



**INFRASTRUCTURE DESIGN & ENGINEERING GROUP
KEY DOCUMENT**

**INFRASTRUCTURE DESIGN CRITERIA
VOLUME B – RAIL INFRASTRUCTURE
PART 1 – MRT STATION**

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CONTROLLED DOCUMENT

**INFRASTRUCTURE DESIGN CRITERIA
 VOLUME B – RAIL INFRASTRUCTURE
 PART 1 – MRT STATION**

Table of Contents

Chapter	Name	Total no. of Pages*
1	Architecture Requirements	56
2	Electrical and Mechanical Requirements	17
3	Operation and Maintenance Requirements	10
4	Security Requirements - Not Available	-
5	Sustainability Requirements	8
6	Safety Requirements	12

List of Annexes

Annex	Name	Reference Chapter	Total no. of Pages*
A	Numbering and Naming Levels	1	2
B	Not Available		
C	Not Available		
D	Tactile and Braille Layout Guidelines	1	54
E	Glazing Criteria	1	16
F	Design Criteria for Advertising and Retail Provisions in Mass Rapid Transit (MRT) Stations	1 & 2	15
G	Not Available		
H	Not Available		
I	Not Available		
J	Not Available		
K	Not Available		
M	Legal Register for Safety, Health & Environmental Management	6	16

*Not inclusive of cover page

CHAPTER 1 – ARCHITECTURE REQUIREMENTS

Table of Contents

1.1	Vision, Objectives and Principles	3
1.1.1	General	3
1.1.2	Design Vision	3
1.1.3	Design Objectives	3
1.1.4	Design Principles	4
1.2	External Public Areas	6
1.2.1	Urbanscape	6
1.2.2	Connectivity & Accessibility	8
1.3	Internal Public Areas	11
1.3.1	Station Entrances	11
1.3.2	Station Concourse	13
1.3.3	Station Platform	14
1.4	Pedestrian Circulation	15
1.4.1	General	15
1.4.2	Horizontal Circulation	16
1.4.3	Vertical Circulation	17
1.4.4	Pedestrian Flow Analysis and Level of Service	20
1.5	Design for Fire Safety	26
1.5.1	General	26
1.5.2	Means of Escape	26
1.6	Station Amenities	27
1.6.1	General	27
1.6.2	Commuter Care Facilities	28
1.6.3	Platform seats	29
1.6.4	Universal Design Features	33
1.6.5	Non-Fare Revenue Services	34
1.6.6	Ticketing and Commuter Services	35
1.6.7	Civic Spaces & Provisions	36
1.7	Interfacing Requirements	37
1.7.1	General	37
1.7.2	Statutory Submission & Requirements	37
1.7.3	Interface with Existing Transport Facilities	38
1.7.4	Interface with Development	38

1.8	Material & Finishes	41
1.8.1	General	41
1.8.2	Quality of Material & Finishes	42
1.8.3	Particular Requirements	42
1.9	Components & Standardisation	44
1.9.1	General	44
1.9.2	Standardised Systems	46
1.9.3	Standard Components	52
1.9.4	Line Wide Identity	52
1.10	Artwork	53
1.10.1	General	53
1.11	Weather Protection & Environmental Design	54
1.11.1	General	54
1.11.2	Flood Protection	55
1.11.3	Rain	55
1.11.4	Sun	56
1.11.5	Wind & Cross Ventilation	56

1.1 Vision, Objectives and Principles

1.1.1 General

1.1.1.1 This chapter of the Infrastructure Design Criteria (IDC) establishes the design criteria for the Mass Rapid Transit (MRT) and Light Rail Transit (LRT) stations in Singapore. It is applicable to new projects, enhancement projects, as well as major renewal works or maintenance works.

1.1.1.2 The document provides guidance to station designers in creating adequate, legible, and timeless station spaces by setting out the intention and purpose of a space or element in the station.

1.1.2 Design Vision

1.1.2.1 Stations that are designed to be safe, secure, pleasant, efficient, well connected and provide an inclusive environment for all commuters.

1.1.2.2 Stations that are conducive for our station staff to work in and are cost effective and easy to operate and maintain.

1.1.3 Design Objectives

1.1.3.1 The Authority has determined a set of key design principles which designers shall adopt to meet the design objectives. Other design objectives may be specified to suit the needs of specific station where applicable.

1.1.3.2 The design shall be appropriate to the local context, simple and clear in planning.

1.1.3.3 Designers shall consider the scale and character of the surrounding when designing aboveground rail transit infrastructures and seek to minimise the impact of these structure on the surroundings.

1.1.3.4 User-centric design shall be adopted for stations to improve its functionality, including but not limited to the following:

- a. response to the site context;
- b. integration with neighbouring developments;
- c. creating universal accessibility and family friendly facilities;
- d. legible and intuitive station environment;
- e. a well-defined architectural identity, through visual balance, art works, etc.

1.1.3.5 Designers shall consider providing unique design features to promote ease of identification, particularly at station platforms and at entrances along a transit line.

1.1.4 Design Principles

1.1.4.1 Clarity & Simplicity

- a. Station design and space planning shall be clear, direct and intuitive. The key considerations include but are not limited to:
 - i. recognition of pathway, destination and function;
 - ii. maximised views between levels, particularly at locations leading to vertical circulation elements;
 - iii. direct and unobstructed pedestrian routes;
 - iv. intuitive wayfinding; and
 - v. maximise sightlines across public areas.
- b. The station design shall be considered holistically where all engineering / building services / security / rail operating system elements, etc., follow a consistent identity and complement / blend with the architectural finish. The station environment shall be clutter free and legible with a balance on the amount of information, retail, security provisions, etc.

1.1.4.2 Design for Buildability

- a. Designers are required to explore innovative solutions for the most appropriate building systems and products to meet statutory requirements according to BCA's prevailing Code of Practice on Buildability.
- b. Repetitive grids and dimensions, connection details, standardisation and prefabricated components shall be identified and used to achieve faster construction and improvements in quality.
- c. Where feasible, building components that can be designed for manufacturing off-site and assembled onsite (DfMA) are to be identified.
- d. Designers shall also work with the project team and contractors to plan for access points and delivery routes to facilitate delivery of prefabricated components.

1.1.4.3 Design for Maintainability

- a. Station shall be designed to facilitate ease of maintenance. All parts of the stations, including components provided by the System-Wide Contractors, are to be easily accessible and removable (where required) for cleaning and maintenance.

- b. Refer to IDC Volume B Part 1 Chapter 3, Operation & Maintenance Requirements for more details.

1.1.4.4 Design for Sustainability

- a. Design for sustainability needs to be addressed holistically to reduce environmental impacts and improve life cycle quality of the overall project, by:
 - i. adopting climatically contextual design;
 - ii. ensuring clear planning for accessibility, mobility and connectivity;
 - iii. identifying opportunities to harness solar and wind resources;
 - iv. maximising energy efficiency;
 - v. using environmentally friendly (SGLS/SGBC certified) materials and finishes where possible; and
 - vi. embracing smart building technologies, etc.
- b. Refer to IDC Volume B Part 1 Chapter 5, Sustainability Requirements for more details.

1.1.4.5 Design for Safety

- a. Designers shall ensure that the proposed design is safe-to-build and safe-to-use, validated through necessary safety review workshops with relevant stakeholders during all key stages of design.
- b. Refer to IDC Volume B Part 1 Chapter 6, Safety Requirements, for more details.

1.1.4.6 Design with Context and for Future Expansion

- a. While planning a new station near developed sites, the existing character of the affected developments shall be maintained, especially for developments with heritage and/or cultural values.
- b. A Heritage Report shall be submitted for acceptance by the Authority during the Concept Design stage. It shall contain, but not limited to the following:
 - i. Identification of significant elements of the affected development, such as iconic architecture, spatial quality, locally significant details such as colour schemes, etc.
 - ii. Proposal for integration of the identified heritage / cultural elements into the proposed design.
 - iii. Drawings, images and illustrations to convey the above.

- c. Stations shall be planned with flexibility to accommodate increase in passenger numbers, connectivity and integration with future developments.

1.1.4.7 Cost Effectiveness

- a. Demonstrate that the design of stations and choice of materials have taken into consideration the lifecycle costs, are fit for the intended purpose and provide value for money throughout the lifespan of the stations.
- b. Station box size and footprint shall be optimized to ensure economy of construction and land take.

1.1.4.8 User-Centric Design

- a. A User-centric approach shall be adopted to promote better experience for operators and commuters, with greater emphasis on catering to the needs of different users such as:
 - i. the elderly;
 - ii. persons with visible / invisible disability;
 - iii. young children;
 - iv. pregnant women, etc.

1.1.4.9 Wayfinding and Signage

- a. Create intuitive wayfinding through a judicious use of materials, colours, daylight, patterns and other creative devices or solutions.
- b. Placement of signage shall be incorporated and coordinated with the architectural finishes as one of the wayfinding tools.
- c. Quality and quantity of information provided, and location of signage shall be optimised and shall be compliant with the standards set out in the Authority's Transit Signage Manual (TSM).

1.2 External Public Areas

1.2.1 Urbanscape

1.2.1.1 Shared Spaces

- a. Stations shall be designed to integrate with the surrounding context so that they are well connected with the neighbouring sites and developments while creating opportunities for future developments to integrate with the stations.

- b. The entrances shall seamlessly integrate with the public realm that lies in between, or form part of the adjacent developments, such as commercial building, shopping malls, civic centre, etc.

1.2.1.2 Aboveground Structures

- a. The aboveground structures for underground stations consist of:
 - i. entrances,
 - ii. escape shafts and ventilation shafts, and
 - iii. mechanical / technical spaces.
- b. For elevated stations, the aboveground structures include:
 - i. the station boxes,
 - ii. entrances,
 - iii. connecting overhead bridges,
 - iv. MRT structures and viaducts, and
 - v. mechanical / technical spaces.
- c. The design of these aboveground structures shall respect the local context and topography of the site in terms of its layout, scale, proportions and palette of materials.
- d. The design of these aboveground structures shall comply with all statutory and technical requirements and undertake all mitigation measures as required by the National Environment Agency (NEA).
- e. Where aboveground structures such as entrances or the ventilation shafts are integrated with external developments, the designer shall ensure:
 - i. compliance with the minimum area and technical requirements of aboveground structures,
 - ii. compliance with statutory requirements such as fire safety and flood protection etc.,
 - iii. station identity is maintained,
 - iv. station entrance remains prominent and easily identifiable, and
 - v. no cross contamination between fresh air intake and exhaust between station and building ventilation openings.
- f. Any elements of the station shall not present a negative environmental impact to its surrounding, adjacent public spaces or buildings, and shall comply with relevant authorities' requirements such as urban landscape, direction of exhaust air / smoke / heat generated by M&E equipment, etc.
- g. Refer to Section 1.9 of this chapter for provision of 'External Components'.

- h. Refer to IDC Volume B Part 1 Chapter 2, E&M Requirements and IDC Volume B Part 1 Annex B, MRT Station Room Datasheet for more detailed requirements for these structures.

1.2.1.3 Landscape and Streetscape

- a. All planting used shall be low maintenance and hardy unless specifically agreed otherwise with the stakeholders, including landowner and the maintenance party.
- b. The landscaping proposal shall reflect the maintenance boundaries of the respective parties for acceptance by all concerned.
- c. Application of fencing, paving, irrigation, planting and turfing shall be in accordance with the requirements of Chapter 12 of the Civil Design Criteria (CDC).
- d. Designers shall consider the planting and security guidelines in accordance with IDC Volume B Part 1 Chapter 4.

1.2.2 Connectivity & Accessibility

1.2.2.1 General

- a. Station entrances shall be connected to footpaths, bicycle paths, bus stops, pick-up-drop-off bays (PUDO) and taxi stand to enhance connectivity and accessibility throughout the local area.
- b. As a guide, commuter facilities could be laid out in the following order from the station entrances:
 - i. bus facilities,
 - ii. PUDO,
 - iii. taxi stand.
- c. Sufficient queuing space shall be allocated. Road safety, bus and taxi operations shall be considered to confirm the layout in consultation with the Authority.
- d. Coordinate design language for entrance roofs, shelters, canopies and covered linkways with due consideration for their coherence and interfacing.
- e. Potential links to interfacing developments to be identified early and proposed for Authority's consideration and acceptance.
- f. For design of commuter facilities refer to IDC Volume C Chapter 1, Commuter Infrastructure and for design of bicycle infrastructure refer to IDC Volume C Chapter 2, Active Mobility Requirements.

1.2.2.2 Pedestrian Access

- a. Pedestrian access to stations shall be direct, seamless.
- b. Ensure that the pedestrian access:
 - i. are accessible to people with varying abilities from entrances in accordance with the prevailing Code on Accessibility in the Built Environment as a minimum;
 - ii. are connected to other modes of transport; and
 - iii. are designed in accordance with the principles outlined in IDC Volume B Part 1 Chapter 4, Security Requirements.
- c. All accessible routes into the station shall, where possible, be part of the main thoroughfare.
- d. The accessible routes and facilities shall be highly visible, and easily accessible from key amenities and services in the station.
- e. At street level, pedestrian movement shall be prioritised around the station entrances through measures such as traffic calming, level surfacing, etc.
- f. Designers shall provide covered linkway from all station entrances to the first commuter facility as part of the accessible route.
- g. Where required, covered linkways to adjoining developments of significant importance or scale shall be identified and proposed for Authority's consideration. The proposal shall include a detailed study on catchment areas, listing the pros and cons, feasibility and other supporting analysis.
- h. Lifts shall be co-located with the entrance escalators or be located in direct line of sight from the entrance escalator where co-location is not feasible.
- i. In addition, designers shall provide tactile ground surface indicator leading to and within the stations according to the IDC Volume B Part 1 Annex D, Guide to the Layout of the Tactile Guidance System in MRT and LRT Stations.
- j. Doors astride the tactile route shall be automatic or held open during operating hours, without obstructing the tactile route. Where automatic doors are provided, sliding doors are preferred over swing doors.
- k. The minimum number of steps that shall be provided to address any change in level shall be three (3). Where the change in level is less than 450mm, designers shall provide sloped access at a gentle gradient of $\geq 1:25$ across the maximum available footprint.

1.2.2.3 Access to Bus Stop

- a. Each station entrance shall be connected to the nearest bus stop with a covered linkway. The proposed location shall be finalised in consultation with the Authority.

1.2.2.4 Access to Taxi Stand and PUDO

- a. Taxi stand and PUDO should be positioned in a linear arrangement with bus stops to avoid the stacked / double bay design.
- b. The shelter for the taxi stand and PUDO shall be connected with the station entrance canopy structure for a seamless weatherproof connection.

1.2.2.5 Cyclist Access

- a. Bicycle parking area to be provided near the station entrances in accordance with IDC Volume C Chapter 2, Active Mobility Requirements and IDC Volume B Part 1 Chapter 4, Security Requirements.
- b. The following shall be considered for the design of bicycle parking area:
 - i. not within road reserve unless Authority's acceptance is obtained;
 - ii. not be sheltered or have any roof structure over it; or
 - iii. where integrated with the station entrance structure and has an incidental roof / shelter, all firefighting provisions in accordance with SCDF requirements shall be provided.
- c. Plan and design dedicated bicycle path in accordance with IDC Volume C Chapter 2, Active Mobility Requirements.

1.2.2.6 Service Access

- a. Access shall be provided for maintenance / delivery and / or refuse collection vehicles.
- b. At least one maintenance parking bay shall be provided for each station.
- c. The maintenance parking bay should preferably be located adjacent to the entrance where a lift provides convenient access to the refuse store at the concourse and/or retail level (where applicable).
- d. The maintenance parking bay should be accessed directly from a primary access road and located within the maintenance boundary of the station. The access and the bay shall be located away from

commuter facilities such as bus stop, taxi stand, PUDO, bicycle parking, etc.

- e. The maintenance parking bay shall also be located adjacent to the bin centre / bin point and with access to the following where applicable:
 - i. letter boxes;
 - ii. tunnel seepage holding tank; and
 - iii. grease pit.
- f. Discharge outlets for the seepage tanks and grease pit should be within 15m of the maintenance parking bay. Alternative access provisions may be proposed to mitigate site constraint, subject to the Authority's agreement.
- g. For stations with large commercial facility (>115 sqm), a dedicated loading / unloading bay shall be provided adjacent to the entrance, in addition to the above maintenance parking bay.
- h. For aboveground stations, unsecured service access shall never be positioned below MRT structure.
- i. Location of all maintenance parking bay and loading / unloading bay shall be included in the 'O&M Handbook' and 'Development Interface Report' (DIR).

1.3 Internal Public Areas

1.3.1 Station Entrances

1.3.1.1 Station entrances serve as a gateway to the station, provide shelter to commuters entering or leaving the station and act as a point of security to the station after operating hours.

1.3.1.2 Location of Station Entrances:

- a. typically located at street level, adjacent to major pedestrian routes;
- b. shall be prominently located so that they are visible from all directions;
- c. shall be orientated to maintain visibility from key focal points on the urban pedestrian network around the station; and
- d. shall be located to provide direct and smooth access into the station while maximizing connectivity.

1.3.1.3 Station entrances shall be easily identifiable, sympathetic to the surrounding context and integrated with adjacent developments where possible.

- 1.3.1.4 As a principle, adequate entrances shall be provided to maximise connectivity and accessibility to the station.
- 1.3.1.5 Entrance location shall be considered based on the following criteria:
- a. within 400m catchment radius of the station;
 - b. proximity to high density catchment area such as residential / commercial developments and key activity centres, etc.;
 - c. proximity to transport nodes such as ITHs, bus interchanges, LRT stations to facilitate intermodal transfers, preferably with a direct connection where possible;
 - d. provide safe and barrier-free accessible road crossing to schools, public hospitals, public amenities, places of interest;
 - e. where station access is cut off by site impediments such as canals, railroads, etc.;
 - f. where entrance would form part of a pedestrian network; and
 - g. construction feasibility.
- 1.3.1.6 Walkability Network Analysis shall be performed to determine the practical walking distance a person can reach in 10 mins, based on the pedestrian network starting from the proposed entrance, and to assess if the entrance locations meet the required catchment of the station.
- 1.3.1.7 Station entrance shall be weather protected to eliminate rainwater ingress by means of canopies, eaves, innovative façade design, etc. while maximising light and cross ventilation. Refer to Section 1.11 Weather Protection' for more detailed requirements on weather protection.
- 1.3.1.8 Where stations entrances are required to be integrated with other at-grade structures such as the supply / exhaust shafts and tunnel ventilation shafts etc., their façade shall be designed in compliance with guidelines and regulations from other agencies such as URA, MHA, NEA, PUB, etc., while minimizing land take.
- 1.3.1.9 Maintain minimum 4.5m clearance measured from the last step of a station entrance to any physical obstruction on street level, such as railing, accessible ramp, retaining wall, etc. or drop in levels of more than 400mm.
- 1.3.1.10 Where the entrance connects to a footpath, maintain minimum 1.5m clearance measured from the last step of the station entrance to the footpath while the 3m wide footpath provides for the pedestrian cross flows.

- 1.3.1.11 The design and placement of exits and at-grade structures shall ensure that commuters exiting the station as well as users along the footpath, cycling path or shared path are clearly visible to one another.
- 1.3.1.12 When developing the entrance design, where possible exit steps shall not face the cycling or shared path directly. Where necessary, there shall also be sufficient buffer/ protection provided to protect commuters exiting the station from on-coming bicycle traffic along the footpath, cycling path or shared path
- 1.3.1.13 Station entrance design shall be compliant with the requirements set out in IDC Volume B Part 1 Annex B, MRT Station Room Datasheet.
- 1.3.1.14 Where entrances are integrated with commuter facilities refer to IDC Volume C Chapter 1, Commuter Infrastructure and IDC Volume C Chapter 2, Active Mobility Requirements for more details.
- 1.3.2 Station Concourse
- 1.3.2.1 Station concourse consists of ticketed and non-ticketed public areas located adjacent to each other.
- 1.3.2.2 Clarity and legibility of space is of utmost importance in the design of the concourse such that it provides:
- a. a safe and secure environment to commuters;
 - b. direct access to station services;
 - c. easy access to station amenities without deviating from their primary routeway;
 - d. direct line of sight to vertical circulation elements leading to platform for effective wayfinding and orientation; and
 - e. direct access to commuter services and information systems.
- 1.3.2.3 The design of the concourse area shall be compliant with the requirements set out in the IDC Volume B Part 1 Annex B, MRT Station Room Datasheet.
- 1.3.2.4 Linkways shall be provided in both the ticketed and non-ticketed concourse for commuters to move between different MRT lines within an interchange station.
- 1.3.2.5 All linkways leading from ticketed or non-ticketed concourse to entrances or interchange platforms shall be prominently located and be easily identifiable.

1.3.2.6 Non-Ticketed Concourse

- a. It is a zone where commuters pause and plan their journey.
- b. It houses many user touch points comprising:
 - i. ticketing kiosks including GTMs, TUM, TUK and ASK, etc.;
 - ii. information signage like locality map, system map, exit directory and directional sign to entrances, etc.;
 - iii. the Passenger Service Centre (PSC) and Automated Fare Collection (AFC) gates; and
 - iv. public amenities such as toilets and retail.
- c. A non-ticketed link shall be provided to connect both ends of a station.
- d. The spatial capacity of this zone shall be appropriately designed for queuing, waiting, circulating, etc. in compliance to the requirements set out in IDC Volume B Part 1 Annex B, MRT Station Room Datasheet.

1.3.2.7 Ticketed Concourse

- a. The ticketed concourse is a controlled area within the station. Staff and BOH areas should preferably be directly accessed from this zone.
- b. The ticketed and non-ticketed concourses shall be separated by the gate lines and half-height glass barrier to ensure visual connection between the ticketed and non-ticketed areas, thereby providing assurance of continuity to the commuters in their journey.
- c. The layout of this zone shall encourage direct passenger movement and have sufficient clearance while avoiding undesired crowding spaces or obstructions.
- d. The design shall be compliant with the requirements set out in IDC Volume B Part 1 Annex B, MRT Station Room Datasheet.

1.3.3 Station Platform

1.3.3.1 Platforms are the first / last destination points on a commuter journey after they alight or before they board a train. The spatial capacity of platforms shall have sufficient clearance to provide for:

- a. Waiting areas for trains (standing or sitting);
- b. queuing space to get off / on staircases, escalators and lifts; and
- c. reading space for wayfinding signs.

- 1.3.3.2 The design shall be compliant with the requirements set out in IDC Volume B Part 1 Annex B, MRT Station Room Datasheet.
- 1.3.3.3 The layout and position of escalators and public staircases on the platform shall be:
 - a. direct and evenly spaced along the platform length; and
 - b. planned to eliminate cross flows and reduce long walking distance from the train doors.
- 1.3.3.4 Information signages on the platform shall be strategically located such that:
 - a. they shall not obstruct the pedestrian flow;
 - b. information on train routes, arrival time, etc. is visible immediately upon arrival on the platform.
- 1.3.3.5 Platform seats shall be provided at various locations on the platform to enhance user experience. For guidelines on placement of platform seats, refer to Section 1.6 of IDC Volume B Part 1.
- 1.3.3.6 Island platforms are preferred over side platforms because they allow more efficient utilisation of vertical circulation, convenient cross-platform transfer where required, and greater capacity to accommodate surges in traffic flow, especially during service interruptions.
- 1.4 **Pedestrian Circulation**
 - 1.4.1 General
 - 1.4.1.1 Pedestrian circulation within the station shall be simple and direct for safety, efficiency, accessibility and intuitive wayfinding.
 - 1.4.1.2 When planning circulation within the station, designers shall consider commuters with varying abilities, regular and non-regular commuters and non-traveling users, etc.
 - 1.4.1.3 The circulation paths shall avoid any area of conflict such as crossflows, obstructions of flows or blind corner in the planning of the station and entrance public areas.
 - 1.4.1.4 Obstruction of pedestrian flows and/or blind corner need to be avoided where commuters exiting from the station meets with pedestrian flow, walkways and/or cycling networks in the surrounding areas.
 - 1.4.1.5 For numbering and naming of various levels in a station, refer to IDC Volume B Part 1 Annex A, Numbering and Naming Levels.

1.4.2 Horizontal Circulation

1.4.2.1 Horizontal circulation in station shall have visible, direct and clear route ways. These includes routes connecting entry / exit points, subway links, ticketed and non-ticketed concourses, and circulation spaces between lifts, escalators, etc.

1.4.2.2 Planning considerations:

- a. Plan for spatial capacity of circulation routes / zones to meet the estimated future demand.
- b. Provide sufficient space for queueing near amenities such as security screening station, PSC, ticketing kiosks, etc. Queueing zones near fare gates and escalators shall be planned to maintain the required Level of Service (LOS) as stipulated in Section 1.4.3 of this chapter.
- c. Design direct routes with minimum change in direction and travel distances. Where change in direction is unavoidable, the change shall not be abrupt, and a clear line of sight shall be maintained.
- d. Ensure pedestrian routes are free from obstruction, avoid dead ends and corners not covered by Video Surveillance System (VSS).
- e. Minimize cross flows at decision, entry and exit points. Eliminate all potential conflicts where cross flows are unavoidable.
- f. Decision points such as cross junctions, entry and exit points, start and end of linkways leading to different lines shall be provided with directional and information signs at appropriate location.

1.4.2.3 Moving Walks (Travellers)

- a. Moving walks can be considered on a case-by-case basis in the design for ticketed connections in interchange stations where the distance between the center of platforms of the two stations 200m or more, AND where the passenger transfer volume is projected to reach 10,000 persons per hour or more.
- b. When underground linkway of the station serves as a key public transport connector to public hospitals, moving walks can be considered on a case-by-case basis.
- c. Where provision of moving walk is assessed to be required in the design, the linkway should have a straight stretch of at least 75m to accommodate installation of the moving walk, and the provision shall be for a pair of moving walks covering at least two thirds the length of the straight stretch.

- d. Where a station meets the above criteria and moving walks are incorporated in the design, structural provisions for fitting-out the moving walks shall be included. However, for the installation of moving walks, assessment shall be carried out separately to verify the need of the provision based on future demand.

1.4.3 Vertical Circulation

1.4.3.1 General

- a. Vertical circulation shall be provided to meet the Pedestrian Level of service (LOS) as stated under section 1.4.4 as well as the requirements of the prevailing Code of Practice for Fire Precautions in Rapid Transit Systems (CPFPRTS)
- b. Designers shall also demonstrate that the provision of vertical circulation satisfies the time required to clear the public areas to avoid congestion in the station.
- c. The area occupied by vertical circulation elements, as well as queues at circulation elements, shall not impinge on the circulation spaces and pedestrian flow during peak conditions.
- d. Vertical circulation elements shall be located to provide balanced distribution and facilitate convenient exiting of commuters from the station.
- e. Where station is integrated into other developments, vertical circulation requirements of the station shall be calculated independently from those provided in the integrated developments.

1.4.3.2 Staircases & Ramps

- a. Tread width and riser heights for all staircases across the station shall be standardised and designed to facilitate prefabrication to meet the minimum percentage of precast staircases required under the prevailing Code of Practice for Buildability.
 - i. Tread widths should be kept to:
 - 300mm for staircases in public areas, and
 - 275mm for exit staircases and staircases in staff areas.
 - ii. Riser heights should generally be kept to 175mm, except:
 - for public areas where lift access is not provided (e.g. entrance stairs from street level etc.) for the ambulant disabled commuters, riser height of 150mm shall be adopted; or
 - for public areas (e.g. platform to concourse or concourse to street level, etc.) where lift access is provided, an alternative standardised riser height between 150mm – 175mm can be adopted.

- b. All public staircases connecting concourse and platform shall be highly visible.
- c. Minimum clear mid-landing and landing depth for all staircases and ramps shall be 1500mm where possible.
- d. Minimum clear width for all ramps provided as barrier-free access into a station shall be 1800mm to facilitate bi-directional movement by 2 wheelchairs.
- e. Where space permits, ramps within stations should have a gradient that is gentler than 1:12 to facilitate independent movement by persons with disability (PwDs).

1.4.3.3 Escalators

- a. Escalators shall be the primary means of moving commuters vertically within a station and any other transport facility integrated with the station.
- b. Typically, one pair of escalators shall be provided at each entrance.
- c. For other functional levels within a station that are accessed by public, minimum 2 escalators shall be provided.
- d. Any additional number of escalators needed between the various levels shall be evaluated based on demand forecast and demonstrated using the pedestrian modelling simulations, such that the desired LOS as described in Section 1.4.3 of this chapter is met.
- e. Considerations:
 - i. All escalators shall be in direct line of sight from the main circulation routes.
 - ii. Where possible, escalators shall be grouped together with staircase so that it can supplement the discharge capacity should any escalator becomes unavailable.
 - iii. Where the platform width does not allow provision of a staircase with the pair of escalators, the staircase must be located in direct line of sight from the escalators to offer an alternative route to the commuters.
 - iv. At transfer between transport facilities, escalators in accordance with the projected passenger transfer figures shall be provided between different platform and concourse levels at locations that are in direct line of sight from the transfer link.
 - v. Maintain a minimum clear distance of 6.0m between end of the comb plate of the escalator and any obstruction.
- f. For maintenance access requirements above escalators, refer to IDC Volume B Part 1 Chapter 3.

1.4.3.4 Lifts

- a. To provide an inclusive transport system, lifts shall be located near the main commuter route, without requiring commuters on wheelchair or with baby strollers, etc. to follow a circuitous route.
- b. Lift car design shall comply with prevailing Code on Accessibility in the Built Environment.
- c. Designers shall consider the visual impact of a lift shaft within the station.
- d. Lifts shall be provided with waiting areas that do not conflict with commuter movements and are adequate for commuters on wheelchair, with baby strollers or carrying bulky items, etc.
- e. Lift quantum and preferred configuration:
 - i. A minimum of one (1) lift shall be provided at every entrance that is designated to be part of the barrier free route.
 - ii. Two (2) lifts shall be provided from each platform and between each publicly accessible level.
 - iii. For stations with a change in level along interchange links, lifts shall be provided with each serving the ticketed and non-ticketed interchange links. For interchange station with only ticketed link, two (2) lifts within the ticketed link can be considered on a case-by-case basis.
 - iv. Lifts shall preferably be positioned together with a common waiting area. Refer to IDC Volume B Part 1 Annex D for preferred lift layout and setting out plan.
 - v. Lift entrances shall face the public area and be clearly visible from the primary circulation routes for easy access.
 - vi. Lifts shall be located at well-lit locations. Accessible route to lifts shall be in accordance with Clause 1.4.1 and 1.4.2 in this Chapter.
- f. Where a lift is required as the main facility for vertical circulation in addition to providing barrier free access, additional capacity shall be accommodated by increasing the lift car size, providing multiple lifts and independent entry and exit at each level.
- g. The lift door jamb shall not be set-in from the adjoining wall finishes such that lift buttons can be easily accessed by commuters on wheelchair. This shall be coordinated across all facilities that are covered under the same lift supply contract.
- h. There shall be no open joints on glass panels for glass lift shafts up to 2500mm height from the finished floor level.

- i. The use of glass for lift shafts at the entrances on street level shall be minimised and sufficiently shaded from sunlight to reduce the heat trapped within the lift shaft.

1.4.4 Pedestrian Flow Analysis and Level of Service

1.4.4.1 General

- a. Pedestrian flow analysis shall be carried out for each station using locally calibrated and recognised software as approved by the Authority.
- b. The scope simulation shall include all public areas of the station and any interface with external any interfacing station or bus interchange (both existing and under construction) and make allowance for all trains and pedestrian movements within the completed interchange and surrounding developments.
- c. The scope for the pedestrian flow study shall include the peak morning and peak evening hours for both opening year and the ultimate design year.
- d. Through the pedestrian modelling simulation and analysis, facilities that can be implemented in stages in anticipation for both opening year and the ultimate design year shall be determined and proposed for consideration.
- e. Pedestrian Flow Analysis (or Congestion modelling) shall be submitted for the concept, preliminary, prefinal and final design stages.
- f. The report shall summarise all assumptions, parameters, design details, volume-capacity ratios. Results of the simulation together with inferences for authority's acceptance. Recommendations for retrofitting measures within the existing infrastructure shall be included in the report.
- g. The report shall reflect the latest design and shall be updated for and any design changes or revision in the projected passenger figures with detailed analysis of the impact to Pedestrian LOS.
- h. Supplementary detailed analysis of critical areas and elements shall be undertaken as and when required.
- i. Pedestrian Flow Analysis shall be used to improve commuter's movement and station capacity, particularly at decision points, vertical circulation elements, fare gates, etc.
- j. Changes made during all design stages shall be reflected in the analysis, demonstrating how these can achieve the desired LOS.

- k. The Pedestrian Flow Analysis shall be used to:
 - i. assess the passenger flow performance of the station during peak hours;
 - ii. ensure that the unavailability of any escalator in the peak scenario does not prevent the station from meeting its passenger flow requirements;
 - iii. identify areas of congestion and crossflows (i.e. bottlenecks and chokepoints);
 - iv. identify the need for any crowd control security screening measures; and
 - v. justify design changes that optimize the design while retaining necessary allowance for future expansion.

1.4.4.2 Simulation Software and Output Format

- a. Prior to modelling, the software to be used shall be submitted for Authority's acceptance based on the following:
 - i. having an extensive portfolio covering public transport infrastructure projects;
 - ii. demonstrating the ability to perform simulation for multiple user types and ability to set different parameters for different user type;
 - iii. details on input / output data, including but not limited to:
 - localised calibration,
 - use of social model forces in the interaction between passengers,
 - ability to model different passenger groups,
 - extensive interfaces with transport modes,
 - user behaviour and adaptive route choice,
 - measurement of LOS,
 - quality of the graphic outputs and format, and
 - output results in video format, which displays the real time and LOS measures together in one frame.
- b. The report shall be supplemented with submission of videos of the am and pm peak hour simulations in appropriate format. The scope of the videos shall cover but not limited to:
 - i. complete 3D simulation model showing all services, obstructions,
 - ii. dynamic LOS maps including graphic indications of the real time LOS and a time counter.
 - iii. video showing one escalator down, and its impact on the other nearby escalators, staircase, faregates and circulation areas at the platform and the concourse.

- c. The Pedestrian Modelling report shall include snap shots of the critical moments from the pedestrian model in 3D.

1.4.4.3 Modelling Parameters and Assumptions

a. Passenger Forecast

- i. All planning figures for both opening year and the ultimate year shall be used as baseline design assumption for pedestrian flow modelling for AM and PM peak hours.
- ii. For simulations and calculation within the peak hour being simulated, a peak within the peak shall be included by introducing a 1.3 weighting factor to the passenger figures (pp/min) to the central 20 minutes of the simulated hour.
- iii. The passenger figures for the first and the last 20 minutes of the simulated peak hour shall be accordingly reduced, so that the overall hourly passenger figures remain unchanged.

b. Calibration

- i. As a base it can be assumed that 100% of the flow will be accommodated using escalators.
- ii. For scenarios where staircase and lifts are to be modelled, the following distribution range can be considered, unless otherwise discussed and agreed with the Authority.

Mode of Vertical Circulation	Between Concourse & Platform	Between Concourse & Street
Escalator	≥ 80%	≥ 90%
Staircase	≤20%	10%

c. Station Modelling

- i. All public areas in both new and interfacing existing stations up until external developments or external covered linkways;
- ii. All lifts, escalators, public staircases, fare gates, ticket machines and platform screen doors individually identified and their influence in terms of queuing and pedestrian flows accurately depicted;
- iii. Obstructions like columns, benches, any floor mounted elements like signage etc.;
- iv. The influence of elements shall be considered where no pedestrian movement is assumed:

Obstructions Type	Extent of “No pedestrian Zone”
Walls, columns, balustrades, railings etc	0.3 m
Shopfront along the access routes	1 m
Waiting and queuing areas for ticket machines or other vending machines	1.8 m

- v. The model must accurately simulate commuter behaviour, including but not limited to the following:
 - Waiting / queuing zones adjacent to and parallel to the PSD;
 - Progressive build-up of commuters around PSD in queues perpendicular to the platform edge;
 - Distribution of commuters along the platform edge outside of the waiting / queuing zone;
 - Desire to spread out along the platform to find a less crowded train that may offer a higher probability of finding a seat.
- d. Catchment Area Studies
 - i. The designer shall undertake catchment area studies in order to predict the split of usage across various entry / exit for a station. They shall base their studies on context, latest land use and density plans issued by URA or any other information provided by the Authority and summarise their assumptions in the pedestrian modelling report for the acceptance of the Authority.
- e. Practical Capacities for escalators, lifts, staircase and fare gates

- i. The practical capacity per lift, escalator, staircase and fare gate shall be based on the following:

Practical Capacity/ Unit	Ppl/hr (max)
Escalator (1m wide & 0.75m/s speed)	7,200
Staircase (1m wide)	3,600
Staircase (2m wide)	<7,200
Fare gate	2,400
Lift	500

- ii. For stations connecting to international transport network (such as airport, etc.) and healthcare facilities (such a hospitals etc.) a 20% deduction in the practical capacity as a factor of safety shall be included for preliminary planning purposes.
- iii. Designers shall undertake benchmark studies or commuter profile assessment to justify using a different practical capacity for various elements, that is more appropriate for the context of the station better. The proposed capacities shall never exceed the values given in the above table and must be submitted for Authority's acceptance.

1.4.4.4 Simulation Types

- a. Base Case Simulation
 - i. The base simulation for both AM & PM peak hour, shall assume 100% of commuters are using escalators with no overflow onto the staircase during an operational peak-within-a-peak scenario.
 - ii. Staircases are to be accounted for in a second simulation test to determine/validate the required public staircase width in an

operational peak-within-a-peak scenario, where the overflow from the optimised number of escalators is supplemented by the use of the public staircase.

b. Stress Testing

- i. The escalator with the highest demand in the base case simulations for both the am and pm peak hours shall be assigned as unavailable and unable to be used as a staircase. In these simulations the remaining escalators shall be reassigned to cater for the upward flow, with downward flow supplemented by the adjoining staircases. It shall be demonstrated that there is no major queuing that causes disruption to flow, and that the platform can still be cleared before the next headway.
- ii. It can be assumed under such scenarios that the remaining escalators shall be reassigned to cater for the upward flow and passengers will use any adjoining staircases for any unaccounted downward flow.
- iii. If the vertical downward flow across the peak hour required by staircase is more than 50% of an escalator capacity and the level difference is more than 6m vertical height this shall be highlighted to the Authority for advice whether any additional redundancy using escalators is required.

1.4.4.5 Simulation Results

a. Level of service

- i. The Fruin Level of Service (LOS), assessment criteria as defined below shall be used to assess congestion within the station:

Level of Service (LOS)	Density (m ² /pedestrian)		
	Circulation Spaces	Staircases / Escalators	Waiting Areas
A	> 3.3	> 1.9	> 1.2
B	2.3 - 3.3	1.4 – 1.9	0.9 – 1.2
C	1.4 – 2.3	0.9 – 1.4	0.7 – 0.9
D	0.9 – 1.4	0.7 – 0.9	0.3 – 0.7
E	0.5 – 0.9	0.4 – 0.7	0.2 – 0.3
F	< 0.5	< 0.4	< 0.2

Figure 1: LOS ranges are as defined by J.J. Fruin (Pedestrian Planning and Design)

- ii. The Maximum allowable LOS for different areas of the station are as summarised below:

Area	Allowable LOS	LOS Representation Category
Corridors with bi-directional flow, linking two transport facilities - no commercial facilities, - no transit facilities (e.g. ticket machines) - no information signage on either side - no waiting or meeting areas - no decision points	LOS D*	Circulation spaces
Escalators and Staircase Queues (loading & discharging zone)	LOS D*	Waiting Areas
Fare Gates Queues	LOS D*	Waiting Areas
Lift Lobby / Waiting Zone	LOS D*	Waiting Areas
All other public areas	LOS C	Circulation spaces
Staircase	LOS C LOS D (under stress testing)	Staircases
* Time spent at LOS D may only be periodic across the peak period and shall be presented for the acceptance of the Authority		

b. Platform Clearance time

- i. For every scenario simulated, time taken to clear the platform shall be reported in the Pedestrian Flow Analysis Report. Designers shall demonstrate that platforms can be cleared within one train headway time / prior to the arrival of the next train during normal peak operations and during stress test scenarios.

c. Maximum Queueing Time

- i. For every scenario simulated, where queueing is observed at escalator landings at both platform and concourse levels or at faregates, the maximum continuous time spent at LOS D or above shall be reported; and ensure that the queue will not impede station pedestrian flow and operations.

- d. Areas of conflict
 - i. Any area of conflict such as crossflows, obstructions of flows or blind corners that are picked up in the simulations shall be highlighted. Where required measures shall be proposed and tested such as offsetting cross flows to enable better merging, setting back elements to avoid obstructions, chamfering turns, providing better segregation of flows and providing more queuing space.
- e. Future Escalators and Faregates Provisions
 - i. Future expansion of escalators and fare gates shall be included in the design to cater for future projected changes in demand.
 - ii. Facilities for the delivery, installation of such elements shall be allowed for and highlighted in the design

1.4.4.6 Stages of Analysis / Simulation

- a. Simulations and analysis shall be carried out and presented at each stage of design.
- b. If the result of any of the simulations is unable to meet the acceptance criteria or is of concern, design changes or additional provisions shall be proposed by the designer for the Authority's acceptance.
- c. The dynamic model shall be used to substantiate the design development and changes in a reiterative manner, until such time that, all the LOS criteria and other conditions of acceptance are met for the require simulations.
- d. If there is a change of the design beyond final acceptance which may affect the commuter flow, the design is to be retested by simulating the updated dynamic model.
- e. All results are to be presented to the Authority and formalized in an updated Pedestrian Flow Analysis Report for acceptance.

1.5 Design for Fire Safety

1.5.1 General

1.5.1.1 The Station shall be designed according to the requirements of the Code of Practice for Fire Precautions in Rapid Transit Systems (CPFPRTS).

1.5.2 Means of Escape

1.5.2.1 Station means of escape shall be provided to evacuate the Platform Occupant Load (POL) as calculated in accordance with CPFPRTS.

1.5.2.2 Escape routes shall be along main circulation routes where possible, rather than via designated exit staircases.

1.5.2.3 The design shall include at least two independent escape routes from the public non-ticketed area at concourse level.

1.5.2.4 Where stations are integrated with other developments, they shall be provided with dedicated escape provisions within the station in compliance with CPFPTS.

1.6 Station Amenities

1.6.1 General

1.6.1.1 Features and facilities that enhance commuter comfort, convenience and experience are considered station amenities.

1.6.1.2 Station amenities can be grouped under the following categories:

- a. Commuter Care Facilities;
- b. Non-fare Revenue Services;
- c. Ticketing and Commuter Services; and
- d. Civic Spaces.

1.6.1.3 Capacity

- a. Ensure compliance with the Building Control Regulations, Code on Accessibility in the Built Environment and other IDC requirements.
- b. Refer to IDC Volume B Part 1 Annex B, MRT Station Room Datasheet for the minimum sizes for planning purposes.
- c. When appropriate, consider the use of analytical techniques or computer aided modelling software to validate proposed capacities and size of waiting and queuing zones, particularly at ticketing kiosks, etc.

1.6.1.4 Location

- a. Locate station amenities such that they are visible from the point of access and are easily accessible by commuters;
- b. Locate amenities where commuters using these do not impede the pedestrian flow or interfere with essential station operations.

1.6.2 Commuter Care Facilities

1.6.2.1 Commuter care facilities in stations include:

- a. male / female public toilets;
- b. accessible toilet;
- c. family toilet;
- d. baby care room (only at interchange stations);
- e. accessible changing room (only at interchange stations);
- f. commuter care room-cum-first aid room; and
- g. platform seats and other universal design features.

1.6.2.2 Design

- a. provide privacy where screening, reflectivity of wall tiles and positioning of mirrors are considered so that toilet interiors and the occupants are not visible from public corridors;
- b. be well ventilated;
- c. provide slip resistant floor tiles;
- d. be easy to maintain;
- e. provide sense of security and safe to use; and
- f. be friendly to persons with disability or special needs.

1.6.2.3 Capacity

- a. Provision of toilets shall be in accordance with Code on Accessibility in the Built Environment and National Environment Agency's requirements.
- b. Ensure excess in size of rooms shall be no more than 10% of the size stipulated in the Room Datasheet.

1.6.2.4 Location

- a. Toilets shall be grouped in a cluster and located in the non-ticketed concourse of the station, visible from the PSC for surveillance purpose.

- b. Other commuter care facilities like baby care room, commuter care room-cum-first aid room and accessible changing room shall also be located in the non-ticketed concourse but at a location where access to these can be monitored and controlled by the Operator.
- c. If toilets are accessed via a common corridor, the width of the common corridor shall be minimally 1800mm clear.
- d. Commuter care facilities shall not be located at dead end corridor or remote part of the station.
- e. Toilet cluster shall be located such that there is no direct line of sight into the toilets.

1.6.2.5 For detailed requirements refer to IDC Volume B Part 1 Annex B, MRT Station Room Datasheet.

1.6.3 Platform seats

- a. To improve commuter experience in the station, seats are provided at platform level to cater to commuters waiting for the train.
- b. Seats must be positioned to avoid obstruction to the movement of commuters.

1.6.3.1 Design

- a. safe, accessible and comfortable for users of all ages and needs;
- b. seats shall have visible colour contrast and at least 30% brightness or luminance contrast with the platform floor and surroundings.
- c. all sides and corners of the seats shall be smooth and not have any sharp edges;
- d. compliant with any prevailing code/ guideline on accessibility provisions;
- e. fixing methodology to allow flexibility to add, relocate or remove the platform seat with minimal damage to the floor finishes or stability of the seat;
- f. adequate use of material or materials for the structure and seat so that it does not add to bulkiness, and minimise material wastage especially where seats are placed back to back or against a wall;
- g. armrests and backrest shall be provided for comfort and assist the ambulant disabled or older persons. Armrests shall be welded to the stainless-steel surface instead of fixed mechanically; and

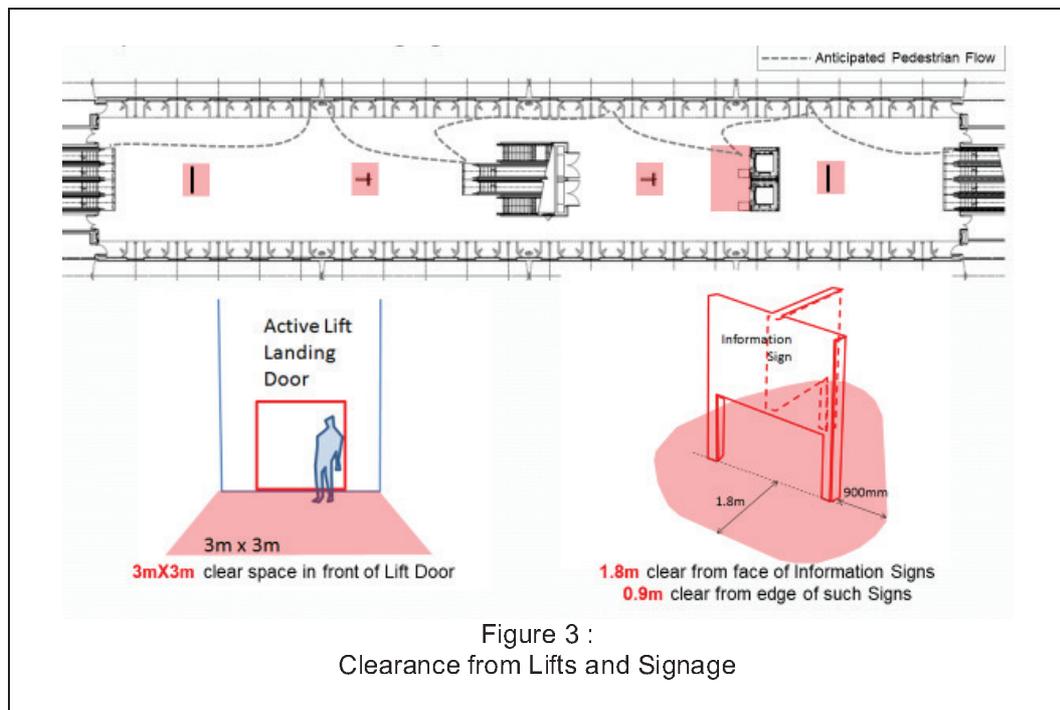
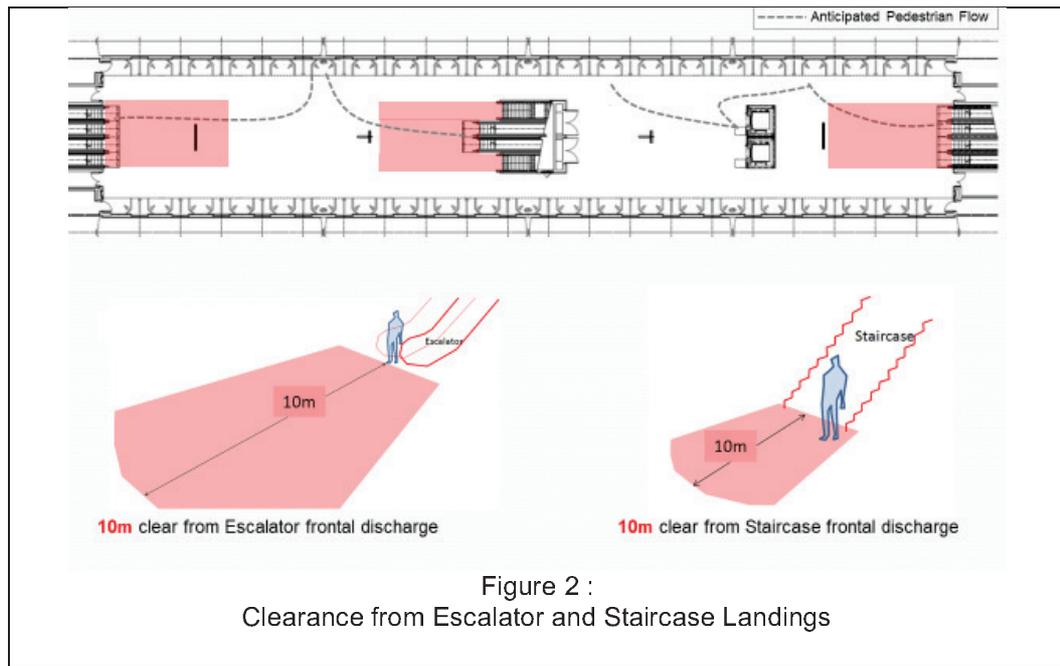
- h. if possible, provide a modular design that can be configured and assembled in various ways to achieve the required number of platform seats.

1.6.3.2 Capacity

- a. Minimum 3.5 seats shall be provided for each train-car per platform with the total rounded up to the nearest whole number.
- b. The number of seats with armrest shall be at least 30% of the total number of seats provided. For example, an island platform with 4-car trains on each bound would require 28 seats (8 cars x 3.5 seats) and 9 (30% of 28) of these shall be provided with armrest.
- c. The final number of seats shall be confirmed with the Authority, based on space availability and station ridership figures.

1.6.3.3 Location

- a. Review anticipated commuter flow in relation to platform design to avoid potential crowded zones.
- b. Preferably placed along or under the escalator or staircase to minimise obstruction to commuter flow.
- c. Maintain minimum 900mm from glass lift shafts and railing / parapet overlooking a void.
- d. Maintain minimum 1800mm from any wayfinding signage.
- e. Avoid locating within 1800mm of an artwork causing physical / visual obstruction.
- f. For minimum clearance criteria from other major platform components, refer to illustrations below:



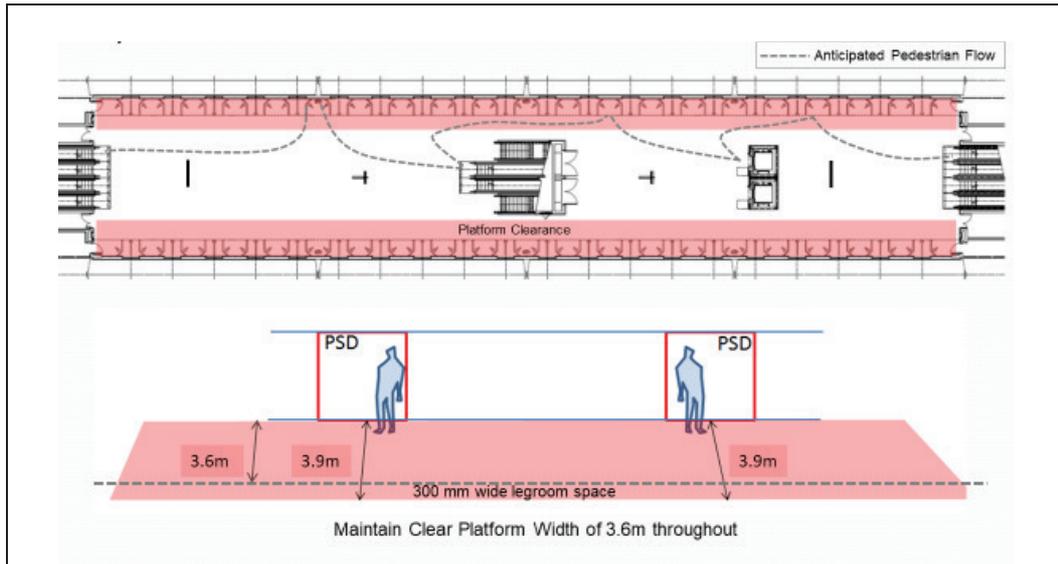


Figure 4 :
Clearance from Platform Screen Doors If seats are located along the queuing areas

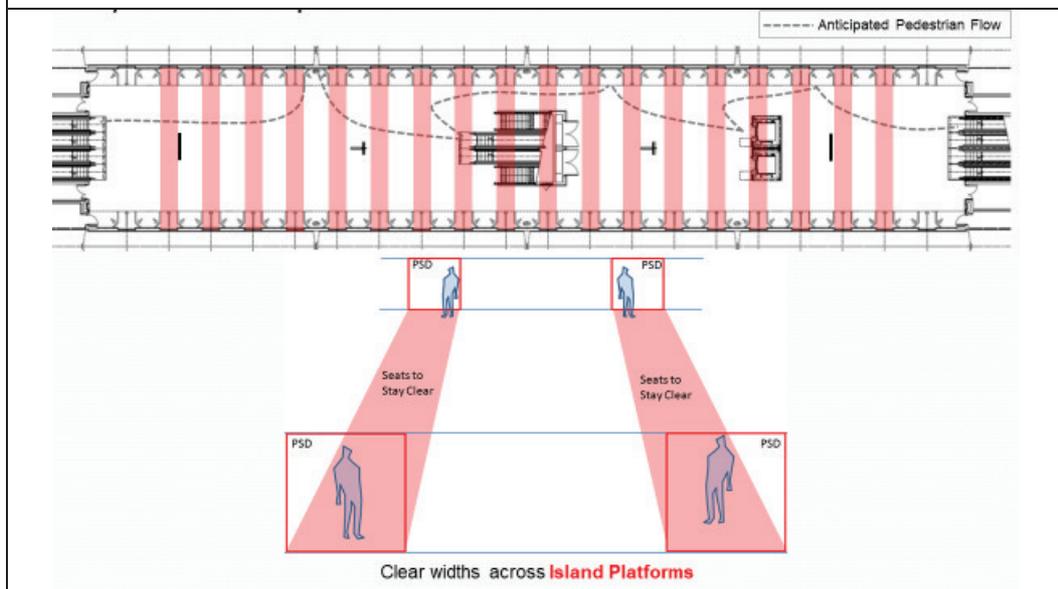
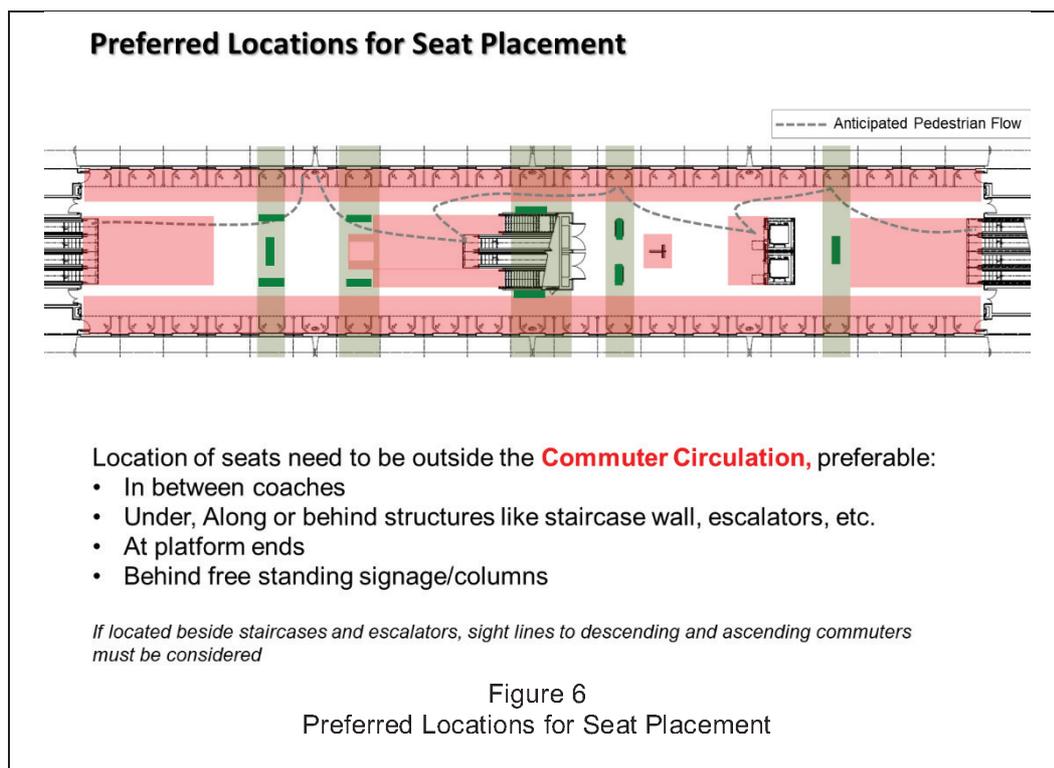


Figure 5 :
Clearance across platform in line of Platform Screen Doors



1.6.4 Universal Design Features

1.6.4.1 Universal design is about making places easy to use for all commuters and station staff. These users include:

- a. people with visual or cognitive impairment;
- b. wheelchairs users;
- c. elderly persons;
- d. persons with stroller or young children;
- e. pregnant women, etc.

1.6.4.2 Access routes shall be free from obstacle and step to accommodate the needs of all users. Access routes should also be direct, without requiring commuters with mobility or other impairments to follow circuitous routes away from primary commuter flows.

1.6.4.3 Station areas intended for public access shall all have a barrier-free route leading to them. Additionally, there shall be a barrier-free accessible route to the station from adjacent public/ private developments, bus stops, taxi stands, etc.

1.6.4.4 Design accessible route as a continuous path connecting all public spaces and facilities in the station for safe navigation by persons with disability.

1.6.4.5 Consideration

- a. Ensure a clutter-free environment with adequate tonal contrast between floor and wall surfaces.
- b. Locate step-free routes at intuitive locations that are not isolated from the main commuter flows, with long sightlines to provide clarity on the directions/ destinations.
- c. Where barriers along a route require commuters with mobility impairment to take a detour, clearly identify alternative routes at the most appropriate decision point to allow timely route selection.
- d. Provide adequate signage to direct commuters with mobility impairment to an alternative accessible route.
- e. Identify all hazards such as platform edges, change in level at stairs, kerbs and ramps with highly contrasting finishes and ensure uniform lighting to minimise possible risk of accidents.
- f. Where change in level is unavoidable, provide handrails or grab bars regardless of how slight the change in level is.

1.6.4.6 Accessibility provisions in the stations for persons with disability and other intended users shall be in accordance with the provisions stipulated in the prevailing Code on Accessibility in the Built Environment.

1.6.5 Non-Fare Revenue Services

1.6.5.1 Non-fare revenue services include retail spaces, ATMs and any other advertising / commercial opportunities.

1.6.5.2 Design for non-fare revenue services shall complement and not compromise station operations and core commuter functions, and shall not result in congestion, confusion or disorientation.

1.6.5.3 Refer to IDC Volume B Part 1 Annex F, Design Criteria for Advertising and Retail Provisions in Mass Rapid Transit (MRT) Stations for detailed provisions of these services.

1.6.5.4 Capacity

- a. size of retail in stations shall be within CPFPRTS limits;
- b. Designer shall study and identify potential for additional retail or other non-fare services according to station location and context;
- c. approval shall be obtained from relevant authorities for proposed retail or other non-fare spaces in excess of the CPFPRTS limits.

1.6.5.5 Location

- a. Locate non-fare services adjacent to, but not interfering with, key commuter routes to create active spaces.
- b. Locate non-fare services so that they are visible and accessible to commuters.

1.6.5.6 For each retail unit, all provisions shall be in accordance with IDC Volume B Part 1 Annex B, MRT Station Room Datasheet.

1.6.6 Ticketing and Commuter Services

1.6.6.1 Ticketing services shall include:

- a. Ticketing Kiosks
 - i. Ticketing kiosks consist of machines such as Ticket Vending Machine (TVMs), General Ticketing Machines (GTMs), Assisted Service Kiosk (ASK), etc.
 - ii. Designer shall locate these services so that they are directly visible from the PSC and easily accessible from the primary commuter route.
 - iii. For quantity, size and location of these services, refer to IDC Volume B Part 1 Chapter 2 E&M Requirements.
- b. Ticketing Service Centres (TSC)
 - i. TSC shall be provided at selected stations, as per guidelines in IDC Volume B Part 1 Annex G, Ticketing Service Centre (TSC) Requirements.
 - ii. TSC provide a comprehensive array of services that cannot be fulfilled by unmanned ticketing machines. Type of services offered include top-up, refund, card sale, card analysis, etc.
 - iii. These also cater to the needs of commuters on concession and tourists, who require more customised assistance.
- c. Passenger Service Centres (PSC)
 - i. One PSC shall be provided for every station.
 - ii. PSC to provide direct surveillance of the station concourse, particularly the fare collection areas and gate lines.
 - iii. It acts as a point of contact for commuters seeking information and assistance.
 - iv. It is where all station equipment are monitored, public announcements are made and emergencies are responded to, etc.
 - v. Refer to IDC Volume B Part 1 Annex C, PSC Design Guidelines and IDC Volume B Part 1 Annex B, MRT Station Room Datasheet for design and technical requirements.

1.6.6.2 Location

- a. Ticketing services should be appropriately located so that it enables the staff to work effectively within the station environment, optimising day-to-day operations and allowing them to best meet station user requirements.
- b. Locate these services such that they are visible from the main access routes and readily accessible to commuters.
- c. Locate these services where passengers using this information do not obstruct commuter flow or interfere with essential station operations.
- d. PSC shall be located next to the primary gate line between ticketed and non-ticketed concourse.
- e. Ticketing kiosks shall be located prominently in non-ticketed concourse near the PSC for surveillance purpose. They shall also be positioned in direct proximity of gate lines such that commuters are able to access them without making a detour or backtrack while approaching the gate lines from the station entrances.
- f. TSCs shall be located in the non-ticketed concourse, preferably near PSC.

1.6.6.3 Considerations

- a. Plan and optimize the layout to suit the core functions of these services.
- b. The point of access for commuter interface shall be clutter free and easily accessible.
- c. Ensure that there is adequate space to accommodate the number and size of such services with regards to station location and anticipated ridership.
- d. Design to cater to commuters with different needs such as those on wheelchair, the visually or hearing impaired.
- e. Avoid obstructing commuter flow or interference with essential station operations.

1.6.7 Civic Spaces & Provisions

- 1.6.7.1 Where opportunity arises for provision of a civic space in or around the station, balance the various stakeholders' needs by identifying the option that works best for the community as a whole, ensuring at every stage that the planning and design provisions improve the commuter's experience.

1.6.7.2 Designers are to work with the community who will be using the civic space to find out what they really want and need, to encourage more creativity, unlock tailored and forward-thinking community solutions. Decision-making shall be more localised to achieve a better understanding of what the commuters want, and greater effectiveness in delivering those changes.

1.7 Interfacing Requirements

1.7.1 General

1.7.1.1 The primary purpose of transport facilities shall not be compromised by the introduction of commercial or other facilities. Where provided, these shall not result in congestion, confusion or disorientation to the commuters.

1.7.1.2 All interfacing and integrations with developments and/or other transport facilities shall meet the following requirements:

- a. planned commuter routes shall maximise spatial efficiency;
- b. entrances into the transport facilities shall be easily identifiable;
- c. connections shall enable seamless circulation flow, easy and intuitive orientation and be user-friendly;
- d. consider the needs of security and operational integrity of the transport facilities;
- e. enable easy determination of the ownership and maintenance boundaries by different stakeholders to ensure independent inspection and maintenance of each property;
- f. ensure the transport facility is able to operate independently from the integrated development; and
- g. ensure maintenance, repair and future enhancement can be undertaken without detrimental impact on the operation of the transport facility.

1.7.2 Statutory Submission & Requirements

1.7.2.1 Any proposed developments adjacent to or above a transport facility shall comply with the prevailing edition of the following:

- a. Code of Practice for Railway Protection;
- b. Rapid Transit Systems (Development and Building Works in Railway Corridor and Railway Protection Zone) Regulations;

- c. Guide to Carrying Out Restricted Activities Within Railway Protection and Safety Zones;
 - d. Building Control Act; and
 - e. Code of Practice for Fire Precautions in Rapid Transit System.
- 1.7.2.2 The developer shall also comply with the transport system operator's rules and regulations when working in, on, or near the transport facility.
- 1.7.2.3 Compliance with these criteria does not preclude the developer from having to obtain full clearance from any other statutory submissions and approving authorities for his proposal. The developer shall submit plans and the required documents to URA, BCA and LTA's DBC for clearance.
- 1.7.2.4 The designer is required to produce a development interface report outlining the interface arrangements and designs for the integration of the future development including all constraints with respect to architectural, civil & structural, electrical & mechanical and other services requirements for the integration.
- 1.7.3 Interface with Existing Transport Facilities
- 1.7.3.1 When interfacing with existing transport facilities, connectivity shall be designed intuitively for direct, seamless, convenient wayfinding and travel.
- 1.7.3.2 Designer shall consider the usage of both existing and proposed transport facilities when evaluating the expected commuter flow. Proposed connections shall be tested using a congestion simulation cum pedestrian flow analysis to ensure that the required Level of Service is met.
- 1.7.3.3 Designer shall identify and propose maintenance boundaries in consultation with the transport system operator and obtain their in-principle acceptance.
- 1.7.4 Interface with Development
- 1.7.4.1 When station interfaces with an existing development, the design shall facilitate safe, intuitive and accessible connections.
- 1.7.4.2 The design shall enable easy determination of the ownership and maintenance boundaries by different stakeholders to ensure independent inspection and maintenance of each property.
- 1.7.4.3 The design shall also facilitate securing of transport facilities after operation hours.
- 1.7.4.4 The station shall be planned to accommodate future increases in commuter numbers resulting from integration with the developments.

- 1.7.4.5 The design shall not compromise the core function of the transport facility. Additional commuter flow resulting from integration with the development shall be factored into the pedestrian flow analysis to ensure that operations, commuter circulation and LOS are maintained or enhanced.
- 1.7.4.6 Where station will form part of a development or where new developments are to be integrated with existing stations, the design shall allow for seamless integration between the two while ensuring the station remains functional and safe while this is being carried out.
- a. Station functions and operations:
- i. The station shall be able to function independently.
 - ii. The development shall not pose obstruction to station operations, emergency escape and firefighting access, maintenance access and equipment replacement routes.
 - iii. The design of the development shall ensure that the functional requirements of the ventilation openings, station access, etc. are not compromised.
 - iv. The ventilation openings shall be coordinated with the development to ensure that there is no recirculation of air resulting in cross contamination between fresh air intake and exhaust air.
 - v. For all ventilation building integration with the development, the ventilation shaft design and fan capacity shall provide sufficient allowance for an additional 10m vertical rise above the entrance level incorporating five 90-degree bends within the permissible pressure drop.
 - vi. Where aboveground services and utilities structures such as ventilation shafts, firemen staircases, cooling towers, etc, are reconfigured or diverted as a result of integrating with the development, the designer shall consult with the Authority and demonstrate that the functional and operational requirements of these services and utilities are not compromised.
- b. Pedestrian connectivity
- i. Knock-out panel (KOP) for future connection directly linking to the station shall be provided in discussion with URA The KOP shall be sized to facilitate erection of hoarding and construction in future.
 - ii. Where entrances into the station are via the development, design for the access routes shall be legible, direct and convenient. Entrance identification and signage shall be provided in accordance with the Authority's requirements. The right of access to the station shall also be maintained during the operational hours of the station or any neighbouring transport facility connected to it.

- iii. There shall be minimum barrier and level changes in the integration such that it does not impede legibility, decision making and wayfinding.
 - iv. Where entrances into the stations are replaced or diverted as a result of the integration, the developer shall consult the Authority and demonstrate that the commuter flow, escape route and ventilation are not compromised by the new entrance configuration. Entrances into stations shall be easily identifiable.
- c. Fire safety and separation
- i. The station emergency escape stairs / exits shall be independent, and fire separated from the development. Likewise, the development shall be provided with emergency escapes independent of the station. The development will not be allowed to evacuate into the station.
 - ii. Evacuation from the station will discharge directly to the point of safety at an open area outside the station. The point of safety and passage of escape shall not be obstructed by any permanent or temporary structure, construction or other activities related to the development.
 - iii. Future developments that encloses / surrounds the station emergency escape stairs / exits shall extend the discharge directly to the point of safety at an open area outside the station and development.
 - iv. For any construction works carried out by the development, a 2-hr fire rated barrier / hoarding shall be provided to separate the station and shall be maintained in place until the construction works are complete, and the Temporary Occupation Permit is obtained.
 - v. For permanent structures, the development shall be separated from the station with a 4-hr fire compartmentation.
 - vi. At KOP / pedestrian connections, 2 numbers of 2-hr fire rated roller shutters, one at each side of the respective boundaries, shall be provided to achieve the required fire compartmentation. The 2 fire rated roller shutters will be connected to the fire alarm of both the development and station. In the event of fire at either side, the fire rated roller shuttle on both sides shall be closed. Bypass doors to be provided where necessary.
 - vii. For future development connecting to the station, the developer shall be responsible to install the 2-hr fire rated roller shutter within the station. The developer shall handover the fire rated roller shutter to the Authority after satisfactory testing and commissioning and obtaining the necessary statutory approvals. Thereafter, the developer shall maintain the fire rated roller shutter for a period of 24 months from the date of handing over to the station. Maintenance records shall be provided at the end of the 24-month maintenance period.

- d. Flood protection
 - i. The proposed connection to the station shall not constitute a route for floodwater into the station.
 - ii. The threshold level of any entrance / exit points leading into the basement of the interfacing development that connects to an underground station shall not be lower than the station entrance flood protection level.
 - iii. During construction of the interfacing development, the developer shall ensure that there is no water inundating the station at any stage of the works.

- e. Structural loading
 - i. Where the station at-grade structures (such as entrances, ventilation buildings, cooling towers, etc.) are expected / required to support an interfacing / integrated development, the designers shall liaise with the developers and their consultant team to coordinate and confirm the loading provisions and structural support required; as well as to resolve the waterproofing and structural connection details.
 - ii. For interface with future developments, in addition to permanent loads, temporary loading conditions during superstructure and basement construction (including excavation) shall be considered and catered for in the permanent station structure design as well as temporary works design.
 - iii. The designer shall provide the optimum structural grid for the development without compromising public safety, movement, organisational clarity, simplicity, or visibility in the facility.

1.8 Material & Finishes

1.8.1 General

- 1.8.1.1 Materials and finishes used shall be appropriate to station context and function, fit for purpose and meet with all health and safety requirements. They shall enhance the character and quality of the station and its functions.
- 1.8.1.2 Designer should consider life cycle costs when specifying materials and finishes, recognising that good design does not equate to higher cost. A sustainable balance between cost, function, performance, maintainability, ease of use and availability, quality and an attractive aesthetic shall form part of the consideration.
- 1.8.1.3 Designers are encouraged to work with a restrained palette of materials with simple, functional and standardised details.
- 1.8.1.4 Material selection shall maximise economy of scale and be designed to ensure safe installation, easy maintenance and replacement.

1.8.2 Quality of Material & Finishes

1.8.2.1 Use materials that are:

- a. fit for purpose;
- b. durable;
- c. vandal-proof;
- d. require minimum maintenance or repair;
- e. comply with fire safety requirements;
- f. certified by local authorities / agencies, such as Singapore Green Building Council (SGBC), etc.; and
- g. not hazardous, such as causing slip, trip and fall, rips and cuts.

1.8.2.2 All materials used shall comply with the Material and Workmanship Specifications and other relevant material standards.

1.8.3 Particular Requirements

1.8.3.1 Materials used aboveground shall be corrosion and stain resistant with particular attention to resistance to fungal growth.

1.8.3.2 Finishes shall not require cyclical painting or re-coating unless agreed with the Authority. Access for replacement and maintenance shall be achievable by safe and commonly available means.

1.8.3.3 Finishes shall not require customised cleaning equipment.

1.8.3.4 Designers shall take note of the following requirements of the materials and finishes identified, including but not limited to the following:

- a. Underfloor Drainage
 - i. Underfloor drainage systems shall be incorporated into public areas directly above non-suspended structural base slab sitting directly on ground to prevent any seepage or rising damp reaching the floor finishes.
 - ii. The system shall include a cavity drain membrane (e.g. egg crate), sandwiched within the floor screed at a gradient not gentler than 1:200 to channel any seepage water for discharge into underfloor drainage outlets (floor wastes with dome gratings) accessible by floor access hatches.
 - iii. The floor screed shall provide adequate cover over the cavity drain membrane for structural stability and to avoid damage to the cavity drain membrane.

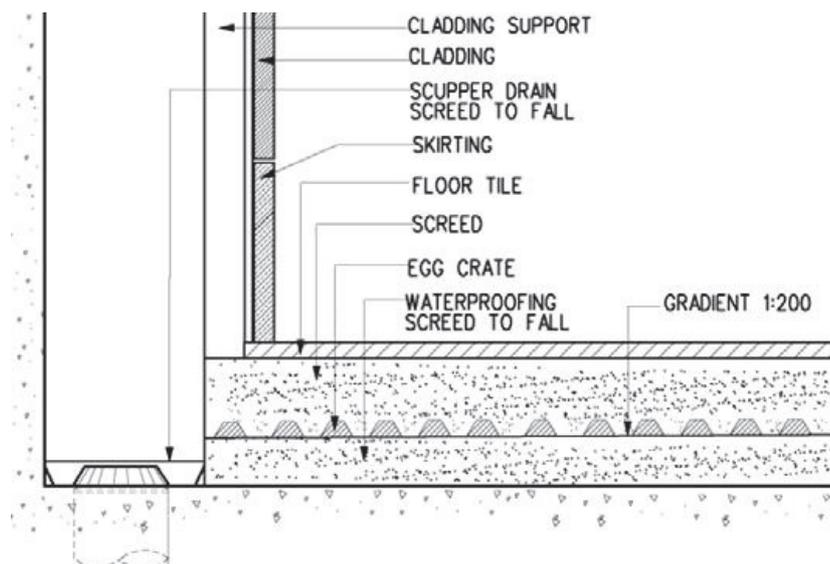


Figure 7: Schematic diagram for underfloor drainage

a. Glazing

- i. Only laminated glass shall be used in the station design.
- ii. All glass shall be framed on at least 2 opposite sides.
- iii. For glass used for above ground application e.g. in facades, skylights, entrance structures etc. appropriate U-values and SHGC values shall be considered and specified to minimize heat gain while maximizing the Visible Transmittance of light.
- iv. Designers shall ensure the panel sizes and weights for all glass panels are in accordance with the required glazing replacement provisions and delivery access routes with no additional equipment than allowed for in the maintenance strategy.
- v. For all non-vertical glass panels for skylights, each glass panel shall not be longer 1.5m and not weigh more than 150kg unless otherwise justified and subject to acceptance by the Authority.
- vi. Designers shall prepare
- vii. A full glazing schedule identifying all types of glass used in the station, including the support system, material properties and location, shall be prepared and included in each formal design submission for acceptance by the Authority.
- viii. Refer to IDC Volume B Part 1 Annex E, Glazing Design Criteria, of for more details on types of glass and glazing system used in MRT stations.

b. Tiling

- i. Unless otherwise specified, there shall be no adhesive fixed tiles in station public areas except toilets and other commuter care facilities.

- c. Access Hatches in Public Areas
 - i. Access hatches for maintenance and services and equipment in the public areas shall be designed and finished to match with the station architectural finishes.
- d. The Finished Floor Level (FFL) of Electrical Rooms
 - i. FFL of electrical rooms shall be 50mm higher than the highest point of the adjacent sprinkler protected corridor's FFL. A slope no steeper than 1:10 shall be provided at the threshold into the electrical rooms.
- e. False Ceiling
 - i. False ceiling shall be easily removable and replaceable.
 - ii. Access hatches in false ceiling shall be provided with key lock and located where regular inspection of detectors and other devices in the ceiling void is required.
- f. Stone
 - i. Layout shall be designed to minimise wastage with standard sizes in 300mm modules. Avoid stones with tonal inconsistency.

1.9 Components & Standardisation

1.9.1 General

1.9.1.1 The design and placement of components shall be coordinated and integrated with the station finishes to improve commuter experience and address operational and maintenance needs.

1.9.1.2 Wall Mounted Components

- a. All wall mounted components shall be well organised, composed and coordinated with the wall cladding modules. Elevations shall be provided to show the relative location of all wall mounted components and alignment with wall cladding joint lines, doors and relevant surrounding features such as landscaping and railings.
- b. All wall mounted components shall be flushed with the wall finishes where possible. The depth of wall mounted elements shall be accounted for when setting out wall cladding details.

1.9.1.3 Floor Mounted Components

- a. All floor mounted components positioned against a wall shall be changed to wall mounted.

- b. Alternatively, front accessed floor mounted components that back onto a wall shall be recessed into a niche within the wall cladding. This niche shall allow for tolerances in the component's dimensions as agreed with the Authority.
- c. Where floor mounted component are recessed into a niche within a wall cladding, removable wall cladding shall be provided to close any gaps to a maximum of 10mm around. Adequate allowance shall be provided for the removable wall cladding to cater for future changes to the component dimensions.
- d. Floor mounted components shall be grouped at a common location and integrated where feasible, located so that they do not obstruct the primary commuter flow or line of sight for commuters and Operators.

1.9.1.4 Ceiling Mounted Components

- a. The ceiling design shall provide a planning grid / principle to organise, compose and coordinate the ceiling mounted equipment coherently with the ceiling finishes.
- b. All ceiling mounted components shall be captured in the reflected ceiling plans to demonstrate full coordination with the ceiling grid, access panels, ceiling support structure and other ceiling mounted components.
- c. The ceiling mounted components are to be arranged to minimise penetrations through the ceiling fabric and shall not compromise the integrity of the ceiling fabric.
- d. Ceiling mounted signage or passenger information displays shall be located such that commuter's view is not obscured and are accessible for maintenance.
- e. Any displays above gate lines shall be 1 to 2 metres away from the edge of the gate lines on the ticketed concourse.

1.9.1.5 External Components

- a. External components include:
 - i. bulk meters;
 - ii. breaching inlets;
 - iii. swan necks;
 - iv. OG boxes; etc.
- b. Designers are to consider the design and integration of all external components with station entrances, landscaping and ventilation structures holistically.

- c. Should any component be sunken or semi-sunken in chambers (e.g. bulk meter), protection against water ingress by raising the threshold or sloping up to the threshold shall be provided. Drainage at the pits or chambers shall be provided in accordance with CDC, Chapter 11.

1.9.1.6 Component Accessibility

- a. Refer to IDC Volume B Part 1 Chapter 3 for more details on Accessibility, Operations & Maintenance Requirements.
- b. The position and height of all components shall comply with the Authority's requirements and any relevant codes.
- c. Only components that are used by the commuters are required to comply with the prevailing Code on Accessibility in the Built Environment.
- d. A clear and level floor space of 900mm x 1200mm shall be provided in front of any components designated for use by persons with disability.

1.9.2 Standardised Systems

- a. Stations consist of the following essential systems that are to be standardised in accordance with Authority's requirement.

1.9.2.1 Waterproofing System

- a. Ensure that the floor, wall and ceiling finishes in areas in direct contact with earth are kept dry.
- b. All wet rooms shall be provided with waterproofing membrane.
- c. Where required, underfloor drainage shall be provided in accordance with the CDC and Section 1.8.3.4 a. of this chapter.

1.9.2.2 Cavity Wall System

- a. Cavity walls, shall be provided to enclose the earth-backed external wall and associated seepage drains for public areas and all designated areas in accordance with the CDC.
- b. Refer to the CDC – Chapter 11 for design of seepage drain and application of cavity wall.
- c. The space between cavity wall and external wall shall be 250mm clear as a minimum.
- d. Cavity wall in public areas may be formed using the public area wall cladding mounted on steel sub-frame.

- e. For spaces behind cavity wall in public areas, access shall be facilitated by:
 - i. providing operable access panel incorporated in the cladding design; or
 - ii. ensuring the public area cladding is fully demountable individually using mechanical fixings for access to any part of the external wall / seepage drain within the cavity for maintenance.
- f. For cavity wall spaces in rooms listed in CDC Chapter 11, access shall be facilitated by:
 - i. providing drywall construction between the external wall and the room where possible;
 - ii. ensuring the drywall, where provided, is fully removable for access to any part of the external wall / seepage drain within the cavity for maintenance, and shall be replaceable/reinstated to its original condition.
- g. Walk-in space shall be provided for cavity wall spaces under the following conditions:
 - i. when unable to provide the required access hatches;
 - ii. where equipment or furniture are mounted on or against the cavity wall; or
 - iii. where cavity wall is not drywall construction.
- h. The walk-in space shall have a minimum clear width of
 - i. 600mm at floor level; and
 - ii. 800mm between the external concrete wall and cavity wall.
- i. Where E&M services are mounted in the walk-in space, the space shall be labelled as “Services Zone” with following requirements:
 - i. clear widths in accordance with Section 1.9.2.4 k. & l. of this chapter;
 - ii. clear headroom of minimum 2.2m;
 - iii. no blockage of access doors / hatches; and
 - iv. the same fire protection measures as the adjoining room.
- j. All metal framing for the cavity wall shall be hot dipped galvanised steel.
- k. All cavity walls shall use external grade materials that are unaffected by moisture and shall maintain their performance when wet.

1.9.2.3 Enclosed Spaces

- a. The station layout shall be rationalised to eliminate any unusable spaces.

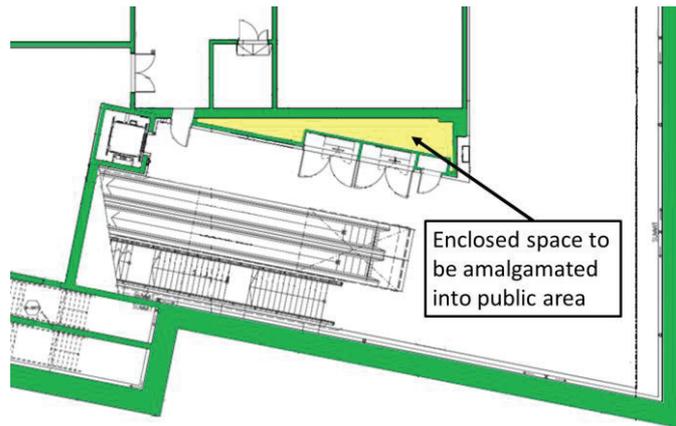


Figure 8: Enclosed spaces opening into public areas

- b. Remnant spaces to be designed as part of adjacent rooms / spaces.

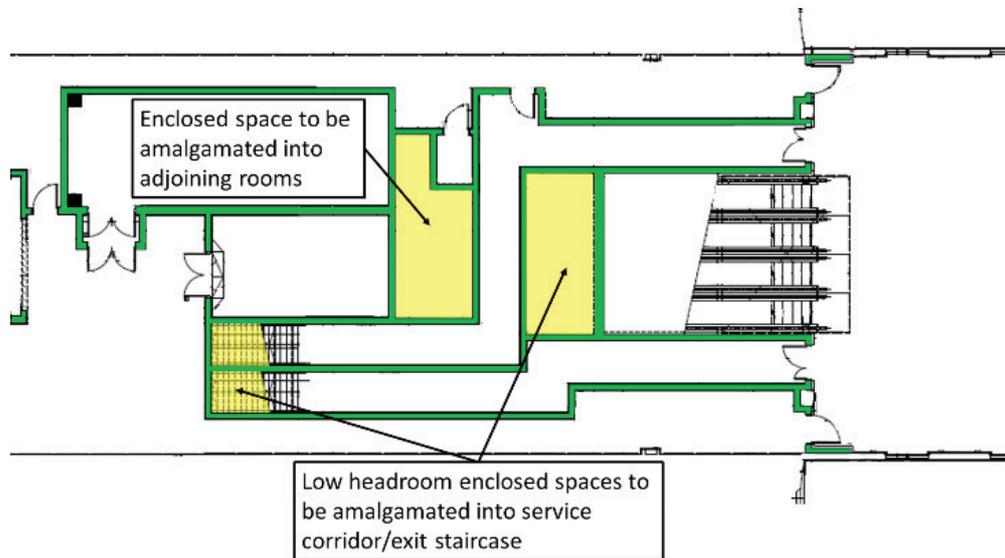


Figure 9: Enclosed spaces opening up into adjoining rooms

- c. Wherever possible, low headroom spaces below staircases and escalators should not be enclosed. Railings to be provided to prevent overhead obstructions below 2m instead.

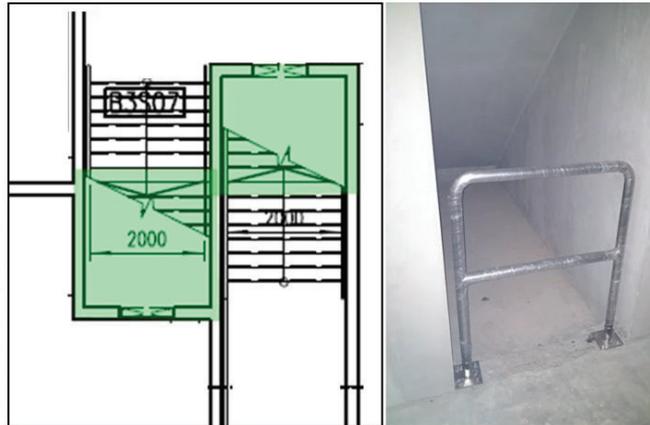


Figure 10: Spaces under staircase to be closed of with railings

- d. Unusable spaces that could not be eliminated are to be labelled as “Enclosed Space”, with the following condition:
 - i. No services, finishes or fittings to be provided within the enclosed space.
 - ii. Drainage discharge point to be provided. The location of the drain shall be such that it is easy to access for maintenance.
 - iii. Wall access hatches are to be provided in accordance with access to confined spaces under IDC Volume B Part 1 Chapter 6 Safety.
 - iv. Two number of power points are to be provided on external wall next to the access hatch to enable temporary lighting and ventilation to be provided to facilitate safe access into the enclosed area for inspection, maintenance and structural repair works.
- e. Remaining unusable spaces which are inaccessible are to be backfilled either with Liquefied Soil Stabilizer (LSS) or lightweight concrete. The backfilling shall include waterproofing course. The additional load from backfilling shall be accommodated structurally and that the design also include protection against seepage to surfaces / spaces bounding the backfilled space.

1.9.2.4 Doors & Hatches

- a. All doors shall have a clear height of minimum 2.2m measured from the finished floor level (FFL) to the underside of the door frame.
- b. All doors for entry into a room shall be self-closing.
- c. Door and hatch requirements shall be included in the station’s BIM model and displayed using 'Door Data Plans', where data of each door shall be displayed in data boxes.

- d. Information in the door schedules shall be capable of being filtered according to:
 - i. floor levels;
 - ii. spaces, e.g. rooms, closets, staircases, etc.;
 - iii. doors types, e.g. security, fire, etc.
- e. The format of both the door schedule and door data plan shall be as advised by the Authority.
- f. All doors leading to and along the fire escape routes shall be identified on the fire escape route plan and door data plan for coordination with SWC for provision of EM locks.
- g. Door Swing
 - i. Door openings and direction of door swing shall be designed such that where two or more sets of doors need to be opened / accessed at the same time, clashes are avoided.
 - ii. Doors shall not open above or directly in front of floor hatches or open pits.
 - iii. Where a door or active leaf of a double door causes obstruction to an escape route when fully opened, the door shall close in the direction of escape.
 - iv. Active leaf of any double door shall be identified on plan. Illustration to define the active leaf shall be included in all door schedules and drawings.
 - v. Door swing for pressurized rooms (such as TVF / Fan Rooms) and shafts / plenums shall be in accordance with IDC Volume B Part 1 Annex B, MRT Station Room Datasheet.
- h. Vision panels shall not be provided at any doors between public and non-public areas unless stipulated in the CPFPRTS.
- i. Access Hatches are hinged elements for access below floors, behind walls and above ceilings.
- j. Wall Access Hatches and Doors
 - i. Where wall access hatches / doors are required in the public areas, they shall be finished to match the adjacent wall design.
 - ii. Wall Access hatches shall be provided as following:
 - For access to cavity walls spaces, minimum clear opening of 600mm width by 1800 mm height at a maximum interval of 4.8m centre to centre and shall coincide with every floor waste position.
 - For access to enclosed spaces, minimum clear opening of 800mm width by 800mm height located 400mm above the FFL at the point of access. Grab bars shall be provided on the wall upon entering the space for safety and ease of access

- iii. All access hatches / doors shall comprise of hinged cladding panels in the public area that are designed and finished to integrate with and match the station architectural finishes and modules.
- iv. Refer to IDC Volume B Part 1 Chapter 4 for Security Requirements on cladged hatches and doors.
- v. Refer to IDC Volume B Part 1 Chapter 6 for Safety Requirements on wall access hatches to enclosed spaces
- vi. Wall access hatches and doors that are not for walk-in shall be secured under separate key groupings as follows:
 - access from back-of-house to inspect cavity wall spaces need not be lockable;
 - access from public areas to inspect ducts, equipment and panels and cavity spaces shall be lockable with locking set “WH” under a common key system with 5 keys to be provided;
 - access to CD equipment and facilities from public areas shall be lockable with locking set “WH” under a common key system with 5 keys to be provided; and
 - access to firefighting equipment from public areas shall be lockable with locking set “WH” under a key differ system with a unique key provided in a break glass for each hatch and an extra 5 common master keys.
- vii. Wall access hatches and doors that are for walk-in access shall be secured as follows:
 - access to walk-in cavity spaces and enclosed spaces from back-of-house area shall use locking set “SA”;
 - access to walk-in cavity spaces and enclosed spaces from public areas where the walk-in cavity is not used to run services shall use locking set “CL”;
 - access to walk-in cavity spaces from public areas where the walk-in cavity is also used to run services shall use locking set “EM”.
- viii. For more details, refer to IDC Volume B Part 1 Annex B, MRT Station Room Datasheet.

k. Floor Access Hatches

- i. Where possible, floor access hatches should not be located within public areas.
- ii. Floor access hatches shall not be provided in circulation or escape routes.
- iii. Wherever possible, floor access hatches in service corridors shall be located in a niche or against the wall to maintain the minimum clear width of the service corridor throughout.
- iv. Floor access hatches shall have a minimum clear opening dimension of 1000mm X 1000mm and be lightweight for one-man operation.
- v. Non-fire rated floor access hatches shall be provided with a loop for latching when in open position.

- vi. Hatch covers in excess of 1000mm X 1000mm and are fixed with floor tiles or are fire rated shall be hydraulically operated.
- vii. Fire rated floor access hatches shall be avoided. Where access to fire compartments on other floors is required it shall be achieved by creating a lobby with fire door where compartmentation is achieved.

1.9.2.5 Ceiling Systems

- a. Where there is exposed ceiling in the public areas, all soffit must be painted black.
- b. Where false ceiling is required, designer shall propose a ceiling system that:
 - i. conceals ceiling services in public areas;
 - ii. meets mechanical ventilation and smoke control opening requirements;
 - iii. provides effective integrated acoustic treatment that meets acoustic performance requirements;
 - iv. enhances station quality and identity;
 - v. creates a clutter-free station environment; and
 - vi. shall fully incorporate and be coordinated with all ceiling mounted fixtures and components.

1.9.3 Standard Components

1.9.3.1 Standard components to be incorporated in stations shall include, but not limited to:

- a. handrails;
- b. service boom
- c. integrated service totem; and
- d. underfloor details.

1.9.3.2 These components shall follow standard designs as provided / approved by the Authority.

1.9.3.3 These components shall be modular in design and application.

1.9.4 Line Wide Identity

1.9.4.1 Identify and develop components that can create a unique identity for MRT Lines by using common architectural style and standard design components.

- 1.9.4.2 Designers shall propose ways in which standardisation can be achieved in the design of such components. These may include, but not limited to:
- a. PSC layout, footprint, location, finishes, furnishing;
 - b. Lift shaft design and finishes;
 - c. Toilet finishes, materials, ware and fixtures;
 - d. Ticketing machine niche;
 - e. Artwork;
 - f. Entrances; and
 - g. Platform seat design and finishes.

1.10 Artwork

1.10.1 General

- 1.10.1.1 Artwork shall be integrated with the station architectural design and finishes.
- 1.10.1.2 Designers shall identify and recommend locations for artwork for Authority's acceptance.
- 1.10.1.3 Artworks should be strategically located to assist wayfinding.
- 1.10.1.4 Artwork shall not impede commuter movement or pose obstruction, tripping and/or public safety hazard.
- 1.10.1.5 The Authority may, at its discretion, engage artists to provide artworks for incorporation into the architectural fabric of the station. Designers shall collaborate with the artists and modify his design, if required, to suit the incorporation of the artworks.
- 1.10.1.6 Designers shall coordinate with all relevant stakeholders to provide advice to the artist in his proposal for the artworks on the following:
- a. suitability of materials;
 - b. maintenance access;
 - c. mounting details;
 - d. safety;
 - e. security; and

- f. interfacing with architectural components, e.g. signage, access panels, firefighting equipment, etc.

1.11 Weather Protection & Environmental Design

1.11.1 General

1.11.1.1 Stations shall offer protection against inclement weather.

1.11.1.2 Designer shall take into consideration the local climate in their design, which requires adequate protection from the full range of weather conditions and need for cross ventilation. Air circulation fans, if required, shall be proposed for Authority's acceptance.

1.11.1.3 Computation Fluid Dynamics (CFD) simulation shall be performed to undertake a comprehensive environmental building analysis for each station design.

1.11.1.4 The results of the environment building analysis shall be used to determine that the station design adequately addresses/respond to site specific local climatic conditions to verify that interior spaces are effectively protected from wind driven rain whilst achieving adequate cross natural ventilation, thermal comfort with or without air circulation fans and smoke ventilation.

1.11.1.5 The environmental building analysis shall include but not limited to bioclimatic analysis, sun-path analysis, wind analysis, solar radiation and insolation analysis, daylight and glare analysis, energy modelling, weather protection, shadow projections, rain penetration, building orientation, natural and mechanical ventilation strategies, landscaping/greening layouts, etc

1.11.1.6 The outputs shall be used to identify issues and design mitigations for any concerns which includes but not limited to the following:

- a. rain penetration and prevention against wind driven rain,
- b. daylighting and sun shading against glare,
- c. adequate natural cross ventilation and mitigation against solar radiation,
- d. energy modelling,
- e. landscaping/ greening layouts, etc.

1.11.1.7 For interchange stations, the environmental building analysis shall include both the new station entrances and the existing station.

1.11.1.8 Designers shall utilise the outputs / results / matrix of the building environment analysis to determine that the station design adequately addresses / responds to site specific climatic conditions and demands.

1.11.2 Flood Protection

1.11.2.1 Refer to the Civil Design Criteria, Chapter 12.

1.11.3 Rain

1.11.3.1 The design of station entrances as well as elevated station platforms and concourses shall ensure protection against wind driven rain.

1.11.3.2 Protection shall be provided on all sides of station entrances as well as elevated station platforms and concourses against rain penetration.

1.11.3.3 Rain penetration from the front of the entrance, if any, shall not reach beyond the steps leading up to the entrance by optimising the depth of the entrance canopy through iterative study using simulation software and presented for Authority's review and acceptance.

1.11.3.4 Entrance canopy and/or eave shall extend beyond the last step of the entrance staircase to prevent any rainwater ingress into the station. The depth of the canopy shall be designed and confirmed through iterative study using simulation software and presented for Authority's review and acceptance.

1.11.3.5 Protection from wind driven rain shall be provided at the interface:

- a. between station entrances and covered linkway;
- b. between and at PUDO / taxi stand / bus stop roofs and covered linkway.

1.11.3.6 Where minor access (including for public, staff or escape) to underground facilities are open to the sky, the following drainage requirements will be adopted:

- a. 6hr (280mm) of rainfall storage capacity.
- b. 100-year stormwater return period shall be used to design the pumps.

1.11.3.7 Where open top vent shafts are provided, the shaft concept shall be designed in such a way that the rainwater is drained off by gravity. If not possible, the less preferred types requiring pumped drainage will be considered provided the following design criteria are adopted:

- a. 24 hours (530mm) of rainfall storage capacity
- b. 100-year stormwater return period shall be used to design the pumps.

1.11.3.8 Drainage

- a. A drainage channel of sufficient volume for the disposal of water shall be provided adjacent to the top of all staircases and escalators leading to any underground station. This drainage channel shall be discharged to an independent external drainage system.
- b. Where required, gutter channels and downpipes shall be provided in accordance with NEA requirements.
- c. The size of drainage channel shall effectively discharge rainwater without causing any overflowing, stagnation, ponding or mosquito breeding.
- d. All drainage channels shall be laid to fall and shall not cause any splashing into the sheltered area.
- e. Recessed floor mats shall be provided at least 2000mm long across the full width of the public entrances at 6000mm from the top of the staircase and / or escalators leading to the concourse. These floor mats shall be located at the top of the flood protection level of each entrance.

1.11.4 Sun

- 1.11.4.1 Entrances shall be designed to minimise glare, heat gain and reflective heat while maintaining natural lighting.
- 1.11.4.2 Use of landscaping is encouraged as a means to provide additional shading to the entrance structures.
- 1.11.4.3 Designers shall undertake solar radiation and shadow analysis to reduce heat gained by station envelope through passive cooling strategies such as solar shading, façade design and treatments, etc.

1.11.5 Wind & Cross Ventilation

- 1.11.5.1 Designers shall design for effective cross ventilation to promote thermal comfort at the entrance, platform and other naturally ventilated spaces in the station.
- 1.11.5.2 The design of naturally ventilated spaces shall incorporate adequate ventilation openings to promote cross ventilation and thermal comfort. If necessary, air circulation fans shall be provided to further supplement air movement and enhance thermal comfort.

CHAPTER 2 – ELECTRICAL AND MECHANICAL REQUIREMENTS

NOT AVAILABLE

CHAPTER 3 – OPERATIONS AND MAINTENANCE REQUIREMENTS

Table of Contents

3.1	Design & Build for Operations and Maintenance	2
3.1.1	General	2
3.2	Physical Accessibility and Visual Inspection Access	4
3.2.1	Electrical and Mechanical Services.....	4
3.2.2	Artwork.....	4
3.2.3	Skylights	5
3.3	Ease of Operation and Human Factors Engineering	5
3.3.1	Station Platform	5
3.3.2	Sidings	5
3.3.3	Floor, Ceiling and Wall Finishes.....	5
3.3.4	Glazing.....	6
3.3.5	Flood Barriers	6
3.4	Maintenance Strategy and Access	7
3.4.1	Maintenance Strategy and Access Report.....	7
3.5	Maintenance Access Equipment (if required)	8
3.5.1	General	8
3.6	Maintenance Boundary	10
3.6.1	General	10

3.1 Design & Build for Operations and Maintenance

3.1.1 General

3.1.1.1 Design & Build for Operations and Maintenance (DBfOM) is a design philosophy to ensure that every infrastructure built or acquired by LTA can be operated and maintained in a practical and economical manner throughout its life cycle without compromising its safety, reliability or functionality.

3.1.1.2 The desired outcome of Design & Build for Maintenance is to ensure that all systems are easy to maintain, achieve high availability with minimal downtime and is cost-effective to maintain. Some of the generic attributes to realise this are summarised below:

- a. Physical Accessibility – considerations should be given to all areas requiring access for inspection and maintenance of installed systems or parts of infrastructure which require maintenance and making necessary design provisions for them. The size of required access openings, work surfaces, and workspaces should be determined and designed for so that components are accessible to maintenance personnel. Also, maintenance work at height and in confined space should be minimised as far as practicable. Furthermore, components that need to be repaired or replaced regularly should be easily accessible without the need for special access equipment/platforms and should not be designed to be deep within the system;
- b. Visual Inspection Access – facilitate visual access by ensuring:
 - i. an opening with no cover except where an uncovered opening might degrade system performance;
 - ii. transparent window is provided if dirt, moisture, or other foreign materials might create a problem;
 - iii. a quick-opening metal cover is provided if a transparent cover will not meet mechanical, structural or other requirements; and
 - iv. information or readings that needs to be read or monitored is unobstructed;
- c. Simplicity – avoid or minimise the need for specialised skill, tools or test equipment. This is to avoid additional training requirement, reduce the complexity of maintenance tasks and allow a wider pool of maintenance staff to perform all maintenance tasks;
- d. Standardisation – a clustering strategy should be adopted so that parts will be standardised as far as possible to reduce the variety, thereby easing maintenance and reducing spares inventory cost. Standardisation of components will also facilitate common inspection and efficient maintenance;

- e. Modularisation – adopt a modular design as far as possible to allow components to be easily replaced at operating site, if possible;
- f. Colour Coding and Labels as Appropriate – labelling, coding, caution and warning displays should be visible during all maintenance activities to increase maintenance efficiency and keep personnel out of danger;
- g. Human Factors Engineering – considerations should be given to the physical limitations of the human body for maintenance tasks in terms of maximum weight allowable for each equipment module.

3.1.1.3 The desired outcome of Design & Build for Operations is to ensure that all systems are easy to operate, resilient (doesn't fail catastrophically or is able to recover swiftly when it fails) and is cost-effective to operate. Some of the generic attributes to realise this are summarised below:

- a. Ease of operation (reach) – whenever human intervention is required, the human-machine interface should be ergonomically designed for the operator to minimise response time as well as to prevent information overload;
- b. Alternative during disruption – alternative routes or backups should be catered at critical nodes so that any disruption can be localised and minimised without crippling the entire network;
- c. Track work alignment for cross-overs, by-pass tracks and emergency sidings – adequate cross-overs, by-pass tracks and emergency sidings should be catered in the network design to enable speedy recovery actions and minimal service disruption during train faults;
- d. Fault/Failure resiliency - avoid designs with single points of failure that will result in catastrophic failure of the RTS system such as crippling of train service or immobilisation of a train on the main line;
- e. Accessibility to emergency recovery by-pass features – provide by-pass features and easy access to perform system fault/failure recovery actions without the need for staff to access track. This is to assure staff's safety and enable swift recovery actions.

3.1.1.4 All infrastructures shall be designed for durability and robustness with maintainability in mind. The designer shall ensure that all parts of the infrastructure, including components provided by the System Wide Contractors, are accessible for carrying out cleaning and maintenance (i.e. inspection, testing, repair and replacement) work.

3.1.1.5 The Designer shall ensure that all maintenance access is provided in accordance with the latest edition of the Workplace Safety and Health (WSH) Regulations.

- 3.1.1.6 The Designer shall ensure compliance with BCA Design for Maintainability Guide: Non-Residential where applicable.

3.2 Physical Accessibility and Visual Inspection Access

3.2.1 Electrical and Mechanical Services

- 3.2.1.1 The maintenance access to all services or equipment and maintenance boundaries shall be coordinated with the E&M Consultant and other interfacing contractors.
- 3.2.1.2 Ensure installation of any services that require maintenance or finishes that require regular cleaning and maintenance are at a height of less than or equal to 10.5 metres and the floor area below the services/finishes is flat to enable easy access via personnel lift.
- 3.2.1.3 Ensure at least 600mm unobstructed space or larger (where advised by equipment manufacturers' requirements) is provided around all E&M equipment for safe maintenance and replacement of components.
- 3.2.1.4 At high void areas, consideration shall be given to mount lights at low level within reach by ladder. This can either be on the surrounding walls, posts, a services boom or staircase/ escalator balustrade.
- 3.2.1.5 Avoid the need for scaffold towers, personnel lifts or track based hanging access systems to reach services or carry out regular cleaning and maintenance.
- 3.2.1.6 Ensure clear access through ceiling void is provided to reach any services that require regular maintenance.
- 3.2.1.7 Ensure adequate ceiling void space are designed to house both the services and any crawl-ways/catwalk within the ceiling.

3.2.2 Artwork

- 3.2.2.1 All artwork shall be above flat ground and easily accessible using ladders or personnel lifts for cleaning and maintenance. If any proprietary system is needed to operate and maintain an artwork, this shall also be highlighted to the Authority.
- 3.2.2.2 For all artwork, a maintenance strategy and access plan shall be considered upfront during the design stage. The Designer shall propose the maintenance strategy, maintenance access and equipment needed at Design Review to the Authority for their evaluation and acceptance. Where an acceptable solution cannot be reached, such an artwork shall be avoided.

3.2.3 Skylights

3.2.3.1 Skylights over voids or escalators in stations shall be avoided. If this cannot be avoided, they must be highlighted to the Authority for approval.

3.2.3.2 Appropriate maintenance equipment shall be catered to ensure that all surfaces of the skylights can be reached for cleaning, maintenance and replacement. If approved for installation, catwalk access must be provided around the skylight at varying levels.

3.3 Ease of Operation and Human Factors Engineering

3.3.1 Station Platform

3.3.1.1 Protruding columns along PSD shall be avoided where possible as it creates security blind spots and block the view of PSD indicator lights when operating the head wall / tail wall unit during degraded operation. If unavoidable, these operation concerns shall be highlighted during the design stage to identify appropriate mitigation measures.

3.3.2 Sidings

3.3.2.1 A dedicated safe and secured access path connecting sidings (side sidings and centre-siding within the station box) to the station shall be provided so that staff can move between sidings and station without crossing the mainline tracks during operation hours.

3.3.3 Floor, Ceiling and Wall Finishes

3.3.3.1 All access panels shall be designed to be removed/opened by one man.

3.3.3.2 Access panels shall be integrated with the surrounding finishes. Ideally both flushed and matching in finish, as well as integrated into the same grid.

3.3.3.3 No access panels shall be located in fire protected areas defined in the SFSRTS.

3.3.3.4 The position of cladding access hatches to scupper drain shall coincide with floor trap locations behind cladding. This is to allow efflorescent accumulated at the floor trap to be removed more easily.

3.3.3.5 All demountable ceiling panels shall be designed to be removed/opened by one man. All demountable ceiling panels are to be designed and secured to ensure the fixing will not loosen over time. The “fully locked” position of the ceiling panels’ securing devices shall be easily seen when visually inspected from below the ceiling.

- 3.3.3.6 In ceiling panel designs where a key is needed to open the ceiling panels, a common/universal key shall be used to ease maintenance.
- 3.3.3.7 Hinged downwards access panels shall be provided for easy opening if access is required on a yearly or more frequent basis. The access panels shall be integrated into the ceiling system.
- 3.3.3.8 Where design includes both fixed and demountable ceiling panels in a station, the location of the demountable ceiling access panels shall coincide with the location of E&M equipment to enable easy access to the E&M equipment.
- 3.3.3.9 Avoid ceiling panels above trackside for above ground station as they are difficult to reach and have limited access time. If unavoidable, the ceiling panels shall not be of material which can absorb water or corrode over time which makes them susceptible to falling off.
- 3.3.4 Glazing
 - 3.3.4.1 The sizes of glazing panels shall be standardized for easy replacement in the event of damage.
 - 3.3.4.2 Panels shall not deflect under its own weight. thereby allowing rainwater to pond on them, otherwise stain marks will form on the glass after evaporation.
 - 3.3.4.3 The panels size shall be kept small for easy handling during replacement. Panels shall be no larger than 2.4m x 3.6m as this is the typical largest size that is stocked by suppliers. Panels that exceed this size will need to be ordered from the factory and thus increasing down time. Provision must be made to facilitate glazing replacement and maintenance in the design.
 - 3.3.4.4 The glazing shall be sloped and the edges shall not be capped such that dirt and leaves falling on them are washed away during rain.
 - 3.3.4.5 The angle of the glass shall be checked against the angle of the sun across the day and across the year to assess the amount of sunlight entering the station or area it shelters. The glare from reflection of sunlight to present and future surrounding developments shall also be checked. This shall be quantified and presented for approval in order to achieve the optimum glazing angle and orientation.
- 3.3.5 Flood Barriers
 - 3.3.5.1 Where an existing station that does not meet the current PUB flood level requirement, and will undergo addition and alteration works to become an interchange station, the designer shall propose an optimum design for flood prevention system which shall
 - a. Require no or minimal maintenance;

- b. Be non-obstructive to commuter flow and does not pose as hazards to the disabled during normal RTS operation;
- c. Not reduce the clear widths of emergency escape routes;
- d. Be lightweight and easily set up by 1 person;
- e. Be stored near where it is to be deployed.

3.4 Maintenance Strategy and Access

3.4.1 Maintenance Strategy and Access Report

- 3.4.1.1 The designer shall provide a maintenance strategy and access report to demonstrate how cleaning, maintenance (inspection, testing and repair) and replacement work can be carried out efficiently. By referring to latest WSH Guidelines and SS 569 Code of Practice for Manual Handling, where an item cannot be handled by a single person, the designer shall propose and provide handling equipment / tools with appropriate mechanisms. This strategy shall be presented in a comprehensive report, which is to be submitted during key milestone (concept design, preliminary design, pre-final design, final design and final deliverables) and reflect all developments in the design / construction. The report shall include:
- a. specifying and demonstrating the means and measures adopted to meet the maintenance requirements under the prevailing Code for Environmental Sustainability of Buildings (New and Existing Buildings);
 - b. specifying all Architectural, Structural, E&M and System items;
 - c. specifying maintenance requirements for all items;
 - d. specifying cleaning requirements for all items;
 - e. Repair manual / method statements for all items;
 - f. the method statements to maintain and replace the systems, including specifying the access path and how maintenance access equipment can be manoeuvred to the respective designated maintenance locations (if required);
 - g. periodical inspection requirement of the glazing system and methodology for replacement of broken glass and routine cleaning. The methodology shall be demonstrated during design stage and verified on site with a full mock up at construction stage. For public

area or where there is impact to operation, site specific access and lifting equipment details shall be submitted for approval to demonstrate that glazing replacement can be achieved, including time frame required for mobilisation and demobilisation of such equipment, for all glass panels within 4 engineering hours;

- h. all equipment and tools necessary to achieve maintenance access. The storage space required to accommodate them within the facility shall be identified and designed for in the station layout. The storage space so identified shall contain all necessary hooks, shelves, and services necessary to store the maintenance access equipment and tools;
- i. safety equipment such as fall arrest systems and their O&M manuals;
- j. details of all specialist tools required for the operation of access panels;
- k. panels inspection including fixings and seepage etc;
- l. O&M manuals for motorised access equipment (if required);
- m. safe access, launching methodology and O&M manuals for the fixed maintenance access equipment;
- n. demonstration of services and associated components replacement from the fixed maintenance access equipment.

3.5 Maintenance Access Equipment (if required)

3.5.1 General

3.5.1.1 Rope access for maintenance shall not be considered unless specifically approved by the Authority. If unavoidable and approved for use, all associated maintenance access and specialised equipment shall be catered for.

3.5.1.2 The designer shall demonstrate where and why access to any services and regular cleaning beyond the limits set in IDC Volume B Safety Requirements is unavoidable and highlight it for design approval. High level access using maintenance access equipment that is either; fixed, portable, or deliverable to each staging/launching location in the facility may be included in the maintenance strategy subject to sufficient demonstration on accessibility and upon agreement of the Authority. Otherwise the designer shall take all necessary steps to lower the services and design for low level access to facilitate regular cleaning and maintenance.

3.5.1.3 Additional restrictions for MRT stations:

- a. Only tower scaffold and personnel lifts (if required) should be considered for use. These will be provided via a separate contract to be awarded by the Authority at a later date;
- b. Other mobile maintenance access equipment besides tower scaffold and personnel lifts shall not be considered within MRT station unless specifically approved by the Authority;
- c. Any proposed maintenance equipment that is fixed to or integrated with the finishes or in addition to the tower scaffold and personnel lift, shall be included and provided under the respective civil contracts (e.g. catwalk).

3.5.1.4 The maximum platform height for personnel lifts and tower scaffold, the footprint (including that of the outrigger, if required) and the need for bracing points shall be stated at each location where it is expected to be used.

3.5.1.5 The maximum platform height for personnel lifts shall be 9.0m (to reach equipment installed at up to 10.5m). The personal lifts shall be of dimension and the weight that can be transported by passenger lifts in MRT station. The deployed footprint shall be less than the space allowed at the usage location.

3.5.1.6 The safety of use and maximum height of tower scaffold shall be certified by a qualified person taking into consideration the floor clearance available at the location where the scaffold is intended to be used. The designer may refer to the following table as a guide and obtain the Authority's acceptance of the design.

Location	Floor clearance available	Provisional Maximum Height of Scaffold Platform
Staircase (narrow)	<1.5m width	2.0m
Staircase (no central railing)	1.5m - 1.9m width	4.5m
Staircase (with central railing)	2.1m - 2.9m width	
Staircase (no central railing)	2m width	6m
Staircase (with central railing)	≥ 3m width	
Open area (narrow)	2m x 2m	5.5m
Open area (general)	3.5m x 3.5m	10m

3.6 Maintenance Boundary

3.6.1 General

- 3.6.1.1 The designer is to work closely with the Authority in identifying the maintenance boundary of the transport facility. The maintenance boundary shall then be clearly indicated on the Site Plan and submitted to the Authority.
- 3.6.1.2 All E&M services and facilities not serving the transport facility shall be located outside the maintenance boundary and designed with independent access.

CHAPTER 4 – SECURITY REQUIREMENTS
NOT AVAILABLE

CHAPTER 5 - SUSTAINABILITY AND BUILDING PERFORMANCE REQUIREMENTS

Table of Contents

5.1	Design for Sustainability	2
5.1.1	General	2
5.2	Building Performance Criteria	2
5.2.1.	Energy & Resource Conservation	2
5.2.2.	Thermal Comfort and Indoor Air Quality	3
5.2.3.	Lighting Design Considerations	3
5.2.4.	Acoustic Design	5

5.1 **Design for Sustainability**

5.1.1 General

5.1.1.1 All stations shall be designed to meet the prevailing Code for Environmental Sustainability of Buildings and shall achieve minimally BCA Green Mark Gold Certification unless otherwise specified or as required under the GreenGov (Public Sector Taking Lead in Environmental Sustainability (PSTLES)) requirements.

5.1.1.2 The design shall aim to deliver environmental, social and economic benefits to all stakeholders and users, throughout the project lifecycle.

5.1.1.3 Designers shall address sustainability in totality by:

- a. establishing measurable robust sustainability objectives and targets for the station at the early design stages of the project through an Integrative design process as per GreenGov (PSTLES) framework;
- b. studying the feasibility of reducing the station depth; during the review of line alignment to minimise station volume;
- c. undertaking the following environmental studies during design stages:
 - i. solar radiation and shadow analysis as per Section 1.11 of Chapter 1 of IDC VOL B.I; and
 - ii. thermal comfort and natural ventilation performance using CFD simulations as per Section 1.11 of Chapter 1 of IDC VOL B.I;
- d. undertaking energy modelling simulation to test station's energy load reduction strategies and energy saving measures, where required.

5.2 **Building Performance Criteria**

5.2.1 Energy & Resource Conservation

5.2.1.1 Station systems and services shall be designed to operate at optimised station environment.

5.2.1.2 Innovative technology-based solutions to be adopted for maximising energy and resource conservation where possible.

5.2.1.3 Water sub-meters shall be provided for public toilets and cooling towers to promote better control and monitoring of station water usage.

5.2.1.4 Explore renewable energy options such as, harness solar energy for generation of electricity by installing PV panels where applicable. For more detailed requirements on provision of Solar PV, refer to Annex B – MRT Station Room Datasheet of IDC Volume B Part I.

- 5.2.1.5 All sanitary ware, fittings and fixtures shall be certified with WELS 'Excellent' rating (3 ticks) or above.
- 5.2.1.6 Non-structural building components and constructions such as architectural finishes and systems, including but not limited to waterproofing, floor systems, wall systems, wall panels, ceiling systems, roof systems, exterior walls, toilet partitions, interior paints, screed, etc., shall be certified with a minimum of 'very good' rating or above by SGBC or Singapore Green Label Scheme.
- 5.2.2 Thermal Comfort and Indoor Air Quality
 - 5.2.2.1 The public and back of house areas in a station shall be designed to meet acceptable thermal comfort level and indoor air quality as prescribed by the prevailing codes.
 - 5.2.2.2 For underground stations that are air-conditioned, the design temperature for public area and subway shall be 25°C and 27°C respectively.
 - 5.2.2.3 Scheduling of air purging system with Local Sequential Controller (LSC) program to automatically purge air before revenue hours shall be adopted to maintain acceptable indoor air quality.
 - 5.2.2.4 For aboveground stations that are naturally ventilated, passive cooling strategies including solar shading, façade design and treatment, etc., shall be adopted to reduce heat gain into interior space to enhance cross ventilation and thermal comfort.
 - 5.2.2.5 Where required, air circulation fans shall be provided to further supplement air movement and enhance thermal comfort in station public areas.
 - 5.2.2.6 The station indoor spaces shall be designed to be free from any Volatile Organic Compounds (VOC) by using products (prefinished coatings, adhesives, paints, etc.) that are low in VOC and certified by SGBC or approved local certification body.
 - 5.2.2.7 Designers shall propose an outdoor air filtration strategy and design provision for required measures such as provision of filtration media, necessary for maintaining acceptable air quality levels within stations.
- 5.2.3 Lighting Design Considerations
 - 5.2.3.1 Designers shall define the architectural lighting concept that integrates with and enhances the overall architectural design intent. This shall extend to all public areas accessible and visible to the public within the station.
 - 5.2.3.2 The architectural lighting concept shall contribute to clarity in the passenger route and support the identification of key station functions such as Passenger Service Centre, ticket kiosks, gatelines, vertical circulation

elements, platforms, and entrance / exit routes. The lit environment shall provide an atmosphere of safety.

- 5.2.3.3 For lighting levels and uniformity ratio for all areas / rooms in a station, refer to Annex B – MRT Station Room Datasheet of IDC Volume B Part I.
- 5.2.3.4 All public spaces are to be lit consistently with additional lighting provided at essential user touchpoints that guide them to move intuitively through the station.
- 5.2.3.5 The station envelop shall be designed to bring in daylight to public areas where possible, while taking care to reduce or eliminate glare from the sun.
- 5.2.3.6 Artificial lighting shall be introduced to supplement daylight only where required.
- 5.2.3.7 Lighting shall be integrated into escalators and staircase balustrades to provide a base level of illumination on all steps.
- 5.2.3.8 Designers shall coordinate the interfacing of lighting fixtures with station finishes and services.
- 5.2.3.9 Designers shall consider maintainability in the lighting design in terms of number of lamp types and accessibility. The maintainability of the lighting system shall be demonstrated in the maintenance strategy report and submitted for Authority's acceptance. Refer to Chapter 3, Operations and Maintenance Requirements of IDC Volume B Part I for more details.
- 5.2.3.10 General principles applicable across the station:
 - a. Design to improve visibility, contrast, visual comfort, especially for partially sighted and commuters with low vision. Avoid sudden change in lux level;
 - b. Glare and dazzle shall be avoided by determining the relative position and angle of light source to the commuters and the reflectivity of finishes;
 - c. Use energy efficient lighting and lighting control systems;
 - d. Platform edges shall be highly illuminated to alert commuters;
 - e. Information zone and signage shall be accentuated;
 - f. Avoid casting shadow on wall mounted signage or artwork; and
 - g. For areas using balustrade lighting, supplementary ambient lights shall also be provided to balance the uplighter effect.

5.2.4 Acoustic Design

5.2.4.1 General

- a. The objective of acoustic design is to engender a desirable environment, physiologically and psychologically safe and comfortable for all occupants, free from excessive reverberation, noises and vibrations, and to permit clear intelligibility of Public Address (PA) announcements.
- b. Calculate the Speech Transmission Index (STI) and the Reverberation Times (RT) for station public area and Passenger Service Centre. The STI shall be submitted for Authority's Acceptance.
- c. Coordinate with the SWCs to review the E&M plant rooms and aboveground structures of the station including vent shafts and cooling towers to identify potential noise sources and recommend mitigation measures (which may include providing acoustic louvers at the cooling tower enclosure and/or acoustic lining within the ventilation shafts and/or E&M plant rooms, etc.) if the noise criteria are exceeded. An acoustic report is to be submitted to demonstrate that the noise generated from these station structures are within NEA's requirement. The effect of potential external noise sources on the station and its entrances shall be taken into account. The design shall avoid exterior noise affecting the PA system.

5.2.4.2 Interior Public Spaces

- a. Interior public spaces shall be provided with adequate sound absorptive treatment, taking into consideration architectural details such as finishes, shape and the volume of major spaces, to satisfactorily attain design reverberation times (RT).
- b. The RT are predicated on intelligibility of speech communication both face to face and through any PA system and shall be provided as follows.
 - i. The RT at 1 kHz shall not exceed 1.8 seconds in any public area. In areas where the ceiling height is lower than 5m, the target RT at 1 kHz shall not exceed 1.6 seconds.
 - ii. The background noise level in interior public areas, excluding noise from the trains, traffic and public, shall not exceed 55 dB(A).
 - iii. The Speech Transmission Index for Public Address System (STIPA) shall achieve the required level in all interior public areas in co-ordination with the PA system supplier.
- c. Additional noise from traffic/ train events, and exterior noises shall be minimised to provide a comfortable acoustic atmosphere.

- d. Background noise shall not interfere with the clarity of public announcement messages or normal voice communication at distances up to 3.0m.
- e. Sufficient noise insulation shall be provided for air-conditioning and mechanical ventilation equipment and ducting to ensure the ambient noise levels within interior public spaces are kept within acceptable limits.

5.2.4.3 Layout

- a. Refer to Annex B – MRT Station Room Datasheet of IDC Volume B Part I for maximum anticipated noise generated within each room.
- b. Plant rooms with an anticipated noise generated in excess of 70dB(A) shall be located away from public areas and segregated from staff office areas where possible.
- c. Location of mechanical equipment and other noise producing devices should be taken into consideration in determining their contribution to the overall noise level where applicable.

5.2.4.4 Noise Containment and Damping

- a. Partitions and the floor/ ceiling construction surrounding mechanical equipment and plant rooms should be of construction rating Sound Transmission Class (STC) of minimum 50.
- b. Doors from rooms with an anticipated noise of 70dB(A) or more shall avoid opening directly to public areas. If unavoidable, appropriate STC rated doors shall be used in order to ensure the public area noise level does not exceed 55dB(A).

5.2.4.5 Staff Offices

- a. Acoustic ceilings and any other treatments shall be employed to attain Reverberation Time (RT) not exceeding 0.8 seconds at 1 kHz for any office or staff room.
- b. Partition construction must be adequate to isolate such spaces from train, traffic and mechanical equipment noises and provide an ambient noise level that is in accordance to SS 553 for general offices.
- c. For acoustic treatment within the PSC and SMR, refer to Annex C – PSC Design Guidelines of IDC Volume B Part I.

5.2.4.6 Interfacing Developments

- a. Noise at the station boundary shall not exceed the limits set out in NEA's Technical Guidelines on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation System in Non-industrial Buildings.
- b. Vent shaft openings and cooling towers shall be orientated and located away from noise sensitive neighbouring properties such as hospitals, residential developments, libraries, etc.
- c. Noise transmission from vent shaft openings, cooling towers and other mechanical ventilation equipment to surrounding commercial and residential properties shall be reduced using noise control mufflers, acoustic louvers, attenuator and/or sound barriers to comply with NEA's guidelines.

5.2.4.7 Vibration

- a. Mechanical equipment located near public spaces shall be mounted on/ with suitable vibration isolation systems. The selection of mounting type and static deflection shall be based on the equipment characteristics and location.
- b. Structural vibration from traffic and train movement shall be calculated/ simulated and mitigation measures shall be proposed so that it is not discernible by occupants of the station. Particular consideration shall be taken for elevated trainways and stations, including any integration with bus interchanges.
- c. Vibration from train movement shall not affect elevated station's roof structure in particular the equipment and features mounted on the roof structure.
- d. Acoustic and structural designers shall work together closely to ensure all findings and recommendations of the study are addressed in the structural design.

5.2.4.8 Acoustic Modelling and Treatments

- a. The acoustic environment of the station shall be modelled in 3D capturing all sources of noise to determine:
 - i. the sound absorption at 1KHz for each surface in public and office areas, in order to meet the required Reverberation Times (RT);
 - ii. the required insulation at each barrier, structure or partition in order to contain and control noise from exceeding the specified noise limits;

- iii. any required separation between structures to prevent propagation of vibrations, including proposed mitigation measures if structures are not separated; and
 - iv. the Speech Transmission Index for Public Address System (STIPA) achieved at each location in the public areas that are required for the performance of the PA system.
- b. Acoustic treatments shall be proposed and integrated into the design in combination with other systems (e.g. finishes, security barriers) with the required coverage and absorption or insulation properties as determined in the model to achieve the required acoustic performances.

CHAPTER 6 – SAFETY GUIDELINES

Table of Contents

6.1	Preamble	2
	6.1.1 General	2
6.2	Construction Safety	2
	6.2.1. General	2
6.3	Operations & Maintenance Safety	2
	6.3.1. General	2
	6.3.2. Working at height	2
	6.3.3. Confined space	4
	6.3.4. Access	4
	6.3.5. Handrails and Railings	5
	6.3.6. Ergonomics	5
	6.3.7. Visual Contrast.....	5
6.4	Public Safety	6
	6.4.1. General	6
	6.4.2. Public Health.....	6
	6.4.3. Handrails and Railings	6
	6.4.4. Slipping and Trip Hazards.....	7
	6.4.5. Avoidance of Obstructions	9
	6.4.6. Avoidance of Hazards	9
	6.4.7. Roadside Safety.....	10
	6.4.8. Visual Contrast.....	10
	6.4.9. Information displays	11
	6.4.10. Rendezvous points	11

6.1 Preamble

6.1.1 General

6.1.1.1 The Workplace Safety and Health Act, relevant subsidiary legislations, approved Code of Practices, Guidelines and published Singapore Standards shall be adhered to.

6.1.1.2 Design for Safety must be taken into consideration in reference with the latest prevailing Workplace Safety and Health (Design for Safety) Regulations and the Workplace Safety and Health Guidelines (Design for Safety).

6.1.1.3 The designer shall with due diligence make reference to the latest prevailing revisions of the legislations and regulations mentioned in the legal register of IDC Volume B Part 1 Annex M. The designer shall ensure that the designs cater for the adherence of these requirements in construction, operations & maintenance as well as for public safety.

6.2 Construction Safety

6.2.1 General

6.2.1.1 Rail infrastructure facilities shall be designed to ensure that it can be constructed in a safe manner. Design considerations must include safety for the workforce and public in compliance with LTA's General Specifications (GS) Appendix A Safety, Health and Environment.

6.3 Operations & Maintenance Safety

6.3.1 General

6.3.1.1 Rail infrastructure facilities shall be designed to ensure the facility can be safely operated, maintained and replaced, in consideration of both the operators and the public using the facilities.

6.3.2 Working at height

6.3.2.1 Avoid the installation of any services requiring maintenance or finishes requiring regular cleaning at a height greater than: 4 metres above level ground or 3 metres above staircases.

6.3.2.2 Ensure there is no installation of any services requiring maintenance or finishes requiring regular cleaning at a height greater than 3 metres above escalators.

6.3.2.3 For high-void areas, mounting lights within safe reach should be considered. Provision of safe access, and catwalks (if feasible) shall be considered in cases where light mounting at high levels cannot be avoided. Alternatively, lights which can be lowered should be considered.

- 6.3.2.4 Design to avoid the need for the use of scaffold towers, personnel lifts or track based hanging access systems to access services or carry out regular cleaning.
- 6.3.2.5 At roof and high void ceiling areas, lifeline fall arrest systems should be provided only when the provision of safe access and catwalks are not feasible for maintaining the facility safely. Ease of inspection/testing of fall arrest system shall be considered. The safe access to the lifeline fall arrest systems shall also be considered.
- 6.3.2.6 The removal of ceiling panels shall be designed such that it could be handled by one worker with platform ladder/personal lifting platform.
- 6.3.2.7 Safety measures shall be taken to prevent removable components from falling during maintenance, removal and reattachment, such as the use of securing safety chains.
- 6.3.2.8 In overhead areas where vibration is expected, the use of screws/bolts with self-loosening prevention system shall be considered.
- 6.3.2.9 Ensure a standing platform is provided below any overhead access hatches to allow for safe access and for ease of opening. The access hatch shall be able to be opened/closed by one hand.
- 6.3.2.10 All lifelines shall be designed for fall arrest application and account for the number of workers required to work at height.
- 6.3.2.11 Fixed ladders shall be provided to connect different levels of roof if the difference in level presents a potential hazard of falling and/or tripping.
- 6.3.2.12 Workers on Building Maintenance Unit or Aerial Work Platform shall be able to disembark safely onto the nearest floor level if power is down or equipment malfunctions during operation.
- 6.3.2.13 Where secured footholds/handholds/railings are not able to be installed, secured anchorage for lifelines and fall arrest systems shall be provided.
- 6.3.2.14 Proper barricade/protection such as parapet walls should be provided for perimeter drains such that the maintenance crew is protected against falling from height.
- 6.3.2.15 Railings shall be installed at all edges of slabs/opening to prevent falling from height during maintenance.
- 6.3.2.16 Where there is equipment in the double slab area, removable railing shall be provided. Wherever possible, cat ladder shall be provided to access height of more than 2m. Where there is no equipment in the double slab area, a signage indicating “No Access” shall be added.

- 6.3.2.17 All floor access hatches shall be marked with yellow and black stripes around as a warning for the floor opening.
- 6.3.3 Confined space
 - 6.3.3.1 For horizontal accesses, it should open upwards. If the spaces are connected by narrow passages less than 600mm, access openings shall be provided for the confined spaces respectively. Access shall be positioned or orientated such that it does not conflict with other access/services.
 - 6.3.3.2 The size of required access openings, work surfaces, and workspace should be determined so that components are accessible to maintenance personnel. Also, maintenance work at height and in confined space should be minimised as far as practicable. Furthermore, components that need to be repaired or replaced regularly should be easily accessible without the need for special access equipment/platforms.
 - 6.3.3.3 If the confined space is reasonably large, more access points shall be provided for easy escape and gas monitoring.
 - 6.3.3.4 Avoid providing utilities and services in the confined space wherever possible.
- 6.3.4 Access
 - 6.3.4.1 Dedicated maintenance access shall be provided where it is practicable and cost-effective, and subject to LTA's approval.
 - 6.3.4.2 All roof and linkways should be designed to allow maintenance access.
 - 6.3.4.3 Ceiling frame over high voids should be designed for maintenance use.
 - 6.3.4.4 Ensure clear access through any ceiling void is provided to reach any services that require regular maintenance.
 - 6.3.4.5 Ensure adequate ceiling void space are designed to house both the services and any crawlways / catwalk within the ceiling.
 - 6.3.4.6 Doors shall be designed to be opened so as to minimise obstruction to user. If feasible, see through window shall be installed on the door.
 - 6.3.4.7 Safe and proper access shall be provided for all parts of the infrastructure that requires frequent inspection and maintenance.
 - 6.3.4.8 All plant rooms shall be adequately sized so that there will be sufficient space for safe and proper access, operation, maintenance and future replacement of the equipment.

6.3.5 Handrails and Railings

6.3.5.1 Barriers shall be provided in accordance with the requirement of the current edition of the Standard for Building Control Regulations and Code on Accessibility in the Built Environment.

6.3.5.2 Kick plates shall be provided for access and maintenance platforms.

6.3.5.3 Removable railing of shall be provided for closet opening to deep volume spaces.

6.3.5.4 Where applicable, railing shall be provided around cat ladder access to water tank area to prevent falls.

6.3.5.5 The fixing bracket to any handrail shall be on the underside and shall not impede the handhold along the whole length of the railing.

6.3.5.6 Refer to the Civil Design Criteria Chapter 3 for requirements relating to live loads at handrailing and balustrades

6.3.5.7 Handrails ends shall turn down or return to the wall or balustrade with no open end.

6.3.6 Ergonomics

6.3.6.1 The infrastructure development process should include a human factors integration plan. Human Factors (HF) is a scientific discipline that looks to optimise the interactions between people and the systems they live and work within. HF should be considered from the early design phase to ensure that the work environment and physical layout and positioning of equipment matches human capabilities and planned task requirements. Consideration should be given to the physical limitations of the human body for maintenance tasks in terms of maximum weight allowable for each equipment module.

6.3.7 Visual Contrast

6.3.7.1 Labelling, coding, caution and warning displays should be visible to increase maintenance efficiency and keep personnel out of danger.

6.3.7.2 In addition, the designer shall also comply with the guidelines in 6.4.8 Visual Contrast for Public Safety.

6.4 Public Safety

6.4.1 General

6.4.1.1 Rail infrastructure shall be designed to ensure a safe environment for public use.

6.4.2 Public Health

6.4.2.1 Adequate drainage and surface slope-to-falls shall be provided to eliminate any possibility of water ponding adjacent to surface structures.

6.4.2.2 Anti-mosquito and pest/vermin control measures shall be taken into consideration in accordance with NEA requirements

6.4.2.3 For all stations, at least 2 Automatic External Defibrillators (AEDs) and 1 SCDF Box holding SCDF equipment shall be provided per line as per following:

- a) A stacked AED Box and SCDF Box flush mounted to a wall adjacent to the PSC at the concourse level non-ticketed area.
- b) A second AED mounted centrally at the platform. This could be located together with one of the required emergency fire phones.

6.4.2.4 Additional AEDs may be required at stations with:

- a) Long subways links, where the outer perimeter of a remote entrance is beyond reach from the AED adjacent the PSC. An additional AED shall be provided at a prominent location near the entry point to the long subway.
- b) Shopping levels, where additional AEDs may also be considered.

6.4.3 Handrails and Railings

6.4.3.1 Barriers shall be provided in accordance with the requirement of the current edition of the Standard for Building Control Regulations and Code on Accessibility in the Built Environment. Barriers shall be provided at all abrupt changes of level greater than 450mm accessible to the public including at public area staircases and landings. These barriers shall be a minimum of 1.2m overall height measured vertically from the finished floor level or pitch line of a flight of stairs to the top of the highest continuous horizontal member.

6.4.3.2 All public area staircases shall include two handrails (one standard and one child) on both sides at 900mm and 700mm measured vertically from the pitch line of the staircase to the top of the handrail.

- 6.4.3.3 The design of railings terminating at an escalator shall be integrated and consistent with any escalator handrail. A proper interfacing detail is required to close the gap between both.
- 6.4.3.4 The fixing bracket to any handrail shall be on the underside and shall not impede the handhold along the whole length of the railing.
- 6.4.3.5 Refer to the Civil Design Criteria Chapter 3 for requirements relating to live loads at handrailing and balustrades.
- 6.4.3.6 Handrails at ramps shall be continuous throughout the entire length (including beside any intermediate landings).
- 6.4.3.7 Handrails and grab bars on the accessible route shall contrast with the colour of its background to aid visibility.
- 6.4.3.8 Central handrails on staircases shall break across all intermediate landings which have at least 1500mm depth as long as the central handrail extends 300mm into the landing at both ends (refer below for required handrail ends) leaving a clearance of at least 900mm. Side handrails shall be continuous across intermediate landings.
- 6.4.3.9 Handrails ends shall turn down or return to the wall or balustrade with no open end.
- 6.4.3.10 Handrails for staircases and escalators should not have overhead obstructions. Where unavoidable, the space above the handrails shall have a minimum of 450mm clearance above the handrail.
- 6.4.3.11 There should be no protrusion within 300mm of the outer edge of the escalator handrail apart from any balustrade.
- 6.4.4 Slipping and Trip Hazards
 - 6.4.4.1 The choice of floor finishes shall comply with the current edition of Singapore Standard (SS) 485 'Slip Resistance Classification of Public Pedestrian Surface Materials'.

6.4.4.2 All floor finishes shall be certified to the following minimum classification under SS 485.

Areas	Wet Pendulum Test Classification	Oil-wet Inclining Platform Test Classification
Ramps or slopes steeper than 1:25 in; <ul style="list-style-type: none"> • External areas, • Covered linkways, and • Commuter facilities 	V or P5	R12
External areas on flat ground (Gradient at 1:25 or gentler)	W or P4	R11
Covered linkways and commuter facilities on flat ground (Gradient at 1:25 or gentler)		
Staircase treads and landings externally and at entrances leading to the subway or concourse level		
All staircase nosing		
Ramps or slopes steeper than 1:25 in; <ul style="list-style-type: none"> • Sheltered Entrance areas, • Internal areas 	X or P3	R10
Sheltered entrance areas		
Station areas up to the first 10m from the entrance staircase or escalator into the subways and concourses areas		
All Staircase treads and landings internally other than those at entrances leading to subway or concourse level.		
Any potentially wet areas within the station public areas and staff facilities (e.g. toilets, changing rooms)	Y or P2	R9
Station areas under natural ventilation beyond 10m from the station entrance staircase or escalator		
Station areas under air-conditioning beyond 10m from the station entrance staircase or escalator		
	Z (reading between 12 and 24) or P1	R9

6.4.4.3 All floor finishes achieving classification 'Z', 'P1' or 'R9' shall also meet the classification of 'F' or 'D1' under the dry floor friction classification of SS 485.

6.4.4.4 Designs shall not incorporate protruding elements or gaps that contribute to tripping/entrapment hazards.

- 6.4.4.5 Where two floor materials meet, the floor shall be level across the junction to avoid any tripping hazard.
- 6.4.4.6 Single risers at changes of level shall be avoided. There shall be a minimum of three otherwise, ramp shall be provided.
- 6.4.4.7 All steps shall be fitted with non-slip grooved colour contrasting nosing tiles between 50mm and 65mm in width.
- 6.4.4.8 Rubber nosing strip, and metal insert are not acceptable for both internal and external staircases.
- 6.4.4.9 All external stair treads shall be well drained to prevent water from ponding on the tread.
- 6.4.4.10 Non-slip drain covers shall be installed levelled with the footpaths. Drain cover designs shall not incorporate openings or gaps that can cause tripping
- 6.4.5 Avoidance of Obstructions
 - 6.4.5.1 Obstructions within public spaces shall be avoided in compliance with current edition of the Code on Accessibility in the Built Environment.
 - 6.4.5.2 Wall mounted furniture and components, including handrail extensions, shall be located to minimise intrusion into the pedestrian flow areas. If unavoidable, design to provide visual warnings or systems to prevent accidental collisions or impacts.
- 6.4.6 Avoidance of Hazards
 - 6.4.6.1 Lightings shall be provided in accordance with the requirements of the Room Data Sheets. Areas of shadow shall be avoided and lighting shall be evenly spread particularly along ramps.
 - 6.4.6.2 Clear line of sight shall be maintained as far as possible with an avoidance of recesses, hidden corners, and visual obstructions.
 - 6.4.6.3 Sharp edges or corners shall be avoided.
 - 6.4.6.4 Rough textured and reflective wall finishes shall be avoided where people may come into contact with it.
 - 6.4.6.5 Upstands (kerbs, parapets, etc.) shall be provided at the sides of all drops to prevent falling objects. The top of upstands shall be sloped to fall away from the lower level below.
 - 6.4.6.6 Doors swinging out into the public area shall be avoided particularly across defined pedestrian routes.

- 6.4.6.7 Freestanding elements such as seats, signboards, art pieces shall not be positioned in circulation areas or pathways.
- 6.4.6.8 The contractor shall design with due diligence to meet the authority's requirements for platform gaps, taking into consideration of factors including the construction tolerances and close interface with external contractors such as those of Platform Screen Doors and Rolling Stocks.
- 6.4.6.9 Low headroom safety hazards shall be avoided for the design of fire protection pipes and services along/across escape staircases and passage ways.
- 6.4.7 Roadside Safety
 - 6.4.7.1 There shall be no shared routes between pedestrians and moving vehicles at all surface structures.
 - 6.4.7.2 Kerb ramps shall not project into the road.
 - 6.4.7.3 Vehicle should not be allowed to reverse through pedestrian routes without a traffic controller.
 - 6.4.7.4 The lateral clearance between the outer edge of the road kerb and any element shall be minimum 0.6m. For other conditions and more information, refer to CDC Chapter 10.
- 6.4.8 Visual Contrast
 - 6.4.8.1 In general, visual contrast for visibility of elements shall be attained by having a minimum of 30% luminance or brightness contrast. The use of colour contrast may also be used subject to the approval of the Authority. Ideally any contrasting colours used to distinguish elements for the visual impaired shall also have 30% brightness contrast.
 - 6.4.8.2 Tactile warning tiles and tactile route indicators shall have 50% luminance or brightness contrast either between the studs and the floor tiles or the floor tiles with tactile and surrounding floor finishes.
 - 6.4.8.3 Seats, sanitary fittings in the disabled toilet, grab bars, door handles, railings, end panels to phone booths and any elements used by the public shall contrast in colour or tone from their surroundings.
 - 6.4.8.4 If an obstruction is inevitable it shall contrast with its surroundings.
 - 6.4.8.5 Floor surfaces shall contrast with the walls in tone and colour, otherwise the skirting must provide a clear distinction between the floor and wall.
 - 6.4.8.6 There shall be a permanent tonal contrast between treads and nosing for all steps.

- 6.4.8.7 Tactile warning strips shall be provided at the top, bottom and intermediate landings leading to another path of travel.
- 6.4.8.8 Tactile warning strips are not required at enclosed intermediate landings where handrails are continuous and do not lead to another path of travel. Colour contrast shall be provided instead.
- 6.4.8.9 Tactile warning strips shall extend the full width of the stairs for a depth of 600mm commencing 300mm back of any staircase as defined by the Code on Accessibility in the Built Environment.
- 6.4.8.10 Tactile warning strips for ramps or slopes shall extend across the full width of the ramp or slope and shall be at a depth of 300mm or 600mm depending on how it ties in with any adjoining staircases, with a setback of 300mm from the edge of the ramp or slope.
- 6.4.8.11 Tripping hazard and slip resistance shall be addressed in accordance with SS 485.
- 6.4.8.12 Should the ramp form part of the tactile route, the tactile routes shall terminate at the top/bottom of the ramp at the tactile warning strip. The termination shall be kept 600mm off to the side of the same handrail.
- 6.4.9 Information displays
 - 6.4.9.1 Passenger information displays should be located so that passengers seeking information do not obstruct the free flow of other passengers.
- 6.4.10 Rendezvous points
 - 6.4.10.1 A rendezvous point for emergency services shall be identified in a place of safety which allows for readily access to their vehicles.