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Department of **Finance**

Maintenance Minimisation Manual

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Amendments in this Release:

Section Number	*Section Title*	*Amendment Summary*
	Introduction	Referencing Finance Technical Guides
1.1	Design for Climate	Mitigating climate change risks
4.3	Roof Design	Concealed fix cladding preferred 10° roof pitch to unclosed spaces Limiting roof pitch to eliminate the need for additional access safety equipment Polycarbonate over entry / egress points not supported
4.4	Roof drainage & Rainwater Goods	Gutters to be outside of building line Box gutters and concealed gutters not permitted
4.5	Slabs	Difference in levels required between FGL and FFL
5.1	Floors	Sealing all slabs receiving resilient flooring
5,6	Lifts	TG007 Vertical Transport Services
6.3	Location and access	Equipment & plant to be on the ground or in dedicated plant rooms

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Introduction

> *Maintenance minimisation is assessed against first cost, replacement cost, system life and the consequence of system failure. Generally, the risk of system failure is minimised by the utilisation of best quality materials and equipment. This criterion also minimises maintenance.*
>
> Wellard Primary School Schematic Design Report 2016
> Stevens McGann Willcock & Copping

This manual outlines design guidelines intended to reduce building maintenance requirements for public buildings, with an emphasis on sustainable building design.

The manual is to be used in conjunction with the suite of Technical Guidelines available from Consultant guidance and forms (www.wa.gov.au)

Part 1 - Design overview

All materials, building components and systems are to be selected for long term efficiency of operation and maintenance costs, balanced against initial capital outlay. Life cycle analysis should be used to determine which materials or components, although initially more expensive, will in the long term prove more effective through greater durability and lower life cycle costs.

In addition to reflecting environmental considerations, designs should be sympathetic with the relevant Work Health and Safety guidelines to promote a high level of safety and awareness. Buildings must be designed so that they can be safely maintained.

Consultants are advised to work with the Project Control Group and Agency Facility Management representatives to establish a long-term maintenance regime for the building and all of its services.

SUMMARY SCHEDULE - Forecast Expenditure for Routine Maintenance

NOTE: All values include cost escalation

Forecasted Expenditure Summary - Routine Maintenance

SUMMARY	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014	2014 - 2015	2015 - 2016	2016 - 2017	2017 - 2018	2018 - 2019	2019 - 2020
RUGBY BUILDING										
Structure	4,331	4,383	6,966	4,524	6,438	7,575	4,811	4,921	8,254	7,486
Finishes	204	6,807	209	7,026	6,309	7,310	226	7,643	237	15,738
Mechanical	45,288	45,832	46,519	47,310	48,209	49,221	50,304	51,461	52,748	54,119
Electrical	15,505	15,692	15,927	16,198	16,505	16,852	17,223	17,619	18,059	18,529
Fire	5,880	5,951	6,040	6,143	6,259	6,391	6,531	6,682	6,849	7,027
Lift	6,216	6,291	6,385	6,494	6,617	6,756	6,905	7,064	7,240	7,429
Hydraulic	4,586	4,641	9,421	4,791	4,882	9,968	5,094	5,211	10,682	5,480
Special Items	101,909	103,132	104,679	106,458	108,481	110,759	113,196	115,799	118,694	121,780
Subtotal	183,920	192,728	196,147	198,944	203,700	214,833	204,290	216,400	222,764	237,588
EXTERNAL ITEMS										
Civil	2,201	2,228	2,261	2,300	2,343	2,392	2,445	2,501	2,564	2,630
Landscaping	30,573	35,581	31,404	36,728	32,544	38,212	33,959	39,951	35,608	42,014
Irrigation	0	0	0	0	0	0	0	0	0	0
Other External	0	0	0	0	0	0	0	0	0	0
Subtotal	32,774	37,808	33,665	39,028	34,888	40,604	36,404	42,452	38,172	44,645
GRAND TOTAL	216,694	230,536	229,812	237,972	238,588	255,437	240,694	258,852	260,936	282,233

SUMMARY	2020 - 2021	2021 - 2022	2022 - 2023	2023 - 2024	2024 - 2025	2025 - 2026	2026 - 2027	2027 - 2028	2028 - 2029	2029 - 2030
RUGBY BUILDING										
Structure	5,315	9,173	5,612	5,766	13,169	6,088	6,255	11,400	6,604	10,548
Finishes	250	8,486	264	8,959	10,107	9,458	294	9,986	311	23,086
Mechanical	55,580	57,109	58,679	60,293	61,951	63,655	65,405	67,204	69,052	70,951
Electrical	19,029	19,552	20,090	20,643	21,210	21,794	22,393	23,009	23,641	24,292
Fire	7,216	7,415	7,619	7,828	8,044	8,265	8,492	8,726	8,966	9,212
Lift	7,629	7,839	8,055	8,276	8,504	8,737	8,978	9,225	9,478	9,739
Hydraulic	5,628	11,566	5,942	6,105	12,546	6,446	6,623	13,610	6,992	7,185
Special Items	125,069	128,508	132,042	135,673	139,404	143,238	147,177	151,224	155,383	159,656
Subtotal	225,717	249,647	238,303	253,543	274,936	267,680	265,617	294,383	280,427	314,669
EXTERNAL ITEMS										
Civil	2,701	2,776	2,852	2,931	3,011	3,094	3,179	3,266	3,356	3,449
Landscaping	37,521	44,338	39,613	46,810	41,821	49,420	44,153	52,176	46,615	55,085
Irrigation	0	0	0	0	0	0	0	0	0	0
Other External	0	0	0	0	0	0	0	0	0	0
Subtotal	40,222	47,114	42,465	49,741	44,832	52,514	47,332	55,442	49,971	58,533
GRAND TOTAL	265,940	296,761	280,767	303,284	319,768	320,194	312,949	349,825	330,398	373,202

Figure 1: Forecasted expenditure summary for AK Reserve Rugby Stadium shows escalating cost of maintenance over 20 years.

These design guidelines should not be considered exhaustive: reference should always be made to other relevant documents such as Australian Standards and the National Construction Code.

1.1 Design for climate

There are significant environmental and climatic variations across Western Australia. When considering maintenance minimisation, consultants should base decisions on what is appropriate in local conditions and should seek out local knowledge, be familiar with the local capabilities for maintenance and repairs and on mitigating risks arising from projected climate change and comply (refer to Technical Guideline TG040).

TG040 Environmentally Sustainable Design Guideline for Non-Residential Government Buildings (www.wa.gov.au)

Where applicable buildings should be designed to cope with:

- rising temperatures
- more intense rainfall
- more intense wind
- more frequent / intense cyclones
- more frequent flooding
- more bushfire events
- more hailstorms and
- increased or decreased humidity (depending on location).

Design of buildings and in particular proposed ground floor levels should consider impact of likely projected increases in sea levels and storm surge, including consideration of the impact of tropical cyclones of varying intensities.

It is recommended that for future critical and emergency response infrastructure should have a finished floor level above the 1% annual exceedance probability or 100-year average recurrence interval for flood/storm event. Consider provision of a factor of safety of finished floor level a minimum 0.5m above the predicted design inundation for 2110.

Part 2 - Civil engineering

2.1 Site assessment

Every site is different and must be assessed so that likely drainage problems can be avoided. Buildings must be sufficiently elevated or drained to prevent flooding. The drainage system should provide appropriate failure or escape mechanisms for extreme rain events.

Recent research indicates that climate change is likely to result in an increase in intensity and frequency of extreme weather events (CSIRO 2015). The design of drainage systems should consider the increased likelihood of such events.

Consideration should be given to high wind and rain intensity and increased likelihood of hailstorms.

All solutions are to be selected for their longevity and low maintenance qualities.

2.2 Storm water drainage

Storm water has the potential to cause major damage to buildings. Drainage should be designed for a 1:100-year storm.

The design of the storm water drainage system should:

- alleviate flooding of infrastructure by creating major storm event flow paths. If underground stormwater piping caters only for a standard rain event, then an overland drainage path should be established to direct water for storms up to a 100-year recurrence level
- provide safe passage for pedestrians and traffic during rain
- include appropriate drainage in all low points of paved areas
- where possible design falls so that low points do not occur on paths
- allow for storm water to be disposed of on site, rather than transported off site and
- consider the quality of storm water entering the water table. Bioswales may be appropriate for the purification of stormwater before entering the stormwater drainage system (see below).

Regional towns may have inadequate or no access to in-ground stormwater drainage infrastructure and cyclonic regions can experience rainfall intensities of up to 380mm per hour. Storm water management systems must be able to cope with significant flows of water. Consider the following:

- stormwater generated onsite
- stormwater generated offsite which may impact the site (capacity of offsite drainage) and
- potential overland flows across the site.

Consider the use of landscaping to manage water flow.

2.2.1 Bio-swales

Bio-swales are an open and usually marshy drainage course. They are designed to slow the flow of water to allow silt and other impurities to settle out before the water enters the stormwater drainage system. Biological factors also contribute to the breakdown of certain pollutants.

Figure 2: Two bio-swales for a housing development. The one in the foreground is under construction, while the one in the background is already established.
Image source: *Wikimedia*

2.2.2 Clay soils

Clay soil has radically different expansion characteristics when compared with sand. This has implications for buildings, structures and materials due to the increased risk of site settling and flooding.

Drainage must be designed to promote site stability. Properly designed drainage systems reduce the risk of mudslides that could otherwise result from inadequate stormwater drainage to retaining walls and embankments.

A geotechnical survey must be obtained for all sites. Obtain advice from both structural and hydraulic consultants in relation to building on clay soils.

2.3 Road Pavement design

Life cycle analysis should be used to select road paving materials that will require minimal maintenance under the anticipated traffic loading for the design life adopted. Proper design of substrate, road verges, drainage and adequate compaction is essential.

Unless otherwise specified the design traffic should be calculated based on the following minimum design lives of pavement:

- flexible, unbound granular – 25 years
- flexible, containing one or more bound layers – 25 years
- rigid (concrete) – 40 years or
- segmental – 25 years.

2.4 Commissioning

A maintenance and operations manual shall be provided to the facility manager or building owner that details the maintenance procedures, recommended by the manufacturer, for all civil works. Facility managers should be present at handover meetings.

Part 3 - Landscaping

3.1 General

Consider water-wise design as a major design criterion.

Materials selected for landscaping should be robust, durable and easily maintained or replaced. The use of design features which are likely to lead to ongoing maintenance problems or will require specialised access or maintenance equipment to service, should be minimised or avoided completely. For example, water features generally require high maintenance and lighting mounted above 3 metres generally requires specialist ladders to change globes.

When designing landscape works, consider access for equipment and vehicles. Where there are grassed areas, access must be provided for lawnmowers. Generally, these access ways should be 3m in width to allow for vehicle movement and the use of ride-on lawnmowers.

Landscaping should support community safety by ensuring areas are easy to observe and patrol at all times of day.

3.2 Hard landscaping

3.2.1 Paving

3.2.1.1 Falls

Drainage falls on paving are to be at least 1:100 gradient to avoid ponding problems. Design paving so that low points do not occur on circulation paths. Only where they are unavoidable, should drains be provided at low points in paving. Falls must always be away from buildings to avoid problems with damp, and to reduce the likelihood of the building flooding in a storm.

3.2.1.2 Design

New pathways should be integrated with existing local pedestrian and bicycle routes. Paths should follow desire lines where possible so that impromptu tracks across landscaping are avoided. Consider the locations of existing trees and avoid positioning paths where there will be conflict with tree roots.

Careful consideration of surface material and finish is required. When deciding on paving materials and gradients, consider the risk of scouring from water sheathing off hard landscape areas into soft landscape areas. Surfaces should not promote slippage. However, paths must be easy to sweep and clean: consider machine-sweeping access where appropriate.

Universal access standards should be followed in accordance with AS1428. Steps should be provided with handrails and tactile guides.

If the building is designed without gutters, ensure drains are installed under building eaves.

3.2.1.3 Material selection

All building external surfaces are to be robust and constructed using low maintenance materials and finishes. Painted finishes that will require future re-application should be minimised, especially where scaffolding is required for re-painting.

Select paving materials and colours to avoid glare and radiant heat problems. Paving with bevelled edges should be avoided due to noise problems. Appropriate non-slip finishes should be selected with care to avoid risk of injury from falls.

3.2.2 Play area surfaces

3.2.2.1 Hard court surfaces

Hard court areas, including tennis and basketball courts, require special attention given that ponding can lead to delamination of acrylic surfaces. These areas should have a 1:100 fall in a single plane side to side, end to end, or diagonally. Hard courts should have a drainage channel along the side of lowest fall.

Bitumen is the recommended substrate for the acrylic finish. The contractor should be required to demonstrate falls, and the lack of ponding, by spraying the surface with water before finishing with acrylic or other sports surface coatings. Unless otherwise specified the design life of the sporting surface should be 25 years. For design a standard non trafficable pavement design approach should be adopted.

To protect against basidiomycetes pisolithus (puffballs), the footprint of the hardcourt should be treated with a solution of Copper Sulphate and water containing at least 300 grams of Anhydrous Copper Sulphate per 100 m^2 immediately prior to laying each of the substrate base layer, bitumen and acrylic surfaces. Consult with Finance Project Manager to determine specific site requirements.

Where courts are adjacent to lawn areas a suitable concrete kerb or mowing strip should be laid flush with the court and sufficiently wide and deep to reduce the likelihood of grass growing into or under the facility asphalt surface.

3.2.2.2 Soft fall surfaces

Soft fall surfaces are to be robust, repairable and non-flammable.

3.2.3 Skateboard damage minimisation

Skate mitigation can incorporate:

- controlling access to attractive skating zones through fencing and other measures
- arranging elements that are attractive to skaters in ways that are difficult to access or use for skating purposes
- surface treatments and other elements that make run-up zones difficult to negotiate or disruptive to skater actions (subject to not adversely impacting DDA outcomes)
- rough surfaces which are unattractive to skaters
- diverting skateboarders to dedicated areas
- built-in vandal proof skate mitigation devices such as metal weatherproof fixings, where other deterrents are not applicable. These are to be fixed using an appropriate mechanical or chem-anchored penetrative fixing (not surface adhesive) or
- any combination of the above.

Figure 3: Anti-skateboard fixings must be vandal resistant.

In cases where skating is permitted designs should include features to protect concrete and masonry from damage, such as steel edging to low walls, steps and ramps.

3.2.4 Cable pits:

Provide separate cable pits of size to suit the electrical service required, with lids labelled to suit and specify any safety risks. Specify the type and size on the drawings.

Avoid putting cable pits in grassed or planted areas. Where this is unavoidable, pits must be complete with a concrete collar to prevent the sides of the pit collapsing. Pits are to have concrete lids in garden beds and steel lids in grassed areas.

Where pits are positioned in roadways, ensure lids are rated to withstand the expected traffic load.

3.2.5 Shade sails

The use of shade cloth shade sails or similar cloth materials should be avoided in non-secure areas. These materials have proven to be problematic as they are:

- easily vandalised
- deteriorate due to UV rays
- are highly flammable or
- have been proven to be a danger in the past as people climb on them and fall through.

Where shade sail structures are utilised, it is recommended that:

1. In the design of the structure, care should be given to ensure that there is no direct access from the playground equipment onto the shade structure or any other adjoining structures. Reducing the risk of children hanging, swinging or climbing on the frame.
2. All fasteners and fittings used should be of high quality, galvanised or stainless steel. The frame should also be galvanised, or rust treated to ensure durability of the structure and reduce maintenance costs.
3. The synthetic shade cloth or the tensioned membrane fabric should comply with the appropriate Australian Standards AS: 4174.
4. Durability of the structure should be considered in the initial design. Life cycle costing including maintenance, replacement of fabric at the end of its useful life, susceptibility to vandalism and damage from storm events should also be considered.
5. The Structural design of shade structures must be designed to cope with expected wind loads in accordance with AS/NZS 1170.2
6. The installation of the shade structure should be undertaken by an appropriately licensed builder or overseen by a registered builder.
7. Consideration is given to extending the soft fall area beyond the line of the shade structure; to reduce the likelihood of injury should someone fall from the structure. Avoid locating hard borders in the “fall zone”.

3.3 Soft landscaping

3.3.1 Trees

3.3.1.1 General

Landscape designs should consider the impact they have with regards to ongoing maintenance, suitability and safety. Consideration must be given to the size and form at maturity and to the location of trees in high use areas.

3.3.1.2 Location

Trees should be positioned to minimise the shedding of leaves into gutters and damage by roots to building foundations or other infrastructure. As a general rule, **do not** plant trees in the following locations:

- closer than 2/3 of their mature height to a building
- under powerlines or
- within 3m of septic tanks, sewerage lines or service pits and infrastructure.

For trees located in grassed areas, maintenance can be reduced by eliminating the need for whipper-snippers to trim grass around the base of the trees. The primary school brief requires a suitable mowing strip enclosure and infill material of no less than 2 metres from the trunk. Where trees are planted in paved areas the paving should not be closer than 1m to the trunk. Tree grates, which can trap rubbish, should not be specified.

Verge vegetation is to be treated on a case-by-case basis. Consult the local government authority for specific information. In schools the verge area is not to be landscaped or reticulated. Acceptable surface treatments are subject to Department of Education Strategic Asset Plan and local authority approval.

3.3.1.3 Selection

Trees should be selected to suit local climatic conditions and consideration given to their form with regards to the amount of shade coverage they provide. Depending on location and life cycle considerations, there may be reason to avoid species with the following characteristics:

- trees which shed excessive amounts of bark, leaves, twigs or nuts
- are poisonous or allergenic
- have troublesome root systems and/or
- are known to be hazardous for shedding limbs.

The Department of Education has compiled a list of tree species to use with caution. A copy of this list is attached as an appendix to this document.

3.3.2 Garden beds

3.3.2.1 Location of garden beds

Garden beds are a high maintenance landscaping item. It is, therefore, important to be strategic about their use. When designing the layout of garden beds, consideration needs to be given to the ongoing maintenance by staff. For example, school landscapes are often maintained by part time staff with little or no level of horticultural knowledge. In this case consultants are encouraged to consider the use of low maintenance and water wise plantings endemic to the area

When locating garden beds care should be taken to avoid major pedestrian traffic routes. Similarly, plants and irrigation infrastructure should be placed in positions that limit tampering from users or conflict with building surrounds. Plantings must not obscure windows and all stock should be installed at least 600mm from buildings and not exceed 1000mm in height upon maturity. This is mandatory in primary schools.

Raised garden beds should not be positioned against building walls as this can cause problems with damp and termites.

Where garden beds are located adjacent to lawn, garden edging should be installed to prevent the invasion of lawn runners and to contain mulch and soil. Garden edges should be of a robust, durable, cost effective and easily replaceable material.

For ease of maintenance slopes should not exceed a gradient of 1:3 in garden beds.

3.3.2.2 Design and plant selection

Garden bed planting should comprise of plants which will be self-sufficient after 2 years and where possible planting of local indigenous species is encouraged. Where suitable microclimates exist, such as protected courtyards, 'specialty' plants like ferns or exotic species may be considered.

Hydro-zoning should be used to ensure plants with similar watering requirements are grouped together. The growth habits of individual plant species should also be considered to ensure an optimal maintenance outcome.

The creation of 'new bushland areas' is to be avoided as such areas have proven to embody a high maintenance burden.

3.3.2.3 Plant stock

To increase the ratio of successful plantings in garden beds, a minimum stock size of 140mmat the time of planting should be specified. All stock is required to be suitably hardened off prior to planting.

3.3.3 Lawns and ovals

Where lawns and ovals are reticulated unauthorised vehicle access is to be prevented.

To reduce maintenance of grassed areas, avoid small, complex, raised or narrow areas of lawn (including amphitheatres) and all grassed areas should be appropriately sized for intended use and access. Consider accessibility for lawn mowing equipment in the design.

Avoid landscaping features that require mechanical edging to maintain and ensure edging strips are installed around garden beds and trees to prevent runners from entering.

When locating lawn areas care should be taken to avoid major pedestrian traffic routes. No lawn should be planted closer than 3 metres from a south facing roofline or have a gradient of more than 1:6. Steep grassed embankments are difficult to mow and may erode in heavy rain.

Ensure lawnmower access (including ride-on and tractor-style mowers where appropriate) is provided to all grassed areas.

3.3.4 Existing vegetation

Consider the retention and protection of existing remnant bushland where possible.

3.4 Irrigation/reticulation

Irrigated landscapes should be designed to maximise water conservation and energy efficiency.

Irrigation systems should be able to be maintained and operated with a minimal level of irrigation knowledge and experience.

Durable materials and equipment should be selected, resulting in a water supply and irrigation system which is efficient, reliable and requires a minimal degree of maintenance.

Irrigation works shall be designed and coordinated such that sprinklers are not placed in conflict with other infrastructure or physical elements. This includes avoiding placing sprinklers directly beneath fences and in zones where the overhang of vehicles will affect sprinkler operation, or where they may spray over paved areas and against building facades and doorways.

3.5 Landscape design for termite management

Damp conditions, together with food sources, attract termites. To reduce the likelihood of termite infestation:

- keep garden beds and plants away from external walls (or provide a gap of at least 300mm between vegetation and the wall)
- avoid using untreated timber for retaining walls and garden borders
- do not plant large trees near buildings. (Tree roots can breach chemical barriers in the soil and branches may overhang roofs)
- keep garden bed soil and mulches clear of drainage or ventilation openings in walls
- avoid raised garden beds against walls
- ensure gutters and downpipes empty into drains or empty well away from the building
- make sure any paving includes falls to drain surface water away from the building and
- keep spaces under suspended floors well ventilated.

Refer Technical Guideline TG013 Termite Management (www.wa.gov.au)

3.6 Commissioning

The landscape contractor should provide a *Landscape Works Maintenance Manual* at practical completion. This manual will document all work required to be undertaken to maintain the works at a satisfactory level.

Part 4 - Buildings externally

4.1 Material selection

All external fabric should be of low maintenance materials and finishes.

Selection of materials should have the following qualities:

- Minimal maintenance requirements
- Durability for long life use (consider that buildings are intended to have a lifespan of 50 or more years.)
- Aesthetic suitability for type and location of building
- Proven track record, historically ie proposed use of new products subject to approval
- Appropriate to climate and local conditions
- Protective treatments or finishes applied to materials as appropriate such as hot dipped galvanised treatment to steel. Refer to Technical Guideline TG016 Corrosion Protection (www.wa.gov.au)

The Primary School Brief includes a list of low maintenance materials appropriate for application in schools.

Note: mandatory standards for building materials and installation should be assessed prior to specification.

4.2 Vandalism

Design to discourage unplanned access to roofs, balconies and covered walkways. Undesired access to roofs generates damage from:

- roof cracking and distortion damage from vandals jumping on roof sheeting and
- damage from vandals riding bikes and skateboards over roofs and covered walkways.

Avoid tempting unwanted access by not locating opening windows and balconies within reach of roofs.

External wall finishes shall be robust, durable and facilitate the removal of graffiti.

External taps should be vandal resistant.

External general power outlets (GPOs) should be lockable.

Design for passive surveillance to minimised opportunity for vandalism. Refer to *The Safer places by design planning guidelines* [1] for further information

[1] Department of Planning, Lands and Heritage . Planning guidelines - Safer places by design (www.wa.gov.au)

4.3 Roofs

4.3.1 Design

Design roofs for a 1:100-year storm as per AS/NZS 3500.

Vapour barriers must be carefully designed for areas with hot humid climates to prevent problems with damp and mould. See Part 6 - Mechanical for more information

4.3.1.1 Pitch

Experience has shown that flat roofs are more prone to leaks. **Design metal roofs with a minimum pitch of 5°, or the manufacturer's recommendation plus 1°, whichever is the greater.** This allows for minor inaccuracies that arise in construction.

For roofs in cyclonic regions, a higher pitch is to be considered. Where those buildings have a short roof span to enclosed spaces, a minimum pitch of **15°** is recommended, while a minimum roof pitch 10° is recommended for unclosed spaces, such as walkways and shade structures.

Limiting the roof pitch to below 24^0 eliminates the need for additional access safety equipment. Refer to 4.3.2

4.3.1.2 Nesting and roosting

Avoid open channel members and beams that provide nesting and roosting opportunities for birds.

4.3.1.3 Roof penetrations and flashings

Design to minimise roof penetrations, such as skylights and roof vents, and ensure quality control of installation is tight.

In cyclonic regions, only cyclonic rated and approved skylights are to be installed.

When mounting apparatus, such as solar panels, on the roof, consider clamping systems over systems which require roof penetrations.

Avoid using slope ventilators over 4m long.

Problems with corrosion and water ingress are often caused by:

- lack of support trimmers between purlins to support roof sheeting around roof penetrations
- ponding around the penetrations on low pitch roofs
- poor workmanship
- incompatible materials generating corrosion, such as contact between metals of differing reactivity or incorrect specification of fasteners in coastal marine environments
- lack of proper supervision of critical details and

- installation of incorrectly sized roof drainage system, not in accordance with design.

4.3.2 Roof access

Refer to the Finance Technical Guide 006 Roof Access: TG006 Roof Access (www.wa.gov.au)

4.3.3 Materials

When specifying a roof material:

- minimise potential roof leaks. Eg
    - tiles are more likely to leak than roof sheeting
    - the use of concealed fix roof cladding is preferred (approved exemptions may apply in cyclonic regions where availability of material or skills restrict viability for construction or future maintenance)
- maximise security, e.g. roof sheeting is more secure than tiles, as individual tiles can be removed to gain access
- ensure finish of specified roofing material is appropriate to local site and environmental conditions and
- specify a roof cladding which is resilient enough to cope with its proposed function. Specify a heavier grade for roof traffic or include access bridges, if roof access is required for servicing
- consider Bushfire Attack Level (BAL)

4.3.3.1 Translucent sheeting

Translucent sheeting, such as polycarbonate, is often used where extra lighting is required inside a building. Where possible it is better to design a narrower building with adequate daylighting from windows rather than a deeper floor plate requiring roof lights. Translucent sheeting and other roof-light materials are less resilient to impact than metal sheeting and are more likely to be damaged in a hailstorm.

If translucent sheeting is used, ensure it complies with the appropriate Work Health and Safety and NCC insulation requirements. Ensure translucent sheeting meets the applicable site wind speed category.

Finance does not support the use of polycarbonate over entry / egress points on State owned facilities due to the risk of the product's failure in the event of a fire. This position exceeds the NCC referenced Standards.

When translucent sheeting is used, it must be installed to the manufacturer's specification with special attention to:

- adequate sheet overlap – where possible, roof lights should run from ridge to gutter to avoid lap joints completely
- correct profile to accord with adjacent sheeting and
- side laps to be properly fixed to exclude water.

Use specified self-drilling fasteners that cut holes in the translucent sheet to permit the correct expansion tolerance.

Ensure sheeting complies with the appropriate safety requirements regarding walking loads and is UV stable to minimise clouding and brittleness. Safety mesh must be provided beneath translucent sheeting where required by AS1562.3.

4.3.3.2 Skylights

Consider the Bushfire Attack Level (BAL) compliance of skylights installed in at risk areas.

Ensure that heat gain through skylights does not cause extra reliance on mechanical conditioning, compromising the benefits of bringing in natural light.

4.4 Roof drainage & rainwater goods

Good roof drainage is essential in reducing maintenance costs. Ensure gutters are designed in accordance with AS/NZS 3500.3 and to meet future climate change considerations.

Where possible, use simple roof designs with eaves gutters instead of complex roof designs.

Ensure all roof plumbing is constructed as designed and that materials specified for roofing systems are corrosion compatible, refer to 4.4.1.3 Material Compatibility.

The use of gutters and downpipes may be optional provided there are effective stormwater disposal systems in place. Consider using landscaping elements to deal with water runoff. NCC performance solutions may be required, depending on building classification.

4.4.1 Gutters and downpipes

Ensure that all gutters and downpipes are adequately sized and positioned. Gutters require adequate fall to downpipes to avoid ponding (1:100 minimum).

Gutters are to be positioned outside the building line.

Design of roof drainage is to consider what will occur when the system is overloaded or fails:

- Where does the overflow run?
- If a blockage occurs where will the water run?
- How will maintenance staff reach any blockages?

4.4.1.1 Box and concealed gutters

Box gutters include those positioned over external areas or within eaves.
Concealed gutters include those installed behind facias (as opposed to above or over these).

Box and concealed gutters and other gutters integrated into the roof structure are not supported by Finance. If these gutters are unavoidable, approval must be given by both Finance and the client agency. This is to be at the earliest possible stage of design and no later than design development.

Approved box gutters must:

- have more than sufficient capacity;
- be robust:
- have adequate falls and other features to encourage self-flushing of debris and prevent water pooling;
- be adequately sized to allow easy cleaning and maintenance and be strong enough to allow a person to walk along them safely
- have overflow relief that is not subject to blockage; and
- not have concealed rainwater heads
- overflow to the outside of the building (including outside of eaves linings/soffits).

Consider how a box gutter will be replaced. Removal of box gutters should not require all of the roof sheets to be lifted. Removable box guttering and sumps are to be considered where box gutters cannot be avoided.

4.4.1.2 Eaves gutters

Eaves gutters allow the water to be managed outside the building. Details that allow water to backflow into the eaves or ceiling space are not suitable. The height of the exposed face of the gutter is to be matched or exceeded by the gutter height on the side flush with the building. Consider using high back gutters.

Care is to be taken to select gutter and roof materials that are corrosion compatible.

Ensure hot water and evaporative cooler unit expansion valve overflows are properly piped away from gutters. Solar hot water relief valve overflows are associated with particularly aggressive corrosion.

4.4.1.3 Material compatibility

Ensure that material compatibility is given every consideration.

Galvanised roof plumbing is not compatible with Colorbond,Zincalume or similar roof sheet materials. Failures within five years have been reported where these materials have been in contact.

The exception to this is where heavy duty (hot rolled) galvanised steel sections are used for roof plumbing with Colorbond or Zincalume roof cladding. The rate of corrosion of these heavy-duty sections is slow enough to result in a life expectancy for box gutters and downpipes of more than 50 years.

Check product information carefully.

4.4.1.4 Downpipes

Ensure downpipes are serviceable and of appropriate size to suit predicted rainfall events. Ensure downpipes can be easily cleared of blockages. Avoid built-in downpipes in cavity walls and columns unless access can be provided to clear blockages and attend to faults. Specify exposed accessible downpipes that are securely fixed to walls or columns to minimise vandalism. Fixing should enable easy access and painting.

Downpipes should take the most direct path to the ground. Eliminate horizontal sections in traditional roof drainage systems.

Angled shoes at the bottom of downpipes should not be specified because they are easily vandalised and are a trip hazard.

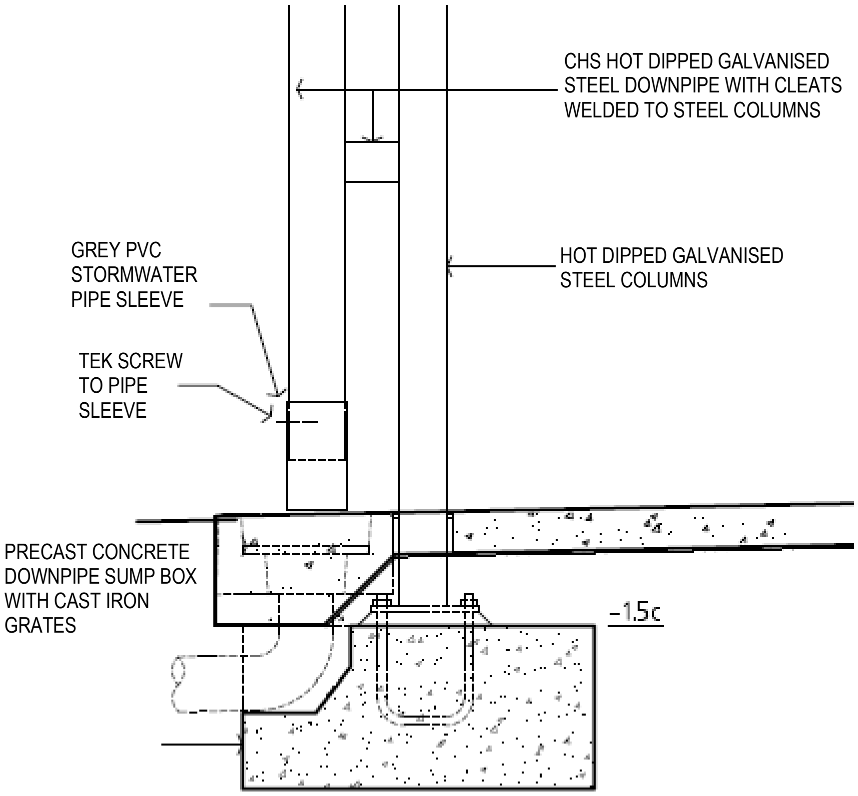

Figure 5: A downpipe detail from the primary school brief that prevents wash to paving and is not a trip hazard.

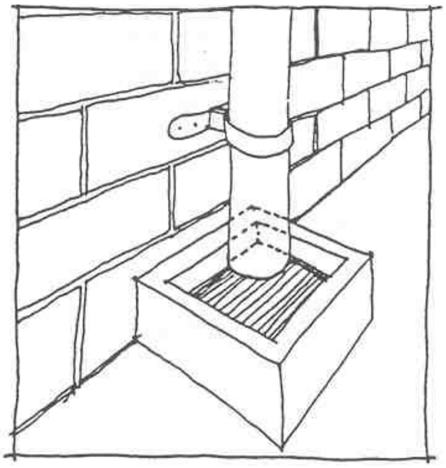

Figure 4: A downpipe detail that provides relief, easy maintenance and prevention of wash to paving. (Should not be located where it may be a trip hazard)

4.4.1.5 Relief to stormwater sump

Downpipes should have relief gaps at the base to allow for the clearing of debris. A raised edge sump box at the bottom of the downpipe helps prevent blockages and water backup while preventing wash to adjacent areas. (See Figure 5.)

Where a raised sump box may be a trip hazard consider a sump box with flush grate at finished pavement level and sleeve over the base of the downpipe to prevent wash to adjacent areas, whilst enabling access to clear blockages. (see Figure 6)

4.4.1.6 Barges

Steel purlins should not be used with the open face outwards (ie toes not to face up slope) as a decorative detail because water will lie in the purlin lip and promote rusting.

4.4.1.7 Siphonic systems

Siphonic roof drainage systems have been installed in Government projects with mixed success. Siphonic systems work on the same principle as a siphon and are designed to drain roofs more efficiently by eliminating air from the downpipes. These systems are engineered for maximum efficiency at a specific rain intensity. At rain intensities less than the design intensity, siphonic systems function in the same way as standard roof drainage systems.

The main advantages of siphonic systems are:

- the ability to incorporate horizontal lengths of downpipes
- reduced number of downpipes
- reduced size of downpipes.

The precise nature of these systems means they are prone to failure if they are not designed, documented and installed correctly to much tighter tolerances than standard systems. Unless there is a significant advantage to the use of a siphonic system on a particular project it is recommended a standard roof drainage system be used.

If a siphonic roof drainage system is to be incorporated in the project, ensure the following is considered when designing the system:

- do not install a siphonic roof drainage system on any roof less than 4.5m in height
- provide all gutters with overflow mechanisms
- ensure system is designed and documented by a hydraulics consultant experienced in siphonic drainage systems.
- ensure system is installed in strict accordance with the siphonic drainage system shop drawings by a fully trained and qualified registered plumber employed directly by the siphonic roof drainage contractor and inspected onsite by a hydraulics consultant experienced in siphonic roof drainage systems
- all siphonic roof inlets for the collection and discharge of the surface water from the roof should be fabricated from non-corrosive, durable materials and fitted with durable baffles designed to restrict the entry of air into the system
- all inlets are required to be self-priming to avoid the build up of water in the gutter system
- the pipework support system should take into account the weight of a full pipe, vibrations, thrust forces and requirements to maintain straight runs and prevent buckling from internal water forces
- pipe should be fixed to allow for the effects of thermal expansion and contraction and to allow for any water hammer that may occur
- consider locating downpipes external to the building structure to prevent damage which may be caused by pipe leaks

- siphonic systems are generally self-cleaning, however a routine maintenance schedule should be undertaken to ensure the system is working at optimum efficiency timed to suit the site and seasonal condition
- the entire siphonic drainage system should be checked in the lead up to a time when severe storm events are expected and
- refer to the Government of South Australia's document Siphonic Roofwater Systems for further information: https://www.watersensitivesa.com/wp-content/uploads/WSUD_chapter_16.pdf

4.4.1.8 Rainwater Tanks

Where rainwater tanks are included consider how they will be maintained. Ensure they are provided with safe access enabling them to be cleaned out.

Tanks should incorporate a simple low maintenance and durable first flush or first rain diversion system, such as a ball and seat system or similar simple automatic system that does not rely on mechanical parts or manual intervention.

When tanks are installed in locations where they may be accessed by the public (particularly children), safety should be a consideration. Incorporate built in safety features including lockable access hatches and utilise vandal and weather resistant fixings and fittings.

4.5 Structure

4.5.1 Floor slabs

All buildings must provide a difference in levels between FFL and FGL of at least one brick course around the full perimeter of building

- external paving can be sloped up to provide a flush threshold at accessible doors, provided the general finished level of that external paving elsewhere is one course to 100mm below internal floor level.
- All external paving should consistently slope away from the building.

4.5.2 Structural steel

Where structural steel components will be inaccessible after completion of the building, or accessible only with significant reconstruction, they shall be designed with a protection system adequate for the expected life of the building.

Structural steel should have corrosion protection in accordance with AS/NZS 2312.

Incorrect surface preparation or treatment of steel, not in accordance with this standard can lead to surface rusting, which is difficult and costly to repair, or even failure of the material. It is important that site inspections are undertaken to ensure the surface treatment of steel has been carried out correctly.

Figure 7: Potential effects of poor corrosion protection.

Any steel reinforcing or bracing used in brick or concrete block cavity walls are required to be hot dipped galvanised. Where hot dipped galvanised steel is cut, welded or the galvanising is otherwise damaged, ensure the damaged areas are cold galvanised to prevent rust.

Exposed steel structures are not recommended in corrosive environments such as coastal locations. Where exposed steel work is used in this type of environment steel works is required to be hot dipped galvanised and applied paint finish should be avoided.

Where cold rolled steel members including Z or C sections are used in corrosive environments steel members should be highest grade steel i.e. Z450 or similar to approval of Superintendent.

Refer to Technical Guideline TG016 Corrosion Protection (www.wa.gov.au)

4.5.3 Structural Concrete

Ensure steel reinforcing is provided with adequate concrete in accordance with AS3600. Take into consideration the corrosive nature of some sites should consider the following:

- achieve adequate concrete cover to reinforcing to
  - prevent corrosion of steel reinforcing and concrete spalling (cancer)
  - achieve the correct fire rating.
- increase grade of concrete and
- consider use of sealants.

Concrete must be cured in accordance with AS3600. Do not apply any sealants or finishes until after concrete has cured as this can lead to reduced durability and adhesion of the applied finish.

4.5.4 Cavity masonry construction

Masonry must be constructed in accordance with AS 3700.

Ensure masonry is constructed with control joints to allow for movement and expansion of the masonry.

Wall ties must be installed with correct spacing and in sufficient number. Site inspections must be carried out to confirm that wall ties have been installed.

Deterioration of metal brick ties, weakened mortar and historic design weaknesses have been known to cause brick wall collapses in WA buildings approaching and surpassing their design life. Due care must be taken in projects that involve renovating, repairing or demolishing existing external double brick walls, particularly if they are a pre-1990s building.

Care must be taken to ensure that the cavity wall is designed and constructed to prevent damp from affecting the internal leaf:

- construct a damp proof course
- ensure insulation does not breach the cavity
- wall ties must be installed so that water flows away from the internal leaf
- design flashing to enable water to escape the cavity via weepholes.

4.6 Walls

4.6.1 Materials and finishes

Specify durable, low-maintenance finishes for external walls, for example face brickwork, non-porous blocks, off form concrete, or composite panels with prefinished external surfaces.

Note that in regions impacted by cyclones, masonry structures may not be appropriate unless they can be reinforced, and core filled with concrete.

4.6.1.1 Applied finishes

Paint is considered a high maintenance finish and is to be avoided where possible, particularly externally. Low maintenance materials such as face brickwork, concrete ceilings and walls, and galvanised finish handrails should not be painted. Do not paint or render over areas that have problems with damp, or deterioration of brick or block work in masonry walls, as this will exacerbate the problem.

Where coloured surfaces are desired, consider rendered finishes with integral colour as these have a longer life than paint. If paint is used externally, consider limiting it to more sheltered areas such as eaves linings. Avoid colours that fade easily e.g. red. Consider glare when selecting pale colours.

When using render consider the appropriateness of the location. For example, render on a corner by a pathway is more likely to be chipped and damaged. Avoid rendering vulnerable areas, and use corner reinforcement beads where appropriate

All selected paints should be water based with low volatile organic compound (VOC) off gassing.

To ensure applied finishes perform to the manufacturer's specification, ensure surfaces are prepared and products applied in accordance with the manufacturer's recommendations.

Surfaces which require anti-graffiti coatings are strongly discouraged. Anti-graffiti coatings should only be applied as a last resort, as they are expensive and require re-application. If proposed, a lifecycle cost benefit analysis is to be provided.

Design to avoid providing large canvasses for graffiti, unless arrangements can be made with artists to cover these areas. Attractive walls do not appear to be targeted by graffiti artists, therefore add colour, include patterns and differentiate materials.

Surfaces which are likely to be subject to graffiti should be finished with hard non-porous materials.

4.6.1.2 Claddings

Claddings such plywood, demand regular and ongoing maintenance regime for sealing or paint finishes. These types of cladding should only be considered for "feature" areas in protected locations in consultation with the Agency and Facilities management.

Brittle or pliable materials, such as fibre cement or metal sheet cladding should not be located where these are susceptible to impact damage, without additional reinforcement.

Consider more robust finishes wherever the cladding may be susceptible to impact.

Where fibre cement is used in locations with high wind speed categories additional substrate may be required.

Prefinished claddings must be assessed on a case-by-case basis and approved by client. Ensure they are installed according to the manufacturer's recommendations. They must meet the requirements of the agency to be robust, durable and have a long lifespan. These products may not be appropriate for regional applications where maintenance is complicated by long lead times, need for skilled trades and specialised tools.

Refer to Technical Guideline TG012 Fibre Cement and Compressed Fibre Cement Cladding (www.wa.gov.au)

4.6.1.3 Decking

The use of timber externally, should be avoided due to high maintenance requirements. Wood-plastic composites (eg Modwood or similar) may be considered where appropriate. There has been some evidence of issues with heat absorption when using these products. Consider locating in shaded or partially shaded locations. Ensure fixings take into account movement and expansion.

4.6.2 Bore stains

Treatments to stop bore staining are expensive and removing stains is pointless if they will return with time. Design to limit and avoid stains by:

- designing irrigation to avoid spray on buildings and paths
- designing xeriscape gardens – choose landscape elements and plants which do not require watering and/or
- planting clear of walls and footings.

4.7 Windows

4.7.1 Glass breakage

Avoid low level glazing below 600mm, or full length glazing to ground level as this is more prone to breakage (particularly from lawnmower projectiles) and sun intrusion.

Replacement of glazing due to breakage or vandalism is a high-cost maintenance item. When specifying glazing consider the cost and ease of replacement. The use of special glass or colours should be avoided, as these are difficult to replace. Standard type glazing is recommended.

4.7.2 Screens

Standard flyscreens should not be specified as they are prone to vandalism. However, windows which are selected for cross ventilation and/or night purging to cool structures must be fitted with heavy duty security screens.

Use of sunscreens to buildings is encouraged where appropriate, particularly to west and eastern facing windows. Selection of materials should consider durability, robustness, and ongoing maintenance requirements.

Use of perforated metal should entail careful consideration of any applied finish to ensure longevity and low maintenance requirements. Metal screens are far more likely to fail in coastal and corrosive environments. Consider the location before selecting a metal screen.

4.8 Cleaning requirements

All external grilles and louvers must be able to be cleaned easily.

Consider safe access for cleaning and maintenance in the design of ceilings, light fittings, exposed beams and fans. If these elements are too high, or otherwise inaccessible, they may require specialist equipment and cleaning personnel to be brought in at an additional cost.

Avoid the use of high-level glazing without permanent access as this is difficult to clean. Low level glazing (below 600mm) should be avoided as it requires constant cleaning.

Ensure gutters and roof drainage systems are able to be cleaned easily and safely.

4.9 Protecting against termites

Refer to Technical Guideline TG013 Termite Management (www.wa.gov.au)

The superstructure of the building (containing the edible components) should be isolated from the ground to protect from termite attack. It is important to be aware that no matter what termite prevention system is selected an annual inspection is still required.

The level of termite activity in northern regions is very high and building detailing to protect against termites should reflect this.

To prevent termite access:

- use resistant materials such as steel, well compacted concrete and treated timber for the structural elements of the building. (This will not protect furniture, and fittings made of timber);
- avoid the use of timber in direct contact with the ground by:
    - attaching wooden posts to steel fittings concreted into the ground; and/or
    - sealing the top of hollow steel members with welded plate to prevent concealed termite penetration;
- design building to force termites to take a visible route, such as exposed slab edge or suspended floor which will provide a horizontal visual barrier. Ensure garden beds are not put in these locations to cover up the visible barrier;
- design building to allow access for visual inspection of potential termite intrusion;
- use **physical barriers** between the superstructure and its foundations such as:
    - termite caps or termite strip shielding, which are constructed of metal with the edge angled downwards at 45°;
    - metal mesh barriers such as; or
    - gravel barriers (finely graded granite chips). Note: “GraniteGuard” is not effective against the large and aggressive Mastotermes species which are found north of the Tropic of Capricorn; and/or
- use chemical barriers including:
    - under slab “rechargeable” reticulation systems using non-organochlorine chemicals (be aware that this system requires recharging on an annual basis, which should be built into the maintenance regime); or
    - hand spraying of Australian Standards approved non-organochlorine chemicals under the slab and applied to the building perimeter (poured into a trench).

Termites are attracted to food sources, particularly damp timber. To make buildings less attractive to termites:

- remove all tree stumps, roots, wood and timber products (including paper and cardboard) from the site prior to construction;
- avoid using timber in wet or damp areas;
- prevent damp conditions by:
    - ensuring stormwater is drained away from buildings; and
    - providing ventilation to subfloor areas;
- use steel as a termite resistant alternative to timber; and
- use treated or termite resistant timber where possible, especially in exposed positions or in contact with the ground.
    - Susceptible timbers include pine, karri, marri, mountain ash, meranti and particle board. All sapwood, even of resistant species, is susceptible.
    - Timber should be treated to the correct hazard class (H1, H2, H3, etc.) for its application as specified in AS 1604.
    - CCA (copper chrome arsenate) timber preservative has been shown to be hazardous in certain situations and is not recommended.

4.9.1 Alterations and additions

If alterations are planned, it is important that the existing termite protection systems are considered at the design stage. Any breaches of existing barriers must be rectified.

Consider the following:

- providing at least a 100mm space between the existing building and any addition;
- using metal stirrups for setting timber posts in the ground;
- using termite resistant materials; and
- where attachments/additions abut a building and there is no clear gap, a barrier should be installed at the interface between the new work and the existing building, at or below ground floor level to deter concealed termite entry.

Always engage a pest control firm or experienced consultant to inspect the building site, and an area of at least 50m surrounding the site for active termites.

Be aware that disturbances to soil near buildings may breach chemical soil barriers and disturbed soil may need to be retreated.

Part 5 - Buildings internally

Building materials and finishes must be environmentally sustainable, safe, durable, cost effective and low maintenance. All products which are specified for building interiors should have low Volatile Organic Compound (VOC) off gassing.

5.1 Floors

Select floor finishes that are appropriate for the purpose. In high traffic areas, select durable long wearing, slip resistant flooring.

There is evidence that applied finishes, such as epoxy to concrete, can exhibit poor impact and ponding resistance properties. Ensure surface is correctly prepared and concrete is properly cured before applying epoxy finishes.

When specifying specialist flooring, such as gymnasium flooring, undertake a risk assessment on water entry through doors, windows, overflowing gutters, blocked or broken pipes, plumbing fixtures and any other sources. Demonstrate that risks have been managed.

When installing a floor finish over a concrete slab, ensure the slab has cured and dried in accordance with AS 1884. If the slab is not adequately cured, this can lead to failure of the finished surface.

Where resilient floor coverings are being installed over either new or existing concrete slabs, those slabs must be sealed in accordance with TG02 Moisture Content in Concrete slabs

Where the Architecture briefs are silent, Australian Standard HB 197 may be referenced for voluntary guidance on minimum floor surface classifications. Over-specifying will generally require a higher frequency of cleaning and escalating operating costs.

5.2 Walls

In high traffic areas, selected materials should be robust. Consider finishes which do not require any maintenance, such as exposed concrete or light-coloured brick. Avoid materials which are easily marked or damaged, such as plasterboard.

Paint which is specified for these areas should be low VOC water based, with a similar durable performance to gloss alkyd paints. Paint should be selected to facilitate easy cleaning. Where appropriate paint finish should have mould and fungal resistance.

Failure of paint finishes on internal walls is often caused by not following manufacturer's instructions. Use of an incorrect sealer can result in early paint coating system failure. Ensure manufacturer's recommendations are followed.

Careful attention must be given to ensuring the substrate is sound and prepared correctly, and that specifications of sealers, undercoats and paint finishes are followed.

If water enters the building during construction, ensure the building is dry before installing internal wall linings and applying finishes.

5.3 Ceilings

Ensure there is easy access to ceiling spaces for maintenance personnel.

Where appropriate, consider ceiling types which do not require painting e.g. metal strip ceilings, ceiling tiles.

Ensure fire and acoustic ratings are met in accordance with project requirements and in a cost-effective manner.

5.4 Doors

Doors should be durable and appropriate for purpose. Door hardware should be heavy duty commercial quality.

All accessible doorways must comply with AS 1428.1. Glass doors must be visually easy to discern.

Roller doors are to be heavy duty construction, with deep guide rails and floor locking devices at both ends to prevent break-ins.

External doors should be tight fitting with weather seals to prevent drafts. This will also make doors more difficult to prise open. In areas at high risk of break-in, doors should be fitted with anti-jemmy plates.

Use locking systems on doors and windows which are not exclusive to one provider for lifetime service and maintenance. Doors and windows should be keyed in accordance with agency requirements.

Door stops or door restrainers should be provided to prevent damage to walls or fixed furniture. Door closers must be appropriate and robust. Ensure they are installed correctly and fine-tuned to the appropriate resistance.

5.5 Fixed furniture

Ensure bench tops and shelving are adequately supported for intended use or storage requirements. (Bench tops to withstand body weight at mid-span).

Bench tops must be selected for long term durability. Plastic laminates are not to be used in high wear areas as edges have been proven to fail.

Undertake a risk assessment for water damage to cabinetwork. Demonstrate that risks have been managed. Timber and ply have been shown to perform badly in wet areas and should not be specified where water damage is likely.

Avoid formaldehyde-based particle board and sheeting because it is known to break down and cause off gassing.

Upholstery and fabrics must have a commercial rating.

5.6 Lifts

Technical Guideline TG007 Vertical Transport Services (www.wa.gov.au) provides guidelines for developing specifications and must be referred to for both new and upgrade projects.

Part 6 - Mechanical

6.1 General

Good passive design is preferred to mechanical air-cooling systems.

- Ensure optimal solar orientation for energy conservation.
- Incorporate thermal mass to reduce heating and cooling requirements.
- Incorporate night purging where possible.
- Incorporate opening windows or vents which can be controlled by occupants or automated to use natural ventilation when possible.

Mechanical equipment should be selected for maximum energy efficiency.

- Select equipment that has an economy cycle, which draws on outside, unconditioned air, when conditions are favourable.
- Consider alternative energy efficient heating and cooling systems such as geothermal, groundwater cooling or chilled beam systems.
- Consider the use of heat-recovery systems.
- Consider the use of cogeneration or tri-generation systems.
- Consider the use of High-Volume Low-Speed (HVLS) fans over mechanical air conditioning, particularly in sports halls.

6.2 Equipment selection

Mechanical equipment should be selected based on a life cycle analysis, including capital, maintenance, and running costs. The system must be appropriate to the local climate.

The selected mechanical systems should be robust, durable and contain easily replaceable or maintainable materials and components. The mechanical system should be designed to be flexible and adaptive, both for spatial function and the integration of future technology.

Evaporative systems serving rooms incorporating heating provisions should incorporate electrically operated shut-off dampers within the supply ductwork to prevent energy loss during heating mode. The damper motors are to be spring return type, such that upon any interruption in power supply the dampers will shut.

Evaporative coolers installed in areas deemed to be at risk of bushfire (ember attack) should be fitted with ember guards. Maintenance conducted on Evaporative cooler units fitted with ember protection must not compromise the protection value of the guards.

6.2.1 Equipment Selection in Hot Humid Climates

Conditioned buildings in hot humid climates must be carefully sealed in order to avoid problems with mould and condensation. When altering existing buildings care must be taken not to compromise existing vapour barriers. Refer to the ABCB and Australian Institute of Architects document Condensation in Buildings Handbook (2023)[2] and Finance's Northern Region HVAC Design Guideline.

Air conditioning systems in humid areas are also required to dehumidify the supply air. Select systems which are capable of removing excessive water vapour from the air without over cooling.

When selecting the type of system for a project / site, particularly in regional areas, the availability of suitably qualified tradespeople should be a consideration.

By reducing the difference in temperature between the interior and exterior the risk of condensation and mould is reduced. In the tropics, A room temperature of 27°C with increased air movement from ceiling fans may provide an occupant effective temperature equivalent to 24°C is likely to be comfortable to the occupant. This will also allow smaller equipment to be used and reduce running costs.

6.3 Location and access

In principle, equipment and plant must be located on the ground or in dedicated plant rooms to provide easy access for ongoing maintenance requirements.

Where access is required into roof spaces or onto roofs, provide adequate safe access including anchor points, ladders, walkways, handrails and lighting, in accordance with the Work Health and Safety Regulations and Finance Technical Guide TG006 Roof Access (www.wa.gov.au).

Walkways in roof spaces should have a minimum head height clearance of 2100mm or to suit the height of materials / equipment on trolleys predicted to require future replacement and movement through these walkways. Where this is not possible and only in isolated locations, clearances should be no less than 2000mm and be clearly identified with lighting, signage, and impact protection.

Roof spaces should also consider ventilation and fire risks.

Equipment located in ceiling spaces and requiring service via ceiling access panels should be installed no more than 600mm above the ceiling level.

Equipment located externally at ground or floor level should have safety barriers which provide adequate protection against personal injury from hot surfaces, moving parts and unauthorised tampering of controls.

[2] Condensation in buildings handbook | ABCB

Equipment shall be adequately protected against vandalism and where necessary be provided with enclosures, protective screens and warning notices to minimise injury or any intentional or accidental damage to the equipment.

Figure 8: Example of poorly accessible mechanical equipment

6.3.1 Roof mounted equipment in cyclonic regions

In cyclonic regions, roof mounted fixtures and equipment are at risk from high winds as well as impact by flying debris. In addition, all roof penetrations are susceptible to leakage over time due to hardening of sealant around penetrations. Roof mounting should be avoided where it is possible to mount equipment in a more sheltered location.

Where equipment is exposed and/or roof mounted, it should be designed for cyclonic wind conditions and with protection from wind borne debris in mind. Detailing of penetrations through roofs must consider cyclonic wind forces and wind driven rain.

Proprietary items to be installed on the roof are required to have evidence of recognised cyclone test certification. Certification should establish the performance of the complete assembly (as it will be installed) for concentrated loads, wind pressure (including fatigue loading for cyclonic areas) and water tightness.

6.3.2 Ground Mounted Equipment

Equipment mounted at ground level in areas prone to flooding, including cyclonic regions, is at risk from inundation during periods of high rainfall and from accumulation of leaf litter, mulch and other landscape items. All equipment should be located out of possible flood paths and should also be mounted on plinths a minimum 100mm above surrounding ground / mulch level so that it can remain above any debris build up.

Part 7 - Hydraulics

Generally, supply of hot (tempered) water for hand basins is not supported as water temperature tolerable to human skin does not have any inherent advantage in removing germs.

Part 8 - Commissioning

Mechanical and electrical systems and equipment should be commissioned to meet design intent and to validate their performance. Refer to specific requirements in procurement and tender documents and reference relevant CIBSE and AIRAH protocols. Refer to NATSPEC clauses: 0791 Mechanical Commissioning.

Commissioning is required for:

- air-conditioning and ventilation systems;
- artificial lighting and power;
- hot water supply;
- swimming pool and spa pool plant;
- pumping systems;
- adjustable or motorised shading devices; and
- any other mechanical or electrical systems or equipment.

These services should be tested prior to practical completion. Between practical and final completion systems should be monitored and tuned to ensure they are running efficiently.

8.1 Operation training and manuals for equipment

Manuals and training of occupants for operation should be provided for all systems requiring commissioning. Manuals should be written in plain English and be user friendly.

The following information should be included:

- the design and operation intent
- the commissioning settings
- the maintenance procedures for the particular systems and equipment
- an asset register of all equipment and its location
- a schedule of replaceable components such as lamps, so that replacements can be sourced without accessing the fittings
- any additional information which may be useful to facility managers for the operation and maintenance of building systems, such as materials safety sheets and guarantees
- provide commissioning information in electronic format to ensure long-term access and storage.

Appendix 1 - Trees to use with caution

As a guide, the following trees should be considered carefully when proposed for use and avoided when a suitable location cannot be designated for them.

Limb droppers	**Poisonous trees**
Eucalyptus botryoides (False Mahogany) Eucalyptus camaldulensis (River Red Gum) *Corymbia citriodora* (Lemon Scented Gum) Eucalyptus cladocalyx (Sugar Gum) Eucalyptus mannifera (Brittle Gum) Eucalyptus rubida (Candlebark) Eucalyptus viminalis (Manna Gum) Eucalyptus grandis (Rose Gum) Eucalyptus robusta (Swamp Mahogany) Corymbia maculata (Spotted Gum) Eucalyptus scoparia Eucalyptus vitrix Angophora costata	Aesculus hippocastanum (Horse Chestnut) *Cassia fistula* (Golden Shower) *Castanospermum astrale* (Morton Bay Chestnut) *Datura sanguineus* (Angel's Trumpet) Duranta repens (Duranta) Euonymus europaeus (Spindle Tree) Euphorbia pulcherrima (Poinsettia) Laburnum anagyroides (Laburnum) Lagunaria patersonii (Pyramid Tree) Melia azederach (Cape Lilac) Nerium oleander (Oleander) Plumeria rubra (Frangipani) Rhus succedanea (Rhus tree) *Ricinus communis* (Castor Oil plant) Robinia pseudoacacia (Black Locust) *Schinus molle* (Pepper Tree) Schinus terebinthifolius (Japanese Pepper Tree)
Troublesome root systems	**Allergenic Trees**
Populus species (Poplars) *Salix babylonica* (Weeping Willow) *Fraxinus* species (some ashes) *Ulmus procera* (English elm) *Ficus* species (Fig) *Callistemon* species (Most bottlebrushes) *Casuarina* species (Most sheoaks) *Eucalyptus botryoides* (Bangalay or Southern Mahogany) Eucalyptus robusta (Swamp Mahogany) Robinia pseudoacacia (Black Locust) Plantanus X acerifolia (London Plane Tree)	Plantanus X acerifolia (London Plane Tree) Platanus orientalis (Oriental Plane Tree)