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# DESIGN FOR MAINTAINABILITY CHECKLIST

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VERSION 1.3



## COMPOSITION OF WORKING GROUP ON DESIGN FOR MAINTAINABILITY

The Design for Maintainability Checklist has been drafted by the Working Group on Design for Maintainability. The Working Group comprises representatives from the following organisations:

### Public Sector agencies

1. Building and Construction Authority (Co-chair)
2. Housing and Development Board (Co-chair)
3. JTC Corporation
4. Ministry of Education
5. National Environment Agency
6. National Parks Board
7. Workplace Safety and Health Council

### Industry stakeholders

8. Association of Consulting Engineers Singapore
9. Association of Property and Facility Managers
10. Environmental Management Association of Singapore
11. International Facility Management Association, Singapore Chapter
12. MOH Holdings Pte Ltd
13. Real Estate Developers Association
14. Singapore Institute of Architects
15. The Institution of Engineers, Singapore

## HISTORY OF AMENDMENTS

S/N	Brief description of changes	Revision date
1	Ver 1.0 – first issue	April 2016
2	Ver 1.1 – second issue	May 2016
3	Ver 1.2 – second issue	Jun 2016
4	Ver 1.3 – third issue	Sep 2016

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### Introduction

Transforming the built environment sector towards higher productivity requires concerted efforts across the entire building and construction value chain. The process must begin at the early design stage with the adoption of labour-efficient and maintainable design strategies to consequently enable productive construction methods as well as efficient maintenance operations in the post-occupational stage of the building.

With greater emphasis on creating sustainable developments and improving building performance, the concept of maintainability is also increasingly relevant in terms of minimising the costs and resources required for building to function efficiently throughout its lifespan.

### 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”* 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:

- (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 maintenance interventions* - 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.

### Purpose of Checklist

The intent of this document is to provide a set of design recommendations and best practices to aid developers and architects in integrating Maintainability concepts in the upstream design processes, thereby promoting quality design with consideration of productivity, safety and labour efficiency in downstream building maintenance activities. The checklist is expected to be a useful reference for architects, engineers, developers, facilities and building managers, and service providers.

It should be noted that the checklist is not meant to be definitive nor exhaustive. The generic nature of this checklist does not account for the variances in maintenance objectives in different building types. It also does not address construction quality, maintenance operations and the economic aspects of design decisions. The checklist is not intended to override or replace any legal rights, responsibilities or regulatory requirements.

### Scope of Checklist

The Design for Maintainability Checklist places emphasis on good architectural planning and design details, as well as the use of appropriate materials and technology to facilitate productive maintenance activities.

The framework of the Design for Maintainability Checklist is structured according to the main components of a building. Each building component is then considered in relation to three critical maintainability design factors.

The main building components identified are:-

#### 1. Main Building Areas

- Facades and External Walls
- Roof Areas
- Common Areas, Lift Lobbies and Corridors
- Parking Areas
- Other Building Areas e.g. washrooms, facilities for cleaners

#### 2. Mechanical and Electrical (M&E) Facilities

- Plant, Machinery and Fixed Equipment
- Security
- Piping and Exposed Services

#### 3. Landscape and Outdoor Areas

- Planting and Turf
- Water Features
- Other Landscaped Areas e.g. outdoor furniture, footpaths

The three critical maintainability design factors are:

##### i) Access for Maintenance

The ability and ease to access, inspect and maintain various parts of a building is a critical factor for enabling efficient routine servicing and maintenance works. Access provisions must be designed to be safe and provide sufficient circulation and working space for maintenance vehicles or personnel carrying tools, equipment and component parts. Where possible, a building should be designed to remove the need for temporary or makeshift access such as scaffolding and ladders.

*Key considerations include:*

- *Adequate provision of access for execution of maintenance tasks including cleaning, inspections, repair and replacement of materials, components or equipment.*
- *Design layout gives sufficient circulation and working space, including headroom*
- *Minimise the need for maintenance at height or in confined spaces.*
- *Where it is not possible to eliminate the need for maintenance at height or in confined spaces, measures should be put in place to reduce the risks associated with working at height or in confined spaces.*

##### ii) Materials and Finishes

Beyond the aesthetics qualities, designers should consider the suitability of materials in terms of their ability to resist defects from normal wear and tear (durability), and perform the intended functions throughout the design life. The appropriate use of materials can minimise the frequency of cleaning, repair and replacement.

*Key considerations include:*

- *Strike a balance between aesthetics, costs, safety and maintenance needs.*
- *Select materials that are durable and suitable for the local climate.*
- *Choose materials that are easily available during the life of the building.*
- *Consider innovative, high-performance materials that require minimal maintenance.*

### iii) Design and Detailing

Proper architectural design and construction detailing can help to minimise the occurrence of defects and reduce the need for maintenance interventions. The main concerns include having careful detailing to prevent staining, water penetration and premature deterioration, as well as to enable simple maintenance methods and replacement of elements.

*Key considerations include:*

- *Proper and effective detailing to reduce the impact of weather.*
- *Design enables simple maintenance methods, such as easy diagnostic checks, installation and disassembly/assembly of components.*
- *Consider standardisation and modular layout of components.*
- *Consider prefabricated materials/ components.*

### How to use this checklist

The designer should indicate “Y”, “N” or “NA” in the Y/N/NA column against the design recommendations.

Abbreviation	Denotes
<b>Y</b>	Yes – meet or exceed the design recommendation
<b>N</b>	No – does not meet the design recommendation
<b>NA</b>	Not Applicable – design recommendation is not applicable

The designer should provide a brief description of the provision. If the design recommendation is not met or not applicable, the designer should explain why the recommendation is not considered and whether alternative solution is proposed. Additional notes, references, drawings, etc could be attached to this checklist as supporting documents.

An example of how the columns are filled is given below:

1.	MAIN BUILDING AREAS			
A.	Façade and External Walls			
A1.	<u>Access</u>	Y/N/NA	Description of provision (Attach relevant drawings, references, etc where necessary)	If No or not applicable, please clarify
A1.1	<b>General</b> The building envelope and appurtenances, including the exterior walls, roof, roof trellis, glass canopies, sky bridges, planters, signboards, fixtures and equipment attached to or protruding from the façade, etc should be accessible for maintenance.	Y	See "façade access strategy" described in the Maintenance Strategy Report	
A1.2	<b>Protruding façade features</b> Minimise the use of extensive niches, large fins and ledges (e.g. >600mm) which are difficult to access for cleaning and maintenance. If the protrusions is too large (>2m), reach to the general façade might be affected.	NA		No protruding features on façade.
A1.3	<b>Internal Access</b> The design should facilitate minor cleaning and repair works to be carried out from interior, while major repair works can take place from the outside to minimise inconvenience to the occupants.  For residential developments, the access for façade cleaning and repair work should not encroach into private spaces such as the residents' balconies, private enclosed spaces (PES) and private roof terraces.	Y	<ul style="list-style-type: none"> <li>Gondola system and elevated walkway access provided</li> <li>No encroachment into private spaces.</li> </ul>	
A1.4	Allow façade/ window cleaning from the internal by providing appropriate openings for cleaners using handheld tools. Use modularised windows panels which are not too large (max 750mm) for ease of cleaning within the reach of the cleaner's arm.	N	<ul style="list-style-type: none"> <li>Modularised window panels (700mm) for tower block</li> <li>Curtain wall for podium block</li> </ul>	Facade of podium block are not operable due to security reasons. All elevations are covered by gondola system.

As the design objectives differ from one building to another, the recommendations of the checklist may not comprehensively address the scope and specific maintenance requirements of a project.

In addition to the use of this checklist, a holistic design approach should entail the development of a "Maintenance Strategy Report" to outline the design philosophy, assumptions and requirements regarding the maintenance activities of the project. A guide on the development of Maintenance Strategy Report is provided in Part III of this document.

Project Details	
Project title	
Project Reference Number	
Project Type <i>(pls delete accordingly)</i>	Residential / Commercial <i>(office / retail)</i> / Industrial / Institutional (pls specify) / Others (pls specify)
Developer	
Design QP (Arch) / Organisation	
Design QP (C&S) / Organisation	
Design QP (Mech) / Organisation	
Design QP (Elec) / Organisation	
Builder	
GFA (m <sup>2</sup> )	
Contract Sum (mil\$)	



## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

1. MAIN BUILDING AREAS				
A. Façade and External Walls				
A1.	<u>Access</u>	Y / N / NA	Description of provision <i>(Pls enclose relevant drawings, references, etc. where necessary)</i>	If No or Not Applicable, please clarify
A1.1	<b>General</b> The building envelope and appurtenances, including the exterior walls, roof, roof trellis, glass canopies, sky bridges, planters, signboards, fixtures and equipment attached to or protruding from the façade, etc should be accessible for maintenance.			
A1.2	<b>Protruding façade features</b> Minimise the use of extensive niches, large fins and ledges (e.g. >600mm) which are difficult to access for cleaning and maintenance. If the protrusions is too large (>2m), reach to the general façade might be affected.			
A1.3	<b>Internal Access</b> The design should facilitate minor cleaning and repair works to be carried out from interior, while major repair works can take place from the outside to minimise inconvenience to the occupants.  For residential developments, the access for façade cleaning and repair work should not encroach into private spaces such as the residents' balconies, private enclosed spaces (PES) and private roof terraces.			
A1.4	Allow façade/ window cleaning from the internal by providing appropriate openings for cleaners using handheld tools. Use modularised windows panels which are not too large (max 750mm) for ease of cleaning within the reach of the cleaner's arm.			
A1.5	<b>External Access</b> The building should be designed with a façade access method that is suitable for the building geometry.  The building should require as few access systems as possible and yet achieve as high coverage as possible.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

A. Façade and External Walls				
A1.	<u>Access</u>	Y / N / NA	Description of provision <i>(Pls enclose relevant drawings, references, etc. where necessary)</i>	If No or Not Applicable, please clarify
A1.6	<b>Building Maintenance Unit (BMU)</b> Where BMU is used for façade maintenance, ensure that the BMU is: a) electronically powered and programmable.			
	b) designed and located to enable positioning/ suspension of working platforms to reach all exterior surfaces of the building.			
	c) easily accessible via common areas.			
	d) designed with suitable restrains and bumpers needed to address high wind loads.			
A1.7	<b>Suspended Access Equipment</b> Where gondola system (suspended cradle/ working platform) is used for façade maintenance, ensure that: a) there are provisions for gondola to be safely affixed to the building (e.g. permanent hook-up points) as well as adequate anchor points for safety ropes and independent anchor for lifelines.			
	b) the gondola is able to reach all exterior surfaces of the building.			
	c) facade features do not obstruct the operation of the gondolas. Surfaces below protrusions/ cantilevered structures are be reachable and maintainable from gondola.			
	d) there are adequate safe launching/ landing places for the cradle/working platform.			
	e) the locations of the launching and landing spaces and the access routes to these spaces are located within common spaces.			
	f) there are appropriate electrical supply provided for gondola operations and ease of access/reaching to the control panel			
A1.8	<b>Provision for use of ladders</b> Provide a suitable firm level surface for use of ladders for safe reaches for cleaning.			
A1.9	Provide anchorage for sliding safety harness and eyebolt fixing for rope to secure ladder.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

A. Façade and External Walls				
A2.	<b><u>Materials and Finishes</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
A2.1	<b>General</b> Consider using materials that age well with time and weathering e.g. rustic stone finishes.			
A2.2	<b>Glass</b> Where Low-E coating is used, apply the coating on non-exposed glass (surface #2/#3) surface to avoid being scratched and worn off.			
A2.3	Minimize the use of non-planar or curvilinear glass surfaces which are difficult to clean and not readily available in the market.			
A2.4	<b>Paint Systems</b> Use suitable paint systems that could enhance weather protection and lengthen the cyclical period needed for façade re-painting (e.g. mineral or polyurethane paint systems).			
A2.5	<b>Fastenings and Fixings</b> Consider using materials that are not easily prone to corrosion or rust e.g. stainless steel.			
A2.6	<b>Selection of Materials</b> Minimise or eliminate the use of materials that are prone to deterioration when exposed to weathering (e.g. plaster or calcium silicate board).			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

A. Façade and External Walls				
A3.	<b><u>Design and Detailing</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
A3.1	<b>External Walls</b> Regularity of the façade surface's plane will affect the even flow of runoff leading to water ponding, penetration and staining problems. Design proper wall details to throw water off general façade surfaces to prevent staining and minimise water penetration.  Provide drip edges to prevent streaking on wall soffit and glazing surfaces.			
A3.2	Top surfaces of all walls to be graded to fall away from external face of walls to minimise streaking on the facade. The coping should overhang the rear side of the walls and comes with drip control to mitigate streaks on the back walls.			
A3.3	<b>Stone Panels</b> Stone panels should be mechanically fixed to avoid the use of plaster/ adhesive which may cause efflorescence.			
A3.4	Stone panels should installed be in a way that allows for inspection of its hidden mechanical connections to ensure that it is not corroded or loose e.g. accessible for fibre-optics inspection.			
A3.5	<b>Weather Control Devices</b> Openings to external should incorporate appropriate weather control devices such as overhanging ledges, copings and rain screens to minimise rainwater ingress.			
A3.6	<b>Metallic Cladding and Fixtures</b> Minimise the use of metallic cladding and wrapping around external building components such as beams and columns near loading/ unloading areas where high delivery volume is expected.			
A3.7	Metallic cladding should be installed in a way that allows for inspection of its hidden mechanical connections for corrosion, dilapidation and loose or defective fixings.			
A3.8	<b>Glazing and Glass Surfaces</b> Minimise the use of inclined glass surfaces which are prone to dirt and dust collection.			
A3.9	Where inclined glass surfaces are designed, provide easy access for cleaning and replacement.			
A3.10	External glazing should be suitably sized such that they can be transported by lifts to facilitate future replacement from within building.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

A.	Façade and External Walls			
A3.	<u>Design and Detailing</u>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
A3.11	Where large glass surfaces are used, apply water repellent coating such as titanium dioxide coating.			
A3.12	Provide movement joints to accommodate movement in large continuous areas, or between adjacent building components (e.g. brick wall and concrete column) and dissimilar substrates.  The backer-rod material in the joint should be compatible with the sealant used.			
A3.13	<b>Planter boxes</b> Planter boxes should be accessible for easy maintenance e.g. located at window sill level, along service balcony/ corridor.			
A3.14	The location of drainage outlets of planters should not cause stains on building facade.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

B. Roof Areas				
B1.	<u>Access</u>	Y / N / NA	Description of provision (Attach relevant drawings, references, etc where necessary)	If No or not applicable, please clarify
B1.1	Access to the external surfaces of the roof should be provided wherever possible from within the building.			
B1.2	Provide at least one direct staircase access to main roof areas for maintenance purpose.			
B1.3	Service lift should preferably land at roof level. Loading of the lift should cater and allow the heaviest equipment to be transported via the lift safely for the replacement purpose.			
B1.4	Designated access should be provided for lift motor room e.g. 'knock-out wall panel' and hoisting beam for servicing and replacement of lift motor.			
B1.5	Provide sufficient working space between M&E installations and components located at the roof.  A minimum space of 1.8m should be provided between the building edge, parapet wall and M&E installations.  Catwalks shall be provided along maintenance path to prevent stepping on rooftop services such as piping/ trunking/ conduit.			
B1.6	<b>Solar panels</b> Provide peripheral working space of minimum 1.5m for the maintenance access and replacement of solar panels at roof areas.			
B1.7	<b>Safety for Maintenance</b> Provide safety barriers or guard rails along the edges of the roof for the safety of maintenance personnel (min height of 1.0m).			
B1.8	Provide clear demarcation of maintenance boundaries and access at roof areas.			
B1.9	Provide fall restraint protection systems at roof areas e.g. provide anchorage points on pitched roofs for securing safety harnesses to facilitate cleaning and washing.			
B1.10	Hoisting facilities and anchorages should be provided at the roof for hoisting of equipment after completion of the building.			
B1.11	Provide safety barriers or guard rails for flat roof openings such as skylights and air wells to prevent fall from sky light.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

B. Roof Areas				
B1.	<u>Access</u>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	If No or not applicable, please clarify
B1.12	Provide proper non-slip steps/platforms over M&E plants and services to avoid climbing over/under pipes and tripping hazards.			
B2.	<u>Materials and Finishes</u>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	If No or not applicable, please clarify
B2.1	<p>Materials used for the roof should be able to withstand exposure to external weathering.</p> <p>Minimize the use of extensive transparent and translucent roofing materials that are prone to discolouration and weathering.</p>			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

B. Roof Areas				
B3.	<b><u>Design and Detailing</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
B3.1	<b>Drainage</b> All flat roof areas and open terraces with horizontal surfaces should be finished to fall with adequate gradients such that storm water is directed away from door openings and flow towards rain water outlets/ floor waste outlets.			
B3.2	Drainage outlet should be provided with “debris trap” to prevent choking of the drainage system. Use leaf guards and overflow spouts to prevent water stagnation.			
B3.3	<b>Roof Design</b> The roof profile should be sufficiently sloped to facilitate self-cleansing (min 3° slope for flat roof).			
B3.4	The placement of M&E plants and services at the roof should be well planned and coordinated to minimise the need for unnecessary screening treatment to conceal the services.			
B3.5	<b>RC Roof</b> The main RC roof slab and roof gutters should be sloped at 1:50 or steeper.			
B3.6	Design two-directional fall to improve drainage and to reduce roof thickness.			
B3.7	Incorporate adequate expansion joints to prevent cracking and support the movement of plant and equipment on the roof.  The expansion joints shall be at regular intervals over the large tiled continuous roof/external areas due to constant weather exposures.			



## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

C. Common Areas, Lift Lobbies and Corridors				
C1.	<b><u>Access</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
C1.1	<b>Air Well and Atrium</b> a) Avoid creating constricted areas, air wells and atrium which are difficult to access and maintain. b) Provide at least 1.2m clear width access space. c) Use materials of non-slip nature in area which may be affected during wet weather. d) Provide maintenance tracks systems around large voids and air wells. Safe access to be provided for “fire detection devices” for the purpose of testing, servicing and replacement. e) BMU Systems should be designed such that all façade surfaces can be accessed and within reach from gondola cradle. f) Avoid high volume voids or “soft storeys” with “flying” beams with no easy access for maintenance.			
C1.2	<b>Ceiling Spaces and Height</b> Minimize extensive lobby areas with high and deep ceiling spaces (e.g. > 5m) which are difficult to access for maintenance.			
C1.3	Where ceiling spaces that require maintenance exceeds 5m in height, provide catwalks, elevated platforms and/or unobstructed access route for maintenance equipment and vehicles e.g. scissors lift and mobile elevated platforms. To facilitate access to high ceiling spaces in sky terraces, provide a service lift of adequate capacity to transport the maintenance equipment and vehicles.			
C1.4	Provide signs and location indicators for services located above high ceiling areas. Services above suspended ceiling to be provided with proper access and marked on as-built drawings.			
C1.5	Where electrical control boards, valves, water and sanitary pipes are installed at high ceiling areas, provide permanent maintenance access and platform for accessing equipment.			
C1.6	Access panels should be provided to ensure concealed services are fully serviceable.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

C. Common Areas, Lift Lobbies and Corridors				
C2.	<b><u>Materials and Finishes</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
C2.1	Minimize the use of spray textured finish on walls and columns where there is heavy human traffic.			
C2.2	Use durable and stain resistant floor finishes in heavy usage areas such as lifts lobbies and common corridors.			
C2.3	For vehicle drop-off areas, use oil-resistant surface or interlocking pavers instead of tiled surfaces to reduce permanent staining caused by vehicles and provision of bollards to separate the vehicle path and the human traffic.			
C2.4	Minimise the use of porous soft stone materials and glossy surfaces for heavy traffic areas.			
C2.5	Avoid combining metal elements with natural stones to reduce risk of staining associated with metal corrosion.			
C2.6	Provide metal or aluminium-finished door (with appropriate fire rating) instead of timber doors for rooms or areas which are exposed to weather or damp conditions.			
C2.7	<b>Ceiling</b> Use moisture resistant ceiling boards for wet areas and places where the ceiling is exposed to external weathering.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

C. Common Areas, Lift Lobbies and Corridors				
C3.	<b><u>Design and Detailing</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
C3.1	<b>Linkways and Drop-off Areas</b> Linkways and drop-off areas should provide sufficient roof gradient for water run-off and minimise the use of flat roofs.			
C3.2	The design of linkways and drop-off porches should adopt a width to height ratio of 1: 1 to minimise rainwater entry.			
C3.3	Provide concrete curb / collar at the base of metal columns to minimise contact with water and reduce corrosion.			
C3.4	Where high openings are provided, drop panels and weather proof louvers should be provided to reduce impact of weathering.			
C3.5	<b>Entrance</b> Provide sheltered area or canopy with a depth of at least 2 times of the entrance width for weather protection.  Entrance floor finishes should have proper screed to fall to facilitate water discharge.			
C3.6	Provide heavy-duty dust control floor mats at the main entrance to reduce entry of dirt and dust into buildings.  Floor mat should flush with the floor finishes to prevent tripping hazards.			
C3.7	<b>External Floor</b> Timber/ concrete floor slabs should be easily removed for inspection and maintenance. Consider the use of composite or synthetic wood for ease of maintenance.			
C3.8	All ground floor and flat surfaces exposed directly or indirectly to weather should be designed with falls and gradient to promote discharge of water to the external drains and scuppers.			
C3.9	Minimise corners and cavities which are inaccessible to cleaning machines.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

C. Common Areas, Lift Lobbies and Corridors				
C3.	<b><u>Design and Detailing</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
C3.10	<b>Ceiling</b> Minimise the use of monolithic ceiling design (joint-less without access) which are more costly and tedious to repair and maintain.  Use suspended modular ceiling panels that are easily demountable for replacement and maintenance.			
C3.11	Provide appropriate warning signs for maintenance crew to prevent stepping on ceiling board.			
C3.12	Where metal ceiling panels are used, they should be designed to prevent sagging and withstand wind loads.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

D. Parking Areas				
D1.	<u>Access</u>	Y / N / NA	Description of provision (Attach relevant drawings, references, etc where necessary)	If No or not applicable, please clarify
D1.1	Where there are services/ plant rooms within the car park, ensure that there are identified service route(s) with adequate headroom and sufficient working space for maintenance vehicle/ equipment. E.g. access space for refuse collection truck, safe and easy backing and turnaround.			
D1.2	Car park lots should not block the doors of M&E rooms.			
D1.3	Provide adequate water and power points at appropriate locations near the staircase (each point to cover a radius of max. 30m) to facilitate washing and cleaning.			
D2.	<u>Materials and Finishes</u>	Y / N / NA	Description of provision (Attach relevant drawings, references, etc where necessary)	If No or not applicable, please clarify
D2.1	The epoxy coating for the car park drive way and parking lot should be different. The epoxy coating for driveways will should be of heavier duty type as compared to the parking lot.			
D2.2	Use darker tone top coat finish for parking areas. The surface material of the driveway should allow easy removal of oil and water stain.			
D2.3	Signage should be in semi-gloss finish for easy maintenance.			
D2.4	All service areas/ car park should be painted in semi-gloss finish for easy maintenance.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

D. Parking Areas				
D3.	<b><u>Design and Detailing</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
D3.1	<b>Guards and Wheel Stoppers</b> Install crash guards to protect columns and walls near to car park lots and driveways.			
D3.2	Use wheel stopper and crash guard to protect exposed pipes and services near car park lots and driveways.			
D3.3	<b>Ramps</b> Provide groove lines at access ramps for better traction and to facilitate water discharge.			
D3.4	<b>Drainage</b> Car park should be designed with adequate surface water drainage via graded floors and scupper drains suitably located at the sides and perimeter of the car park or behind car park lots to prevent water ponding.  Provide adequate outlets to prevent water stagnation.			
D3.5	Scupper drain should be provided at the ends of wheel stoppers to allow for proper drainage.			
D3.6	Colour the wheel stopper/scupper drain to prevent tripping and spraining of ankles.			
D3.7	Cut-off drains of adequate depth should be located at all areas of the car park that are exposed to weathering including: a) the top and bottom of entry ramps.			
	b) open/partially exposed staircase (at intermediate landing and/or base of staircase).			
D3.8	Locate electrical services away from open voids that are subject to external weather.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

E. Other Building Areas and Considerations				
E1.	<b><u>Access</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
E1.1	<b>Washrooms</b> Hand soap dispensers should be fitted above instead of under the vanity top for ease of replacement/refill.			
E1.2	Washing dispensers (soap/hand towel)/hand dryer to be placed next to wash basin.			
E1.3	To facilitate floor cleaning, use wall-mounted wash basins and water cisterns.			
E1.4	Consider suspending the cubicle partitions from the top to facilitate floor cleaning and prevent the partition panels from constant contact with damp floor.			
E1.5	<b>Supporting Facilities for Cleaners</b> Provide at least one service lift to facilitate access of cleaning machines and equipment.			
E1.6	Provide a store room on each level for storage of daily use cleaning tools/equipment, chemicals and supplies.  Equip these store room with utilities supply for washing of cleaning tools and equipment, as well as splash proof socket points to facilitate the charging of cleaning tools/equipment.			
E1.7	Provide a designated room of sufficient size for cleaners to rest and store personal belongings.			
E1.8	Provide a central store room/area for storage of large cleaning machines, e.g. ride-on sweeper/scrubber, etc, which is easily accessible via service lift.  Equip these store room with utilities supply for washing of cleaning machines and dosing of chemical/detergent, as well as splash proof socket points to facilitate the charging of cleaning machines			
E1.9	<b>Service Ledge for External Air-conditioning Unit</b> Where maintenance access to the service ledge is via windows or wall apertures, the size of the openings should allow safe and easy access for maintenance personnel carrying tools, equipment and component parts. Maintenance activities should not require the dismantling of services and building elements.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

E. Other Building Areas and Considerations				
E1.	<u>Access</u>	Y / N / NA	Description of provision (Attach relevant drawings, references, etc where necessary)	If No or not applicable, please clarify
E1.10	Provide safety barriers or guardrails along the edges of the service ledge for the safety of maintenance personnel.			
E2.	<u>Materials and Finishes</u>	Y / N / NA	Description of provision (Attach relevant drawings, references, etc where necessary)	If No or not applicable, please clarify
E2.1	<b>Washrooms</b> Materials and finishing used within washrooms should be durable and easy to clean e.g. glazed ceramic or homogenous tiles, with anti-fungal/ mould resistance property.			
E2.2	Metal gratings should be of sufficient quality and durability to prevent rusting.			
E2.3	Use modular and smaller basin mirrors instead of full-span wall mirrors for ease of cleaning.			
E3.	<u>Detailing and Design</u>	Y / N / NA	Description of provision (Attach relevant drawings, references, etc where necessary)	If No or not applicable, please clarify
E3.1	<b>Washrooms</b> Provide wash basin bowls of appropriate size and depth to reduce splashing and wetting of floors.			
E3.2	Provide sufficient water points and socket points to facilitate the use of electrical cleaning equipment. Socket points should be provided with splash proof covers.			
E3.3	<b>Finishes - General</b> All materials used should be suitable for its application and performance. For example, stainless steel components should not rust, flooring materials should have anti-slip properties, construction components should be of adequate dimensions such that the works are not subject to warping or such defective effect, etc.			



## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

E. Other Building Areas and Considerations				
E3.	<b><u>Detailing and Design</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
E3.4	All finishing materials should have the correct thickness, gauge and dimensions so as to achieve good and consistent appearance and resistant to damage from mechanical impact.			
E3.5	<b>Finishes – Masonry, Stone and Tiles</b> Appropriate and compatible sealer/ impregnator should be provided to the sides, top and bottom surfaces of stone works.			
E3.6	Where masonry/ stone finishes are used near to planters, water features and other wet areas, the stone should be appropriately treated (e.g. sealant, admixture, water repellent) and detailed to prevent efflorescence.			
E3.7	Adhesive used for installing finishes should be compatibility tested with the finishes so as not to induce any damage or adverse effect on the appearance of finished works e.g. efflorescence, staining, marks, discolouration, surface pitting /flaking etc.			
E3.8	Ensure that sufficient expansion joints are provided to external and internal finishes to prevent cracking, warping, etc.			
E3.9	Provide adequate expansion joints along wall/ floor junctions to prevent popping of stone/ tiles.			
E3.10	<b>Finishes - Timber</b> All timber finishes should be kiln-dried and well-seasoned to prevent shrinkage, spits and deformation.  All timber finishes should be treated for fungi and insect attack, including anti-termite treatment, with an approved wood preservative.			
E3.11	<b>Public areas and Driveway</b> All public area should avoid using light colour tone stone and tiles. If stone finishes are used for driveway, the stones should be treated against staining by oil or grease.			
E3.12	<b>Drainage</b> All concealed drainage, rainwater down pipes should have access openings.			
E3.13	Avoid locating water pipes in the vicinity of electrical services and equipment. Provide double slab or stainless steel gutters where this cannot be avoided.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

E. Other Building Areas and Considerations				
E3.	<b><u>Detailing and Design</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
E3.14	Recessed floor lights should individually be provided with drainage to prevent water-logging.			
E3.15	<b>Bathroom (Residential)</b> Kerbs of at least 100mm height should be constructed at the base walls to act as barriers against lateral movement of water.			
E3.16	The waterproofing membrane should turn up to a minimum of 300mm to create a minimum tanking protection against migration of water to spaces adjacent or below the wet area.			
E3.17	At bath and shower areas, the waterproofing membrane should be applied at least 1800mm height and 1500mm width of the wall or the entire enclosure.			
E3.18	The wall or substrate immediately adjacent or behind a basin, sink or similar fixture must be applied with waterproofing membrane to a height of not less than 300mm above the fixture.			
E3.19	Avoid laying tiles directly bonded to the waterproofing membrane. As a protective measure against damaging the membrane during tiling, a layer of screed should be laid over the membrane after the curing of the membrane.			
E3.20	Shower cubicle door should be of water-resistant material.			
E3.21	Door frame/ architrave should be raised above the wet areas and terminate above the floor level e.g. at threshold level or bedroom/ living floor level.  Consider installing sub-frames above the screed level to reduce the chance of water ingress from the wet floor through the masonry works.			
E3.22	Inspection and access panel for long bath tub should not be obstructed by the water closet.			
E3.23	Provide ceiling access panels near floor traps, valves, water heater and air conditioning equipment to facilitate inspection/ maintenance of services.			
E3.24	<b>Pipes and penetration (Residential)</b> Avoid concealing drain pipes in the screed of dry areas such as living room and bedroom.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

E. Other Building Areas and Considerations				
E3.	<u>Detailing and Design</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings, references, etc where necessary)</i>	If No or not applicable, please clarify
E3.25	Minimise the number of penetrations through the slab and wall which affects the continuity of the waterproofing membrane and increases the probability of leakage.			
E3.26	Waterproofing membrane should be dressed up at pipe penetrations to the finished floor level and dressed down at least 50mm into the floor outlet. Waterproofing membrane should be applied at least 100mm horizontally around the pipe.			
E3.27	<b>Door Details</b> Where doors are subject to external weathering, incorporate details such as overhang at the top, and water-bar or threshold kerb at the bottom to minimise water ingress.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

2. M&E FACILITIES				
A. Plant, Machinery and Fixed Equipment				
A1.	<u>Access</u>	Y / N / NA	Description of provision (Attach relevant drawings, references, etc where necessary)	If No or not applicable, please clarify
A1.1	<b>General</b> Access to M&E equipment and facilities should be via common areas rather than occupied spaces.			
A1.2	Access provisions must be suitable and safe for maintenance personnel carrying tools, equipment and component parts.			
A1.3	Access openings to ducts, voids and roof areas should be properly secured against unauthorised entry. e.g. use of warning signs, card access, fencing to restrict and control access			
A1.4	Wherever possible and appropriate, M&E elements and services should be labelled and marked for easy identification.			
A1.5	<b>Safety</b> Access walkways and plant locations should be suitably illuminated, and provided with fire alarm sounders. A suitable alternative means of escape from these areas should be provided.			
A1.6	<b>Access Design</b> Good design and configuration <u>should facilitate access for maintenance consistent with the frequency and type of maintenance required</u> to be undertaken.  Plants and equipment such as cooling towers, chillers and AHUs that require <u>frequent access</u> (up to monthly) for inspection and maintenance should provide clear and immediate access such as permanent stairs and catwalks.  e.g. A minimum of 1.2m clear depth should be provided between beam soffit and false ceiling where chilled water AHU system is used. A minimum of 0.8m clear depth should be provided between beam soffit and false ceiling for VRV cassette system.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

A. Plant, Machinery and Fixed Equipment				
A1.	<b>Access</b>	Y / N / NA	Description of provision <i>(Attach relevant drawings, references, etc where necessary)</i>	If No or not applicable, please clarify
A1.7	Plants and equipment such as tank rooms and plumbing that require <u>occasional access</u> (up to 6-monthly intervals) for inspection and maintenance should provide semi-clear access through clearly marked hatches and panels.  For high level places, access could be via permanent guarded ladders, catwalks and hydraulic powered platforms. Such maintenance activities should not require the dismantling of services and building elements. For access more than 3m high, cage ladders shall be provided.			
A1.8	Maintenance activities that require <u>infrequent access</u> (up to yearly intervals) and repair or replacement (e.g. plant components, pipework, ductwork), access could be provided through demountable partitions and semi-permanent panels.  For high level places, temporary access equipment such as scaffolding, staging and ladders could be considered. Such maintenance activities should not result in extensive re-decoration works.			
A1.9	Where specialist or proprietary access equipment is required, due allowance should be made for this equipment to be provided and securely accommodated.			
A1.10	<b>Headroom</b> Provide minimum 2m clear headroom for M&E rooms and access walkways/ service corridors to facilitate easy access and maintenance.  Occasional obstructions that result in reduced headroom should be clearly identified and marked.			
A1.11	<b>Working Space</b> Adequate space for maintenance should be provided around all plant areas in accordance to the manufacturer's requirements. Otherwise, provide at least minimum 600mm clear space around the M&E equipment surface to walls for safe maintenance and replacement of components.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

<b>A. Plant, Machinery and Fixed Equipment</b>				
<b>A1.</b>	<b><u>Access</u></b>	<b>Y / N / NA</b>	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
A1.12	<p>All plant and maintainable components must be installed in accessible positions that will not expose maintenance staff to undue risk.</p> <p>e.g. for FCU, there should be access for motor, fan belt, filters, chilled water isolation valves, modulating valves</p>			
A1.13	<p>Minimise multi-tiering of services. If unavoidable, multi-tier cables distributions should be provided with maintenance/access space for installation of services cables.</p> <p>e.g. A minimum of 600mm access should be provided in the ceiling space to allow maintenance personnel to access each and every tier of service.</p>			
A1.14	<p>Ensure adequate consideration to the installation and removal of mechanical equipment e.g. space to operate lifting equipment.</p>			
A1.15	<p><b>High Ceilings</b></p> <p>The positioning of light fittings, ventilation equipment, fire alarms, etc should be considered in relation to future maintenance tasks. Consider the use of uplighters and suspended lighting systems for rooms with high ceilings e.g. atria, lecture theatres, reception or lobby areas and stairwells.</p>			
A1.16	<p><b>Maintenance Routes</b></p> <p>Maintenance routes for equipment delivery for future replacement should be planned and designed in advance.</p> <p>e.g. A minimum clear width of 1m should be provided for all roof spaces with equipment installations. The 1m access should provide access to each and every equipment.</p>			
A1.17	<p><b>Documentation</b></p> <p>Prepare as-built drawings showing equipment layout, routing of major M&amp;E services and concealed services routing for end-users' future reference and maintenance purposes.</p> <p>The as-built drawings should also include plumbing, sanitary, landscape and outdoor services where applicable.</p>			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

<b>A. Plant, Machinery and Fixed Equipment</b>				
<b>A2.</b>	<b><u>Materials and Fittings</u></b>	<b>Y / N / NA</b>	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
A2.1	Service rooms and corridors should use darker tone epoxy top coat for the floor finishes.			
A2.2	Provide metal chequer plate wall panels (up to 1.2m high) for heavy duty surface protection in areas subject to frequent, heavy wheeled traffic e.g. service corridors, loading areas.			
A2.3	Door kick plate should be provided for M&E rooms.			
A2.4	Weather-resistant material (e.g. aluminium doors) should be provided for all services doors exposed to weathering. Service doors shall also be of suitable fire-rating.			
A2.5	Lighting switches and socket outlets for M&E rooms should be durable and certified with Safety Mark. Use IP rated switches and socket outlets.			
<b>A3.</b>	<b><u>Design and Detailing</u></b>	<b>Y / N / NA</b>	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
A3.1	<p><b>Plant Rooms</b> M&amp;E plant rooms should be well-lit and sufficiently ventilated.</p> <p>To provide backup emergency lighting in event of power failure. Adequate lighting should be provided to facilitate night maintenance.</p> <p>Electrical systems and Emergency power should be designed for shutdown maintenance.</p>			
A3.2	<p><b>Ductworks/ pipes across floor</b> Avoid ductwork/ pipes crossing plant room floors so as to minimise trip hazards and damage due to maintenance personnel stepping on the duct work/ pipes.</p> <p>All pipe and duct works should have isolation valves and be properly identified to enable tracing for maintenance and troubleshooting.</p>			
A3.3	<p><b>Mechanical Installations</b> Provide appropriate labels and details of weights, lifting points to facilitate replacement and removal.</p>			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

A. Plant, Machinery and Fixed Equipment				
A3.	<b><u>Design and Detailing</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
A3.4	<b>Cooling towers</b> Adequate water points to be provided at the roof top in proximity to the cooling towers so as to facilitate top up and cleaning in the event of pump failure.			
A3.5	Provide adequate lighting to service access areas for the cooling towers.			
A3.6	<b>AHU</b> Provide suitable waterproofing for AHU rooms. Where possible, avoid locating wet areas above electrical rooms.			
A3.7	Provide kerb at AHU room, water tank room and electrical rooms to prevent water ingress/ egress.  Flood mitigation measures should be provided for plant rooms located at basements especially lower most basements.			
A3.8	<b>Utilities</b> Manhole covers should be suitable for their location and should not be placed within a structure.  Manholes should be located away from high traffic areas to minimise risk during maintenance.  Size of manhole / cable trench cover/ grill should be moveable by one person. The risks of manual handling should be addressed for both the internal and external areas of the building.			
A3.9	<b>Service Risers</b> Service risers should be designed with adequate width and depth to allow ease of maintenance. .e.g. Minimum width of 600mm shall be provided to access all parts of services and accessories.			
A3.10	Risers that require maintenance personnel to enter should be provided a load bearing floor.  Large fire stops should be avoided as fire stop material are non-load bearing. Instead the openings should be cast back.			
A3.11	Uninterruptible Power Supply (UPS) should have maintenance by-pass for ease of access and maintenance.			



## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

A.	Plant, Machinery and Fixed Equipment			
A3.	<u>Design and Detailing</u>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
A3.12	<b>Power Points</b> Power points (with lockable box enclosure) are to be located at 20m centres at common area to allow for servicing /maintenance. Design circuit points that can be disconnected where necessary.			
A3.13	<b>Building Management System (BMS)</b> Install appropriate computer-based BMS to control and monitor M&E equipment such as ventilation, lighting, power system, fire protection services, plumbing and security system.  To consider BMS systems which have analytic features such as monitoring, charting and trending reports for optimal maintenance planning.			
A3.14	<b>External Air-conditioning Units</b> Air-conditioning units should not be located in building recesses or enclosed areas to prevent the rejected heat from recirculating into the equipment intakes			
A3.15	Screenings or sound barriers for air-conditioning equipment should be designed in removable sections to facilitate easy access and maintenance.  All insect screens and filters at louvers shall be modular type for easy removal and replacement."			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

B. Security				
B1.	<b><u>Access and Control</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
B1.1	Central control console should be located in areas with 24-hours manning.			
B1.2	<p>Locate the fire command centre and security centre to oversee at least one main ingress/ egress point or critical area.</p> <p>The FCC should be designed such that the operator is able to view all alarm signage from his sitting position instead of having to turn round to see the alarm soundings.</p>			
B1.3	Use turnstile with proximity security access passes.			
B1.4	<p><b>Remote monitoring/ CCTV</b> Use CCTV surveillance technology with motion sensing alert to reduce security man count. Provide CCTV surveillance at all common and critical areas including but not limited to:</p> <ul style="list-style-type: none"> <li>• Car park</li> <li>• Lift lobbies</li> <li>• Entries into staircases</li> <li>• Main lobbies</li> <li>• All exits of the building/ car park</li> <li>• Last landing of escape staircase staircases</li> <li>• Loading/unloading area</li> <li>• Mailroom</li> <li>• Essential plants and equipment rooms</li> </ul>			
B1.5	<p><b>Visitors Management System</b> Use computer-based Visitors Management System to record the usage of the facilities by specific visitors and provide documentation of visitor's whereabouts.</p>			
B1.6	<p><b>Security Access to Critical Areas</b> Provision of programmable door access to all critical areas</p>			
B1.7	<p><b>Security Patrol Layout Route</b> Consider a proper routing plan and for security patrols to cover all critical areas. This should include designated movement corridors for vehicles and visitors in the vicinity</p>			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

<b>B. Security</b>				
<b>B2.</b>	<b><u>Materials and Fittings</u></b>	<b>Y / N / NA</b>	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
B2.1	Use weather proof material for outdoor mechanical and electrical devices such as cameras reader and break glass.			
<b>C. Piping and Exposed Services</b>				
<b>C1.</b>	<b><u>Access</u></b>	<b>Y / N / NA</b>	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
C1.1	<b>Sanitary and Rainwater downpipes</b> Avoid positioning and casting of sanitary pipes within wall structures. Sanitary waste stacks and downpipes should be easily accessible from common areas for maintenance. Floor trap shall not allowed within soffit of electrical rooms.			
C1.2	Avoid locating sanitary and waste pipe in high traffic volume areas e.g. above escalators and within high voids above common staircases.  There shall be no wet services directly above Data Centres, Server Rooms, Lan Rooms and all electrical rooms.			
C1.3	'Cleaning eye' for sanitary/waste piping system should be clear from obstruction and easily accessible for maintenance. Avoid placing 'cleaning eyes' at high levels.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

<b>C. Piping and Exposed Services</b>				
<b>C2.</b>	<b><u>Materials and Fittings</u></b>	<b>Y / N / NA</b>	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
C2.1	<b>Sanitary and Rainwater downpipes</b> Provide anti-corrosive material for pipings and installations (e.g. UPVC pipes).  Use materials that meet quality specification that resist staining and rusting (e.g. suitable grade of stainless steel).			
C2.2	<b>Signage</b> All external signage should be of weather proof type.			
<b>C3.</b>	<b><u>Design and Detailing</u></b>	<b>Y / N / NA</b>	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
C3.1	<b>Sanitary and Rainwater downpipes</b> Provide labelling and colour coding of piping and conduits in accordance to universal standards.  Provide directional signs and valve status on pipelines for ease of identification.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

3. LANDSCAPE AND OUTDOOR SPACES				
A. Planting and Turf				
A1.	<u>Access</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings, references, etc where necessary)</i>	If No or not applicable, please clarify
A1.1	Landscaped areas should have suitable access routes (e.g. pavers and pebble stones) of adequate width and construct to facilitate maintenance access of both workers and equipment.			
A1.2	<b>Green roof (Extensive)</b> Extensive green roofs are usually installed on non-accessible roof space. To minimise the risk of fall along unprotected roof edges, provide suitable edge protection (e.g. guardrail) or life line/ rail. The use of permanent edge protection/ safety barrier is preferred.			
A1.3	<b>Vertical Greenery</b> Vertical green wall should be designed with appropriate maintenance access.  <u>Access via the front of green wall</u> For green wall no more than 2m in height, allow maintenance access from the front via suitable elevated work platform (e.g. ladder stand platform, tower scaffold, etc.), pole pruner and/or a combination of these equipment.			
A1.4	For green wall more than 2m in height, provide a flat stable landing surface of adequate loading capacity in-front to allow safe and effective deployment of suitable elevated work platform and equipment.			
A1.5	For green wall more than 2m in height, provide a flat hard-paved foreground landing with adequate load bearing capacity for safe deployment of elevated work platform such as MEWPs (mobile elevated work platforms).			
A1.6	For green wall more than 4m in height, the foreground when turfed/vegetated, should be designed, dimensioned and installed with suitable supporting underlayers to provide adequate load bearing capacity for safe and effective deployment of MEWPs.			
A1.7	<u>Access via the rear of green wall</u> Provide permanent rear access and workspace (e.g. walkways and platforms) alongside the elevated greenery surfaces, allowing safe maintenance access to all parts of the green wall.  The rear access must be designed with edge protection to prevent worker falling out during maintenance. The maintenance walkway should have a minimum 600mm internal clearance width.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

A. Planting and Turf				
A1.	<b><u>Access</u></b>	Y / N / NA	Description of provision <i>(Attach relevant drawings, references, etc where necessary)</i>	If No or not applicable, please clarify
A1.8	Each maintenance walkway level should have direct access to the building's permanent stairs core, to ease worker movement during normal operations and emergencies.			
A1.9	The supporting system parts, such as the substrate, drainage, irrigation pipe lines, supporting sub-frames, grating, etc., need to be safely accessible for periodic inspection and maintenance.			
A1.10	All designated access/inspection points should be marked and identified.			
A1.11	<b>Sky courts</b> Sky courts are often sheltered and due to insufficient direct sunlight in sky courts, plants tend to grow etiolated over time.  For example, over time a tree canopy will grow with a lean towards the direction of daylight and become lopsided. The potential leaning of the tree canopy and branches beyond the edge of the building can challenge safe maintenance.			
A1.12	<b>Rooftop Plants</b> Safe and accessible work spaces around rooftop trees, palms and tall plants should be provided for maintenance access.			
A1.13	<b>Large fields (Schools)</b> Position large school fields near fire engine access way with proper width gates to facilitate access of machineries e.g. for turf mowing.			
A1.14	<b>Irrigation</b> Irrigation system should be accessible for servicing, maintenance and replacement. This includes subsurface irrigation.			
A1.15	Consider the use of automatic-irrigation system with rain sensor.  Ensure that the vegetation under sheltered areas remained irrigated even on rainy days.			
A1.16	Provide proper maintenance access such as footpath leading to the tap.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

A. Planting and Turf				
A2.	<b><u>Materials and Finishes</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
A2.1	<b>General</b> Consider the use of durable and stain-resistant materials (e.g. pebblewash, dark stone finishes for landscape areas).			
A2.2	<b>Plants selection</b> Select plant species in response to the expected environmental conditions e.g. plant appropriately for sunny/ shady areas, wet grounds, high traffic areas, etc.			
A2.3	For vegetation abutting water features and water bodies, avoid selecting plant species with excessive shedding of leaves.			
A2.4	Avoid using plant species with invasive roots system near basement walls.  Proper provision of roof barrier for such basement walls will help further safeguard the built structure's integrity.			
A2.5	Consider the use of synthetic turf for surface areas with high level of human traffic and activities (e.g. school fields), as well as those areas with difficulty of access (e.g. green islands within pool/ water feature).			
A2.6	Some plants species (e.g. species of bromeliad, alocasia) do trap water and will require regular monitoring for signs of mosquito breeding.  In areas where plant inspection is infrequent and/or cannot be effectively conducted, use of such plant species should be avoided.			
A2.7	Plants suspected of harbouring pests and disease pathogens should not be introduced into any new or existing planting areas, as eradication of pests and pathogens once established will be difficult.  Do not replace with the same plant species after root or wilt infections. If the same plant species is desired, all the contaminated soil should be replaced with clean soil before planting. Resistant varieties of the same species should be considered.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

A. Planting and Turf				
A2.	<b><u>Materials and Finishes</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
A2.8	<b>Test Plots</b> Prior to the skyrise greenery installation, set up plant test plots (mock-up surfaces, etc.) in consultation with skyrise greenery consultants to ascertain the horticulture performance of selected greenery systems and plant species.  The test plots will aid in identifying the suitable plant species as well as manage the building owners' and users' expectations of the relevant greenery systems and the subsequent maintenance.			
A2.9	<b>Irrigation system</b> Irrigation pipes and systems should be designed with adequate strength and durability.			
A3.	<b><u>Design and Detailing</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
A3.1	<b>Planters</b> Provide sufficient soil depth for the roots to grow. In general, groundcovers and shrubs require a soil depth of between 300mm and 500mm depth, while small and medium trees (mature heights of 8m to 10m) require a depth of between 1m to 1.5m.			
A3.2	<b>Drainage</b> Planters should be designed with effective surface drainage systems. Avoid large overall difference in invert level due to long run of surface drain to reach the discharge point.			
A3.3	Avoid un-edged planting areas. Enclose planting within planter boxes to reduce soil erosion and spillage onto common areas.			
A3.4	Landscape footpaths should be at least 50mm higher than the sump pit top level for effective drainage. The footpaths should be sloped to fall effectively to the nearest sump drain.			



## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

A. Planting and Turf				
A3.	<b><u>Design and Detailing</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
A3.5	<p>The roof slab should be sloped towards the drainage outlet with silt control system.</p> <p>Waterproofing membrane should be properly installed around the drain opening so that water drains off from the waterproofing membrane to the roof outlet. Plants should not be allowed to grow into guttering.</p>			
A3.6	Ensure rainwater runoff from roof of shelters and structures does not fall directly on planting (provide materials to reduce impact if necessary, e.g. gravel).			
A3.7	<p>Provide appropriate drainage outlets for vertical greenery installations so as to avoid unsightly puddles forming at the base of the green wall.</p> <p>Consider using drainage trays at the base of the installation or locating the green wall strategically at a natural drainage outlet.</p>			
A3.8	<p><b>Turf</b></p> <p>Turf requires regular mowing. Avoid planting turf right up to the base of the tree to minimise the risk of mechanical damage to the tree bark during turf mowing.</p>			
A3.9	<p><b>Roof Gardens</b></p> <p>Avoid planting shrubs beyond parapets so that workers do not have to lean over the parapet to reach the foliage during maintenance.</p>			
A3.10	Avoid placing tall plants/ trees near the peripheral edges of roof gardens to facilitate ease of access and maintenance of the foliage.			
A3.11	The finish level of the roof garden should be lower than adjoining indoor threshold to avoid rainwater ingress into indoor spaces.			
A3.12	In circumstances where the roof garden finish level is higher than the indoor finish level (e.g. retrofitted roof garden in an existing building), provide an up-stand or cut-off drain of adequate capacity to minimise rainwater ingress at the indoor threshold.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

A.	Planting and Turf			
A3.	<u>Design and Detailing</u>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
A3.13	<b>Anchorage for Tall Plants</b> Design considerations should be made to address risk of tall plants/trees being uprooted by strong wind and fall over the edge thus endangering people below.  Provide necessary anchorage to the roof structure to ensure the stability of trees.			
A3.14	<b>Waterproofing</b> Waterproofing system at landscaped areas and planters should be designed and made to be root resistant and/or alongside a suitable root barrier.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

<b>B. Water Features</b>				
<b>B1. <u>Access</u></b>		<b>Y / N / NA</b>	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
B1.1	Provide access routes of adequate width for the maintenance of water features and landscape elements.			
B1.2	Provide adequate and safe access to pump room, balancing tanks and other pump equipment which serves the water features.  Adequate lighting and ventilation should be provided for such spaces.			
<b>B2. <u>Materials and Finishes</u></b>		<b>Y / N / NA</b>	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
B2.1	Water features should be built of durable materials to withstand harsh weather conditions.			
B2.2	Use armoured cable for outdoor/ underground electric supply to water features. Underwater lights / devices should be of minimum IP 68 rating and be easily accessible for maintenance.			
<b>B3. <u>Design and Detailing</u></b>		<b>Y / N / NA</b>	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
B3.1	Where water features are designed with stone claddings, concealed brackets system is preferred for to avoid efflorescence and stains on grouting.			
B3.2	Avoid water features with rough edges and surfaces as they are prone to dirt accumulation and algae growth.			
B3.3	Backwash of filters should be provided; Coarse screens shall be provided to keep dry leaves and rubbish getting into pump. Precautions to be taken in design to avoid pump overheating due to pump suction being choked with debris.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

C. Other Landscaped Areas and Considerations				
C1.	<b><u>Access</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	If No or not applicable, please clarify
C1.1	<b>Lightings</b> Pole lightings should be safely accessible for lamp replacement either by means of mobile platform or scaffolding.			
C2.	<b><u>Materials and Finishes</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	If No or not applicable, please clarify
C2.1	<b>Timber Decking and Outdoor Furniture</b> Avoid extensive use of timber decking and timber benches for outdoor areas unless they are properly treated with water repellent.			
C2.2	Consider the use of composite wood for outdoor purposes.			
C2.3	<b>Driveway Paving</b> Minimise the use of rough stone paving for driveway as they are more prone to trapping dirt.			
C2.4	<b>Glass Parapets</b> Minimise extensive use of glass parapet walls at outdoor areas as weather stains on glass surfaces are more visible and require more frequent cleaning.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

C. Other Landscaped Areas and Considerations				
C3.	<b><u>Design and Detailing</u></b>	Y / N / NA	<b>Description of provision</b> <i>(Attach relevant drawings, references, etc where necessary)</i>	<b>If No or not applicable, please clarify</b>
C3.1	<b>Storm Water Drains</b> Provide anchor points or ladders to facilitate safety and access to drains for inspection and maintenance.			
C3.2	Drain gradient should be in the range of 1:300 to 1:200 to avoid water stagnation. The width: depth ratio of drain should not be less than 1:2 so as to facilitate ease of access.			
C3.3	Metal drain covers should be provided with hinges at intervals for ease of cleaning and maintenance.			
C3.4	<b>Outdoor Furniture</b> Permanent fixed outdoor furniture should be positioned on paved/hardscaped/decked surfaces to minimise the need for turf mowing beneath such permanent fixtures.			

## PART II: DESIGN FOR MAINTAINABILITY CHECKLIST

4. OTHER GOOD PRACTICES				
A.	Design Processes	Y / N / NA	Description of provision <i>(Attach relevant drawings, references, etc where necessary)</i>	If No or not applicable, please clarify
A1.	<b>Design Brief</b> Provide a clear design brief for maintenance performance and operations.			
A2.	<b>Participation of maintenance managers</b> Allow maintenance professionals to participate throughout the design and construction phases, including input to and review of design drawings and specifications.			
B.	<b>Building Information Modelling (BIM)</b>			
B1.	Use BIM to facilitate integration of relevant information on facility and asset management and better coordinated documentation for maintenance operations.			
C.	<b>Building Records</b>			
C1.	As-built records should be prepared, regularly updated and kept for record purposes. To facilitate proper management of maintenance, the records should provide information in sufficient details of building structures and services. All maintenance personnel should be made aware of such records.			
D.	<b>Innovation</b>			
D1.	<b>Self-cleansing Facade</b> Consider the use of cement or façade panels with self-cleansing properties (e.g. titanium dioxide coating) to reduce the frequency of façade cleaning.			
D2.	<b>Pneumatic Refuse Collection System (PRCS)</b> Consider the use of PRCS to improve productivity in refuse collection and disposal. PRCS can be fitted with sensors to monitor waste disposal patterns and the volume. The frequency of waste collection can be adjusted based on the volume of waste collected.			
D3.	<b>Smart Lighting/Sensor</b> Consider the use of lighting with sensors to help understand human traffic patterns and optimize/reduce the provision of lighting in low traffic areas. This can help to reduce energy and maintenance.			

### **Maintenance Strategy Report**

It is important to ensure that all parties understand future maintenance obligations before the building has been constructed. Notwithstanding the recommendations in the Design for Maintainability Checklist, designers are advised to prepare a Maintenance Strategy Report at the early stage of the design process to document their maintenance philosophy and operational assumptions.

### **Report Content**

In the Maintenance Strategy Report, designers should state their proposed maintenance 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
- particular materials/ equipment that have specific maintenance requirements
- proposed/ assumed maintenance methodology (equipment, methods, etc)
- maintenance activities that create specific risks and/or safety issues to maintenance personnel and building users

The report is not intended to be a voluminous paperwork. Information provided in the report should be clear, concise and in a format (e.g. design notes, drawings, tables, charts and written information - see example below) suitable for parties involved in constructing the building, operating the premises or carrying out maintenance works.

### **Consultation with Stakeholders**

In developing the Maintenance Strategy Report, designers should consult relevant stakeholders such as building managers, maintenance contractors and end-users who can advise on the safe, appropriate and cost-effective solutions. The consultative process will ensure that the proposed maintenance methodology is coherent with the future maintenance regime and that all stakeholders are made aware and amenable to the strategy.

### **Updates and Handing Over**

Updates should be made to the report to document the revisions made and eventual maintenance strategies adopted during the design development and construction phases.

Upon construction completion, the Maintenance Strategy Report should be handed to the building owner/ manager and used as a reference for contractors undertaking the maintenance work.

### Example

A sample of a proposed maintenance strategy for façade cleaning:

A. EXTERNAL AREAS					
	Building Area/ Element	Routine Maintenance	Major Maintenance	Solution	Comments
1	Tower Block - Façade curtain wall <ul style="list-style-type: none"> <li>Full height from ground level to roof</li> <li>All elevations including recesses and protrusions</li> </ul>	<ul style="list-style-type: none"> <li>Façade cleaning and inspection</li> </ul>	<ul style="list-style-type: none"> <li>Glass replacement</li> <li>Curtain wall repairs</li> <li>Façade lighting repairs</li> </ul>	<ul style="list-style-type: none"> <li>Routine maintenance</li> <li>Major maintenance</li> </ul>	<div>A</div> <ul style="list-style-type: none"> <li>Permanent suspended platform with monorail system to access all façade surfaces</li> <li>Integrated restraints in façade system</li> </ul>
2	Tower Block – External planters	<ul style="list-style-type: none"> <li>Routine inspection and cleaning</li> <li>Planting, pruning and fertilising</li> </ul>	<ul style="list-style-type: none"> <li>Plant/ soil replacement</li> <li>Drainage/ irrigation repairs</li> </ul>	<ul style="list-style-type: none"> <li>Routine maintenance</li> <li>Major maintenance</li> </ul>	<div>A</div> <ul style="list-style-type: none"> <li>Permanent suspended platform with monorail system to access all planters</li> <li>Integrated restraints in façade system</li> <li>Protection rail for hanging planters</li> </ul>
4	Tower Block - Entrance glass canopy <ul style="list-style-type: none"> <li>Top and underside including structural element</li> </ul>	<ul style="list-style-type: none"> <li>Cleaning</li> <li>Luminaire replacement</li> </ul>	<ul style="list-style-type: none"> <li>Glass replacement</li> <li>Building services repair (drainage, electrical, etc)</li> </ul>	<ul style="list-style-type: none"> <li>Routine maintenance</li> <li>Major maintenance</li> </ul>	<div>B</div> <ul style="list-style-type: none"> <li>Access using self-propelled access platform</li> <li>Accessible via paved fire engine access</li> <li>Fall arrest system provided on surface of canopy</li> </ul>
5	Covered walkways	<ul style="list-style-type: none"> <li>Cleaning</li> </ul>	<ul style="list-style-type: none"> <li>Cladding repairs</li> <li>Building services repair (drainage, electrical, etc)</li> </ul>	<ul style="list-style-type: none"> <li>Routine maintenance</li> <li>Major maintenance</li> </ul>	<div>C</div> <ul style="list-style-type: none"> <li>Accessible via ground level walkway</li> <li>Fall arrest system provided on surface of canopies</li> </ul>
B. INTERNAL AREAS					
	Building Area/ Element	Routine Maintenance	Major Maintenance	Solution	Comments
6	Atrium	<ul style="list-style-type: none"> <li>Glass cleaning</li> <li>Cleaning shading devices</li> <li>Luminaire replacement</li> </ul>	<ul style="list-style-type: none"> <li>Glass repair/ replacement</li> <li>Ceiling/ shading devices repair</li> <li>Building services repair</li> </ul>	<ul style="list-style-type: none"> <li>Routine maintenance</li> <li>Major maintenance</li> </ul>	<div>D</div> <ul style="list-style-type: none"> <li>Personnel lifting hoists for suspended platforms</li> </ul>
<p><u>Legend</u></p> <p>Solution A –Suspended platform with monorail system (see details in Annex 1)</p> <p>Solution B – Self-propelled access platform (see details in Annex 2)</p> <p>Solution C – Rope access (see details in Annex 3)</p> <p>Solution D – Personnel lifting hoists (see details in Annex 4)</p>					



### **REFERENCES**

- Centre for Urban Greenery & Ecology, 2015. Sustainable Landscape. Singapore
- Centre for Urban Greenery & Ecology, 2015. CS E11:2014 – Guidelines on Design for Safety of Skyrise Greenery. Singapore