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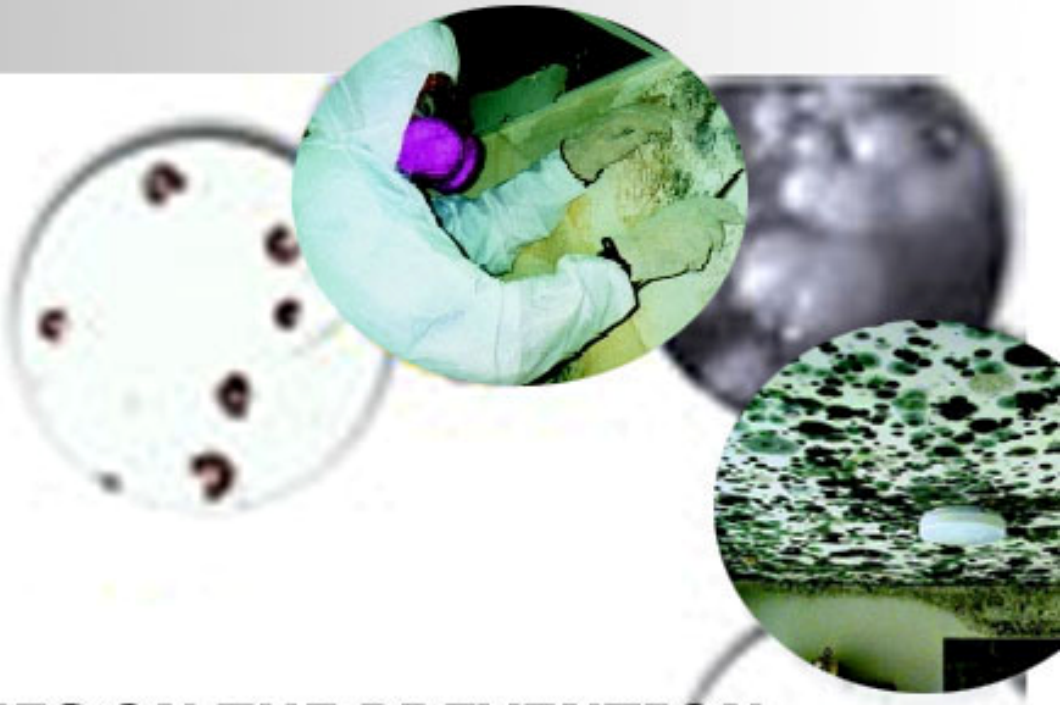

GUIDELINES ON THE PREVENTION OF MOULD GROWTH IN BUILDINGS

JABATAN KERJA RAYA MALAYSIA
2009

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PART 1

1.0 GENERAL

1.1 BACKGROUND

The increasing number of reported cases of mould growth found in new buildings, involving hospitals, clinics and in some instances, VVIP residences and office buildings has been a cause of concern with building engineers and owners. The reality is, if this problem is left unaddressed, it will affect the overall building operation and functionality. Mould growth in building affects the indoor air quality greatly. Besides odour problems, mould sometimes causes irreparable damage to furniture, wall finishes, expensive equipment and worse still is hazardous to health.

The hot and humid climate in Malaysia is conducive to mould growth whether out in the woods or inside a building. The introduction of moisture or humid air into a building envelope will encourage mould growth, which is most undesirable inside a building. Hence, factors that encourage this occurrence should be thoroughly considered at the initial stage of the building design process

A poorly designed air conditioning system could promote mould growth in a building but, it is not the sole contributor to the problem. A poorly designed building envelope would cause a significant amount of outdoor air to infiltrate into the building, contributing to mould growth. Some building materials could promote and even propagate mould problems, if used inappropriately. Water leakage is another very obvious contributing factor to mould problems in buildings.

This document provides brief guidelines on how to prevent mould growth in buildings. This guidelines are not exhaustive but provide the basis for the prevention of mould growth.

1.2 DEFINITION OF MOULD

There are thousands of known species of moulds, which include opportunistic pathogens, exclusive saprotrophs, aquatic species and thermophiles. Like all fungi, moulds derive energy not through photosynthesis but from the organic matter on which they live. Typically, moulds secrete hydrolytic enzymes from predominantly hyphal tips. These enzymes degrade complex biopolymers such as starch, cellulose and lignin into simpler substances which can enter the hyphae. In this way, moulds play a major role in causing decomposition of organic material, enabling the recycling of nutrients throughout ecosystems. Many moulds also secrete mycotoxins which, together with hydrolytic enzymes, inhibit the growth of competing micro-organisms.

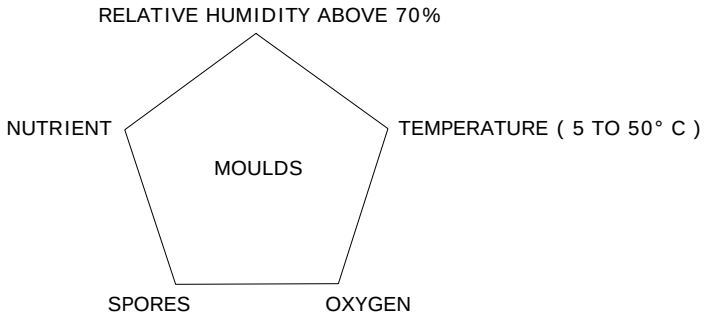
Mould requires a nutrient source, proper temperature and moisture to grow. Mould does not require light to grow. It does not produce food, but instead absorbs nutrients by breaking down hydrocarbons. As such it will grow on any organic building material such as paper ,adhesives, resins, etc. It will even grow on the patina of dust that collects on surfaces. The dust in the office buildings consist primarily of paper dust and skin cells so that it provides an adequate nutrient source for mould growth. Nutrients to support mould growth are everywhere in the building environment. The temperatures required for mould growth are in the same range as indoor building environment. The pervasive nature of nutrients and a temperature range suitable for mould growth leaves control of moisture as the only practical way to control mould growth.

1.3 FACTORS CONTRIBUTING TO MOULD GROWTH

In general, there are a few factors as listed below that contribute to mould growth in built environment:-

- Mould spores – which are readily available in the air
- Nutrient – such as dirt, dust cellulose and starch

- Temperature range between 5ºC to 50ºC
- Relative Humidity consistently above 70%
- Oxygen



Mould Factors Diagram

Air with high moisture content constitutes one of the key elements for mould growth. Therefore, to prevent mould growth, all possible factors that can introduce moisture into a building should be identified and eliminated.

Low surface temperature (below dew point temperature) of the air adjacent to the wall and/or floor slab will cause condensation on the surface and if left unattended to, will become ideal breeding grounds for mould to grow

1.4 OBJECTIVE

The objective of this guideline is to provide sufficient information and measures to be taken in preventing mould formation inside buildings through proper quality control in design, construction and operation. It also stressed the need to identify the contributing factors and prepare proper action plans to monitor, prevent and overcome mould problems in buildings

1.5 ROLES OF PARTIES INVOLVED

Mould growth control essentially needs a multidisciplinary approach. All relevant parties have to play their role to prevent mould growth in buildings. In this guideline, the roles of each party are outlined below:

a. ***Designers –*** Architects, Civil & Structural Engineers and Mechanical Engineers should design the building and its internal services in such a way that the risk of mould growth inside the building is reduced or if possible, eliminated.
b. ***Contractors*** – Construction Contractors should play a role in eliminating the risk of mould growth in a building by providing skilled and experienced labour to handle materials and they should adhere to specified procedures during building erection.
c. ***Manufacturers*** – Suppliers and Manufacturers should ensure all supplied building materials and equipment are of good quality that does not promote mould growth (i.e. materials with low moisture absorption rate).
d. ***Facility Managers*** – The facility managers should plan, execute and supervise maintenance works, as well as schedule inspection with the overall task of preventing mould growth in buildings during operation

PART 2

2.0 MEASURES TAKEN AT VARIOUS STAGES OF THE BUILDING PROCESS TO PREVENT FORMATION OF MOULD GROWTH IN A BUILDING:

Prevention of water intrusion can be done most effectively during design and construction. Opportunities to prevent problems shrink as the building process moves from conceptual design through construction. The cost of correcting a problem increases dramatically as the project moves forward, with most expensive corrections occurring after the building is in operation.

2.1 Four Basic Criteria

The following are the four basic criteria that need to be evaluated in order to reduce the risk of building getting infested with mould:

- **Performance Criteria**
  Written design criteria and performance requirements for a building at the very beginning of the project.

- **Design Review**
  Periodic design reviews on evaluation of construction design documents to identify faults as well as opportunities to improve building design construction technology.

- **Design Validation (Peer Review)**
  Validation upon finalization of design reviews to compare design and construction outcomes to the project criteria.

- **Performance Testing**

  Sub-system testing as building components is installed and integrated system performance testing during the start up phase of the building.

2.2 Problems Of Moisture Intrusion

Mould growth is closely linked to moisture intrusion and typically becomes a problem due to one of the following reasons:

2.2.1 Design Or Construction Flaws

Selection of wrong materials for a building component, installation of damaged materials, improper sizing of the air-conditioning & ventilation system and other design flaws can lead to a wide range of conditions that can contribute to mould growth.

2.2.2 Building Component Or System Failure

A window or wall structure, or other component may be defective or improperly installed, allowing moisture to intrude.

2.2.3 Operational Failure

Building equipment may not be operated in accordance with the design parameters, resulting in leaks, condensation or flooding and home mould growth.

2.2.4 Buildings Change

Space may be reconfigured; major equipment may be replaced; tenants may add specialized equipment. Any of these changes can compromise the ability of the building to shed moisture. Therefore, it is critical to establish procedures that prevent moisture intrusion and mould manifestation.

3.0 ARCHITECTURAL CONSIDERATIONS

3.1 Design Stage :

3.1.1 Walls

i) External walls separating 24-hour air-conditioned space and external area shall be double brick cavity walls with a minimum of 25mm gap filled with fire retardant PU foam (or other equivalent insulation materials), and for window openings shall be double glazing. Wall sealer (vapour seal) shall be applied on the external side before painting. PU paint shall be applied on both sides of the wall.(Refer Figure 1).

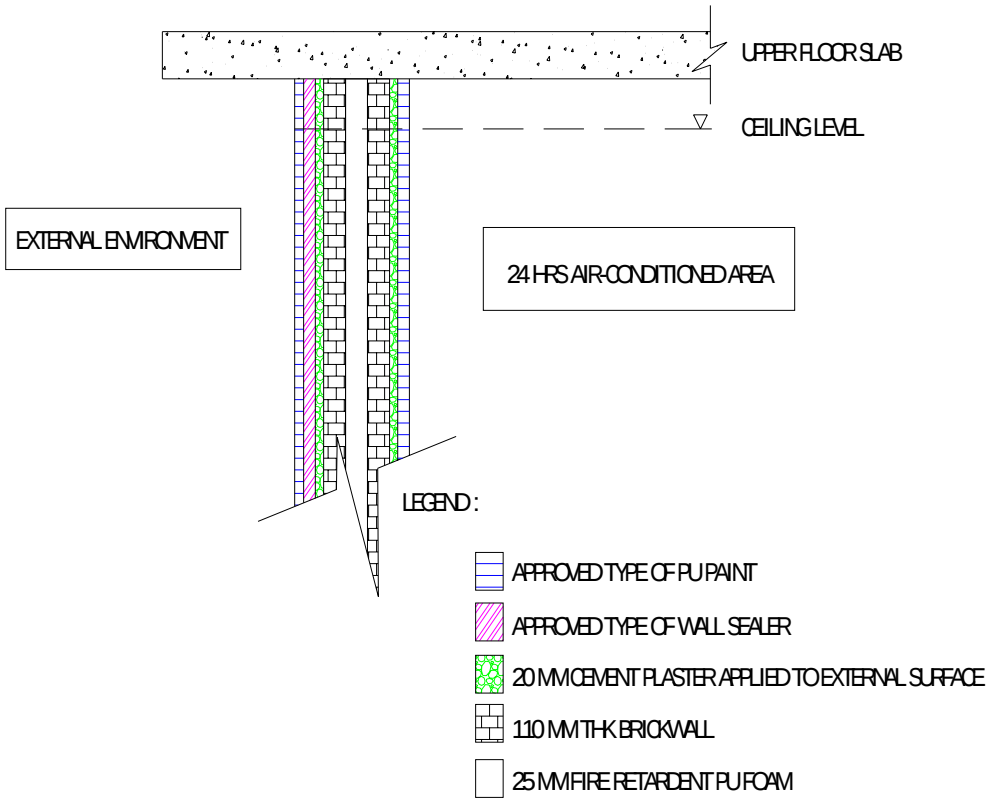


Figure 1

ii) Internal walls used to separate 24-hour air-condition space and non-air-conditioned or part day (8 hour) air-conditioned space shall also be double brick cavity wall with a 25mm gap filled with fire retardant PU foam. Wall sealer shall be applied on the external side before painting. PU paint shall be applied on both sides of the wall. (Refer Figure 2). However, alternative material can be proposed as substitution to the brick wall of the 24-hour air-conditioned side if the wall is not required to hold electrical wires, plug points, pipes and other services.

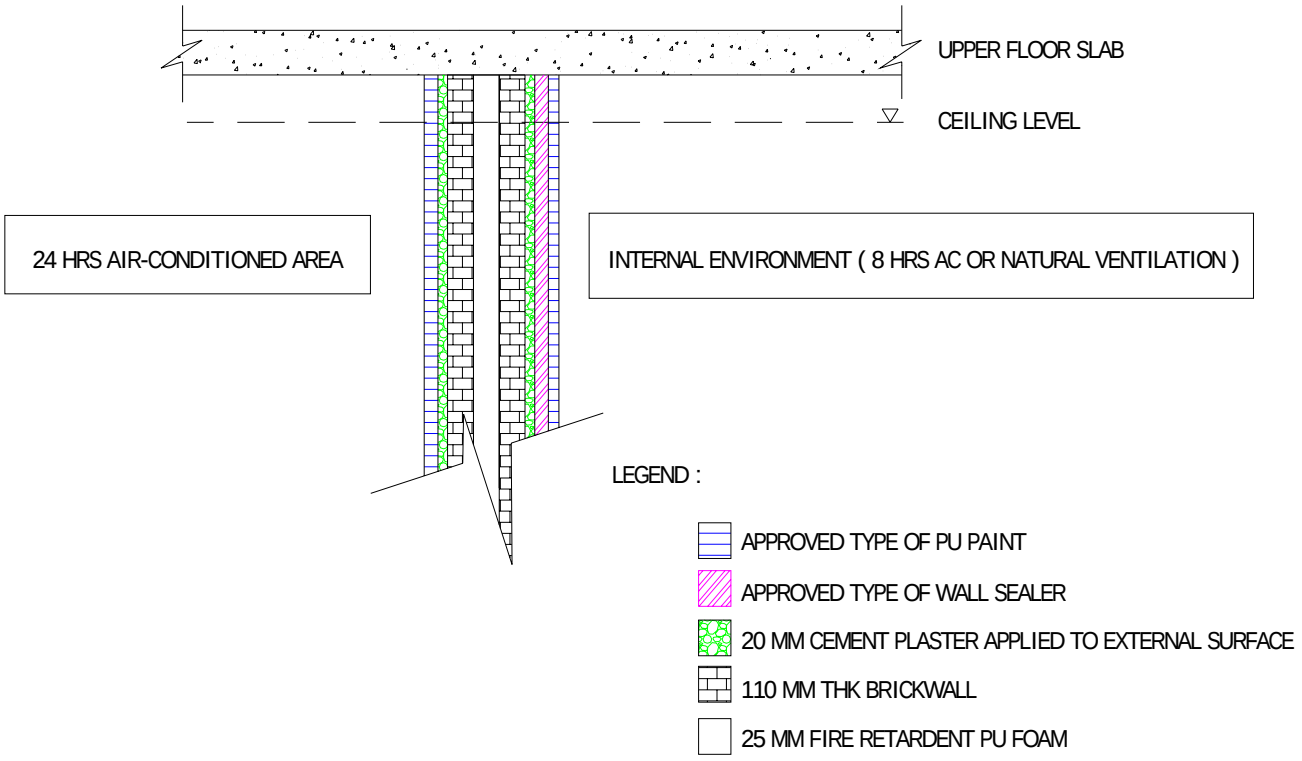


Figure 2

iii) All brick walls separating 8 hour-air-conditioned and non air-conditioned spaces must be applied with wall sealer (vapour seal) on the external side before painting with PU paint. *(Refer Figure 3)*

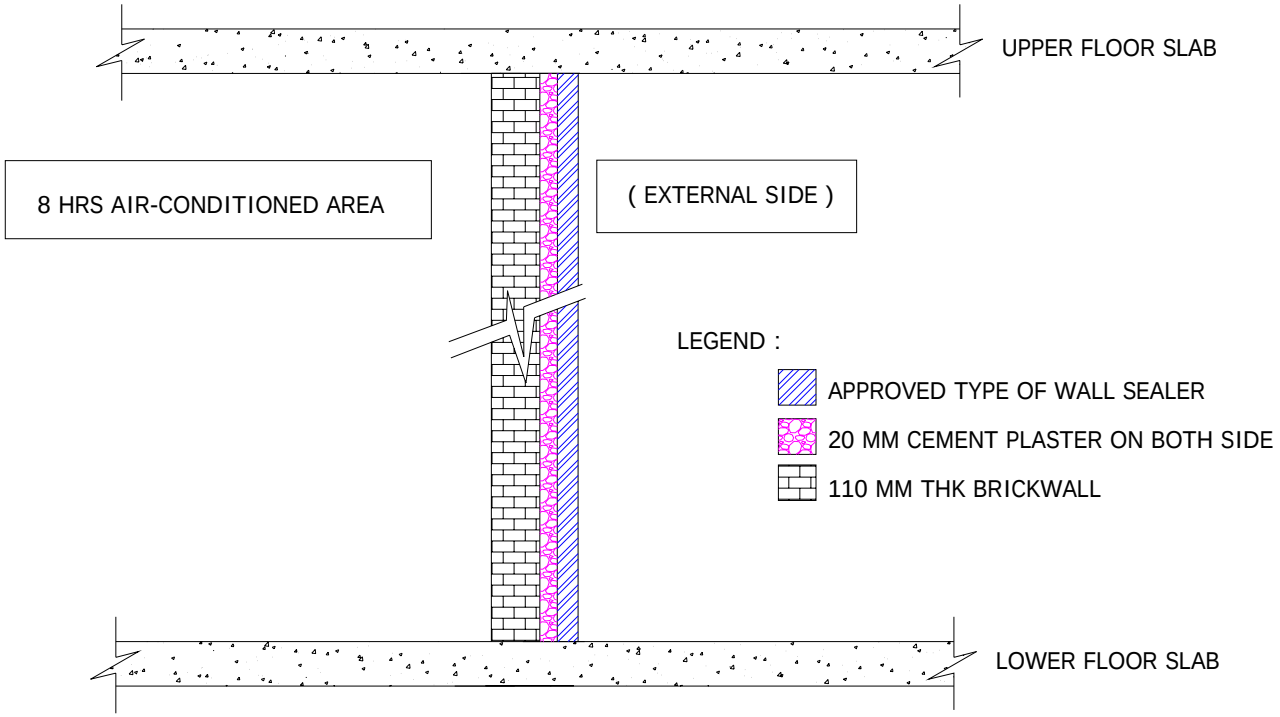


Figure 3

iv) In addition, the walls must be fully partitioned i.e. right up to the floor-slab with plaster, wall sealer and PU paint. (NB: irrespective whether ducted return or free air return through ceiling)

v) The design of dividing walls, floor and ceiling shall be constructed to specification where the air-conditioning system operates intermittently.

3.1.2 Floor Slabs

i) For areas served with 24 hours air-conditioning, the Contractors is required to apply vapour sealer followed by minimum 50mm thick fire retardant P.U. foam under the floor slab above it, and also the same under the floor slab below it. This requirement shall be extended to the adjoining floors up to 3 meters away. The Contractor may propose other alternative solutions, if any, to avoid condensation problems from occurring. (Refer Figure 4)

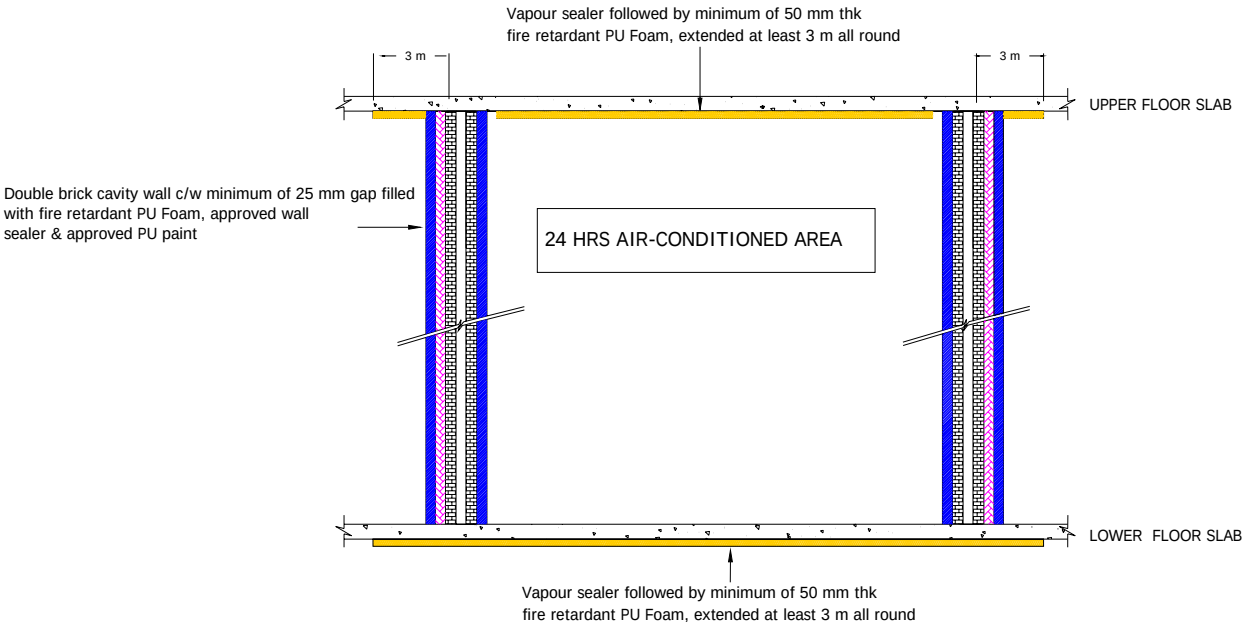


Figure 4

3.1.3 Ceiling

i) All ceilings for 24 hours air-conditioned rooms as well as ceilings below these rooms shall PVC laminated gypsum boards or moisture resistant board of not less than 9.5 mm thick and of size 600mm x 600mm.

ii) All ceiling over 8-hr air-conditioned space must be of vapour-proof material.

iii) All wet or humid clinical areas in the laboratories, pharmacy and CSSD shall be PVC laminated gypsum boards or moisture resistant board of not less than 9.5 mm thick and of size 600 x 600 mm.

iv) Ceiling to toilets and stores shall be 6mm thick lightweight and non porous board, such as calcium silicate or moisture resistant board of size 600 x 600 mm.

3.1.4 Doors

i) Wide door opening (more than 6 feet when fully opened) between air-conditioned and non air-conditioned areas must be of air-lock design.

ii) Location of automatic doors must be such that the doors open only for people to enter or exit, and not indiscriminately open whenever people pass by (with no intention to enter or exit).

iii) Door leaves with hold-open mechanism must exceed 1.2 m per leave to deter people from making them open inadvertently.

3.1.5 Windows

i) Windows in public areas must be lockable or permanently closed type to prevent unauthorized opening of windows.

3.1.6 Finishes

i) Finishes for non air-conditioned rooms located adjacent to rooms with air-conditioning shall be non-porous and anti-fungus.

ii) All internal architectural fixtures shall not be exposed to extreme external weather.

3.1.7 Wet Area

i) All separating walls between wet/moist area and dry area shall be provided with 2 coats of damp-proof membrane which shall turn up the walls to a height of 2100 mm, before installation of ceramic tiles (to prevent dampness and in line with Garis Panduan Bilik Air [Kubikel Tandas & Kubikel Mandi] Awam di Seluruh Negara, Bil.JKR 20802-0005-06).

ii) Generally, glazed ceramic wall tiles or other equivalent material shall be provided as back splash behind worktops, hand wash basins and sinks.

iii) Approved damp proof course and membrane must be applied to all ground floor areas, wet areas, and planters, areas sensitive to water penetration such as areas with parquet finish, vinyl floors, timber strips at floors and walls.

3.1.8 Internal Corridors

i) Internal corridors that are not air-conditioned have experienced condensation or dampness on the corridor walls when the adjacent rooms are air-conditioned. Such walls shall be insulated on the air-conditioned side with 25 mm thick fire retardant P.U. insulation held back by approved wall finish material, ***(****Refer Figure 2)*

3.1.9 Stack-effect and Mechanical Ventilation

i) Underground or semi-underground areas (one side on ground and the other side underground in undulating areas) of buildings which are not air-conditioned such as basement must be mechanically ventilated for 24 hours per day.

ii) Non air-conditioned buildings such as Quarters and Hostels shall be designed for night cooling via stack-effect ventilation. For Hospital wards/beds, which are not designed for natural cross-ventilation, mechanical ventilation shall be provided.

3.1.10 Internal Courtyard

i) Internal courtyard shall be planned in such a way to avoid stagnant air. Wherever possible it shall be designed with through ventilation or free flow.

ii) Avoid designing spaces that causes air stagnation. Cross ventilation shall be strictly observed on all non air-conditioned building layouts.

3.1.11 Services

i) Services routing above sensitive areas such as Operating Theatres and Cafeteria, shall be avoided to prevent water/waste leakages from these pipes.

ii) Water and waste pipes from 24-hour air-conditioned areas running through ceilings of non-air-conditioned areas shall be insulated to prevent condensation.

3.1.12 Architectural Detailing

i) All drawings shall be thoroughly checked by the principal architect before endorsing as construction drawings.

ii) All drawings shall show architectural detailing. The typical is as shown in Appendix 2 : (TYPICAL ARCHITECTURAL DETAILING: Do's & Don'ts)

3.1.13 Thermal Analysis

In order to determine material selection of buildings, preliminary thermal analysis for 24/7 air-conditioned area should be done before final design .

3.2 Construction Stage:

3.2.1 Delivery Dry Materials.

All construction materials delivered to site especially architectural components shall be dry, mould free, and properly protected when they arrive on site.

3.2.2 Protection of Materials On Site

Contractors shall establish procedures and set up areas on the site to store and protect materials from rain, flood and construction process water from the time they arrived until they are installed. Common materials such as furniture, carpets, suspended ceilings, all type of wood products and others, shall be stored properly and protected to avoid being damaged

3.2.3 Address Water Problems

Moisture is incorporated into many materials during construction. For example concrete, masonry, drywall tapping compound, and some paints have water as a component. Construction moisture can equal or even exceed the safe

moisture storage capacity of the material. This water must be able to escape from an assembly otherwise moisture problems and mould growth can occur. For water based coatings this can be a simple matter of maintaining environmental conditions favorable for drying for a period after application.

In instances where a surface is to be covered with an impermeable covering or coating the substrate must be adequately dry prior to covering. Measurement of concrete moisture prior to application of resilient flooring is an example of this situation. In situations where a moisture laden component such as concrete or masonry is built into an assembly it may be necessary to allow the materials to dry before covering with other construction.

Inspect and document work areas every day to make certain that finish materials are not installed before dry-in or over wet, leaking, or mouldy infrastructure.

3.2.4 Protect Finishes

Comprehensive measurement of moisture content on the wall floor and ceiling should be carried out to determine if the surfaces are dry enough for the installation of final selected architectural finishes. Inspect completed work to make certain it is dry and mould free.

3.2.5 Remediate Immediately

Discard wet or mouldy materials before installation and remove and replace wet or mouldy materials as soon as they are discovered.

Any wet/damp wall surfaces before the building works is completed, should be thoroughly investigated and the root

cause of the dampness shall be recorded. If the cause is due to burst pipe inside the wall, it should be attended immediately within 48 – 72 hours.

4.0 MECHANICAL CONSIDERATIONS:

Heating, Ventilation & Air Conditioning System (HVAC), Fire Protection System and Cold Water Supply System are the mechanical system that can causes mould growth in a building.

4.1 Design Stage

4.1.1 Heat Load Calculation

A detailed cooling load calculation for any air conditioned space is required to be carried out. As for spaces with 24/7 (*24 hours and 7 days running*) air conditioning system or those with fluctuating loads, all possible contributing factors should be taken into account when estimating the cooling load. This is to ensure that the equipment selected is capable of maintaining the relative humidity at below 70% during partial load operation.

4.1.2 Building Operation Load

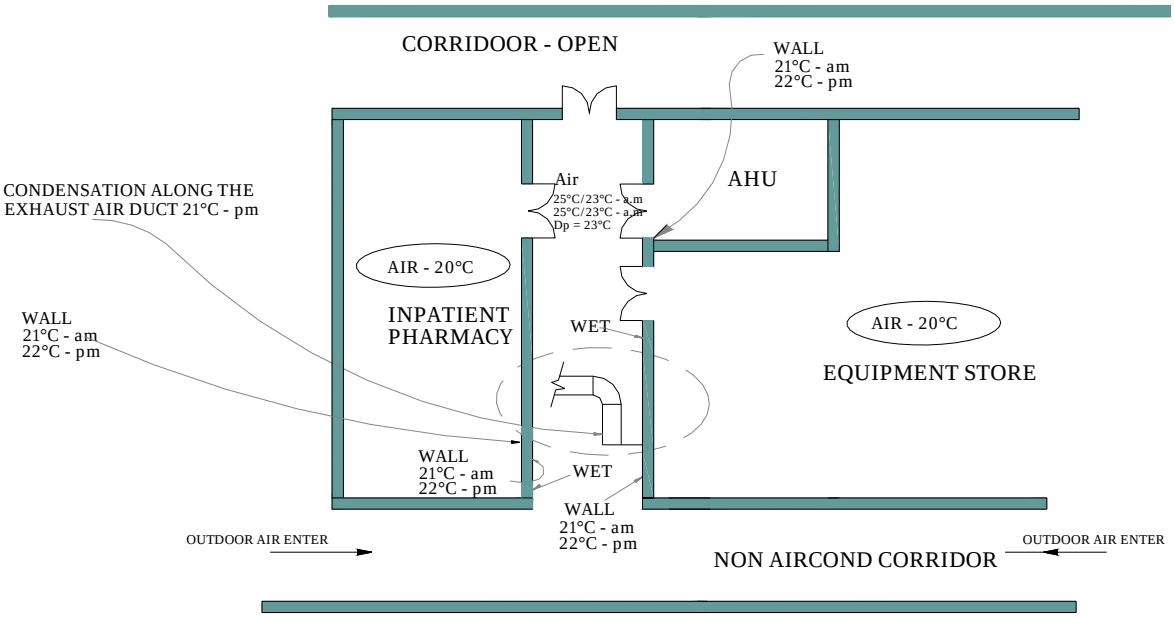
Building operation should be thoroughly evaluated to calculate the required cooling load (sensible and latent) of the cooling coils.

4.1.3 Prevent Oversize Cooling Coil

An over-sized cooling coil may not operate in dehumidification mode during partial load and this will then cause high space relative humidity. An oversized performance specification proposed by the consultants/contractors should not be accepted.

4.1.4 Adequate Air Change

Mechanical ventilation with adequate air change shall be provided for enclosed or partially enclosed areas without air conditioning or natural ventilation, in reference to Third Schedule (By-Law 41) UBBL requirements. This is to avoid stagnant air which may cause higher risks of condensation on the surface separating air conditioned and non air conditioned areas. *(Refer Figure 5)*



EXAMPLE OF AIR STAGNATION IN SEMI ENCLOSED CORRIDOR

Figure 5

4.1.5 System selection

The use of chilled water fan coil units in 24/7 areas shall be minimized due to its higher condensation risks. Use of centralized air distribution system is desirable.

4.1.6 Accessibility

Pipes shall be located such that leakages are easily spotted and remedial action can be carried out promptly.

4.1.7 Location of Fresh Air Intake

Locate fresh air intakes away from areas such as cooling towers, damp environment etc, to keep any prevalent mould spores from entering the air conditioning system.

4.1.8 Internal Duct Insulation

The use of open porous insulation and fibrous internal duct liners as duct insulation shall be avoided for health care applications, as such materials are conducive to mould growth when laden with moisture carried over from the wet coils.

4.1.9 Location of AHU (Air Handling Unit) / FCU (Fan Coil Unit)

In areas where a 24/7 operation is required, AHU/FCU shall not be placed in concealed ceiling under a pitch roof to avoid condensation.

4.1.10 Pre-Insulated Pipe Insulation

Use pre-insulated pipes for the chilled water to ensure a more consistent insulation quality.

4.1.11 Drain / Condensate Pipe Insulation

Drain/condensate pipes shall be well insulated with closed cell material to JKR standards. If site condition permits, avoid sharing of drain pipes. For gravity flow, the pipes shall be sloped at least 1:100 and discharge to the nearest drain.

4.1.12 Exhaust Ducts

Exhaust ducts emanating from an air conditioned space shall be insulated when traversing a non-air conditioned space.

4.1.13 Location of Supply Air Diffuser

Supply air diffusers shall not be placed less than 1 meter away from a wall as this may cause *cold spot* on the wall and result in condensation. Under such circumstances, use three-way throw diffusers.

4.1.14 Pipes Routing

i) Pipe routes shall avoid penetrating cavity wall to maintain the wall thermal integrity.

ii) Avoid water pipes passing through ceiling space of 24/7 air conditioned areas.

4.2 Construction Stage:

4.2.1 Equipment Selection

Air Conditioning equipment should be selected according to approved JKR specifications and nearest to design data (based on proper cooling load calculation).

4.2.2 Proper Duct Installation

i) Ensure that ducting system is properly installed and that insulation used is of *JKR approved material*. i.e PE Foam & Fiberglass .Ensure there are no leakages in duct joints. Duct leakage tests should be conducted in accordance with SMACNA (*Sheet Metal and Air conditioning Contractors National Association)* standards.

ii) Support for flexible duct shall follow SMACNA recommendations.

4.2.3 Approved Sealant

Sealants used on duct joints shall be of *JKR approved materials* and external ducting insulation shall be installed according to SMACNA procedure.

4.2.4 Drain Pan Gradient

Condensate pipes and drain pan for fan coil unit shall be installed with a minimum 1:100 slope to effectively drain the condensate water by gravity.

4.2.5 Collar Joint

Collar joints between ducting and air diffuser shall be properly installed to avoid leakage.

4.2.6 Control Valve

All Control Valves for AHU / FCU shall be *approved by JKR* and shall be properly insulated. This is to avoid leakage and to provide effective control of chilled water flow as ineffective control will impair moisture removal at the cooling coil.

4.2.7 Infiltration of Outside Air

Ensure that there is no outside air infiltration into air conditioned space or into the ceiling plenum. Any opening above the ceiling level (internal or external wall) shall be properly sealed.

4.3 Testing, Balancing & Commissioning Stage:

4.3.1 Air Balancing

Air balancing shall be carried out in accordance with ASHRAE (*American Society of Heating, Refrigerating and Air-Conditioning Engineers)* Standard 111 or SMACNA's HVAC (*Heating,*

Ventilating and Air-Conditioning) Systems – Testing, Adjusting and Balancing or equivalent, to verify conformance with total fresh air intake and space air flow requirements.

4.3.2 Water Balancing

Water balancing shall be carried out in accordance with ASHRAE Standard 111 or JKR T&C Specification – FORM 17or equivalent, to verify water flow requirements.

4.3.3 Testing & Commissioning Procedure

Testing & commissioning shall be carried out in accordance to ASHRAE 111 or JKR T&C Specification – FORM 17 and the result shall be within the allowable range as per design specifications.

4.3.4 Air Tightness Test

Where specified, an air tightness test shall be carried out to control moisture and energy usage.

4.3.5 Control System

Control system shall be thoroughly tested. Motorized valves, heaters/heat pipes and all other ancillary components shall be tested to the design specifications

4.3.6 Leakage Test

For duct system of 4” (1000 Pa) w.g class and higher it is recommended to carry out the test to prevent the condensation at the duct joints. (Refer SMACNA 1.7.1)

5.0 STRUCTURAL CONSIDERATIONS:

5.1 Design Stage

5.1.1 Quality of structural members

All structural timber works shall be of the strength group SG 1, SG 2, SG 3 and SG 4 in accordance to MS 544 and made up of heavy hardwood and duly treated where applicable.

All structural steel, otherwise specified shall be in ROLLED SECTIONS, STRUCTURAL HOLLOW SECTIONS, PLATES AND BARS and shall comply with the appropriate standards mentioned in the JKR Standard Structural Steel Work Specification. The structural steel material shall be at least Grade 43 or higher.

5.1.2 Corrosion Prevention

All structural steel members shall be given protective treatment against corrosion and shall comply with the JKR Standard Structural Steel Work specification. The protective treatment shall be designed for a minimum service life of 20 years.

5.1.3 Flat Roof

The design of flat roof is not recommended.

5.2 Construction Stage:

5.2.1 Watertight Floor

All toilet floor areas shall be constructed to be watertight. The floor area shall be tested for water tightness through a 24 hour ponding test, to ensure that there are no damp patches or leakage underneath the floor slab.

5.2.2 Sanitary fittings installation

All sanitary fittings, pipes shall be cast in-situ into concrete components to prevent leakages. No hacking/break-up is allowed to hardened concrete slab.

5.2.3 Application of Damp proof course & membrane

Damp proof course and membrane must be applied to all ground floor areas, wet areas, and planters, areas sensitive to water penetration such as areas with parquet finish, vinyl floors, timber strips at floors and walls.

5.2.4 Water proofing materials

The Contractor must provide the best ground water-proofing material and shall take extra precaution and ensure proper ground water-proofing works being provided. This is to prevent water seepage to the floor.

5.2.5 Dry structural element

To ensure all structural element inside building in dry condition all the time.

5.2.6 Avoid water leakage

Water leakage in the building shall be avoided. The leakage can be caused by improper materials, process and workmanship in construction, especially in water proofing works.

5.2.7 Site cleaning

Any used material especially wood (typically used for form-work) should be removed from site and not left in the building. Certain construction materials, if left unattended, will provide nutrients to mould growth.

6.0 BUILDING OPERATION AND MAINTENANCE STAGE

6.1 Repair Work by Competent Persons

Any repair work on air conditioning system components shall be carried out immediately by competent and registered HVAC contractors. Any downtime of HVAC system can contribute to failure of moisture control.

6.2 HVAC Monitoring

Daily monitoring of HVAC system through BAS shall be carried out.

6.3 Clean/Replace Air Filters

All air filters shall be cleaned regularly and/or replaced as per manufacturer's recommendation. Dirty air filters may serve as ideal breeding ground for mould growth.

6.4 Quality of Chilled/Condenser water

Chilled water quality shall be chemically analysed annually and condenser water quality analysed monthly. This is to avoid reduction in thermal performance caused by propagation of scale, corrosion, bacteria, slime and algae.

6.5 Outside Air Infiltration

Ingress of excessive outside air to air conditioned space due to opening of windows, doors etc shall be controlled. Ingress of outside air will cause condensation on walls and ceilings.

6.6 Control System

HVAC controls and interlock with BAS shall be tested and calibrated at least once every two (2) years.

6.7 Renovation Works

Renovation works in building can create indoor air quality problems by emitting dust, odors, microorganisms and spores. To prevent mould growth, air conditioning shall be shut down during renovation work. After the completion of all renovation works, both exhaust and supply ducts must be cleaned up. An alternative method is to isolate the work area by blocking return vents in the work area and/or installing temporary barrier.

6.8 Ventilation

Prevent excessive moisture levels in the air in the building by using the exhaust fans in toilet and pantry.

6.9 Vent For Moisture Sources

Appliances that produce moisture, such as cloth dryers, stoves, and heaters must have the moisture / vapour vented to the outside where possible. (Combustion appliances such as stoves and heaters produce vapor and will increase humidity unless vented to the outside)

6.10 Attend To Moisture Immediately

Moisture detected on any wall, shall be attended to as soon as possible. Generally, the cause of the problem shall be identified within 48-72 hours.

6.11 Mould Growth Monitoring

Surveillance of mould growth shall be carried out at least quarterly. Immediate action to exterminate mould growth at the early stage is critical. Identification and reporting procedures of mould contaminated material shall be conducted.

6.12 Mechanical Maintenance Works

Mechanical System maintenance works shall be carried out in accordance to the specified maintenance schedule (e.g. air filters shall be changed in accordance to manufacturer's recommendation)

6.13 Eliminate The Spores

Office furniture shall be kept clean at all times, especially those not being used for a long periods of time. This will reduce the opportunity of mould growth on furniture.

6.14 Windows & Doors

In air-conditioned space, all doors and windows shall be shut at all times (day and night) to avoid the increase of air moisture.

6.15 Access For Maintenance

In buildings where clients have plumbing and air-conditioning & ventilation related renovation, access and spaces should be provided for the maintenance purposes.

6.16 Periodic Maintenance

Periodic maintenance works as stipulated in the maintenance manual of the equipment should be strictly adhered to avoid major problems later. In cases where building have been renovated, due access for air-conditioning and plumbing maintenance works must be provided.

6.17 Routine Assessment

It is also advisable for the client to engage a competent person to conduct routine environmental assessment of spaces inside their building which could include :

i) to identify the presence of moisture and mould.

ii) Inspection and performance measurement on the air-conditioning and ventilation system.

iii) Inspection of the building envelope, including roof, exterior walls, windows, doors, ground levels and below ground level walls.

iv) Inspection of interior floors, walls and ceilings.

6.18 Water Seepage

Construction joint shall be protected from water seepage.

6.19 Removal of Unwanted Materials

The Contractor shall remove all materials or rubbish that may caused the mould growth and water stagnation resulting from any type of construction works and dispose of them in safe and satisfactory manner out of the site.

6.20 Room Temperature

The room temperature shall not be below the design temperature. Low room temperature will cause low surface temperature which contribute to condensation

7.0 CORRECTIVE ACTIONS

Mould prevention requires constant diligence. Routine inspections are the best way to identify and correct mould problems. Problems must be corrected in a timely manner. Mould can grow quickly in the right environment. After identifying and rectifying the root cause of condensation, leakage, etcs. the following corrective actions shall commence :

7.1 ACTION PLANS

7.1.1 General rules in deciding when to inspect for mould is if:

a. Fungal spore counts are high.

b. Source of water or dampness found on the surface of the wall

c. High relative humidity or visible water condensation.

d. Visible mould growth.

7.2 CORRECTIVE MEASURES

7.2.1 *Steps to be taken if a decision is made to conduct a thorough investigation, the following steps shall be followed as a guide:*

a. Visit the site and collect data

b. Make decision whether it is necessary to appoint a qualified specialist consultant to carry out further detail investigation. If the service of a qualified specialist consultant is required, one should be appointed immediately.

c. Study the report prepared and the recommended remedial measures proposed by the specialist consultant.

d. Appoint a qualified contractor to carry out the corrective and remedial works as recommended.

e. Visit the site to certify that all corrective and remedial works carried out by the contractor are in accordance to the consultant's recommendation.

f. Avoid repeating the same problem again. The consultant's report and recommendation shall take into consideration into this matter.

7.2.2 Cleaning Mould Remediation Sites.

7.2.2.1 Areas subjected to mould removal such as remaining structural components, floors, and other surfaces should be thoroughly cleaned, vacuumed, wiped, and sealed if a sealant was to be used.

7.2.2.2 There shall be no demolition debris left in the building.

7.2.2.3 All mould contaminated material, which cannot be cleaned, should be removed from site.

7.2.2.4 Remediate areas should be free of visible mold.

7.2.3 Follow up

Inspect the area/site affected after 3 months completion of remedial works to check if there is any recurrence.

7.2.4 Fungicidal sealant

Use of fungicidal sealants as an extra assurance against movement of remaining incidental spores and to reduce potential future moisture uptake in wood and thus future mould growth.

APPENDIX 1

MOISTURE PROBLEMS AND SOLUTIONS

Source of Moisture	Solution
High relative humidity	***ACTIVE*** o Air Conditioning System Heat load calculation shall take into account all load factor (lowest anticipated load & peak load) o Choose a suitable safety factor o Avoid stagnant air by providing sufficient ventilation o Avoid over-sizing of equipment (air-side cooling coil) o Air balancing should be carried out according to designed flow rates. o Testing and commissioning should be carried out properly o BAS operation should be checked. BAS interlock and calibration should be carried out and approved. o Where deemed critical, AHU cooling coil part load performance test should be verified ***PASSIVE*** o Building inspection should be carried out to maintain the integrity of building envelope components. o All openings that permit outside air infiltration should be sealed properly.

Source of Moisture	Solution
Pipe leakage	***ACTIVE*** o Minimize the installation of ceiling concealed chilled water fan coil units unless easily accessible for regular maintenance. o Drain pipes/pans shall have proper gravity flow o Hydraulic tests (pressure and leak) should be carried out. ***PASSIVE*** o Dry walls should be kept away from any possible water source. o Ceiling material should have very low water absorbance characteristic. o All structures should be kept dry at all times.
Condensation	***ACTIVE*** o Chilled water / drain / refrigerant pipe shall be well insulated in accordance to specification. o Exhaust duct from air-conditioned space which traverses non air-conditioned space should be adequately insulated. o Drain pan shall be well insulated. o The use of double skin AHU/FCU is desirable. o Supply air diffuser located near a wall should be of a three-way throw type, o Pipe should not be routed through cavity wall to avoid thermal bridge. o Ensure air duct and diffuser's collar installation procedures adhere to specification.

	PASSIVE o U-shape and extended corridor architectural design without air ventilation system should be avoided where cross ventilation is not achievable. o Cavity wall & vapour seal shall be properly constructed. o An applicable insulation procedure to separate the air-conditioned and non air-conditioned space shall be established. For example, cavity wall, drywall, PU o Alternative wall materials should have a total U-value of not more than 0.85 W/m^2K.
Nutrient	o Regular cleaning should be carried out.

Note :

ACTIVE : Works related to Mechanical & Electrical

PASSIVE : Works related to Architectural and Civil

APPENDIX 2

TYPICAL ARCHITECTURAL DETAILING: Do's & Don'ts

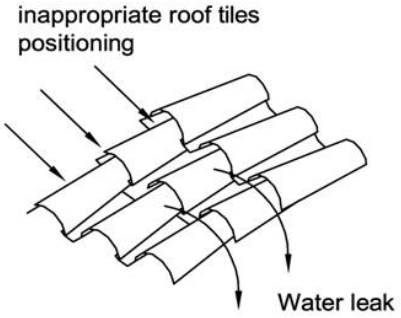


Figure 1a: Water leaking due to inappropriate roof tiles positioning.

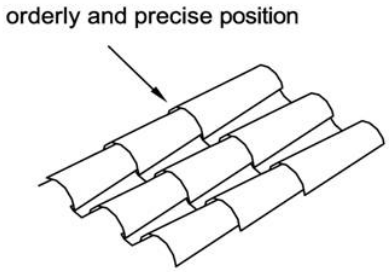


Figure 1b: Roof tiles must be orderly and precise.

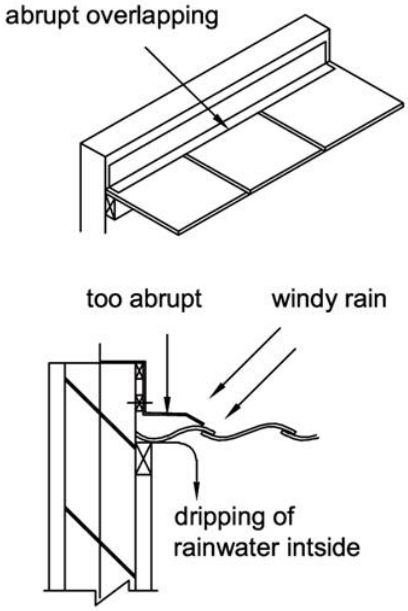


Figure 2a: Water leaking through flashing.

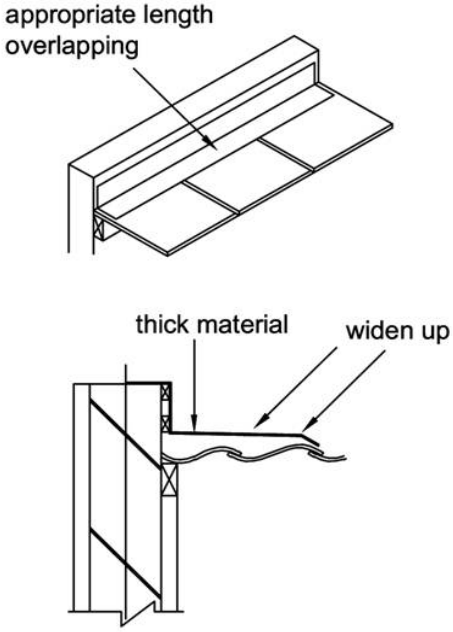


Figure 2b: Material for flashing must be stable with the wide overlapping.

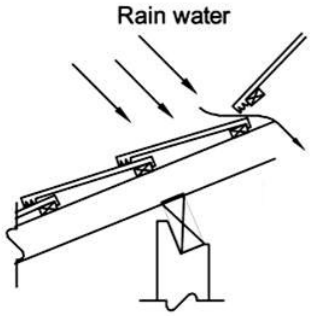


Figure 3a: Water exceeding through two combined slope.

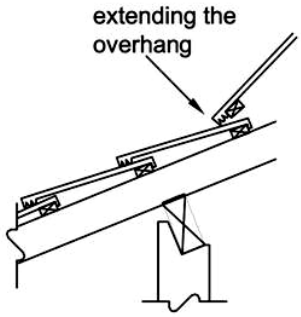


Figure 3b: Imprecise detail must be wide enough or locked with flashing.

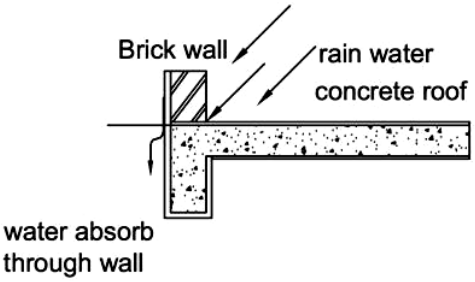


Figure 4a: Water soak out through shield due to cracks on the concrete and brick.

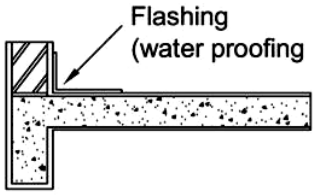


Figure 4b: Water proofing is layered at parapet wall and imprecise building detail.

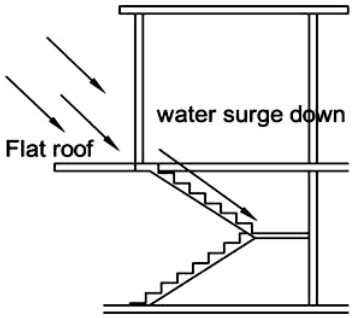


Figure 5a: Door open to inside direction.

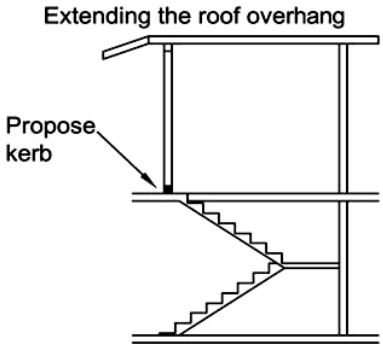


Figure 5b: Door must be open to outside direction. Proposed roof overhang to house the staircase, curb and shade.

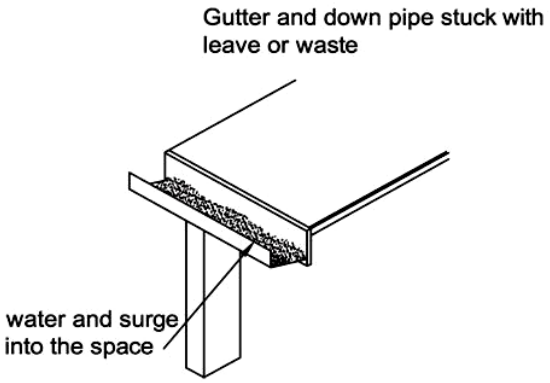


Figure 6a: Water over flow when gutter stuck.

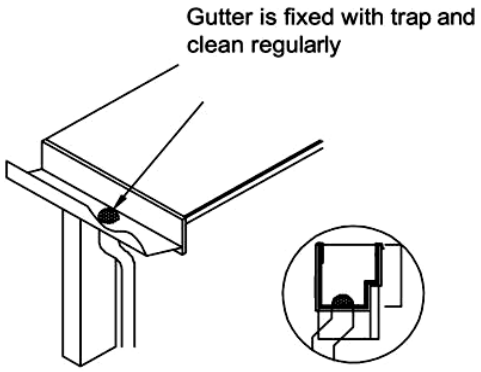


Figure 6b: Ensure that the gutter and rain water down pipe clear from waste .

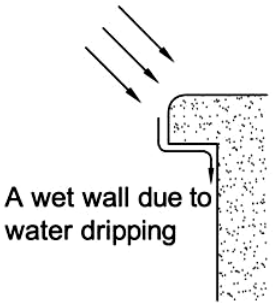


Figure 7a: Water seeping and wet through the wall.

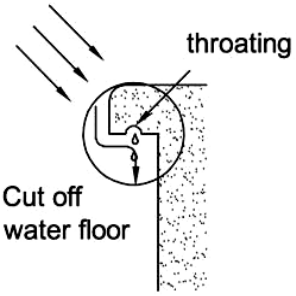


Figure 7b: Throating design could disconnect the water flow.

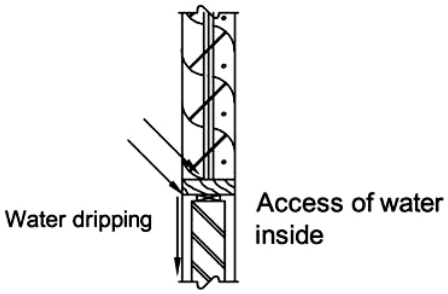


Figure 8a: Water soak in through structure detailed .

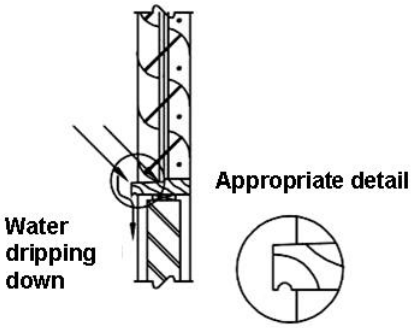


Figure 8b: Framing connecting between window head, window foot and window frame must be appropriate.

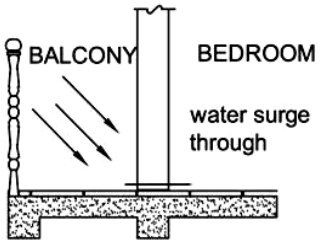


Figure 9a: Water exceed from balcony floor level.

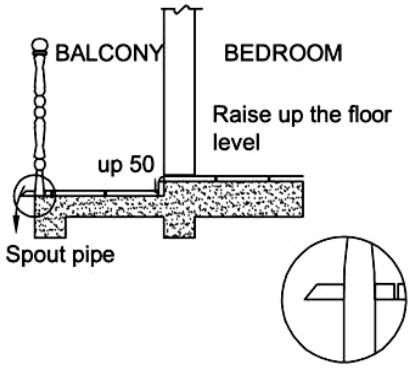


Figure 9b: Balcony floor level must be lower than bedroom floor level.

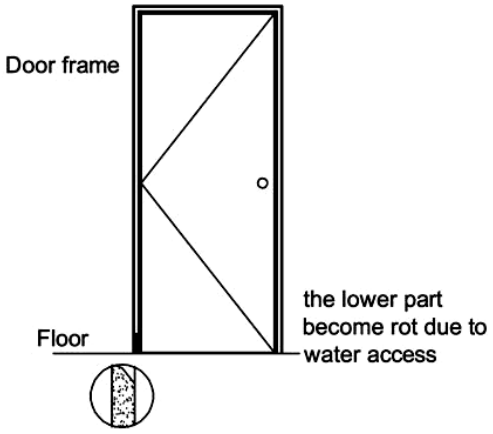


Figure 10a: The lower part of the door frame become rot.

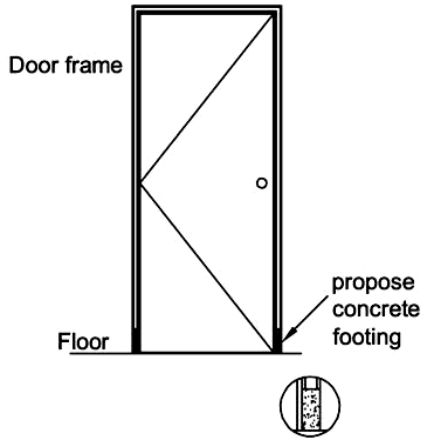


Figure 10b: Concrete material is more suitable for the lower part of the door frame.

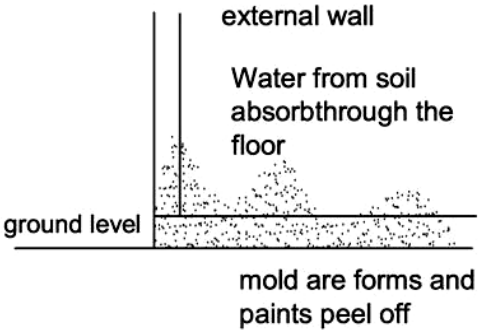


Figure 11a: Cultivation of fungus could be found at the lower part of the exterior.

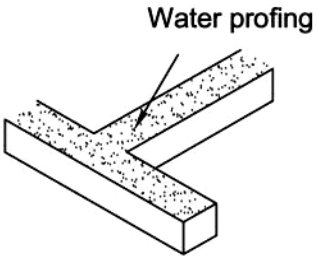


Figure 11b: Water proof membrane must be laid in layers.

Reference :

1. SMACNA (*Sheet Metal and Air conditioning Contractors National Association)* standards.
2. Uniform Building By Laws (UBBL)
3. Building Air Quality – A Guide For Building Owners and facility Managers by EPA (September 1991)
4. Recognition. Evaluation and Control of indoor mould. AIHA 2008

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The working group on Mould Guideline consists of the following representatives :

Public Works Department (JKR) of Malaysia

1. Dato' Ir.Che Mat Bin Wanik	Senior Director of Mechanical Engineering Branch, Jabatan Kerja Raya Malaysia Head Quarters Kuala Lumpur, BSc(Hons)(University of Strathclyde, Scotland.), MSc(Applied Energy)(University of Cranfield England) PEng, MMIM, FIEM
2. Ir.Ang Choo Hong	Director of Mechanical Engineering Branch, Jabatan Kerja Raya Malaysia Head Quarters Kuala Lumpur BE(Hons)(Mech)(UTM),M.Eng Sc. PEng, MIEM, MIQ
3. Ir.Gopal Narian Kutty	Senior Principal Mechanical Engineer, Mechanical Engineering Branch, Jabatan Kerja Raya Malaysia Head Quarters, Kuala Lumpur, Malaysia. Bsc (Hons) in Mechanical Eng., University of Strathclyde, Scotland., Msc in Construction Project Management (UMIST) England., P.Eng., FIEM
4. Ir.Aziah Bte Wan Abdullah	Senior Principal Mechanical Engineer, Mechanical Engineering Branch , Jabatan Kerja Raya Malaysia Head Quarters Kuala Lumpur BSc(Hons)(University of Sunderland,England) P.Eng.

5. Ir.Mohamed Azly Abd.Aziz	Senior Mechanical Engineer, Mechanical Engineering Branch , Jabatan Kerja Raya Malaysia Head Quarters Kuala Lumpur BE(Hons)(Mech.Eng)(ITM) MSc (Process Systems Eng)(University of Cranfield, England) P.Eng.
6. Mr.Wan Shah Wan Senik	Mechanical Engineer, Mechanical Engineering Branch , Jabatan Kerja Raya Malaysia Head Quarters Kuala Lumpur BE(Hons)(Mech.Eng) (University of Bradford, England)

Architect Branch of JKR

1. Dato' Ar. Nur Haizi Bt Abdul Hai - Pengarah Kanan Cawangan Arkitek,
2. Mr.Baharuddin Abd.Jalil, - Pengarah II, Cawangan Arkitek,
3. Mr.Ibrahim Isa - Ketua Penolong Pengarah Kanan, Caw.Arkitek
4. Puan.Yong Razidah Rashid - Ketua Penolong Pengarah Kanan, Caw.Arkitek
5. Puan.Farah Abdul Samad - Ketua Penolong Pengarah, Caw.Arkitek
6. Mr.Thulasaidas Sivasubramaniam - Penolong Pengarah Kanan, Caw.Arkitek)

Special thanks to the following individual who helped to produce this document:

1. Ir. Ng Yong Kong - Managing Director, NYK Engineering & Trading Sdn Bhd.
   - President (2001-03), Malaysia Air-Conditioning & Refrigeration, Association (MACRA), B.E. (Hons.) U.M., MBA (HULL), AFPM, MIEM, P.Eng

2. Ir. Chen Thiam Leong - Managing Director, Primetech Engineers Sdn Bhd
   President (2007-8), American Society of Heating, Refrigerating and Air conditioning Engineers Malaysia Chapter (MASHRAE)
   BSc (Mech Eng) Univ Of Leeds, UK , IEM, FASHRAE, MIFireE, PEng, CEng

3. Ir. Ong Ching Loon - CEO, Cofreth (M) Sdn Bhd.
   - Vice President, Malaysia Association of Energy Service Companies (MAESCO)
   B.Sc (Hons), MBA (Bath),MIEM, PEng, M.ASHRAE, MCIAbr

4. Dr.Puteri Shereen -International Islamic University of Malaysia (IIUM)
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