This Singapore Standard was approved by the Building and Construction Standards Committee on behalf of the Singapore Standards Council on __________.

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- Singapore Green Building Council  
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Foreword

This Singapore Standard was prepared by the Technical Committee on Building Maintenance and Management under the direction of the Building and Construction Standards Committee.

It aims to enhance high maintainability of facilities through identifying the common maintainability issues and the corresponding requirements for good practices by designers, constructors and facilities managers at the outset of the planning/design stage.

In preparing this Standard, reference was made to the following publication:


Acknowledgement is made for the use of information from the above authors.
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0 Introduction

The standard is intended to provide guidance and methodologies to building professionals involved in the design, construction and maintenance of a facility.

The objectives are:

a) To enhance high maintainability of facilities through identifying the common maintainability issues and the corresponding requirements for good practices by designers, constructors and facilities managers at the outset of the planning/design stage.

b) To recommend best practices for the respective professionals from design, construction to maintenance stages, in a practical, concerted and conscientious manner towards high maintainability, safety and productivity goals.

c) To create a self-learning and practicing platform for all building professionals to collaborate consistently, in up-keeping the whole life performance and economic value of a facility within the environmental constraints.

1 Scope

The standard identifies common maintainability issues of facilities and recommends the relevant best practices applicable to design, construction and facilities management. Major components of a facility include basements, wet areas, facades, common areas, roofs and M&E systems.

Actions to be taken in accordance to existing or new standards or requirements that should be considered at the design, construction and maintenance stage are outlined in the respective schedules.

2 Normative references

TBA

3 Good Practices for Design, Construction and Operation

3.1 General

Design and construction for maintainability should consider the needs and requirements of the owner and users of the facilities. The key principles are that the operational requirements and expected maintenance performance outcomes of the buildings and facilities should be considered from the outset through the design and construction stages and into operation.
In order to achieve high maintainability of facilities, coordination among professionals and accurate transfer of information throughout the complete delivery process (from design through construction and into operation) are essential.

### 3.2 Good practices for design

In general, the design team (including Architect, M & E Engineer, and Structural & Civil Engineer) is required to do the following as good practice:

a) To consider the implications of design on future maintenance of the buildings and facilities i.e. how the design features should be maintained in a cost-effective and safe manner.
b) For complex or unique design features, to provide a statement on how these special features should be maintained.
c) To explore attributes of building materials, in order to specify the correct materials and building components for use in construction.
d) To appreciate the different M & E systems, in order to specify the correct systems for use in construction.
e) To alert owners or users on the impact of new materials and systems on future maintenance that are incorporated in the buildings and facilities.
f) To improve on the design and detailing of the buildings and facilities with a view to achieving maintainability but without sacrificing on the design.
g) To explore the use of green materials and design.
h) To consider the lifecycle of the materials and products in accordance with the requirements of the owner.

To have a better structural design that will lead to a better maintainability of structures in the future, the structural designers should have a good overview on the possible maintainability issues especially in the wet area, basement, façade and roof. As most of these maintenance issues are related to seepages, leakages and water tightness, besides the structural integrity and other structural compliances to the relevant code of practices, the integration with all other critical disciplines such as architectural works, M&E items are crucial. While a lot of specialist details may be left to the contractors during project execution stage, a good structural designer should first ensure no conflict and crashes with items by other disciplines, addressed the integration issues up front, and ensure the specialist details submitted during project execution in compliance with the design intend, functionality and specifications.

### 3.3 Good practices for Construction

In general, the construction team (including Builder, Sub-Contractor and Supplier) is required to do the following as good practice:

a) To focus on achieving good workmanship in construction to reduce defects and failures.
b) To ensure proper and safe integration and co-ordination of different trades and elements during the construction.
c) To suggest more efficient design and to adopt more effective construction methods to achieve higher maintainability.
d) To suggest the use of suitable materials to improve maintainability of buildings and facilities.

Include a summary of the main issues for construction
3.4 Good practices for operation and maintenance

In general, the maintenance team (including Facilities Manager and Property Manager) is required to do the following as good practice:

a) To promote proper and safe usage of buildings, systems and plants.
b) To use correct equipment and tools in maintenance work.
c) When possible, to establish a feedback loop to design and construction in the value chain by examining the gaps between design and maintenance, and construction and maintenance.
d) To consider the application of technology such as use of electronic devices to record, retrieve maintenance records and progress.
e) To consider the application of technology such as use of robots to maintain difficult or inaccessible sites.
f) To undertake regular upkeep and maintenance by establishing effective maintenance programmes.
g) To engage owners, tenants and occupiers in the maintenance programmes.

4 Overview

Potential issues and factors that should be taken into consideration during the design, construction and maintenance of the major components of a facility are appended in the following annexes.

A. Basement
B. Wet area
C. Facade
D. Roof
E. Common areas
F. Mechanical & Electrical Systems
Annex A
(Normative)

Basement

A.1 Design Concerns : Structural

A.1.1 Corrosion/spalling of concrete


b. Specify admixtures (e.g. water reducing agent, pozzolanic products, pore refiner, etc.) to reduce permeability. Alternatively, for moisture control in special areas with a high-risk of water penetration, an electrochemical treatment can be specified; a process where electrochemical drying of concrete occurs by passing a current through the reinforcement, similar in principle to cathodic protection (BS EN 1504-9: 2008).

A.1.2 Seepage through cracks

a. Surface cracks (caused by applied loads, or thermal and shrinkage effects) should not exceed width of 0.3mm (SS EN 1992-1-1:2008).

b. Provide rebar layout to facilitate vibrations/compactions.

c. Water-resistance is a primary design concern (BS EN 1992-3:2006)—seepage through cracks in structural elements is unacceptable for basements.


A.1.3 Seepage through porous concrete

Monolithic basement construction (wall/floor) is required for water-tightness. Specify the proper waterproofing with suitable material and consider aggressive conditions and proper mix design as per BS 8102: 2009 (see also SS CP 82:1999).

A.1.4 Flood Control

a. For basements in water-bearing soils, ensure that the upward water pressure is uniform below the whole area of the floor. It must be capable of resisting the total pressure less the weight of the floor. The walls must be designed to resist the horizontal pressures due to the waterlogged ground, and prevent the basement from flooding (BS 8004:2015).

b. Provide design features to protect basements from flash floods (e.g. humps and flood barriers) B1. Provide alternative surface water retention systems; and suggest preparation of standby sand bags and floorboards for residential buildings located in low-lying areas [B2,B3].

A.1.5 Good Practices for Basement Water Tightness Base on Intended Usage

There are good practices of water tightness for basement structure depends on its intended function and usages. These guides are applicable to basement wall and slab in contact with ground. An illustration of these good waterproofing practices is as shown in fig. XXX.
A.2 Design Concerns: Architectural

A.2.1 Proper installation of construction joints

a. Specify the use of expansion joints where effects of temperature and moisture are too large to absorb as a strain in order to separate framed structures from joints' sections (BS 6093: 2006+A1: 2013).


d. Provide internal/ external waterstops to accommodate differential movements (Flanges of water-stops tied to RF in adequate intervals) [B4].

A.2.2 Seepage through joints


b. Provide comprehensive design detailing of joints to avoid the promotion of mould and plant growth; discolouration due to UV radiation and biological, physical or chemical action; showing of internal structure (in part or all); and dust collection (BS 6093:2006+ A1:2013).
A.2.3 Water ponding

a. Conform to the proper drainage design (slope/outlet) [B5,B6].

b. Comply with the proper compacting of ground/soil to maintain even settlement (BS 8004:2015, SS CP 4: 2003(2012)).

c. Abide to requirements in basement construction as per PUB: Code of Practice on Surface Water Drainage [B2].

A.2.4 Waterproofing

a. Minimise wall joints in wet areas. Kerbs to be constructed at the base of walls to halt lateral movement of water. Basement masonry structure is not recommended. Select waterproofing types A, B, or C* or a combination of them, depending on the performance requirements of usage cases (BS 8102:2009, SS CP 82: 1999).


c. Architectural, structural, and M&E coordination drawings of affected wet areas are reviewed together to ensure proper integration and reliability of waterproofing system.

d. Provide proper design for adequate drop of cast concrete to maintain floor gradient and to prevent water from migrating to the dry area. A screed should be laid over the membrane as a protective measure and sloped towards the floor outlet [B7].

A.2.5 Wall finishes – Paint

e. Specify the use of a breathable paint system to reduce trapped moisture and to avoid wetness and dampness of basement walls. Fungi-resistant paint is also required.

f. Avoid the use of Alkyd based paint on concrete surfaces that may lead to saponification (i.e. the formation of oily patches) (BS EN 1504-2:2004).

g. Ensure that coatings are always applied in a minimum of two coats. The material should possess some degree of flexibility (i.e. be elastomeric) to reduce the risk of cracking due to thermal/moisture movements (BS 8000-0:2014, SS 150:2015).

A.2.6 Flooring

a. Ensure the design works as a monolithic unit to comply with requirements for durability, strength, dimensional stability, resistance to wear, slip and dampness (BS 8204-2:2003+A2:2011).

b. Specify type of additives to use (e.g. air-entraining superplastisizing, set retarding admixtures, low heat Portland cement, in-surface organic resin sealer). Avoid Alkyd based paints that may cause saponification [B4].

c. Specify suitable, good-quality aggregate for concrete (SS EN 12620: 2008) and mortar (BS EN 13139:2002).
A.3 Design Concerns : Services

A.3.1 Drainage

a. Provide an internal basement drainage design since it is more cost-effective and affordable than an outside system, and is relatively easier to service and maintain.


A.3.2 Penetrations for services

Service penetrations are weak points and are vulnerable to leakage. They should be grouped, pre-planned and boxed out to minimise penetration through waterproofing. Install penetrations in cast-in-situ sleeves to allow independent movement of pipes and to reduce coordination between different trades (BS 8102: 2009, SS CP 82:1999).

A.4 Construction Concerns : Structural

A.4.1 Corrosion/spalling of concrete

a. For the construction of basements, refer to the guidelines and provisions stipulated in SS CP 4:2003 (2012). (See also BS 8004:2015).


c. Use corrosion resistant bars and corrosion inhibitors. Apply proper vibration (compaction) and curing. Consider concrete sealing to avoid exposing the aggregate in concrete work (mitigate pitting, scaling, spalling, powdering, or chalking of concrete).

A.4.2 Seepage through cracks


b. Special considerations on stress concentrated areas such as joints and interfaces between different materials. A crack width limit of 0.2 mm normally applies to all cracks, irrespective of whether or not they pass completely through the section. Where the appearance of a structure is considered to be aesthetically critical, a limit of 0.1 mm is recommended (BS EN 1992-3:2006).

A.4.3 Seepage through porous concrete

For quality workmanship, adhere to the recommended curing process; ensure sufficient reinforcement cover; and proper vibration (for well compacted mortar) of concrete to avoid honeycombs as per CONQUAS 21 recommendations [B7].

A.4.4 Flood Control

d. During construction, ensure that there is always an excess of downward load to exceed the worst credible upward force due to the water by a substantial margin (BS 8004:2015).

e. Permanent deep basement structures create permanent change in ground water patterns when its dead load exceeds the total upward force on the structure. During construction, the
level of groundwater near the basement needs to be controlled by pumping or other means. Consider methods such as open pumping, pre-drainage, cut-offs or exclusion. Water that has infiltrated the building due to structural porosity needs to be drained using dedicated pipes to sumps and subsequent pumping [B8].

A.5.1 Proper installation of construction joints

a. Seal construction joints to withstand multi-directional stresses. Ensure proper installation of waterstops [B4].

b. Provide proper surface preparation for the installation of sealants and gaskets (ensure that gaskets should not be stretched during installation) (BS 6093:2006+ A1:2013).

c. Slow down the drying of concrete to avoid plastic shrinkage and provide joints/planes of weakness to confine cracking to determined positions (BS 6093:2006+ A1:2013).

d. Joint gap width can be changed from the time of erection to sealing. Hence, the best time for sealant application in movement joints is when joint gap is at the mean trending to the maximum (BS 6093:2006+ A1:2013).

A.5.2 Seepage through joints

a. The use of wet joints is essential in minimising water seepage through joint areas. Ensure its proper installation with suitable backer rod and sealant application [B5].

b. For vertical joints, a baffle provides the overlapping needed to stop water seepage. The baffle needs to extend beyond the groove and not shortened due to creep (BS 6093:2006+ A1:2013).

A.5.3 Water ponding

a. Perform proper levelling of floor surface to avoid ponding in falls for wet area [B6].

b. Establish full specification and procedure for repair, propping and testing, and handing over with the as-built drawings [B9].

A.5.4 Waterproofing

a. Ensure proper surface preparation of concrete using mechanical or chemical cleaning. Ensure that the substrate is dry, so as to avoid blistering of non-breathing waterproofing material.

b. Allow for good ventilation and check with a moisture meter. Conversely, pre-saturate substrate if cementitious membrane systems are used for improved adhesion.

c. Use of continuous angle fillet (25x25mm, 1:3 cement sand with 1:4 bonding agent and water) for membrane to lay gradually over internal corners and floor–wall joints.

d. Waterproofing products mixed as per manufacturer’s specifications in a controlled environment. Application also as per manufacturer’s specifications [B7].

e. Protective measures should be taken into consideration to prevent the waterproofing membrane from damage by any activities on site (e.g. by use of Styrofoam) (BS 8102: 2009, SS CP 82:1999).

A.5.5 Wall finishes – Paint

b. If it is brush-applied, the second coat should be at right-angles to the first coat to help eliminate pinholes and avoid chemical attacks (BS 8000-0:2014, SS 150: 2015).

A.5.6 Flooring

a. Provide falls (max 1:40) on base concrete for good drainage. Fall should be in finishing not in screed. Insert induced contraction joints at about 6 m to 8 m from centre-to-centre (c.t.c.) to avoid cracking. It should be sawn within a day of laying and should be in a proper straight line to avoid differential contraction [B10].

b. Checks for levelness and surface regularities should be done within 24 hours of casting, as delays can mean no possible rectifications. Measure from the underside of a 2m straightedge (between points of contact) placed anywhere on surface and using a slip gauge. (BS 8204-1:2003+A1:2009).

A.6 Construction Concerns : Services

A.6.1 Drainage

Ensure that access to the basement should have a crest level of min. 150mm higher than the platform level to segregate catchments. Runoff from the roofs, rainwater downpipes and all premises at and above ground level should be channelled into surface gravity drains. Provide cut-off drains across the access way [B11].

A.6.2 Penetrations for services

Ensure there are no congestions around pipes for easy pouring and vibration of concrete. Additional reinforcement is required to counteract concentration of shrinkage stress especially at corners of openings (BS 8102:2009, SS CP 82:1999). Conduits should be made in order not to allow water leaks in the basement.

A.7 Maintenance Concerns : Structural

A.7.1 Corrosion/spalling of concrete

a. Conduct regular inspection in accordance to BS 8210: 2012 to identify defects and ensure repair work is carried out before associated damage can occur.

b. Testing of concrete via depth of carbonation to identify possible corrosion of rebar as per BS 1881-210:2013; or via phenolphthalein method as per BS EN 14630:2006.

c. Repair and protect damaged concrete due to corrosion of reinforced steel as per BS EN 1504-9:2008.

A.7.2 Seepage through cracks

Conduct routine inspection of basement areas for visible signs of water seepage such as efflorescence, especially at high risk areas such as joints and pipe penetrations. Protect against ingress and increase moisture resistance with (e.g.) hydrophobic impregnation, coating (BS EN 1504-2:2004), or filling of cracks (BS EN 1504-5:2013). Concrete restoration with (e.g.) hand-applied mortar, recasting or spraying with concrete/mortar (BS EN 1504-
A.7.3 Seepage through porous concrete

Regular inspections of basement area as per BS 8210:2012. Repair identified seepage defects by injecting cracks, voids or interstices (refer to EN 1504-5:2013). Enforce a full recorded survey of condition before problems are hidden below patch repairs, coatings or waterproofing (BS EN 1504-9:2008).

A.7.4 Flood Control

a. Check and confirm by inspection and testing for any deviations from as-built drawings; any indications of defective or substandard construction; indications of severe local environments from ponding, waterproofing breakdown, and seepage; and for the current trends of deterioration and likely long-term trends (BS 1504-9:2008).

b. Conduct periodic inspection for ponding and make visual observations of free flowing water towards the outlets to ensure that water has drained off, so as to avoid leftover ponding on reinforced concrete (BS 8221-1:2012, SS 509-1:2015).

c. Monitor basement carpark water-level using sensors and warn building users in a timely manner [B1].

A.8 Maintenance Concerns: Architectural

A.8.1 Proper installation of construction joints

a. Conduct visual inspection on the integrity of the joints (BS 8102:2009, SS CP 82: 1999). Use non-destructive field diagnostic techniques to identify seepage through joints where visual inspection is not sufficient (e.g. Infra-red thermography for moisture detection, portable microwave tomography to identify source of leakage).

b. Replace old sealant with a suitable one (ASTM C1193-16).

c. Joints inspected at intervals equivalent to one-fifth of their expected life (additionally, all joints subject to movement be inspected for signs of premature failure after first year in service) (BS 6093: 2006+A1:2013).

A.8.2 Seepage through joints

a. Conduct routine visual inspections of joints and look for tell-tale signs of water seepage in basement areas (e.g. deteriorated or damaged wall/floor/ceiling material, biological growth).

b. If seepage through joints is suspected, non-destructive tests can assist with the identification of the sources of water.

c. A water spraying test should be carried out at the precast joints to check for water-tightness (BS 8102:2009, SS CP 82:1999).

A.8.3 Water ponding

Conduct periodic inspection for ponding and make visual observations of free flowing water towards the outlets. Ensure that water has drained off to avoid leftover ponding on the reinforced concrete. Drains should be inspected for efficiency prior to water washing (BS 8221-1:2012, SS 509-1:2015).
A.8.4 Waterproofing
   a. Concrete surface cleaning and repair applications of a continuous waterproofing barrier system should be carried out (BS 8102:2009, SS CP 82:1999).
   b. Take precautions to avoid leaks. Any joints suspected or confirmed to be leaking should receive immediate attention as delay can cause extensive damage. Proper insulation should be provided for all external and exposed piping (BS 8210:2012).

A.8.5 Wall finishes – Paint
   a. Inspect at reasonable intervals to identify necessary repairs (BS 6150: 2006+A1:2014, SS 542: 2008) (depending on type of coating, degree of exposure to elements, and accessibility, it can range between 3–10 years).
   b. Walls that are lightly-soiled should be washed with water and a mild detergent. For severe soiling, wash with a strong alkali solution in warm water.
   c. Re-paint the walls regularly. Repair hairline cracks by re-painting the wall with a flexible sealant/ elastomeric paint to seal the cracks. For wider cracks, engage a contractor to carry out repair works.

A.8.6 Flooring
   b. Identify and clean grease stains using an aqueous solution of alkaline salts (caustic soda, sodium meta-silicate, tri-sodium phosphate, appropriate proprietary detergent, etc.).
   c. Identify sealant deterioration in joints through routine inspection. Clean joints and reseal with hard sealants (e.g. synthetic resin composite). Movement joints need flexible sealants [B47].
   d. The cleaning method selected should be chosen on the basis of minimising damage to existing surfaces. Aggregate rich surfaces should not be cleaned by processes that can damage the binder (BS 8221-1:2012, SS 509-1: 2015).
   e. Ensure that water collecting points, channels and scupper drains are cleared, cleaned, free from debris and mortar droppings and adequately ventilated to prevent any build-up of saturated atmosphere inside the cavity (BS 8102:2009, SS CP 82:1999).

A.9 Maintenance Concerns : Services

A.9.1 Drainage
   Conduct quarterly inspection to check the condition of the drainage system. Ensure the functioning of emergency maintenance services (e.g. pumps) and automatic alarm systems that notify pump failure. Clean drains and sump 4 times per year and, if possible, clean internal cavity twice a year.

A.9.2 Penetrations for services
   a. Routinely inspect locations of pipe penetrations, such as service entries, which are particularly vulnerable to water leakage. Keep access points clear and free from obstructions to avoid excessive hacking of finished surfaces.
Annex B
(Normative)

Wet Area

B.1 Design Concerns : structural

B.1.1 Accessibility

a. Locate stack risers in easily accessible areas for maintenance.

b. Consider exposed services when aesthetically possible. Access panels should be provided at adequate locations and in the right size, such that all concealed plumbing are fully serviceable.

c. Select and locate utensils that are highly accessible for ease of cleaning, and which impose minimal obstructions for cleaning and maintenance of the walls and floor [W1].

B.1.2 Seepage through structural joints

a. Minimise the provision of structural or construction joints to maintain monolithic construction (BS EN 1992-3:2006).


B.1.3 Leakage through concrete slab


B.1.4 Leakage through cracks and porous walls/floors

a. Design specifications for appropriate cement and reinforcement for concrete work in wet areas. Proper design of waterproofing to prevent seepage through wall and slab, especially at vulnerable points such as penetrations [W2]. Detailing to avoid embedded pipes in floors/ walls to maintain sufficient cover to reinforcements [W3]. (See also BS 8215:1991). Ensure the segregation of dry and wet zones [W4].


B.1.5 Corrosion and spalling of concrete


b. Design of concrete must prevent cracking/spalling of walls at points of support due to differential settlement. Design of concrete must inhibit cracking, spalling, and local bulging
of non-load bearing and partition walls due to thermal and moisture movements of partitions or supporting structures (ISO/NP 4356).

**B.2 Design Concerns: Architectural**

**B.2.1 Efflorescence**


- c. Prevent water penetration of the exterior wall by providing waterproofing and architectural details (e.g. isolation of exterior brick wythe with an air cavity. If no cavity wall, separate the brick wythe from the backing with a damp-proof coating) (ASTM C1400-11).

**B.2.2 Biological stains**

- a. Detailing of wall surfaces in terms of regularity and surface texture to prevent staining [W1].

- b. Wet areas with high water splash must be impervious with waterproofing membrane up to a minimum of 300mm (height). Also such surfaces must be without impediments to ensure ease of cleaning [W3].


**B.2.3 Paint**


**B.2.4 Tile interface with other elements**

Specify an adhesive that is cured by hydration and avoid the use of dispersion adhesion over impervious tiles as it is highly unlikely that the adhesive will achieve full curing (BS EN 12004-1:2017). In wet areas, the minimum adhesive coverage of tiles should be at least 90% (BS 5385-1:2009, SS CP 68:1997).

**B.2.5 Tile cracks**

- a. Design to accommodate differential movements of the structure and provide movement joints to mitigate differential settlement or shrinkage of cracks. Recommended minimum wall joint width of 3mm (5mm preferred) and minimum floor joint width of 5mm. Spacing of movement joints on internal wall should be 5–6m horizontally and vertically, while space for internal floor should be 6–7m in all directions (BS 5385-1:2009, SS CP 68:1997). Specification of less water-permeable tiles for wet areas [W5]; Recommend testing of tiles against design specifications before mass installation (ISO 10545-1:2014).

- b. Cracks at tile joints are commonly due to the settling process, and thus requires pointing (BS 5385-3:2014).
B.2.6 Tile staining

a. When selecting tiles, consider the following criteria: impermeability (resistance against water absorption); slip resistance (both dry and wet); impact and abrasion resistance; and resistance against chemicals, dirt and stains (ISO/DIS 13006).

b. The use of pre-packed mortar is preferred with proper mixing [W6].

c. Select and specify the use of stain resistant tiles (ISO 10545-1:2014).

d. Specify for allowable levels of unevenness of tiled surfaces as per SS CP 68:1997 (see also BS 5385-1:2009).

e. Specify for larger tiles to reduce the incidence of grouting. Design for correct grouting width between tiles. Alternatively, use polymer-modified grout to reduce risk of shrinkage cracks.

B.2.7 Tile joints

a. Ensure that the joint location, tile’s width and substrate are consistent. The maximum recommended spacing for internal wall and floor is 5–6m; while the minimum joint width is 3–5mm for wall and 5mm for floor. Refer to movement joint guidelines as provided by SS CP 68:1997 (BS 5385-1:2009).

b. Specify grout which are compatible with the tiles and which possess resilience and compressibility [W7].

c. Provide detailed specifications of surface regularity and tolerance levels for quality

B.2.8 Floor gradient and screed

a. Screed provides protection to the waterproofing membrane and constructs the slope for drainage [W1].

b. Provide adequate thickness to embed the service pipes by at least 20mm. For thicker screed, coarse aggregates of a smaller size should be used. Increase drop considerably in cases where the layout requires soil pipe to be embedded in the screed, to maintain a minimum screed depth [W8].

B.2.9 Waterproofing

a. Select waterproofing material and check for required material properties as per related standards (BS 8102:2009, SS CP 82:1999).

b. For wet walls in showers/bathrooms, waterproofing should be applied to at least 1500mm (width) and 1800mm (height) of the wall. If a basin or sink is within 75mm of the wall, the wall adjacent to and behind it should receive waterproofing for a minimum height of 300 mm. Specify fibreglass/reinforcements/fillets at wall-floor interfaces [W3].


B.3 Design Concerns : Services

B.3.1 Penetrations for sanitary fittings (piping layout)

a. Provide a well-planned layout and detailed working drawing to reduce chances of hacking or porous infill of cold joints (BS EN 12056-2: 2000).
b. Number of penetrations should be minimised by using common discharge stacks and cast-sleeve:
   i) For WC/Urinal—1 trap for a max. of 10 urinals.
   ii) For WB—1 washbasin trap to serve 10 WBs. More than 1 trap provided if over 10 WBs.
   iii) For Wash/shower/bath—1 floor trap for every 3 WC cubicles. Two more penetrations for common stacks (drainage and vent).

B.3.2 Fixture and fittings

a. Shower or wash area is a wet zone and should, ideally, be separated from the common toilet area (dry zone) so as to minimise the impact of water from affecting the entire floor. It should be separated by a sunken floor or kerb (min. 75 mm) [W3].

b. For wash basins, a minimum centreline distance of 900 mm, and a minimum distance of 450 mm between the centreline of adjacent wall is recommended. For water closets (WC), a minimum of 450 mm between the centreline of the fixture and adjacent wall or modesty board is recommended. For urinals without a partition or modesty board, a minimum centreline distance of 900 mm between adjacent fixtures is recommended [W9].

B.3 Construction Concerns: structural

B.3.1 Accessibility

a. Install access panels that are large and central enough to accommodate the movement required for maintenance; in most inconspicuous manner. Ensure all pipework are concealed, except final connections to fixtures [W9].

b. Proper installation of pipe joints in concealed areas to provide prolonged water-tightness without need for maintenance. After installation and curing, conduct a full pressure test on pipe work to ensure no leaks from joints before embedding into concrete and use.

B.3.2 Seepage through structural joints


B.3.3 Leakage through concrete slab


B.3.4 Leakage through cracks and porous walls/floors


b. Ensure sufficient reinforcement cover and proper vibration of concrete to avoid honeycombs [W10].
c. Ensure accurate batching of fresh concrete and full compaction at the earliest possible time. Conduct water ponding test; flood waterproofed area (25mm depth) for 24 hours, inspect deck below for leakage [W3].

B.3.5 Corrosion and spalling of concrete

b. Ensure sufficient ventilation to reduce the humid environment that speeds up carbonation [W11].

c. Assess cracking (as a precursor to spalling) in the compression region of concrete structural components, since such cracks form parallel to the principal compression stresses which may signal an increased damage severity (ISO 28841:2013).

B.4 Construction Concerns : Architectural

B.4.1 Efflorescence
a. Store construction material on site, off ground, with some form of covering as to protect them from moisture ingress. Avoid wetting if possible as this will eventually trigger future efflorescence outbreak [W12].

b. Clean and free all intended mortar joints of debris, and fill them completely; avoid cavities and air spaces. Use mechanical vibration to consolidate the grout to reduce voids. Use dense tooled mortar joints to impede salt migration. Install sealant joints between masonry and door/window frames, expansion joints and other vulnerable interfaces (ASTM C1400-11).

B.4.2 Biological stains
a. Exterior surfaces of porous building material (e.g. brick, stone, cement rendering) can develop biological growth (e.g. mosses, lichens, algae). Any such growth should be avoided as much as possible with treatments of anti-algae/ anti-fungus solutions and allowed to dry before painting/repainting.


B.4.3 Paint
a. For painting (protective and decorative), apply the relevant sections of BS EN ISO 12944-4:1998 and BS 6150:2006+A1:2014 and ensure that substrates are sound before commencing painting work.

b. Completed paint work should be cordoned off and protected until adequately dried to avoid stains and other damages. Adhesion and visual properties to be consistent with the approved sample during final inspection [W13].

B.4.4 Tile interface with other elements
a. Maintain consistent tile interface with ceiling, window frames, door frames, pipes, etc. [W14] (BS 8000-0:2014)

b. Adhesive coverage is critical at edges of tiles. Full coverage would eliminate the formation of water pockets under the tiles (BS EN 12004-1:2017, BS 8000-9:2003, BS 8000-11:2011).
B.4.5 **Tile cracks**

a. Comply with the tile fixing method as per SS CP 68:1997 (BS 5385-1:2009, BS 8000-11:2011), including:

   i) Careful cutting and handling of tiles during application;
   ii) Soak tiles to relieve its dry condition before laying;
   iii) Screed needs to be properly cured, rendered and cleaned;
   iv) Tiles should not be laid over cracks or be subjected to any loading; and
   v) Tiles should be properly tapped in place, and have their surfaces wiped after tiling

b. Tiles should resist cracking from soaking or transverse elongation. They should be of a thickness adequate for resisting cracks from direct impact. Use a proper key at the back of the tiles for good bonding.

B.4.6 **Tile staining**

a. Pre-packed mortar mix is recommended for consistency. Adhere to recommended mixing proportions. Use mechanical mixers prior to screeding. Rigorously supervise on-site work for high quality workmanship (BS 8000-0:2014).

b. Pre-treat tile edges and front surface evenly with water-repellent impregnator. Use suitable adhesive according to supplier’s recommendations [W6].

c. Check tile installation for consistency in size, thickness of skirting, pointing, alignment of joints, evenness, cleanliness and colour tone of surface, and any signs of chipping, cracking, or hollowness. Once the tiles have been installed, immediately cover them with polythene sheets, cardboards or wooden boards to protect the surface from foot traffic, abrasion, and impact [W7].

B.4.7 **Tile joints**

a. Grouts should be of suitable fineness and consistency according to the joint width stipulated in BS 5385-3:2014. Samples of grouts need to be tested at an accredited laboratory.

b. Joints should be aligned and of a consistent size (between 1–2 mm) [W6].

c. Ensure joints are pointed neatly with no voids within them and no excess or uneven grout. (BS 5385-1:2009, SS CP 68:1997).

d. Tiling should be divided into bays at all expansion/ structural joints and points of stress concentration [W14]

B.4.8 **Floor gradient and screed**

a. Ensure quality control of workmanship as per BS 8000-0:2014 for proper pouring, curing and compaction. Concrete floors must be air-dried for a minimum of 4 weeks after curing. Slope should be maintained using a series of spot levels. Special attention must be given to the installation of all penetrations and movement joints. The pipes embedded in the screed should be checked for proper layout and jointing [W3].

b. Movement joints in structural slab should be carried through the screed (BS 8204-1:2003+A1:2009).
B.4.9 Waterproofing

a. Surface prior to waterproofing membrane application should be even, with fine roughness and without sharp corners or protrusions. Surface should be thoroughly cleaned and dried such that moisture content is <6%. [W13].

b. When applying the waterproofing, begin from the corner furthest away from the entrance and work towards the door so as to avoid stepping on the freshly applied membrane. Ensure minimum upstands and lapping; and the laying of fibreglass/reinforcements/fillets at corners as per design specifications. Add a slurry coat to protect the membrane against any damage at installation [W3].

B.4.10 Floor gradient and screed

a. Ensure quality control of workmanship as per BS 8000-0:2014 for proper pouring, curing and compaction. Concrete floors must be air-dried for a minimum of 4 weeks after curing. Slope should be maintained using a series of spot levels. Special attention must be given to the installation of all penetrations and movement joints. The pipes embedded in the screed should be checked for proper layout and jointing [W3].

b. Movement joints in structural slab should be carried through the screed (BS 8204-1:2003+A1:2009).

B.4.11 Waterproofing

a. Surface prior to waterproofing membrane application should be even, with fine roughness and without sharp corners or protrusions. Surface should be thoroughly cleaned and dried such that moisture content is <6%. [W13].

b. When applying the waterproofing, begin from the corner furthest away from the entrance and work towards the door so as to avoid stepping on the freshly applied membrane. Ensure minimum upstands and lapping; and the laying of fibreglass/reinforcements/fillets at corners as per design specifications. Add a slurry coat to protect the membrane against any damage at installation [W3].

B.5 Construction Concerns: Services

B.5.1 Penetrations for sanitary fittings (piping layout)

a. The membrane should be dressed up at pipe penetrations and down at least 50mm into the floor outlet. Use of reinforcing fibreglass mess along with the upstand is a better solution. The membrane should extend horizontally around the pipe by min. 100mm and overlap with subsequent membrane applied to the entire floor (BS 8102:2009, SS CP 82:1999) [W3].

b. A PVC flange should be bonded to the flooring and the PVC waste pipes before other fixtures (e.g. grates) are fitted (AS 3740:2010).

B.5.2 Fixture and fittings

a. Installation should comply with manufacturer’s instructions or as specified by codes. No valve or faucet should leak upon installation (BS 8102:2009, SS CP 82:1999).

c. Conduct full pressure test on the pipe work upon completion to check for leaks from joints and connections. Connect and test waste water discharge pipe as per specifications [W15].

d. Handle fixtures and fittings carefully to avoid damaging waterproofing membrane [W3].

B.6 Maintenance Concerns: Structural

B.6.1 Accessibility

a. Adopt an efficient inspection system for the wet area and conduct regular inspection of the plumbing system to identify any defects (BS 8210:2012).

b. Any sign of water seepage should be further investigated and quickly resolved before associated damage can occur to the wet area.

B.6.2 Seepage through structural joints

a. Conduct regular inspections of wet area, especially at vulnerable interfaces/joints between different materials. Use non-destructive testing (NDT) in this regard. Water leakage can be identified using thermography images (BS ISO 10880:2017) or by using a moisture meter (BS 812-109:1990) to determine the presence of moisture.

b. Repair work can be done using polyurethane (PU) grouting/injection for local seepages. For more severe incidents, laying of new waterproof screed is strongly recommended [W3].

B.6.3 Leakage through concrete slab

a. Avoid water infiltration into the structure by keeping the concrete slab as dry as possible, using good housekeeping practices.

b. Provide protective measures to prevent waterproofing membrane from damage by any activities on site (BS 8102:2009, SS CP 82:1999).

B.6.4 Leakage through cracks and porous walls/floors


b. Remediate any leakage by removal of screed, clearing all loose particles and re-application of waterproofing. Localised porous concrete can be repaired by PU grouting by injecting into either the passive or active side of the slab/wall. Repair leakage at cracks by either injecting polyurethane (PU) grout, or by using the Flood Infusion Method [W16].

B.6.5 Corrosion and spalling of concrete

a. Preventive: Paint concrete every 3 to 5 years using anti-carbonation or good quality paint to prevent carbonation. Check regularly for any holes or cracks and seal up any holes immediately to prevent moisture and carbon dioxide from entering the concrete [W11].


c. Corrosion and spalling must be attended to immediately [W11] by means of patch repair with approved polymer modified sand cement mortar.
B.7 Maintenance Concerns: Architectural

B.7.1 Efflorescence

a. Conduct regular cleaning of efflorescence as per SS 509-1:2015 (BS 8221-1:2012).

b. New efflorescence stains can be removed with water and a scrub brush, while older stains may require water blasting or sandblasting. For difficult stains, the use of hydrochloric or phosphoric acid is recommended. However, as chemical solutions can discolour the affected area, all visible concrete in the area is cleaned to maintain a consistent appearance [W17].

c. Rinse surface thoroughly after removal of efflorescence and carry out timely repair/maintenance of leakage to avoid future efflorescence.

B.7.2 Biological stains

a. Conduct regular cleaning by chemical and mechanical applications (e.g. alkaline or solvent cleaning agents, hydrofluoric acid, air or water abrasive cleaning) and clear dirt regularly as per SS 509-1:2015. (See also BS 8221-1:2012).

b. Remove moulds, lichens and other growths with a stiff brush and treat the residue with biocide chemicals [W18].


B.7.3 Paint


b. Conduct regular cleaning as per site condition. Avoid excessive moisture exposure on painted surface to avoid mildew or fungus formation. Wash minor stains and dirt with clean water, and wash heavy stains with mild detergents.

B.7.4 Tile interface with other elements


b. Conduct random checking of bedding by removing tiles and assess fault distribution to avoid voids left behind tiles (BS 5385-1:2009, SS CP 68:1997).

B.7.5 Tile cracks

a. Conduct surface cleaning and repair applications. Use a stiff brush to loosen joint grout and reinstate joints with suitable tile grout.

b. Remove and re-tile the affected areas (BS 8102: 2009, SS CP 82:1999); (there may be a colour mismatch if stocks of extra tiles are unavailable).

c. For areas where the wear is negligible, a mixture of cement and water slurry with a hardener may be painted over them. However, for large worn surfaces, it is necessary to hack off the screed and patch up with a suitable mix of cement and sand screed together with a hardener (BS 8221-2:2000).
d. Perform regular mopping/buffing of tiled surfaces. Proper handling of equipment to prevent damages to the tile surface.

B.7.6 Tile staining

a. Mopping and buffing of commercial areas should be thrice a day while other areas should be twice a day. Fortnightly, machine scrub floors to remove grout stain. Perform monthly hand scrubbing of walls. Use commercial tile cleaner to remove efflorescence twice a year. Use diluted chlorine bleach/mildew-retardant spray for mildew, and in areas of deep soiling and hard to reach areas. However, the source of staining should first be removed (BS 8221-1:2012, SS 509-1:2015).

b. Biological growth can be removed by scrubbing with an acid/alkali based cleaner. Biocidal washes may be applied to prevent further growth. Remove severe soiling by scrubbing with acid/alkali based cleaner.

B.7.7 Tile joints

a. Perform surface cleaning so tiles are dry, free from dust and foreign materials (BS 8102:2009, SS CP 82:1999).

b. Remove affected tiles by saw cutting grouted joints. Clean adhesive off the tile surface before it sets in, without disturbing the tiles. Use a stiff brush to loosen joint grout and reinstate joints with suitable fresh tile grout. Ensure substrate surface is free from loose particles and of correct level before replacement of new tiles (BS 5385-1:2009, SS CP 68:1997).

B.7.8 Floor gradient and screed


b. Check integrity of screed and perimeter divorcement. Ensure there is no obstruction to flow of water, so that water will drain off along the gradient (BS 8102: 2009, SS CP 82:1999).

c. Regularly inspect for initial signs of water seepage. If the space is above ground floor, check the space or ceiling directly under for any sign of water damage [W19].

B.7.9 Waterproofing

a. Conduct a full inspection (for seepage, dampness, relative humidity (RH), mould growth, soiling, corrosion, etc.) of wet area at least once a year. Suggest using thermographic imaging to detect any sub-surface leakage.


c. Check adhesion using the pull off test. Average tensile pull out strength of the five spots should be ≥ 0.40 N/mm²; and the individual pull-out strength of each sample should be ≥ 0.30 N/mm² [W3]. Conduct water-tightness test for floor (ponding test) [W14].

B.8 Maintenance Concerns : Services

B.8.1 Penetrations for sanitary fittings (piping layout)

a. Wash and clean bathroom fittings regularly with mild detergents and remove any solid waste that may cause choking.
b. Check pipe fittings regularly and, if necessary, have them repaired by a PUB licensed plumber [W20].

c. Check for water-tightness. Give careful consideration to possible openings and penetrations in fittings [W21].

d. Remedy penetrations on pipe entries using local grouting via injection packers (BS EN 1504-5:2013).

B.8.2 Fixture and fittings


b. Recommended frequency of general (thorough) cleaning of wet areas:
   i) Offices: 4 to 5 times per day; or
   ii) Hotels: 6 times per day; or
   iii) Retail spaces: 6–8 times/day.

c. Spot cleaning should be carried out the rest of the time.

d. For WBs, use disinfectant cleaners and scrub with scrubbing pads to remove stubborn stains weekly.

e. For WCs, use disinfectant or mild abrasive cleaners and scrub with scrubbing pads to remove stubborn stains weekly.

f. For mirrors, use neutral or ammonia-based cleaners and wipe mirrors daily.

Note:
   i) Rinse off any excess cleaners.
   ii) For stainless steel/chrome fixtures, brush off any scales or rust. Polish monthly.
   iii) For plastic/PVC items use neutral based cleaners for monthly cleaning. Do not scrub the surface.
Annex C
(Normative)

Facade

C.1 Design Concerns: Structural

C.1.1 Cracks


b. Any deflection/deformation of the concrete structure due to vertical loading should be compatible to the degree of movement acceptable by other elements (i.e. the finishes, services, partition, glazing, and cladding) (BS EN 1992-1-1:2004+A1:2014).


d. Understand the causes, effects, and methods of prevention and repair for cracks (e.g. longitudinal cracks, transverse cracks, cracks above prestressing strands, web crack at or near the prestressing strands, corner crack, and miscellaneous cracks) in precast concrete wall panels (BS EN 13369: 2013, SS CP 81:1999). Limit the design crack width with reference to SS CP 65-2:1996(1999).

e. Conduct laboratory mechanical tests to measure deformations on horizontal joints between load-bearing walls and concrete floors (ISO 7845:1985).

C.1.2 Alkali-Silica reaction (ASR)

a. Carefully analyse all cementitious material and aggregates during material selection and sourcing. Specify the use of non-reactive aggregates. Recommend low alkali cement, and take steps to prevent alkaline solutions from coming into contact with and penetrating the concrete [F1].


C.1.3 Movement joints


C.1.4 Rising dampness

Conform to the proper waterproofing design detailing for reinforced concrete structures. To avoid rising dampness, use suitable DPM/ DPC for the site ground conditions (SS CP 82:1999).

C.1.5 Corrosion of RC


C.2 Design Concerns: Architectural

C.2.1 Material selection and handling

a. Design curtain walls to withstand live loads resulting from regular maintenance activities (BS EN 13830:2015, SS CP 96:2002 (2011)).


c. Classify clay and calcium silicate brickwork and select the appropriate maintenance method (BS 8221-1:2012, SS 509-1:2015).

d. Mullions, panels, fascia, column covers, windows, doors, trim, roofing, gutters, flashing, hardware and other items where minimum maintenance is anticipated should be of austenitic stainless steels of type 301, 302 and 304, in compliance with BS EN 10088-2:2014.

C.2.2 Sealant deterioration


b. Comply with the grading of sealant (i.e. pourable or non-sag) as per ASTM C920 – 14a (tested in accordance with ASTM C639 – 15).

c. Make provisions for access for regular sealant inspection and avoid placing design features/services across joints that impede access for maintenance [F2].

C.2.3 Corrosion of metal cladding

a. Material selection for metal cladding should be based on aesthetics, cost, availability, formability and corrosion resistance (BS 5427:2016).

b. Evaluation of corrosion resistance of the metal should be based on product warranty, environmental effects (external, internal, industrial, and acid rain), and maintenance (unwashed areas).

c. Aluminium infill panels to comply with BS EN 485-1: 2016. Mild steel infill panels to comply with BS EN 10346: 2015.
C.2.4 Delamination of facade


b. Ensure proper detailing of window, door, and abutment points where water seepage can occur and cause delamination.


C.2.5 Weather-tightness

a. Specify and ensure joint sealant performance are of suitable form to withstand air penetration during assembly, transportation, installation and operation of the curtain wall system (BS EN 12152:2002, BS EN 13830:2015, SS CP 96: 2002(2011)).

b. Comply with the recommendations for water-tightness of external walls as per SS CP 82:1999.

c. Refer to the provisions for water-tightness of precast concrete slab and wall panels as per BS EN 13369:2013, SS CP 81: 1999.


C.2.6 Window/fenestration (leakage rate of windows)


C.2.7 Staining


b. Throw off water from the facade altogether through an outward projecting sill or overhanging eaves (which incorporate a throat or drip lines on its underside) or provide blocking features such as copings/flashings. Use efficient scupper drains/downpipes to channel water down and away from the facade.

c. Specify paint system which is permeable to avoid any paint defects which may cause staining.

d. Render the detailing for open joints as opposed to butt joints to avoid sealant staining.

e. Recommend joint designs which are able to retain runoff within joints and expansion joints designated to provide vertical runoff carrying dirt down along the facade surface [F3].

f. Specify facade self-cleaning applications (e.g. TiO₂, superhydrophobic paint products, etc.) with due consideration given to site orientation, sunshades and protruding features.
C.3 Design Concerns : Services

C.3.1 Accessibility

a. Consider key accessibility issues (including for management and maintenance of built environment) for early stages of planning (ISO/NP 21542).

b. Ease of access, relative cost of hiring and erecting scaffolding and the probable frequency of maintenance should be considered when making decisions on facade work (BS 8221-2:2000, SS 509-2: 2005 (2015)).


d. The facade access system should withstand all loadings, provide easy and safe access to all facade areas, have maximum coverage, and not disrupt tenant activities during operations [F3].

C.3.2 Fixtures and fittings

Comply with accessibility requirements, to allow maintenance personnel to reach fixtures and fittings on the facade (ISO/NP 21542).

C.4 Construction Concerns : Structural

C.4.1 Cracks

a. Use two-stage joints for precast facade construction to ensure higher water-tightness performance, since doing so avoids seepage through hairline cracks—as is the case with one-stage joints.

b. Horizontal joints for load bearing walls should be sealed off with non-shrink grout.

c. Minimise cracks in rendered brick walls by using appropriate mix ratio, thickness and number of coats.

d. Provide bonding bars at interfaces between different material in order to minimise cracks (e.g. where brick wall abuts concrete). Alternatively, the bonding bars can be cast together with the concrete member [F2].

e. At the completion of the construction stage, minor repair work or fixing adjustments may be acceptable. Enhance the durability of vulnerable parts of construction; ensure that surfaces exposed to water are freely drained; provide adequate cover to steel; use protective coatings for either steel or the concrete, or both (BS EN 1992-1-1:2004+A1:2014, SS EN 1992-1-1:2008, SS EN 1992-1-2:2008, SS CP 65-1:1999).

f. Components whose predicted service life is less than the design life of the structure must be inspectable and replaceable (ISO 13823:2008).
C.4.2 Alkali-Silica reaction (ASR)

   a. Use information from field performance history to determine the susceptibility of ASR. Perform testing for ASR in cementitious materials and aggregate in mortar bars as per guides ASTM C1567-13/ ASTM C1293-08b (2015).

   b. If historical experience or test results show a potential concern, provide additional supplementary cementitious materials (SCMs) to inhibit ASR (ASTM C618 – 15, ASTM C989 / C989M - 16e1).

C.4.3 Movement joints


   b. Joint should prevent movement, spread of flame, transmission of airborne sound between dwellings and be weathertight (if external) (BS EN 13369: 2013, SS CP 81: 1999). Use overlapping to ensure water-tightness even under vertical movements [F2].

C.4.4 Rising dampness

Provide adequate damp-proof course/membrane at a height of at least 150mm above the surrounding finished floor level, to prevent upward movement of moisture through capillary action or rainwater bouncing off the ground. Provide adequate surface drainage and adequate coating, and/or hydrophobic materials, and/or chemical injection as moisture barrier (BS 8215:1991, BS6576:2005).

C.4.5 Corrosion of RC

Ensure reinforcements are surrounded with adequate thickness of good quality, well-compacted, homogeneous concrete, free from honeycombing or other defects. Perform material selection with the aim to reduce chloride content in concrete in mind, so as to reduce corrosion risk of embedded metal.

C.5 Construction Concerns : Architectural

C.5.1 Material selection and handling

   a. Strict supervision required to achieve quality for surface evenness, finishing, and alignment without noticeable staining or cracking. Refer to relevant facade material standards as per CONQUAS [F4].

   b. Precast walling components should be transported, handled and stored so as to avoid damages. Handle material as per guidelines set out in SS CP 81:1999. (See also BS EN 13369: 2013).


   d. Facility manager and designers to make maintenance manual during commissioning (including maintenance life and other construction requirements) (ASTM E2266-11).
C.5.2 Sealant deterioration


c. Conduct non-destructive and destructive inspection procedures of weatherproofing sealant joints as per guide ASTM C1521-13. (See also BS EN 15651-1:2017).

C.5.3 Corrosion of metal cladding

a. Ensure the use of manufacturer’s fasteners/ brackets/stiffeners and all fixings and accessories to prevent sacrificial corrosion (AS3566-2002), as well as transmit all imposed loads and stresses of the cladding.

b. Avoid scratching and damage of protective coating/film during site handling and installation. Alert designer/supplier if cladding is exposed to high concentrations of sulphur and chloride containing gases. Refer to lightning protection as per SS CP 33. Remove drill swarf and other visible contaminants from the cladding surface to avoid corrosion [F5].

C.5.4 Delamination of facade

a. Sufficiently remove curing agent (used for early stripping of formwork) to ensure proper adhesion on the substrate. Ensure proper substrate preparation (cleaning) prior to application of plaster/tile finishing. Perform quality workmanship on facade through the correct handling and angle of application to prevent delamination (BS 8000-0:2014).

b. Adhere to the performance requirements for curtain walling, including safety as per BS EN 12179:2000. (See also ASTM E2270-14).

C.5.5 Weather-tightness

a. Air permeability of joints between precast concrete external wall components is measured in accordance with ISO 6589:1983 or BS EN 12153:2000.

b. Test weather resistance of the external facade against acceptable performance criteria. Detect water leakage through facade by simulating rainwater penetrations under pressure using a water-tightness test.

c. Maintain water-tightness with respect to rainwater which would otherwise give rise to moisture stains on internal face, or cause damage to the facade or other building elements (ISO 7361:1986). Water-tightness of joints between two prefabricated ordinary concrete external wall components (ISO 7729: 1985).

C.5.6 Window/fenestration (leakage rate of windows)

a. Keep an attic stock on-site for future uncertainties, especially important for reflective or low-emissivity coated glass as replacement stock may result in colour or reflectivity matching problem (ASTM C1401-14).

c. Cleaning of fenestration products shall be in strict accordance with the manufacturer's installation instructions. Maintenance requirements shall be passed on during commissioning stages.

C.5.7 Staining

a. Facade surfaces should be painted evenly with no patchiness. The finished texture should be uniform in colour [F4]. Ensure proper rendering to control surface granularity and local faults as it influences colour uniformity of the external facade (ISO 7361:1986).

b. Correct sealant applications to ensure consistent and continuous quality. Avoid misaligned panels of cladding (BS 8000-0:2014).


d. Use self-cleaning coatings on newly built substrates for increased success in its performance. All construction/repair works on a facade surface must be done prior to application of a water repellent (BS 8221-2:2000, SS 509-2:2005(2015)).

e. Serviceability of exterior facade surfaces is important as it dictates the building’s individual and corporate identity (ASTM E1667-95a (2012)).

C.6 Construction Concerns : Services

C.6.1 Accessibility

a. Implement comprehensive safety plan for working on facade, which must include a fall prevention plan, permit-to-work system and fall control measures (including fall prevention systems and personal fall arrest systems) [R4].


C.6.2 Fixtures and fittings

Serviceability of facade LED lightings. All components’ life spans are indicated in the schematics, including their points of failure (e.g. Faulty Facade LED lighting).

C.7 Maintenance Concerns : Structural

C.7.1 Cracks


b. Record and retain documentation of all executed works on facades, including photographs and non-destructive survey techniques, to provide background information prior to further assessment or work.


e. For cases of cracked or broken stones: 1) seek assistance for stone replacement; 2) if fragments are stable and secure, tuck point or caulk crack with sealant; 3) monitor closely for additional cracking or movement. Monitor joints for continued movement (ASTM C1496-11, BS 8298-1:2010).

C.7.2 Alkali-Silica reaction (ASR)

Where there is potential for ASR, be on the lookout for typical visual symptoms such as: unusual expansion of concrete, evidenced by longitudinal cracks; map cracking (random cracking pattern); closed joints; spalled surfaces; displacement of adjacent structural components; pop-outs; efflorescence (surface deposits); or discolouration (dark or blotchy areas). Identify ASR using a petrographic microscope (ASTM C856 – 17), electron microscopy, or an ASR detect kit (coloured dye field test kit).

C.7.3 Movement joints

A visual inspection of the facade is key in identifying defects in movement joints. Inspections for general defects and moisture ingress can be carried out either quarterly or during facade cleaning exercises. Recommend housekeeping of joints by cleaning on a routine basis to remove any dirt or debris that may inhibit their movement. Repair defects at movement joints through proper re-application of sealants.

C.7.4 Rising dampness

Identify tell-tale signs of moisture entry/rising dampness (e.g. wetness, staining, darkening due to trapped moisture, discoloration, efflorescence deposits). Diagnose rising dampness through surface-breaking flaws with a liquid penetration test. To remedy rising damp, expose lower surfaces of facade and allow drying; then damp-proof and provide additional drainage (ASTM C1496-11, BS 8298-1:2010).

C.7.5 Corrosion of RC

a. Conduct appropriate maintenance of the fenestration product and its interfaces with the wall system to ensure long-term delivery of the desired water penetration resistance.

b. Maintain records of building use, maintenance and performance problems, as well as responses to those problems (ASTM E241-09(2014)e1).

C.8 Maintenance Concerns : Architectural

C.8.1 Material selection and handling

a. Inspect and test adhesion of structural/weather seal sealants. Check for movement failures, moisture, condensation, and on the condition of the organic coatings on metal surfaces (ASTM C1401-14).

b. All buildings with more than 25% of facade in curtain wall must be inspected every 6 to 12 months for deterioration of aluminium framing. Condition of coating, hardware, glass,

c. Proper maintenance should be carried out on structural timberwork components to maintain effectiveness during the intended lifespan (BS EN 1995-1-1:2004+ A2: 2014, SS CP 7:1997 (2014)).

C.8.2 Sealant deterioration

a. Multi-story structures require a periodic facade inspection at an interval of about 5 years to identify areas where remedial sealant repair or maintenance work is required (ASTM C1193-16).


c. Suspected failure of waterproofing to be tested using ASTM C1521-13 (BS EN 15651-1:2017).

d. Remedial work for glazing sealant should be in accordance with ASTM C1487-02(2012).

C.8.3 Corrosion of metal cladding


b. Conduct routine cleaning to remove surface contaminants from metals in order to ensure maximum corrosion resistance of the metal. The cleaning process chosen should be selected based on type of contaminant, the required degree of cleanliness, and cost (ASTM A380/A380M-13, BS EN 1993-1-4:2006+ A1:2015, BS EN ISO 12944-8:1998). Special care should be taken in order not to damage the cladding surface during cleaning/ maintenance [F5].

C.8.4 Delamination of facade

a. Repair of spalled surfaces should be done by cutting loose and flaking material to the base and replacing with new bricks or blocks, or made with layers of mortar. Consolidate weathered masonry (to stabilise the degradation) as per SS 509-2:2005(2015). (See also BS 8221-2:2000).

b. Maintenance and repair of renders should be carried out in accordance with BS EN 13914-1:2016. (See also ASTM C926 – 17). Attend to cracks on facade surface promptly to control moisture ingress in order to avoid delamination. Re-tile debonded tiles or over-clad existing facade to remedy delamination [F7].

C.8.5 Weather-tightness

a. Integral seals in window units require maintenance or replacement within the duration of the service life (ASTM E2266-11). Check condition of windows and caulk seals annually (ASTM E241-09(2014)e1).

b. Maintain repair records to identify a pattern of leakage; and to identify if repairs may be causing or contributing to current leakage. Use of maintenance records to diagnose buildings with chronic leakage problems (e.g. areas that have been subjected to several attempts at remediation). Suspected water leakage in glazing systems should be evaluated using Guide ASTM E2128-12. NDT methods can be used (e.g. thermography, fiberscope, elastic recovery meter).
C.8.6 Window/fenestration (leakage rate of windows)

a. Conduct regular maintenance of the fenestration product and its interfaces with the wall system to ensure water penetration resistance (ASTM E241-09(2014)e1). Clean glazing system's exterior surface to control accumulation of environmental pollutants, as well as to avoid staining and disfiguration of glass. Conduct periodic maintenance as required for window gasket seals and operating hardware (ASTM C1401-14).

b. Use cleaning solvents in strict accordance with solvent manufacturer's instructions and applicable codes, safety regulations, and environmental regulations. MEK (Methyl ethyl ketone) and similar solvents may damage organic sealants, gaskets, and finishes used on fenestration products (ASTM E2112-07 (2016), BS 8213-4:2016).

C.8.7 Staining

a. Consider availability of adequate water supply, drainage provisions and electrical power supply to choose facade cleaning method. Records of cleaning operations (including; photographs before and after cleaning, and drawings of nature of deposits, thickness and patterns) should be kept for buildings of significance (BS 8221-1:2012, SS 509-1:2015).

b. Maintain facade in a state as near as possible to its new condition. Ease of facade maintenance can be expressed by frequency of necessary maintenance operations; labour and supplies necessary for each maintenance operation; and notice of possible ways of removing stains, graffiti, etc. (ISO 7361:1986).


C.8 Maintenance Concerns : Services

C.8.1 Accessibility

a. The least hazardous product and system should be selected for the facade cleaning operation. All risks should be identified, assessed and managed (BS 8221-1:2012, SS 509-1:2015).

b. The safe use of permanently installed building maintenance units for facade maintenance should be done according to ASME A120.1-2014.

c. For safety requirements for hoists and lifts during construction/maintenance/demolition refer to ANSI/ASSE A10.4-2016.

d. Cleaning robots can be used to overcome the dangerous and time consuming nature of cleaning work [F3].

e. Facade access systems should be maintained in strict compliance with the relevant codes and standards (SS 598:2014, BS 6037-1:2003).

C.8.2 Fixtures and fittings

Defective downpipes, gutters, flashing, lead coverings, and jointing should be repaired quickly, and obsolete cables and fixings should be removed (BS 8221-2:2000, SS 509-2:2005(2015)).
Annex D
(Normative)

Roof

D.1 Design Concerns : Structural

D.1.1 Roof leakage (through cracks at drainage/expansion joints and through slabs)

a. To prevent potential construction and maintenance issues, consider good design practices such as allowing proper flow paths to suitable discharge points, specifying suitable waterproofing membrane, and using the necessary movement joints. Properly detail all openings, penetrations, upturns, and corners to ensure water-tightness (BS EN 1107-2:2001, BS EN 12039:2016, BS EN 12730:2015, SS CP 82:1999).


d. Ensure positive drainage in all low-slope roofs [R1]. Design roof gutter according to the performance requirements set by BS EN 12056-3:2000, SS 525:2006. Roofing components should follow the allowable thermal stresses under temperature variations (ISO 13823:2008).

D.2 Design Concerns : Architectural

9.2.1 Water ponding

a. Flat roofs made of reinforced concrete should be designed with an adequate fall to prevent ponding and maintain minimum pitch variation over the entire roof to avoid water ponding at the perimeter and water leakage through the roof slab/parapet wall junction (BS 6229:2003, BS 8218:1998, BS 8000-0:2014, SS CP 82:1999).

b. Ensure positive drainage in all low-slope roofs. Do not obstruct joints of areas prone to water, ice and freeze/thaw damage [R1].

9.2.2 Waterproofing


D.3 Design Concerns: Services

D.3.1 Accessibility

a. Provide safe access to building roof during design, and if required, implement fall prevention system, and building maintenance units. Conform to the recommended accessibility design guidelines (ISO/NP 21542).

b. Conduct risk assessment and designate controlled access zones to design for proper safety systems. Provide anchorage for personal fall arrest systems where necessary (e.g. permanent horizontal anchor-cable systems).

c. If it is unavoidable to work on fragile roofs, preventive measures have to be put in place such as use of roof access equipment for fragile roofs (e.g. board walk, roof walk systems) [R3].

D.3.2 Penetration for services

a. Joints at pipe penetrations/ fittings/precast elements, etc., should be designed with shapes and dimensions that do not constitute local weak points in the elements (e.g. at corners). Avoid joints that are difficult to construct. Penetrations should be kept at a minimum as far as possible.

b. It is preferable to have a clear and uninterrupted roof deck for continuous waterproofing. Services should be grouped, pre-planned and boxed out to minimise penetration through waterproofing (BS 6229:2003, BS 8218:1998, BS 8000-0: 2014, SS CP 82:1999).

c. Penetration of services in any roof system are most susceptible to water entry; thus the design of all flashing details (e.g. cants, kerbs, nailers, flashings, etc.) should be carefully considered by the designers [R1].

D.3.3 Drainage


b. Provide required number of internal rainwater outlets and drainage downpipes. Specify for minimum falls of 1:40 for flat roofs to ensure a 1:80 finished fall (BS 6229:2003, BS 8217:2005).

c. Conform to drainage requirements of the building (floor gullies and roof drains) as per BS EN 1253-2:2015, BS EN 476:2011. Comply with manufacturer’s details during design for roof components such as drains and base flashings to enhance roof’s buildability.

d. Ensure positive drainage in all low-slope roofs. Do not obstruct joints of areas prone to water, ice and freeze/thaw damage [R1].

D.4 Construction Concerns: Structural

D.4.1 Roof leakage (through cracks at drainage/expansion joints and through slabs)

construction quality control to ensure proper curing of concrete prior to membrane application.

b. Consistency of construction quality in terms of; installation of fixtures and fittings; proper dressing of pipe penetrations; and good lapping and adhesion of waterproofing membrane to base with no mortar stains. Check for any signs of leakage during construction [R2]. The sealant material used must be tolerant of climatic variations on-site and be able to accommodate high movement if necessary. Joint sealing slots need to be cleaned (i.e. remove all dust). Proper installation of backer rod necessary to avoid sealant adhering to the base of the slot. Tightly pack joint filler to slot. Consider providing an upturn at expansion joints (with metal capping). Expansion joints should be properly constructed as per BS 6093:2006+A1:2013.

D.5 Construction Concerns : Architectural

D.5.1 Water ponding

a. Ensure quality waterproofing by maintaining adequate and correct fall directions and angles to gutters (BS EN 12056-3:2000, BS 8490:2007, BS 8000-0:2014). The waterproofing and drainage must be coordinated to form an integrated waterproofing system.

b. Conduct visual inspections and ensure that all gutters are tested for ponding upon construction (BS EN 12056-3:2000, BS 8000-0:2014, SS 525:2006).

D.5.2 Waterproofing

a. Before laying the liquid applied membrane, ensure that the surface is cleaned, dried, and free of surface defects/sharp protrusions (concrete surface to have a plain and even finish prior to receiving the membrane). Ensure that all openings, penetrations, upturns, corners, etc. are properly installed to ensure water-tightness. Additional consideration should be given to flashing and kerbs for movement. Allow concrete/screeding to cure for at least 7 days prior to laying of the membrane.

b. Waterproofing membrane should be protected from traffic and weathering. It should be applied soon after the primer is cured (BS 6229:2003, BS 8218:1998, BS 8000-0:2014, SS CP 82:1999).

D.6 Construction Concerns : Services

D.6.1 Accessibility


b. Use scaffoldings as per SS CP 14:1996. Properly construct and install safety systems. Provide demarcation of access routes plan for equipment maintenance.

c. For new roof installations or where extensive repair or replacement of existing roof is planned, it is recommended that an access tower or a personnel and materials hoist be provided [R4].

D.6.2 Penetration for services

a. Waterproofing membrane at pipe penetrations must be applied with an upturn onto the pipes. In precast construction, a cast in sleeve is used to avoid pipe openings which have to be
b. Once installed, ensure that the membrane is protected from damage by construction activities and detrimental exposure conditions. A protection system that is quick and easy to install is recommended. Pipe penetrations should be effectively fire-stopped by replacing the insulation material at the junction (BS EN 13501-5:2016, SS 553:2016).

D.6.3 Drainage


b. Roof covering should not extend too far into gutter, so as to accommodate easy cleaning and maintenance. Jointing type for gutters and rainwater pipes should allow thermal movement to take place without leakage, or distortion and displacement of fittings (BS EN 12056-3:2000, SS 525:2006).

c. Service fixtures, planters etc. may be designed to stand over the waterproofed deck on concrete pads (BS 6229:2003, BS 8218:1998, BS 8000-0:2014, SS CP 82:1999).

D.7 Maintenance Concerns : Structural

D.7.1 Roof leakage (through cracks at drainage/expansion joints and through slabs)

a. Conduct inspection to determine the current roof condition and document visible evidence of water leakage. Indications of wear and tear, maintenance, attempted repairs, damage from non-weather related causes such as impacts, or structural movements must be recorded (ASTM D7053/D7053M-17). Sealants can crack/lose adhesion at its interface under solar radiation (ISO 13823:2008).


c. Gutters and downspouts must be maintained to enable free/undisrupted flow of water and be kept clear of leaves and other debris to avoid exposure to excessive roof runoff and eventual leakage (ASTM E2128-12).

d. Review work orders and purchase orders for building maintenance and other activities that may relate to water leakage problems. Maintain service history: the known performance record of the roof system, including the physical symptoms of water leakage, progression of leakage behaviour, maintenance and repair history, extent and locations of leakage, etc. (ASTM D7053/ D7053M-17).

e. Repair materials/methods should be designed to manage environmental factors (e.g. chemical/ physical/mechanical conditions). Adhere to the specifications of grouting materials for repair as set under ISO/TR 16475:2011.

D.8 Maintenance Concerns : Architectural

D.8.1 Water ponding

a. Flat roofs should be inspected for ponding. Visual observations of free flowing water towards the outlets must be made to ensure that the water drains off thorough, so as to avoid leftover ponding in the gutter or on the reinforced concrete flat roof (BS 8221-1:2012, SS 509-1:2015).
b. Free flow in gutters and downspouts must be maintained. They must be kept clear of leaves and other debris to avoid exposure to excessive roof runoff and eventual leakage (ASTM E2128-12).

D.8.2 Waterproofing

a. Good quality waterproofing membrane requires minimal maintenance. However, it depends mainly on its exposure conditions and external factors. Conduct regular inspections and cleaning of roof surface.

b. Roof area drains should be inspected for efficiency prior to water washing (BS 8221-1:2012, SS 509-1:2015).

c. Diagnosis of roof membrane defects can be done using infra-red thermographic surveys which identify moisture build-up within the structure. Diagnosis of waterproofing membrane failures leads to remedial actions if required. Actions can range from patch repairs to re-roofing. It can also include creating effective slope, or adding roof drains or taper systems.

D.9 Maintenance Concerns: Services

D.9.1 Accessibility

a. Develop and implement safe maintenance work plan for any activities at roof areas. Proper supervision of workers at heights is recommended. Provide maintenance workers with safe means of getting to and from the roof. The access ways need to be in place before commencing work. Access should be located where the work on the roof is to begin [R3].

b. Use safety systems during roof repair work, including the roof anchorage provided for PPE (personal protective equipment) to be attached to, and travel restraint systems with other fall prevention methods such as guard-rails and personal fall arrest systems for roof works [R4]. Train maintenance personnel on proper usage of fall protection systems (BS EN 363:2008).

D.9.2 Penetration for services

a. Periodic walkthrough to check roof and underside of roof deck areas (special care needs to be made at hard to access areas) to identify signs of water seepage. A thermo-tracer can be used to locate moisture accumulating at pipes penetrations.

b. Check for roof leaks yearly, especially at roof penetrations (ASTM E241-09(2014)e1).


D.9.3 Drainage

a. Rainwater pipes, gutters, and outlet gratings should be inspected and thoroughly cleaned at least once a year or more, especially if the building is near an industrial area or trees, or subjected to extreme temperature differences (BS EN 12056-3:2000, SS 525:2006).

b. Clear gutters and downspouts, if and when needed. Frequency depends on proximity of trees to the building. Special attention should be given to birds' nests, as they may cause blockages (ASTM E241-09(2014)e1).

Annex E
(Normative)

Common Areas

E.1 Design Concerns: Outdoor open spaces

E.1.1 Universal design

a. Conform to the design guidelines for accessibility, ingress/egress to/from building, kerb ramps, accessible routes, horizontal circulation, doors, etc. as per Code on accessibility [C1]. (See also BS 8300: 2009+ A1: 2010 and BS 9266:2013).

b. Provide slip-resistant and threshold-free layout, avoid sudden changes in surface levels; design ramps with appropriate slopes and adequate space, elevators and other lifting systems, and stairs with appropriate dimensions and hand grips, to facilitate accessibility (ISO/IEC Guide 71:2014).

E.1.2 Poorly-designed drop-off areas

A designated drop-off zone, for alighting and boarding, should either be provided with a common level or ramp [C2]; be sheltered from the weather [C3]; and comply with the requirements set by the Code of Accessibility. (See also BS 8300: 2009+ A1:2010 and BS 9266: 2013). The buffer between the building entrance and car drop-off zone should have a minimum width of 2500 mm, and be provided with seating and guard rails. The drop-off points should be as close as possible to the main entrance, and should have a minimum length of 9000mm and a width of 3600mm, and be served by a kerb ramp (ISO/NP 21542).

E.1.3 Insufficient outdoor lighting

a. Adhere to the guidelines and design criteria for lighting of work places (outdoors) as per SS 531-2:2008(2014). (See also CIE S 015/E:2005).

b. Provide a hierarchy of lighting effects that correspond to the different zones and uses of the outdoor area [C4].

E.1.4 Slip and fall

a. Select playground surfacing material as per SS 495:2001, ASTM F 1292-04. Classify surface materials’ slip resistance through Wet pendulum test, Dry floor friction test, Wet/barefoot ramp test and Oil-wet ramp test. (See also BS EN 1177:2008).


E.2 Design Concerns: Indoor open spaces

E.2.1 Poorly-designed way-finding, directory and advertisement boards

a. Design work for wayfinding boards should begin with a comprehensive study of the environment, user groups and needs, and user-traffic flow (SS 599:2014). (See also ISO 28564-1:2010).
b. Signage should be in a flexible modular system that is consist in design, materials, construction and finish. Limit number of variations within the range of sign components in order to enjoy the benefits of economies of scale during production and maintenance.

E.2.2 Poor ventilation

Comply with the ventilation requirements of car park spaces (above ground/ basement) using fan systems as per SS 553:2016. (See also ANSI/ASHRAE/IES Standard 90.1:2013). Use hot smoke test/CFD fire modelling to show effectiveness of jet fans system. (See also AS 1688.2).

E.2.3 Insufficient/compromised indoor lighting

a. Factors affecting luminous environment (i.e. luminance distribution, illuminance, glare, directionality of light, colour aspect of the light and surfaces, flicker, daylight, maintenance) must be considered. Comply with the design values provided in SS 531-1:2006(2013) Clause 5. (See also ISO 8995-1:2002).

b. Ensure that the lighting in indoor spaces are efficient, comfortable, and safe for visual tasks in the work period; ensuring visual comfort, visual performance, and visual safety (SS 531-1:2006(2013)). (See also ISO 8995-1:2002).

c. For stairs, escalators, and travellators: maximum lighting power density is 6 W/m2 as per SS 530:2014. (See also ANSI/ASHRAE/IES Standard 90.1:2013).

d. Ensure that common area receives >150% of designed illuminance on a typical rainy day. An automatic daylight control, either determined by a photo-sensor or schedule, is mandatory (SS 530:2014). (See also ANSI/ASHRAE/IES Standard 90.1:2013).

e. The lighting scheme should be designed with maintenance factor for selected lighting equipment, space environment and specified maintenance schedule, calculated—as defined in CIE 154: 2003 (SS 531-2:2008(2014)).

E.2.4 Universal design

a. Conform to the design guidelines for accessibility, horizontal/vertical circulation, doors, staircases, lifts, clear headroom, accessible individual washrooms, seating spaces, drinking fountains, signage, etc. as per [C1]. (See also BS 8300:2009+A1:2010 and BS 9266:2013).

b. Key accessibility issues (including for management and maintenance of built environment) should be considered from early stages of planning (ISO/NP 21542).

E.3 Design Concerns : Staircases

E.3.1 General

a. 4Staircase design to comply with requirements (steps profile, detectable warning surfaces, stair handrails) set in the Code on accessibility. (See also BS 8300:2009+A1:2010 and BS 9266:2013).

b. A flight of stairs should have a minimum of 3 risers. As a safety precaution, flights containing only 1 or 2 steps should be avoided. After a maximum of 16 risers an intermediate landing should be provided. Floor landings must have a level platform of the same width as that of the stairs.

c. Vertical height between stairway landings should be minimised to accommodate individuals with limited strength [C6].
E.3.2 Handrails

Handrails for stairs should be installed on both sides; at a height between 800mm and 900mm (measured from the pitch line vertically to the top of the handrails) and continue from the base of the stairs through the entire length. They should extend beyond the top and bottom steps by no less than 300mm [C1]. (See also BS 8300:2009+A1:2010 and BS 9266:2013).

E.3.3 Slippery access routes

a. Provide stair nosing based on minimum pendulum or ramp recommendations as per SS 485:2011, and install tactile strips at the start and end of every flight of stairs [C3]. (See also AS 1683.15.1:2000; AS HB 197:1999 and AS/NZS 4663:2004).

b. All steps should be fitted with non-slip nosing strips between 50mm and 65mm in width, with permanent contrasting colours. Nosing should have no abrupt undersides nor project more than 25mm over the back edge of the step [C2]. (See also BS 8300: 2009+A1:2010 and BS 9266:2013).

E.3.4 Accessibility

a. Stairs and steps should be designed to accommodate the elderly and disabled people, and must comply with the provisions stipulated in the Code on accessibility in terms of considerations relevant to the design of stairs (ISO/TR 22411:2011).

b. Provisions for staircases for ambulant disabled access include continuous handrails on both sides (extended >300mm beyond the top and bottom steps), tactile and Braille signs, uniform risers and no open risers [C1]. (See also BS 8300: 2009+A1: 2010 and BS 9266:2013)

E.4 Design Concerns : Landscaping

E.4.1 Green roof / Green wall

a. The structural integrity of a green wall system should be certified by professional structural engineer. Safety and maintenance concerns should be thought of and addressed early, during the design stage [C7].

b. Frequency of maintenance and cost issues should be considered when selecting the plants and materials [C8]. Considerations for a safe environment rely mostly on matching the proper plant to the proper place.

c. New gutters for green roofs should be provided with stainless steel leaf covers, and should be located at or less than 15mm above ground level (SS 525: 2006) (See also BS EN 1253-2:2015).

d. Adhere to proper specifications in waterproofing (SS 374:1994) to prevent water seepage on columns between two vertical greenery systems. (See also BS EN 13416:2001 and BS EN 12039:2016).

e. Inaccessible or difficult to access green roof/green wall installations create issues in maintenance planning and execution. It has implications for labour costs such as increased man hours and the resultant higher cost. They also pose safety risks triggered by the lack of access and safety provisions.
E.4.2 Chokage of discharge
   a. New gutters should be provided with stainless steel leaf covers, and should be located at or
      less than 15mm above ground level (SS 525:2006). (See also BS EN 1253-2:2015).
   b. Locate drains at the edge of landscaped areas. Drain inlets should be durable and
      appropriate for the climate zone.
   c. Adhere to the landscape’s specifications for proper drainage layout and system as per BS

E.5 Design Concerns : Swimming Pools

E.5.1 Slip and fall
   a. Design considerations include; amount and type of expected traffic; wear resistance and
      cleanability of material; exposure to anticipated contaminants; and environmental factors
      (e.g. visibility issues and contamination minimisation) (SS 556:2010). (See also AS 2610.1-
      2007 and AS 2610.2-2007).
   b. Use non-slippery and smooth grip tiles along the edges of the pools [C9,C10].
   c. Abrupt changes in floor level, including steps, should be avoided in ‘wet’ areas wherever
      possible. The slip resistance of any given surface will diminish if the gradient becomes
      steeper than 1 in 30 or is less than 1 in 60 [C11].

E.5.2 Compromised/poor access and egress
   a. Provide access and egress from pool using one or a combination of stairs/steps, ladders,
      swim-outs, pool-seats, landings, ramps or beach entries (SS 556: 2010). (See also BS EN
   b. Ramps may be provided for people with disabilities, for ease of access to the pool. It should
      have a gradient that does not exceed 1 in 15; have a clear 1m width; have a slip-resistant
      surface and handrails on both sides of the ramp [C11].

E.5.3 Building materials
   a. Ladders must be made of corrosion-resistant materials and have slip-resistant tread surfaces
      with maximum distance (300mm) between ladder rungs. Provide two handholds or handrails
      to all rungs (max. dia. Of handrail 50mm and min. dia. of handrail 30mm) (SS 556:2010).
      (See also AS 2610.1-2007 and AS 2610.2-2007).
   b. Consider water presence, pool, and cleaning chemicals when specifying building materials
      (e.g. concrete, tiles, adhesives, grouts) (BS EN 1992-3:2006). (See also AS 2610.1-2007
      and AS 2610.2-2007).
   c. Floor gullies, gutters and valleys should not constitute a tripping hazard; refer to the detailed
      design issues related to these features as per Time Saver Standards [C11].

E.5.4 Water quality – pH value
   a. Provision of accurate and reliable testing kit(s) (to measure the pool water’s pH level, as well
      as to check for free residual chlorine, total available chlorine, bromine or other chemical
      disinfectant residuals, cyanuric acid (if used), total alkalinity, calcium hardness, and copper
b. The pool must be so designed that the water quality will always remain safe for the public during its operation [C12]. Refer also to BS EN 16713-1:2016; BS EN 16713-2:2016; BS EN 16713-3:2016 and AS/NZ 1926.3-2010.

c. Ensure that pool design specifications require the maintenance of the pool water at a pH value between 7.2 and 7.8 [C12].

E.5.5 Sharp edges due to breakage of tiles

a. Aquatic facility water bodies should not be designed or constructed with obstructions that can cause users to become trapped or injured (SS 556:2010). (See also BS EN 16582-1:2015 and BS EN 16582-2:2015).

b. Fixtures and fittings in the walls and floors of the water body shall be fitted flush and have no sharp and protruding edges. Specify that all the edges and corners of the facility shall be rounded [C9,C10].

E.6 Construction Concerns: Outdoor open spaces

E.6.1 Universal design

a. Comply to the construction requirements for making buildings accessible to persons with disabilities and families with young children as per Code on Accessibility [C1]. (See also BS 8300: 2009+: 2010 and BS 9266:2013).

b. Outdoor paths should be firmly constructed with a slip-resistant, even surface, free from drainage gratings (ISO/NP 21542). Surface material adjacent to the path should not display different slip-resistant characteristics [C1]. (See also BS 8300: 2009+A1: 2010 and BS 9266:2013).

E.6.2 Poorly-designed drop-off areas

a. In the absence of kerb ramps, which provide separation marking between pedestrian and vehicle zones, the construction of a tactile strip (at least 0.60 m wide) at the edge of the pathway is necessary to provide a transition warning to a vehicular area [C13]

b. Ground and floor surfaces along accessible routes and in accessible rooms and spaces—including floors, walks, ramps, stairs, and curb ramps—must be stable, firm, slip-resistant, and in compliance with the Code of Accessibility [C1]. (See also BS 8300: 2009+A1:2010 and BS 9266:2013).

E.6.3 Insufficient outdoor lighting

Building facade lighting fixtures must adhere to a total facade lighting power < 5% of total interior lighting power (SS 530:2014). (See also ANSI/ASHRAE/IES Standard 90.1:2013).

E.6.4 Slip and fall

a. The minimum slip resistance on surface systems (e.g. moulded tiles, mats, cast in-situ rubber surfaces) when tested for any direction, under either dry or wet conditions must not fall below 0.40 (SS 495:2001). (See also BS 7188:1998+A2: 200).  

E.7 Construction Concerns: Indoor open spaces

E.7.1 Poorly-designed way-finding, directory and advertisement boards

a. Use sufficiently robust and durable materials with proper construction detailing to withstand the normal wear and tear of signage (SS 599:2014). (See also ISO 28564-1:2010).

Refer to the minimum illuminance of all areas on signs—200 lux or approximately 50 lux above the surrounding light level (whichever is greater) for externally illuminated signage; 300 cd/m² based on the white foreground of the backlit sign-face on internally illuminated (backlit) signs.

b. For large-scale developments or where appropriate, signage strategies should preferably be tested in the form of mock-ups and be evaluated with a walkthrough as a user before final implementation.

E.7.2 Poor ventilation

Jet fan system integrated with carpark fire safety system within the same level for smoke control. Minimum headroom for installation of jet fan system is 3m [C5].

E.7.3 Insufficient/compromised indoor lighting

a. The lighting installation should meet the lighting requirements of a particular interior, task or activity without wasting energy. Recommended task lighting levels are provided as maintained illuminance (i.e. depends on maintenance characteristic of the lamp, the luminaire, the environment and maintenance programme). A sufficient level of lighting is required to maintain safety (ISO/TR 22411:2011).

b. To reduce and eliminate stairway accidents, the switches that control the stair lights should be placed at a sufficient distance from the stairs—far enough to eliminate the risk of a person falling while reaching for the switch. Three-way switches should be installed at the top and bottom of the stairs [C6].

c. Provide ceiling lights to orient people along walkways and use contrasting colour luminance at base boards, walls and doors to delineate access routes. especially for people with limited vision and people with autism or cognitive disabilities [C13].

d. Installation of lightings should be uniform; avoid extreme differences in the levels of brightness. Ensure that lights are acceptably bright but do not cause glare or cast shadows that would give rise to optical illusions.

E.7.4 Universal design

a. Comply with the construction requirements (e.g. plans, specifications, permits) for making buildings (residential/ shophouse/office/shopping complex/hotel, etc.) accessible to persons with disabilities and families with young children [C1]. (See also BS 8300: 2009+A1: 2010 and BS 9266:2013).

b. Ensure that the grab bars and handrails installed will be able to resist a force of at least 1.3 kN; applied vertically or horizontally.

E.8 Construction Concerns: Staircases

E.8.1 General

a. Risers should have a maximum dimension of 150mm and treads should have a minimum dimension of 300mm [C2].
b. Risers and treads should have consistent dimensions. The minimum width of stairs should be 1200mm and must be adjusted according to the expected flow of traffic.

c. Staircases of widths wider than 2300 mm should be separated by a handrail into segments between 1100mm and 1800mm [C14].

d. Construction of safe holding areas or safe refuge/rescue assistance areas should comply with the fire safety and evacuation plan.

E.8.2 Handrails

a. Handrail is most effective when height is approximately equal to the average height of the hip joint of users (ISO/TR 22411:2011).

b. Additional handrails for children are recommended. Handrails for children should be provided at 600mm from pitch line [C2].

E.8.3 Slippery access routes

a. Ensure that nosing are securely fastened to the steps and are made of durable material (e.g. stainless steel, ceramic, cast-iron) that also suit the building’s usage.

b. Provide visual contrast between landings and the top and bottom steps of a flight of stairs and ensure similar frictional characteristics between different materials used in steps and landings (ISO/NP 21542).

c. Ensure that the constructed ramp is stable, firm and has slip resistant materials [C13].

E.8.4 Accessibility

a. The minimum clear headroom for all vertical circulation routes is 2000mm [C14].

b. A detectable guardrail or other permanent barrier should be provided where headroom is less than 2000mm. Such elements should be at a maximum height of 580mm so that they can be detected by the visually impaired [C1].

c. Design for wheelchair stair lifts should conform with provisions in the Code on accessibility [C1]. (See also BS 8300: 2009+A1:2010 and BS 9266:2013).

E.9 Construction Concerns : Landscaping

E.9.1 Green roof / Green wall

a. The constructed roof garden should not allow plant roots to damage the building structure (e.g. roof waterproofing membrane) [C15].

b. Safe work procedures to be adhered with proper site supervision and correct usage of equipment. This is to prevent incidents resulting from falls from heights and falling objects.

c. Inspect plants carefully upon their arrival at the site for damage to leaves/stems and broken branches during transport and handling. The landscape contractor should refer to the plant list for seasonal requirements related to the time of planting, and to contract specifications for additional requirements.

d. Use of sharp and extremely angular grained aggregates, which can affect the stability of material during installation, is discouraged. Installation of staking and guying can take reference from the methods and standards specified in the latest ANSI A300 Part 3 and
should be read in conjunction with the rest of the ANSI A300 when carrying out such installations.

E.9.2 Chokage of discharge

a. Provide eave gutters to maintain fall of 1 in 150 to prevent water ponding and debris build-up. Roof covering should not extend into the gutter, so as to accommodate easy cleaning and maintenance (SS 525:2006). (See also BS EN 1253-2:2015).

b. Maintain construction quality control during the installation of green roof/ green wall components, waterproofing, pipes and fittings, and the planting of vegetation.

E.10 Construction Concerns : Swimming Pools

E.10.1 Slip and fall


b. Conform to the recommended minimum Pendulum test values for pedestrian flooring in the pool’s surroundings, communal shower rooms (W), pool ramps, and stairs leading into water (V) (SS 485:2011). (See also AS HB 197:1999 and AS/NZS 4663:2004).

c. During construction, ensure that there is a wide band of tile of a contrasting colour near the edge of the pool, which slightly slopes upwards to indicate to people (especially people with limited vision) that they are nearing the edge of the pool.

E.10.2 Compromised/poor access and egress

a. The construction should bear full and empty conditions of the pool. Pool features should be constructed with inert, stable, non-toxic materials that are durable and watertight.

b. Ensure that during and after construction, the facility is free from any obstructions which might cause entrapment or injury [C9]. Ensure that floor and stair surfaces are durable and slip-resistant.

c. Walls and floors should be smooth, impervious, durable, easily cleaned and continuous, with no cracks, joints or protrusions other than structural joints (SS 556:2010). (See also AS 2610.1-2007 and AS 2610.2-2007).

E.10.3 Building materials

a. The construction should bear full and empty conditions of the pool. The pool/pool features should be constructed with inert, stable, non-toxic materials which are durable and watertight. Working stresses are to be based on predetermined ultimate strengths of materials used, with a factor of safety of not less than 2t/z [C11]. (See also BS EN 1992-1:2006, BS EN 1992-3:2006, BS EN 15288-1:2008, AS 3600-2009 and AS 3735-2001).

b. Appropriate surface finishes should be used. They are to enhance the safety and hygiene of the premises, and to assist in effective maintenance by enabling dirt and visible contaminants to be easily detected [C10].

c. Walls and floors should be smooth, impervious, durable, easily cleaned and continuous, with no cracks, joints or protrusions other than structural joints (SS 556:2010). (See also AS 2610.1-2007 and AS 2610.2-2007).

E.10.4 Water quality – pH value

a. Do not plant landscape and trees too close to pool, to prevent overflow of water from the planting strip(s) that may contaminate the water in the pool and also create maintenance problems [37].
b. The choice of material for pool furniture should withstand dampness and exposures to UV light. Ensure that during and after construction, there are no depressions in the concourse which will result in water pooling and/or lead to microorganism growth [C9,C10].

c. Installation of the water treatment system should conform as per SS 556:2010. Refer also to BS EN 16713-1:2016; BS EN 16713-2:2016; BS EN 16713-3:2016 and AS/NZ 1926.3-2010.

E.10.5 Sharp edges due to breakage of tiles

a. Tile selection during construction should be based on tile properties (safety, slip-resistance, weight, chemical and abrasion resistance, water absorptivity) and traffic considerations [C9].

b. Ensure that the expansion joints created between the coping and the pool deck are caulked. This will allow the stone to expand and contract while preventing pool water from freezing in the joint and cracking the coping stones [C19].

c. Ensure that all the edges and corners of the facility are of round finish.

E.11 Maintenance Concerns : Outdoor open spaces

E.11.1 Universal design

a. Regular inspection of premises and subsequent correction of irregularities is required for effective housekeeping practices. Clear passageways to allow easy access during firefighting.

b. Outdoor storage areas should be located separately from building to prevent fire spread [C16].

c. Daily/frequent inspection of accessibility and horizontal circulation routes (e.g. look out for broken/detached tiles, blocked and dirty accessibility routes for wheelchairs, etc.) and perform prompt corrective maintenance [C1]. (See also BS 8300: 2009 +A1:2010 and BS 9266:2013).

E.11.2 Poorly-designed drop-off areas

a. Keep covered walkways free from obstructions and perform routine mopping/cleaning of water especially during / after rain.

b. Non-slip floor finish should be used throughout the drop-off area. Proper drainage should be maintained to prevent ponding in drop-off areas.

c. Install signs to identify the drop-off zone, in order to prevent its misuse as a parking space [C17]. (See also BS 8300:2009+ A1: 2010 and BS 9266:2013).

E.11.3 Insufficient outdoor lighting

Comply with the minimum outdoor lighting requirements (SS 531-2:2008(2014) (See also CIE S 015/E:2005):

i) pedestrian walkways 5 lux

ii) Slow moving traffic areas (<10km/h) 10 lux

iii) Regular vehicular traffic (<40km/h) 20 lux

iv) Pedestrian passages, loading/unloading points 30 lux

v) Reading labels 50 lux
E.11.4 Slip and fall
   b. Keep footpath surfaces clear of any dirt, waste, or liquid spills (water) which might result in slip hazards.
   c. Provide visual demarcation of wet floor areas and slip hazards [C16] during cleaning and maintenance.

E.12 Maintenance Concerns : Indoor open spaces

E.12.1 Poorly-designed way-finding, directory and advertisement boards
   a. Provide adequate directional signage and provide for mounting, power and data points. Allow efficient update of signage whenever information is subject to change.
   b. Signage components should also be easy to clean, repair and update (SS 599:2014). (See also ISO 28564-1:2010).
   c. Formulate a comprehensive strategy for updating, maintenance, control and enforcement, future procurement, and records.
   d. Allow a 200 lux level of illumination on signs when emergency lighting is used.

E.12.2 Poor ventilation
   a. Compliance of air change rate with SS 553:2016. (See also ANSI/ ASHRAE/IES Standard 90.1:2013).
   b. Quarterly inspection for noise, accumulation of dust and controls function.

E.12.3 Insufficient/compromised indoor lighting
   a. The essential documents to be handed over to Maintenance are:
      i) As-built lighting layout
      ii) Lighting schedule
      iii) Lighting data sheets
   b. Lighting zoning in accordance to operational requirements. Use energy-efficient lighting such as LED. All LED lightings must be visibly flicker-free when dimmed. Lux level and uniformity to comply with SS 531-1:2006(2013). (See also ISO 8995-1:2002).
   c. Where daylighting is available, lighting control strategies can be employed to reduce energy consumption while maintaining the desired illuminance level. Provide sensor to dim lights by 50% when no one is using the staircase (within compliance to local Fire Codes) (ANSI/ASHRAE/IES Standard 90.1-2016).
   d. Preparation of comprehensive maintenance schedule to include lamp replacement, luminaire cleaning intervals and cleaning method (SS 531-2:2008(2014)). (See also CIE S 015/E:2005).
   e. Ensure that the illumination level for access routes is at 150 lux and that all ramps and staircases are well-illuminated [C13].
E.12.4 Universal design

a. Implement proper housekeeping practices (e.g. 5S method: Sort, Set in order, Shine, Standardise, and Sustain) to prevent slips, trips, and falls; limit spills; ensure machine safety; prevent fires; and ensure that exits and access routes to fire equipment are clear [C16].

b. Provide adequate janitor rooms with storage for equipment (such as trolleys, etc.). Provide power points for equipment such as vacuum cleaners.

E.13 Maintenance Concerns: Staircases

E.13.1 General

a. Building owner/operator must implement a regular maintenance programme for the staircase [C18].

b. Periodic inspection as well as the rectification of any irregularities (e.g. accumulation of debris, damaged treads/risers/ nosing, etc.), should be carried out by trained maintenance personnel.

c. Ensure that escape staircases are adequately lit via an emergency power supply during emergencies.

e. Electric illumination sources must be kept in good operating condition [C11].

E.13.2 Handrails

a. Handrails and balustrades must be kept in good repair, firmly fixed, and structurally sound [C11].

b. Ensure that the right grade of stainless steel is installed, to prevent corrosion.

E.13.3 Slippery access routes

a. Install anti-slip strips along stairway steps to avoid slip-and-falls.

b. Dust, debris or spills on the floor can create a slipping hazard. Staircase surfaces must be cleaned regularly and kept dry and free of dirt and dust [C18].

c. Install strips of a contrasting colour at the top and bottom of the ramp. Ensure that detectable warning indicators (e.g. signs, housekeeping equipment, etc.) are provided especially during cleaning, maintenance and repair works.

E.13.4 Accessibility

a. Building owner/operator must operate and maintain the required accessibility features in proper working condition for the use of any disabled personnel.

b. Alternative facilities or equipment need to be provided in case accessibility features are under repair or maintenance for a prolonged period of time.

E.14 Maintenance Concerns: Landscaping

E.14.1 Green roof / Green wall

a. Prevent obstruction of structural elements to ensure easy periodic maintenance. Conduct periodic inspection of supporting structures [C20].
b. Hardy plants that require less water and sunlight (especially for those installed in indoor environments) and routine maintenance practices are required in roof garden maintenance.

c. Monitor conditions on a regular basis to head off problems such as insect attacks, irrigation, disease or soil problems. Refer to the ANSI standards for pruning (ANSI A300:2017); and ANSI safety requirements for tree care operations (ANSI Z133:2012) [C4].

d. Rainwater pipe works, gutters and gratings on green roofs should be inspected and thoroughly cleaned annually (SS 525:2006).

e. The drip irrigation piping should preferably have provisions to counter plant-room penetration as plant roots may clog up drip holes.

f. Conduct annual or semi-annual inspections to control or prevent bird interaction with vertical greenery system (VGS), for plant survival must be taken into account. To minimise evaporation losses, water the plants between 4 to 7am or 6 to 9pm.

E.14.2 Chokage of discharge

a. Inspect and thoroughly clean rainwater pipe works, gutters and gratings annually (SS 525:2006). (See also BS 7370-5:1998).

b. Monitor conditions on a regular basis to head off problems such as insect attacks, disease, or soil problems.

c. Long term care requires periodic cleaning and sealing of joints and re-setting of grates and pavement finishes or turf grades due to settlement or silting.

E.15 Maintenance Concerns : Swimming Pools

E.15.1 Slip and fall

a. Conduct regular high jetting of perimeter to prevent moss growth due to dampness. Ensure that inspections and tests are carried out at the specified intervals as a preventative measure, and that any remedial action required is promptly dealt with. Ensure that the floors and stairs are kept clean, are drained where necessary, and are not slippery [C10].

b. Comply with the maintenance policy and practices in compliance with occupational, health and safety requirements; special provisions for slip hazards (guards and handrails); and alternative information sources (use of contrasting colours and warning signs) (SS 485:2011). (See also AS HB 197:1999 and AS/NZS 4663:2004).

E.15.2 Compromised/poor access and egress

a. Specify and ensure that the right grade of stainless steel is installed, to prevent corrosion.

b. Ensure that inspections are carried out at the specified intervals as a preventative measure, and any remedial action that is required is promptly dealt with. Ensure that the floors and stairs are kept clean, are drained where necessary, and are not slippery [C10].

E.15.3 Building materials

a. Materials used for landscaping of the pool edge should have a smooth surface, to facilitate easy cleaning (SS 556:2010). (See also AS 2610.1-2007 and AS 2610.2-2007).
b. Ensure the clear display of safety signage and behaviour rules [C10]. (See also ISO 20712-1:2008 and AS/NZS 2416.3:2010).

c. Ensure that the concourse directly surrounding aquatic facilities does not accommodate considerable amounts of water (to avoid pooling and microbial growth), nor have any irregularities (to avoid slip-and-trip hazards) (SS 556:2010). (See also AS 2610.1-2007, AS 2610.2-2007 and BS EN 15288-2:2008).

d. Where divers are used for installing, maintaining, repairing or cleaning of swimming pools, the requirements of the Diving at Work Regulations should be followed.

E.15.4 Water quality – pH value

a. Use adequate level of a chemical in water to destroy micro-organisms (e.g. chlorine). Reduce chloramines in water using ozone, UV light irradiation, or addition of non-chlorine oxidising chemicals. (SS 556:2010). (See also BS EN 16713-3:2016 and AS/NZ 1926.3-2010).

b. Conduct monthly bacteriological sampling and constantly check that the disinfectant level and pH value are correct, to ensure the bacteriological quality of a well-run pool. Water quality testing should be conducted by an accredited laboratory at least monthly for physico-chemical parameters (SS 556:2010, BS EN 16713-3:2016). Tests for microbiological analysis should also be carried out (ISO 19458:2006).

E.15.5 Sharp edges due to breakage of tiles

a. Conduct routine safety audits on existing pools to improve facility safety; e.g. by replacing/overlaying finishes with anti-slip finishes and providing additional safety features to address protrusions in the pool area (SS 556:2010). (See also BS EN 16582-1:2015 and BS EN 16582-2:2015).

b. Ensure that inspections are carried out at the specified intervals as a preventative measure, and that any remedial action required is promptly dealt with [C10].
Annex F  
(Normative)  

Mechanical & Electrical Systems  

F.1 Design Concerns : HVAC  

F.1.1 Chiller Plant  

F.1.1.1 Insufficient cooling/slow cooling  
Design chiller plants for required cooling demand with provisions for future expansions in accordance to SS 553:2016 and in compliance with the requirements of SS 554: 2016.  

F.1.1.2 Chilled water pipe and condenser pipe leakage and condensation  
   a. Conform to the pump system design calculation and required outputs as per ISO 13612-1:2014.  
   b. Specify the use of Unplasticized PVC pipe for cold water services/industrial use (SS 141:2013).  
   c. Provide flow meters for chilled / condenser water loops.  

F.1.1.3 Cooling Tower biological fouling  
   a. Provide a suitable cooling tower design to prevent dirt accumulation and stagnation.  
   b. Minimize tower fan power and size towers for close approach as per SS 564-1:2013.  
   c. Provide automatic chemical dosing system to ensure access hatches, level indicators, mixers, pumps etc. can be easily reached by personnel for maintenance and operation.  
   d. Provide adequate reach to all parts of the cooling tower for cleaning so as to prevent bacterial growth.  

F.1.1.4 Filter media choked at the air terminal  
   a. Provide locations for intake and return air terminals. Conform to the minimum filter requirements with regard to the use of air filters for cleaning outdoor air (MERV) so that no unfiltered air can enter the air handling system. Follow the recommended use of a secondary filter of 80% dust spot efficiency (SS 553: 2016, AS 1668.2-2012).  
   b. Provide sufficient access space for easy cleaning and replacement of filters.  
   c. Provide a display system for temperature and relative humidity at each floor and at each tenanted area.  

F.2 Design Concerns : Plumbing and Sanitary Systems  

F.2.1 General Plumbing  

F.2.1.1 Water supply – general defects  
Conform to the pipe sizing requirements based on hydraulic design and pump performance. Provide allowance for head loss, and frictional loss due to internal roughness, loss at fittings, turbidity, surge and pumping facility. Do not oversize piping as slow flow will cause stagnation. Specify standard fittings such as tees, elbows, etc. (BS 7291-1:2010, BS EN 598:2007+ A1:2009, BS EN 545:2010).
F.2.1.2 Leaky joints in inaccessible areas

a. Adhere to the recommended requirement to maintain sufficient distance (> 400mm) from structure or other services running parallel to each other, for easy maintenance and to avoid interference or damage.

b. Pipes should be of adequate strength and durability, and adequately supported (BS 8558:2015, SS CP 48:2005).

F.2.2 Water Supply System

F.2.2.1 Corrosion and scaling of pipe/valve

a. Specify materials that are resistant to corrosion and non-reactive to the conveyed water and surrounding ground (BS EN 545:2010, BS EN 598:2007 +A1:2009), and that do not impart any taste or toxicity to the water (BS EN 1796:2013, SS 375-1:2015).

b. Use of single material for the entire system is preferable for easy connection/jointing. Specify pipe system material that does not react with the pumped medium.

F.2.2.2 Damaged piping


Provide adequate longitudinal support to pipe installations below ground to cater for loads and traffic vibration.

F.2.2.3 Water hammer


b. Design airlocks and low supply pressure to minimise turbulent flow.

c. Evaluate the required strength of valves and tightness of body and in between the inlet and outlet chamber as per BS EN 1567:1999.

F.2.2.4 Excessive vibration

a. Ensure that pumps are properly sized to meet the required pressure. Head loss, frictional loss and loss at bends should also be considered. Sewage pumps should be able to handle long and fibrous material. If required, pre-treatment (e.g. crushing) is provided.

b. Specify variable speed drives (VSD) that are able to handle both maximum and variable demand. Ensure that the pump is mounted on an isolation bed (e.g. 150mm insulated padding) and that no site adjustment in height or position should be done.

F.2.3 Water Tank

F.2.3.1 Unauthorised/poor accessibility

a. Provide a permanent climbing ladder for easy inspection and cleaning of interior. If the ladder rises a vertical distance of more than 3 metres, then additional fall prevention measures should be considered such as install a safety cage [R4]. Provide a minimum of
600mm space, on all sides of the tank. Install minimum possible number of openings to each compartment; each opening should be fitted with a cover/trapdoor.

b. Provide corrosion-resistant, mosquito-proof netting for overflow pipe/vent.

c. Construct a series of tanks instead of one large tank, to meet demand for isolation during maintenance, for ease of access.

F.2.3.2 Leakage from water tank

a. Ensure the proper design detailing of pipe penetrations at the tank to avoid leakage.

b. Avoid cracks in concrete tanks; ensure water-tightness, through proper structural design.

c. Specify appropriate waterstops and sealants where pipes penetrate the structure.


F.2.3.3 Corroded water tank body

a. The body of the water tank should be made of watertight and corrosion-resistant material, such as reinforced or pre-stressed concrete, steel, and glass fibre reinforced plastics (SS 245:2014, BS EN 13121-3:2016).

b. Specify surface treatments, waterproof coating, or lining coating to resist water seepage and weathering. Ensure that such finishes do not affect the stored water’s quality of hygiene (BS 8558:2015, SS CP 48:2005).

F.2.3.4 Overflow of water

a. Decision on the size(s) of the tanks should be made based on water demand, supply, probability of pump failure, time needed for repairs, ratio of peak hours to average flow rate, provision of alternative supply or storage, etc. (SS CP 48:2005, BS 8554:2015).

b. Ensure that the tank is capable of handling various loads (as applicable) without showing cracks, stress or deformation (SS 245:2014, BS EN 13121-3:2016).

F.3 Design Concerns : Fire Safety

F.3.1 Faulty Detection

F.3.1.1 Faulty fire alarm panel

a. Design system to accommodate false alarm management as per SS CP 10:2005 and Fire Code [M3].

b. Locate fire alarm panel in corrosion resistant cabinet without any exposure to excessive dampness. Fire panel connectivity should be independent and compatible with the building automation system (BAS).
c. Specify red wiring for fire alarm system. Segregate from other ELV cables to remove electromagnetic interference.

F.3.1.2 Faulty manual call point

Designate locations of manual call points along all exit routes and at final exits (BS 5839-1:2013, BS 5839-6:2013).

F.3.1.3 Faulty fire detector

Comply with the fire detection system requirements of Fire Code 2013 by SCDF [M3], SS CP 10:2005, ISO 7240 series, BS 5839-1:2013, BS 5839-6:2013. Ensure detectors are accessible for maintenance and replacement. Conform to the selection of heat, smoke, and flame types based on requirements on-location. For decisions regarding the number of fire detectors, and their location and spacing design requirements, refer to SS 575:2012, BS 9990:2015.

F.3.1.4 Inaudible/unidentifiable alarm

a. Design fire alarm system (e.g. location, type and number of alarms) as per SS CP 10:2005 (see also BS 5839-1:2013); and emergency voice communication system as per SS 546:2009 (see also BS 5839-9:2011).

b. Alarm sound selected should be distinguishable from general clutter. Use a visual alarm where there is excessive background noise.

c. Propose incident communication facilities (as per SS ISO 22313:2013) and determine internal/external communication needs (e.g. through PA system integrated with iBMS) as per SS ISO 22301:2012.

F.3.1.5 Malfunctioning or damaged backup power/lighting


b. A standby generator may be used solely to provide power to emergency lighting systems, or in addition, to meet requirements other than those directly associated with emergency lighting.

F.3.2 Fire Hydrant System

F.3.2.1 Fire hose damaged (cut kink, leak, missing part, abrasion)

a. Ensure that the fire hose reel is suitable for the particular use of the facility in question, and that it complies with the related standards (BS EN 694:2014, BS EN 1947:2014).

b. Comply with the technical quality acceptance for fire hoses as per BS 6391:2009.

c. Fulfil cabinet specification (size and mounting) as per standard guidelines. Follow the distribution and number of fire hose reel cabinets as per SS 575:2012. (See also BS 9990:2015, NFPA 14).
d. Ensure that access to or visibility of fire hose is not obstructed.

e. Fire hose cabinet should be made of maintenance-free fire-proof material. The location should allow for 180° opening of cabinet door. The wall mounted type is only allowed in riser main shaft.

F.3.2.2 Accessibility problems (difficulty in accessing fire hydrant)

a. Conform to the location and number of fire hydrants as per Fire Code [M3].

b. Comply with the positioning of breeching inlets as close as possible to rising main/hydrant (BS 9990:2015, SS 575:2012, NFPA 14).

c. Locations should be accessible, with no obstructions from parking, loading bays, landscaping, building elements, etc.

d. Provide protection to hydrants from mechanical damage.

e. Install easily visible/identifiable signage and colour as per SS 508-3:2013 (see also ISO 3864-1:2011).

F.3.2.3 Faulty fire hydrant point (damaged, jammed, leaky)

a. Specify hydrant pillar to be constructed of materials that are strong and rust-proof (e.g. gunmetal parts) (BS EN 1982:2008).

b. Rising main and other pipework should be made of wrought iron or steel. Pit covers on roadways should be able to withstand vehicular load (BS 9990:2015, SS 575:2012, NFPA 14).

F.3.3 Sprinkler System

F.3.3.1 Faulty/compromised sprinkler system

a. Sprinkler design requirements should consider hydraulic principles and parameters such as, hazard class, discharge density, and AMAO (assumed maximum area of operation) (SS CP 52:2004, ISO 6182 series, NFPA 13). The usual requirement is 75L/min for 2.5m wide area.

b. Specify rust resistant material to avoid corrosion, pitting and scaling.

c. Potential obstructions should be considered during planning stage.

F.3.4 Fire Extinguishers

F.3.4.1 Poor discharge of portable fire extinguisher

a. Ensure that the locations and number of portable fire extinguishers are based on the maximum travel route (SS EN 3-7:2012, BS 5306-8:2012, ISO/PRF 7165).

b. Access to or visibility of extinguishers should be unobstructed. Extinguishers should be visible along an escape route (preferably near room exits, along corridors and staircases, in lobbies, and on landing).
F.3.4.2 Fire door obstructed

a. Fire door should be selected in terms of stability, integrity and insulation as per requirement of SS 332: 2007. (See also NFPA 80).

b. Except for the fire door’s thickness, internal construction, facing, edging, and construction technique, any other aspects of the fire door may be customised.

F.4 Design Concerns : Electrical Systems

F.4.1 Switchgear

F.4.1.1 Unsafe switchboard/ electrical power distribution

a. Comply with the requirements of electrical installations as per BS 7671:2008+A3:2015, SS CP 5:1998, NFPA 70 [M4]; including the location and number of power points. Ensure switchboards have adequate space and access for operation and maintenance.

b. Specify suitable switch closets with regard to moisture exposure conditions. Refer to the definition of types and functionality of RCCBs and specifications for RCBOs as per SS 480:2016 (IEC 61009-1:2010+AMD1:2012 +AMD2:2013 CSV BS EN 61009-2-1:1995).

c. Install sub-metering system with remote measurement capability and link to BMS/EMS to track energy consumption data trends.

F.4.2 Standby generator

F.4.2.1 Standby power generator issues

a. Design mains failure standby power generation system as per code requirements. Provide sufficient headroom (>2600mm) in generator rooms for maintenance tasks—i.e. sufficient height to enable any portion of the generating set or equipment to be raised freely for dismantling—as per SS 535:2007. (See also BS 7698-7:1996, ISO 8528-7:1994, NFPA 110).


c. Adhere to the recommendations for daily diesel service tank package and tank storage (i.e. safety and suitability of design, emergency provisions, and minimisation of vapour hazard) as per SS 532:2016. (See also BS 5908-1:2012).

F.4.3 Artificial lighting

F.4.3.1 Faulty/compromised artificial lighting and control system

a. Ensure that lighting design will improve energy and sustainability objectives of the building.

b. Specify a centralised lighting control system that allows easy monitoring; or automate the system with a proper control strategy.

c. Ensure the following:
   i) the lighting control is readily accessible;
ii) Lamp efficacies and ballast energy performance should meet the latest Minimal Energy Performance Standard (MEPS) and

iii) Lighting power density is calculated for the building and, that it meets the lighting power budget in SS 530:2014 (see also ANSI/ASHRAE/IES Standard 90.1-2016).

d. Calculate daylighting as per BS ISO 10916:2014

F.4.4 Lightning Protection System (LPS) and Earthing

F.4.4.1 Lightning protection system (LPS) defects (Corroded/exposed parts)

a. Adhere to protection measures to reduce risk of damage by lightning (e.g. injury to living beings, physical damage and failure of electrical and electronic systems) as per SS 555-1:2010, BS EN 62305-1:2011, NFPA 780.

b. Provide external lightning protection system (LPS) to intercept direct lightning flashes to the structure. Conform to design considerations for system earthing, including selection of type of earthing system to be used. Material selection and minimum dimensions (for earth-electrodes to resist corrosion) must comply with SS 551:2009 (see also BS 7430:2011+A1:2015).

c. Provide lightning electromagnetic impulse protection measures (LEMP) as per SS 555-4:2010. (See also IEC 62305-4:2010).

F.5 Design Concerns: Elevators, Escalators and Moving Walkways

F.5.1 Compromised/poor condition of elevator machine room


b. Provide ease of access to the elevator machine room with outward opening door (minimum clear opening of 0.6 x 1.8m) and permanent safe access for personnel and heavy equipment.


F.5.2 Poorly-maintained elevator pit


b. Specify corrosion resistant material and components in elevator system to minimise damage by presence of water or excessive moisture.

F.5.3 Lift lobbies with poor accessibility for the disabled

a. Encourage through or two-end entries for lift lobbies; or provide added space for dead-end lobbies to ensure the better distribution of waiting passengers (BS 5655-6:2011, BS 5655-11:2005, BS EN 81-20:2014, SS 550:2009).

b. Provide rain covers for lift lobbies in residential buildings for protection from torrential rains.

F.5.4 Common Faults
F.5.4.1 Inaccurate elevator car levelling with the landing


b. The stopping accuracy of the elevator car against the landing floor must be ±10mm [M5].

c. Collate global standards on lift safety as per ISO/TR 11071-2:2006 (i.e. assumption of safe operation assured to 125% of rated load, assuring reliability of electric safety devices, mechanical devices built and maintained according to good practice).

F.5.4.2 Faulty door operation

a. The gap for the elevator car doorway must not exceed 12mm, and the clearance between elevator car door panels must be less than 10mm. The elevator car must not make any movement if the car doors and landing doors are not properly closed and locked [M5].


F.5.5 Elevator Safety

F.5.5.1 Compromised safety and reliability


b. Ensure compliance to global essential safety requirements (GESRs) for lifts and local safety standards as per ISO/DTS 8100-21.

c. Lift must be designed to ensure all lift parts do not affect safe operation under reasonable levels of depreciation [M5].

F.5.5.2 Faulty suspension ropes due to overloading


c. Consider designing separate service and passenger lifts. Specify durable materials for service lift floor and walls to withstand rough usage.

F.5.5.3 Failure to activate overspeed governor

a. The governor ropes should be made from iron, steel, Monel, metal, phosphor bronze or stainless steel (ASME A17.3-2008).


F.5.5.4 Energy efficiency
F.5.5.4.1 Inefficient energy performance

a. Select and design lift equipment that will cater to expected traffic needs with energy efficiency, as attained by proper equipment management (BS 5655-6:2011, BS 5655-11:2005, BS EN 81-20:2014, SS 550:2009).

b. Conform to the energy calculation and classification for lifts as per ISO 25745-2:2015.

c. Comply with the minimum energy efficiency requirements as per SS 530:2014. Refer to planning for energy efficiency of lifts and escalators to VDI 4707.

F.5.5.4.2 Poor/compromised lighting

Lift car should be provided with permanently fixed electric lights (no less than two lighting fittings per car to be provided). Ensure lighting intensity of at least 50 lux at floor level (BS 5655-6:2011, BS 5655-11:2005, BS EN 81-20:2014, SS 550:2009).

F.5.6 Escalators

F.5.6.1 Escalator and passenger conveyor related maintainability issues

a. Landing area of escalators and passenger conveyors should have a surface that provides a secure foothold for a minimum distance of 0.85m (measured from the root of the comb teeth) (SS CP 14:1996). (See also AS 1735.1:2016).

b. Ensure that the escalator and its surroundings have sufficient and adequate illumination. The supporting structure for escalators and passenger conveyors should be designed as per BS EN 115-1:2008+ A1:2010, SS 626:2017.


d. Incorporate anti-climbing, anti-sliding, access restriction and deflecting devices to maintain safe operation (SS 626:2017).

F.6 Construction Concerns : HVAC

F.6.1 Chiller Plant

F.6.1.1 Chiller frequently unloading (stop-start); Compressor not starting

a. For applications with high dynamic load conditions of a facility, install and commission chillers with variable speed drive (VSD) compressors.

b. Ensure that schematics and maintenance regime of refrigerant leak detection system are handed over to maintenance personnel upon completion.

F.6.1.2 Insufficient/slow cooling
a. Conduct proper commissioning of chiller plant and set reasonable points. Perform post-installation monitoring of the installed instrument’s performance through the BMS (building automation system) or EMS (energy measurement system).

b. Document as-built drawings (including concealed services) for building user phase. Prepare and handover maintenance checklists for service and repair of each instrument during commissioning. Refer to measures for recommended monitoring procedures for chiller efficiency as per SS 591:2013.

F.6.1.3 Chilled water pipe and condenser pipe leakage and condensation

a. Ensure proper workmanship during pipe installation and testing, especially at joints.

b. Perform proper insulation of chilled water pipes to avoid condensation.

c. Use primary-only variable flow chilled water pumping systems (SS 564-1:2013).

F.6.1.4 Cooling Towers

F.6.1.4.1 Biological fouling

a. Prepare and submit an Operation and Maintenance (O&M) manual for the chemical dosing system after the successful commissioning of the system.

b. Install equipment to routinely observe chemical tank levels and the tank condition of the automated dosing system. During installation, ensure that access hatches, level indicators, mixers, pumps, etc. can be easily reached by personnel for maintenance in the operation phase.

F.6.1.4.2 Legionella outbreak

a. Perform proper commissioning to ensure safe operation of cooling towers. Develop Cooling Tower maintenance manual including cleaning/water treatment/decontamination procedures and handover during commissioning.

b. Ensure system is clear of dirt/debris/organic matter and clean before operation.

F.6.2 Air Handling Unit (AHU)

F.6.2.1 Air distribution system efficiency

a. The installation (and subsequent operation) of the AHU should comply with the fire safety requirements of the Code of Practice for Fire Precautions in Buildings (SS 553:2016).

b. The vibration control of fan systems is to conform to the requirements of SS CP 99:2003 upon installation/commissioning. (See also ISO 9996:1996).

c. Install/integrate AHU system components (e.g. VFD, control dampers/actuators) off-site to ensure quality installation.
d. Merge continuous commissioning with the preventive maintenance programme to ensure optimal operation (ANSI/ASHRAE/IES/USGBC Standard 189.1-2014).

F.6.2.2 Noisy operation and excessive vibration


F.6.3 Air Distribution and Terminal Systems

F.6.3.1 Dirty and mouldy ductwork

Comply with the construction and installation requirements for air duct systems and their fittings and accessories. Ensure that the ducts or duct linings (where glass fibre or mineral wool is exposed to the air stream) are suitably protected to prevent fibre erosion. The ducts should be sturdily supported—provide metal hangers and brackets for supporting ducts. Guarantee that the inner surfaces of the ducts for supply and return air are smooth and resistant to abrasion in order to reduce dust accumulation (SS 553: 2016, AS 1668.2-2012).

F.6.3.2 Filter media choked at the air terminal


b. Perform a one-time vet airflow test during commissioning and keep proper record of the report to ensure the cooling capacity is adequate as per design load in accordance to the BCA Green Mark requirement, and that the noise level is within the desired level in accordance to NEA noise pollution standards.

F.7 Construction Concerns : Plumbing and Sanitary Systems

F.7.1 General Plumbing

F.7.1.1 Water supply – general defects

a. Comply with the installation of water fittings as per PUB guidelines as stipulated in SS CP 48:2005. (See also BS 8558:2015).

b. Fittings that are fabricated by welding together segmented pieces are not recommended. Avoid haphazard pipe laying.

F.7.1.2 Leaky joints in inaccessible areas

a. Ensure that the pipes and fittings are stored and installed as per manufacturer’s instructions.

b. Prevent any interior contamination. If contamination occurs, clean before installation.

c. Take special care when joining two dissimilar materials.

F.7.2 Water Supply System

F.7.2.1 Corrosion and scaling of pipe/valve
a. Pipe penetrations and joints should strictly comply with manufacturer's instructions.

b. Jointing material should not enter pipe. Caulking at penetration sleeve should be made watertight.

c. Fulfil proper installation while ensuring that the protective coating is not lost/damaged during installation (BS 8558:2015, SS CP 48:2005).

F.7.2.2 Damaged piping

a. For underground pipe laying, bedding should be fully compacted prior to installation and the correct depth of trench, gradient, width and bottom condition should be maintained.

b. Properly align pipe work and use suitable joints. Ensure careful backfilling at an adequate depth for underground pipe laying. Completed sections should be tested for defects using leakage tests and should be rectified by the contractor as required. Maintain proper water pressure in piping system to avoid bursting from over pressurisation.

F.7.2.3 Water hammer

a. A water hammer may arise when the electric valves on appliances or single control valves are shut off fast. Although all noises due to water flow and pipe expansion cannot be removed, the contractor is responsible for fastening the pipes properly and commissioning valves/actuators to minimise the water hammer.

b. Install check valve to control the creation of a vacuum in discharge pipe (BS EN 16767:2016, BS EN 545: 2010).

F.7.2.4 Excessive vibration

a. Conform to the installation of pumps as per manufacturer’s instructions. Ensure proper construction of isolation beds and installation/mounting of equipment.

b. Special attention should be given for tightness of joints, and alignment of bearings and pipes.

c. Conduct testing and commissioning of the auto and manual interchange of duty and standby pumps.

F.7.3 Water Tank

F.7.3.1 Unauthorised/poor accessibility

a. Ensure there is adequate access space to and around the tank. Edge protection e.g. guardrail, must be provided to prevent personnel from falling from open sides of the tank. [R4].

b. Ensure that the tanks are not compartmentalised, so as to avoid the shutting off of the whole supply during cleaning (inconveniencing building users).

c. For the purpose of safety and security, provide a lock to water tank, so that only authorised personnel can access it. Ensure that the access is easy and safe, and for authorised persons only.
F.7.3.2 Leakage from water tank

a. Construct the tank body as per specifications (additive, coating, and lining), and render as a monolithic and watertight container. Maintain the exact size and positions of installed devices (SS 245:2014, BS EN 13121-3:2016).

b. Commission tank by testing for water-tightness; check for any leakage, seepage, and water loss. Ensure that all components are functioning well.

F.7.3.3 Corroded water tank body

a. Structure of water tank should be constructed with adequate strength and be free from any deformation. Refer to BS EN 10088-2:2014 for standards for a Stainless Steel Sectional Water Storage Tank (Minimum Grade 316).

b. The water storage tank’s installation must be certified by a Professional Engineer to ensure that it is structurally sound with regard to hydrostatic pressures, deflection and leakage.

F.7.3.4 Overflow of water

Use disinfectant to clean water tanks (BS EN 805:2000). Once disinfectant has been sprayed on inner surfaces and pipes for the designated period, it should be thoroughly cleaned/removed.

F.8 Construction Concerns: Fire Safety

F.8.1 Faulty Detection

F.8.1.1 Faulty fire alarm panel

a. Installer should identify circumstances that can lead to a high rate of false alarms and should inform both the designer and user. Check to ensure acceptable levels of false alarms during commissioning (SS CP 10:2005, BS 5839-1:2013, BS 5839-6:2013).

b. Install neatly and protect with sleeve as per manufacturer’s requirements (care to be taken in concealed spaces).

c. For the protection of joints in junction box, refer to minimum joint requirements.

F.8.1.2 Faulty manual call point

a. Ensure that manual call points are securely mounted and properly aligned (SS CP 10:2005).

b. Upon installation, test the system (e.g. three-second response test for manual call point, battery removal test, etc.) (BS 5839-1:2013, BS 5839-6:2013).

F.8.1.3 Faulty fire detector

a. Ensure the proper fitting of each fire detector, to avoid misalignment or damage caused by shock.

b. Ensure quality workmanship so as to avoid detector obstruction and or detector being covered by paint.

c. Remove paint, dust or any foreign material that can affect its function from detector.

F.8.1.4 Inaudible/unidentifiable alarm
a. Establish, implement and maintain procedures for warning and communication (e.g. life safety); and incident communication procedures (SS ISO 22313:2013).

b. Link lifts with audible warnings, emergency detection system and BMS, for emergency evacuation as per ISO/TR 25743:2010.

F.8.1.5 Malfunctioning or damaged backup power/lighting


b. Individual luminaires should be mounted to avoid glare and if possible, should be positioned at least 2m above floor level (measured from floor to the underside of the luminaires).

c. The horizontal illuminance on the centre line of any exit cannot be less than 0.5 lux. A fuel supply must be readily available to ensure that emergency lighting operates continuously for the rated period following the failure of normal power supply (SS 563-2:2010).

F.8.2 Fire Hydrant System

F.8.2.1 Fire hose damaged (cut kink, leak, missing part, abrasion)

a. Protect hose reels from mechanical damages. The reel should be mounted overhead, but the nozzle retainer, hose guide and inlet valve must be kept at 900mm above finished floor level (BS 9990:2015, SS 575:2012, NFPA 14).

b. During commissioning, the hose should be flushed out to remove harmful matter.

c. Conduct flush out test to remove any kink or knot and to ensure that all valves and nozzles are operational.

d. Ensure that reel brackets are firmly fixed, so that the hose can be used properly.

F.8.2.2 Accessibility problems (difficulty in accessing fire hydrant)

a. Ensure good project coordination.

b. Installation should be secure and safe, with special consideration given for potential sources of damage.

c. Ensure connections and position of valves comply with specifications. Risers must be securely anchored before any pressure or flow test is performed.

d. Hydrants should be made operable immediately after completion, and should be tested to protect the construction site.

e. Mounting height of hydrant and breeching inlet should be strictly maintained during installation (BS 9990:2015, SS 575:2012, NFPA 14).

F.8.2.3 Faulty fire hydrant point (damaged, jammed, leaky)

a. Ensure the proper installation of all components (parts-stem, cap, plug, thread, etc.) without damaging them.

b. Lubricate and paint for additional protection.

c. Tighten outlet properly after commissioning and testing.
F.8.3 Sprinkler System

F.8.3.1 Faulty/compromised sprinkler system

a. Installation and testing of sprinkler system, its associated controls, fire pumps and water supply should comply with SS CP 52:2004. (See also NFPA 13).

b. Mounting should be carried out according to the design approved by the authority and as per manufacturer’s instructions. Conform to general guidelines as per NFPA 13.

c. Ensure the careful installation of sprinkler system to maintain correct orientation without hindrance by supports.

d. Maintain spare sprinklers and sprinkler spanner after installation for future needs.

F.8.4 Fire Extinguishers

F.8.4.1 Poor discharge of portable fire extinguisher

a. Ensure the proper positioning (designated location, hung properly with label facing out) of fire extinguishers.

b. Installation of Small Fire Extinguishers (≤ 4 Kg): Hung on wall with hanger or bracket such that the handle is about 1.5m from floor. Hangers should be securely fixed.

c. Installation of Heavier Fire Extinguishers (≥ 4 Kg): Carrying handle should be about 1m from floor. Ensure that the arrangement would not hurt the person carrying it. Parts should be attached as per manufacturer’s instruction.

F.8.4.2 Fire door obstructed

a. Fix fire door as per manufacturer recommendation. Fire door must be the same make and model as the tested prototype. Door frames installed during wall construction should be thoroughly grouted in cavity as deeply as possible with corrosion-proof anchor. Screws for attachment should be driven properly, and not hammered or placed in other positions (SS 332:2007, NFPA 80).

b. Proper workmanship to avoid damaging/jamming/ sagging door (e.g. tilted hinge).

F.9 Construction Concerns : Electrical Systems

F.9.1 Switchgear

F.9.1.1 Unsafe switchboard/ electrical power distribution


b. Refer to BS 8512:2008 for storage, handling and installation of power cables on wooden drums.
c. Install sub-metering system with remote measurement capability and link to BMS/EMS to track energy consumption data trends.

d. All accessible metal parts of connection units should be in electrical contact with the earthing terminal(s) (BS 1363-4:2016, SS 403:2013).

F.9.2 Standby generator

F.9.2.1 Standby power generator issues


b. Install indoor fuel tank with a level indicator that can be easily accessed for observation. List and mark electrical wiring and equipment located near/within hazardous zones (i.e. day tank) (as defined by NFPA 70 or IEC 60079) for installation in an appropriate manner (SS 532:2016, BS 5908-1:2012).

F.9.3 Artificial lighting

F.9.3.1 Faulty/compromised artificial lighting and control system

a. Conform to the recommended illumination levels for office areas and task activities as per SS 514:2016 (see also CSA Z412-2000 (R2016), ISO 8995-1:2002/Cor 1:2005).

b. Comply with specifications for luminaires, for general requirements and tests (SS IEC 60598-1:2016).

c. Maintained illuminance depends on the maintenance characteristics of the lamp, the luminaire, the environment and maintenance programme (ISO 8995-1:2002/Cor 1:2005, SS 531-1:2006 (2013)).

d. Display and ornamental lighting should be separately controlled.

F.9.4 Lightning Protection System (LPS) and Earthing

F.9.4.1 Lightning protection system (LPS) defects (Corroded/exposed parts)

a. Construct and install air-termination system and LPS as per IEC 62305-3:2010, SS 555-3:2010. Installation to be performed by certified LPS installers.

b. Choose electrode locations that avoid the drainage of fertiliser and other materials into the area. Top soil should not be mixed with the backfill around an electrode.

c. To avoid hazards to adjacent ground systems, the electrode system should either be of compatible metals or protected by adopting cathodic protection (BS 7430:2011+A1:2015, SS 551:2009).

F.10 Construction Concerns : Elevators, Escalators and Moving Walkways

F.10.1 General

F.10.1.1 Compromised/poor condition of elevator machine room
a. Provide good ventilation to the machine room (natural or mechanical). For natural ventilation, a 20% opening of the floor area is recommended to achieve cross-flow. Provision for mechanical ventilation is recommended when the ambient temperature of the room exceeds 32ºC. (BS 5655-6:2011, BS 5655-11:2005, BS EN 81-20:2014, SS 550:2009).

b. Properly commission elevator prior to operation as per BS 8486-1:2007+A1:2011. Lift machine and drive must be securely mounted. All movable parts, the gear box, and joints should be sufficiently lubricated [M5].

F.10.1.2 Poorly-maintained elevator pit


b. Avoid any damage to waterproofing membrane during elevator installation.

F.10.1.3 Lift lobbies with poor accessibility for the disabled

Construct lift lobby pedestrian flooring as per recommended minimum pendulum ratings specified in SS 485:2011. (See also AS HB 197:1999 and AS/NZS 4663:2004).

F.10.2 Common Faults

F.10.2.1 Inaccurate elevator car levelling with the landing


b. Every lift must be provided with a capacity plate located in a conspicuous place inside the car, indicating the rated load in kilograms and, in the case of passenger lifts, the maximum number of passengers to be carried (BS 5655-6:2011, BS 5655-11:2005, BS EN 81-20:2014, SS 550:2009).

F.10.2.2 Faulty door operation

a. Test elevator car and landing doors to withstand an impact that is similar to the impact when a person collides with the door at running speed (BS EN 81-20:2014).

b. The main guiding elements of door should operate as intended. Doors must include retainers to keep the door panels in place (BS EN 81-20:2014).

c. Partially-closed door must open (if button controlling door opening is pressed); while the door must remain open when the door open button is pressed [M5].

F.10.3 Elevator Safety

F.10.3.1 Compromised safety and reliability

a. Map out safety checks for lifts and classify them according to safety and comfort requirements. Safety gear must be able to stop/hold lift car and counterweight within allowable distance as per SS 550:2009. (See also BS 5655-6:2011).

b. Proper installation and commissioning of Emergency Battery Operated Power Supply (EBOPS) of lift car, braking system, call buttons, load alarm, safety switches functions, safety logic, emergency lighting and supply, etc. [M5].
F.10.3.2 Faulty suspension ropes due to overloading
   a. Overload weighing device should be provided and must activate an alarm when the load in
   the car exceeds the rated capacity (BS 5655-6:2011, BS 5655-11:2005, BS EN 81-20:2014,
   SS 550:2009).
   b. Install suspension ropes as per ISO 2408:2004, BS EN ISO 16841:2014 and ensure it is
   properly and equally tensioned. If rope is damaged during installation, even if it passed tests
   prior to elevator service, the damaged rope should be replaced with a new rope, instead of
   just replacing the strands (ASME A17.6-2010).
   c. Lift capacity rate should be located at a noticeable position in the elevator car. It should
   indicate the rated load in kilograms and state the maximum number of passengers.

F.10.3.3 Failure to activate overspeed governor
   a. For safety code for the construction and installation of the overspeed governor refer to BS
   b. For the type of examination for overspeed governors, refer to BS EN 81-50:2014, which
   requires a minimum of 2 tests conducted with 0.9 – 1.0 gn acceleration to check the strength
   of the overspeed governor.
   d. Commissioning to ensure that overspeed governor functions as intended, for safety under
   all operating conditions [M5].

F.10.4 Energy efficiency
F.10.4.1 Inefficient energy performance
   a. Fulfil energy performance and verification of lifts as per ISO 25745-1:2012.
   b. Install luminaires which adhere to the maximum lighting power density for lift lobbies; i.e. 7
   W/m².
   c. Install equipment to measure energy consumption on installed equipment of lifts with
   reference to ISO 25745 series. (Refer also to SS 530:2014).

F.10.4.2 Poor/compromised lighting
   a. Install emergency luminaires in lift cars in accordance with SS 550:2009 (BS 5655-6:2011,
   b. Use energy efficient lighting with sensors during installation for energy efficiency.

F.10.5 Escalators
F.10.5.1 Escalator and passenger conveyor related maintainability issues
   a. Installation of escalators must comply with relevant standards and codes for safety and
   b. All machinery must be mounted securely and be defect free (e.g. should not have any oil
   leakage).
c. To ensure safe operation without issues due to corrosion and wear and tear, all escalator components should be of durable and reliable make.


**F.11 Maintenance Concerns : HVAC**

**F.11.1 Chiller Plant**

**F.11.1.1 Chiller frequently unloading (stop-start); Compressor not starting**

a. Set up appropriate cut-in and cut-out temperatures in chiller to avoid frequent unloading.

b. Inspect evaporator tubes for excessive oil, dirt or frost; check operating condition of expansion valve; check condenser tubes for air, dirt, scale, and sludge, and clean/purge if necessary. Check condenser water supply and cooling tower efficiency. Inspect overload relay, and the condition of high-pressure and low-pressure cut-outs.

c. Conduct monthly inspection on refrigerant level to avoid low pressure cut-outs of chiller (ANSI/ASHRAE/ACCA Standard 180-2012).

**F.11.1.2 Insufficient/slow cooling**

a. Inspect temperature controllers and thermostatic control valve for any malfunctions and then reset.

b. Perform routine inspection of condenser pipes and clean and conduct servicing (de-scaling) if/when necessary.

c. Routinely inspect insulation for any damaged/worn-out layers. Daily logging of chiller system to ensure system operates at optimal conditions. Any deviation from the intended chiller operation or alarms need to be attended to promptly.

d. Perform annual shutdown or overhauling as per manufacture’s guidelines (ANSI/ASHRAE/ACCA Standard 180-2012).

**F.11.1.3 Chilled water pipe and condenser pipe leakage and condensation**

a. Conduct quarterly check for pitting noise in pumps. Avoid harsh cleaning methods that may damage pipes or cause the thinning of pipes.


**F.11.2 Cooling Towers**

**F.11.2.1 Biological fouling**

a. Perform frequent overall visual inspection and cooling tower sequencing. Clean tower fill, basin and drift eliminators. Conduct weekly check on fan motor; clean screen; make up water float and water sampling.

b. Conduct monthly check of motor supports, fan blades, motor alignment.
c. Check on condition of bearings and motor, as well as for nozzle clogging, annually. Clean cooling tower at least once a year.

d. Perform monthly check for legionnaire, scaling and corrosion in/of the condenser system. Disinfect and manually de-sludge cooling towers if required.

F.11.2.2 Legionella outbreak

a. Monitor cooling tower’s water temperature, since elevated temperatures and moisture at air-water surfaces provide ideal conditions that may serve as a nutrient source for legionella growth.

b. Check and conform with chemical concentration limits of cooling tower effluents as per local codes and regulations (e.g. Sewerage and Drainage (Trade Effluent) Regulations 1999).

c. If cooling tower is not in use, it must be kept drained and dry. If not in use for more than 5 days, it should be drained, cleaned and disinfected before operating. Conduct regular testing for legionella bacteria, and get water samples from the cooling tower pond (ASHRAE 12, ANSI/ASHRAE 188).

F.11.3 Air Handling Unit (AHU)

F.11.3.1 Air distribution system efficiency

a. Clean dirt from impeller, fan scroll and blower blade, washable filters, filter frames and AHU frame slot. Clean cooling coil face with water. Flush with chemical cleaner, but avoid over dosage. Conduct chemical wash followed by thorough cleaning with water. Check for any dents on the coil fins. Comb/replace as needed. Clean off any hardened and dirty grease or grime from fans and motor shaft, and lubricate properly.

b. AHU rooms should not be used for storage, and should avoid housing installations that are not associated with the air-conditioning system (SS 553:2016, AS 1668.2-2012).

F.11.3.2 Noisy operation and excessive vibration

a. Conduct inspection to determine noise levels (AHRI 260). Inspect chiller plant with maintenance experts if abnormal sound occurs.


F.11.4 Air Distribution and Terminal Systems

F.11.4.1 Dirty and mouldy ductwork

a. Conduct noise and air loss check when necessary.

b. Perform testing and rating of performance of ducted air-conditioners (ventilation, exhaust and leakage air flow) as per ISO/FDIS 13253.
c. Conduct yearly check of ducting insulation.

d. Perform duct leakage test (for ducts designed to operate at static pressures in excess of 750 Pa) as per industry requirements (SS 553:2016, AS 1668.2-2012).

F.11.4.2 Filter media choked at the air terminal

a. Monitor air pressure and pressure drop across the filter and replace filter when needed. If filter is heavily dented, the filter should be replaced.


c. Conduct monthly check and observe the dust accumulation level in ducts or grilles.

F.12 Maintenance Concerns: Plumbing and Sanitary Systems

F.12.1 General Plumbing

F.12.1.1 Water supply – General defects

Perform thorough investigation to check compliance with SS CP 48: 2005, and BS 8554:2015. Conduct monthly inspection of water flow rate and pressure, and position and functioning of valves. Conduct maintenance inspections of the pipe installation and identify/rectify physical defects such as broken pipe braces, dents, or leaks. (See also BS 8558:2015, BS EN 806-5:2012).

F.12.1.2 Leaky joints in inaccessible areas


b. Repair the pipe joints properly using the correct jointing method. Tighten valve stems by replacing/fitting any missing gasket/washer.

F.12.2 Water Supply System

F.12.2.1 Corrosion and scaling of pipe/valve

a. Conduct quarterly chemical and bacteriological analysis of water used [M6].

b. Perform monthly check of water supply for visual signs of leakage, scaling and corrosion of pipes, joints and valves. Increase frequency of inspection for damp or polluted areas (BS 8554:2015).

c. Conduct monthly inspections and clean off/remove any rust or scale. Re-paint parts in a timely manner if needed (BS EN 806-5:2012).

F.12.2.2 Damaged piping

a. Conduct thorough cleaning and disinfection of service pipes on a monthly basis, and clean the main pipes semi-annually. If required, removal of blockage with manual cleaning method (e.g. plunger, drain rod, spring auger) should be performed.

b. Conduct chemical de-scaling quarterly (care should be taken so that it does not harm the pipes or jointing by giving consideration to chemical type or contact time). Perform maintenance schedule to check for clogged outlets (BS 8558:2015, SS CP 48:2005, see also [M7].
F.12.2.3 Water hammer

a. Conduct monthly pressure test by operating pump for min. 1 hr with 125m head or 150% of working pressure (whichever is greater) and check for any individual leakage or overall leakage.

b. Conduct semi-annual pressure test for sewage pumps.

c. Provide additional bracing or anchor block support at bends and branches in order to withstand the hydraulic thrust.

F.12.2.4 Excessive vibration

a. Lubricate pump parts with oil or grease as per manufacturer’s instructions.

b. Conduct routine check, clean motor starter and all heavy current contacts, and replace worn parts.

c. Visually check for any damage or missing parts (screw, nuts, strainer, etc.).

d. Ensure that after installation, pump is tested with power on mode for any unusual vibration, noise, leakage or burnt smell.

F.12.3 Water Tank

F.12.3.1 Unauthorised/poor accessibility

a. Conduct general housekeeping within and around the tank room to remove any obstructions to maintenance access. Perform monthly cleaning of wash-out pipes to ensure proper flushing out of the water.

b. Remove sand and dirt deposits in cisterns and tanks. Remove rust stains and repaint affected parts as required. Prevent dirt, dust, insects, birds, etc. from entering the tank.

c. Conduct thorough cleaning and disinfection of tank interiors semi-annually.

F.12.3.2 Leakage from water tank

a. Inspect drainage lines and basin.

b. Conduct routine checks for rusting of metal tanks and apply anti-corrosive paint/coatings where necessary.

c. Perform routine checks on float valve and liquid level indicator for damages to avoid potential overflow.

F.12.3.3 Corroded water tank body

a. Ensure that the parts (e.g. pipes/strainer) are corrosion-resistant and can be replaced over time.

b. Perform timely re-application of coatings to avoid peeling and delamination of coat (for steel tanks), and water seepage (for concrete tanks).

F.12.3.4 Overflow of water
a. Conduct monthly inspections to check the operation of float valve or any other effective device for controlling the inflow of water. All valves should be periodically operated to ensure that the working parts are moving freely (BS 8558:2015, SS CP 48:2005).

b. Inspect condition of overflow warning alarm for the water tank. Inspect the condition of warning alarm which indicates when water levels fall below 50mm from the invert level of the pipes.

**F.13 Maintenance Concerns : Fire Safety**

**F.13.1 Faulty Detection**

**F.13.1.1 Faulty fire alarm panel**


b. Conduct daily check to ensure normal operation, and to record and rectify any faults. Perform weekly tests to check battery and voltage conditions. Conduct monthly simulation of zonal fire and fault conditions. Clean fire alarm panel for proper operation and visibility (NFPA 72).

c. Keep fire panels safe and secure from unauthorised tampering.

**F.13.1.2 Faulty manual call point**

a. Conduct monthly test of manual call points on all alarm zones to ensure each part is functional, and especially check whether the remote auxiliary facilities are initiated or not.

b. Monitor power supply and faulty wiring of call points and other elements of the fire detection system.

**F.13.1.3 Faulty fire detector**

a. Practice proper housekeeping to maintain cleanliness and avoid obstructions (especially at poorly accessible points).

b. Inspect fire detectors weekly, and conduct monthly fire alarm simulations from a randomly selected detector to check the entire system.

c. Perform annual test of 20% of all detectors; all detectors will be inspected over a five-year period (SS CP 10:2005, BS 5839-1:2013, BS 5839-6:2013).

**F.13.1.4 Inaudible/unidentifiable alarm**

a. Inspect alarms for defects (e.g. loose or blocked gong bolt, damaged or corroded alarm, alarm spoilt by temperature fluctuations, etc.).

b. Conduct annual check of all installed speakers, amplifiers, and connecting appliances (including cables) and keep records.

c. Conduct routine check of fire alarm panel indicator bulb operation and battery (NFPA 72).

d. Perform real time monitoring and management of system performance.

**F.13.1.5 Malfunctioning or damaged backup power/lighting**

b. Conduct monthly fire simulation test. Simulate failure of main power supply and test the efficiency of the standby battery.

c. Ensure visual and audible fault signals are activated once the battery is disconnected.

F.13.2 Fire Hydrant System

F.13.2.1 Fire hose damaged (cut kink, leak, missing part, abrasion)

a. Perform proper housekeeping and avoid mishandling.

b. Once a month, check for corrosion/leakage (of drum), and ensure that hose, nozzle, stopcock, hinges, break glass device and cabinet are in acceptable working condition. Lubricate as required.

c. Conduct monthly water flow pressure test and annual hydrostatic test (BS EN 1402:2009) to check for defects or leaks, especially if the hose has been exposed to chemical or severe stress. During the test, the hose is completely run out and subjected to operational pressure. After the test, it should be dried and properly secured with a Velcro strap.

d. Ensure that fire hose is stored in a cool, dry place (ISO 2230:2002).

5.13.2.2 Accessibility problems (difficulty in accessing fire hydrant)

a. Perform proper daily housekeeping practices at hydrant points to remove obstructions (debris, stacked material) that impede accessibility.

b. Ensure that the storage tanks are accessible for maintenance. Ensure that the valve pit is accessible for inspection and cleaning.

c. Conduct semi-annual check for rust, dirt, or foreign material on valves, or other operating parts; as well as clean, paint and lubricate as required.

d. Ensure that additional building elements, landscaping, etc. (during building operation and maintenance phase) do not impede accessibility to hydrant points (BS 9990:2015)

F.13.2.3 Faulty fire hydrant point (damaged, jammed, leaky)

a. Conduct weekly check of isolating valves to ensure that they are kept locked in open position daily and that breeching inlets are functioning (NFPA 25).

b. Conduct monthly checks for any leakage, blockage or corrosion, and for workable line pressure.

c. Perform thorough inspection of booster pump and associated systems semi-annually.

d. Ensure that a thorough inspection of the hydrants is annually performed by a competent professional.

F.13.3 Sprinkler System

F.13.3.1 Faulty/compromised sprinkler system
a. Conduct quarterly visual inspection of all sprinklers for any leakage, damages or grease/dirt in spray nozzle and replace as necessary.

b. Conduct annual inspection of pipes and hangers for corrosion and mechanical damage (clean, paint or replace as necessary).

c. Clean quarterly and remove any obstruction affecting efficient discharge from sprinklers. Check for any sign of corrosion or deposit of dirt, paint or foreign material (NFPA 13).

d. Practice good housekeeping to avoid stacking of material leading to obstruction of sprinklers.

F.13.4 Fire Extinguishers

F.13.4.1 Poor discharge of portable fire extinguisher

Conduct regular servicing to confirm required working condition. (Refer to the recommended schedules for maintenance as per BS 5306-3:2009). Conduct monthly inspection to ensure that the pressure gauge is in operative range and check for any sign of corrosion of the body of the extinguisher. Comply with the recharging frequency as per type of extinguisher.

Charging, testing and maintenance of fire extinguishers must conform to SS 578:2012 specifications. Extinguishers must be recharged with the same agent only. No mixing or cross contamination allowed and no overfilling. (See also BS 5306-9:2015, NFPA 10).

F.13.4.2 Fire door obstructed

a. Inspect fire doors at least once a year, to ensure that self-closing mechanism functions as intended at all times. Check for and remove any door stoppers, or materials stacked near or by the fire exit door. Remove any obstructions.

b. Check integrity of door leaf for superficial damage, structural damage and excessive bowing or deformation. Inspect hinges, latches, bolts and pull handle weekly. Automatic release mechanisms should be tested in accordance with BS 5839-3:1988.

c. Ensure that egress is unobstructed in case of emergency evacuation as per NFPA 101.

F.14 Maintenance Concerns : Electrical Systems

F.14.1 Switchgear

F.14.1.1 Unsafe switchboard/ electrical power distribution


b. Check for insulation damages (e.g. cracks, blisters, warping) caused by overheating, physical impact or by spillage of cleaning chemicals. Check for potential short circuits or ground faults. Ensure that switchboards are not exposed to direct sunlight or alternative heat sources.

c. Conduct annual shutdown to eradicate hot spots along the distribution network as witnessed by the owner and certified by a Licensed Electrical Worker (LEW). Provide necessary warning notices/labels at switchboards (e.g. shock hazard warnings).

F.14.2 Standby generator
F.14.2.1 Standby power generator issues

a. Practice proper housekeeping and avoid stacking and storing of combustible materials in the generator house. Maintain records of preventive maintenance activities in a secure manner. Conduct general inspections daily and check on fuel, lubrication and cooling systems.

b. Perform a monthly running of the generator on no load for half an hour. Check battery charger, starting batteries and drive belt tension.

c. Adhere to the requirements for operation and maintenance of standby generator systems for buildings. Once a year, run load test on the generator and check to ensure that emergency supply can support all essential emergency services (SS 535:2007, BS 7698-7:1996, ISO 8528-7:1994, NFPA 110).

F.14.3 Artificial lighting

F.14.3.1 Faulty/compromised artificial lighting and control system


b. Practice proper housekeeping by dusting off and cleaning lamp surfaces.

c. Conduct regular inspection of light fittings and replace if burnt-out. Consider group relamping if lamps in the same batch are failing.

d. Conduct routine check on transformers and drivers of luminaires.

e. Check exterior lights for corrosion, torn cables, compromised watertight seals and discolouration; take remedial action where needed.

F.14.4 Lightning Protection System (LPS) and Earthing

F.14.4.1 Lightning protection system (LPS) defects (Corroded/exposed parts)

a. Perform a thorough check on surge arrestors and the earthing system once a year, together with the annual shutdown.

b. Monthly inspection must be conducted by a Licensed Electrical Worker (LEW). Such inspection should cover internal LPS to avoid occurrence of dangerous sparking within the structure caused by lightning current flowing in the external LPS or other conductive parts of structure (IEC 62305-3:2010, SS 555-3:2010).

F.15 Maintenance Concerns : Elevators, Escalators and Moving Walkways

F.15.1 General

F.15.1.1 Compromised/poor condition of elevator machine room

a. Conduct regular inspection of room condition and practice proper housekeeping. The room should not be used as storage; remove all non-elevator related materials from the machine room. Adequate lighting should be provided in the elevator machine room to allow workers to conduct maintenance works safely and efficiently [M8].


F.15.1.2 Poorly-maintained elevator pit

a. The pit areas should always remain dry. If there is any presence of water, the source of water must be identified and eliminated.

b. Conduct routine inspection of the elevator pit for water seepage due to faulty waterproofing membrane.

F.15.1.3 Lift lobbies with poor accessibility for the disabled

a. Practice proper housekeeping to keep the lift lobbies clean and clear of dirt, and avoid any obstruction or stacking to accommodate easy egress and ingress.

b. Conduct routine inspection of lift call buttons and indicator displays; check that they are in acceptable working condition.

F.15.2 Common Faults

F.15.2.1 Inaccurate elevator car levelling with the landing

a. Upgrade the control system, braking, and motor types. A micro-processor controller will electronically monitor and control motor rotation to ensure that the elevator car accurately stops at floor level. Review levelling of car to ensure the value is acceptable by standards to avoid risk of passengers tripping and falling (e.g. wheelchair users) [M5].

b. Permit to operate (PTO) to be displayed in the lifts [M5].


F.15.2.2 Faulty door operation


b. Review the service call frequency for the door. Increased service calls signify the need to upgrade/replace door operators.

F.15.3 Elevator Safety

F.15.3.1 Compromised safety and reliability

a. Conduct conformance test for electronic components of lift machines which are susceptible to damage from high temperatures that may impair reliability (ISO/TR 25743:2010).

b. Conduct monthly safety-levelling of the car and landing. Follow the mandatory incident reporting procedure in the case of an accident/incident [M5].

F.15.3.2 Faulty suspension ropes due to overloading
a. Periodic maintenance should be done by a BCA registered lift contractor at intervals not exceeding one month. An annual inspection and system test should be done by an independent Authorised Examiner (AE). Adhere to the guidelines for the operation and maintenance of permanently installed electric lifts as per SS 550:2009. (See also BS 5655-6:2011, BS 5655-11:2005, BS 7255:2012, BS EN 13015:2001+A1:2008).

b. Conduct annual test of safety equipment without load. A full load test should be conducted every 5 years. Sufficiently lubricate ropes frequently to avoid abrasive wear between and within the strands. Ensure the timely replacement of ropes if they are permanently kinked, bent, or deformed as per criteria set out in ASME A17.6-2010.

c. Lift ropes shall be tested against requirements of ISO 4344:2004 for signs of excessive wear and tear.

F.15.3.3 Failure to activate overspeed governor

a. Inspect the general condition of the speed governor, governor rope and diameter, tripping mechanism and governor switch and governor data plate with no power.


c. Governor rope should not show any sign of excessive wear and tear, in accordance with the requirements in ISO 4344:2004.

F.15.4 Energy efficiency

F.15.4.1 Inefficient energy performance

a. Comply with the measurements of energy consumption. Conform to the energy calculations and classification of escalators and moving walks as per ISO 25745-3:2015.


F.15.4.2 Poor/compromised lighting


F.15.5 Escalators

F.15.5.1 Escalator and passenger conveyor related maintainability issues

a. Ensure proper housekeeping of escalator to keep it clean and free of debris. Building owner/operator need to conduct monthly maintenance of escalators (including maintenance of safety switches, sensors, emergency stops, and handrails) as per SS 626:2017. (See also BS EN 115-1:2008+A1:2010). The annual inspection and testing should be performed by an independent Authorised Examiner (AE).
b. Access to the escalator or passenger conveyor should be barred by suitable devices and notices/signage displaying “No access/no entry” should be provided during maintenance, repair works, or inspections (BS EN 115-1:2008+A1:2010, SS 626:2017).

c. Adhere to the inspection criteria for safety of escalators as per JIS A 4302:2006. Refer to procedure for ride quality measurements of escalators and moving walks as per BS ISO 18738-2:2012.

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