements.

##### Verification Stage

- Sanitary shop/as-built drawings showing the vertical risers and offsets.
- Calculations showing the % of risers without any offsets.

## 3.6 FIRE PROTECTION SYSTEM (2 points)

### 3.6.1 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.*

#### 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.

## 3.7 SWIMMING POOL SYSTEM (3 points)

### 3.7.1 Provide adequate access for filtration pump maintenance (3 points)

**Intent**

To provide adequate space for the safe access and efficient maintenance of filtration pumps.

**Design strategy and assessment: (2 points)**

a. **Provide minimum 600 mm clear working/walking space in the filtration pump room for regular maintenance. (prerequisite)**
*Note: The access space for replacement of major component must follow manufacture's recommendation.*

b. **Provide minimum headroom of 2 m for filtration system (Measured from FFL). (2 points)**

*Note: Items a and b are not applicable to projects without swimming pool.*

#### Documentation requirements

Design Stage

- Filtration system drawing capture the access space and headroom requirements.

Verification Stage

- Shop/as-built drawing indicating the actual access space provisions.
- Photographs showing the space provision.

**Design strategy and assessment: (1 point)**

c. **Provide clear access route with width of minimum 1.2 m from lift lobby or carpark area to the filtration system.**

#### Documentation requirements

Design stage

- Tender drawing showing the access route from service lift to the filtration room.

Verification Stage

- Mark-up on shop/as-built drawing showing the access route from service lift to the filtration system with minimum width of 1.2 m.

## SECTION 4 - ELECTRICAL

## 4.1 LIGHTING SYSTEM (1.5 points)

### 4.1.1 Reduce frequency of light replacement (0.5 point)

**Intent**

To select more reliable light fittings for less frequent replacement.

**Design strategy and assessment: (0.5 point)**

a. **Use reliable light fixtures such as LED light (LM-80[30] B30 L70 @ L50,000) which requires less frequent replacement.**
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 vs design strategy*

| Incremental cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 45%-50% | 35%-40% | 35%-40% | 1-2 |

*Baseline: not reliable lighting at height*
*Design strategy: LED with reliable drivers at height*
*LCC results: 60%-70% man-hour savings*

**Documentation requirements**

Design Stage

- Drawings/lighting specifications showing the light fixture specifications.

Verification Stage

- Technical data sheet and card-sheet showing the light fixture specifications.

Note: Points scored for 4.1.1c can be apportioned.

[30] IESNA-LM-80: IES approved method: measuring lumen maintenance of LED light sources

**Worked Example 8:**

Springdays Condominium has been designed with the following light fittings. Only 5W LED downlight selected comply with 4.1.1.c requirement.

| Description | Type of lighting | Number of light fittings | Compliance | Points scored after apportioning |
|---|---|---|---|---|
| 4.1.1c - Use reliable light fixtures such as LED light (LM80 B30 L70@ L50,000) which requires less maintenance. | 3W LED downlight | 300 | No | 0.15 |
| | 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 0.5 = 0.15 point**

Therefore, the final score after apportioning for section 4.1.1.c will be 0.15 point.

### 4.1.2 Reduce 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.*

[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.

**Worked Example 9:**

Springdays Condominium has been designed with the following light fittings. Only 5W LED downlight selected comply with 4.1.2 requirement.

| Description | Type of lighting | Number of light fittings | Compliance | Points scored after apportioning |
|---|---|---|---|---|
| 4.1.2a - Specify constant DC output type LED driver complying with the following IEC standards to minimise flickering. | 3W LED downlight | 300 | No | 0.15 |
| | 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 0.5 = 0.15 point**

Therefore, the final score after apportioning for section 4.1.2 will be 0.15 point.

### 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.

[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.

  Note:

  Points scored for 4.1.3 can be apportioned.

**Worked Example 10**:

Springdays Condominium 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 | Points scored after apportioning |
|---|---|---|---|---|
| 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 | 0.3 |
| | 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.

## 4.2 POWER DISTRIBUTION (3 points)

### 4.2.1 Reduce risk of water Ingress into electrical room (prerequisite)

**Intent**

To prevent damage to electrical equipment inside the electrical room.

**Design strategy and assessment: (prerequisite)**

a. **Electrical room must be raised by minimum 100 mm against the outside passageway.**

Raising the switch room floor level against its external passageway will prevent water ingress and avoid severe damage to electrical panels. The water can come from regular washing of passageway 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.

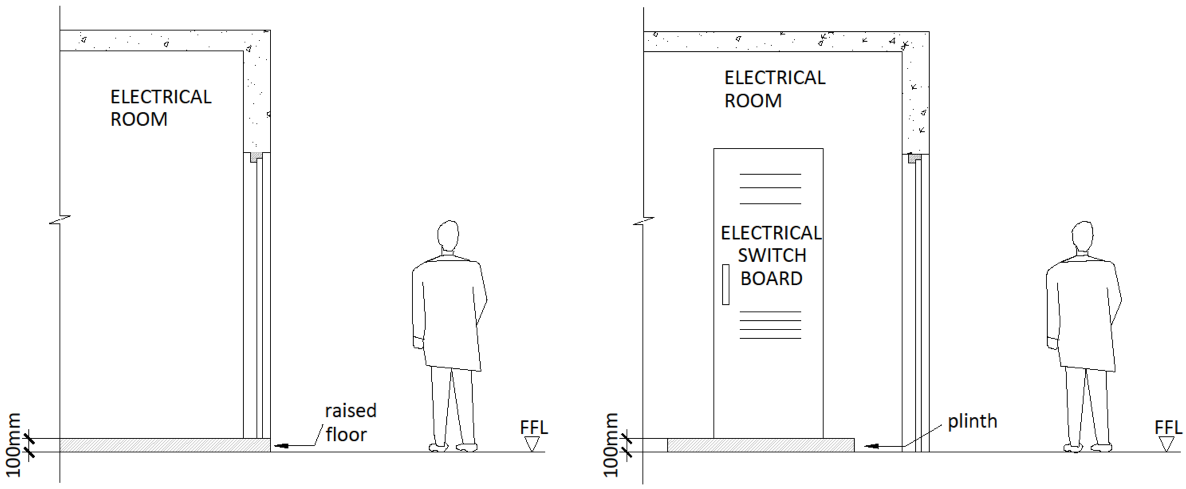



*Figure 32: Raised electrical room (left) and switchboard plinth (right)*

### Documentation requirements

#### Design stage

- Tender specifications indicating the requirement.
- Drawings indicating the electrical room location and level with respect to passageway.

#### Verification Stage

- Shop drawings/as-built section drawings indicating the electrical room location and level with respect to passageway.
- 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: (1 point)**

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 33 below for surge arrestor with indicators.

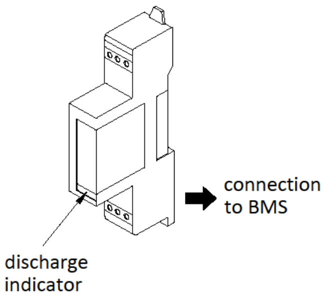



*Figure 33. Surge arrestor with discharge indicator and remote monitoring*

#### Documentation requirements

Design stage

- Tender specifications/drawings showing the discharge indicator requirement.

Verification Stage

- Photographs showing the discharge indicator.

## 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: (1 point)**

**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.

**Documentation requirements**

Design Stage

- Tender specifications/drawings showing the heat sensor requirement and location.

Verification Stage

- Electrical panel technical data sheet/cut sheet, as-built drawings etc. indicating the heat sensor location and specification.

## 4.2.4 Design to facilitate swimming pool cleaning (1 point)

**Intent**

To facilitate swimming pool cleaning and improve labour efficiency.

**Design strategy and assessment: (1 point)**

**a. Provide at least 1 power point for every 25m length of swimming pool (minimum 1 power point for one swimming pool).**

For swimming pool with 50m length, minimum 2 power points shall be provided.

*Note: This item is not applicable to projects without swimming pool.*

**Documentation requirements**

Design Stage

- Tender specification/drawings showing the provision of power point to swimming pool cleaning.

Verification Stage

- Photographs of showing the implementation.

## 4.3 EXTRA LOW VOLTAGE SYSTEM (3 points)

### 4.3.1 Provide access 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**

*Note: This item is not applicable to projects without CCTV installed above 3m.*

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 34 for foldable pole and arm.

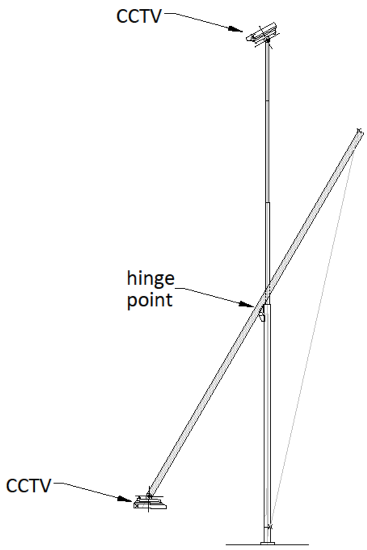



*Figure 34: CCTV with foldable pole and arm*

***(OR)***

**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 35 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 must 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 must depend on the proposed type MEWP to be used and the manufacturer's recommended clearances through the access way.

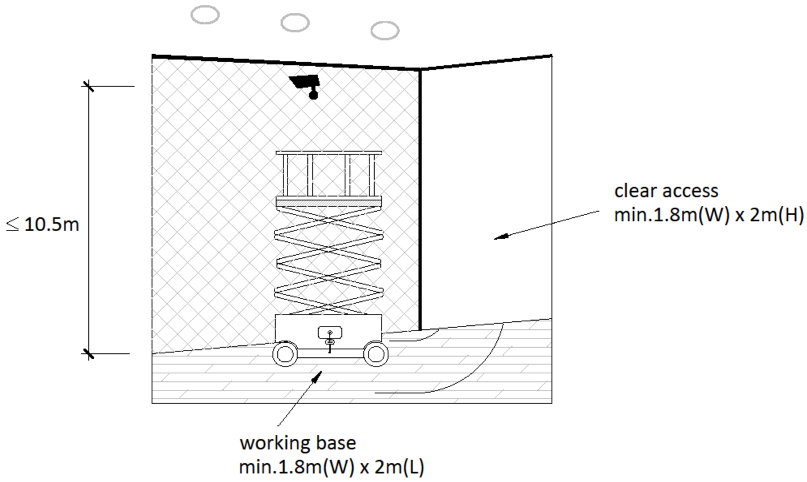



*Figure 35: Clear access for CCTV with mounting height ≤10.5m*

## 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 point)

**Intent**

To make provision for ease of future expansion.

**Design strategy and assessment: (prerequisite)**

**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: This item is not 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 is not 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 gondolas (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 must 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 spacing 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

- Coordinated services drawings indicating the lightning protection strip interfacing with façade access systems.
- Photographs showing the implementation.

## 4.5 VERTICAL TRANSPORTATION (2 points)

### 4.5.1 Access to lift motor room for maintenance (prerequisite)

**Intent**

To provide adequate access for safe and efficient lift maintenance.

**Design strategy and assessment: (prerequisite)**

**a. Provide permanent access (staircase with handrail) to the lift motor room**

*Note: This item is not applicable to projects where only motor room less lifts are provided.*

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.

### 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 (2 points)

**Intent**

To provide predictive maintenance for lift, improve the efficiency, and reduce the manpower requirement for lift maintenance.

**Design strategy and assessment: (2 points)**

**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 vs design strategy*

| Incremental cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 100%<br>(No provision for baseline) | 65%-70% | 25%-30% | 10-11 |

*Baseline: reactive maintenance for lift*
*Design strategy: predictive maintenance for lift*
*LCC results: 60%-70% man-hour saving*

### 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.

## 4.6 CAR PARK ENTRY SYSTEM (Prerequisite)

### 4.6.1 Reduce security manpower required to manually open/close carpark gantries (prerequisite)

**Intent**

To facilitate the work of security guards and improve labour efficiency.

**Design strategy and assessment: (Pre-requisite)**

a. **The EPS antenna must be positioned on the driver's side – i.e. where the IU card reader is located – for the entrance and exit barriers to accurately read the registered car information so as to avoid manual opening of the barrier.**

*Note: This item is not applicable to projects without EPS carpark system.*

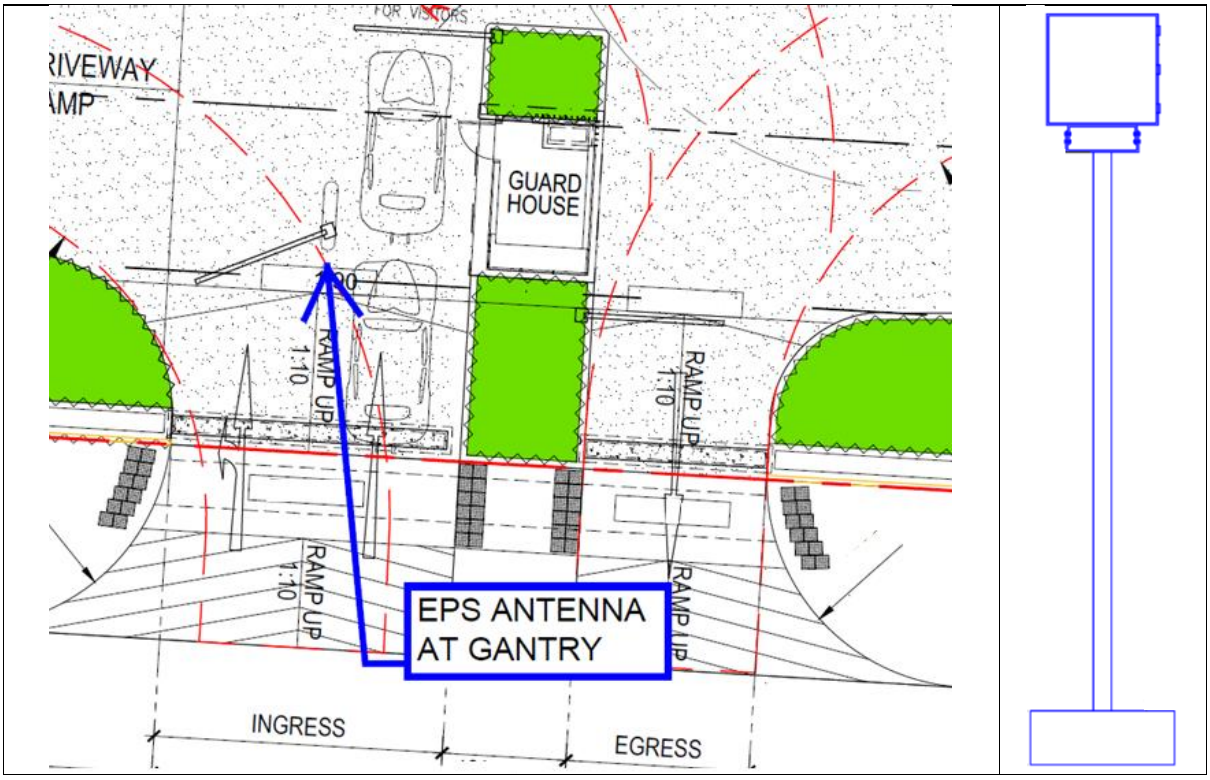



*Figure 36 - Example plan drawing of EPS antenna located at driver's side and installation detail of EPS antenna*

### Documentation requirements

Design Stage

- Tender specification showing the installation requirement of EPS antenna which must be on the same side of car reader.

Verification Stage

Photograph or Shop/as-built drawing indicating the location of EPS antenna with compliance.

# SECTION 5 – LANDSCAPE

## 5.1 SOFTSCAPE (1 POINT)

### 5.1.1 Reduce labour-intensive irrigation for landscape (up to 1 point)

**Intent**

To improve the operational efficiency of landscape irrigation, through optimal selection of systems and materials.

**Design strategy and assessment: (prerequisite)**

**a. Design for water points with maximum 20m 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 point)**

**b. Specify rain sensor and auto-irrigation with timers.**

*Note:*

- *Once the rain sensor gets activated due to sufficient rainfall, the selected irrigation system 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.*

[35] PUB, Best practice guide in water efficiency – Buildings

**Documentation requirements**

Design stage

- Tender specification indicating auto irrigation system with rain sensor and timer.
- 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 provision of rain sensor and the extent of implementation.
- Photographs of completed works highlighting the sensors and types of auto irrigation systems.

**Design strategy and assessment: (0.5 points)**

**c. Specify auto-irrigation with timers.**
*(Points cannot be scored if project has already scored for solution (b))*

*Note: Scheduled auto-irrigation systems provide precise coverage, eliminating concerns of over or underwatering the landscape and thereby reducing the manhour required for irrigation.*

*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% | Up to 5% | Up to 5% | 4 - 5 |

- *Baseline design strategy: Surface drip-tubing 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.

Verification stage

- As-built (Irrigation shop drawings) showing the provision of rain sensor.
- Photographs of completed works showing the rain sensor at site.

**Advanced efforts: (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 irrigations system and remote monitoring capabilities.

Verification stage

- Shop drawing/ final IO 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 (4 points)

### 5.2.1 Access for maintenance of underwater lighting systems (up to 2 points)

**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.*

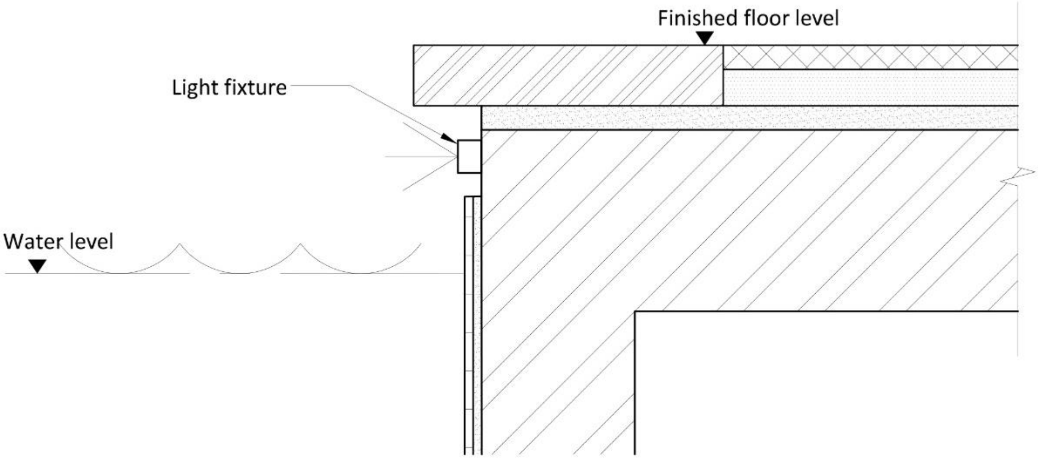



*Figure 37- Example of lighting system located above the water*

**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 vs design strategy*

| Incremental Cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 75% - 80% | 55% - 60% | 5% - 10% | 7 - 8 |

*Baseline design strategy: Lighting fixture with integrated driver submerged in water*
*Proposed design strategy: Lighting fixture with integrated driver outside water*
*Study period: 10 Years*
*Yearly labour savings: 90% - 100% 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.

## Design strategy and assessment: (1point)

**b. For swimming pools, design lighting fixture within a depth of 500mm and along the perimeter.**
*(calculated from base of light to finished floor level for in-ground water bodies/ to point of access for above-ground water bodies)*

*Note:*
- *Consider providing minimal services underwater to avoid draining the water body for maintenance.*
- *Provide electrical cable longer than 1 m to facilitate ease of light replacement outside the water.*

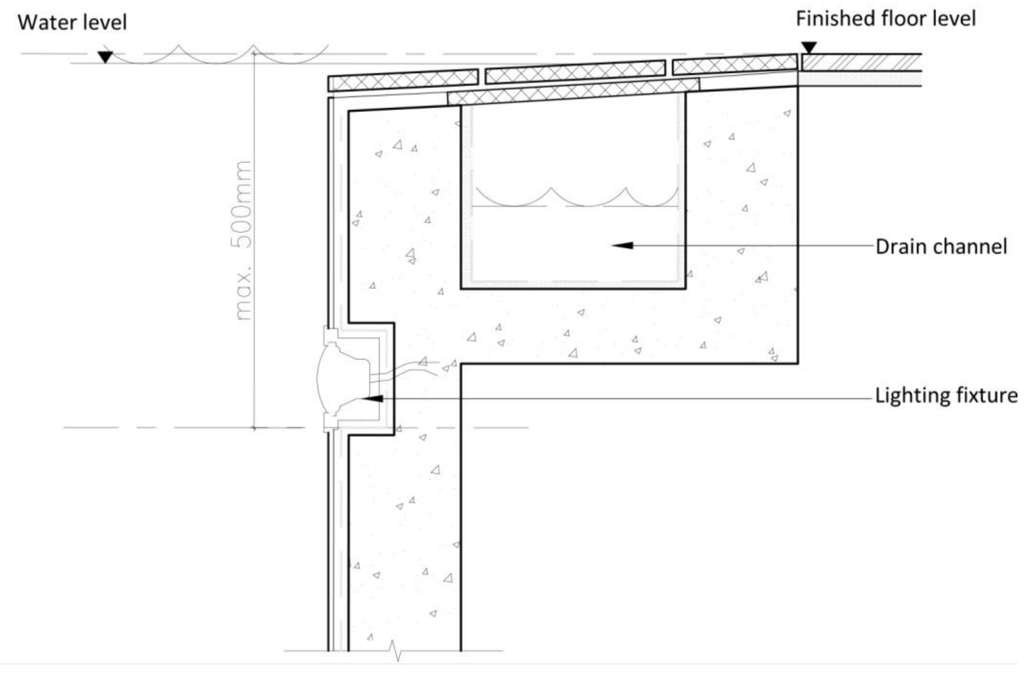



*Figure 38 - Section showing the light fixture at accessible distance for repair and maintenance*

### Documentation requirements

#### Design stage

- Tender drawings (plan and typical section) indicating the depth of lighting fixture from the point of access.

#### Verification stage

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

## 5.2.2 Reduce risk of damage/degradation to outdoor fixed 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.**

*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% | 65% - 70% | 5% - 10% | 45 - 6 |

*Baseline design strategy: Engineered /Reconstituted/ Composite deck with higher water absorption rate*
*Proposed design strategy: Engineered /Reconstituted/ Composite deck with water absorption rate less than 0.5%*
*Study period: 10 years*
*Yearly labour savings: 80% - 90% man-hour savings*

### Documentation requirements

#### Design stage

- Tender specification indicating engineered wood along with maximum water absorption rate.
- Plan drawing highlighting the location of application.

[36] BCA Good industry practices, Composite fibre plastic material chapter 11, Page 82

### 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 stainless steel or aluminium for metal selections.**

#### **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.

### 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.

## 5.2.3 Access for maintenance beneath decking (1 point)

**Intent**

To ensure ease of access for maintenance of services beneath deck, through appropriate design & detailing.

**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.*

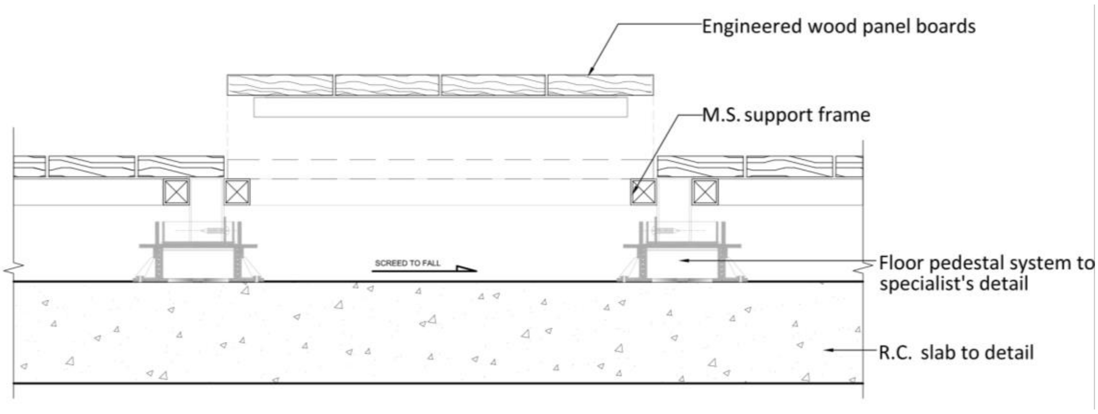



*Figure 39- Typical section showing demountable fixture deck system*

### 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

### 5.3.1 Access to all parts of green wall installations for maintenance and replacement of perished plants (prerequisite)

**Intent**

To ensure ease of access for safe and efficient maintenance of vertical greenery.

**Design strategy and assessment: (prerequisite)**

**a. Provide direct 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.*

[37] CS E11:2014 Guidelines on Design for Safety of Skyrise Greenery, NParks Centre for Urban Greenery & Ecology, 2014n

*Life cycle cost analysis: baseline vs design strategy*

| Incremental Cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 45% - 50% | 85% - 90% | 50% - 55% | 4 - 5 |

*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.

## 5.4 ROOF, SKY TERRACCES, AND PLANTER BOXES ON BUILDING EDGE/FAÇADE (1 point)

### 5.4.1 Access to landscape on roofs and sky terraces (1 point)

**Intent**

To ensure ease of access for safe and efficient maintenance of landscape on roof top and sky terraces.

**Design strategy and assessment: (prerequisite)**

**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.
- Photographs of the completed works.

[38] BCA Façade access design guide, 4.1 Roof Access, 4.1.1 Vertical access to roof

**Design strategy and assessment: (prerequisite)**

**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.*

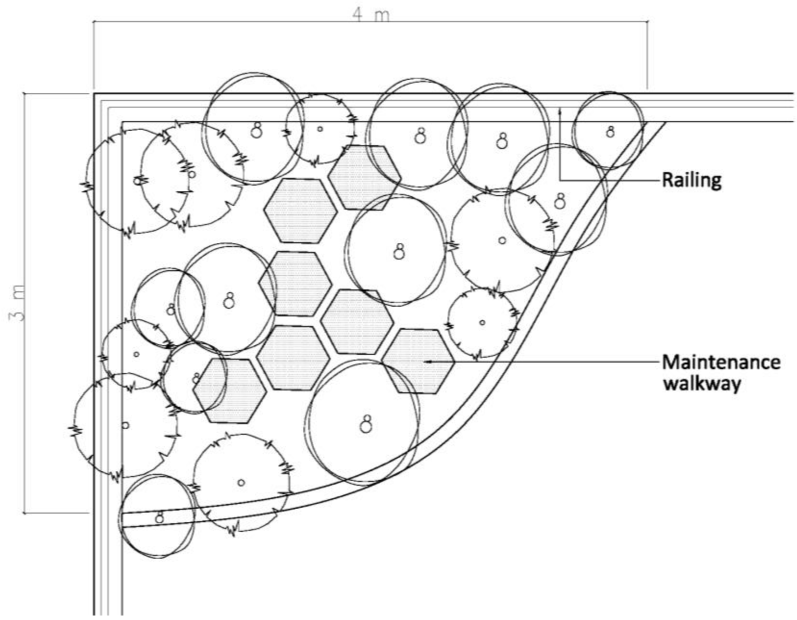



*Figure 40- Maintenance walkway for planter box more than 18m wide*

## 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.*
- *This criterion is applicable to above L1.*

[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

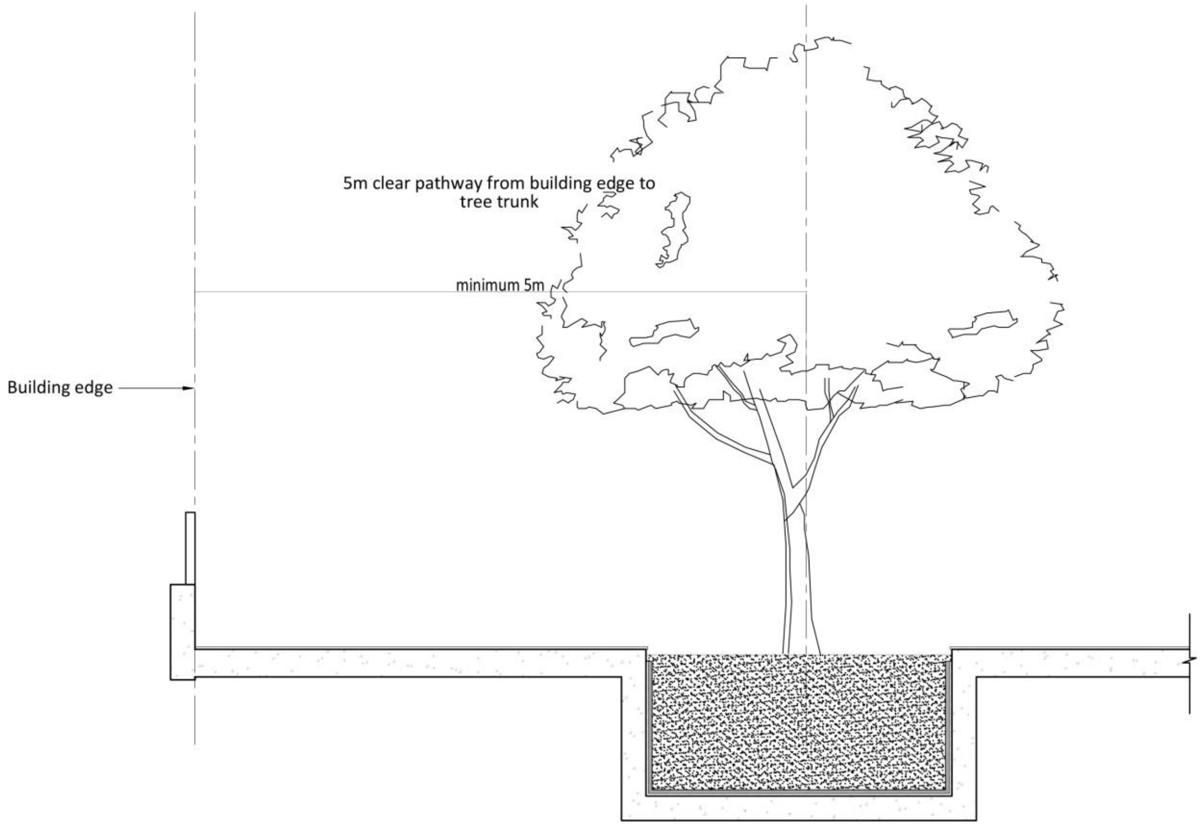



*Figure 41- Typical section showing buffer zone required for trees*

### 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.

## 5.5 Water retaining structure (3 points)

### 5.5.1 Reduce risk of water leakage from swimming pools/water bodies (up to 2 points)

**Intent**

To reduce the frequency of repair and maintenance of water bodies due to water leakage, through optimal selection of materials and design & detailing.

**Design strategy and assessment: (2 points)**

a. **Specify prefabricated water retaining structures, e.g. fiberglass reinforced or stainless-steel-made.**[40]

### Documentation requirements

#### Design stage

- Tender specification indicating the prefabricated water retaining structure.
- Plan and sectional drawings showing the location of water retaining structure.

#### Verification stage

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

**Design strategy and assessment: (2 points)**

b. **For concrete pools - specify integral liquid waterproofing admixture in concrete mixes and additional layer of waterproofing layer on the inside of the pool.**

### Documentation requirements

#### Design stage

- Tender specification indicating the integral waterproofing admixture system and the type of waterproofing layers on the inside of the pool.
- Plan drawing showing the location of the waterbody/swimming pool.
- Typical sectional drawing showing the layers of waterproofing.

#### Verification stage

- As-built drawings to show implementation.
- Delivery order for the specified internal water proofing.
- Photographs of waterproofing system application during the construction stage.

## 5.5.2 Access provision for maintenance of infinity pools (1 point)

**Intent**

To ensure ease of access for safe and efficient maintenance of infinity pool edge.

**Design strategy and assessment: (1 point)**

a. **Provide maintenance access of minimally 600mm[41] with safety barrier along the water flow edge**.

[40] SS 556: 2010 Code of practice for the design and management of aquatic facilities.
NEA Code of practice for the design and management of aquatic facilities

[41] Building and Construction Authority Singapore https://www1.bca.gov.sg/docs/default-source/docs-corp-news-and-publications/circulars/advisory-on-infinity-pools.pdf

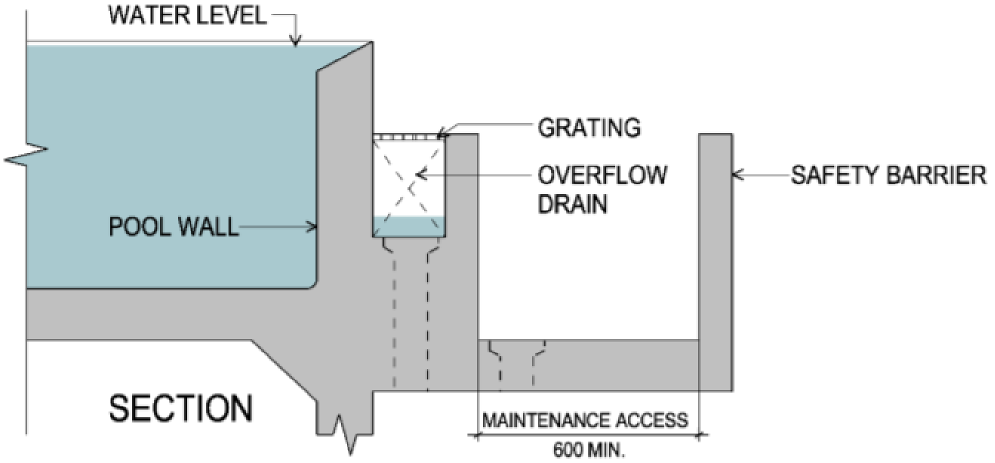



*Figure 42- Typical section showing provision of overflow drain and maintenance access*

### Documentation requirements

#### Design stage

- Plan and sectional drawings to show location of infinity pool edge along with the provision of access.

#### Verification stage

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

## 5.6 Standalone structures (1.5 points)

### 5.6.1 Reduce water ponding and degradation of outdoor standalone structures, e.g. pavilions (up to 0.5 point)

**Intent**

To reduce the frequency of repair and replacement of outdoor pavilions through optimal selection of materials and appropriate design & detailing.

**Design strategy and assessment: (prerequisite)**

a. **Design for outdoor standalone structures roof slope to be not 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 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.**[42]

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)*

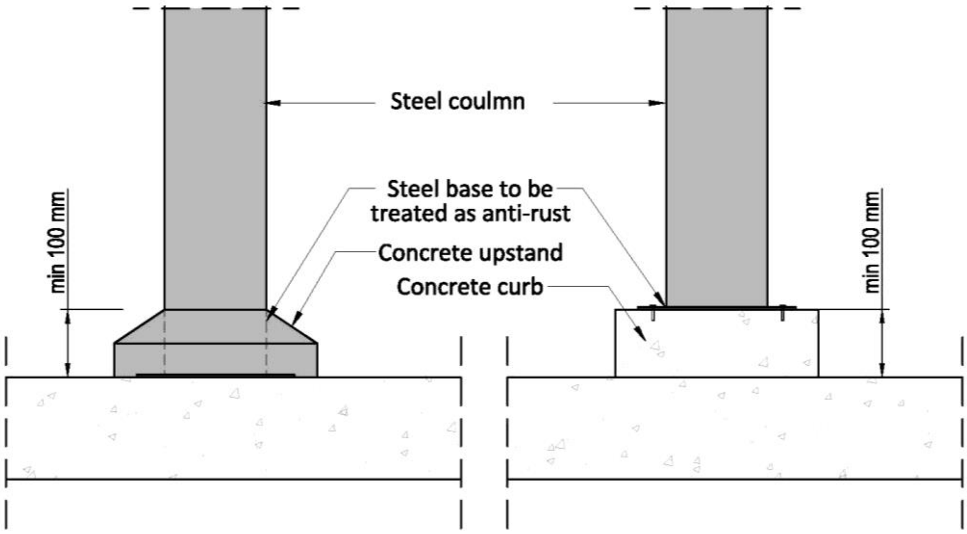



*Figure 43- Concrete upstand protection for steel base*

### 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.

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

## 5.6.2. Reduce risk of warping/deterioration of ceiling panel system on outdoor standalone structures (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% | 95% - 100% | 15% - 20% | 5 - 6 |

*Baseline design strategy: Moisture Resistance monolithic plaster ceiling (gypsum board)*
*Proposed design strategy: Metal Panel ceiling*
*Study period: 10 Years*
*Yearly labour savings: 80 - 90% man-hour savings.*

### Documentation requirements

#### Design stage

- Tender specification indicating the type of metal suspended modular ceiling panel.
- Plan drawings 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 reduces 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.
- Plan drawing showing the extent of the moisture-resistant false ceiling plan layout.

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.
- Plan drawings showing the extent of open ceiling plan layout.

Verification stage

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

## SECTION 6 – FACILITIES

### 6.1 OUTDOOR GAMES COURT (2 Points)

#### 6.1.1 Reduce risk of water ponding on games court (prerequisite)

**Intent**

To reduce the frequency of repair and replacement to outdoor courts caused by water ponding by adopting appropriate design & detailing.

**Design strategy and assessment: (prerequisite)**

a. **Ensure slope and gradient as per the court guidelines, e.g. For non-porous tennis courts minimum of 1:120 and maximum of 1:100**[43].

**Documentation requirements**

Design stage

- Tender (Plan) drawings showing the location of outdoor court and the intended slope as per the guidelines.

Verification stage

- As-built (construction) drawings to show implementation.

#### 6.1.2 Reduce development of flooring blisters/bubbles (2 points)

**Intent**

To reduce the frequency of repair and replacement caused by blisters and bubbles through optimal selection of materials and design & detailing.

**Design strategy and assessment: (1 point)**

a. **Design to provide perimeter drain channel to prevent moisture accumulation beneath court surface.**

   *Note:*

   - *Excess water that flows back onto the court surface or beneath the court can destabilize the soil beneath the base slab.*

**Documentation requirements**

Design stage

- Tender drawings showing the perimeter drain channel.

Verification stage

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

[43] ATP tennis court guidelines

**Design strategy and assessment: (0.5 point)**

**b. Specify for semi-permeable surface coating to allow for moisture to escape, e.g. acrylic surface coating.**

*Note: Semi-permeable surface coating allows small to moderate amount of vapour transmission and helps reducing the flooring blisters.*

### Documentation requirements

#### Design stage

- Tender specification indicating the semi-permeable surface coating on the court surface.

#### Verification stage

- As-built (shop) drawings to show implementation.
- Relevant technical material specification for the semi permeable property of the surface coating.

**Design strategy and assessment: (0.5 point)**

**c. Specify for installation of vapour barrier below the base structural slab to reduce water ingress from beneath the court.**

*Note: Vapour barrier below the base slab prevents hydrostatic pressure, in the form of water vapour, from beneath the surface. When the sun heats up the court surface, sub-surface water turns to vapour and creates vapour pressure to escape. If enough water builds up beneath the slab and pushes upwards, it can create bubbles and blisters in the coatings and lead to peeling.*

*Life cycle cost analysis: baseline vs design strategy*

| Incremental Cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 100%<br>(No Provision for Baseline) | 45% - 50% | 10% - 15% | –6 - 7 |

*Baseline design strategy: Reinforced concrete tennis court without Vapour Barrier*
*Proposed design strategy: Reinforced concrete tennis court with Vapour Barrier*
*Study period: 10 Years*

### Documentation requirements

#### Design stage

- Tender specification indicating the vapour barrier layer beneath the base slab.

#### Verification stage

- As-built (shop) drawings to show implementation.
- Photographs taken during implementation.

## 7.1 SMART FM (UP TO TOTAL 5 POINTS)

### 7.1.1 Adopt innovative technologies that improve FM labour efficiency and service delivery (Up to total 5 points)

**Intent**

To use innovative technologies to improve operation and maintenance and enhance labour efficiency.

**Design strategy and assessment: (prerequisite)**

**a. Type 1 – Use of digitized workflow automation to optimize the workflow, productivity and service delivery:**

**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. Use of Property Management Software for workflow automation
2. Smart visitor management system
3. Online facility booking system
4. Smart exit lights
5. Smart monitoring system for fire extinguishers
6. Smart security system such as video analytics for access control
7. Smart lighting
8. Mobile APP for residents (Example, the APP could be used for booking common facilities, receiving notice from MA, payment of maintenance fees, reporting maintenance issues and etc.)

*Life cycle cost analysis: baseline vs design strategy*

| Incremental cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 85% - 90% | 40%-45% | 30%-35% | 1-2 |

*Baseline: Conventional lighting control system (Manual)*
*Design strategy: Smart lighting control system*
*LCC results: 50%-60% man-hour saving*

*Life cycle cost analysis: baseline vs design strategy*

| Incremental cost | Yearly operation and maintenance cost saving | Total life cycle cost saving | Simple payback (years) |
|---|---|---|---|
| 3X | 90%-100% | 20%-30% | 3-4 |

*Baseline: Conventional exit light*
*Design strategy: Smart exit light*
*LCC results: 90%-95% man-hour saving*

### 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 finalized 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

**Design strategy and assessment: (1 point each)**

**b. Type 2 – Use of data analytics and artificial intelligence for system optimization and predictive maintenance:**

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. Implement predictive maintenance for equipment failure i.e. fault detection and diagnostics of water pumps.

### 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 finalized 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

**Design strategy and assessment: (1 point each)**

c. **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.

## CHAPTER 4: RESPONSIBLE PARTIES FOR KEY MAINTENANCE ITEMS

The table below outlines the responsible parties for each Key Maintenance Items (KMIs). The Developer / Building Owner must direct the responsible parties (where applicable to the project) to work together and comply with the KMIs.

| KEY MAINTAINENCE ITEMS (Residential Building) | Responsible parties |
|---|---|
| **SECTION 0 – ARCHITECTURAL EXTERIOR** | |
| Promote inclusion of Design for Maintainability (DfM) at planning and design 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 sky bridges | Architect / Façade consultant |
| 1.2 Cladding system: 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, BIPV, façade screens etc. | Architect / Façade consultant |
| 1.5.2 Reduce risk of corrosion of exposed steel structures | Architect |
| 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) | Architect / Façade consultant |
| 1.5.4 Reduce risk of tile / stone from detaching off facade | Architect / Façade consultant |

| | |
|---|---|
| 1.6 Entrance Lift Lobby / integrated drop-off at blocks | |
| 1.6.1 Reduce risk of water ingress at entrances | Architect |
| 1.7 Exposed above-ground corridors, lift lobbies and link bridges | |
| 1.7.1 Reduce water ponding in above-ground exposed corridors, lift lobbies and link bridges caused by wind driven rain | Architect |
| 1.7.2 Reduce risk of water ingress into lift shaft | Architect |
| 1.8 Roof | |
| 1.8.1 Reduce risk of water ponding on roofs | Architect |
| 1.8.2 Reduce risk of waterproofing failure/decay on concrete roofs. | Architect / Water proofing specialist |
| 1.8.3 Reduce risk of corrosion on metal roofs | Architect / Metal roof specialist |
| **SECTION 2 – ARCHITECTURAL INTERIOR & COMMON AREAS** | |
| 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 Walls and Partitions | |
| 2.2.1 Reduce risk of stains on wall surfaces in common areas | Architect / Interior consultant |
| 2.3 Ceilings | |
| 2.3.1 Access to services within double slab areas for maintenance purposes | Architect / Interior consultant |
| 2.3.2 Access to services within the ceiling in common areas such as clubhouse, function rooms, common corridors and lobbies | Architect / Interior consultant |
| 2.3.3 Access to ceiling for maintenance | Architect |
| 2.3.4 Reduce risk of warping/deterioration of ceiling panel system that are weather-exposed, at locations such as sky terraces, drop-off porches, corridors, and lobbies | Architect / Interior consultant |

| | | |
|---|---|---|
| 2.4 | Common toilets | |
| 2.4.1 | Reduce risk of mould and fungus formation on walls in toilets | Architect / Interior consultant |
| 2.4.2 | Reduce risk of damage to toilet cubicle partitions and enable ease of cleaning | Architect / Interior consultant |
| 2.4.3 | Reduce risk of water spill on floor, and splashing and soap dripping on the counter and floor | Architect / Interior consultant |
| 2.4.4 | Reduce the need to replace entire mirror glass pane when damaged | Architect / Interior consultant |
| 2.4.5 | Reduce degradation of false ceiling system in toilets | Architect / Interior consultant |
| 2.5 | Basement | |
| 2.5.1 | Reduce risk of water ingress/seepage in basement | Architect / C&S consultant |
| **SECTION 3 - MECHANICAL** | | |
| 3.1 | Air Conditioning System – Direct Expansion System (DX Units) | |
| 3.1.1 | Access to AC ledge for Condenser Unit (CU) maintenance | Architect / M&E consultant |
| 3.1.2 | Access space around the AC ledge for maintenance of condenser unit | Architect / M&E consultant |
| 3.1.3 | Reduce risk of air shot circuit due to the poor location of AC ledge/condenser unit | Architect / M&E consultant |
| 3.2 | Air Conditioning System – Variable Refrigerant Flow (VRF) | |
| 3.2.1 | Access to VRF outdoor units | Architect / M&E consultant |
| 3.3 | Air Distribution System | |
| 3.3.1 | Access to FCU mounted at heights in common areas (i.e. lobby, atriums, clubhouses, etc.) | Architect / 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 | Provide adequate access space for maintenance of ejector pump | Architect / M&E consultant |
| 3.5.3 | Reduce risk of chokes in the sanitary pipe | Architect / M&E consultant |

| | | |
|---|---|---|
| 3.6 | Fire Protection System | |
| 3.6.1 | Reduce risk of damage and periodic replacement of fire-rated boards due to exposure to high humidity and water | M&E consultant |
| 3.7 | Swimming Pool System | |
| 3.7.1 | Provide adequate access for filtration pump maintenance | Architect / 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 / Lighting consultant / Interior Design consultant |
| 4.1.3 | Reduce risk of LED light colour shift | M&E consultant / Lighting consultant / Interior Design 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 |
| 4.2.4 | Design to facilitate swimming pool cleaning | 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 system 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 |
| 4.6 | Car Park Entry System | |
| 4.6.1 | Reduce security manpower required to manually open/close carpark gantries | 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 | 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, and Planter boxes on building edge/facade | |
| 5.4.1 | Access for landscape on roof and sky terraces | Architect / Landscape Architect |
| 5.5 | Water retaining structure | |
| 5.5.1 | Reduce risk of water leakage from swimming pools/water bodies | Architect / C&S consultant |
| 5.5.2 | Access provision for maintenance of infinity pools | Architect |
| 5.6 | Standalone Structure | |
| 5.6.1 | Reduce water ponding and degradation of outdoor standalone structures | Architect / Landscape Architect |
| 5.6.2 | Reduce risk of warping/deterioration of ceiling panel system on standalone structures | Architect / Landscape Architect |

| SECTION 6 – FACILITIES | | |
|---|---|---|
| 6.1 | Outdoor Games Court | |
| 6.1.1 | Reduce risk of water ponding on games court | Architect/ Games court consultant |
| 6.1.2 | Reduce development of flooring blisters/bubbles | Architect/ Games court consultant |
| **SECTION 7 – SMART FM** | | |
| 7.1 | Smart FM | |
| 7.1.1 | Adopt innovative technologies that improve FM labour efficiency and service delivery | Client/ Architect/ M&E consultant |