



DESIGN FOR MAINTAINABILITY GUIDE: MUNICIPAL INFRASTRUCTURE

VERSION 1.0



Design for Maintainability Guide (Municipal infrastructure) Revision Log

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Design for Maintainability

Design for Maintainability (DfM) is the practice of integrating operations and maintenance experience in the planning and design process to achieve ease, safety, and economy of maintenance tasks throughout the life of an infrastructure. A lack of maintainability considerations at the onset of a municipal infrastructure project often creates avoidable maintenance demands which can lead to higher upkeep costs and manpower needs.

The four main principles of DfM are:

- 1) *Forecast maintenance* – Designers should understand the impact of their designs and the expected downstream maintenance works, thereby making necessary upstream design provisions.
- 2) *Access for maintenance* – Designers should give due considerations for all areas requiring access for inspection and maintenance, thereby making necessary design provisions.
- 3) *Minimise maintenance interventions* - Designers should give adequate attention to materials performance and detailing to minimise common and critical defects.
- 4) *Enable simple maintenance* – Designers should consciously consider standardisation and prefabricated components to facilitate easy inspection and productive maintenance.

Municipal Infrastructure

Municipal infrastructure are often small-scale, localized in nature, and built for use by public¹. Some examples include benches, covered linkways and footpaths in public areas.

In general, cleanliness and maintenance of infrastructure and greenery are among the concerns of our citizens based on municipal feedback received by public agencies. Downstream cleaning and maintenance operations can be kept efficient and effective by applying DfM to:

- 1) Discourage litter and accumulation of litter/detritus
- 2) Facilitate greater use of machines
- 3) Ensure safety and accessibility for cleaning and maintenance operations

Purpose

This guide provides a set of design recommendations and best practices to aid facilities' owners and designers in integrating maintainability concepts in the upstream design processes. This guide is also a useful reference for facilities managers, service buyers and providers, who are involved in the design decision process.

The DfM Guide is not meant to be definitive nor exhaustive. It does not address construction quality, maintenance operations and the economic aspects of design decisions. This guide is not intended to override or replace any legal rights, responsibilities or regulatory requirements.

¹ For similar infrastructure that are within the boundaries of building developments, please refer to the DfM Guides (Residential/Non-Residential).

Scope

The DfM Guide (Municipal Infrastructure) places emphasis on good planning and design details, as well as the use of appropriate materials and technology to facilitate efficient maintenance activities. The guide is structured according to the type of facility in the municipal infrastructure context. Each facility type is then considered in relation to three critical design factors.

The three critical design factors are:

1) Access for Maintenance

The ability and ease to access, inspect and maintain the facilities 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 machines, vehicles or personnel carrying tools, equipment and component parts.

Key considerations include:

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

2) Materials and Finishes

Beyond the aesthetics qualities, designers should consider the suitability of materials in terms of their ability to minimise 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:

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

3) 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:

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

The main facilities identified within the municipal infrastructure context are:

- 1) Connectivity Related Facilities
- 2) Street furniture, Equipment and Community Facilities
- 3) Greenery and Landscape
- 4) Drains

How to use this guide

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

Abbreviation	Denotes
Y	Yes – meet or exceed the design recommendation
N	No – does not meet the design recommendation
NA	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 and drawings could be attached to this guide as supporting documents.

As the design objectives differ from one facility to another, the recommendations of the guide may not comprehensively address the scope and specific maintenance requirements of a project. The designer should use this DfM Guide in conjunction with other applicable codes, regulations, and design guidelines.

Example of how the guide is used:

A1.	Access	Y / N / NA	Description of provision (Attach relevant drawings or references, etc. where necessary)	If No or Not Applicable, please explain
A1.6	Structure Adopt cantilevered shelter to maximise the walkway width in order to facilitate the movement of cleaning machines.	N	<ul style="list-style-type: none"> • <i>There are columns on both sides and the clear width of the walkway is maximised to 2.1m for manoeuvring of the cleaning machines.</i> • <i>See attached section drawing</i> 	
A2.	Materials and Finishes			
A2.1	Roofs Minimise the use of extensive transparent and translucent roofing materials that are prone to discolouration and weathering. Materials used for the roof should be able to withstand exposure to external weathering.	Y	<ul style="list-style-type: none"> • <i>Aluminium composite panels are used for the roof of the covered linkways</i> • <i>See attached detail drawings</i> 	
A2.2	Columns Use anti-stick paint on columns to discourage illegal advertisements.	Y	<ul style="list-style-type: none"> • <i>Anti-stick paint is used on columns of the covered linkways</i> 	
A2.3	Walkways Use durable and stain resistant floor finishes. Use materials of non-slip nature in areas which may be affected during wet weather.	Y	<ul style="list-style-type: none"> • <i>Homogenous/dark coloured tiles</i> 	

A. CONNECTIVITY RELATED FACILITIES

A1. ACCESS TO CONNECTIVITY RELATED FACILITIES

Objective:

Provide safe and easy access for:

- Inspection and maintenance of connectivity related facilities such as covered linkways/walkways and vehicular drop-off points

A1.	<u>Access</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc. where necessary)</i>	If No or Not Applicable, please explain
A1.1	Covered Linkway/Walkway, Bus shelters & Vehicular Drop off Point Ensure that design is modularised with demountable parts (primarily securing with bolts and nuts connection; on-site welds are discouraged) for ease of maintenance, where required, and to facilitate access for maintenance vehicle.			
A1.2	Provide anchor points for lifelines on the roof to ensure the safety of workers when performing maintenance works at height.			
A1.3	Provide minimum 2.4m headroom clearance to facilitate the use of cleaning machines like the All Terrain Litter Vacuum (ATLV)			
A1.4	Walkways should have a minimum width of 1.8m to facilitate the movement of cleaning machines, where allowable.			
A1.5	Pedestrian Overhead Bridge Provide inspection eyes at elbows/bends of water downpipes to facilitate cleaning and inspection.			
A1.6	Structure Adopt cantilevered shelter to maximise the walkway width in order to facilitate the movement of cleaning machines.			

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A1.	<u>Access</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc. where necessary)</i>	If No or Not Applicable, please explain
A1.7	Underpasses Ensure that sufficient space, access and lifting facilities/equipment are provided for ease of maintenance of pump rooms.			
A1.8	Illumination Ensure that public spaces are well-illuminated, especially at common blind spots like the side of Pedestrian Overhead Bridges. Consider using adequate LED light fittings that are more durable.			

PART II: DESIGN FOR MAINTAINABILITY GUIDE (MUNICIPAL INFRASTRUCTURE)

A2. CHOICE OF MATERIALS & FINISHES TO CONNECTIVITY RELATED FACILITIES

Objective:

Select appropriate materials and finishes:

- to minimise the frequency of cleaning, repair and replacement.
- that are resistant to normal wear and tear, stains, and exposure to weather elements.

A2.	<u>Materials and Finishes</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc where necessary)</i>	If No or Not Applicable, please explain
A2.1	<p>Roofs Minimise the use of extensive transparent and translucent roofing materials that are prone to discolouration and weathering.</p> <p>Materials used for the roof should be able to withstand exposure to external weathering.</p>			
A2.2	<p>Columns Use anti-stick paint on columns to discourage illegal advertisements.</p>			
A2.3	<p>Consider using columns of standardised designs with minimal embellishments for ease of maintenance and replacement.</p>			
A2.4	<p>Walkways Use durable and stain resistant floor finishes.</p> <p>Use materials of non-slip nature in areas which may be affected during wet weather.</p>			
A2.5	<p>Consider the use of granolithic finishes (e.g. aggregate finish) on walkways/ramps at crossing areas or at inclined walkways instead of tiles for better traction and maintainability.</p>			

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A2.	<u>Materials and Finishes</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc where necessary)</i>	If No or Not Applicable, please explain
A2.6	Tiled Walkways Use standardised tiles in terms of typical colour, size and type. Avoid using light colour tone tiles for walkway areas.			
A2.7	Avoid uneven surfaces due to tiles, aeration slabs and blocks that can trap silt and litters, hinder cleaning and/or trap water resulting in stagnant water/potential mosquito breeding habitat.			
A2.8	Provide open drain with hinged gratings at one side of the walkway to catch surface run-off instead of both sides.			
A2.9	Lamination and External Stickers Lamination and external stickers that are pasted onto surfaces should be robust and not peeled off easily (e.g. black and yellow sticker on bollards at bus stops).			
A2.10	Mechanical Equipment for Lifts/Escalators at Overhead Bridges/Underpasses Ensure that mechanical equipment closets are adequately IP rated and waterproofed to prevent ingress of water and possible short-circuit.			

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A3. DESIGN & DETAILING FOR CONNECTIVITY RELATED FACILITIES

Objective:

Provide proper and effective detailing to:

- Reduce the impact of weather and frequency of maintenance interventions
- Enable simple, efficient maintenance methods

A3.	<u>Design and Detailing</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc where necessary)</i>	If No or Not Applicable, please explain
A3.1	Pedestrian Overhead Bridge Drainage pipes on pedestrian bridges should not be less than 300mm in diameter for effective drainage.			
A3.2	Covered Linkway/Bus Shelter Provide flashing between linkways at different heights as well as linkways and bus shelters, so as to channel the rain water to the closest drain.			
A3.3	Walkways and overhead bridges should provide sufficient roof gradient (min 3° slope for flat roof) to facilitate self-cleaning and allow effective water run-off. Minimize the use of flat roofs.			
A3.4	Ensure rainwater runoff from roof of shelters and structures does not fall directly onto planted areas. Provide a threshold/buffer area with materials such as gravel to reduce the impact of runoff, where necessary.			
A3.5	Overhangs Avoid designing overhangs that protrude more than 50% laterally over planted areas as it will pose problems to the establishment of plants (e.g. lack of sunlight and rainfall).			
A3.6	Provide vertical panels/sufficient overlap between roofs of different heights for rain protection.			

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A3.	<u>Design and Detailing</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc where necessary)</i>	If No or Not Applicable, please explain
A3.9	<u>Columns</u> Provide concrete curb or collar at the base of metal columns to minimise contact with water and reduce corrosion.			
A3.10	<u>Underpasses</u> Ceiling and wall panels should be easily removable to facilitate structure inspection and maintenance.			
A3.11	Storage space should be catered for contractors to store equipment and spares for maintenance works.			
A3.12	Consider providing alternative access to ground level so that maintenance work on escalators/ lifts can be done with minimal disruption to commuters.			
A3.13	<u>Walkways</u> 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.			
A3.14	Walkways should be at least 50mm higher than the drain level for effective drainage.			
A3.15	Avoid using gratings on walkways as the surface coating are more prone to wear and tear due to prolonged impact. Minimise gratings on sloped walkways by leveraging on the natural terrain for effective water run-off.			
A3.16	Where gratings are used along walkways, they should be installed with sound dampers and anti-slip coating should be applied.			

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A3.	<u>Design and Detailing</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc where necessary)</i>	If No or Not Applicable, please explain
A3.17	For new walkways to be built next to existing trees, reinforcement or other measures (e.g. ensure sufficient space and use of appropriate porous materials) should be taken to minimise upheaving by the existing nearby trees.			
A3.18	To be constructed to slope towards the road to channel surface runoff to the roadside drains through DICs.			
A3.19	Minimise corners and cavities along walkways that are inaccessible to cleaning machines.			
A3.20	<p><u>Earth Pits</u></p> <p>Earth pits should not be installed along walkways as continuous impact on these from pedestrian traffic will result in increased maintenance.</p> <p>Earth pits should be covered with clean washed sand and permeable to prevent mosquito breeding and to allow excess water to pass through.</p>			
A3.21	<p><u>Mechanical Equipment for Lifts/Escalators at Overhead Bridges/Underpasses</u></p> <p>Ensure visual contact can be established between mechanical equipment (e.g. lifts) and control panels to facilitate maintenance work.</p>			
A3.22	Ensure sufficient lighting is catered for mechanical equipment and its related accessories (e.g. lift shaft, escalator pits, closets).			

B. STREET FURNITURE, EQUIPMENT AND COMMUNITY FACILITIES

B1. ACCESS TO STREET FURNITURE, EQUIPMENT AND COMMUNITY FACILITIES

Objective:

The design and configuration of street furniture, equipment and community facilities should allow easy access for maintenance.

B1.	<u>Access</u>	Y / N / NA	Description of provision <i>(Pls enclose relevant drawings or references, etc. where necessary)</i>	If No or Not Applicable, please explain
B1.1	<p><u>Lightings</u> Lamp posts should be safely and easily accessible for lamp replacement (e.g. surrounding areas should have firm surface to allow proper deployment of ladders)</p>			
B1.2	<p><u>Working Space</u> Provide at least 1m clear working space around all equipment (e.g. lamp posts, Over Ground (OG) boxes or letter boxes)</p>			
B1.3	<p><u>Pavilions</u> Pavilions should be provided with unobstructed access to facilitate the use of cleaning machines.</p>			

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B2. CHOICE OF MATERIALS & FINISHES FOR STREET FURNITURE, EQUIPMENT AND COMMUNITY FACILITIES

Objective:

Select appropriate materials and finishes:

- To minimise frequency of cleaning repair and replacement
- That are resistant to normal wear and tear, exposure to weather elements, vandalism etc
- That can be easily replaced and readily available in the market

B2.	<u>Materials and Finishes</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc where necessary)</i>	If No or Not Applicable, please explain
B2.1	<p><u>Open-air Surface Car Park</u> Use darker tone top coat finish for parking areas. The surface material of the driveway should allow easy removal of oil and water stain.</p>			
B2.2	<p><u>Timber Decking and Outdoor Furniture</u> Avoid the use of natural timber decking and timber benches for outdoor areas. Consider the use of composite wood that are more durable and easily replaced.</p>			
B2.3	<p><u>Pavilions, Shelters, etc</u> Avoid the use of transparent or translucent materials (e.g. polycarbonate) which is difficult to clean and maintain</p>			
B2.4	<p>Avoid using suspended/false ceilings for pavilions and linkways as they are more prone to damage and deterioration.</p>			
B2.5	<p><u>External Signage</u> Use weather-resistant materials and in semi-gloss finish for easy maintenance.</p>			
B2.6	<p>Consider mounting 2 or 3 signs on a single post or lamp post to reduce the number of posts to be maintained on the streetscape.</p>			

PART II: DESIGN FOR MAINTAINABILITY GUIDE (MUNICIPAL INFRASTRUCTURE)

B3. DESIGN & DETAILING OF STREET FURNITURE, EQUIPMENT AND COMMUNITY FACILITIES

Objective:

Provide proper and effective detailing to:

- Reduce the frequency of maintenance interventions and enable simple replacement of elements
- Deter littering and accumulation of litter through design

B3.	<u>Design and Detailing</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc where necessary)</i>	If No or Not Applicable, please explain
B3.1	<u>Open-air Surface Car Park</u> Avoid creating uneven surfaces due to tiles. Such surfaces could hinder cleaning, trap litters and water resulting in stagnant water.			
B3.2	Avoid angular, irregular kerb-side parking bays that limit the use of mechanical road sweepers and/or trap litters.			
B3.3	<u>Seating facilities</u> Avoid using benches or tables with small gaps in-between to deter littering and facilitate cleaning.			
B3.4	<u>Pavilions, shelters, etc</u> The roof profile should be sufficiently sloped to facilitate self-cleaning (min 3° slope for flat roof) and allow effective water run-off.			
B3.5	Provide access openings and cleaning eyes for shelters/pavilions with concealed drainage and/or rainwater downpipes.			
B3.6	Provide concrete curb or collar at the base of metal columns of pavilions/shelters to minimise contact with water and reduce corrosion.			

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B3.	<u>Design and Detailing</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc where necessary)</i>	If No or Not Applicable, please explain
B3.7	<u>Retaining Wall</u> Retaining walls adjacent to the public streets and walkways should be designed to full hydrostatic pressure to avoid having discharge pipe/weep holes.			
B3.8	<u>External Features (e.g. feature walls, estate signs)</u> Provide proper detailing (e.g. drip edges) to throw water off vertical surface to prevent staining and water penetration.			
B3.9	<u>Elevated Flat Surfaces (e.g. Over Ground (OG) boxes, ledges with height up to eye level etc.)</u> Provide a sloped top surface to facilitate self-cleansing and deter littering.			
B3.10	<u>OG/Control Box</u> OG/control boxes to be mounted on raised plinth (min 400mm) on ground level and topped up with clean-washed sand to prevent water ingress and stagnation as well as mosquito breeding in stagnated water.			
B3.11	<u>Outdoor Furniture</u> Place outdoor furniture on paved/hardscape/decked surfaces to minimise the need for turf mowing beneath such permanent fixtures.			

C. GREENERY AND LANDSCAPE

C1. ACCESS FOR GREENERY AND LANDSCAPE

Objective:

Provide safe and easy access for inspection and maintenance of plants.

C1.	<u>Access</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc. where necessary)</i>	If No or Not Applicable, please explain
C1.1	Landsaped areas should have suitable access routes (e.g. pavement, gravel, mulch paths etc) of adequate width to facilitate maintenance access for workers, equipment and materials.			

PART II: DESIGN FOR MAINTAINABILITY GUIDE (MUNICIPAL INFRASTRUCTURE)

C2. MATERIALS & FINISHES FOR GREENERY AND LANDSCAPE

Objective:

Select appropriate plants species and landscape materials to:

- Minimise the frequency of maintenance interventions such as pruning, cleaning and replacement
- Prevent trapping of water which are potential mosquito breeding habitats

C2.	<u>Materials and Finishes</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc. where necessary)</i>	If No or Not Applicable, please explain
C2.1	<u>General</u> Use durable and stain-resistant materials (e.g. pebblewash, stone finishes for landscape areas).			
C2.2	<u>Plants Selection</u> Select plant species in response to the expected environmental conditions (e.g. choose plants which are appropriate for sunny/shady areas, waterlogged grounds, high pedestrian footfall areas, elevated edges, sloped terrain, wind conditions etc).			
C2.3	Avoid planting fruit trees next to walkways to reduce maintenance due to falling fruits.			
C2.4	For vegetation abutting water features and water bodies, avoid selecting plant species with excessive shedding of leaves and blooms. Accumulated plant debris may end up choking the water systems.			
C2.5	Avoid plants species (e.g. species of bromeliad, alocasia) with thick axils that trap water and require regular monitoring for signs of mosquito breeding.			
C2.6	Plant ferns and hardy ground covers (instead of turf) on sloping grounds to prevent soil erosion and minimise the need for frequent maintenance.			

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C2.	<u>Materials and Finishes</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc. where necessary)</i>	If No or Not Applicable, please explain
C2.7	Avoid planting short thick shrubs along walkways as they trap litters and hinder cleaning.			
C2.8	Road-related elements (e.g. lamp-post, OG box, fire hydrant, directional signs) should not be obscured by plants to facilitate accessibility for maintenance. The access path and the buffer area around the elements should only be turfed and not planted with shrubs.			
C2.9	<p>Avoid planting trees near existing signs so as not to affect the visibility of such signs. Similarly, avoid placing directional signs near existing trees.</p> <p>Some examples of suitable small to medium-sized tree species for consideration are <i>Carallia brachiata</i> 'Honiara', <i>Garcinia cymosa</i> forma <i>pendula</i>, <i>Garden tubifera</i> etc.</p>			

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C3. DESIGN & DETAILING FOR GREENERY AND LANDSCAPE

Objective:

Provide proper and effective detailing for planted areas and landscape features to:

- Reduce the frequency of maintenance interventions
- Facilitate plant maintenance such as pruning and turf mowing

C3.	<u>Design and Detailing</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc. where necessary)</i>	If No or Not Applicable, please explain
C3.1	<p><u>Un-edged Planting Areas</u></p> <p>Planting soil should preferably be 50mm lower than unedged planters flushed in level to adjacent hardscape finishes, so as to reduce soil erosion and spillage onto common and public areas. These are applicable to areas such as true-ground planting, sunken e-deck, roof gardens.</p>			
C3.2	<p><u>Planting on Ground</u></p> <p>Planting should be carried out directly on ground wherever possible to reduce the use of planter boxes. If located on true ground, the planter boxes should be built on true ground and not on concrete surface to ensure proper drainage.</p>			
C3.3	<p><u>Planting of Appropriate Trees beside Independent Footpath Slab</u></p> <p>For tree planting next to footpath slab without box drain below, small to medium-sized trees and appropriate clearance distance should be considered to prevent any potential conflict between tree roots and footpath infrastructure.</p>			
C3.4	<p><u>Turfs</u></p> <p>Avoid planting turf right up to the base of trees. This makes turf mowing difficult and may risk damaging the tree bark.</p>			

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C3.	<u>Design and Detailing</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc. where necessary)</i>	If No or Not Applicable, please explain
C3.5	Grass surface should be at the same level or slightly higher than adjacent hard surfaces (e.g. pavements) to ease turf mowing.			
C3.6	<p><u>Trellis & Planting Frames</u></p> <p>For trellis systems and planting frames that form part of covered linkways, both the trellis and frame should be designed to be easily detachable without affecting the main infra-structures, and with a tensioning system that allows easy tightening when necessary. A 300mm gap between the frame and parent structure is to be kept to facilitate parent structure inspection. The trellis and frame are to be durable and weather-resistant.</p>			
C3.7	<p><u>Tree Wells & Gratings</u></p> <p>Tree well gratings are to be durable and weather-resistant with effective drainage to avoid waterlogging issues.</p> <p>Gratings should be designed to prevent litter from entering the tree well, facilitate inspection access (i.e. designed with moveable modular segments, etc.) to the tree well and cater for installation of tree support system and future tree growth in girth.</p>			

D. DRAINS

D1. ACCESS TO DRAINS

Objective:

Provide safe and easy access for inspection and maintenance of drains.

D1.	<u>Access</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc. where necessary)</i>	If No or Not Applicable, please explain
D1.1	<p>Provide metal drain covers with hinges at intervals for ease of cleaning and maintenance.</p> <p>Hinged gratings of open drains should be easy to lift and be locked in position for cleaning and safety.</p>			
D1.2	<p>Where possible, covered drains should not be hidden within turf areas or concealed by vegetation to ensure that they are visible for cleaning or inspection.</p>			
D1.3	<p>Provide anchor points or aluminium rungs to facilitate safe access to storm-water drains for inspection and maintenance.</p>			
D1.4	<p>Avoid locating drain covers and Drop-Inlet Chamber (DIC) gratings within or at the entry points of pedestrian crossings to minimise obstruction to inspection and maintenance works. Instead, use appropriate grading to channel storm-water to the nearest DIC for drainage.</p>			

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D2. MATERIALS & FINISHES FOR DRAINS

Objective:

Select materials and finishes that are durable and resistant to corrosion.

D2.	<u>Materials and Finishes</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc. where necessary)</i>	If No or Not Applicable, please explain
D2.1	<u>Railings along Drains</u> Use corrosion resistant material such as aluminium or stainless steel.			

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D3. DESIGN & DETAILING FOR DRAINS

Objective:

Design of drains should facilitate self-cleansing and ease of maintenance.

D3.	<u>Design and Detailing</u>	Y / N / NA	Description of provision <i>(Attach relevant drawings or references, etc. where necessary)</i>	If No or Not Applicable, please explain
D3.1	The velocity of flow in a drain should not be lower than 1m/s for self-cleansing action to take place.			
D3.2	Avoid covering cut-off drains that are located adjacent to the slope for efficient drainage of storm-water runoff.			
D3.3	Vertical gratings should be installed at outlet discharge point(s) of the internal drain located within development site.			
D3.4	<p>Manholes</p> <p>Manhole should be located away from high traffic areas, where feasible, to minimise risk during maintenance</p> <p>The manhole/cable trench cover/grill should be moveable by one person. The risks of manual handling should be addressed.</p>			

References

Source	References
BCA	<p>Approved Document</p> <p>BIM Guide for Asset Information Delivery</p> <p>Code on Accessibility in the Built Environment</p> <p>Façade Access Design Guide</p>
Enterprise Singapore	SS485 Specification for Slip resistance classification of pedestrian surface materials
LTA	<p>Architectural Design Criteria</p> <p>Architectural Materials and Workmanship Specifications</p> <p>Civil Design Criteria</p> <p>Code of Practice on Street Works Proposals Relating to Development Works</p> <p>Materials and Workmanship Specifications</p> <p>Standard Details of Road Elements</p>
MOM	WSH (Design for Safety) Regulations
NEA	Code of Practice on Environmental Health (2017 edition)
NParks	<p>Guidelines on Greenery Provision and Tree Conservation for Developments</p> <p>Landscape Design Guidelines for Productive Maintenance</p>
NParks (CUGE)	Sustainable Landscape
PUB	<p>Code of Practice on Sewerage and Sanitary Works</p> <p>Code of Practice on Surface Water Drainage</p>

Acknowledgements

The Inter-Agency Team on facilitating cleaning and landscape maintenance of public infrastructure (IAT2) formed by the Municipal Services Steering Committee (MSSC) consists of representatives from the following organisations:

- Municipal Services Office (Co-Chair)
- National Environment Agency (Co-Chair)
- Housing & Development Board
- Ministry of Education
- Land Transport Authority
- National Parks Board
- People's Association
- PUB, Singapore's National Water Agency
- Singapore Land Authority
- Urban Redevelopment Authority

The Working Group appointed by the Inter-Agency Team (IAT2) to assist in the preparation of this Design for Maintainability Guide for Municipal Infrastructure comprises:

- National Environment Agency (Chair)
- Building and Construction Authority
- Housing & Development Board
- Land Transport Authority
- Municipal Services Office
- National Parks Board
- PUB, Singapore's National Water Agency