CONSERVATION TECHNICAL HANDBOOK

A GUIDE FOR BEST PRACTICES

Volume 8 | Managing Change

ICOMOS SINGAPORE

URBAN REDEVELOPMENT AUTHORITY

Conservation Technical Handbook
Volume 8 | Managing Change

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Cover photograph courtesy of National Arts Council (photography by Jeremy San Tzer Ning): Column capitals revealed after removal of false ceilings, ground floor lobby of Victoria Concert Hall during restoration, addition and alteration works, 2012.

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Preface

Urban Redevelopment Authority, as the national land use planning and conservation authority, is pleased to present this series of conservation handbooks. Through judicious planning, Singapore has conserved more than 7,000 buildings and structures since 1989. They cover different building types, architectural styles, scales and genres. They are our precious legacy that must be protected for current and future generations of Singaporeans.

This series is a culmination of URA's collaboration with ICOMOS Singapore, our local chapter of the International Council on Monuments and Sites. This worldwide non-government organization is the official Advisory Body to UNESCO, advising the latter on heritage, conservation and preservation matters and issues. It taps on the technical expertise and experience of ICOMOS Singapore members to take the protection of our heritage gems to a higher level.

The eight volumes in the series are designed as step-by-step guides to carry out best practices in conservation. They will aid those undertaking works on heritage buildings. They contain a wealth of insights gleaned from projects in and around Singapore, taking into account climatic conditions, materials available in the market, new techniques brought by technological advances, and the types of skills offered by the industry.

I hope building owners, developers, professionals in the industry, builders and others who are interested in this field will find this series rewarding. I believe we can foster a strong partnership to protect our heritage. Together, we can make Singapore not just a distinctive liveable city, but also a home that holds meaning for us all.

Fun Siew Leng (Ms)
Chief Urban Designer
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About This Series

Since the 1970s, when historic monuments were first granted legal protection and the first shophouses were rehabilitated, architectural conservation has evolved and taken root in Singapore. Heritage buildings form a significant part of our urban landscape today, as brick-and-mortar repositories of memories straddling generations and as treasured focal points for diverse communities.

In the early days, the main challenge was overcoming the prevailing perception of these historic buildings as crumbling, unsanitary and inefficient structures worthy only of demolition (though in need of rehabilitation, they are embodiments of artisanship, history and urban character). Another uphill battle was the polarized view that conservation is a zero-sum game in terms of economic growth and urban development (it is an indispensable component in all creative, dynamic, well-loved, liveable and competitive cities).

With growing appreciation and awareness of heritage, many have since come around to the idea that conservation is not about fighting change but about how it is managed. Across the city, historic neighbourhoods have found a new lease of life as places to live, work and play, and a growing number of national monuments have been carefully restored in recent years.

While much progress has been made and lessons learned in the past four decades, there is still much room for improvement in skills and knowledge of best conservation practices. This guide is intended to help bridge this gap by laying out the ways to identify and appreciate heritage attributes, understand historic materials and assess their condition, as well as the methods and principles of restoration and long-term maintenance.

Built heritage can be seen as a public good, and every stakeholder – including the owner, developer, authority, building professional, builder and user – serves as a custodian of these precious assets. There is shared responsibility to safeguard each historic structure and ensure its safe passage onwards to the next generation. This series is conceived to provide guidance along the way.

Dr Kevin Y.L. Tan
Founding President (2014-2019)
ICOMOS Singapore

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About This Volume

Look out for box stories and margin notes such as this one, for more information, advice, or links to other relevant chapters of the series.

What do the icons mean?

General tips and advice

Concepts learnt in other chapters or volumes in the series

External references

Further reading and topical notes

Volume 8: Managing Change is the eighth and final book in the **Conservation Technical Handbook Series**. It provides a framework for understanding, assessing and managing intervention works on historic buildings arising from building performance requirements, such as changes in use, modern building standards and regulatory compliance. The volume also looks at the common types of interventions and their potential heritage impact, and presents key principles and examples of how the optimal balance between conservation intent and new requirements may be achieved – "to do as much as necessary and as little as possible". Volume 8 is anchored by local project case studies illustrating good practices and realised design solutions.

While advanced technical solutions would require professionals and specialists, the Handbooks provide decision-makers and other stakeholders an overview of what constitutes good conservation/maintenance practice and a basic understanding of the underlying principles, which will hopefully inform better building management and works planning for developing historic properties.

Chapter 1 Introduction summarises the common interventions undertaken in conservation projects, typical heritage impact caused, and key principles underlining good conservation intervention design. The chapter is organised by the types of building performance requirements giving rise to intervention works – Building Safety, Accessibility and Fire Protection; Integration of M&E Services; Energy Efficiency Design and the Historic Facade; Drainage and Flood Protection.

Chapter 2 Shophouses and Townhouses and **Chapter 3 Bungalows** address issues faced when carrying out works on some of the most commonly found historic building types in Singapore. Both chapters are organised similarly – beginning with a description of the **Historic Character and Attributes** of the respective building type, followed by a broad discussion and **General Notes on Alterations/Adaptive Reuse**, including common new uses and typical interventions that may result in significant heritage impact. The chapters end with **Case Studies** that exemplify how intervention challenges could be overcome with considered, sensitive and enlightened design thinking.

Each of **Chapters 4, 5 and 6** provides a more in-depth look into a project, laying out the changes required and analysing the conservation design strategies devised to sensitively negotiate these challenging interventions. Chapter 4 features the **Cathedral of the Good Shepherd**, a national monument that retains its original function but required structural rehabilitation and upgrading works. Chapter 5 covers the **former Traffic Police Headquarters**, an institutional building with living quarters that underwent adaptive reuse to become an office building. Chapter 6 profiles two monuments – the **former Supreme Court** and **City Hall** – that were redeveloped into the National Gallery, a high-specifications use that called for substantive interventions on the historic fabric and remodelling.

1 INTRODUCTION

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Overview

Refer also to Volume 1: Introduction, Chapter 2 Planning Works for Your Heritage Building, for an overview of conservation works planning and general principles.

Change is inevitable for the **long-term sustenance** of historic buildings and landscapes, for these to remain **socially relevant, economically viable and culturally engaging**. These changes are often necessitated by factors including:

- A **new use** that is different from the original function
- Introduction or upgrading of modern-day **building systems** such as air-conditioning
- Evolving **user standards** and requirements such as acoustics and thermal performance
- Compliance with current-day **building codes** for building safety, energy efficiency and fire protection

This final volume of the Conservation Technical Handbook focuses on **interventions** arising from building performance requirements and regulatory compliance.

Restored verandah with design modifications and additions to railings to meet building codes for safety.

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Refer to *BCA: Understanding the Approved Document*, a useful reference document in relation to Building Control Act.

Examples of overseas building codes for listed buildings include Historic England's *Heritage Protection Guide*, section on Building Regulations Compliance; and *International Existing Building Code*, Chapter 12 Historic Buildings.

The key **building regulations** that affect historic buildings include, to name a few:

- Building Control Act
- Code of Practice for Fire Safety Precautions in Buildings (Fire Code) 2018
- Building Control (Environmental Sustainability) Regulations 2008
- Code on Accessibility in the Built Environment 2019
- PUB Code of Practice on Surface Water Drainage

The key aims of building regulations or codes are to ensure **public health, safety and comfort**, as well as to reduce operational energy consumption as part of larger **environmental sustainability** goals. However, it is not a straightforward matter when applying performance codes meant for new buildings to historic structures that need to undergo preservation or retrofitting works. Unlike countries such as the UK and Germany, Singapore currently does not have a separate and consolidated building code governing works carried out on historic properties.

In fact, **conflicts with conservation aims** – such as adverse visual impact, harm to the building's character, or even irreversible loss of significant features – do arise. Sometimes, well-intentioned but misinformed improvements may increase the **risk of long-term deterioration** of fabric or fittings. Nonetheless, these conflicts can be prevented, or mitigated, when changes are **well-conceived, managed with care, and sensitively executed**.

The grand staircase in the Raffles Hotel main lobby, a key heritage feature, remains in its historic configuration thanks to new fire escape staircases located elsewhere.

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Refer to Volume 1: Introduction, Chapter 2 Planning Works for Your Heritage Building, section on 'Conservation Intervention Works' for an overview of the different types and extent of interventions.

Below left: Fresh air intake grilles for air conditioning are artfully integrated behind randomised window top lights.
Below right: When the former Nan Hwa Girls' School campus was adapted into a preschool, safety railings and secondary windows were sensitively incorporated while retaining key historic features such as the main staircase and open verandahs. New M&E equipment for the air-conditioned classrooms are inconspicuously located on the roof of the open staircore.

KEY PRINCIPLES FOR CONSERVATION INTERVENTIONS

Good conservation design does not mean adopting a code compliance checklist approach but being informed by a holistic understanding and appreciation of the historic site's significance and character-defining elements, to seek a **balanced outcome**. The following are key guiding principles:

- **Identify and prioritize facades, character-defining elements and spaces** to manage change. For example, within key interior spaces, extant elements and finishes should be holistically assessed for their historic, aesthetic and craft significance. Architectural planning can be carried out in a sensitive way such that significant spaces and elements retain their historic building environment intent and function as much as possible, such as maintaining the openness of five-foot ways and courtyards, the passive cooling of modern tropically designed atriums, or integrating restored historic downpipes into the new rainwater drainage design.

- **Assessment of viability for restoration or new interventions:** Examination of existing building fabric should be undertaken to identify and assess the quality, sensitivity and methods of past alterations. If significant parts have been modified by additive changes, i.e., layered on the existing, and if these changes have not accrued significance, it is recommended to remove such alterations and restore the obscured historic design. Where past modifications are found to be subtractive, with the original demolished, this presents an opportunity for new interventions.

Above left: *Dropped ceilings beneath existing ornamented beams in the public areas of the former City Hall allow the historic features to remain visible, while concealing new uplights and electrical conduits.*
Above right: *The historic timber ceiling at the Cathedral of the Good Shepherd has been restored, with new recessed lighting seamlessly integrated into the overall design. New ceiling fans complement the air-conditioning system in achieving cooled interiors, while reducing the risk of moisture condensation on the interior surfaces.*

- **Adopt a conservative approach** that minimises interventions that have a negative impact on the building character and significance, premised upon a holistic understanding of the historic structure, its physical and material attributes, as well as patterns of air and moisture movement. Some buildings or parts of buildings are of such quality, importance or completeness that they should not be altered at all, save for the most exceptional circumstances.

- **Innovating customised solutions instead of one-size-fits-all prescriptions:** This recognises that unlike a new building, engineering interventions such as new M&E or structural strengthening should be targeted and closely tailored to the heritage building, to strike a balance between heritage preservation and present-day requirements. Sensitive modification of construction details to address inherent design flaws should aim to improve building performance without compromising heritage character.

- **Reversibility and compatibility of interventions:** Alterations need to be properly considered in all their various aspects – avoidance of damage, minimising of disturbance, ease of reversing modifications in the future, and so on. Understanding how the building works, in terms of its construction system and layout changes in the past, is critical to determine which alterations are compatible.

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DESIGN AUDIT AND HERITAGE IMPACT ASSESSMENT

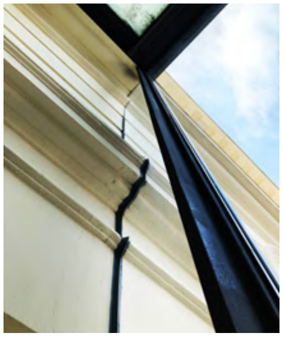
Good conservation practice is about **managing change**. Intelligent visioning of how new interventions may enhance the performance of historic buildings – while taking care to maintain their vital qualities and significance – is essential to improve their resilience and ensure their sustainability in the long run.

When planning for historic building performance upgrades, it is imperative that the design process is subject to a rigorous building performance audit and impact assessment. The project team – client, architect, engineers, and specialists in conservation, acoustics, sustainable design and so on – will need to work hand in hand to maximise beneficial impacts and reduce adverse ones, and find creative ways of achieving project objectives without damaging the heritage significance of the site.

Key heritage impacts of building performance code compliance can include:

- Removal or replacement of historic structural elements due to **design loading changes**
- Historic facade modifications and penetrations to accommodate **M&E services**
- Replacement of historic fenestration and glazing to meet **energy efficiency** ratings
- **Fire compartmentation** affecting significant historic interiors and staircases
- Negative impact of **ACMV loading** on permeability of historic building envelope (condensation, mould problems and so on)

Below left: *Replica dormers were added to house air supply and exhaust systems for ACMV. However they were too numerous and closely spaced, affecting the heritage presentation of the neoclassical building.* ***Below middle:*** *Invasive interface detail between new glazed enclosure and historic rusticated wall.* ***Below right:*** *Adverse visual impact of surface-mounted M&E services on historic facade.*



Where low dropped ceilings are unavoidable, careful routing of the M&E services concealed within the plenum and sufficient setback of the ceilings from key architectural elements such as column capitals and fenestration, allow these to be clearly expressed while mitigating the impact of the new intervention.

Mitigating measures are critical to resolve any conflicts that arise. Where conflicts cannot be mitigated satisfactorily through design measures – for example, fire compartmentation of a key historic staircase – a **waiver** application to the relevant authorities may need to be considered.

In this chapter, the following aspects of building performance requirements and their impact on historic buildings will be covered, outlining best practices as well as acceptable solutions in select case studies:

- Building Safety, Accessibility and Fire Protection
- Integration of M&E Services
- Energy Efficiency Design and the Historic Facade
- Drainage and Flood Protection

ACOUSTIC PERFORMANCE AND MITIGATION OF CONSERVATION IMPACT

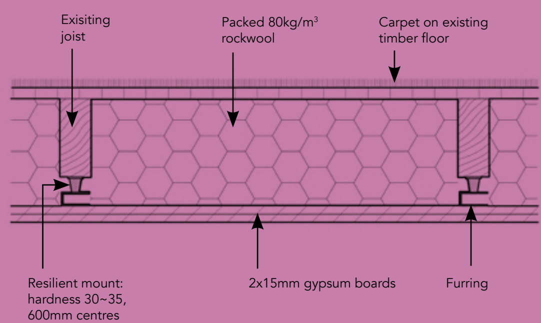
Poor acoustics is an indoor stressor and may result in discomfort for occupants. As the built environment becomes intensified, noise from neighbouring buildings and public roads needs to be controlled in order to minimise disturbance within interiors. Sound insulation between floors becomes important especially when the building has a mix of **'noisy' use** (such as a restaurant) and **'quiet' use** (apartments). Acoustic performance may become more stringent when there is a change of use in a historic building, for example, from an office building to a luxury hotel. Shown here are some examples that illustrate sensible design strategies – mainly additive, reversible interventions – that aim to achieve the technical requirements while minimizing disruptions or loss of heritage character.

Sound insulation of windows and doors

It is common to introduce new secondary windows and doors with aluminium frames and seals that are able to achieve the desired acoustic rating, in a design that is compatible with the retained historic windows.

Sound insulation of timber floor

Instead of replacing the original floor construction in timber joists and boards with a reinforced concrete slab, sound insulation can be achieved through introducing an isolating acoustic mat beneath the floorboards. Alternatively, a sandwich timber floor can be introduced to conceal build-up layers of insulation material between and below the floor joists.



Above: ***Example of retained timber flooring with acoustic insulation detailing.***

Left: ***New secondary acoustic doors behind those of historic design.***

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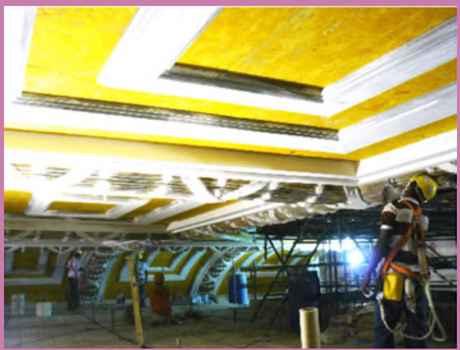
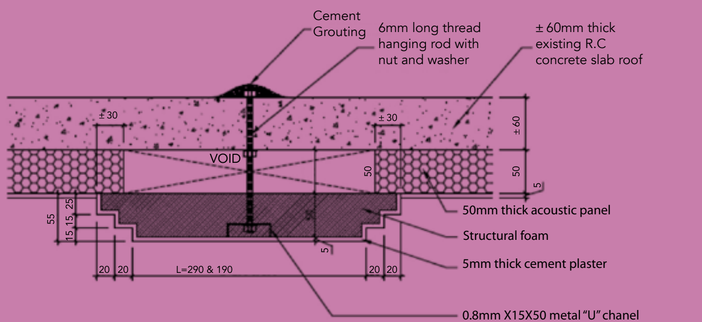
Acoustic design integration with ornamented historic interiors

In high specification interiors such as concert halls and theatres, intact architectural ornamentation would need to be taken into consideration, with new acoustic panelling installed only at strategic locations where absolutely necessary. Alternative means of tempering the acoustic properties through electronic systems should be looked into.

Sometimes, as in the case of the Capitol Theatre, lost or missing ceiling ornamentation provided an opportunity to replicate these features in new, acoustically superior materials in order to offset the need to clad over other surfaces that are relatively intact.

Before *(left)* ***and after*** *(right)* ***careful restoration of the richly ornamented interiors of Capitol Theatre.***





Left and right: ***Missing architectural features such as the ceiling coffers were reinstated using acoustic panelling whose design matched the historic details.***

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Building Safety, Accessibility and Fire Protection

Refer to BCA Building Safety Approved Document, Section H 'Safety from Falling'

BUILDING SAFETY

Other than required structural repairs and strengthening, building regulations governing **public safety** are important considerations when retrofitting historic buildings. These safety requirements can potentially have a high impact on the physical appearance and integrity of key architectural elements such as parapets, staircases and fenestration, as these play an important role to prevent persons or objects from falling from a height. With present-day safety codes that specify ever-increasing heights and minimal gap dimensions, **physical barriers** must:

- **be sufficiently high to prevent a person from falling over the top of the barrier –** In historic buildings, the parapet and railing heights are often less than the minimum required – typically measured vertically from the finished floor level to the top of the barrier. For staircases, the height of the barrier is to be measured vertically from the pitch line to the top of the barrier.
- **not have any opening or gap that will allow a person or object to fall through the barrier –** The affected architectural elements are historic balustrades where the spacing between balusters do not meet the minimum width.
- **not have any features that facilitate a person climbing over the barrier –** Some historic parapet or balustrade designs are now considered to possess a higher safety risk due to the presence of 'climbable toe holds'.

__Below left:__ Discrete glass balustrades are added to the low parapets of the old NCO Club verandah. __Below middle:__ Clear glass balustrade is added on the exterior of the historic handrail to preserve the verandah spatial character. __Below right:__ Addition of new child-friendly secondary railings and tactile pavement to the retained historic main staircase of the former Nan Hwa Girls' School.

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__Left top:__ Safety railings installed behind reinstated low parapets. __Far left top:__ Safety barriers preventing people from climbing the French windows.
__Left below:__ Glass panels added to a historic balustrade that does not meet minimum gap requirements.
__Far left below:__ Historic balustrades with 'climbable toeholds' were fitted with steel mesh panel and a higher top railing. Planter boxes serve as a visual barrier.

Historic floor finishes such as cement screed, terracotta tiles and encaustic tiles may not meet BCA's **slip resistance rating**. One possible solution is the use of compatible specialist products such as a densifier to consolidate the floor material surface, to enhance its slip resistance without altering its physical appearance.

Refer also to *Volume 5: Doors and Windows*, Chapter 1 Introduction, section on 'General Notes on Conservation and Intervention'.

Even for windows and parapet walls on **roofs and corridors,** the heights of some of the older windowsills and parapets from the floor finish levels may not meet the minimum requirement. In some cases the balustrades and parapet walls will also need to be assessed for their ability to withstand **horizontal load** (e.g. of a person leaning on them).

Interpreting these regulatory requirements literally may lead to complete replacement of historic architectural elements. However there are actually many alternative design solutions available to address the above issues while mitigating any heritage impact. Many are **additive and reversible interventions**, using new elements of sympathetic and compatible design:

- Addition of a **secondary barrier** separately and away from the existing barrier, that allows the latter to be fully exposed and visible.
- Addition of a **safety handrail on top** of a solid barrier, such as a parapet
- Addition of **safety rail within the opening** or window frame while not obstructing the operation of the historic fenestration.

GLASS AT HEIGHT

Where glass is used as a part or whole of the facade, roof, canopy or other type of overhead glazing of a building located at a height of 2.4 metres or more, whether situated within the interior or forming the exterior of a building, appropriate measures shall be taken to minimise the risk of injury to people in the event of **spontaneous breakage** of such glass elements.

Generally, for most historic buildings that are more than 50 years old, float (or annealed) glazing that is not prone to spontaneous breakage has been used, and is **exempt from replacement**.

It is thus important to establish whether the **type of historic glazing** falls under the exempt category to avoid unnecessary loss of historic fabric.

Top: ***The historic coloured glass in the lofty cast iron feature window of the former Straits Settlement Volunteer Corps Drill Hall has been retained, as the glazing type is not under the Safety Code's high-risk categories.***
Above: ***Historic green tinted glazing being reinstalled after the mild steel window frames are restored.***

Refer to *BCA Building Safety Approved Document*, Section N 'Use of Glass at Height'.

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Refer to BCA Code on Accessibility.

ACCESSIBILITY

Accessibility and universal design requirements are key pillars to create an **inclusive built environment** in Singapore, to address the needs of an ageing population as well as persons with special needs. Historic residential and non-residential developments alike are subject to the **accessibility code**. Due to their potential visual and physical **impact on historic fabric and heritage presentation**, the incorporation of railings, lifts, ramps and even parking in heritage buildings and neighbourhoods requires a careful balance of user needs and site constraints and should be sensitively executed.

Accessibility design should be integrated in architecturally opportune places that could enhance user experience while providing safe and comfortable movement. Where new lifts and ramps are required, in-depth **building history research** into original spatial and structural configuration should inform the location of these new elements, so as to **minimise heritage impact** and **avoid excessive structural modifications** to accommodate them. These new elements should assume a discreet design and be sensitively detailed so as not to detract from the building's heritage presentation.

*During the refurbishment of Atbara, a 19th century house, as a gallery, a new access ramp to the interiors, raised one storey above ground level, was added. The sizeable new element was discreetly located at the rear, and well-integrated with the lush landscape design **(left)**. The ramp is thus not visible from the main approach **(right)**, providing universal access without detracting from the heritage presentation of the historic house.*

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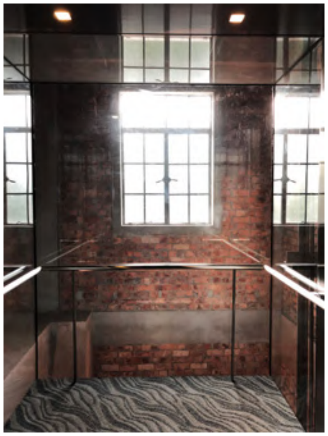
__Left:__ A bespoke frameless glass elevator is inserted within a heritage building. The new lift shaft takes the preserved historic walls as its 'enclosure', capitalising on the play of natural daylight through existing windows, and features indoor lighting wash on the exposed brick finish.
__Far left:__ New railings are added to geometrically complex front entrance steps in a sensitive manner, to provide additional support for the elderly and infirm. The balusters are bolted onto the plainfaced staircase risers so as not to damage the historic marble treads.



Where possible, **lifts** should be added in **new extensions** rather than within the historic building footprint, to minimise disturbance to the existing structure. However, when this is not an option, the placement of a new lift should take into consideration the **existing height and roof profile** of the historic building, so as to properly size the equipment to avoid any clash with the existing foundation or roof framing structure. Lift pits or lift overruns (motor rooms) may sometimes necessitate localised modification of an existing structure, though this should be avoided as far as possible. Sometimes, glass lifts may be chosen to miminise visual obstruction within the historic interiors.

Ramps mitigating undulating terrain or varying platform levels could also be sensitively integrated with the site's landscape and public circulation design, keeping to or even enhancing the historic character and heritage presentation of the place while ensuring inclusivity.

Different platform levels between new built and historic parts of South Beach development are navigated via a system of stairs and ramps integrated into the urban landscape design.

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Refer to Fire Code 2023, Clause 9.9.1

FIRE PROTECTION

Fire protection requirements usually impose a **high design intervention load** on historic buildings due to stringent design requirements for means of escape, fire-resistant construction, prevention of fire spread, smoke extraction and discharge, and so on. Fire safety is paramount especially for shophouses and terraced townhouses – forming the bulk of Singapore's conserved building stock – closely packed in dense urban street blocks. Historically, party walls between units built of non-combustible materials such as brick and reinforced-concrete exist to compartmentalise each building.

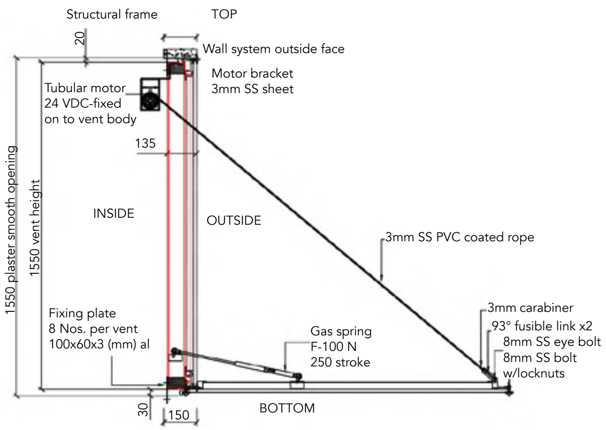
Left: *Modifications to a historic timber door were necessary – such as addition of glazed panels over the timber louvres – to convert it into a code-compliant fire escape doorway. The doors are kept open at all times when the premises are in operation, while a new set of secondary frameless glass doors serves to keep the air-conditioned indoors cool.*
Middle: *Fire access panels are sensitively integrated into reinstated mild steel windows (shown with thickened window frames with handles).*
Far left: *Fire hose reel and control panel are housed in wall recesses and enclosed behind new mild steel doors, along a five-foot way.*

According to the fire code, **residential** shophouses and terraced houses require mainly **passive fire protection**. This includes:

- Fire-rated doors
- Treated floorboards
- Party walls
- Air vents
- Mechanical ventilation
- Fire compartmented internal staircases and escape route

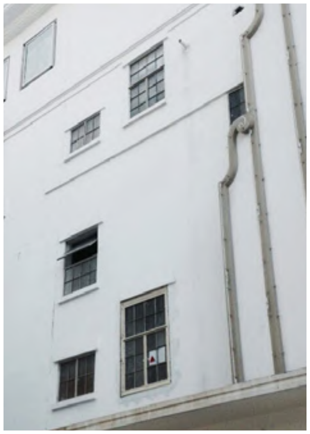
However, **commercial** shophouses require additional **active protection** measures on each floor that comprise:

- Fire alarm systems
- Fire sprinklers
- Hose reels
- Fire extinguishers



SECTION VIEW | SCALE 1:15

Left and below left: *Smoke exhaust panels are integrated within Capitol Theatre's clerestorey openings, which will be electronically activated in the event of a fire. Detail drawing shows open configuration of an activated smoke exhaust panel.* ***Below right:*** *Smoke extraction fan systems could be integrated within existing jackroofs to avoid puncturing the facade walls.*



Historic mild steel windows are selectively modified to convert them into fire access panels. In this case, the original window leaves are permanently fixed, and then mounted onto a new steel frame so that the entire panel operates as a single casement unit.

Notwithstanding technological advances, fire protection regulations have a potential high impact on space planning, architectural design and M&E integration. Some of the requirements translate into a direct impact on historic facades, and need to be **sensitively integrated** so as not to result in detractive elements:

- **Unprotected openings are not allowed within 1.5m of the exit staircase discharge** – as a result new fire-rated boards are installed behind the windows, which are kept closed permanently.
- **Smoke extraction and discharge** – High-level smoke extraction and discharge equipment is required for large span interiors in non-residential buildings, and will need to be integrated within the historic building envelope, whether it is through high-level facade openings, or jackroof spaces.
- **Fire access panels** can be integrated with historic/new windows at inconspicuous locations.
- **Hose reel, breeching inlets and fire extinguishers** are to be visible to firefighters and located within a recessed compartment if located on prominent exterior locations.

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__Right:__ Original concrete escape staircases may be dilapidated and require replacement – the new escape staircase design (on the right) should be sympathetic to the historic neighbourhood.
__Far right:__ Inward-opening historic doors are kept permanently open, while new frameless glass vestibules with automatic sliding doors function as escape doorways.

Means of Escape
For multistorey buildings, **staircases** serve as a principal means of escape in the event of a fire and have to be protected under prevailing fire safety codes. For non-residential shophouses and terraced houses, existing historic staircases generally need to be **compartmentalised** with fire-rated construction, and the timber elements pressure-impregnated with **flame-retardant** chemicals.

In the case of a non-code compliant staircase with significant heritage value where replacement or fire compartmentation is unfeasible, a **new escape staircase** can be provided at a less conspicuous location. Open **verandahs** that are heritage features may be subject to compartmentation if designated as a key escape corridor, and need to be carefully evaluated if there are less intrusive alternatives. For **historic doors** that do not open in the direction of the exit, these will need to be kept open permanently and a new set of **secondary doors** added that open in the direction of the exit.

Refer also to *Volume 7: Paints and Coatings*, Chapter 3 On Timber and Metal, section on 'Fire Protection'.

Fire-Resistant Construction
Timber structural members, especially timber floorboards and joists, are character-defining elements of historic buildings such as shophouses and bungalows. Treatments of timber floor joists and floorboards include:

- Fire-retardant treatment for timber floor joists and floorboards
- Fire-rated boards and insulation between floor joists

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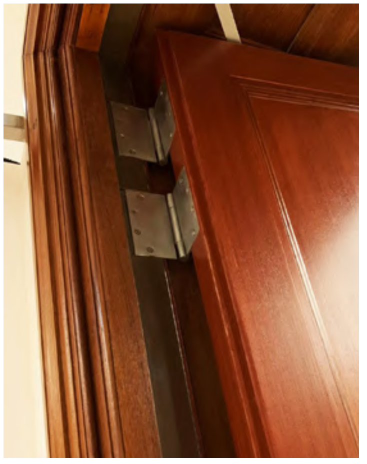
Historic doors of significance should be retained with minimal modifications as far as possible. For timber panelled doors, the fire resistance rating could be upgraded using flame-retardant treatment without altering their external appearance. In cases where there are no alternative strategies to meet fire protection requirements, and existing timber panelled doors have to be replaced, new fire-rated metal composite doors with timber cladding customised to the historic design could be considered.

Fire-rated metal doors with timber panelling and trim detailing to ensure that the historic design of the original doorway is maintained.



Treatments of **exposed steel structural members** are mainly through the use of intumescent paint so that these can be left exposed instead of being clad over.

Steel escape staircase finished in intumescent paint, with fire sprinkler running below the treads.

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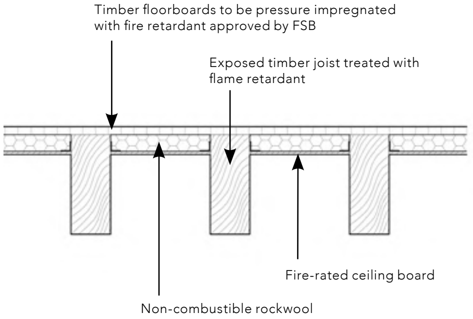
At times, the proposed fire protection methods inevitably diminish the historic character of the building. For example, the installation of fire-rated ceiling boards obscures the originally **exposed timber floor joists and floor boards**. Some alternative design approaches include:

- Installing the fire-rated ceiling board and insulation between joists, so that these remain exposed when viewed from beneath. Timber strips could also be installed over the fire-rated boards to evoke the visual aesthetics of exposed floor boards.
- Encasing existing timber joists with additional sacrificial timber, which helps improve fire resistance. However this many obscure existing carved timber details.

Prevention of Fire Spread

Contemporary fire protection provisions such as **sprinkler systems** can be visually striking when set within an intact heritage interior replete with ornamented mouldings, or against a backdrop of timber floorboards and joists. Concealment and discreet arrangement of these fixtures and piping are advised, for example, running along the edges of the side walls and extended parallel to the direction of the timber joists and rafters wherever needed. Large **sprinkler tanks and pumps** present another challenge in concealment. Where possible, they should be consolidated in a single location for space efficiency, ideally within a new extension, to minimise interference with intact historic interiors. **Fire-rated roller shutters** or fire curtains may also be installed to compartmentalise large spaces, in concealed housing that is integrated with existing structural elements, such as party walls.

Left: *Timber floor enhanced with fire-rated boards and fire retardant treatment to achieve the required fire rating.*
Middle: *A secondary timber strip ceiling is installed under fire-rated boards to retain the heritage character of the historic timber floor construction.*
Right: *Fire-rated roller shutters concealed within the party walls are used to compartmentalize this open-plan office that spans across multiple terraced housing units, in the event of a fire.*



Integration of M&E Services

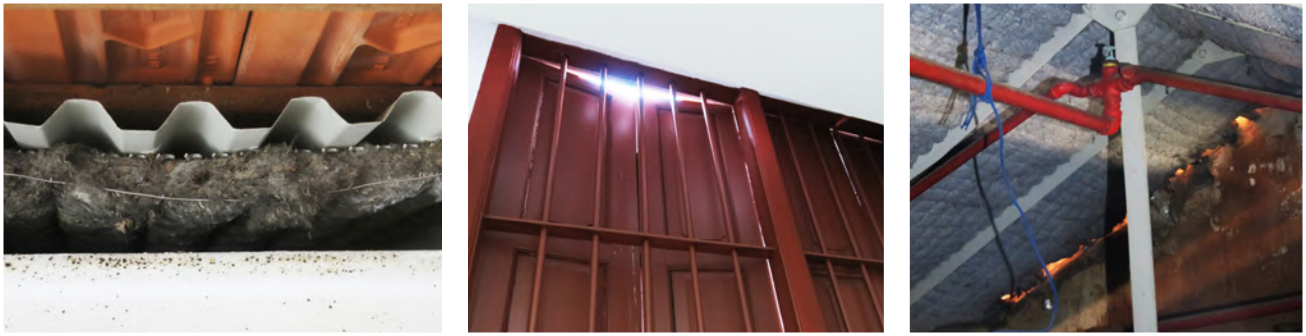
Modern building services were first introduced in Singapore in the early 20th century, in the form of early **cooled air systems**, **sanitary piping** and **elevators** in a few bespoke commercial buildings such as theatres and banking halls. From the late 1970s onwards, the use of **air-conditioning** became widespread in new high-rise residential and commercial buildings that proliferated during Singapore's urban renewal. Requirements to introduce airconditioning in retrofitted historic properties like shophouses and religious monuments such as churches, museums and so on has been on the rise in the past decades.
Today, with larger concerns over **environmental sustainability** and **energy efficiency**, the 'default' use of air conditioning has been examined more critically to reduce environmental impact as well as explore alternative means to achieve indoor thermal comfort. In the wake of the Covid-19 pandemic, planners, regulators, developers and designers are also taking a relook at reducing enclosed spaces and encouraging more **mechanically or naturally ventilated public areas**. In this regard, heritage buildings with open verandahs, high ceilings, porous building envelopes with large window and door openings that promote cross ventilation and provide indoor thermal comfort should be considered as a form of 'pandemic-resilient' design approach, with more reason to preserve these historic features when upgrading the premises.

Left: *The lofty ground floor verandahs of Raffles Hotel has been maintained for more than a century as a historic tropical design feature.* ***Middle:*** *Careful integration of M&E services to minimise ceiling-mounted fixtures helps to retain the heritage character of the high-ceilinged verandah - such as the use of side-throw cool air supply and task lighting.* ***Right:*** *M&E equipment is consolidated at the rear roof deck and screened by a low-key pergola. Lightning tape is laid on the pitched roof with sightline considerations to avoid becoming a detractive element.*

Except for small-scale and simple retrofitting projects, it is essential to engage an **M&E consultant** with the requisite experience and knowledge to ensure proper building services integration that is at the same time sympathetic towards, and appropriate for, the historic building, at the outset of design. A first step to carry out is visual inspection or **M&E audit** of the existing building to survey routing and plant locations, and to identify possible strategies for ensuring the new M&E infrastructure runs inconspicuously and with minimum damage to the historic fabric and ornamentation. The **cooling load** has to be properly evaluated taking into consideration the entire building design. The information used for the design is important as both over- and under-designed systems could result in problems.

Airtightness

A key aspect to consider when integrating an air-conditioning system into a previously naturally ventilated building is airtightness. Many heritage buildings in tropical climates such as shophouses, warehouses and bungalows were previously naturally ventilated. **Warm, moisture-laden external air** can infiltrate the building envelope and come into contact with **cold internal surfaces**, often resulting in condensation and corrosion. Conversely, when airtightness is not achieved, cool air may escape, resulting in **energy loss** and possibly also **condensation**. Simulation software is currently available to evaluate the energy usage, comfort level and also preservation of materials. Several types of simulation include energy building performance, fluid/airflow, ventilation, thermal comfort and building hygrothermal performance.



In desiging the integration of a cooling system, the historic building should be assessed for any potential spots where air leaks may occur and that needs to be addressed, such as (from left) gaps between roof insulation and roofing sheets; fenestrations that cannot be properly closed; and deteriorated or poorly designed joints between roof and gable end or party walls.

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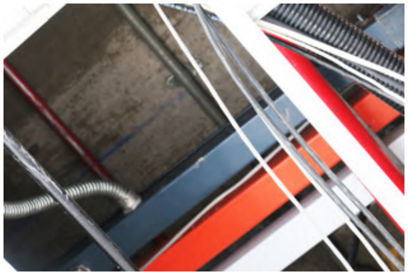
Compatibility and Reversibility

Care should be taken to ensure proper installation, minimal risk of condensation and ease of maintenance. During installation, **cables should never be chased into original fabric**, and when unavoidable, penetrations should be reversible – chased into mortar instead of brick or stonework. Technological innovations such as wireless control systems can be used to reduce cabling.

Right: Wires and conduits cluttering up plenum space. *Far right:* Mechanical system installed in confined spaces with limited maintenance access.



Maintainability

M&E systems require regular periodic maintenance, as such it is critical to make provision for proper **access** right at the start. Unlike smaller buildings with simpler M&E requirements, larger buildings will require a system consisting of a cooling tower, chiller, chilled water pump, air handling unit, fan coil unit, and where required, dehumidifiers, exhaust, filters and many more components.

Access to equipment, ducting and conduits is essential to minimise damage to fabric for maintenance and future addition. It is very important that **adequate protection** and **regular maintenance** be provided. Mechanical equipment and plant are sometimes placed externally due to the lack of a properly designed space, and often left exposed to the harsh tropical environment. These may include water/ sprinkler tanks, genset, pumps and VRV equipment. Inadequate protection results in corrosion, condensation and water seepage.

Corrosion of mechanical systems located outdoors.

Left: *Naturally ventilated open verandah is retained, with original high ceiling, lofty door openings and structural elements fully expressed, minimally enhanced with pendant lights serviced by exposed cable tray running below the beams.*
Right: *Careful M&E service integration within the interior spaces ensures that the original architectural features and spatial proportions are preserved while providing modern amenities and comforts.*

The equipment should be neatly consolidated, preferably within the new extension, and not visible from the main approach to the building. The **equipment placement** should be sensitively designed and shielded by discreet screens so that it does not detract from the building's heritage presentation.

Within building interiors, **electrical conduits** and wiring run within plenum spaces together with **runners, ventilation and air conditioning ducting**. Internal services include **electrical/data cables, refrigerant pipes and sprinkler pipes**. Oftentimes, the installation of different systems by different parties is not properly coordinated, resulting in a maze-like clutter which hinders subsequent maintenance. Adequate and **safe access** should be provided to enable **maintenance and inspection**. Examples of best practices include:

- Neatly designed service trays to expose architectural features
- Minimising the extent of false ceiling, so as to expose floor joists
- Custom-designed ceiling profile to conceal M&E services without covering vents

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Top: *Historic shophouse back elevations overwhelmed by ACMV equipment.*
Above: *The adverse impact of inappropriate ACMV ducting design includes insensitive modification to historic architectural features such as the arched doorway, obscured cornices, a low ceiling, and loss of original spatial proportions.*

AIR-CONDITIONING AND MECHANICAL VENTILATION

Finding the ideal ACMV solution for a heritage building depends not just on technical considerations – such as specifying an energy-efficient system based on whole building performance – but also the design sensitivity in devising a strategy with minimal impact on the historic fabric and character. Some historic buildings may not be able to accomodate M&E equipment without extensive structural strengthening. In such cases it is best to **decant** these out of the historic building and house them elsewhere, such as in new extensions. In general, new mechanical ductwork that is visible externally, or adversely impacts the interior spatial quality, should be avoided. Window type AC units should not be used as they would mar the historic facades. In some cases, **well-coordinated and designed exposed interior ductwork** may be a better solution compared to a concealed system that may compromise historic fabric, such as in industrial heritage buildings.

Left: *Natural daylight is introduced into the Raffles Hotel atrium by replacing the jackroof tiles with glazed ones. Air-conditioning supply is introduced along the two sides of the clerestory so as not to visually clutter up the ornate timber trusses.* ***Right:*** *ACMV equipment is neatly arranged on a new deck, discreetly screened off.*

Left: *M&E services are designed and laid out in two layers, such that they are able to compactly fit within the ceiling space without obstructing the historic top vents.*
Right: *FCUs are concealed in low cabinets, allowing the high ceilings to be retained.*

Daylight and solar heat in the air-conditioned back lanes of the Capitol development are attenuated through low-emissivity glass and fabric shades below. At the street level, air-conditioning supply air is integrated with the historic ventilation blocks along the retained rear boundary walls of the 'finger' rear blocks.

Examples of sensitive ACMV design include:

- **Optimising the original historic ventilation fixtures and spaces**, whilst adapting them to house modern apparatus that can be hidden with additional plenums
- **Condensing units on the roof over the rear court of shophouses are neatly consolidated and screened** at least-visible locations. Sometimes, the level of the RC flat roof over rear court are lowered to minimise the visual impact of ACMV plant.
- **Consolidating condensing units in multi-tenanted buildings** by using customised and sensitively concealed ducting space, and coordinating future provisions
- **Fan coil unit housing design is sensitive and well integrated** with the architecture of the building – such as being strategically placed within timber-clad false ceilings and hidden behind timber grilles
- **Mitigation of any undesirable impact of introducing a new interior climate on historic materials,** such as mould growth and water seepage due to condensation, through skilful engineering design and indoor air quality investigation, monitoring by M&E or building science specialists.

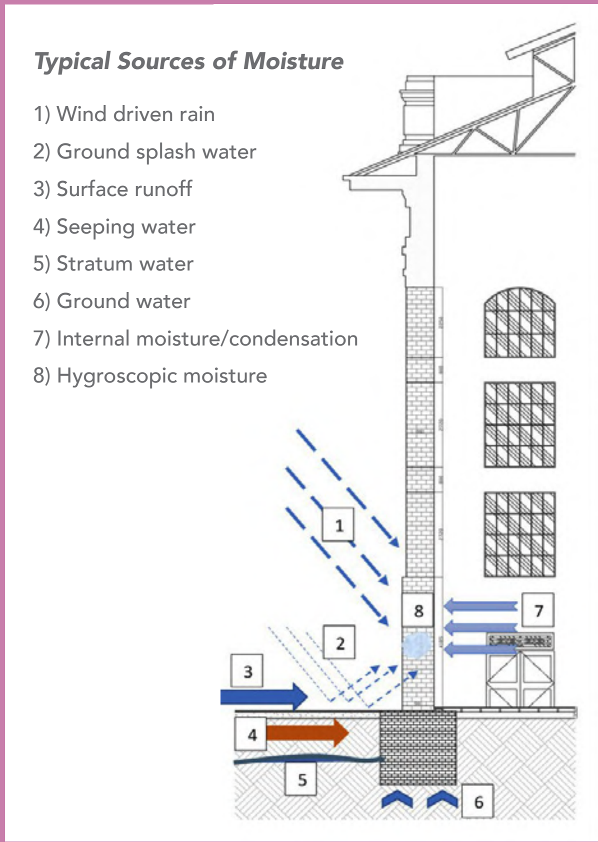
Left: *The original high-ceilinged classroom of the former Victoria School features clerestory lights, which have been revealed by introducing an inclined ceiling that slopes away from the wall surface. This creates an interesting light scoop effect and lets ample daylight into the deep plan office.* ***Middle:*** *To preserve the spatial character and unique ceiling and skylight design, M&E services are discreetly placed along the edges of the enclosure walls.* ***Right:*** *Air intake and exhaust vents are integrated into the roof eave soffits of the conserved building, reminiscent of the original roof vent design.*

HYGROTHERMAL PERFORMANCE AND INDOOR AIR QUALITY

Most historic buildings were designed to facilitate natural ventilation through generous provisions for fenestrations, vents, high ceilings, jack roofs, deep eaves and so on. Together with the use of 'breathable' building fabric, this enables effective passive cooling and moisture evaporation to achieve indoor comfort.

On the other hand, the requirements for air conditioning run counter to many of these tropical design features, calling instead for **airtightness**, **insulation**, and **moisture barrier.** As such, one of the most common problems faced in a refurbished (and air-conditioned) historic building is **condensation**, which leads to unsightly **stains**, **salt attack**, **mould growth** and **compromised indoor air quality**.

Typically, condensation occurs where inadvertent air movement results in the **meeting of hot and humid air with cold air or surfaces**. In the local context, typical daytime temperature is around 32°C and relative humidity (RH) is usually above 75%, while air-conditioned interiors are on average 23°C with a RH of 65%. Historic buildings not designed to be hermetically sealed thus become particularly susceptible to condensation issues when there is ingress of hot air and moisture. This could be due to **lack of building airtightness, inadequate insulation or thermal bridging**.



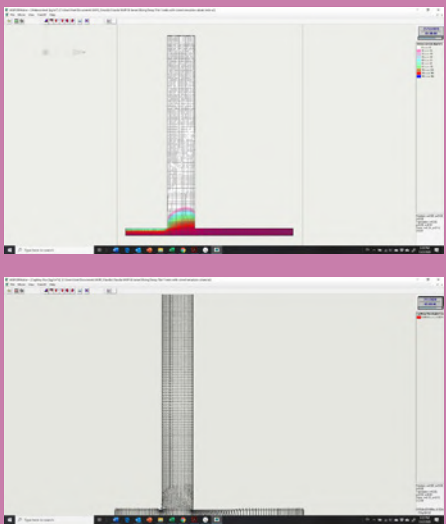
Moisture presence resulting in salt attack** (left), **mould growth** (right) **and poor indoor air quality.

Another source of moisture is **rising damp**, which is movement of groundwater upwards through footing into the building footing and wall. Moisture may be also absorbed from **rainfall**. If moisture remains in the building fabric over a prolonged period, it will cause deterioration. While planning for alterations in historic buildings, it is important to **identify locations with such risks** and mitigate the problem through sensitive design.

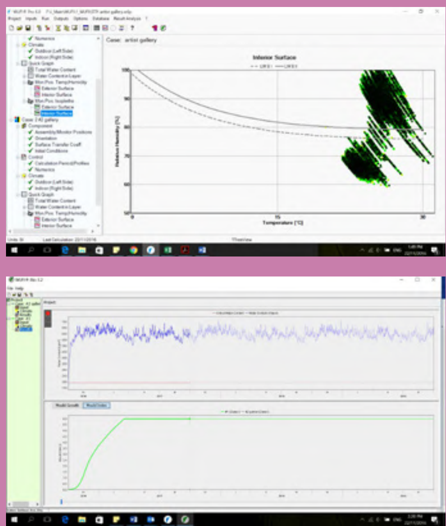
A building's **hygrothermal performance** refers to how its design, construction and materials moderate the movement of heat and moisture, and whether it meets building environmental requirements. Typically building materials may repel, absorb and exude moisture depending on environmental conditions and material properties. **New materials** on historic walls need to be thoughtfully applied as they may have adverse effects on the originally 'breathable' historic fabric.

Likewise, selection of materials for framing and fastening should be carefully considered to prevent the formation of thermal bridges that expedite condensation. Placement of **vapour and moisture barriers** in roof construction is critical to prevent accumulation of trapped moisture.

The hygrothermal performance of a building can be evaluated using **computer simulation** to determine the **risk of condensation**. Modelling tools provide a designer with the flexibility to experiment with various feasible design options before selecting the promising ones. **Hygrothermal simulation softwares** includes HygIRC, Therm, WUFI and others.



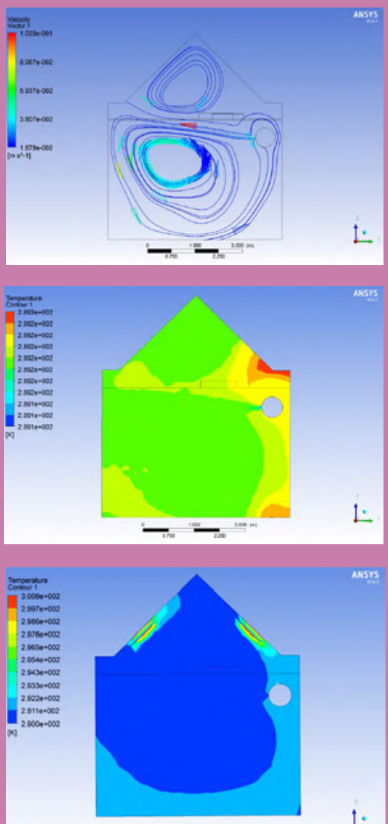
WUFI simulation output showing** (top) **rising moisture** (above) **direction of capillary movement.



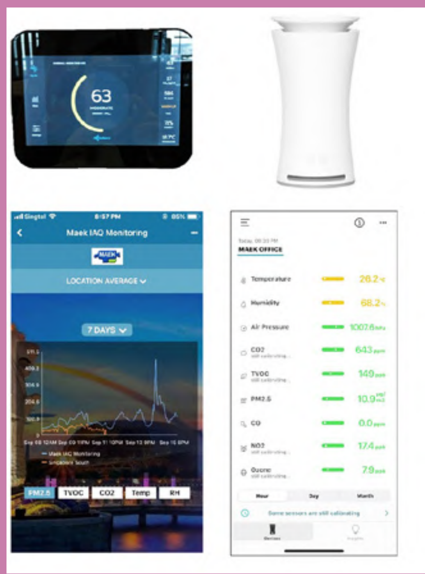
***WUFI simulation assessing potential for moisture build-up** (top) **and risk of mould growth** (above).*

Internal air movement within a space can also be simulated to evaluate air circulation and cold spots. This can be carried out using **computational fluid dynamic (CFD) simulation**.

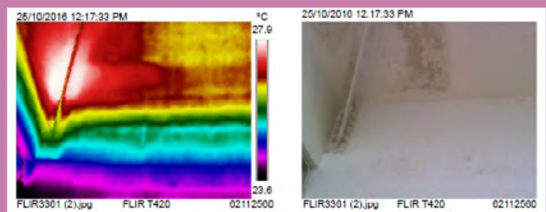
Indoor air monitoring sensors could also be installed for continuous monitoring and logging of indoor air parameters, especially for older historic buildings subjected to long hours of air conditioning. Elevated levels and fluctuations of indoor air components such as carbon monoxide, carbon dioxide and particles could be an indication of uncontrolled air exchanges between indoors and outdoors, or inadequate ventilation. Besides monitoring for harmful volatile organic compounds (VOC) and ensuring a healthy indoor environment, a closer reading of the sensor log could thus help detect building deterioration factors, even before they manifest as visible dilapidation.



***Airflow simulation** (top) **and temperature distribution within the space for day time** (middle) **and night time** (above).*



Monitoring sensors and mobile applications for indoor air monitoring.



IR thermography detects temperature variation and could be used to assess condensation risk.

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SANITARY SERVICES

The integration of **drainage and plumbing systems** within a historic setting has to be carefully considered. Not only will improper sanitary services planning affect the historic design and spatial character, it can also damage the building fabric should water leakage and seepage occur.

The main principle governing the installation of plumbing systems and sanitary fittings is to minimise invasive works. **Existing perforations** should be reused, with limited, **localised interventions** only if the need arise. For historic buildings with **exposed old sanitary piping** on the exterior, the refurbishment process could be an opportunity to relocate these within the interior in accordance with current regulations. However, this may entail the penetration of floor slabs internally, which should be done with caution.

Internally, plumbing pipes and ductworks can be **concealed** in closets, service rooms or above false ceilings, taking care to **avoid historic finishes** as far as possible, and especially timber elements, given the possibility of leakage. New wet areas should be planned to avoid these sensitive locations; the hacking of floor slabs should be minimal and away from areas with feature floor finishes such as encaustic or terrazzo tiles. Sometimes there may be **pre-existing inspection chambers and manholes** – these should be properly integrated with the interior finishing.

Ideally, wet areas should be arranged in a **single stack** in a multistorey building, to **minimise pipe runs**. This also reduces the need to conceal long pipe runs with extensive false ceilings that will diminish the original spatial character.

Solid walls and exposed sanitary pipes at the rear of this colonial government staff quarters indicate the location of bathrooms. Most of these historic houses were constructed with timber joist-and-board flooring. The exceptions were wet areas such as bathrooms and kitchens where ferro-concrete slabs were used instead, for their better resistance to water damage.

FLUES AND VENTILATION

General **design principles** for flues, vent stacks, exhaust pipes and mechanical ventilation include:

- **Minimising new perforations:** New air intake and exhaust vents (such as for kitchens) are to be placed behind existing vents or fanlights instead of making new perforations on the external walls.
- **Reuse of existing provisions:** Existing flues should be retained or reused where possible
- **Sensitive design and placement of the new:** A new flue is to be neatly located in either the rear slope of the main roof or the rear secondary roofs or abutting the wall of rear facade/ rear service block within the rear court. The number of such openings should be kept to a minimum.

Neatly integrated kitchen exhaust flues on the rear service blocks of shophouses.

Uncoordinated kitchen exhaust flues penetrating rear facade elements and causing visual clutter.

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ELECTRICITY AND GAS

The installation and routing of electrical and gas services in a historic building should follow the same general principles of **minimal invasivity** (visually and physically), while ensuring **efficiency and safety** for building users. As a general rule, chasing in electrical conduits and gas piping into high key **heritage finishes**, such as timber or terrazzo dadoes, must be avoided at all cost. It is also recommended to avoid chasing into **load-bearing brick masonry** walls or columns, especially if the historic plaster is found to be of inadequate thickness to accommodate electrical conduits, as this would mean removing the brickwork and affecting the integrity of the structural element.

A thorough **audit of existing concealed services** should be carried out to assess if these are appropriately installed and if they can be reused, so as to avoid making new perforations.

__Top:__ Chasing in M&E conduits and pipework causes irreversible damage to historic structure and fabric.
__Bottom:__ Insensitive installation of electrical wiring and conduits often result in adverse impact to heritage features. In this case the CCTV conduit is inappropriately routed through the historic decorative top vent.

Electrical distribution board, water meter and telecoms panel are recessed within a newly built compartment, behind a historic timber screen, part of which has been modified into a service access door.

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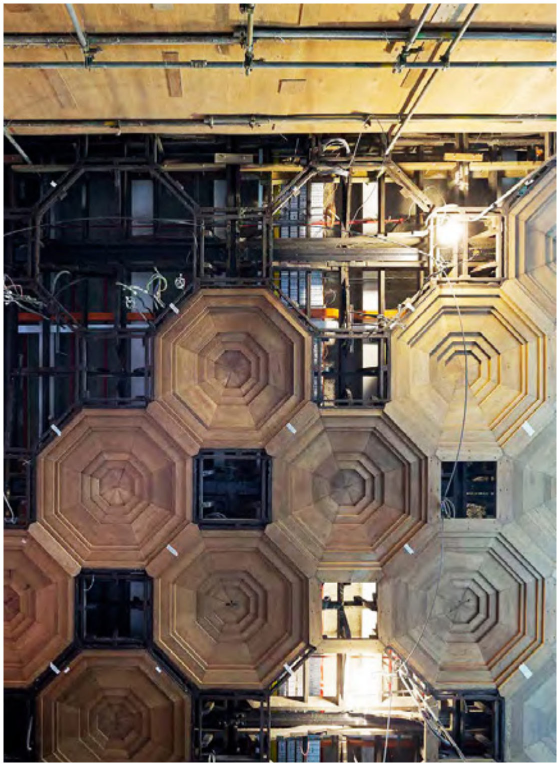
For **new installations**, wiring should be consolidated in trunking and conduits that run **above false ceilings**, **behind interior wall panels**, or that are **sensitively surface-mounted** in close coordination with the interiors. Switches and powerpoints should be similarly coordinated in their surface-mounting locations so as to minimise adverse impact on historic finishes. Distributor boxes should be located at inconspicuous areas.

When, after exhausting other options, and where surface-mounted electrical conduits may not be viable, carefully designed **false walls or pelmets** may be introduced to conceal them.

For **gas services**, piped gas is recommended where possible. Otherwises LPG cylinders should be housed within the property boundary in a recess (for example, within a shophouse rear boundary wall) to comply with fire safety requirements.



Left: *New wall dadoes are introduced as an integral part of a major interior design refurbishment of a historic monument to conceal electrical and other M&E conduits, so as to avoid chasing these into the load-bearing masonry walls.* ***Middle:*** *M&E services are tightly coordinated to allow these to be efficiently packed within a narrow ceiling space.* ***Right:*** *New recessed downlights are carefully integrated within the historic teak ceiling panels at the former Supreme Court (now National Gallery of Singapore), within the smaller square panels. The octagonal feature panels were left intact and restored. New M&E services are designed to run above the panels, with dedicated access panels for servicing.*

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Energy Efficiency Design and the Historic Facade

Refer also to the following regulatory codes and guidelines:

- General Design Code on Environmental Sustainability for Existing Buildings
- Green Mark for Non-Residential Buildings NRB:2015 Technical Guide and Requirements
- BCA Guidelines on Envelope Thermal Transfer Value

When planning an **energy performance upgrade** to a historic building, the existence of historic **passive environmental design features** – such as verandahs, light wells, porches, louvres, awnings, jackroofs and skylights – should be included in **energy audits** and **modelling**. The **heritage impact** of each intervention should be carefully considered, with preference given to minimally invasive treatments that are least likely to damage historic elements and materials. A variety of analytical tools can be employed to carry out a detailed study of the building's energy efficiency performance and potential, before deciding on the appropriate retrofitting works.

ETTV AND HISTORIC FENESTRATION

The thermal performance of a building envelope is assessed based on its **Envelope Thermal Transfer Value (ETTV)**, which measures three basic components of solar heat gain through the external walls and windows of the structure. All air-conditioned buildings – historic properties included – are subject to an upper ETTV limit of 45W/m^2. To achieve this target, it has become commonplace for building owners and designers to replace historic windows and glazing with modern ones that meet the requirement. However, these fixtures are also important character-defining elements of a historic building elevation. Alternative measures to improve energy efficiency should be considered, to **avoid irreversible loss** of historic fabric and heritage character.

Historic French window with louvred shutters and secondary glazed lattice casement windows on the inside behind decorative railings. Interventions on historic fenestrations such as these should be minimised to avoid irreversible loss of heritage character. Modifications, if needed, should be additive, reversible and localised.

New glazing enclosure in heavily tinted solar glass resulted in the loss of legibility of the historic verandah, and adversely altering the heritage presentation of the main facade.

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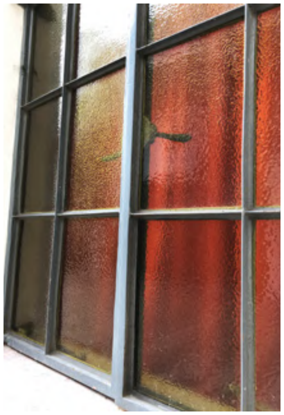
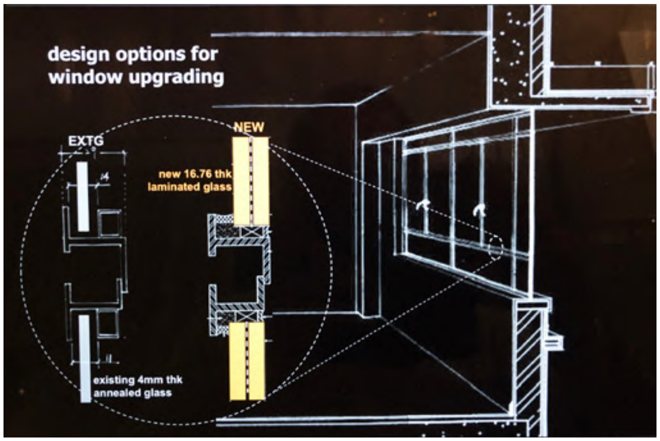
Following are guiding principles for degrees of intervention presented in different scenarios:

- Where historic windows are **highly intact**, complete with original glazing that does not meet ETTV requirements, code-compliant **secondary glazed windows** should be installed internally while retaining the historic external windows.



Right: *Restored mild steel window with historic tinted glazing retained.*
Far right: *Customised timber-framed secondary windows that are compatible with the historic windows, with added acoustic seals for additional sound insulation.*

- Where historic windows are **moderately intact**, with the majority of their original glazing replaced, **new high-performance glazing** may be introduced to replace the originals, in matching dimension, colour and tint. **Localised modifications** of existing window frames may be necessary to accommodate the thicker and heavier glass.



After extensive design studies, the historic mild steel windows of the former Asian Insurance Building were retained, with slight modifications to accommodate new DGU (double-glazed units) that are required for the building's conversion from offices to serviced apartments.

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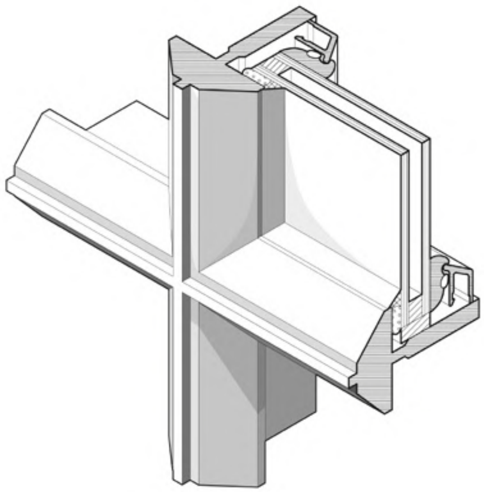
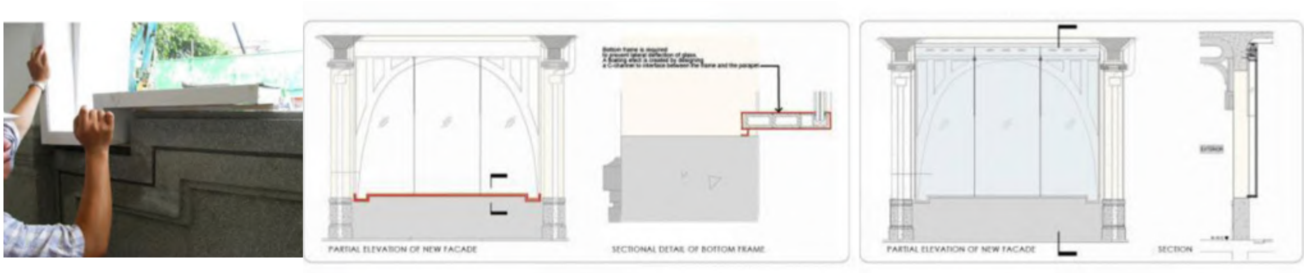
- Where historic windows are deteriorated **beyond repair**, or if these are **no longer intact**, there is an opportunity to design **new reinstatement windows** that match the originals in size, profile, proportion and appearance, with modifications to accommodate high-performance glazing such as Double-Glazed Units (DGU). The tint and texture of the new glazing should match the original glass, to reinstate as much as possible the historic character of the element and the facade.

New mild steel window replica detail based on the historic design, but modified to take in the extra weight and thickness of a DGU.



- Where **new enclosures** are planned for locations where there were none, it is critical to sensitively design the support, framing and glazing, to **minimise impact** on the historic fabric and heritage presentation. The new enclosure design should also take into account **maintenance and access**.



New infill glazing for old Clifford Pier was sensitively introduced, with customised framing support detail that interfaces well with the historic parapet walls. Glass panels were placed behind the arch and designed to be suspended from the top. The panels sit lightly on discreet new frames that cantilever from the parapets.

Cardboard mock ups of the design was tested on site

Left: *The original atrium skylight of Jurong Town Hall is reinstated, along with upper storey windows which were previously sealed up – restoring a core spatial and historic character of the monument.*
Right: *For the reinstatement of these mild steel clerestory windows, to evoke the historic darker green glazing while still allowing sufficient natural daylight to illuminate the deep plan interiors, light green tinted glass was selected.*

OPTIMISING DAYLIGHTING

Minimally invasive strategies to optimise daylighting include:

- Reopening historic fenestration that has been sealed up – this strategy also helps to improve airflow and cross ventilation.
- Retaining features that provide daylight to internal corridors, such as half-glass partitions, glazed doors and top lights
- Retaining verandah spaces that allow natural daylight to enter rooms

On the other hand, where necessary, **new skylights or dormers** on rear or less visible roof elevations may be considered, provided that these are discreetly located and do not negatively impact the building's historic character. Automated controls can be installed on interior artificial lighting systems to ensure adequate indoor illumination while promoting the energy-saving use of daylighting.

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Drainage and Flood Protection

Refer to *Volume 1: Introduction*, Chapter 3, section on Environmental Factors for an overview of other environmental stress factors.

The building envelope acts as a barrier between the interior spaces and occupants and the external surroundings, and bears all the pressures from the environment – climatic elements, ground moisture and movement, excessive vibration, atmospheric and noise pollution, and so on. Historic buildings in particular have been increasingly subjected to these **environmental stress factors** over the past decades following rapid urban growth and renewal and, increasingly, climate change.

ROOF AND RAINWATER DISCHARGE

The best defence against water seepage is to ensure effective and fast water **drainage** off the building envelope. The roof drainage system in a significant number of historic buildings in Singapore usually comprises rainwater gutters and downpipes. In order to function properly, a roof drainage system needs to discharge water at a rate minimally equal to the rate of water accumulation for a given rainfall amount.

Refer also to the relevant guidelines and codes in *NEA Code of Practice on Environmental Health*

In Singapore, traditional **roof gutters and rainwater downpipes** are being phased out under National Environment Agency (NEA) guidelines to prevent mosquito breeding. For historic property owners who wish to retain the roof gutters and downpipes, a waiver is required to be submitted for approval. This has led to a general trend of **freefall rainwater discharge** directly from the roof eaves following the removal of gutters, which require alternative design solutions to ensure effective conveyance and drainage of rainwater, and also to avoid excessive splashback onto adjacent historic facades and surfaces.

Left: *Restored rainwater chain and receptacle at the former Trinity Theological College Chapel, a character-defining element.*
Far left: *Historic cast iron rainwater downpipe that is retained and continues to serve its original function.*

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There are a number of deciding factors that relate to the success or failure of the roof drainage system. These include:

- **Climate change:** Much heavier rainfall is expected today as compared to the past, due to climate change over time. The original design of the existing gutter and rainwater downpipe system is likely unable to accommodate the much higher rainfall intensity.
- **Improper design modifications:** Attempts to modify the existing roof drainage system of a historic building without the proper design and calculation of its hydraulic performance may also contribute to water overflowing issues.
- **Maintenance:** The lack of regular maintenance could further cause or aggravate the blockage problem of the gutter and downpipe system, due to accumulation of dried leaves and environmental dirt at the opening of water outlets. This may result in standing water along the gutter, inefficient water drainage and backflow issues.
- **Material deterioration:** It is important to ensure the upkeep of the drainage system. In most cases, downpipe and gutter systems in historic buildings are made of metallic material, such as cast iron, steel or copper. Any prolonged corrosion left without repair may lead to sectional loss of the material, holes being formed, compromised connections, eventually resulting in water leakage.

As a result of the above, backflow of rainwater into the building interior will lead to a great extent of moisture-related damage and deterioration of historic elements.

Plant growth on roofs and rainwater goods is an indication of compromised drainage, usually resulting from trapped environmental dirt/contaminants and water stagnation. This can be avoided through regular, appropriate maintenance.

Prolonged poor drainage may lead to water leakage from the roof causing brownish water stain marks and deterioration of the eave soffit, ceiling board and paint.

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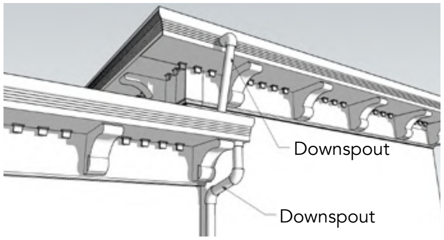
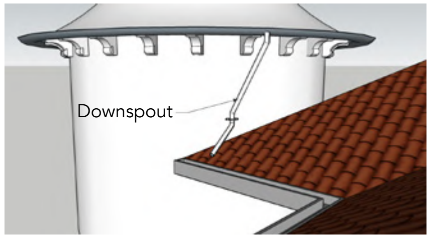
Recommendations

For the upkeep of the roof drainage system to ensure its full efficiency, there are a number of recommended approaches to be taken.

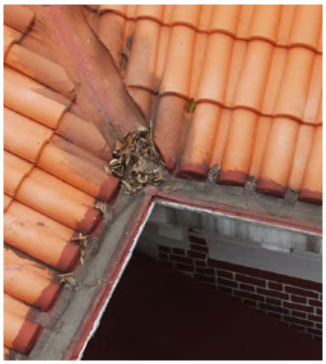
1. **Periodic inspection**
   Visual inspection should be carried out on a periodic basis. This should be conducted at an elevated height to allow a clearer view and understanding of the roof drainage system and its condition. This can be carried out by erecting access equipment, or by using an unmanned aerial vehicle (drone).





Modeling of roof drainage system of a historic house with complex roof form, following inspection. Latter-day modifications without due consideration for drainage capacity allowed rainwater from the upper roof gutters to discharge via downspouts into lower roof gutters, instead of discharging directly to ground level drains. This led to overflow and backflow in the lower gutters, and water ingress to the building interior.

2. **Periodic cleaning and maintenance**
   It is recommended for regular maintenance work scope to include removal of debris and foreign/obstructing objects and thorough cleaning of the roof drainage system. If damage or deterioration of rainwater goods is observed during the inspection, repairs should also be carried out. For iron-based elements, it may be necessary to reapply anti-corrosion protective coating.

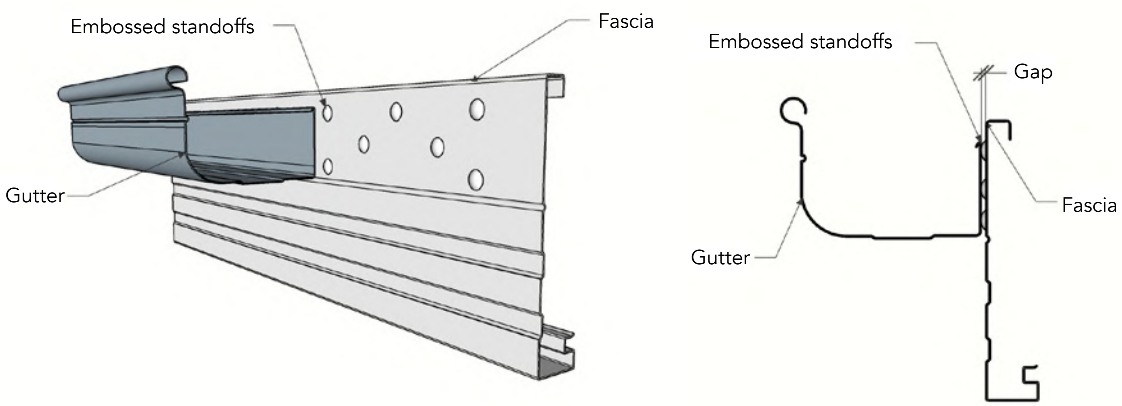


Particularly for low rise buildings in the vicinity of tall trees, the maintenance regime should include clearing of plant growth and debris that may accumulate on roofs and rainwater goods, causing chokage.

3. **Design enhancement**
   Following an inspection and evaluation, if a building water drainage system is assessed to be ineffective or inefficient, it should be enhanced or redesigned to meet the required performance.

   In order to cope with the trend of increasing incidents of torrential rainfall caused by climate change, the following methods to enhance the drainage capacity of an existing roof drainage system could be considered:

   a. Introduce additional siphonic action in downpipes
   b. Make adjustment for the appropriate depth of freeboard (height between expected water level and top edge of gutter)
   c. Integrate additional overflow configuration/design into the existing drainage system
   d. Modify or improve the hopper's design for high velocity of water discharge
   e. Increase the number of downpipes or enlarge the size of gutter without creating significant visual impact on the architectural character of the building



An example of 'continuous overflow' option, which can be integrated into the existing system by installing embossed standoffs along the fascia to create a gap between gutter and fascia. This allows excessive water to drain off instead of penetrating into the building by backflow.

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Eroded projecting ledge resulting in water ponding and staining of the facade. If left untreated, there will be increased risk of rainwater seepage into the interior.

ENHANCING FACADE WATER SHEDDING CAPABILITY

As buildings age, weathering and wear and tear may result in the decreasing performance of their **facade water shedding capability**. The typical **historic features** affected may include projecting roof eaves, wall copings, cornices, string courses, windowsills and so on. Weathering erosion of these critical elements can result in the **loss of incline gradient**, or even **concavity** that could result in water ponding, facade staining, algae growth, and even water backflow into the interiors through vulnerable interfaces.

During regular maintenance inspections of historic buildings, it is important to ascertain if there are any areas where facade water shedding is no longer adequate, so as to plan for **rectification or enhancement works** in the next cycle of maintenance repairs or conservation work. Sometimes it may be necessary to reinstate or even enhance the gradient of projecting cornices, copings and seals if water ponding on these areas is assessed to carry significant risks of seepage into the building exterior, or has resulted in heavy biological growth and persistent facade staining.

Left: *Historic architectural elements such as projecting ledges, cornices, string courses and windowsills are part of a sophisticated facade water shedding system, facilitating rapid rainwater runoff as well as helping to prevent dirt staining due to ponding water.* ***Right:*** *Stainless steel flashing installed as enhancement detail on the projecting cornices and copings of a historic facade.*

LIGHTNING PROTECTION

Given Singapore's reputation as a 'lightning capital' with one of the highest rates of lightning activity in the world, the country also has stringent lightning protection requirements for buildings. **Lightning protection tapes**, installed along roofs and facades, can be visually detractive if their **placement** is not sensitively planned to avoid key features. In recent years, for safety reasons, down lightning tape needs to be encased (if surface-mounted) or embedded in facade finishes from ground level to 1.5m height. Where this is unfeasible due to the presence of significant architectural finishes such as natural stone, fairfaced brickwork or Shanghai plaster, **alternative solutions** need to be devised. One possible way is to conceal the down lightning tape within decommissioned cast iron rainwater downpipes that are retained for heritage presentation (alongside a new separate rainwater discharge system).

Lightning tape running across facade rustication disrupts its legibility – more inconspicuous locations, such as at the side walls, should be explored.

Right top: ***Copper lightning tape is used to better complement the copper shed dormer roof, and the aquamarine blue glaze and profile of the pantile roof tiles.***
Right: ***Down lightning tape should be avoided on high key facade finishes such as fairfaced brick tile and granite. These may be concealed within interior structural elements and clad over.***
Far right: ***Surface-mounted lightning tape on fairfaced brick facade, concealed behind retained rainwater downpipe.***

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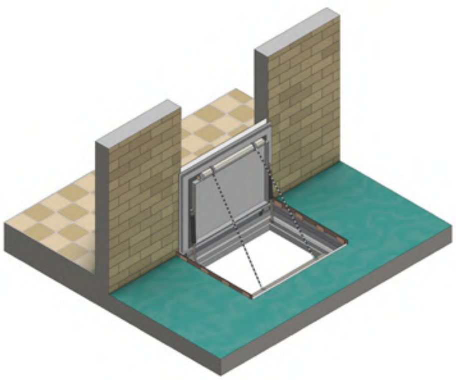
Refer to Code of Practice on Surface Water Drainage

FLOOD PROTECTION AND MITIGATION

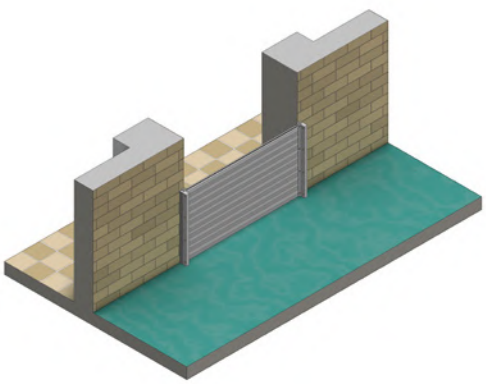
Rising sea levels is a global phenomenon that has affected how cities are being planned and renewed, and how new buildings are being designed. Being a densely built up and compact city-state, Singapore is not spared from the need to **floodproof** its built environment by **prevention**, **protection** and **mitigation** measures. Minimum Platform Level (MPL) is imposed on all new developments by the Public Utilities Board (PUB) in its Code of Practice for Surface Water Drainage (2011), which dictates the required minimum ground level – depending on type of building and geographical location – that should rise above the highest recorded flood level.

Conserved buildings, on the other hand, are exempt from such requirements due to the technical unfeasibility of raising the MPL of historic sites. Floodproofing a historic building should be done via **upgrading existing drainage systems**, complemented by **landscaping measures** such as bioswales. Other flood mitigating measures with minimal visual impact to the buildings may be introduced, such as the following:

- Automatic floodgates
- Manual swing or stackable flood barriers
- Transparent screens behind openings



Manual Swing Floodgate (activated mode)



Manual Stacking Floodgate (activated mode)

Existing site topography and vegetation can also contribute to the **sustainable floodproofing** of a historic building. New landscaping features such as bioswales and retention tanks, if compatible, can be introduced to enhance **storm-water management** and **on-site water reuse**. For developments with **varying platform levels**, for example where new structures complying to MPL are built alongside heritage buildings, there is a need to mitigate the level differences. This require careful study, sensitive design and integration in landscaping and hardscape design to achieve the flood protection objectives without compromising the heritage presentation of a historic site, and even enhance the visitor experience.

Above: *Due to higher incidents of torrential rainfall trend, there is a need to provide wider and deeper perimeter drains, that should form part of the development's hardscape design.*
Right top and right: *The different platform levels from the Singapore River edge to the Asian Civilisations Museum are skilfully integrated in the landscaping and public space design.*

2 SHOPHOUSES AND TOWNHOUSES

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Historic Character and Attributes

Refer to Volume 1: Introduction, Chapter 1 Understanding Your Building's Significance, section on 'Historic Building Types', part on 'Shophouse/ Townhouse' for more information on the possible origins of these historic built forms.

Terraced row building forms make up the majority of the 7,000-plus conserved buildings in Singapore, one of Southeast Asia's ***'shophouse cities'***. In historic settlements such as Kampong Glam and Kreta Ayer, entire city blocks are made up of these single-bay, long and narrow shophouses/townhouses.

USE AND MORPHOLOGY

Historically the **shophouse** was intended for commercial or light industrial uses on the ground floor with living spaces above, whereas the **townhouse** was purely residential. On the exterior a key difference lies in the ground floor facade. A typical shophouse frontage would have a large entrance opening spanning the building width, while the townhouse would assume a domestic window-door-window configuration. As ownership, tenancy and uses changed through the years, frontages were also modified accordingly.

From left: *A shophouse with a large shopfront opening; a townhouse with a common five-foot way; a townhouse with a private forecourt.*

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Other historic terraced building types may also be found alongside shophouses/townhouses, from which they are often not easily distinguishable by facade design. Examples include **warehouses, clan houses, temples, hotels, houses, schools** and so on. Internally the space may span across bays even though the facade may assume the appearance of a few adjacent shophouses.

Most of these historic urban terraced building types are connected by the characteristic **five-foot way**, while more exclusive townhouses come with private forecourts.

Like their counterparts in the region, shophouses/townhouses have evolved since the 19th century, from simple two-storey brick-and-timber structures to three-storey affairs featuring elaborate facades, and – from the 1920s onwards – modern designs in reinforced concrete.

Above: *The historic Goh Loo Club spanning three bays of a row of terraced town houses.*
Left top: *Cundhi Gong temple along Keong Saik Road, with attached caretakers' quarters to the left; it looks similar to a regular shophouse.*
Left: *Kwong Wai Siew Li Si She Shut, a clan house on Ann Siang Hill flanked by townhouses.*

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Right: Shophouse roofscape showing party walls demarcating long, narrow plans, punctuated by air/light wells.
Far right: An early aerial view of the Kreta Ayer historic settlement showing rows of terraced shophouses.

CONFIGURATION AND CONSTRUCTION

The building form itself remained largely similar, shaped by commercial interests, construction practices, the colonial regulatory milieu, and the tropical environment. Common features include:

- **Low-rise high-density urban forms** of two to four storeys high
- **Five-foot ways,** stipulated since the 19th century to create a city-wide network of sheltered public walkways
- **Backlanes**, introduced in the interwar years by colonial planners to facilitate night soil collection and improve public hygiene
- **Long and narrow plan** to maximise the number of units with street frontage. A typical plan spans a single structural bay, and is four to six metres wide and at least two to three times as deep
- **Courtyards or air/light wells** that punctuate the deep plan to introduce ventilation and natural daylight
- **Steep double-pitched roofs** that allow for effective drainage in a tropical rainstorm, typically finished in red V-shape unglazed clay tiles
- **Party walls** between units that rise above the roof finishing level and serve as firestops
- **Fire escape spiral staircase** in metal or precast RC at the back facade
- **Typical construction systems of**
    - **Load-bearing masonry party walls** supporting **timber floor/ staircase and roof systems,** with **timber/plasterboard partitions and false ceilings**
    - (From 1910s onwards) **RC frame and masonry infill** structure with RC or timber floor/staircase, and steel or timber roof systems

Refer to Volume 4: Structures, for more information on historic structural and construction systems, defects diagnosis and restoration methods.

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Refer to Volume 3: Facades, for the historical background, diagnostic and restoration approaches of the various facade finishes.
Refer also to Volume 5: Doors and Windows, for the historical background, diagnostic and restoration approaches of the various fenestration types.

CHARACTER-DEFINING ELEMENTS

Collectively they form **an imageable and variegated streetscape of intimate scale** that characterises Singapore's historic urban fabric. The **facades** are decorated variously in

- Stuccowork
- Ornamental glazed tiles
- Mural artwork
- Chinese shardwork reliefs
- Shanghai plaster
- Fairfaced brick and granite
- Mosaic
- Precast elements such as fins, and so on

Right top: *Shophouses and townhouses give much character to Singapore's historic urban streetscape.* ***Right, far right:*** *Modern reinforced concrete shophouses with characteristic geometric design and precast fins.*

Left top: *Carved timber windows, fascia and ventilated soffit.*
Left: *Ornate carved timber pintu pagar of a townhouse previously owned by a Straits Chinese family.*
Above: *Fairfaced brick with geometric pattern, precast fins and mild steel windows with green glazing.*

Facade **fenestration** of various colours and shapes provides visual rhythm and character to the shophouse streetscape. Common types include:

- **Timber casement or French windows** on the upper floors, with balustrade, vents and top lights, adorned with carved mouldings and reliefs. Window leaves are often integrated with operable louvres for climate control.
- Modern shophouses may be fitted with imported **mild steel windows.**
- At the ground level, a townhouse entrance may have an added **pintu pagar** or salon door for privacy, and **security grilles** at the windows, while shopfronts may be secured with **dismountable planks,** collapsible **accordion gates** or **sliding-folding metal gates.**

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General Notes on Alterations/Adaptive Reuse

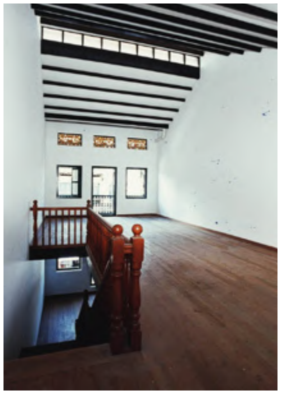
Refer to Chapter 1: Introduction in this volume, for key principles of carrying out conservation design integration for new uses, code compliance, services and so on.

Best practices in conservation adaptive reuse design are underpinned by a thorough understanding of the building's historic character, sensitive and customised response to its heritage attributes, and enlightened design thinking that interprets limitations as opportunities.

Below are some of the common design challenges arising from changes in use and requirements. These should be negotiated with utmost care and consideration to achieve the optimal balance between conservation intent and new requirements – 'to do as much as necessary and as little as possible'.

CHANGES IN USE AND REQUIREMENTS

Shophouses are essentially commercial, even speculative, developments, and **changes in use** have been occurring organically even prior to them being gazetted for conservation. The **accelerated gentrification** of historic shophouse districts began in the 1980s-90s, with many original functions impacted and rendered obsolete by the mass resettlement of the city centre population to suburban New Towns. Numerous shophouses and townhouses have since been converted to purely commercial use; in many cases multiple units, entire rows or city blocks have been amalgamated and remodelled as hotels, offices and malls. Some **traditional functions**, including clan houses, coffee shops, warehousing, light industrial workshops, as well as the upper storey residential component of shophouses, were also gradually phased out.



Right: *Upper storey interior of a restored shophouse, adapted for office use.*
Far right: *Reroofing works underway for The Sultan, an amalgamation of multiple units remodelled as a boutique hotel.*

Right: *Restored carved timber windows with new aluminium secondary windows behind.*
Far right: *Historic spiral fire escape staircases should be retained and restored as significant character-defining elements of shophouses and heritage streetscape. M&E equipment located on new flat roof at the back, can be neatly concealed with screen.*

Structural loading requirements are also higher for uses of a more public nature such as hotels and museums – and may necessitate structural strengthening, relative to private commercial uses like offices and restaurants.

Refer to Volume 4: Structures, for more information on historic building structures and principles of conservation structural interventions.

Common uses today such as offices, hospitality, retail, services and F&B are in fact not new to shophouses/townhouses. However radical shifts in **planning policies, building regulations, building technology, design conventions, maintenance practices, market demand, environmental comfort standards and aesthetic preference** in the past few decades have resulted in significant modifications to the historic building fabric when new owners or tenants carry out renovation works. Building and programmatic requirements with significant impact on the historic fabric include:

- **Mechanical and electrical services** such as air conditioning and plumbing
- **Fire safety regulations** such as escape routes, fireproofing, fire-compartmentalisation, sprinkler systems
- **Building safety regulations**, including structural loading, railing or parapet heights, staircase design
- **Environmental comfort requirements** such as noise level, indoor temperature and humidity, lighting
- **Universal design** for barrier-free access, ramps, lifts
- **Energy efficiency** requirements such as low-emissivity glass, airtightness of fenestrations

Following are case studies of shophouse/townhouse adaptive reuse projects that exemplify how sensitive and skilful conservation design can significantly mitigate the heritage impact of adaptive reuse changes.

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Refer to jury citations for URA 2019 Architectural Heritage Award, 105 Onan Road, for more information on the adaptive reuse project.

Case Study: 105 Onan Road

Location: Joo Chiat Conservation Area, Secondary Settlement

Project: Single unit conserved townhouse with historic residential use preserved; additions and alterations with new rear extension

Year: 2011

This case study looks at the conservation design and interventions carried out on a prewar townhouse and intermediate terraced unit within the Joo Chiat Conservation Area. It features a typical masonry and timber construction, with brickwork party walls, timber floor board-and-joists system, and timber roof structure with unglazed terracotta V-shaped tile finish. The house is reconfigured as a **single household residence,** with additions and alterations to meet new functional requirements.

Left: *1980s view of a similar Onan Road townhouse.*
Right: *Onan Road terraced townhouse, restored as contemporary residence.*

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CONSERVATION APPROACH

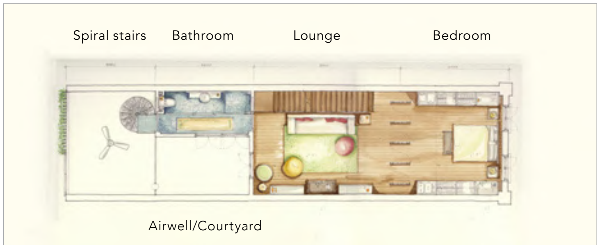
When the current owners took over, the historic townhouse was subdivided into multiple rooms as a dormitory, with the original backyard roofed over and converted into a kitchen. The historic timber floor joists, still intact, were completely obscured by false ceilings.

The owners and architect undertook to recover the **heritage materiality and spatial character** of the house, and to showcase the restored elements by adopting a **'light touch' conservation design** approach.

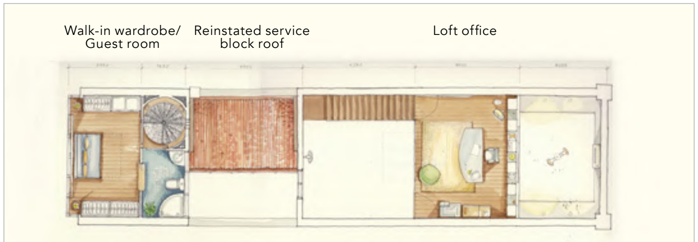
Though not mandated, the historic backyard and service wing were reinstated, while the original timber floor and roof structures were retained and restored.

New additions such as the **mezzanine attic study** and **rear extension block** are designed as discreet insertions with **minimal impact and loading on the historic building fabric**.

FIRST STOREY PLAN



SECOND STOREY PLAN



THIRD STOREY PLAN

ROOF PLAN

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Refer to Chapter 1: Introduction in this volume for key principles of carrying out conservation design integration for new uses, code compliance, services and so on.

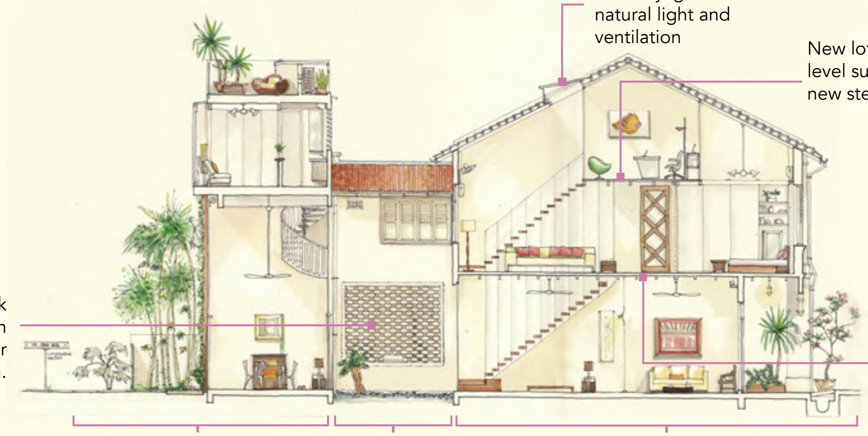
DESIGN AND INTEGRATION

While there is no change of use from the historic residential function, contemporary requirements to be catered to include modern sanitation, electrical wiring and air conditioning, with the attendant piping, ducting, and other M&E equipment to be accommodated.

Key strategies for services integration exemplified in the project include:

- **Locating more heavily serviced function areas out of the main house**
- **Reducing ACMV loading and equipment**
- **Discreet or concealed routing design**

LONGITUDINAL SECTION



Services could be integrated during the reconstruction ***(above)*** *of the service wing, and concealed above false ceilings* ***(top)****.*

New extension and rebuilt service wing

To minimise M&E intrusion in the historic main house, functions requiring more services are confined to the new extension and the reconstructed service wing.

Rather than going for the maximum allowable five-storey rear extension, the owners opted for a restrained three-storey block. The **extension block** is set back from the main house, with the kitchen and landscaped courtyard in between, and designed to be no higher than the historic roof ridge.

As the owners wanted a larger living area in the main house, a **new double-volume dining hall** was catered for in the new extension. An **en suite guest room** occupies the upper storey, with a **roof terrace** above for enjoying views of the green surrounds and neighbourhood.

A connecting wing that serves both the main house and the new extension, the **reconstructed service block** houses the **kitchen** on the first storey and **master bathroom** above. Although the original masonry structure was rebuilt in RC to enable a larger ground floor opening, this allowed for consolidation and discreet integration of new services. The relocated distribution board, main air-con ducting, sewer and drainage piping could be laid and concealed during its reconstruction. In mitigation, the old timber windows and roof tiles were salvaged and reinstated on the rebuilt service wing.

Right: *View from living area towards courtyard, kitchen in the service wing, and the extension dining hall beyond.* ***Far right:*** *View from the kitchen towards the double-volume dining hall.*



Above left: *Originally exposed timber floor concealed at the five-foot way.*
Above right: *Restoring timber joists found intact above false ceilings.*


Left: *Historic timber roof purlins being restored in situ as interior features.* ***Middle:*** *A new lightweight steel frame of beams, joists and slender columns extending to the first storey being installed for the new attic.* ***Right:*** *Completed new attic deck and restored historic timber purlins, exposed by installing roof insulation and ceiling board between members.*

New attic structure

Capitalising on the lofty roof space of the main house, a new **mezzanine deck** is introduced on the second storey, creating a study that overlooks the lounge and master bedroom. Four slender mild steel columns extending to the first storey are installed to take the main load of the new timber deck. These are complemented by a pair of steel beams attached on both sides to the party walls. Steel attic joists are interspersed with timber ones and along with the steel columns and beams form a **lightweight structural frame insertion** designed to minimise impact on the historic building fabric.

The new beams also provide avenues for M&E routing, while the steel columns and joists serve as door frames for the series of master bedroom pivoting doors that span between the party walls.

Interiors

Rather than expediently replacing the old timber structures to 'play safe', the structural engineer opted to have the historic timber floorboards, joists and roof purlins carefully inspected, retained and restored. The M&E provision had to be then carefully devised to avoid visual clutter and minimise impact on the heritage presentation of these restored elements.

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The number of air-conditioning fan coil units was reduced, along with the amount of trunking needed, by providing **options for mechanical and natural ventilation,** such as the use of **fans** and the introduction of an **openable skylight** at the rear of the main roof.

Services are discreetly routed along the new steel beams on the second storey, as well as concealed within slim box beams tucked under the timber floor joists and hugging the party wall at the first storey. Instead of concealing the entire extent of the roof underside, a false ceiling is added between roof purlins, which, like the floor joists, are revealed as an interior heritage feature.

Sensitive planning, streamlining and confining M&E provision to less visible areas allow for optimal presentation of the carefully restored historic interiors.

Left: *View of living area showing restored historic joists as interior features, and the discreet new steel columns. Services are routed via discreet box beams to minimise visual clutter.*
Right: *View of second storey lounge area and master bedroom lit by natural daylight from the new skylight. The interior heritage character of the townhouse can be fully appreciated with the restored timber floor and purlins.*

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Refer to jury citations for *URA 2012 Architectural Heritage Award, 101 Jalan Sultan,* for more information on the adaptive reuse project.

Case Study: 101 Jalan Sultan

Location: Kampong Glam Historic District

Project: Amalgamation of nine terraced townhouses and a former publishing house (all conserved) and adaptive reuse as a boutique hotel development

Year: 2011

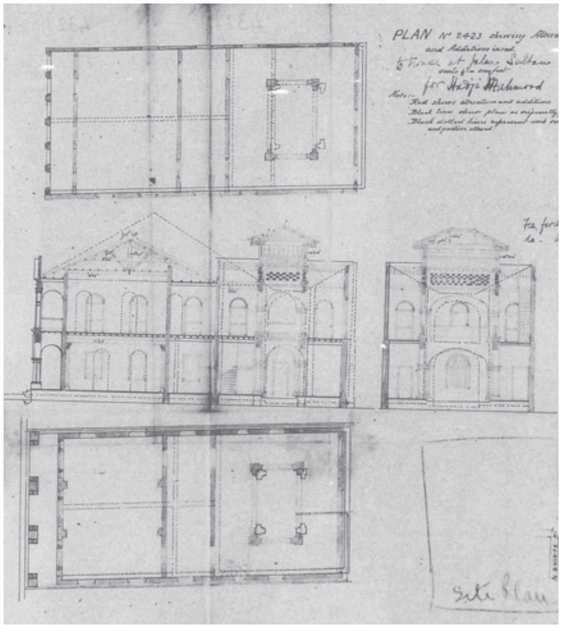
The site occupies an entire city block in Kampong Glam, comprising two back-to-back rows of nine townhouses/shophouses and a former residence turned publishing/press house. Units 54, 56, 58, 60, 62, 64 of the Aliwal Street wing and 105, 107, 109 of the Jalan Sultan wing date from the late 19th to early 20th century. 101 Jalan Sultan, erected in the 1900s possibly as a purpose-built press house, features a highly ornamented facade designed to look like three bays of townhouses, replete with a five-foot way.

Left: *1970 photo of 101 Jalan Sultan when it housed the Al-Ahmadiah Press.*
Right: *The Sultan - adaptive reuse of nine townhouses/shophouses and the press house into a boutique hotel.*

CONSERVATION APPROACH

Although the 10 units were combined into a single development, new functions are sensitively planned and tailored to best fit the **historic building configuration and spatial character.** The reception lobby and F&B amenities are accommodated at the **former publishing house,** capitalising on its spacious halls. Meanwhile, the **shophouses** are capitalised on for their scale, dimension, narrow plans and party walls, well suited for subdivision into guest rooms. Original **alleyways** serve as public circulation that also segregates the more public functions of the publishing house-lobby from the quiet domain of the shophouse-guest rooms.

New functions are organised to fit the segmented plan of unit 101, where a generous stair hall separates the front and back halls, now used respectively as lobby and restaurant. As such, the historic spatial organisation remains discernible to a current-day visitor entering the lobby, further signposted by restored features such as ornamented columns and arches.



Left: *Archival drawing showing historic segmented plan of the 1900s triple-bay unit at 101 Jalan Sultan.*
Right: *Programmatic usage allocation to match historic spatial attributes.*

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Refer to *Chapter 1 Introduction,* for key principles in carrying out conservation design integration for new uses, code compliance, services, and so on.

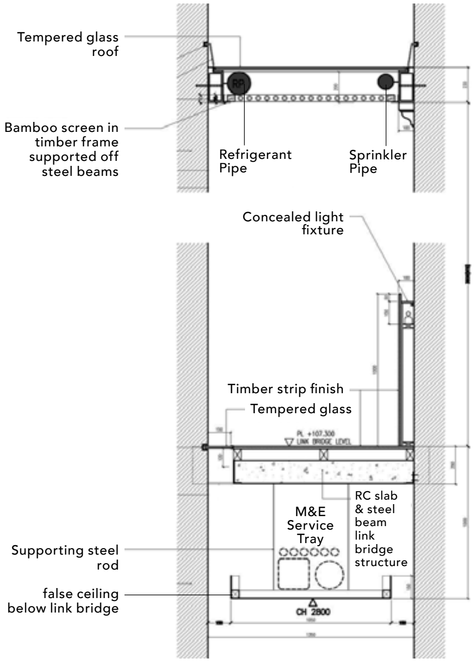
DESIGN AND INTEGRATION

The conversion to new hotel use required the integration of substantial building services systems and compliance to modern building codes that historic shophouses were not designed for. These include air-conditioning, ventilation, universal access, lifts and fire safety provisions, with their attendant sizeable equipment and spatial requirements.

At The Sultan, new design interventions are strategized with care and sensitivity to synchronise services integration and code compliance with design requirements.

Key integration strategies exemplified in the project include:

- **Reducing air conditioning and mechanical ventilation (ACMV) loading by having a hybrid system with naturally ventilated spaces**
- **Streamlining M&E design to minimise trunking and equipment** to be housed
- **Diverting the routing and placement** away from key historic spaces
- **Discreet or concealed routing and inlet/outlet design** to minimise visual impact and avoid obstructing heritage presentation of key historic elements



Right: *The covered link bridge is designed to be visually light and set back from the facade, so that the side alley is still perceivable.* ***Far right:*** *Section of new covered link bridge showing design integration of services: refrigerant and sprinkler pipes run between the bamboo ceiling and glass roof, while the M&E service tray is accommodated below the slab.*

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New courtyards, jackroofs and skylights
Services provisions were closely studied and streamlined, while new features and detailing were devised for sensitive design integration.

Common circulation areas are designed to be **naturally ventilated** to recall shophouse interiors of the past. This significantly lessens the ACMV load and reduces heritage impact by minimising the amount of equipment and trunking needed. While the open backyards are roofed over and enclosed, four new landscaped **courtyards** have been created across the development serving as light and air wells punctuating the common circulation spaces. This introduces air movement and diffused daylight for environmental comfort.

Exhaust ducting is decentralised such that foul air is channelled through a few outlets, via the second storey and new jackroofs, rather than a singular location that would have required a sizeable duct running through the historic interiors.

Air movement through the hotel is facilitated by the new courtyards and natural ventilation.

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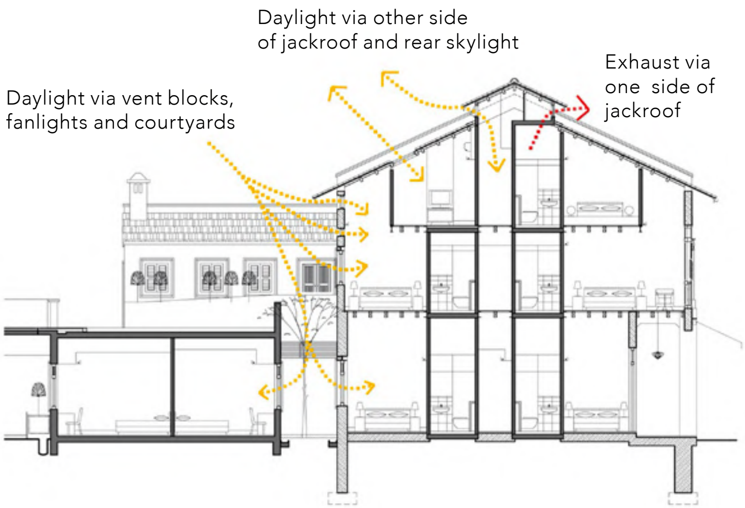
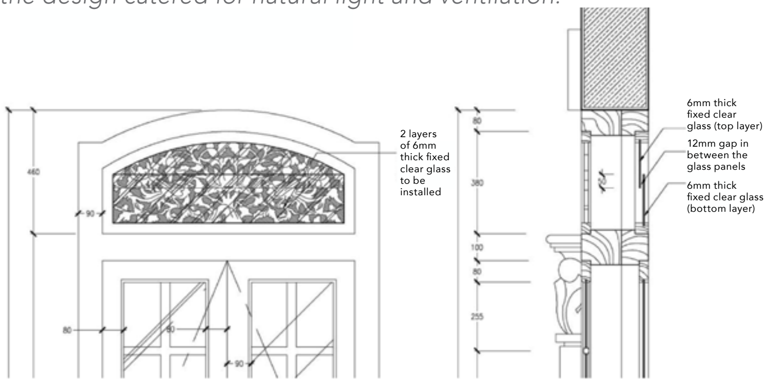
Jackroofs and **skylights** are introduced as useful design devices that are also in keeping with the historic architectural vocabulary of townhouses/ shophouses. The new jackroof and skylight added to each unit serve to channel natural daylight into the deep plan and double-up as ventilation inlets/outlets.

Fresh air ducting for guest rooms is completely omitted by introducing a **special detail** to the window top vents. The glass screen, installed behind the ornamental top vents to enable efficient air-conditioning, is composed of two overlapping panes with a gap in between that allows fresh air intake.

New jackroofs are introduced, in keeping with the architectural vocabulary of townhouses/ shophouses.



Section across a typical unit for guest rooms, illustrating how the design catered for natural light and ventilation.



Window glass panels with modified details to introduce fresh air - this allows for omission of fresh air ducts, and more ceiling height.

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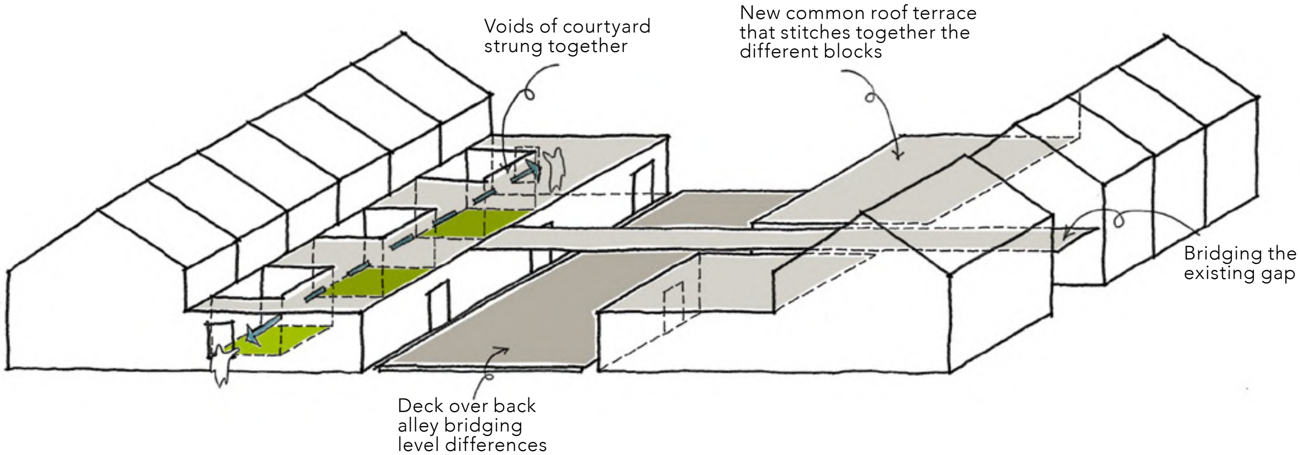
Discreet placement of M&E equipment on the roof terraces.

New roof terraces and link bridges

A common design strategy for developments amalgamating multiple townhouses/shophouses is the introduction of **a second storey flat roof** over the backyards of all units. This creates more covered area on the ground floor, a usable terrace, and design opportunities to accommodate M&E and regulatory provisions.

New roof terraces are built over the back of both the Jalan Sultan and Aliwal Street wings, to increase usable area on the ground floor for guest rooms. This extends over the gap between unit 101 and the Jalan Sultan wing to become a **link bridge** connecting the two, sheltered with a trellised roof overhead. Special permission was further sought to install another **link bridge** spanning across the public back lane, to connect the two wings. Designed as a landscaped timber deck overlooking the quiet back lane, the terraces serve as a **dining patio, private lounging area** for guests, **circulation linkage** and **universal access** across the second storey of the entire development, in addition to integration of other utilitarian requirements.

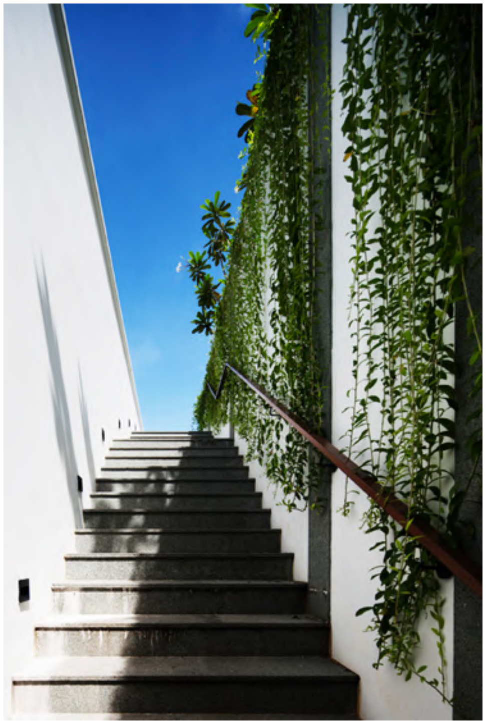
M&E equipment serving the Aliwal Street wing is confined to both ends of the terrace, while that for the Jalan Sultan wing is located on the third level flat roof of unit 101 – all shielded from view by discreet timber screens or parapets.



Schematic sketch of new roof terraces and link bridge

Fire safety provisions, including sprinkler systems and escape route planning, present some of the most challenging aspects of design integration for historic buildings. At The Sultan, the sprinkler networks servicing unit 101 and the two wings could be connected via the roof terraces and link bridge into a single system, with only one set of tank and pumps to be accommodated. A new basement was excavated at one of the corner units to house this equipment, so it would not take up prime interior space.

Fire escape staircases are a regulatory requirement that often cause adverse heritage impact especially if they are located indoors, due to the need for enclosures to achieve **fire compartmentalisation.** To reduce such impact, two fire escape staircases serving unit 101 and the Jalan Sultan wing have been diverted to the exterior, accessed via the new roof terrace. The open-air stairways along the back boundary wall serve as landscaped vertical connections from street level to the terrace, as well as fire escape routes discharging into the back lane.



Above: *New roof terraces connect the two wings while serving as a dining patio and open-air lounge.*
Right: *Open-air fire escape stairs leading from the roof terrace to the back lane*

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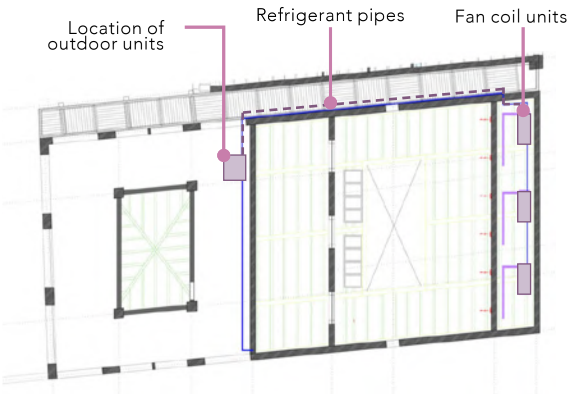
Interiors
The design approach for the interiors took into consideration **heritage presentation**, ensuring that the buildings' historic internal features and spatial character would remain discernible to their new users. This included retaining the **high-volume spaces** and **exposed upper storey timber floor joists** for ceiling design as much as possible.

Design parameters are put in place to ensure that as far as possible, **services are confined to the margins and less visible areas, or integrated within new design features.** For example, the new roof terraces and link bridges provide cover to discreetly run services on the side and back elevations, **minimising intrusion within** the historic buildings. At the second storey dining hall of unit 101, air-con equipment is kept on the exterior: fan coil units are concealed within the verandah ceiling space in front, and outdoor units are parked behind flat roof parapets at the back, with refrigerant pipes running along the gable wall, housed together with sprinkler pipes within the link bridge shelter structure. **Air-con outlet penetrations** are carefully located to avoid ornamental plasterwork such as cornices, and synchronised with existing French windows.



Left and middle: *Second storey dining hall with air-con units, service pipes and trunking decanted outside. Outlet penetrations are discreet and carefully coordinated with the interior historic elements.* ***Right:*** *Verandah outside the dining hall, with a false ceiling concealing the FCUs.*

At the main lobby, where the air-con equipment and trunking could not be completely kept outside, the **drop ceiling** created to accommodate them is **confined** to one end of the space. Where necessary, **discreet box beams** and **false ceilings between joists** are selectively introduced to conceal sprinkler pipes, conduits and light fittings.

Communal decks and pocket park *(accessibility and safety)*
The landscape and urban design is conceived as a strategy to reconcile discrete urban blocks, soften the urban interface between the site and its neighbourhood, and facilitate **barrier-free access.**

A special application was made to secure permission for the hotel management to undertake design improvement and maintenance for two public areas - the **back lane** between the two wings, and the open drain along the **front of the Aliwal Street wing**.

Main lobby with exposed timber ceiling joists. Drop ceiling is kept to one end, with false ceiling selectively installed between joists where needed to accommodate services and lighting.

Special permission was sought to cover the back lane with timber deck to enable universal access.

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Timber deck and planters were introduced along the front of the Aliwal Street wing.

Prior condition of street interface with uncovered drain and uneven pavement levels.

Removable timber decks are laid over the open drains along Aliwal Street, interspersed with planter seats, for a safer and more welcoming street frontage. Timber decks are also laid across the back lane matching the floor level within the hotel compound, and ramped at both ends for barrier-free access to and from the main streets.

Installed with planters and trellises, these areas became an extension of the landscaped roof terraces and courtyards into the public realm. The **'borrowed spaces'** provide an uninterrupted spatial experience for the hotel guests, and in return the hotel spruces up and maintains them as a **neighbourhood pocket green.**

3 BUNGALOWS

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Historic Character and Attributes

Refer to Volume 1: Introduction, Chapter 1, section on 'Historic Building Types', part on 'Bungalow' for more information on the possible origins of this historic built form, and key variants.

Bungalows were built since Singapore's early colonial period to house the **privileged** such as plantation owners, managers, professionals, the merchant class, and senior colonial government or military officers.

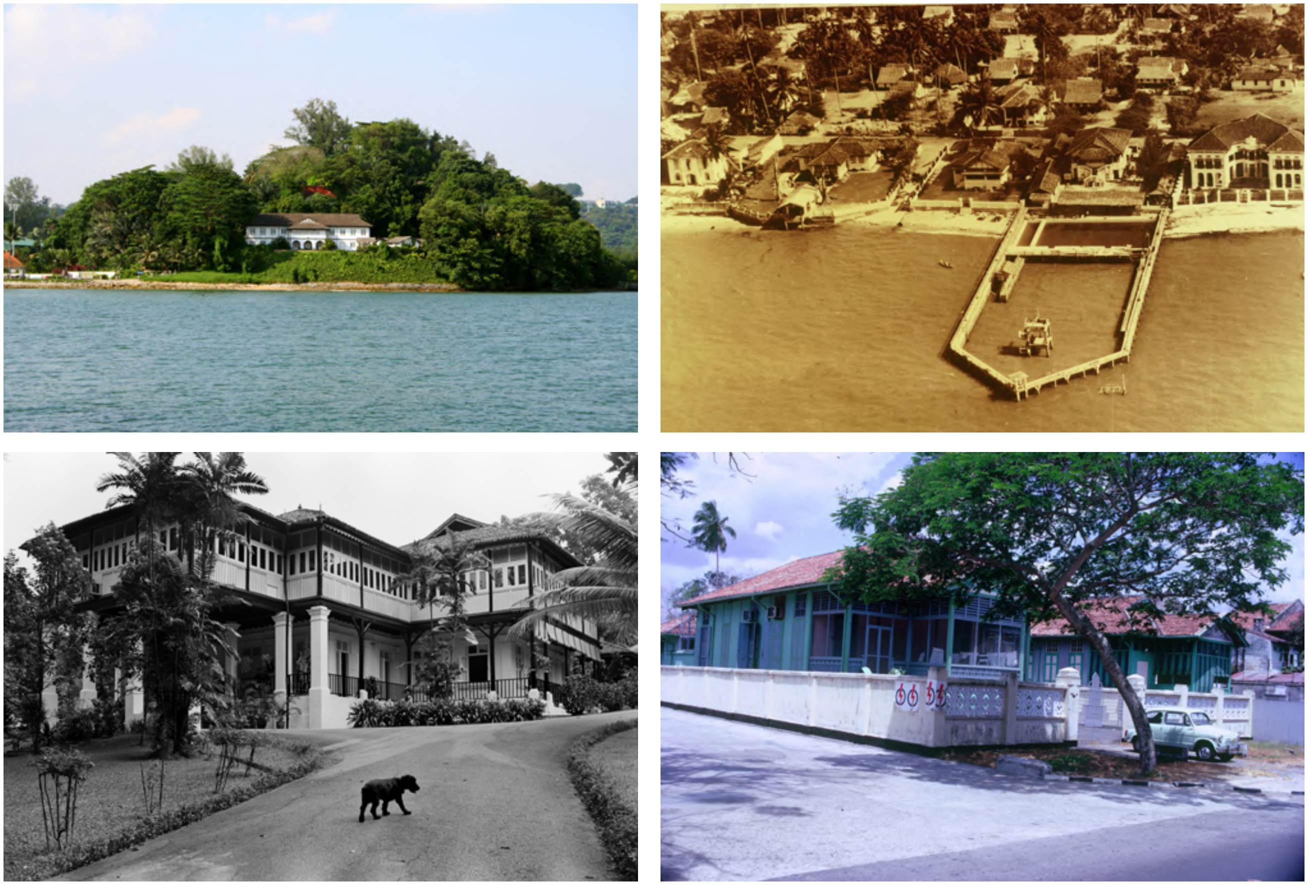
Following its import from British India and evolution in British Malaya, 'bungalow' in local parlance has come to refer generally to a **single- or double-storey freestanding house within a compound**.

SITING AND SETTING

Historically **high grounds** were considered choice sites, being naturally flood-free, well-drained, enjoying prevailing winds and offering the best views. In general, more exclusive private and government housing estates were located on hills, where the summit would usually be reserved for the grandest house, occupied by the wealthiest or highest ranking. Examples include Mt Sophia/Mt Emily (private estates), Mt Faber (company estates) and Tanglin/Goodwood Hill (colonial government estates).

Suburban estates of smaller bungalows with modest plots also proliferated along early **arterial road** developments to **city fringe areas**, and some can still be seen today in locations such as Serangoon, Balestier and Siglap.

*1933 survey maps showing (**left**) Mount Rosie/Malcolm Road Government Quarters developed around hilly terrain, with the General Officer Commanding (GOC) residing at the largest house (Flagstaff House) at the summit of Mount Rosie; (**right**) smaller bungalow plots proliferating around East Coast Road, with larger houses, many of them holiday homes, occupying choice coastal sites.*



Clockwise from top left: *The former port master's house and its coastal setting; seaside bungalows along Amber Road flanking Chinese Swimming Club (with swimming enclosure shown); single-storey Anglo-Malay private bungalows in Tanjong Katong; a hilltop two-storey colonial government bungalow for high-ranking officers.*

A number of upper-class households residing in or near town also owned **holiday homes** at idyllic **seaside** locations such as Pasir Panjang and East Coast.

The **historic setting and landscape of the compound/estate** play a critical role in the heritage presentation of the bungalows, and in understanding the group and setting value of historic bungalow estates. For example, the winding roads, undulating hills, majestic trees and lush greenery of a colonial bungalow estate are arguably key character-giving attributes that, if removed or significantly altered, would greatly reduce one's appreciation of the historic houses.

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CONFIGURATION

The **main dwelling floors** were often **raised** to guard against **ground moisture** and **floods**. Single-storey houses may be designed with low or high masonry/timber/RC piers, while double storey bungalows would be raised on masonry/mass concrete plinths. **Living and dining rooms** were usually located at the front of the house plan (or ground floor for double-storey houses), while the more private **bedrooms and bathrooms** were situated at the back (or upper floor).

For houses on storey-high piers, the **undercroft spaces** could be put to ancillary use such as storage, animal rearing or play area. As flood incidents subsided with drainage improvements over the years, it was not uncommon for owners to subsequently enclose such undercroft spaces and convert them to more usable and rentable dwelling areas.

Prior to the widespread adoption of modern sanitary systems, toilets were located outside the main house, often linked by a covered **linkway**. Other functions accommodated in **ancillary structures**, or outhouses, included kitchens and quarters for servants, nannies, cooks or syces (drivers). The well-heeled might even have several **outhouses**, **tennis courts** and even **garages** within the bungalow's expansive compound.



*Ancillary spaces and structures are integral elements of the historic bungalow compound – **from top:** spacious undercroft may be used for storage, animal rearing, as workspace or play area; servants' quarters in the outhouse connected by linkway; garage designed as a miniature of the main house.*

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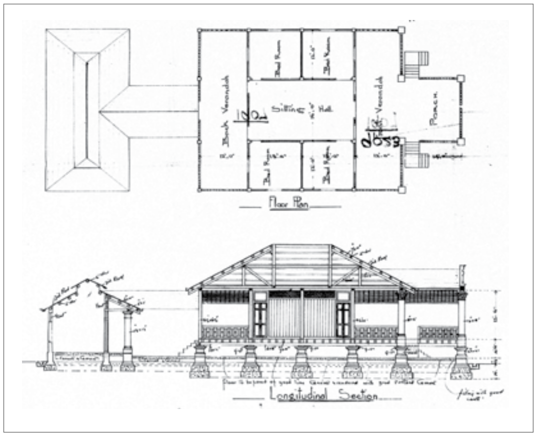
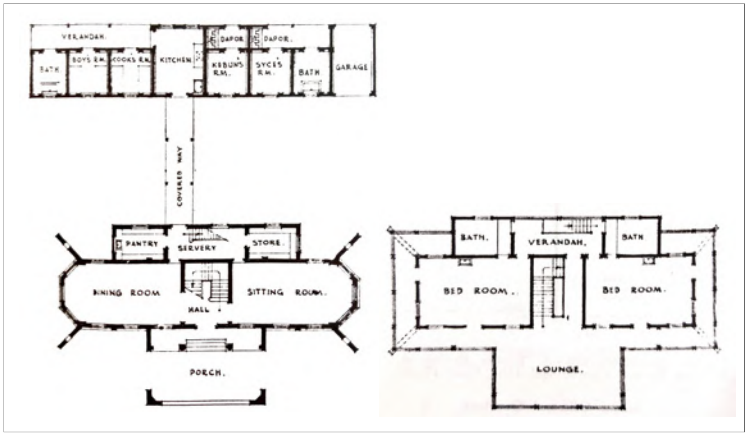
1890s photo of a ground floor verandah of a bachelors' mess, with a billiard table in the background. Recreational amenity structures built in bungalow estates often look similar to the houses in design.

Especially for former company or military estates mostly occupied by single males in the past, there may be variations in **building function and planning**. Although the appearance may be similar to a bungalow, some of the 'houses' are in fact purpose-built **mess halls** with shared amenities such as dining, recreation or event spaces serving the estate occupants. Other examples include **boarding houses**, where multiple tenants occupy a series of en suite rooms and share the dining and living rooms. A **shared compound** may also be planned with a few bungalow households that share a tennis court, outhouses (along with servants/ cooks/drivers) and a common garage.





Left: *1907 building plan of a single-storey Anglo-Malay bungalow at Bukit Timah, with the main house raised on piers, and an outhouse connected by a linkway.*
Right: *Ground floor plan and upper floor plan of a typical prewar colonial government Class IV quarters bungalow. Ground floor plan shows main house, linkway and ancillary structures.*

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Refer to Volume 4: Structures, for more information on historic structural and construction systems, defects diagnosis and restoration methods.

KEY CONSTRUCTION AND DESIGN VARIANTS

Some construction systems observed in existing historic bungalows include:

- **Timber structure:** Timber main structural frame with tiled roof, brick and plaster infill walls, timber partitions, timber floor joists and boards raised/upper floor, mass concrete ground slab, masonry column base and foundation
- **Timber and masonry hybrid structure:** Load-bearing brick masonry first storey walls/columns, timber frame with brick and plaster infill upper storey, timber joists and boards raised/upper floor, mass concrete ground slab, masonry foundation
- **Masonry structure:** Load-bearing brick masonry walls/columns, timber joists and boards raised/upper floor, mass concrete ground slab, masonry foundation
- **Reinforced concrete (RC) and masonry hybrid structure:** Load-bearing brick masonry walls/columns, ferro-concrete (early RC) beam and slab and/or timber joists and boards raised/upper floor, mass concrete ground slab, masonry foundation
- **Reinforced concrete structure:** RC main structural frame with masonry infill, RC slab and/or timber joists and boards raised/upper floor, mass concrete ground slab, RC foundation

Most historic bungalows are hybrid construction. Bungalows such as this typically feature loadbearing masonry, half-timbered walls on the upper storey and timber roof structure, as well as ferro-concrete bathroom floors.

Planter's bungalow.

Historic bungalows range widely in scale and design, with several common variants, broadly grouped by construction systems as follows:

Timber or timber-masonry structure:

- **Planter's villa** generally refers to a typology that was originally designed for surveillance – usually located on elevated ground and raised on high piers to provide strategic vantage points (e.g., a planter's villa that facilitated surveillance of a plantation, or the harbour master's house that had a view of the coastline and approaching vessels)
- **Anglo-Malay bungalow:** single-storey house raised on low piers and relatively modest in scale, and often featuring an ornamented entrance stairway and porch
- **Black and white half-timbered house:** single- or double-storey bungalow characterised by articulated black timber structural main frame with white stucco infill walls, commonly associated with colonial government quarters

Right: *Anglo-Malay bungalow.*
Far right: *Black and white half-timbered house.*

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Left: *Bungalow with classical revival influence.* ***Right:*** *Eclectic.bungalow design*

Refer to Volume 4: Structures, for more information on historic structural and construction systems, defects diagnosis and restoration methods.

Masonry, RC-masonry or RC structure:

- **Classical revival/eclectic bungalows** are usually two-storey and ornamented with stuccowork in adaptive revivalist styles including Neoclassical, neo-Gothic, Tudor and so on
- **Art Deco** bungalows are usually two-storey, feature simple geometric form and sparse stylised ornamentation and often sport nautical design elements such as porthole windows, mild steel railings, curved corners and streamlines.
- **Arts and Crafts** bungalows are usually two-storey, often found with a domineering pitched roof, geometric fenestration grille design, coupled with expressive use of materials as a form of decoration, such as textured plaster, fairfaced bricks, articulated timber frame, exposed stone chipping finish and so on.



Left: *Bungalow with Art Deco design.* ***Middle to right:*** *Prewar and post-war bungalows with Arts and Crafts influence.*

Top: *A house with a jackroof, deep eaves, and a verandah protected by louvred screens.*
Above: *A generous verandah with high ceilings at the ground floor of a bungalow.*

CHARACTER-DEFINING ELEMENTS

Built to optimise interior comfort in the hot and humid climate, bungalows here are often found with varied combinations of the following **tropical design features**:

- **Roof:** deep eaves, jackroofs, dormers, roof ventilators, ventilated soffits, gable vents
- **Facade:** generous porches and verandahs, ventilated parapets, louvred topscreens, sunshading fins/hoods, wall vents
- **Fenestrations:** louvres, monsoon windows, top and bottom vents
- **Piers** elevating the house, allowing for ventilation through the undercroft
- **Interiors:** high ceilings, high wall vents, ventilated ceilings, alignment of openings to facilitate cross ventilation
- **Orientation:** north-south orientation to shield from the western sun and catch prevailing winds

Other **historically significant design features, material finishes and elements** that contribute to the heritage character of a bungalow include:

Exterior

- **Roof forms** such as hip and valley, flared eaves, pediments, Dutch gable, flat roof, etc.
- **Roof accessories** such as rainwater goods, chimneys, ridge/eave ornaments, finials, carved timber fascia (valence), eave brackets, eave corbels, etc.
- **Articulated construction** such as timber frame, fairfaced masonry, granite column pads, etc.
- **Feature columns and pilasters**, including timber and cast iron columns
- **Balconies, bay windows** and balustrades, including bottle balusters
- **Fenestrations,** including glazing and ironmongery
- **Precast** elements such as ornaments, vents, fins, hoods

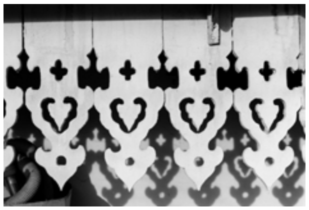

***Left:** Raising houses on high piers also aided ventilation. **Right:** A breezy upper floor verandah sitting room decked out in carved timber elements, with a porous enclosure of louvred French windows, balustrade and top vents.*

Interior

- **Carved timber** elements such as fenestrations, staircases, handrails, balustrades, dadoes, built-in furniture, ceilings, cornices, skirting, etc.
- **Timber floor joists, floorboards and corbels**
- **Stuccowork** such as cornices, architraves, skirting, ceilings
- **Staircases and balustrades**, including service stairs
- **Ceilings** such as **plasterboard ceilings with timber beading, stamped metal ceilings**

Finishes

- **Roof finishes:** V-shaped tiles, Marseille tiles, metal roofing, shingles, slate
- **Stuccowork**, including rustication
- **Paints and coatings**
- **Feature plaster:** Shanghai plaster, textured plaster, exposed stone chippings
- **Exposed material: fairfaced** brick and stone, **half-timbered** walls, **timber siding/lattice**
- **Tiles:** encaustic floor tiles, cement tiles, porcelain tiles, mosaic
- **Other flooring materials:** terrazzo, imprinted screed, parquet



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General Notes on Alterations/Adaptive Reuse

Refer to *Chapter 1: Introduction* of this volume, for key principles and best practices for conservation design integration of new uses, code compliance, services and so on.

Refer to jury citations for *URA 2008 Architectural Heritage Award, No. 14 Cable Road*, for more information on the historic bungalow A&A project featured below.

Best practices in conservation adaptive reuse design are underpinned by a thorough understanding of the building's historic character and attributes – such as those detailed earlier in this chapter – sensitive and customised response to its heritage attributes, and enlightened design thinking that interprets limitations as opportunities.

In assessing the heritage value and planning for interventions or adaptive reuse of historic bungalows, it is pertinent to take into account not just the main houses, but to consider in entirety the **wider historic landscape and cluster value that include the ancillary structures, settings and landscape**. Within the house, **historic interior elements, finishes and details** should be carefully documented, studied and restored as far as possible as key heritage assets of a building type that is centred on domestic life.

Below are some of the common changes in use and requirements that give rise to design challenges in adaptive reuse or additions and alterations bungalow projects. These should be negotiated with utmost care and consideration to achieve the optimal balance between conservation intent and new requirements – "to do as much as necessary and as little as possible".

Left: *Most remaining historic bungalows retain their residential use, but still undergo significant A&A works to meet modern requirements. At 14 Cable Road, a discreet modern extension has also been added to the right, sensitively designed in response to the proportion and elevation of the historic house.* ***Right:*** *Beaulieu House - historic bungalows in picturesque settings sometimes find new life as destination restaurants.*

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CHANGES IN USE AND REQUIREMENTS

Given their spatial configuration with a mix of rooms and common spaces, bungalows have been historically predisposed to being adapted as hotels, boarding houses, and institutions such as schools and clan houses. Other uses include restaurants/beer gardens, warehouses and offices. More recently, bungalows have also been adapted as galleries/ museums, condominium clubhouses, and childcare centres that capitalize on the open compound as a play area.

Sometimes multiple units are leased together, and the compounds combined as one development. In the case study included in this chapter of 12, 13 and 17 Rochester Park, three historic bungalow compounds are merged and restored as a corporate training facility in a landscaped setting.

Unlike shophouses and townhouses, the majority of historic bungalows have maintained their original residential use. However, with or without changes in use, many of these historic houses have been significantly modified, often when new owners or tenants undertake renovations. These may be due to shifts in **lifestyle habits, building regulations, building technology, maintenance practices, environmental comfort standards, aesthetic preferences**, and often, a **lack of knowhow** in addressing defects in historic construction and materials, or even **underappreciation** of the houses' heritage attributes.

Refer to jury citations for *URA 2008 Architectural Heritage Award, No. 43 Amber Road*, for more information on the historic bungalow adaptive reuse project featured below.

A historic house with a large compound may be conserved and adapted as a condominium clubhouse when the site is redeveloped and intensified. At The Seaview Clubhouse, formerly a residence, the sitting room with restored carved timber panelling has been sensitively fitted with a VRV air-conditioning system.

Refer to jury citations for URA 2010 Architectural Heritage Award, 124 & 126/126A St. Patrick's Road, for more information on the historic bungalow adaptive reuse project.

In this bungalow-turned-clubhouse at 124 St. Patrick's Road, air conditioning is channelled through a floor unit concealed in timber cabinetry on the left, devised to complement the historic interior design and proportions.

Building and programmatic requirements with significant impact on the historic fabric may include the following – with continued residential use being less affected by the last three:

- **Mechanical and electrical services** such as air conditioning, wiring and plumbing
- **Building safety regulations**, including structural loading, railing or parapet heights, staircase design
- **Fire safety regulations** such as escape routes, fireproofing, fire compartmentation, sprinkler systems
- **Environmental comfort standards** such as noise level, indoor temperature and humidity, lighting
- **Universal design** for barrier-free access, ramps, lifts
- **Energy efficiency** requirements such as low-emissivity glass, airtightness of fenestrations

The following case study of bungalow adaptive reuse development exemplifies how sensitive and skilful conservation design can significantly mitigate the heritage impact of redevelopment changes and safeguard the aforementioned historic attributes.

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Refer to jury citations for *URA 2015 Architectural Heritage Award, Rochester Park*, for more information on the adaptive reuse project.

Case Study:
12, 13 and 17 Rochester Park

Location: Rochester Park

Project: Adaptive reuse of three conserved former colonial military bungalows as corporate training facilities

Year: 2015

This project comprises three **Art Deco colonial bungalows** and their **outhouses** in Rochester Park, a military housing estate likely built in the 1950s. The main houses are in reinforced concrete (RC) column, beam and slab structure with masonry infill walls, and timber roof frame with clay tile finish. The outhouses are in RC frame construction with RC flat roofs.

Investigated and found to be in sound condition, the **main RC and timber structures** of the houses were repaired and restored. **Character-defining historic elements** that were restored or reinstated like-for-like included timber eave brackets, ventilated eave soffits, precast RC canopies, timber fenestrations with Art Deco grille design, and front verandahs with ventilated balustrade.

Far Left: *Rochester Park and its verdant, undulating environs, 1990.*
Left: *Constructed in reinforced concrete, the bungalows feature character-defining elements such as ventilated soffits, verandahs with ventilated balustrade, and clerestories with Art Deco grill design.*

CONSERVATION APPROACH

The adaptive reuse scheme set out to create a **corporate training retreat** conducive for both structured learning and informal social interaction. The scheme adopted a **light touch** and fully capitalised on the existing **historic structures** and **verdant tropical setting**.

Even though the heritage setting was not mandated for protection, the historic **undulating terrain** and **semi-wild greenery** were identified as a **central feature** anchoring the scheme. Conserved and curated through **considered arborist intervention** and **sensitive landscape design**, the heritage setting, along with a new linkway and communal decks, serve as a common datum that brings together the three house compounds.

By conserving the historic green setting and embracing naturally ventilated verandahs and alfresco spaces as valid functional areas, the scheme **maintains the cool, shady microclimate** of the compound and **reduces the campus' air-conditioning and mechanical ventilation (ACMV) load and energy consumption.**

Aerial view of the campus compound with three historic bungalows amidst semi-wild tropical landscape.

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Refer to *Chapter 1: Introduction* in this volume for key principles of carrying out conservation design integration for new uses, code compliance, services and so on.

DESIGN AND INTEGRATION

Compared to residential use, commercial institutional function typically comes with more demanding programmatic requirements such as acoustics, higher air-conditioning load, as well as increased need for code compliance for fire safety, bathroom provision, barrier-free access and so on.

Key integration strategies exemplified in the project include:

- **Decanting bathrooms to the outhouse**, thus reducing sanitary service intrusion at the main houses
- **Reducing ACMV loading** by not enclosing verandahs and having outdoor interaction spaces
- **Discreet or concealed routing design** that minimises impact on conserved historic features
- **Use of ramps and platform lifts to navigate level differences** across the compound so as to minimise the need to modify historic terrain

Historic residences are adapted for commercial institutional use, with seminar rooms for structured learning as well as informal interaction spaces.

Right - BEFORE: *The overgrown colonial garden landscape with wayward trees.*
Right below - AFTER: *Heritage landscape trimmed of unhealthy growths and conserved – including the inclined sculptural umbrella tree.*

Below: *A trellised sheltered linkway of footpaths, ramps and steps weaves through the semi-wild undulating terrain, providing barrier-free access.*

Heritage landscape
Vacant since the 1990s, what was once a manicured garden landscape in the colonial days was found to have become an unkempt array of overgrown vegetation and mature trees. The design team worked closely with an arborist; eventually more **historic trees** were preserved than was mandated by the authorities to maintain the lush tropical heritage setting and **microclimate**. These included an inclined sculptural umbrella tree (*Schefflera arboricola*) in front of house no. 13 that was recommended for removal but eventually retained and propped up with a new steel support.

Instead of levelling or decking over the terrain, the undulating contours are retained as a historic landscape feature and negotiated using **footpaths, ramps, steps** and **platform lifts**, modified only where needed to accommodate the 1:12 ramp gradient for **barrier-free access.**

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Left: *Front verandah restored as tropical sitting lounge with a view, also serving as an environmental buffer for the air-conditioned interiors.*
Right: *Extension of the tropical sitting room into the landscape.*

Discreet addition of steel and timber fire escape stairs leading from the verandah.

Bungalows and outhouses
Rather than being glassed in, the bungalows' **front verandahs** have been restored to their original historic design as open, breezy lounges with immersive views of the greenery. The verandahs also serve as an **environment buffer** between the warm, humid outdoors and air-conditioned building core spaces.

The concept of **tropical sitting rooms** is further extended to the landscape, where a **pavilion, communal decks** and **open green** become spontaneous learning and interaction spaces outside of the formal classroom setting.

For houses no. 12 and 13, **fire safety requirements** necessitated an **escape route** from the verandahs; a lightweight timber and steel straight flight was added to the side elevation of each house, leading from one end of the verandah to the ground floor.

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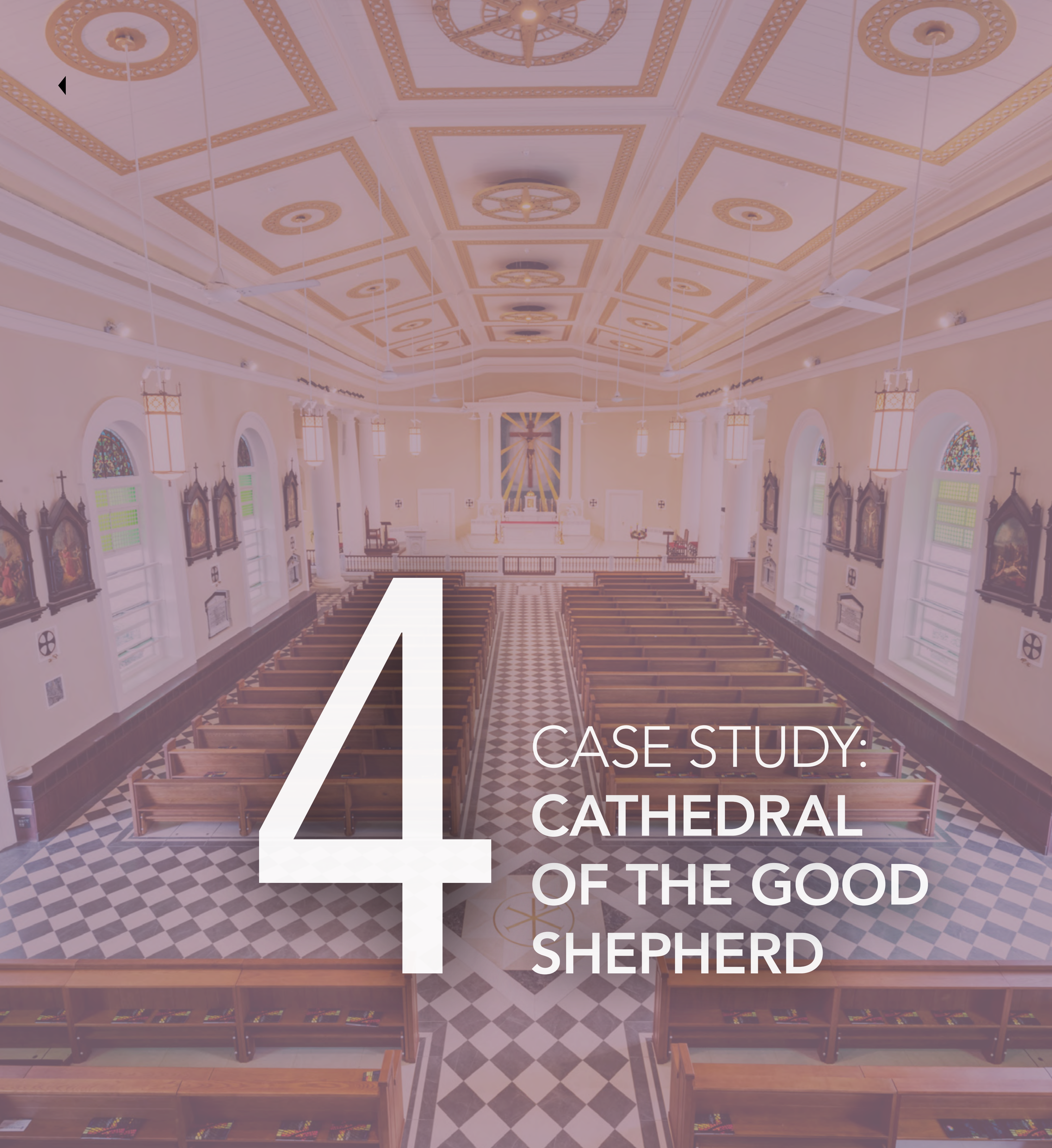
Existing **timber fenestrations**, found to have deteriorated from ad hoc modifications and termite infestation, were **replaced like-for-like** with chengal replicas constructed with the same joinery and design details. The replacement also allowed for **design modifications and integration** of devices to secondary doors and windows, while the exterior sets were faithfully reinstated. The modifications include acoustic treatment such as use of laminated glass and acoustic seal, use of low-emissivity glass to reduce glare and thermal heat gain, as well as incorporation of security card readers and cameras on the secondary door frame.

The reinstatement of historic casement window design, replete with secondary windows, provides users with the **option of natural ventilation**. Variable Refrigerant Volume (**VRV**) system is adopted for air-conditioning the bungalow interiors, chosen for its energy efficiency and the ability to use a **streamline AC grille** that can be more easily integrated with the interior design, with no need for a visible AC unit. While **drop ceilings** are needed to conceal ducting, these are **coordinated and set back** from the reinstated windows and Art Deco clerestories to minimise visual impact on heritage presentation. **Condenser units** are parked next to the outhouses and concealed with **timber screens**.

Left: *Incorporation of Low-E glazing and security card reader on the secondary layer of like-for-like replacement fenestrations.*
Right: *Discreet AC outlet grille integrated in drop ceiling that is set back from the feature clerestories.*

Although not mandated for conservation, the **outhouses**, found to be in good condition, were retained as **integral historic components** of the colonial house compound. Originally used as kitchens and servants' quarters, these were adapted to accommodate the increased quantum of washrooms required for the change to institutional use. **Sanitary piping** existing on site was damaged by invasive tree roots and deteriorated beyond repair; new lines had to be laid and connected to the sanitary inspection chamber. The **routing** is carefully **coordinated with the tree plan** to avoid affecting the roots of retained trees.

*Historic ancillary structures such as outhouses are an integral part of the heritage compound (**above**). These are retained here and adapted as washroom blocks (**right**). Condenser units are parked right behind, concealed by a timber screen.*



4 CASE STUDY: CATHEDRAL OF THE GOOD SHEPHERD

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Refer to Jury Citations for *URA 2017 Architectural Heritage Award, Cathedral of the Good Shepherd,* for more information on the restoration project.

Case Study: Cathedral of the Good Shepherd

Location: "A" Queen Street

Project: Historic use preserved, with additions and alterations to the National Monument to upgrade amenities, and add a new block.

Year: 2016

Completed in **1847**, the Cathedral of the Good Shepherd is the oldest Roman Catholic church in Singapore. It is also the cathedral church of the Roman Catholic Archdiocese of Singapore, and the seat of its archbishop. The cathedral building, rectory building, and associated structures within the church grounds have been collectively gazetted as a **National Monument** since 28 June 1973. It underwent a three-year restoration project and reopened in November 2016.

1847 painting of the Church of the Good Shepherd by Father Jean-Marie Beurel upon its completion, depicted with blue-grey slate tile roofs.

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BRIEF HISTORY AND CHARACTER-DEFINING ELEMENTS

Established in 1832 by missionaries from the Société des Missions étrangères de Paris (MEP), the Cathedral of the Good Shepherd was under the charge of its parish priest **Father Jean-Marie Beurel**. A competition to design the church building was launched, and the scheme by **Denis McSwiney** was selected as it would be less costly to build, more easily maintained, better suited to Singapore's climate, without compromising on grandeur. The 'modern, simple but majestic' building is laid out on a **cruciform plan**, with four pedimented **porticoes**, each flanked by eight massive columns. A **bell tower** was added just two years after its completion to house a large bell acquired from Manila, Philippines.

In **1888**, the building underwent one of its largest transformation when it was consecrated as a Cathedral. It was **extended by three bays** towards the west, and adorned with new stained glass, paintings and statues. Numerous changes were made to the Cathedral throughout the years, including the addition of a new roof and ceiling in 1897, new ornamented boundary walls in 1909, a mezzanine loft for the pipe organ in 1912, mild-steel and glass windows by 1939, and a remodelled altar by pioneer Singapore architect Alfred Wong in 1958 – all of which were funded by contributions of the churchgoers. These distinct **layers of history** are still intact and observable in the Cathedral today.

Below left: *Church of the Good Shepherd, showing its original building extent.*
Below right: *1910 photograph of the Cathedral of the Good Shepherd, with a three-bay extension to its current size.*

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Refer to *Chapter 1 Introduction,* for key principles in carrying out conservation design integration for new uses, code compliance, services, and so on.

CONSERVATION APPROACH AND KEY CHALLENGES

The early 2000s saw unprecedented underground construction works in the cathedral's vicinity, such as the Circle Line MRT stations and tunnels, and basement areas of Singapore Management University. The cathedral's original foundation of compacted earth and boulders was affected, leading to **uneven settlement** of the building. This resulted in large and **extensive cracks** in the floor slab, walls and columns. By 2009, the bell tower at the east facade had tilted, and the portico columns had to be propped up by massive timber struts. Horizontal elements such as door lintels, window frames and cornices also showed visible shearing. The interiors were not spared either, with large cracks and delaminated finishes observed at the front altar wall, and multiple cracks had also propagated across the mosaic floor. At the north and south transepts, continuously growing cracks in the window frames prompted the church to dismantle two valuable **stained glass panels** for safekeeping in 2010.

The east facade with the bell tower suffered the most extensive structural damage. Massive timber shoring was installed to prop up this area. On the interior ***(bottom far right)****, extensive cracks appeared on the altar wall below the bell tower.*

The restoration project of the cathedral is first and foremost focused on **urgent repairs and rehabilitation** to its damaged substructure and superstructure. At the same time, the extensive works provided an opportunity to introduce new amenities such as **air conditioning** within the historic interiors, construction of a **new annex building** that housed activity rooms and a heritage centre, and an underground prayer hall and crypt. Taken together, the works aimed to also symbolically restore the status of the cathedral as the 'mother church' of the Roman Catholic community.

The conservation approach is to ensure that, notwithstanding the extensive structural repair and strengthening works, as much **historic fabric** as possible is preserved– given the cathedral's status as one of Singapore's oldest National Monument with **high historic, architectural, social and cultural significance**. Being subjected to stringent preservation guidelines, the rehabilitation works required a conservative approach that will safeguard both the historic facades and interior character-defining elements to the **maximum extent** possible.

In addition, the building needed to be retrofitted with modern building services and systems to meet contemporary needs. **Customised solutions** tailored to work around site constraints had to be adopted, with **reversibility** and **material compatibility** to the old fabric being of utmost importance. New enhancements to key areas such as the sanctuary were informed by the liturgical concept of **'noble simplicity'**. In this regard, overt ornamentation was eschewed in the treatment and detailing of these elements. Only as much work as necessary was carried out, since funding was acquired primarily through public contributions and an **NHB Monuments Fund** grant.

*Overview of the cathedral from its west facade main entrance, before **(left)** and after **(right)** the restoration project.*

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KEY ASPECTS COVERED IN THIS CASE STUDY

The two key interventions – structural rehabilitation and repairs, together with introduction of new M&E systems – are analysed holistically for any **heritage impact**. Given the numerous ad hoc modifications through the cathedral's nearly two-centuries-old existence, archival research, field investigation, laboratory analyses of the extant historic fabric, elements and fittings provided valuable insights that facilitated the **design and integration** of new requirements, while at the same time revealed **opportunities for interventions** that could reinstate the heritage character and lost features in a distinctly contemporary yet sensitive manner.

This case study is focused on the following:

- Design integration of **new M&E services** using opportunities presented by **structural repairs and rehabilitation**
- Design integration of contemporary **daylighting requirements** with historic fenestration
- Designing for compliance with **safety, accessibility and fire protection** regulations
- Integrating **lighting** provisions with historic interiors

Left: *Underpinning works in progress, with massive shoring in place to ensure the structural stability of the cathedral during the rehabilitation works.*
Right: *Mortar repointing of brick columns had to be carried out as part of the structural repairs.*

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Structural Rehabilitation with Services Integration

Refer to Volume 4: Structures, for more information on foundation strengthening and temporary support.

The restoration and enhancement works were governed by the philosophy of maximising what could be retained, and minimising invasive interventions. Due to the heaving and extensive cracking of the **cathedral's floor**, it had to be entirely **reconstructed**, while the structurally compromised **foundations** had to be fully **underpinned**.

At the same time, a **new ducted air-conditioning system** was to be introduced to cool the lofty, high ceiling space along the entire length of the nave, as well as at the altar. The ornamented timber ceiling that was a replica of the historic 1902 one was considered a key character-defining element to be preserved. Overhead ACMV ducting and diffusers were ruled out early in the project as it would mean extensive modifications and also structural strengthening to the roof trusses. Rather, it was decided to integrate **new trenches** within the reconstructed floor slab to consolidate and house ACMV ducts, M&E cables and conduits. These would be concealed underneath new floor finishes, with access panels placed at intervals to facilitate long-term maintenance, and replacement of faulty components once every 15 years.

Above: *Large cracks on the floor slab prior to restoration works.*
Right: *Overall view of restored interiors of the cathedral, with the restored decorative timber ceiling kept free of obstrusive M&E installations. Enhancement works such as M&E upgrading had to be carefully planned and designed to harmonise with the heritage character and spatial quality of the cathedral.*

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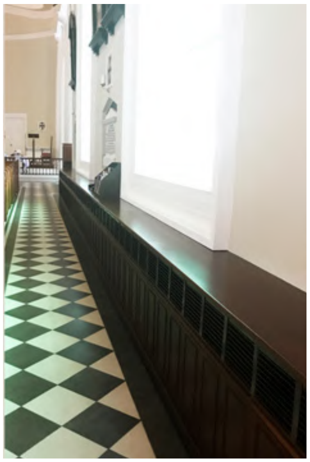
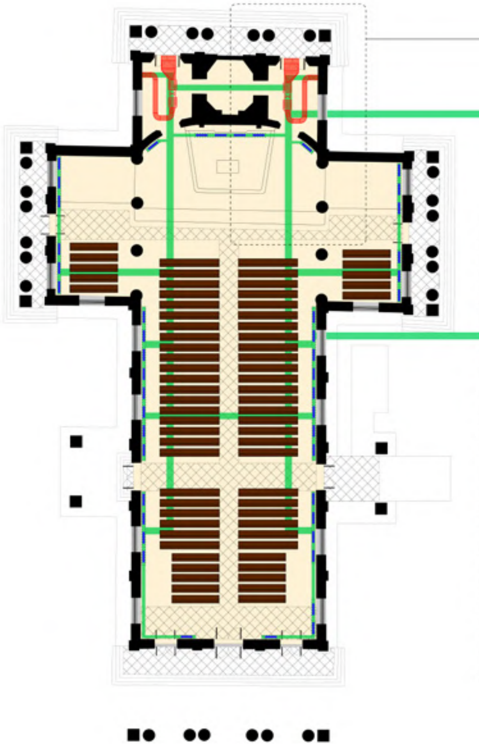
Refer to Chapter 1: Introduction, for key principles and best practices in ACMV Design Integration.

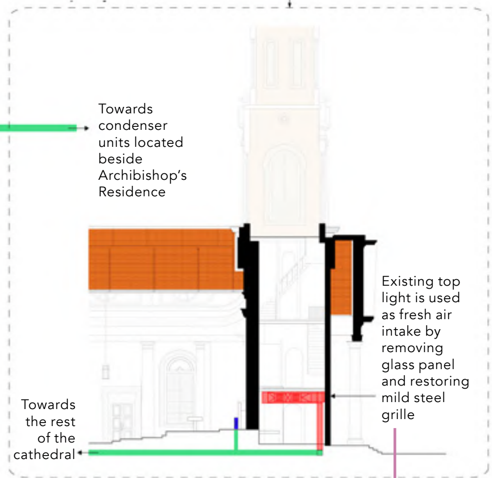
Two banks of **floor-mounted air-conditioning fan coil units** run alongside these trenches along both side walls of the nave, neatly tucked under the massive window architraves. The equipment is housed in **timber cabinetry** with cleverly disguised diffuser grilles, giving the appearance of wall dadoes within the voluminous hall. This design treatment freed up the cathedral walls and ceiling from unsightly M&E conduits and ductwork, while enhancing the heritage character of its interiors.



Top: *New M&E trenches were cast together with the new floor slab to house ducts, cables and conduits. Panels at regular intervals provide maintenance access.* ***Above:*** *Air-conditioning FCUs housed within custom-made timber cabinets on both sides of the nave.*

ROUTING PLAN OF AIR-CONDITIONING M&E





PART SECTION AT SACRISTY SHOWING FRESH AIR INTAKE

Fresh air intake via the original top lights at the rear elevation of the cathedral.

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Having a consolidated underfloor ducting and cabling trench also meant much **less M&E penetration** on the historic brick masonry walls. In a conventional scenario, floor-mounted ACMV fan coil units (FCUs) would necessitate refrigerant and condensate piping to puncture through the wall enclosure to a row of outdoor condenser units, which would clutter up the historic facades. The alternative strategy adopted ensured that these were routed to a **consolidated bank of condenser units** housed a distance away – at the boundary wall between the cathedral and the archbishop's residence. The condenser units are concealed within metal louvred screens and landscaping, separated from the cathedral by a driveway and parking spaces.

Fresh air intake is through two **modified historic top lights** at the rear facade of the cathedral, with the glazing replaced by metal netting installed behind the restored mild steel window grilles. This is fed into two air-handling units (AHU) suspended above the double-volume space of the sacristy, positioned directly behind the top light intake points. The air is then ducted underfloor to the FCUs lining the walls.

Left: *Matching white air-conditioning FCU cabinets sensitively placed at the altar to reduce visual impact.*
Right: *Condenser units housed away from the cathedral, screened with metal louvre casing and camouflaged with dense planting.*

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Besides architectural planning, **sensitive and precise engineering design** to size the AHUs and ductwork as well as determine the numbers and distribution of FCUs was critical to ensure optimal ACMV performance comparable to a conventional system with ceiling-mounted FCUs. The various site constraints and operation requirements – such as cooling patterns, space availability, equipment performance, cost and ease of maintenance had to be carefully balanced and considered by the consultant team working closely together to achieve seamless design integration.

Finally, the new floor slab also provided the opportunity to install a **flooring design** that draws inspiration from archival photographs showing historic cathedral interiors with marble tiles laid in a black and white diagonal 'chequerboard' pattern. Rather than attempting a literal replica of the historic flooring, of which there are no design records, new large ceramic tiles in two contrasting tones were used to reinterpret the chequered pattern. The new design takes into account BCA's safety requirements for slip-resistant tiling, as well as the required size and distribution for floor access panel.

Left top and bottom: *Reinstated flooring drawing inspiration from the historic design.*
Above: *Archival photo of cathedral interior showing original chequerboard flooring pattern.*

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SAFETY, ACCESSIBILITY AND FIRE PROTECTION

Being a publicly accessible congregation space, safety, accessibility and fire protection is paramount. As the cathedral was constructed prior to 1969, the building is **exempt** from the prescriptive and more onerous requirements in the Fire Code, such as sprinklers. Special consideration for **performance-based code-compliance solutions** is given on a case-by-case basis, on the grounds of historic preservation. The cathedral's simple layout, with numerous doorways that are easily accessible and clearly laid out was advantageous in fulfilling fire escape and exit requirements.

New **frameless glass sliding doors** were added behind the historic timber doors, which are kept open at all times. Ceiling **smoke detectors** are installed and painted to match the colour of the timber feature ceiling. **Exhaust fans** are installed over the drop ceiling panels, and discharge is channelled through the historic **jackroof vents**.

A key issue was the **choir loft** that is supported on massive timber joists and steel beams, which is only accessible via two 1912 cast iron staircases. To avoid replacing these historic stairs with code-compliant dog-leg staircases, **alternative means of fire escape** were explored.

Secondary frameless glass automated sliding doors are added behind the restored historic doors, which are held open during operating hours.

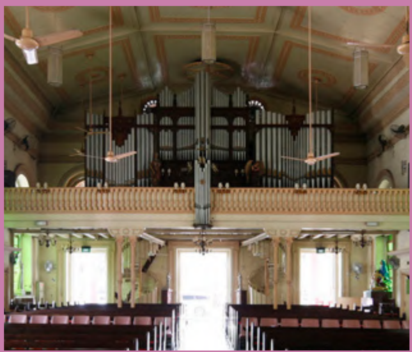
Above: ***Alternative means of fire escape for the choir loft were explored***
Left: ***Existing ventilated ceiling features were adapted as smoke extractor vents, with discharge through the historic jack roof.***

Refer to *BCA Building Safety Approved Document, Code on Accessibility,* and *Clause 9.9.1 of the Fire Code 2023*.

Refer to *Chapter 1: Introduction* for key principles and best practices for safety, accessibility and fire protection design.

These included emergency inflatable slides (such as those used in aircraft) that would be mounted behind two historic windows, which could allow people to be discharged directly outwards onto the west entrance portico. However, these options were extremely costly, untested locally, and thus not adopted. The final solution was to **restrict the number of persons** who could access the choir loft (on a daily basis). **Fire retardant** was applied to the large timber beams that were considered secondary structures, allowing them to be exposed to view.

Safety requirements were met by installing visually unobtrusive lightweight metal mesh barriers behind the historic metal balustrades of the cast iron staircases, as well as timber railings on the loft.



Top row: ***The wide non-compliant gaps of historic railings and balustrades were once sealed up with plywood boards, altering the character of these historic elements.***
Bottom row: ***Metal mesh is now used instead, reinstating the visually light historic design character. Designed for reversibility, the mesh is attached using metal hooks and clamps.***

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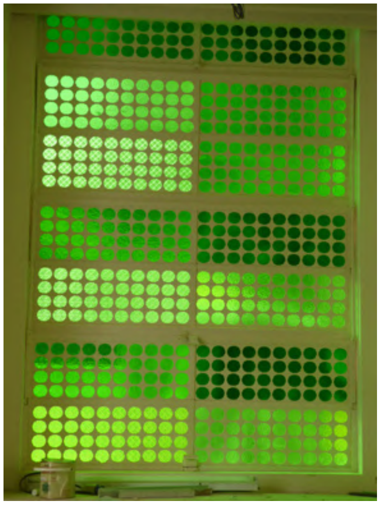
Daylighting and Historic Fenestration

Refer to Chapter 1: Introduction for the principles of optimising daylighting.

Refer also to Volume 5: Doors and Windows, for the principles, methods and best practices in the conservation of historic fenestrations.

The restoration approach was premised on the central idea that the cathedral is a living monument, where the physical fabric of the building is a rich repository of information on its storied past and the changes it has undergone, and embodies the care and effort of its community to improve, beautify and repair a beloved place of worship. Each layer of the building bear its own social value, and needed to be treated with respect and sensitivity. It was imperative to retain as much of the historic fabric and elements as possible so as to prevent unnecessary loss of these features, as well as to safeguard its authenticity for future generations.

One such example that best exemplifies the aforementioned ethos is the cathedral's **mild steel windows**, which replaced their timber louvred predecessor in the 1940s. The large, expansive pivoted mild-steel framed windows originally featured dark green tinted hand-rolled glass that was believed to reduce glare and heat from the tropical sun. They also allowed the interiors to be well ventilated, being fully openable. Over the decades, wear and tear, as well as localised replacement with clear glass, has resulted in a distinctive patchwork of differing shades, hues and textures of glazing, illuminating the cathedral's interiors with an uncommon light quality.



Original condition of louvred mild steel window with glass panels and wire mesh, in various green tints and textures.

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These windows could no longer remain freely operable with the introduction of **air conditioning** to the cathedral. If the windows were to be closed and sealed, the interiors would experience much less natural daylight illumination, and would have needed to rely heavily on artificial lighting, increasing long-term operating costs. There were serious concerns that worshippers would not take kindly to a permanently darkened prayer hall with green tinted light. Several options were studied and weighed – including partial or full replacement of green glazing with clear glazing.

In this case, the conservation ethos of maximum retention of historic fabric appeared to be in direct conflict with new requirements for air conditioning and more natural daylight. In the end, the 'best compromise' that balanced between the two was selected, based on the **principles of reversibility and compatibility.**

It was decided to **retain** as many **variations of the glazing** as possible, as they serve to highlight the past contributions of the church community. To do so, each panel of glass was tagged and labelled to ensure it was returned to its specific position. Broken panels were replaced with matching like-for-like pieces.

Above left: *Tagging and removal of glass to repair corroded mild steel window casements.*
Above right: *Reinstallation of glass into restored casements.*
Right: *Latter-day clear glass panels are retained at the north and south transepts to allow ample daylighting for the sanctuary and altar area. Additional track lights mounted on the lower cornice provide extra illumination during religious services.*

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In order to optimise natural daylight streaming into the cathedral, whilst regulating the interior thermal comfort, several decisions were made. Drawing functional inspiration from the dark tinted stained glass lunettes, the top three green glazed panels were shut to **mitigate glare** and **provide shade**. To let in **natural light** without the green tinge, the bottom six panels were pivoted to the open, horizontal position and held in place with clamps and screws, allowing them to function as **sun-shading devices** at the same time. **Secondary clear glass panels** were introduced to keep out the elements and maintain the interior air conditioning. These interventions are **reversible** if there is intention to reinstate the windows' operability in the future.

Top row: *The green glass panels at the top are closed to reduce glare, while those at the bottom section are opened into a horizontal position to allow daylight to enter.*
Bottom row: *Adaptation of louvred mild-steel windows for the air-conditioned interiors, with clear glass panels added in between, using reversible fixing methods.*

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STAINED GLASS RESTORATION

***An important part of the cathedral restoration was the conservation repairs to its stained glass, which included installation of new protective external glazing** (bottom left).*

A gap is maintained at the top or bottom of the stained glass to ventilate the interstitial space, and to reduce condensation risk.

Refer also to Volume 5: Doors and Windows, Chapter 5 Stained Glass.

INTERIOR LIGHTING DESIGN

Given the friable nature of the brick masonry, and the thin plaster layer, all new electrical conduits are either **surface-mounted** or **concealed** in lightweight panel **box-ups**. To light up the restored timber ceiling, new track lights with exposed electrical trunking were installed out of sight above the highest cornice line. The **historic pendant lamps** dating to the 1950s were retained, with their tungsten filament luminaires replaced with LED lights. Originally, it was intended to install additional uplights directly below the restored Stations of the Cross paintings that line both sides of the nave. However, this would mean unsightly exposed conduits at regular intervals. To overcome this, new **spotlights** mounted on top of the pendant lights were used instead. Latter-day pendant lamps along the centre bay of the timber ceiling were removed and replaced by **recessed downlights** that are integrated into the centre of the ceiling 'starburst' motif, reinstating the historic character.

Top: ***Closeup of refurbished pendant lights with new LED luminaires, and additional spotlights to illuminate the Stations of the Cross paintings.***
Middle: ***The interior lighting levels can be adjusted to accommodate projection of images onto the sanctuary walls flanking the altarpiece. This was a conscious decision to not mount new projection screens or LED TVs that would otherwise detract from the historic character of this important space.***
Bottom: ***During evening services, the cathedral interiors are lit using a combination of track lights that illuminate the timber ceiling, recessed downlights, and refurbished historic pendant lights.***

5 CASE STUDY: MAXWELL CHAMBERS SUITES | **FORMER TRAFFIC POLICE HEADQUARTERS**

Case Study: Maxwell Chamber Suites | Former Traffic Police HQ

Location: 28 Maxwell Road

Project: Adaptive reuse of the conserved building as serviced office, with additions and alterations to upgrade amenities.

Year: 2019

Completed in **1928**, 28 Maxwell Road is a four-storey complex that housed the former Traffic Police Headquarters for more than 70 years.

The Maxwell Road building was left vacant after 1999, when the headquarters moved to Ubi. Only in 2005 did it undergo a round of renovations to be converted for commercial and office use, and painted a fire-engine red to signal the building's anchor programme as Red Dot Design Museum. It was gazetted for **conservation** in 2007. The museum vacated the building in 2015, and restoration of 28 Maxwell Road into the current Maxwell Chambers Suites began in 2016. The building was reopened in 2019.

Left: *The Traffic Police Headquarters as seen from Maxwell Road and Wallich Street Junction, 1974.*
Right: *Driving tests were conducted in the open-air area behind the Traffic Police Headquarters, where drivers obtained their licences.*

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BRIEF HISTORY AND CHARACTER-DEFINING ELEMENTS

Purpose-built as the Traffic Police's **barracks** and **operational headquarters**, the four-storey building was designed by the Public Works Department (**PWD**), under its chief architect Frank Dorrington Ward. With its main elevation stretching an entire city block, the pared-down **'Stripped Classical'** facade expression with repetitive rows of timber windows and rusticated pilasters is punctuated by Art Deco-inspired crown pediments over key entrances. The rear facade adopted an even more austere approach: only elements that served a practical function, such as chimneys, window hoods and vents, were expressed.

Internally, the long repetitive structural bays with open continuous verandah corridors encircle open-to-sky courtyards. Linkways provide intermediate access between the front block, primarily used for **office and administrative** functions, and the rear block, primarily used as **barracks** and as service spaces.

Following are some of the **character-defining elements** of the building:

- Open courtyards
- Verandah corridors
- Clay-tiled roof
- Plainfaced and ornamented plasterworks
- Timber doors and windows
- Window hoods, chimneys and vents
- Metal works: Cast iron rainwater downpipes, grilles and railings

In the early 2000s the building was renamed Red Dot Traffic and painted bright red.

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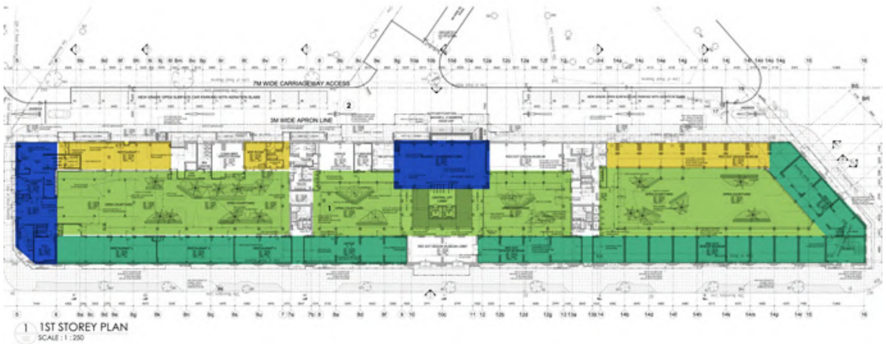
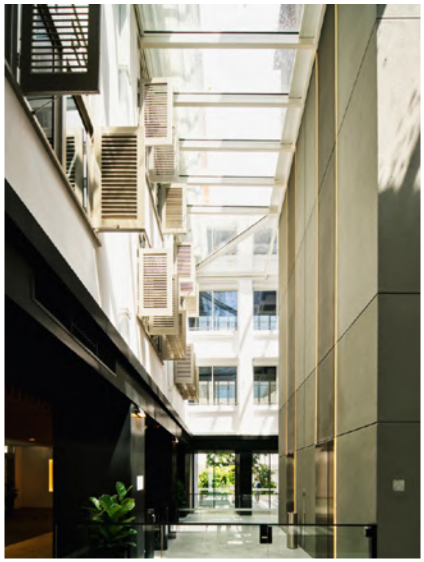
Refer to *Chapter 1 Introduction*, for key principles in carrying out conservation design integration for new uses, code compliance, services, and so on.

CONSERVATION APPROACH AND KEY CHALLENGES

The former Traffic Police Headquarters building (TPHQ) was converted to the Maxwell Chambers Suites, which houses **premium office** spaces catering to the needs of international law firms and arbitration services, with amenities such as a **concierge, business suites, meeting rooms and F&B** establishments. This is planned as an extension to Maxwell Chambers, an internationally renowned legal arbitration centre converted from the neighbouring former Customs House in 2010.

Aside from Maxwell Chambers Suites' city centre location and proximity to Maxwell Chambers, its being housed in a sensitively refurbished and upgraded historic building was intended as a selling point to attract prospective tenants. Thus, restoration of the building's heritage character and historic spatial qualities was a key consideration of the conservation project. Notably, the original series of **five courtyards** that had been partially built over through the decades were reinstated to their original open-to-sky configuration. This also gives users and the public interconnected access on the ground level throughout the building. At the two extreme ends of the complex, new architectural volumes that housed large-span, column-free meeting rooms were sensitively inserted on one side of each courtyard.





Above: *A schematic diagram of the building layout. There were originally five courtyards (highlighted in light green), which were subdivided during later rounds of works.*

Right: *Restored central lobby of Maxwell Chambers Suites with a glazed roof over the courtyard.*

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Though spared from major structural issues, the project faced a twofold challenge – the requirement to reinstate the integrity of the original architecture, and the need to adapt the historic building for current uses according to the latest building code requirements for safety, accessibility, M&E services, and so on.

One of the existing conditions that posed a great challenge to the adaptation of the building into high-end offices was the relatively **low floor-to-ceiling height**, which meant that M&E services had to be accommodated in a limited space to preserve as much headroom as possible. Due to the building's historic construction phases, **floor levels are varied** within and between different building wings – which posed a challenge in achieving seamless circulation and universal access across the whole complex.

An off-white base monochromatic colour scheme has been selected for Maxwell Chambers Suites, befitting its historic architecture and matching Maxwell Chambers next door, connected by a new link bridge.

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KEY ASPECTS COVERED IN THIS CASE STUDY

This case study contains examples of best practices in sensitive interfacing and M&E design integration to a large historic structure to befit modern office use. Key focus will be placed on:

- Reinstatement of the **courtyards** to optimise **daylighting**
- Design integration of **M&E systems** within tight constraints, e.g. along **courtyard corridors, in offices, and facade coordination**.
- Restoration of **historic rainwater discharge system**
- **Circulation design** addressing issues of varying floor levels and **accessibility** compliance

Above left: *The austere rear facade of the building, with retained and restored hooded windows and chimneys, which hark back to the days when the rear wing housed the police barracks.*
Above right: *New secondary fixed glass panels were installed to accommodate air conditioning and meet the stringent acoustic rating required for the new office suites.*
Right: *Reinstated metal grilles and ornamented architraves are some of the building elements that underwent conservation works.*

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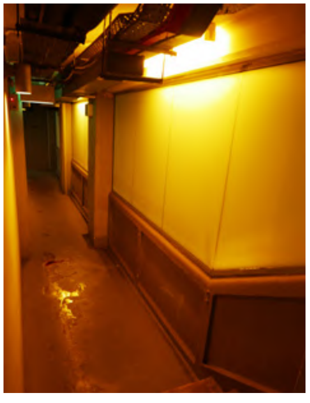
Daylighting and the Historic Courtyards

Refer to Chapter 1: Introduction, for principles of optimising daylighting.

Built in an era when air conditioning and artificial lighting were considered luxuries even for government buildings of such a scale, the Traffic Police Headquarters was designed to maximise natural ventilation and daylight entry. It features **north-south building orientation, one-plan-deep single-loaded corridors and five courtyards**.

Previous A&A works had introduced new roofs enclosing the courtyards to increase the total indoor floor area of the Design Museum. This resulted in a deep plan space, with the lower levels perpetually dark and in need of artificial lighting in daytime.

One of the main restoration strategies was to remove these latter-day structures and slabs, and **reinstate the historic open-air courtyards**. This would restore the compound's openness and light, airy spatial character.



Right top and bottom: *Some of the existing corridors were enclosed with a latter-day opaque cladding, creating rather dark and unpleasant spaces within.*
Far right top and bottom: *Latter-day flat roofs enclosed original courtyards to create more usable floor area, including the exhibition hall of the Red Dot Museum.. However existing interior spaces on the first and second storeys were also deprived of natural daylight.*

The main conservation strategy aimed to restore the original courtyards, considered key character-defining elements of the building, in order to serve as effective orientation points within the complex, as well as optimise daylight entry.

Instead of opaque partitions, public and private areas at the ground level are subtly differentiated by design cues such as new column cladding and hardscape treatment; the private lift lobby is not enclosed, and even security gantries are low key and visually light. Together with the restored open courtyards, this ensures **visual porosity across the ground level**. The series of courtyards are designed to be distinguishable through different architectural treatments, such as a new glass curtain wall, infill glazing or aluminium cladding. These courtyards become important orientation devices, facilitating **wayfinding** for both tenants and visitors.

Bottom left: *New annex blocks are discreetly inserted on one end of the courtyards.* ***Bottom right:*** *The open ground floor and landscape design aim to enhance spatial porosity and to create pleasant informal spaces.*

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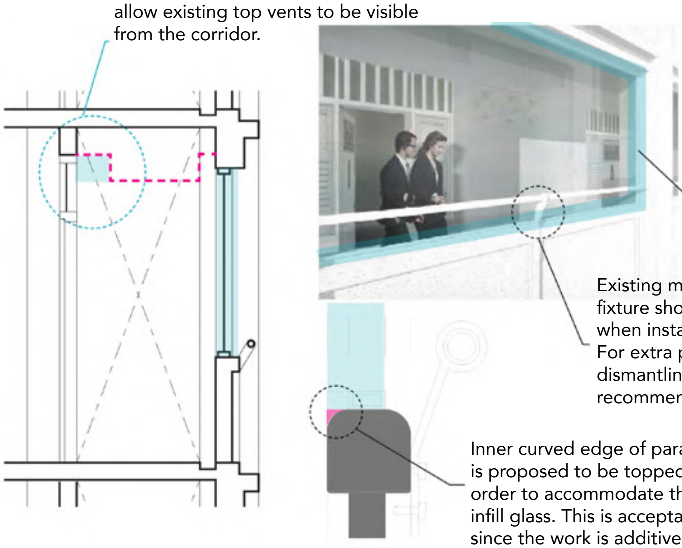
Given the shallow depth of the open corridors, it was deemed critical for them to be weatherproofed to protect building users from the elements such as driving rain, as they moved between offices and around the building. Fixed glazing panels using low-emissivity glass were installed to enclose the corridors while allowing views out and daylight to enter; the courtyards remained open-to-sky. This strategy was preferred over roofing over the courtyards which would have vastly increased the ACMV cooling load of the development. The **rainproofed corridors** also provided an avenue for the integration of M&E routing throughout the building.

Typical office entrance along the inner leaf facades. The original door leaf was modified to replace the solid timber panel with glazing, to introduce more daylight from the courtyards into the suites.



New glazing panels were added to weatherproof the narrow courtyard-facing corridors, with sensitive detailing that would minimise physical and visual impact on the historic architecture.

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Design Integration of M&E Systems

Refer to *Chapter 1: Introduction* of this volume for key principles and best practices for M&E design integration in historic buildings.

The Traffic Police Headquarters was designed and built as a **'workhorse' mixed-use building** with administrative offices, training and operational departments, living quarters, communal facilities – achieved with great economy of means, especially in terms of construction materials and spatial provision. M&E provision appeared to be minimal, relying instead on passive design features that promoted cross ventilation and natural daylighting through the courtyards, open-sided verandahs and a porous building envelope with numerous facade openings.

The **design challenge** was to adapt a naturally ventilated institutional building for **premium office usage**, to be fully equipped with a whole slew of modern provisions such as ACMV, telecommunications, fibre network, security and fire protection. Compared to new-built 'Grade A' office tower spaces conventionally favoured by premium commercial tenants, TPHQ poses many physical constraints. In particular, the floor-to-ceiling height in most interior spaces was barely 3 metres. The **ceiling space to accommodate services** is further limited by the 2.7 metres height of the historic interior doors with top vents. Cable trays or false ceilings have to be confined above this height to avoid obscuring these character-defining elements. This critical issue was recognised and prioritised by the architect and engineers, and close design coordination commenced very early on in the project.

View from the courtyard of the glazed corridors and its neatly integrated exposed ceiling M&E conduit trays.

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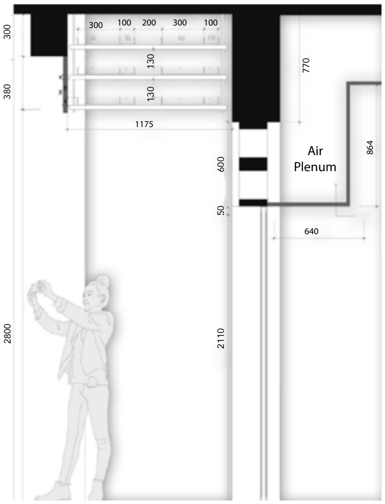
From the early design stage, the architect eschewed the use of extravagant new finishes in the upgrading works, being cognisant of the associative value of the historic architectural finishes of plainfaced plaster and cement screed to the original function of the building. A **restrained material palette** in a monochromatic colour scheme was introduced through various materials such as dark grey floor tiles for public circulation corridors, pebble-wash for the open courtyards, white perforated aluminium screens and grey-tinted infill glazing. These carefully curated finishes not only suited the historic architectural expression but also complemented the exposed design of the M&E services.

STREAMLINING CORRIDOR M&E CEILING

The new glazed-in courtyard corridors were designated as the main M&E 'arteries' where the main conduits, comprising numerous cables and ducts, would be accommodated below the ceiling soffit. The main strategy was to consolidate the services into six **exposed cable trays**, tightly stacked in three layers. The final design sees a staggered arrangement of the layers, providing easy access for maintenance. Corridor lighting, a public announcement system and fire safety provisions were cleverly integrated within the gaps of the cable trays. False ceilings were omitted to maximise headroom height; the exposed cable trays were carefully detailed to ensure they did not become detractive elements. This solution optimised the limited available space while fulfilling all requirements for modern services, and in addition, achieved design and conservation intentions.

Schematic section of the cable tray arrangement in common corridors on the first storey.



Below left: *Final design of the three-tier cable tray system with integrated lighting, PA and fire protection system on the first storey*
Below right: *The ceiling height of the fourth storey was considerably more limiting than the lower storeys. The cable trays are kept suspended above historic interior doors. Where required, FCUs are suspended at the location of historic vents.*

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ACMV INTEGRATION

The provision of **air conditioning** was deemed necessary for the building's new use as premium office suites. A fairly common requirement in the adaptive reuse of historic buildings, air conditioning presents a challenge in conservation design integration without damaging or detracting from the original architecture.

For Maxwell Chambers Suites, a centralised **variable refrigerant volume (VRV) system** with individual suspended fan coil units (FCUs) was utilised to cool the building's interior. This system is commonly used for medium to large commercial buildings. The air-conditioned spaces were confined to office units, ancillary uses, circulation spaces and the central courtyard lobby. Other courtyards remained open-air, greatly reducing cooling load if compared to the alternative of enclosing and air-conditioning all courtyards.

Large **VRV units** were located on the flat roof of the rear block, replacing previous cooling towers, and screened off with metal grilles. To reduce their visual impact, the placement was also set back from the facade and existing chimneys. At the same time, interior refrigerant ducts were concealed above the other M&E services.

The key ACMV integration strategy involved fine-tuning the design and distribution of **fresh air intake ducts** while preserving the integrity and legibility of the facades as much as possible. There were two alternatives – ducting fresh air from the courtyards, or from the street fronting facades. The former was not adopted due to a longer travel distance of the ducting and more penetrations through the historic inner-leaf facades, which were deemed unfeasible. The final solution adopted the latter approach, facilitated by findings from historic research and field surveys of the facades.

Right: *ACMV equipment is located on the flat roof, discreetly screened by aluminium trellises.*
Far right: *Fresh air intake ducts are located on the facade, designed to be integrated with historic fenestrations so that no extra wall openings are needed.*

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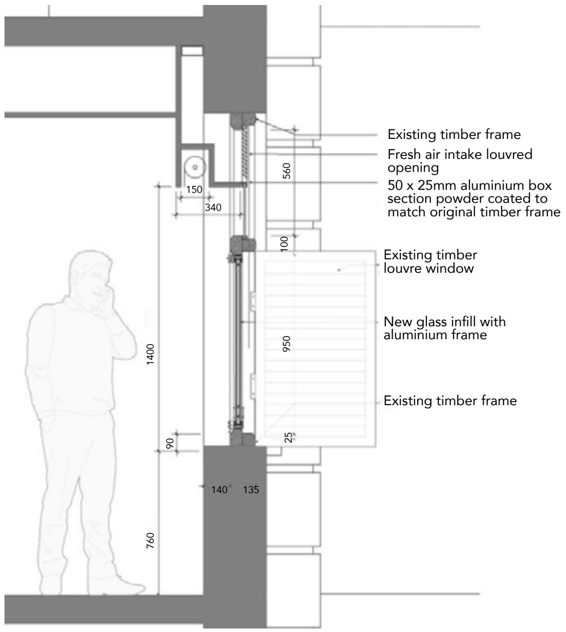
It was found that many windows had undergone ad hoc alterations. In particular, the original window toplights had mostly been replaced with latter-day ones of incompatible design. These were recommended for reinstatement to recover the legibility of the historic facade design – this presented an opportunity to **integrate fresh air intake with the reinstated toplights**. An aluminium grille was installed behind each selected reinstated top hung panel. The latter would be kept permanently half-open for fresh air intake to the ACMV ductwork, concealed within the plenum behind the toplights. The final design is unobtrusive; at the same time, the selection of top lights for modification was randomised across the building elevation, enlivening the otherwise regimented facades.

Left: *Insensitively modified windows, many of which had their characteristic louvres and vents removed, were slated for restoration to their historic design.*
Middle and right: *Fresh air intake grille being installed behind a selected top light, connected to FCUs within the office units.*

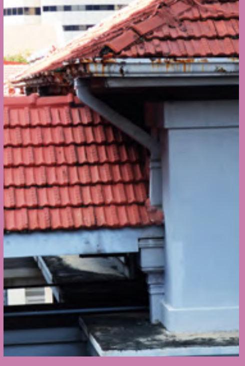


Above: *The intake ducts are camouflaged by being located at randomly open top lights, creating visual interest on the facade.*
Right: *Schematic section of fresh air intake ducts with aluminium grilles installed behind partially open window top lights that were reinstated.*

RESTORATION OF HISTORIC RAINWATER DISCHARGE SYSTEM

In most cases, historic buildings that undergo adaptive reuse require modification of the rainwater drainage system to comply with NEA regulations. Unfortunately this often results in their complete removal. In some cases, historic cast iron rainwater goods may be sealed up and retained as an ornamental feature, while rainwater discharge occurs by free-fall from the roof eaves, or via a new siphonic discharge system. For Maxwell Chambers Suites, these options were deemed unfeasible due to site and project constraints.

Instead, the historic cast iron rainwater goods were **restored for continued use**. The rainwater goods were found to be badly deteriorated, with signs of corrosion, breakage and loss of components. A number of historic gutters had also been inappropriately replaced with galvanised steel parts in the previous refurbishment, resulting in the need for extensive **new fabrication**. **Localised repair and partial replacement** were prioritised over complete replacement of the rainwater goods where possible.



Left: ***Badly deteriorated historic cast iron rainwater goods.*** *Middle and right:* ***Restored historic rainwater gutter and rainwater downpipes along all facades and internal courtyards of the building.***

Refer to NEA Code of Practice on Environmental Health for the relevant compliance guidelines regarding building rainwater discharge and rainwater goods.

Refer to Volume 2: Roofs, Chapter 7 Roof Accessories and Ornaments, section on Rainwater Goods, for more information on the restoration of these historic elements.

Refer also to Chapter 1: Introduction of this volume for key principles and best practices for roof and rainwater discharge.

Cold welding technique was used to repair cracked areas to avoid temperature differential, which could cause further cracking.

Prior to recasting missing and broken elements, the composition of original cast iron goods was identified through testing, and similar **metal composition** was used for the replacements. The approach ensured that the original material fabric was preserved as much as possible, while new replacements matched the historic goods in both appearance and compatibility. The use of cast iron also ensured the **material compatibility and durability** of restored goods, as compared to when galvanised steel replacements were used.

Design enhancements were also introduced to the restored rainwater drainage system to address some inherent flaws in the original design. One of the main challenges was to devise an efficient **gutter gradient** without over-reliance on waterproofing coatings, which could trap debris. The final solution was to physically gradate the gutters to form a slope. This had to be carefully calculated due to limited surface area available for fastening the gutters. New strengthened connection details were designed to ensure that these gutters were securely fastened onto the roof fascia.

Molten iron being poured into a mould to recast rainwater gutters.

Left: ***A newly cast segment of rainwater downpipe.***
Right: ***Newly installed gutter. The repaired and replaced cast iron goods are treated with anti-rust coating and paint to protect them from deterioration.***

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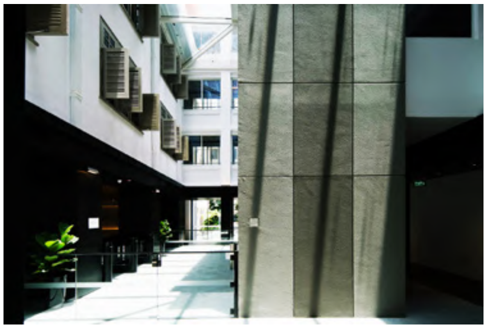
Accessibility and Circulation

Refer to Chapter 1: Introduction for key principles and best practices for accessibility and universal design.

Refer to BCA Code on Accessibility for the relevant compliance guidelines for universal design.

Main vehicular entrance at the rear facade of the building, with steps and ramps leading into the raised main lobby.

Universal design and accessibility at Maxwell Chambers Suites was embraced at different levels, from the widest sense down to details. At the planning level, a **new bridge** was constructed to link the third storey of the building with the adjacent Maxwell Chambers. On the ground floor, a **24-hour public access thoroughway** was introduced, connecting the front Maxwell Road entrance with the rear of the development. To ensure seamless universal accessibility from the exterior to the interior, sheltered **accessibility-compliant ramps** were introduced at the vehicular drop-off point at the rear entrance.



Left: *Each courtyard has distinctive architectural treatment and landscaping to provide wayfinding and orientation.*
Middle: *A visually porous main lobby with clear sightlines to the lift core greets tenants and visitors. 24-hour public access to Maxwell Road is provided along this major thoroughfare.*
Right: *The new lift lobby with black clad columns and glazed atrium roof defining the secured lobby for tenants.*

***Left:** Elevation outside the newly added corridors (on the left) subtly contrasts with the adjacent and opposite historic corridors. **Right:** Schematic section depicts introduction of accessibility-compliant ramps to offset level differences.*

NEGOTIATING DIFFERENT FLOOR LEVELS

Since its completion in 1928, the Traffic Police Headquarters saw numerous addition and modification works throughout its almost 90 years of use. These resulted in **varying floor levels** between different wings of the complex, and on different storeys. This posed a serious challenge when designing for universal access, especially for the ambulant-disabled.

In particular, the rear block sees varying floor levels over short distances longitudinally. These were previously negotiated through short flights of steps, which were not ideal for universal access. To maintain a clear entrance to each office unit, a **new multistorey corridor** 'core' was added to accommodate new ramps. These extensions avoided directly interfacing with or obscuring historic architectural features of the original corridors. The elevation design of these corridor 'cores' took reference from its surroundings while subtly differentiating itself as a new addition.

ELEVATORS

Another key universal access design issue involved **vertical circulation planning**. There was an existing bank of elevators in the central courtyard, which needed to be upgraded. The old elevator landings were a few steps out of alignment with the historic floor slab levels.

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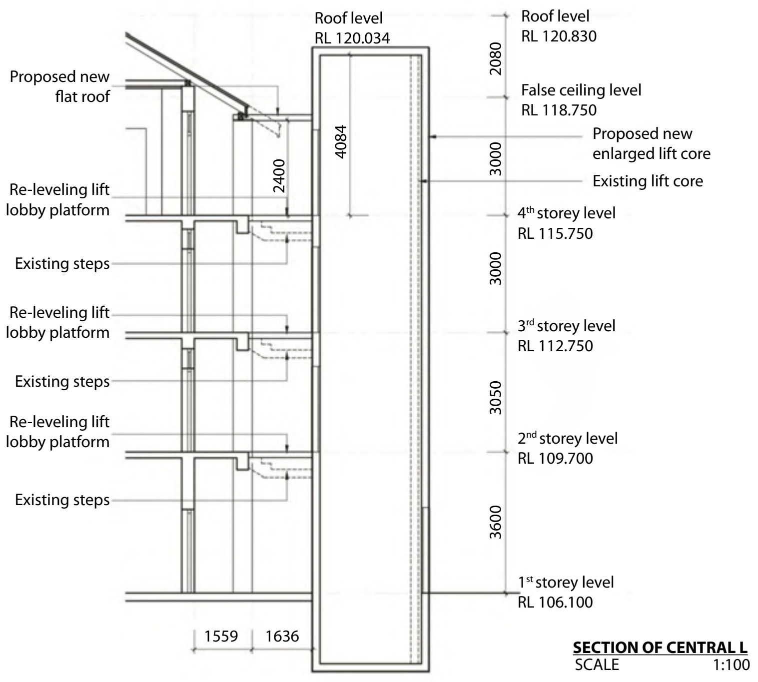
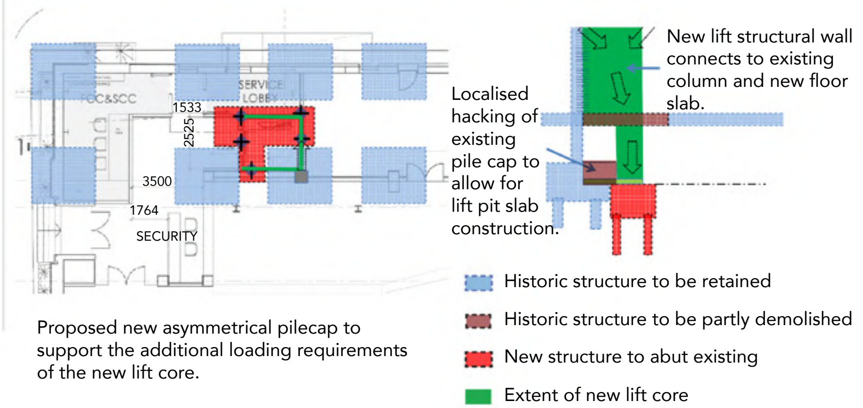
__Above:__ Prior to this round of restoration in 2016, a small flight of steps was required to access the elevator lobby on every level, presenting challenges in accessibility.
__Right:__ Section demonstrating existing accessibility barrier (dotted lines) and the enhanced design.



In this round of restoration works, it was decided to retain the elevator structural core at its original centralised location, while reconstructing the **lift landings** to match the rest of the building to achieve a completely **level and step-free configuration**. Elsewhere, a **new service lift core and lobby** was inserted at the Wallich Street side entrance. Skilful structural design ensured that invasive works were carried out only where absolutely necessary, safeguarding the integrity of the historic fabric as much as possible.

Sensitive structural strengthening to the foundations to allow for the new service lift core was undertaken to ensure maximum retention of historic fabric.



6 CASE STUDY: NATIONAL GALLERY SINGAPORE | **FORMER SUPREME COURT AND CITY HALL**

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Case Study: National Gallery Singapore | Former Supreme Court and City Hall

Location: 1 St. Andrew's Road

Project: Adaptive reuse of two National Monuments as the national art gallery, with remodeling interventions, structural strengthening and integration of heavy services.

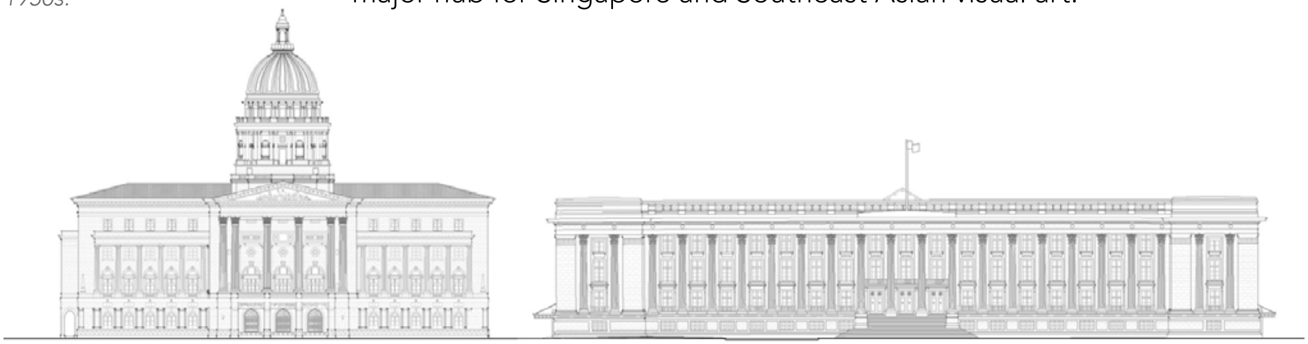
Year: 2015

Refer to Jury Citations for URA 2015 Architectural Heritage Award, National Gallery Singapore, for more information on the restoration project.

The Supreme Court and City Hall buildings in their urban surroundings circa 1950s.

With their impressive colonnaded facades fronting the **Padang**, and an unparalleled sea view for much of the 20th century, the former City Hall and Supreme Court buildings occupy the most **prominent location** in Singapore's old civic district. The monumental edifices took centre stage at momentous historical events as well. In 1945, the **Japanese surrender** to the Allied Forces took place in the City Hall Chamber, marking the end of World War II. Singapore's first **Prime Minister Lee Kuan Yew** took his oath of office in the same space in 1959, and the country's full internal **self-government** was jubilantly declared on the grand steps. Both buildings were gazetted as National Monuments in 1992.

Following a high profile design competition, the former City Hall and Supreme Court underwent substantial remodelling from 2006 to 2015 to house the new **National Gallery Singapore** (NGS), envisioned as a major hub for Singapore and Southeast Asian visual art.



The imposing colonnaded facades sought to convey the benevolent power of colonial governance.

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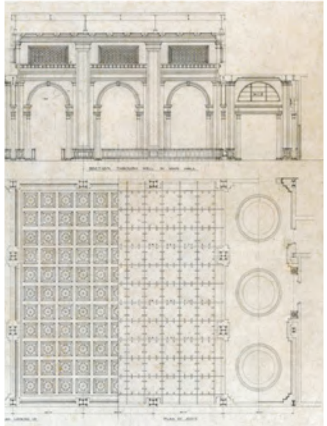
Left: *Louis Mountbatten inspecting the naval guard of honour outside the Municipal Building (later known as City Hall) with its grand colonnaded facade, prior to the surrender ceremony held there in the Chamber, on 12 September 1945.*
Right: *The restored City Hall Chamber, one of the most significant interiors in Singapore history.*

BRIEF HISTORY AND CHARACTER-DEFINING ELEMENTS

The two buildings' **neoclassical** architectural expression finished in **granolithic artificial stone**, also known as Shanghai plaster, belies their thoroughly modern **steel and concrete construction**, the preferred material choice for government buildings of such scale during the interwar years.

The four-storey City Hall building (originally known as the Municipal Building until 1951), constructed in **1929**, was designed by Municipal Architects **Alexander Gordon** and **S.D. Meadows**. It used to house the offices of the **Municipal Council**, later known as the City Council, which was responsible, among other things, for the provision of essential infrastructure such as water, electricity and roads within the city limits. The City Hall saw numerous governmental departments occupy its premises until 2005 – amongst them the Public Service Commission – and an annex extension to the adjacent Supreme Court.

Majestic **Corinthian columns** define the City Hall's principal elevation, alternating with rhythmic rows of large **mild steel windows** on the innerleaf facade. To efficiently utilise the site while ensuring ample lighting and ventilation, the architects configured the building layout into a figure '8', where cellular office spaces with common corridors encircle two large **courtyards**. The central connecting block houses the City Hall's lavishly appointed **Chamber** featuring **teak dadoes** and massive **marble-clad columns** with **bronze capitals**.



Left: *Finely wrought details on one of the Corinthian column capitals that were painstakingly restored.* ***Middle and right:*** *The old Supreme Court interior is a tightly orchestrated series of architectural spaces, elements and finishes, and was largely intact before the restoration project.*

Old newspaper advertisements for the novel finishes used in the old Supreme Court building.

The old Supreme Court was constructed in **1937**, serving as Singapore's highest seat of justice for close to 70 years. The facilities moved to the adjacent new complex in 2005, and the building was vacated alongside its neighbour, the City Hall. Designed by Government Architect **Frank Dorrington Ward** of the Public Works Department, the neoclassical revivalist architecture features a grand central portico with a massive **tympanum** featuring the **Allegory of Justice statuary** and is crowned by a striking **copper dome** on a **colonnaded rotunda**. The introverted interiors are dominated by a grand entrance foyer and main hall. Administrative functions are located on the lower levels, while well-appointed **courtrooms** and a **library** occupy the upper storeys.

Compared to the sparsely decorated office spaces within the City Hall – save for the City Hall Chamber and stair halls clad in marble and replete with bronze fittings – **novel architectural finishes** abound within the old Supreme Court. Most notable is the **Cressonite rubber flooring** in marbleised effect, lauded as a modern material with an acoustical dampening effect, low maintenance, design versatility, and most of all hygienic properties. Alongside, **Eldorado acoustic cork tiling** is used on the floors and walls of the courtrooms for similar reasons. A further example is the use of **Crittall mild steel windows** throughout the building, where the slender frames and large glazed area optimise daylighting.

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Refer to Chapter 1 Introduction of this volume for key principles in carrying out conservation design integration for new uses, code compliance, services, and so on.

CONSERVATION APPROACH AND KEY CHALLENGES

Adapting historic buildings to accommodate significantly different programmatic and spatial requirements requires extensive design consideration on interface, circulation and spatial experience. Particularly, a gallery is subjected to stringent **environmental controls** and **security requirements** to ensure proper preservation of artworks and artefacts, including:

- Lighting
- Temperature and relative humidity (rH)
- Pollution and dust
- Theft protection
- Blast protection
- Fire protection

Besides reconfiguring these two buildings to perform as a single art institution, increased loading from visitors and equipment also meant **structural and remodelling work**. Yet, their National Monuments status placed stringent preservation requirements on the historic architectural elements, materials and key spaces. Given their sheer scale, historic significance, age and intactness, even the most basic intervention would have some degree of impact on the historic fabric. There was constant **negotiation** between the requirements of the **new design brief** and **conservation prerogatives** – at times conflicting, and even irreconcilable – throughout the entire design and construction process.

Exterior view of the restored building facades, with the new glazed canopy demarcating the new grand atrium entrance.

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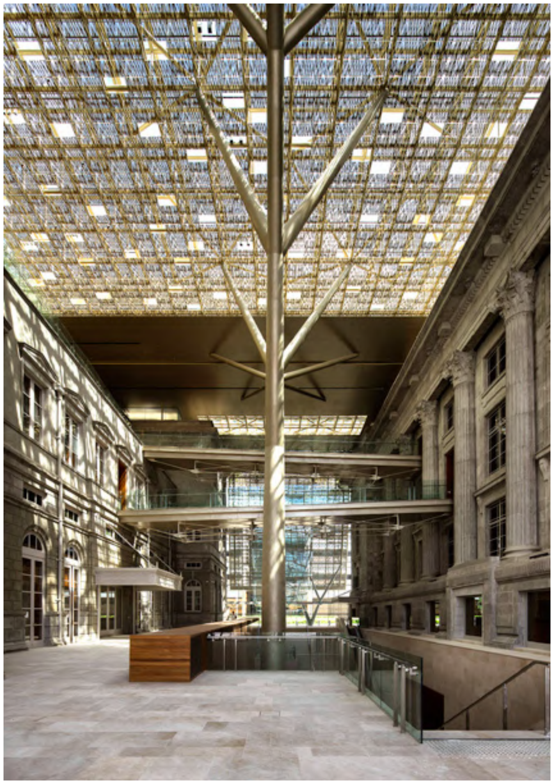
__Above:__ The open-air car park between the two buildings prior to restoration works.
__Right:__ The canopy, linkways and new basement concourse are the main strategies to unify the two buildings in this restoration.

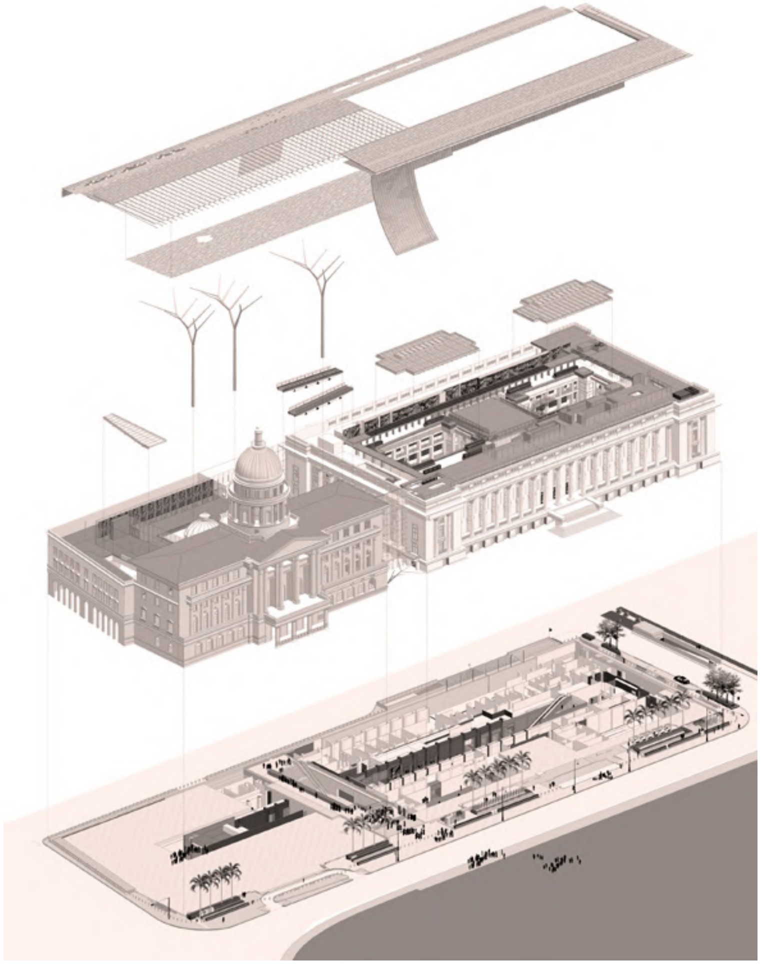


Being highly recognisable landmarks in the urban skyline of Singapore, and cemented in collective memories of Singaporeans as the setting for national pageantry, the legibility of the buildings' facades had to be maintained as much as possible. An expansive, **patterned glazed canopy** was introduced over the former open-air car park between the two buildings to create a new **triple-volume common atrium**. Conceived as the key unifying architectural device, the atrium features **link bridges** spanning dramatically between the two monuments, juxtaposed against the sweeping but visually light canopy. The design and materiality of new insertions were **restraint yet distinct** from the carefully restored historic fabric.

Refer to *Volume 4 Structures,* for more information on structural interventions on historic buildings.

New areas were needed to meet high-specifications gallery usage and building performance requirements. In the winning design scheme, this took the form of a **deep basement under the monuments**. However this called for extensive structural remodelling and rebuilding, with significant **impact to the historic fabric**.

Due to the deep pile foundation of the Supreme Court, a strategic decision was made to locate most of the basement under the City Hall which had a raft foundation. Compared to the highly intact interiors of the Supreme Court, **City Hall**, having undergone more latter-day modifications, was also considered as having more latitude to accommodate interventions. The **remodelling** presented an opportunity for **structural upgrading**, allowing the galleries for changing exhibitions, with its higher loading requirements, to be housed in the City Hall. The critical exceptions to these radical transformations were the facades, the Chamber and the marble-clad stair halls – areas of primary historic significance that were prioritised for careful in situ **retention and restoration**.



Above: *The carefully restored stair hall of the old City Hall, clad in Sicilian marble panelling.*
Right: *The key 'signature' interventions of the National Gallery project – the canopy, the basement linkage, and adaptive reuse of the two monuments.*

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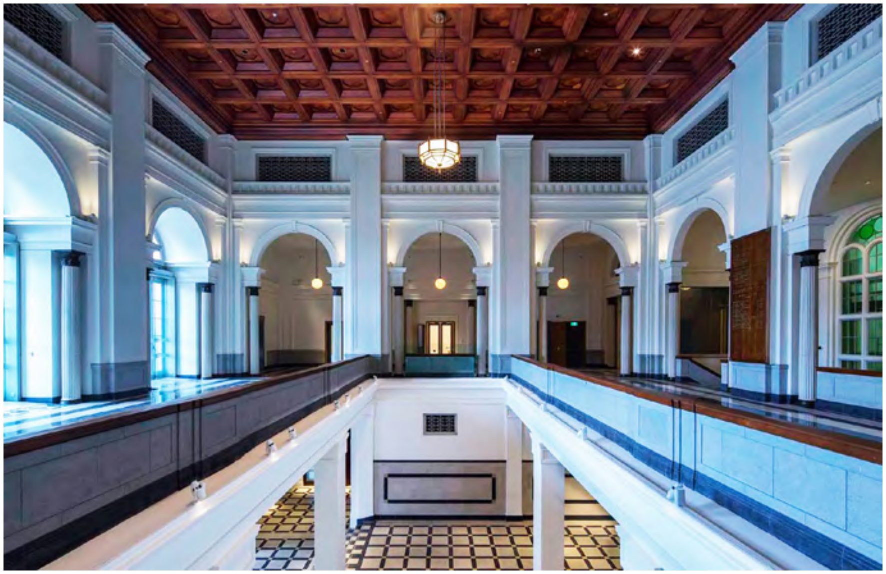

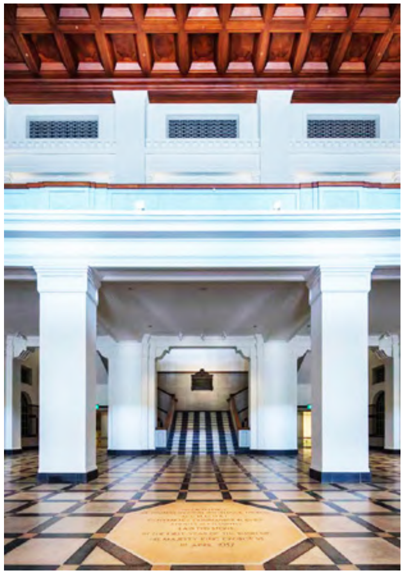

The decanting of new operational and back-of-house facilities of NGS enabled the historically and architecturally significant spaces – such as the Main Hall of the old Supreme Court – to be free from encumbrances and modifications and preserved in their entirety, including meticulously restored historic finishes such as the timber coffered ceilings, terrazzo flooring and moulded wall finishes.

On the other hand, the **Supreme Court** building had highly intact and spatially varied historic interiors. The overarching strategy prioritised the **repair and restoration** of extant elements in the high-key spaces such as the halls and courtrooms, and minimising intrusive interventions. Great care was taken to preserve the heritage attributes and spatial quality. Major intervention in the form of **structural strengthening** was achieved through surgical insertion of a new steel frame so as to safeguard the maximum extent of heritage features and finishes possible.

Heritage interpretation was further introduced to facilitate better appreciation of the historic monuments, including the retention and restoration of two of the historic prisoner holding cells in the old Supreme Court.

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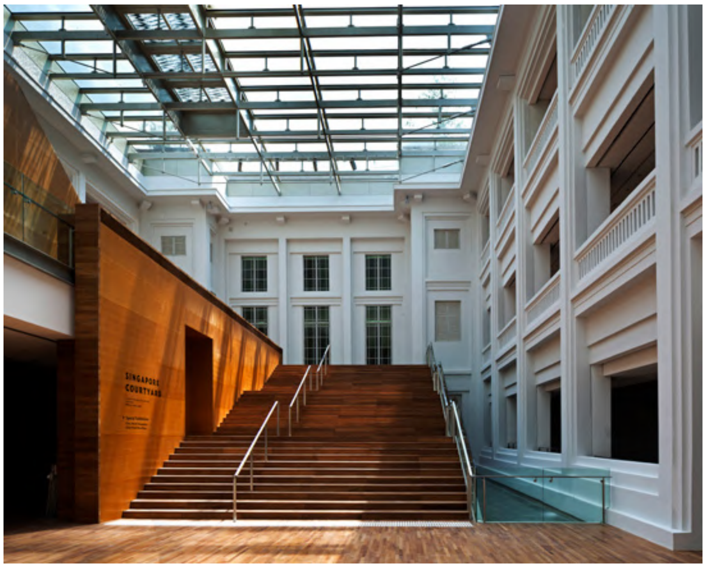
Refer to Chapter 1: Introduction of this volume for key principles and best practices for M&E design integration in historic buildings.

KEY ASPECTS COVERED IN THIS CASE STUDY

This case study examines the adaptive reuse of significant historic buildings that were subject to a **high degree of intervention** due to a **major change of use** and **demanding performance requirements**. According to the architects, limiting the extent, minimising invasivity, and maintaining the legibility of new interventions underscored the decision-making process, to safeguard and to **mitigate any negative impacts** on the historic fabric. Key strategic thrusts needed to strike a balance between inserting contemporary interventions and preserving the historic fabric, and at times the **'best compromise'** was sought to overcome directly conflicting demands. The key focus of this case study will be placed on:

- Major M&E design integration strategies – the **new basement concourse**, **new 'fat walls'**, **new roof terrace and plenum**
- Various design solutions addressing compliance for **accessibility and safety**, **security**, and **fire protections**
- Restoration of the **Courtrooms**, and design adaptation for services integration



Above: *The old City Hall courtyard prior to restoration.*
Right: *New atrium converted from the City Hall courtyard, with glazed roof that incorporates fire protection systems such as sprinklers and smoke extractors.*

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Key Design Integration Strategies

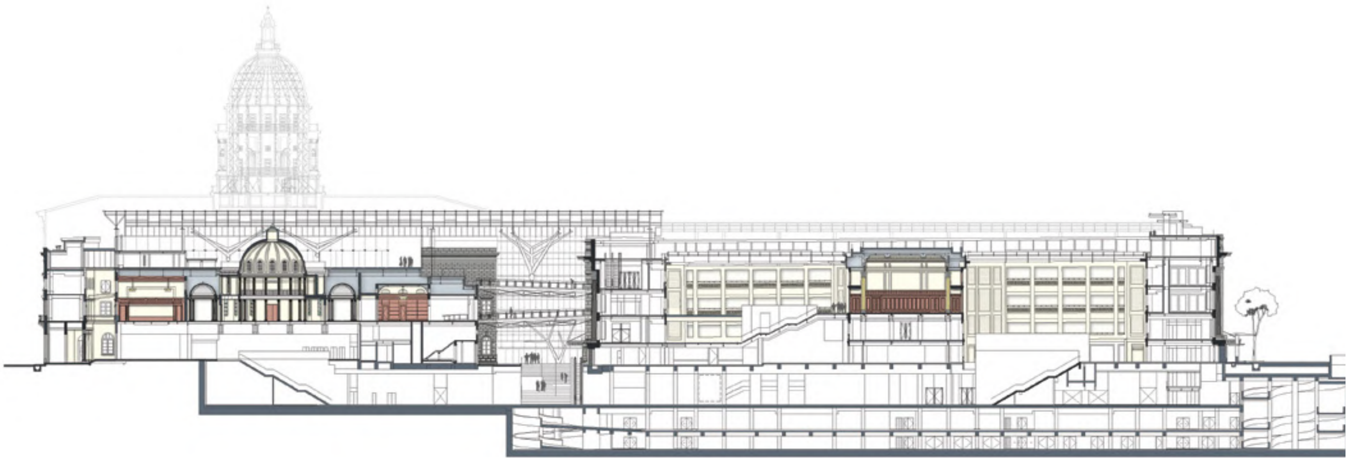
Aside from serving as a physical connector and new entrance point to the NGS, the new basement serves as a back-of-house and M&E spine between the two historic buildings.

For historic buildings, a material change of use often triggers extensive building performance upgrades that can translate into tremendous stress on their structure and fabric. Adapting the old City Hall and Supreme Court buildings into the NGS called for extensive upgrading and addition of M&E services, plant and equipment, some of which imposed an increase in structural loading requirement on the existing structures.

NEW BASEMENT CONCOURSE

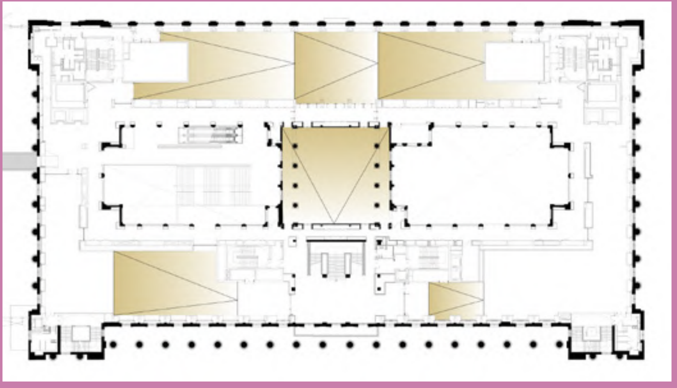
Besides the glazed roof canopy and common atrium, another major design intervention that serve to unite two very different buildings as a single art institution was the new **three-storey basement concourse**. Due to the deep pile foundation of the Supreme Court, the basement was mostly located under the City Hall which had a raft foundation. However this still called for extensive structural remodelling and rebuilding, causing significant impact to the historic fabric.

The concourse presents a new **shared entrance** into the buildings and also houses critical operational facilities such as ticketing, artwork handling, offices as well as heavy M&E plants. Decanting most of the utilitarian and back-of-house uses to the new basement minimises the need for them to occupy the historic spaces. The restored main halls of the City Hall and Supreme Court could thus remain relatively free from encumbrances, keeping their heritage character intact.

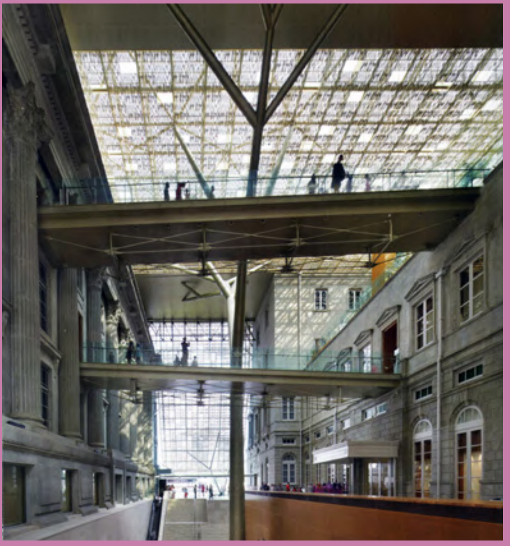


UNIVERSAL ACCESS AND SAFETY

RESOLVING LEVEL DIFFERENCES:
Likely due to its shallow foundations and past underground MRT works in proximity, the City Hall had undergone differential settlement, resulting in a level difference of almost 900mm from one diagonal end of the building to the other. To ensure seamless connectivity throughout all the public spaces in the building, slopes and ramps of gentle gradients were meticulously positioned through the new floor plates of each storey so as to mitigate the level differences.



DESIGNING FOR SAFETY:
New mild steel safety railings in low-key design were added to the grand staircase at the old City Hall podium.



CONNECTIVITY BETWEEN THE WINGS:
Within the atrium, two link bridges are created to connect the two buildings on two levels. On the third storey, the link bridge forms an axial connection between the former library at the old Supreme Court and the City Hall Chamber, both spaces of high heritage significance. Besides offering a dramatic visitor experience, the link bridges are important elements that promote universal access within the large complex.

Refer to BCA Code on Accessibility for the relevant compliance guidelines for universal design.

Refer to Chapter 1: Introduction for key principles and best practices for accessibility and universal design.

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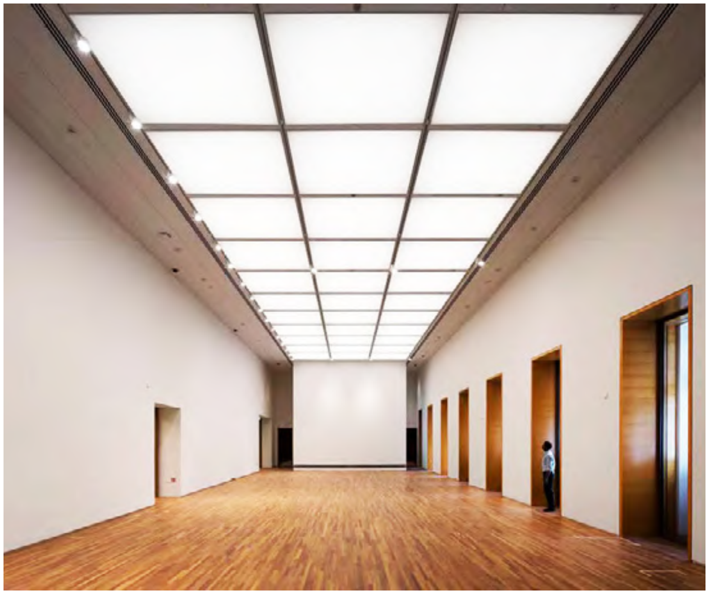
Please refer to *Chapter 1: Introduction*, sections on Airtightness and Hygrothermal Performance for design principles and considerations.

NEW 'FAT WALLS'

The preservation and presentation of artwork in a gallery require strict **environmental control**. Fluctuations in temperature, humidity, exposure to pollutants and UV will adversely affect materials and pigments used for artwork. **Ideal conditions for artworks** generally include: minimum exposure to UV light, a temperature of 16 – 20 degrees, and relative humidity (RH) of 30 – 60%. These conditions are usually achieved by the integration of computer-controlled HVAC systems and monitoring devices such as hygrothermograph to ensure optimal environmental conditions around the clock.

The 'fat walls' of NGS – a new **secondary peripheral drywall** installed behind the historic facades – cleverly integrate this modern HVAC equipment while leaving original openings intact. Although the wall thickness takes up some usable floor area, several **critical building performance upgrades** – structural strengthening, M&E conduits, exterior lighting, daylight control, new secondary doors and windows with thermal, acoustic, anti-blast requirements – could be integrated within this single architectural gesture.



The introduction of dry partition 'fat walls' hugging the interior side of the historic facade walls was intended for the design integration of extensive services without obscuring existing openings or drastically changing spatial proportions.

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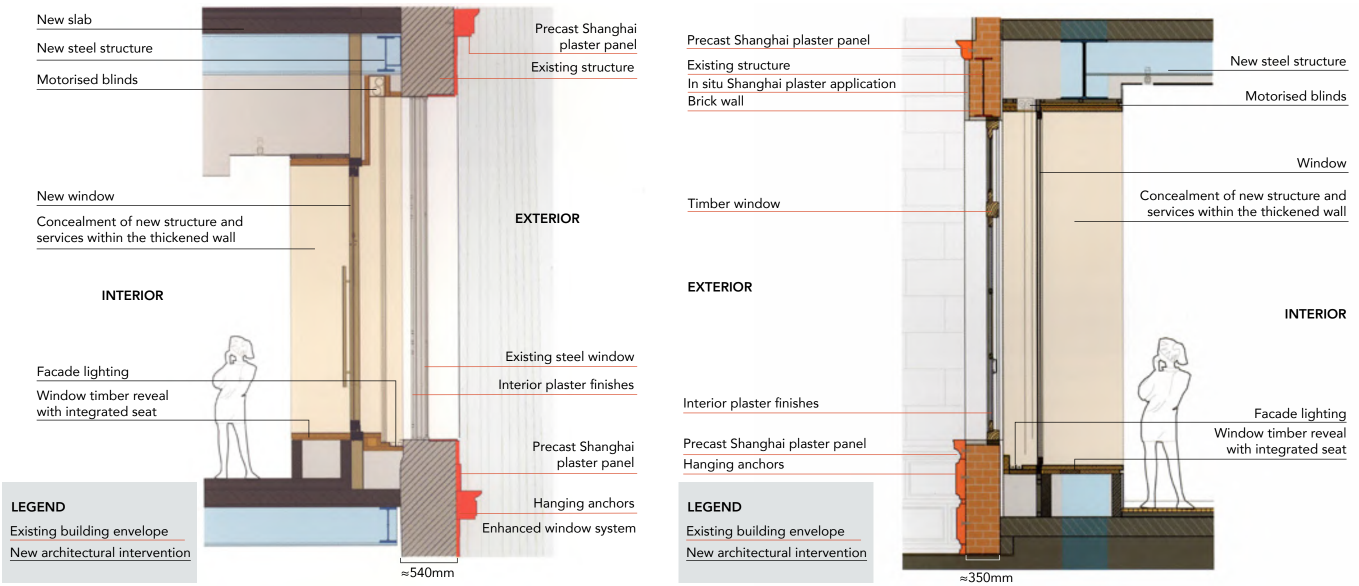
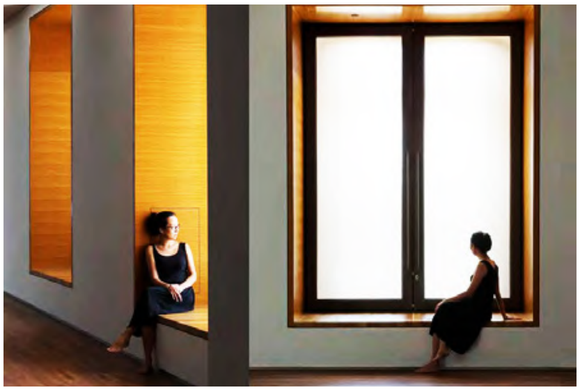


*Sectional details of the 'fat walls' at old City Hall (**left**) and Supreme Court (**right**).*

The 'fat walls' serve to attenuate the harsh tropical sunlight and maintain a stable internal environment, through incorporating new **secondary windows** with high-performance glazing to cut down on solar heat gain. The majority of the existing timber and steel framed windows and green-tinted glazing were retained as a result. This strategy thus ensured that the original scale and spatial quality of the historic architecture is maintained, while stringent performance requirements for a modern gallery are met.



Translucent secondary glazing allows details of the restored historic windows to be appreciated from the inside while fulfilling climatic and security performance.

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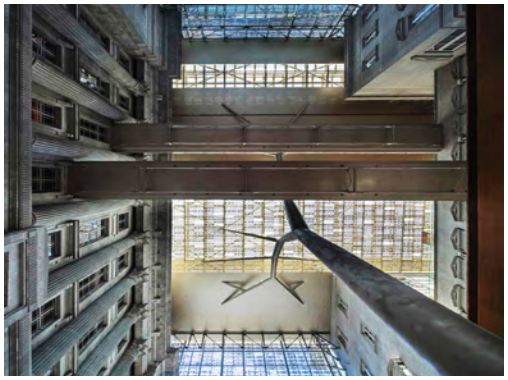
The new glazed canopy drapes over the new main entrance to the NGS atrium.

NEW ROOF CANOPY, TERRACE AND PLENUM

The central atrium serves as the main entrance foyer, where a monumental flight of steps leads to the basement ticketing concourse. The voluminous atrium is roofed over by a **patterned glazed canopy** that drapes downwards at both ends, described by the architect as a **'veil'** that filters the harsh glare from the overhead tropical sun, with low-emissivity glazing layered above perforated aluminium shading screens. The **filtered daylight** illuminates the interior spaces through the numerous openings on the monuments' facades facing the atrium. This reduces dependence on artificial lighting and preserves the **characteristic light quality and ambience** of the historic interiors.

This glazed canopy extends above the Rotunda dome of the former Supreme Court, over a **new roof terrace** designated as an event space. The roof terrace allows visitors to appreciate up close the smaller dome, a little-known feature previously hidden from public view. This key design gesture and intervention to the formerly exposed roofs of the Supreme Court is driven by a few interrelated considerations.



Left: *Sunlight is filtered through perforated metal screens installed below the glazed panels, supported on a few slender 'tree columns'.*
Right: *The Rotunda dome restored in plaster and paint finish. The new roof terrace allows visitors to view the dome up close. Attractive shadow patterns reminiscent of traditional rattan weaving craft are cast.*

The historic roofscape – hidden from public view – originally comprised a series of barrel vaults, circular jackroofs and pitched roofs over the courtrooms.

Historically, all the courtrooms were housed in the rear and side wings, around the central Library Rotunda, linked by circumambulatory hallways. To allow **daylight and natural ventilation** through the deep plan, the **hallways** were crowned by **barrel vaults with clerestories** at both ends, and punctuated at junctions by **circular jackroofs**. Each of the four large courtrooms, capped by their own pitched roof, were illuminated by generous **mild steel framed clerestories** as well. When air conditioning was later introduced, the M&E equipment was installed on this roof space.

Over time, however, this rather sophisticated daylighting and ventilation system has not weathered well under the tropical climate. The complex, fragmented roofscape with its numerous interfacing joints and varying construction was challenging to maintain, and led to perennial rainwater seepage. This caused extensive deterioration to the historic interior finishes, such as the beautifully hand-rendered terrazzo walls.

The introduction of a new terrace above this historic roofscape was the **'best compromise' solution**, providing permanent weather protection. With the added roof plane, the second-storey hallways were no longer lit by daylight entering through the clerestories and skylights, with their historic ambience and spatial character somewhat diminished. Although there was still some diffused daylight through the restored corridor windows, the dramatic illumination highlighting the vaults and hallway junctions has largely been replaced by artificial lighting.

The clerestory lights facilitate daylighting and natural ventilation of the deep plan interiors, with dramatic illumination highlighting the corridor junctions, vaults and reflecting off the mother-of-pearl terrazzo finishes.

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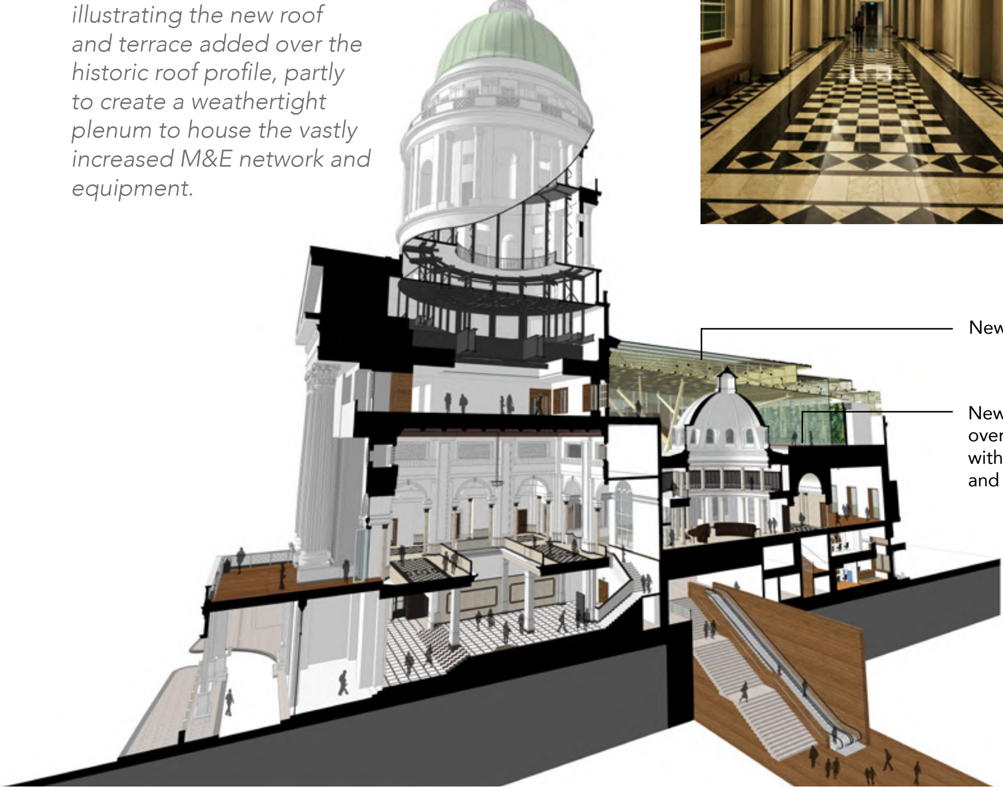
Nevertheless, the roof terrace and glazed canopy extension critically restored the **watertightness** of the old Supreme Court's building envelope, resolving the inherent design flaws of the original fragmented roof design. The airspace between the old and new roof planes could also be utilised as a continuous **building services plenum** where the thick swath of conduits such as ACMV ducting could be neatly accommodated and routed. These served the **heavily serviced new permanent collection galleries** converted from the **old court rooms,** routed through existing clerestories that opened into the rooftop service plenum space.

The second-storey passageway after restoration, where a new roof terrace was added above the existing barrel vaults, cutting off the entry of daylight through the semicircular clerestories. The space is now artificially and evenly lit throughout the day.

Sectional drawing illustrating the new roof and terrace added over the historic roof profile, partly to create a weathertight plenum to house the vastly increased M&E network and equipment.



SECURITY

For high-security buildings, **apertures** in the building fabric present additional considerations. For this reason, some early building retrofits took the approach of sealing up original fenestration deemed to pose high security risks. Restored at a time when the threat of global terrorism was on the rise, an **enhanced security classification** on the National Gallery resulted in stringent requirements. **Anti-blast glass** is used for new enclosures such as the new roof canopies, and added to historic fenestrations via new **secondary windows**. A coordinated design can effectively conserve historic apertures while fulfilling security requirements.

The restored Rotunda Library. New secondary anti-blast windows that match the historic design are installed at the clerestory lights of this space.

Refer to *Guidelines for Enhancing Building Security in Singapore*

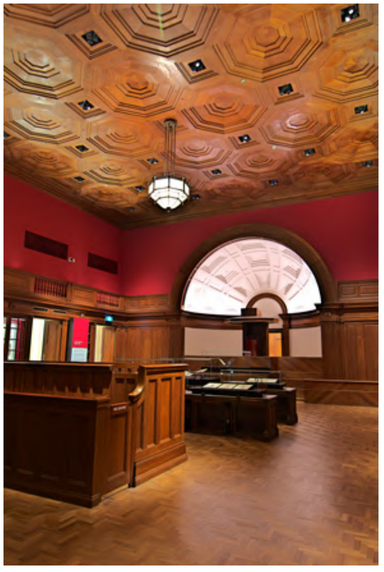
The Courtrooms: Services Integration for Historic Interiors

Refer to Volume 6 Interior Elements for conservation and intervention principles in the restoration of historic interiors, and for more information on the restoration processes and best practices of specific materials such as timber.

As spaces of **primary historic signficance** in the former Supreme Court building, the old courtrooms were slated for **maximum retention** of character-defining elements, materiality and spatial quality. Other than intact architectural finishes, such as the **octogonal coffered timber ceiling**, these rooms were also found with **intricate timber furniture**, fittings and cabinetry that imparted a stately, dignified quality. These were all painstakingly dismantled and restored; the cabinetries were installed with security glass and repurposed as display cases for artefacts and artwork. The **Chief Justice's Courtroom** is today the most intact, with all its furniture and fittings preserved and adapted as part of the New Gallery, including the judges' proscenium and bench, prisoner's dock, and witness benches.

The main challenge in these spaces was the **integration of new M&E systems** such that it would not obstruct, obscure or, worse, cause damage to these significant historic features. From early conception of the project, the architects and engineers closely coordinated to explore alternative routes for new mechanical equipment in the courtrooms.

__Right:__ The Chief Justice's Courtroom before restoration.
__Far right:__ The fully restored old Chief Justice's Courtroom with original furniture and fitments retained and restored. The mezzanine-level clerestories were sealed from the interior for fire compartmentation, as well as ACMV supply and return air grilles.



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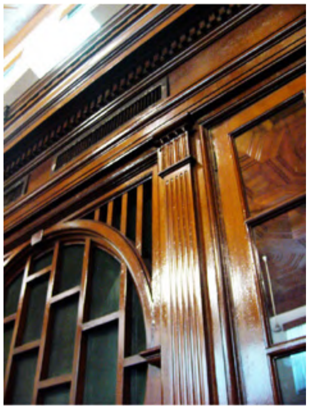
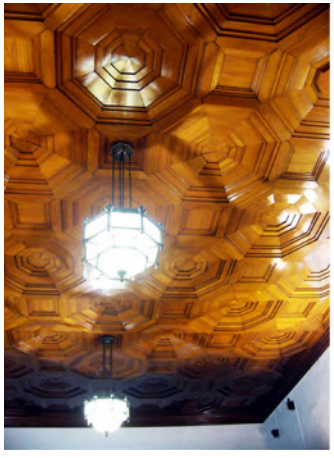
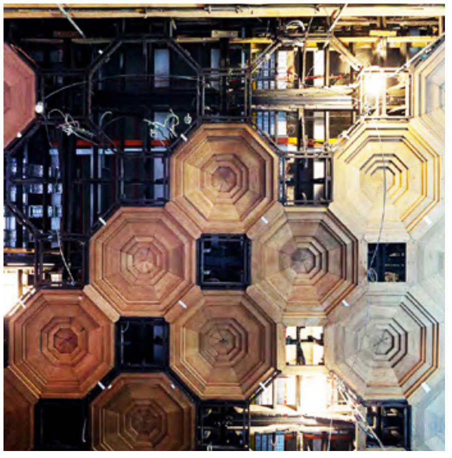
The historic Solo-Air cooled air system was cleverly integrated within the original timber shelves and dadoes of the courtrooms. These cavities and flues were partially reused in the NGS, and provided inspiration for similar treatment to conceal new M&E services within the architecturally important courtrooms.



As far as possible, the design team capitalised on and expanded **existing service interstitial spaces** to accommodate the new, much increased M&E provision. This included the **Solo-Air** cooled air ventilation ducting and flues cleverly integrated within timber panelling, cabinetry and furniture – one of the unusual historic design features in the old Supreme Court and an innovation of its times. A dense network of wiring and ducting was also integrated in the **existing ceiling space** above the restored timber ceilings. The result of this rigorous coordination is the elegantly restored courtrooms, adapted as the Permanent Galleries of the NGS.





Left: *The teak ornamented ceilings with historic bronze light fixtures before restoration.* ***Right:*** *The restored ceiling with new recessed downlights and fire protection sensors sensitively incorporated in a visually non-obtrusive way.*

Ornamented timber ceiling in the process of restoration, revealing a host of M&E services concealed above.

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Existing service spaces were still insufficient given the extensive servicing needed, and other areas of secondary significance were judiciously selected for intervention using the 'best compromise' approach. New secondary dry walls concealing air-conditioning ducts were installed along the length of the **courtroom mezzanine gallery walls**. These also covered up the mezzanine clerestories, now used as M&E entry points from the rooftop service plenum. While the historic mezzanine internal elevation and **mild steel clerestories** are obscured, and daylighting is sacrificed, the changes enabled the air-conditioning and strict interior lighting and humidity control requisite for gallery use.

Exterior view of mild steel windows at the courtroom mezzanine, prior to restoration.

Left top: *One of the courtrooms undergoing restoration. The mezzanine was originally lined with pivoted mild steel windows providing the interiors with daylight illumination.*
Left bottom: *A fully restored courtroom with original fittings, and new mezzanine dry walls installed over the mild steel windows. New services to control the room's environment are discreetly concealed within the dry walls and ceiling.*

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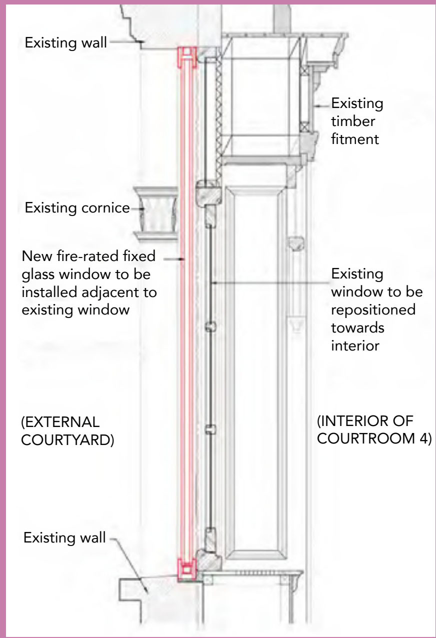
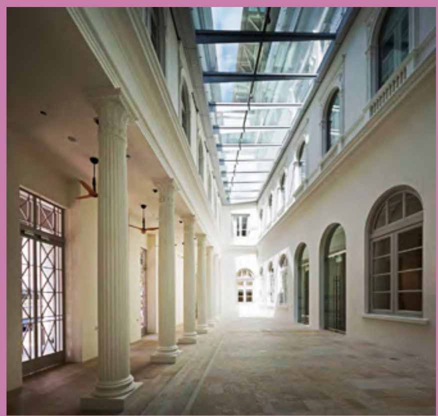
FIRE PROTECTION

The former **Court of Appeal** (Courtroom 4), adjacent to a narrow open-air courtyard that was enclosed with a new skylight, had to be **fire-compartmented** from this new double-volume atrium space to prevent fire spread. After deliberation on the appropriate approach, conventional solutions such as a fire-rated curtain were deemed unfeasible due to the lack of space to conceal the working mechanism.

Finally, new **fixed fire-rated glazing** was carefully added within the window reveals, after the original timber window and frames were carefully dismantled and repositioned to allow for this new installation. The existing window architrave, as well as the interior spatial quality of the courtroom, were not affected by this modification.



Window design enhancement for fire-compartmentation requirements.



Left and middle: ***The open-air courtyard before and after restoration; windows requiring fire protection are on the right side upper storey.*** *Right:* ***View of enhanced historic windows from within restored interiors.***

Refer to Fire Code 2023, Clause 9.9.1

Refer to Chapter 1: Introduction for key principles and best practices for fire protection design.

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Owner: Sharon Tay
Architect: Ezra Architects
Engineer: JS Tan Consultants Pte Ltd
Builder: Sage Builders Pte Ltd
URA Architectural Heritage Award 2019 Special Mention

101 Jalan Sultan (Completion: 2011)
Owner: O & Y Builders Pte Ltd
Architect: Kay Ngee Tan Architects
Engineer: Ronnie & Koh Consultants Pte Ltd
Builder: Towner Construction Pte Ltd
Winner of URA Architectural Heritage Award 2012

12, 13 & 17 Rochester Park (Completion: 2015)
Owner: BASF Southeast Asia Pte Ltd
Architect: Forum Architects Pte Ltd
Engineer: Ronnie & Koh Consultants Pte Ltd
Builder: Towner Construction Pte Ltd
Winner of URA Architectural Heritage Award 2015

"A" Queen Street, Cathedral of the Good Shepherd (Completion: 2016)
Owner: Titular Roman Catholic Archbishop of Singapore
Architect: Architects 61 Pte Ltd
Engineer: ECAS Consultants Pte Ltd
Conservation Consultant: Studio Lapis Conservation Pte Ltd
Builder: Shanghai Chong Kee Furniture and Construction Pte Ltd
Winner of URA Architectural Heritage Award 2017
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28 Maxwell Road, Former Traffic Police Headquarters (Completion: 2020)
Owner: Ministry of Law Singapore
Architect: W Architects Pte Ltd
Engineer: KTP Consultants Pte Ltd
Conservation Consultant: Studio Lapis Conservation Pte Ltd
Builder: Guan Ho Construction Pte Ltd

1 St. Andrew's Road, Former Supreme Court and City Hall (Completion: 2015)
Owner: National Gallery Singapore
Architect: CPG Consultants Pte Ltd & Studio Milou Pte Ltd
Engineer: CPG Consultants Pte Ltd
Conservation Consultant: ARC Consultants Pte Ltd
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ICOMOS 1964 Venice Charter
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Standards and Codes of Practice
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Building Control Act
BCA Building Safety Approved Document
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