SECTION

04

Victorian Case Studies

GROWING GREEN GUIDE

Case Study

The Venny Green Roof

Location

JJ Holland Park 85 Kensington Road, Kensington, Victoria

Completion Date

September 2010 (remediation works July 2013)

Cost

$123,000

Area

108m² lower roof, 103m² upper roof on a new building

Description

The Venny green roof comprises a lower flat roof, with planting designed around three sections – A, B, and C (Figure 1) – and an upper, sloping green (roof D), a later addition to the original brief. The green roof can be viewed from the ground, access is only available for maintenance. The upper roof contains an array of photovoltaic cells (44m²), two solar hot water panels and a roof ventilator, leaving approximately 46m² for planting.

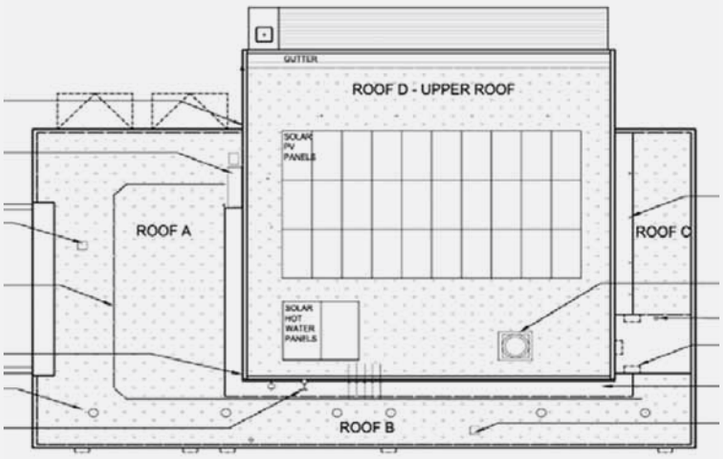
Introduction

The Venny is a community facility for children from the Melbourne suburb of Kensington and surrounding neighbourhoods. Design of The Venny was commissioned by the City of Melbourne, incorporating the use of recycled shipping containers. As protection was needed to insulate the spaces below the metal containers, a green roof was suggested as the most appropriate solution. It was also anticipated that the roof would expand the local knowledge of green roof design, installation and maintenance at a residential scale.

The project was a joint venture between the City of Melbourne, The University of Melbourne and Melbourne Water. The roof has also been a research site for The University of Melbourne, with funding provided through the Australian Research Council.

Detailed design of the lower areas was undertaken by The University of Melbourne and the upper green roof was designed by Junglefy Pty Ltd.

Figure 1: Schematic plan view of the Venny roof



Design and components

A ZinCo system was used for the waterproofing and drainage components. A low cost membrane material, Volclay Swelltite®, was used. The lower green roof comprises a ZinCo system, including a 25 mm drainage cell, and two different mineral-based substrates developed by The University of Melbourne. The upper roof used an alternative system incorporating a basal protection layer with irrigation (capillary irrigation matting) and, originally, a 100 per cent coir media at 100 mm depth. Galaku erosion control netting was used to hold the plants in place on the upper roof.

Plants for the green roofs were researched and selected by The University of Melbourne, based around aesthetic properties, drought tolerance and low resource inputs (water, fertiliser and maintenance). Most were succulents, particularly sedums, aloes and related species. They were planted at high densities to provide rapid cover and discourage weed infestation.

The upper roof has been designed to hold a green roof with a saturated load of 160kg/m^2 (including all plants, substrate, irrigation system and waterproofing). In addition to the 160kg/m^2 there has been an additional live load allowance of 40kg/m^2.

Maintenance

Management and maintenance was considered in the initial design, and a safe maintenance access point was important. A lockable alcove was designed with a purpose-built ladder and signage to comply with occupational health and safety standards. Paths of chipped recycled brick were incorporated into the initial design of the lower roof to minimise the impact of maintenance and research activities on plants and green roof infrastructure. These factors, combined with the specific species selection of drought tolerant plants and a close planting design, were considered to culminate in a green roof that could be safely managed, with low impact, and low maintenance requirements.

The first two years of maintenance and management was undertaken by The University of Melbourne, as part of its research studies, and Junglefy Pty Ltd. A comprehensive management plan was devised by The University of Melbourne and handed over to the City of Melbourne. This was the first green roof that the City of Melbourne's landscape maintenance team had experienced and some problems did occur when the irrigation system failed over summer. The maintenance visits also became infrequent which meant that the health of some of the species was compromised. After approximately six months' maintenance by the City of Melbourne the roof was evaluated and it was determined that while the lower green roof was satisfactory, the upper roof had not performed well. The coir growing media failed to support plants adequately – the only surviving species had drifted to the base of the roof slope. While disappointing, the substrate was used as a trial and the substrate and plant replacement was not an unexpected expense for the project.

Remediation of the upper green roof took place in July 2013. The University of Melbourne was contracted to develop a lightweight, mineral substrate and complete a planting design. Junglefy were re-engaged to take the lead in the remediation works – including the removal and replacement of the growing medium and the installation of new plants.

New ZinCo products, specifically designed for sloped roofs, were used, a 'back to base' alarm system for monitoring irrigation was installed, and Junglefy has continued ongoing maintenance of this space.

Plant species used on the upper roof 2010
Lampranthus deltoides
Sedum xrubrotinctum
Sedum mexicanum
Sedum pachyphyllum
Sedum reflexum

Roof A was planted with a mix of Australian and exotic herbaceous and succulent plant species

Costs - lower green roof

The lower green roof cost $69,070. Specific costs of project components are shown in the table.

Component	Cost
Shipping container steel frame	Recycled
Drain pipe system	$5,000
Bentonite Liner	$16,000
Concrete Screen	$18,000
Zinco System (Supply)	$7,150
Zinco System (Install)	$1,360
KISSS "Below Flow Flat" irrigation and associated controls	$6,330
Substrate growing median & crushed brick paths	$5,900
Coir Mulch Matting	$1,270
Plants (Supply)	$4,520
Plants (Install)	$3,540

Costs - upper green roof

The upper green roof cost $11,000, including the waterproofing layer, growing substrate, irrigation, plants and planting, labour and materials.

Note: it would be unrealistic to expect to replicate such a build for the same price today. Junglefy's involvement in construction was undertaken at cost due to its interest in developing this industry.

Remediation works in 2013 cost approximately $43,000.

Results and reflections

According to The Venny manager, the roof adds environmental, educational and economic benefits to the building. As a small-scale building the design could be applied in a residential context.

Lessons learned included that:

- the bentonite liner and concrete screed on the lower roof, expensive items which did not live up to expectation, would be avoided in future
- the use of 100 per cent coir as a substrate on the upper roof would be avoided (this was addressed in the remediation)
- the slope called for a water retention layer (this was added in the remediation in 2013).

The Venny has proven to be a pioneering project that has provided a valuable learning experience for the emerging green roof industry. Those involved in similar projects should invest in good materials for waterproofing and drainage, as well as consulting those with expertise in design and application to ensure plants are appropriate for the type of roof.

A consistent message in the reflections of The Venny green roof partners was that patience is required when undertaking something that is untested: it is a collaborative learning process through all stages from design through to management.

Mixed plantings and non-vegetated zones on The Venny roof

Sedum *x*rubrotinctum *surrounded by the larger, spreading* Carpobrotus modestus

Case Study

The Triptych Green Wall

Location

8-10 Kavanagh Street, Southbank, Victoria

Completion Date

2009

Cost

$350,000

Area

206m² on a new building

Description

Triptych Apartments include a large hydroponic green wall on the building's exterior south-east facade, extending up from the second level, above the footpath. It is visible to all vehicular and pedestrian passers-by, and is viewed by neighbouring office and apartment buildings.

Introduction

Visible from the street, the green wall feature was considered by the developer to provide a 'wow-factor', setting the building apart from other inner-city residences and blending in with the leafy streetscape.

The purpose of the green wall was to:

- obscure the view of the exterior of the multi-level parking area
- use foliage to soften the built environment
- provide habitat and increase diversity through the use of native and exotic plant species
- utilise collected rainwater

The property was owned by the Stable Group, and the project was completed by Nettletontribe architects and green wall specialists, Fytogreen.

Design and components

The wall includes 362 planting panels measuring 100 cm x 500 cm x 15 cm along with 44 planting panels measuring 75 cm x 50 cm x 15 cm. It is designed for a weight loading of 80kg/m² dead load.

A spray-on waterproofing material was used. A root barrier layer was not required because the air barrier between the wall and the modular system allows for air pruning. (Roots become exposed to the air, which dehydrates them and stops them growing further.) Polyurethane foam, a Fytogreen patented product, with felt wrapping was used as the growing medium. The foam modules are held in a steel cage, mounted on a wall using steel brackets.

Fytogreen's concept drawing shows the arrangement of species in swathes across the Triptych green wall

This view of the established green wall shows how the concept was translated into a lush, vegetated space

Plant species used
Dianella 'Little Jess'
Dianella 'Emerald Arch'
Dianella 'Breeze'
Lomandra 'Tanika'
Lomandra 'Wingarra'
Viola hederacea Native Violet
Rumohra adiantiformis Leatherleaf Fern
Nephrolepis obliterata Sword Fern
Asplenium bulbiferum Mother Spleenwort
Correa 'Dusky Bells'
Ficinia nodosa Knobby Club Rush
Orthrosanthus multiflorus Morning Iris
Campanula poscharskyana Serbian Bellflower
Liriope muscari 'Evergreen Giant'
Plectranthus ciliatus Spurflower
Aristea ecklonii Blue Star
Pachysandra terminalis Green Carpet
Sarcococca confusa Sweet Box
Liriope spicata Lilyturf
Arthropodium 'Parnell'
Arthropodium 'Te Puna'
Davalia tyermanii Bear's Paw Fern
Schefflera aboricola Dwarf Umbrella Tree
Strobilanthes anisophyllus Goldfussia
Erigeron karvinskianus Seaside Daisy
Acorus gramineus Green Acorus
Rosmarinus officinalis horizontalis Prostrate Rosemary
Chlorophytum variegatum Spider Plant
Cerastium tomentosum Snow-in-summer
Escallonia 'Newport Dwarf'
Euphorbia 'Chameleon'
Euphorbia 'Blackbird'
Viola odorata Sweet Violet

Plants are irrigated using a controlled release dripper system that runs to each separate module, using collected rainwater supplemented with mains water as required. Fertiliser is also delivered via the irrigation drip system. The stainless steel facia surrounding each panel guides any excess moisture to a steel drip tray at the base of the vertical garden.

Irrigation equipment includes a controller for timed irrigation cycles; a fertigation system for controlled fertiliser dosing through the irrigation system; water meter; pressure gauge; controlled volume drip irrigation line; and water storage tanks, filters and pumps.

Native and exotic plant species, chosen for aesthetic appeal, durability and biodiversity, are featured. The planting plan considered the differing levels of sun and shade across the wall surface, and the impact of plants shading one another as they grew. At 15 plants per panel, a total of 5,958 plants was required. For the planting stock, 140 mm container specimens were grown in an offsite greenhouse for eight to 12 weeks before installation. The benefit of using fully-grown plants is the immediate visual impact when installed.

The swathes (planted sections of different species) were specifically designed to control lateral wind movement over the host wall surface, either mitigating wind damage or creating niches for species in the leeward sides.

In addition to aesthetic appeal, plant species were chosen to be hardy, low maintenance and shade tolerant. Many of the species feature coloured foliage or flowers throughout the year, contributing to the beauty of the design.

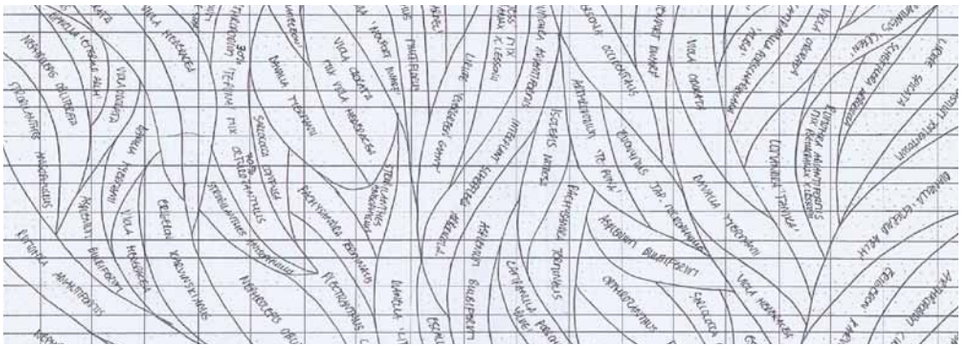
Careful consideration was given to the combination of species used, and their placement in relation to each other. All species were selected to offer cumulative control of pests and disease spread, wind, light and moisture, and to manage competition between species. The long-term growth patterns and likely reaction to the environment were also considered. High foliage coverage was sought for visual appeal and also to out-compete weeds.

Maintenance

By choosing species that respond well to each other, the green wall requires less maintenance than a more rigid design. The owners favoured this approach because it offered a long-term, adaptable and sustainable solution.

Fytogreen is contracted to undertake the maintenance. Maintenance is moderately fluid, pending seasonal changes and the client's aesthetic expectations. The Triptych owners embraced natural aesthetic forms and ongoing species self-adjusting, leading to a less restrictive maintenance process. Knuckle Boom lift access, requiring a small team of horticulturists, is generally conducted every three months.

Monthly checks, conducted by one person, assess water supply, quality and general garden condition.



The initial planning sketch by Fytogreen

Cost

The green wall project cost $350,000. This budget included a 12-month contract with Fytogreen covering maintenance of the green wall and defects liability. After this time, the maintenance contracts were negotiated between the parties and open for tender.

Results and reflections

Fytogreen reports that this is a statement green wall that has proven to be functional in terms of water usage, visual impact and has assisted with the selling of apartments. Using harvested rainwater from the building the plants are thriving and habitat is being created. Fytogreen notes the visual amenity provided to all surrounding parties, including passers-by.

In retrospect Fytogreen states it would have changed only one thing, and that was to have set up the wall to also be a research space for vertical garden species.

Fytogreen concludes that this is a large-scale green wall that puts Melbourne on the map. As it is free to view to all passers-by it provides inspiration to all to question technology, property value and the impacts of vegetation on built surfaces.

The green wall at Triptych adds another element to the street level vegetation

Images courtesy of Fytgreen

Case Study

RMIT University Building 21 Green Facade

Location

RMIT University city campus 124 La Trobe Street, Melbourne, Victoria

Completion Date

2011

Cost

$230,000

Area

122m² on existing building

Description

The green facade was constructed on the north and west-facing external walls of Building 21, a 60-year-old brick building. Planter boxes at the base of the facade support plants that climb up a trellis stretching the height of the wall. The wall can be viewed by the general public and is mostly seen by RMIT students and staff.

Introduction

The RMIT University city campus in Melbourne is a publicly accessible space made up of historical and modern buildings, interspersed with functional open areas. With the completion of University Lawn Precinct and the refurbishment of all of the surrounding buildings, Building 21 needed a facelift as the last piece in the precinct. A green facade was constructed on the rear of the building.

The Building 21 green facade was a joint project between RMIT University, Peter Elliot Architecture and Urban Design, engineers BHS Consultants, landscape architects Rush Wright Associates and TJS Services. The specific facade structure was provided by Ronstan Tensile Architecture.

Design and components

The facade includes the following elements:

- a Ronstan X-TEND mesh trellis system in a diamond-shaped pattern. The trellis system is secured in place by steel framing at the top, bottom and sides of the wall. There is a 40 cm gap between the trellis system and the brick facade of the building so no root barrier or waterproofing layers were needed
- planter boxes, which are mounted to the existing brick facade using a galvanised steel frame which encases the entire planter box. Zinc sheet vertical cladding covers the front of the boxes and extends down to hide the drainage system below

The sides and base of each planter box are lined with Atlantis® 30 mm Flo-Cell™ drainage cell and slotted Agridrain Pipe, and then covered with 2 mm geotextile Bidim® A14G membrane. The bases are lined with a 40 mm sheet of Hyrdocell hydro foam.

A drip irrigation system is used, with a slotted drainage pipe running along inside the base of the planter boxes to provide drainage.

Hydrocell 40 extensive media, a lightweight soil mix, was chosen to reduce stress on the existing brick wall. The substrate was topped with a 45 mm thick stone mulch layer to provide protection from the elements.

1 *Pre-construction*
2 *8 months post-construction*
3 *26 months post-construction*

Images courtesy Ronstan Tensile Architecture

Forty-nine individual 140 mm plants, *Kennedia rubicunda* (Dusky Coral Pea), were installed in the planter boxes. Temporary bamboo supports were used to help the plants grow up and onto the trellis. Plastic clips were used at intervals of 40 cm to secure the climber to the trellis. Provided by Ronstan, the clips are designed to allow for the plants' growth.

Maintenance

The design of the green facade included maintenance requirements. The site can be accessed with an elevated work platform. The planter boxes are raised above pedestrian level, but are low enough to be accessed using a ladder.

The green facade requires a moderate level of maintenance, contracted to the university's general landscaping contractor. Regular maintenance tasks include:

- monthly inspection of irrigation system function
- twice yearly (spring and autumn) pruning and retraining climbers around windows
- twice yearly (spring and autumn) fertilisation, plus additional if required
- monthly comprehensive visual inspection
- weekly general inspections (including removal of rubbish)

Cost

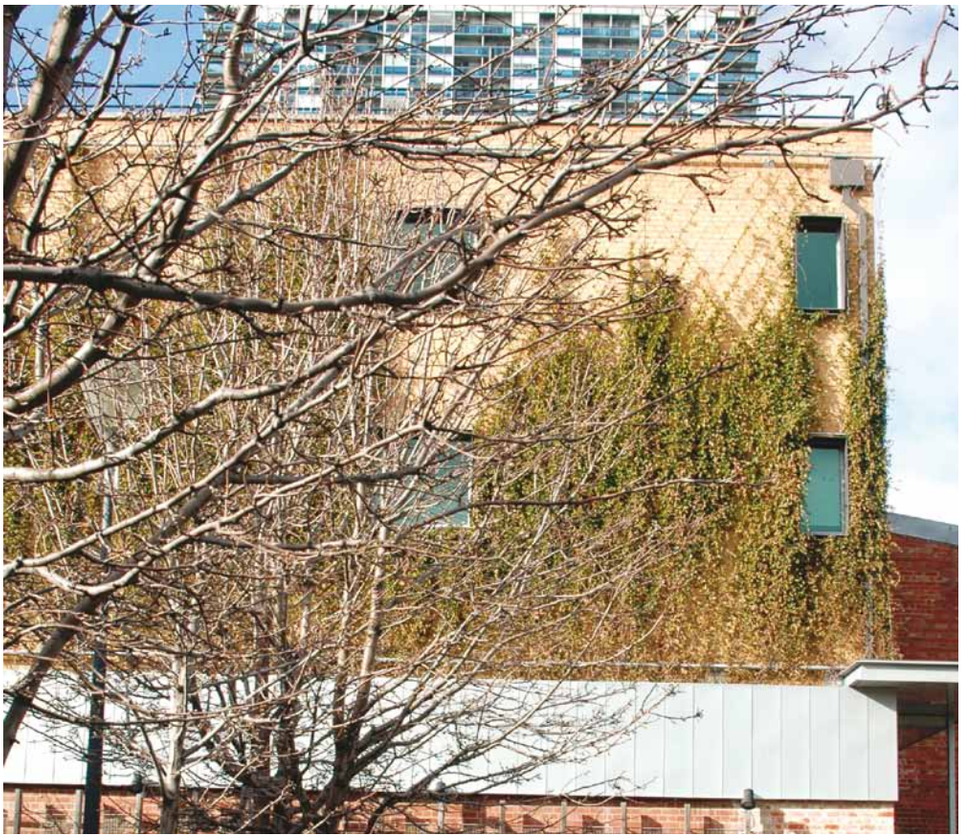
The project cost $230,000, excluding ongoing maintenance. Specific costs of project components are detailed in the table.

Item	Cost
Planter boxes	$80,000
Plants and substrate	$25,000
Plumbing and irrigation	$25,000
Trellis system	$90,000
Access equipment hire	$10,000

Results and reflections

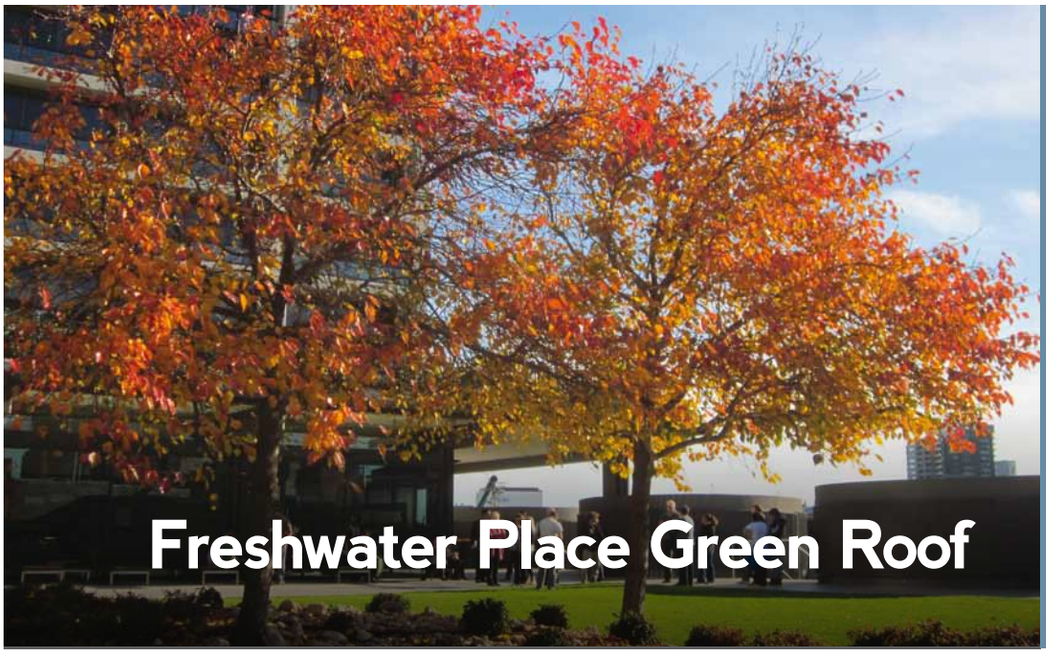
The architect believes that the building now sits comfortably as a backdrop to the University Lawn Precinct, with the creeper-covered walls meshing into the urban landscape. He notes the appearance of the building has been successfully transformed through the softening effect of the creeper-covered wall. Initial plant growth has exceeded expectations but will need to be monitored to be maintained into the future.

The ongoing level of required maintenance can be carried out as part of general RMIT landscaping. RMIT reports that no plants have been removed or replaced to date, due to adequate facade coverage.



The green facade is now a key element of the view from the University Lawn Precinct

Case Study



Freshwater Place Green Roof

Location

Freshwater Place Apartments 1 Queensbridge Square, Southbank, Victoria

Completion Date

2004

Cost

Undisclosed

Area

1650m² on a new building

Description

The green roof is an elevated landscape located on top of the nine-storey car park. It is made up of a series of garden mounds, a grass lawn, storage sheds and planter boxes for growing vegetables. A windbreak wall was added to protect the site from the strong southerly wind.

Introduction

Freshwater Place is a residential complex containing 534 apartments, located on the Southbank side of Melbourne's Yarra River. The aim of the project was to provide residents with a functional outdoor space that would enhance their inner-city lifestyle and add value to the property. The green roof is part of the communal facilities, which include barbeque areas, pool, gym and function spaces. Residents and their guests have full access to the level 10 roof and it can be seen from most of the apartments as they extend many floors higher than the car park. Maintaining the green roof's aesthetic appeal is the priority for all maintenance activities.

The green roof was a collaborative project between Bates Smart Architects, Australand and Laurence Blyton Landscape Architects. The green roof components were installed by Fytogreen and are maintained by Facility Management Victoria.

Design and components

The roof was installed using the following layers:

- waterproofing spray-on layer, installed by JA Dodds
- waterproofing protection layer, low-density polyethylene (LDPE) foam
- Flo-Cell™ drainage layer
- Bidim® geotextile layer
- Fytogreen Hydrofoam hard foam RG30
- growing substrate

Vegetable planter boxes, provided by the Little Veggie Patch Co, are made from recycled apple crates. Measuring 1.2 m along each side, and about 80 cm tall, the boxes are anticipated to last more than 10 years. The vegetable crates are located on the west side of the site and receive less sunlight than the other sections of the roof.

There are 30 established trees growing in the green roof garden beds, surrounded by a range of shorter shrubs. The substrate in these beds is 70 cm deep to accommodate the trees' root systems. Comparatively, the substrate under the large lawn area is only 35 cm deep. The substrate mix used throughout the site was prescribed by Fytogreen, and

is made up of sand, organic material and water retention flakes. A river stone mulch layer sits on top of the substrate to reduce evaporation, reduce weed growth and stabilise the soil in the wind.

There is a mix of permanent green elements, seasonal interest from foliage and colourful flowers. There is also one lemon tree on the roof, after a request by a resident that it be planted. It is yet to fruit, but is growing well.

Replacement species have been selected from existing plants that have grown well.

The specific plant species used on the Freshwater Place green roof are listed in the table to the side. All species are low maintenance, can be grown in most climates and soils, are tolerant of drought and wind, and prefer to be grown in full sun to part shade. They can be grown in urban areas where pollution levels may be high.

The green roof drains into a 160,000-litre storage tank that sits beneath the paved area. Rainwater is also collected into this tank from other building surfaces. The collected water is used for irrigating the garden and can sustain the plants for up to three weeks in the height of summer, and as a result, potable water is rarely used.

A drip irrigation system was installed beneath the substrate in the garden beds as part of the initial construction, but this system is no longer used. Although it was functioning correctly, the system did not allow for the different water requirements of trees and other plants. In 2010, the maintenance team installed separate drip irrigation systems for the trees and shrubs, which run along the surface of the soil. The grass lawn is watered using automated sprinklers.

The plants are monitored daily to ensure that the irrigation is sufficient and to identify problems before the plants showed signs of distress.

In the initial design, five round plant rooms on the roof were topped with vegetation to provide residents in the apartments above with a consistent green outlook onto the green roof. Sloped at a slight angle to allow for drainage, these roofs were planted with succulents in a shallow substrate made of fine stone aggregate. Parts of these roofs became waterlogged and caused some plants to fail, resulting in patchy green coverage when viewed from above (see image). Although the drainage could have been repaired and the roofs replanted, maintenance staff chose to not replace the plants, leaving the area with just the stones. This decision was made to ensure that the residents had a pleasing outlook onto the roof at all times.

Plant species used
Pyrus ussuriensis Manchurian Pear cultivar
Dianella 'Little Jess'
Juniperus sabina Savin Juniper
Liriope cultivars Lily Turf
Viola hederacea Native Violet
Viola labradorica Labrador Violet
Ixia cultivars Corn Lily
Escallonia cultivars
Ipheion uniflorum Spring Star
Freesia cultivars
Iris cultivars
Rahiolepis umbellata Yeddo Hawthorn
Pennisetum clandestinum Kikuyu
Trachelospermum jasminoides Star Jasmine

Aerial view of the Freshwater Place green roof after construction

Maintenance

Although the green roof at Freshwater Place has been designed to minimise maintenance, there are ongoing challenges. A different level of maintenance is required for the intensive garden beds and the extensive lawn area. For an annual fee of $25,000, the maintenance is carried out under contract and includes replacement of plants. Maintenance activities include:

Irrigation	Three times per week in summer; varies for the shrubs and trees.
Pruning	Annually for trees; shrubs as required
Plant evaluation	Weekly
Lawn mowing	Weekly in spring; fortnightly at other times
Scarifying the grass	Every three years
Fertilising	Monthly for turf; plants every six months; annually for trees
Plant renewal	As required in winter
Cleaning & monitoring of hard landscape elements:	Weekly
Inspection of irrigation system function:	Daily in summer; monthly at other times

A key challenge for maintaining the green roof has been ensuring that plants get enough water to maintain optimum growth and to look healthy and visually appealing. This requires regular monitoring, so it is important that the maintenance contractor understands the environment and how it can change very quickly.

Originally, Tall Fescue grass was used as lawn cover, but the maintenance team found it difficult to keep it looking good through water restrictions and the hot summer months. At times security staff hand-watered in summer to keep the grass green. Following a review of plant maintenance in 2007, the tall fescue was replaced with Kikuyu grass, a species with lower water requirements, and it has been very successful.

Exposure to the elements has also been a challenge, particularly for the maintenance of the large Manchurian Pear trees. The strong wind has caused them to grow at an angle, particularly in the older tree stock, due in part to the use of fully-grown trees at installation. As a consequence, the root systems did not establish in the soil as well as they could had younger plants been used. Their lack of stability in the wind required the use of support cables. Recently, some of these trees were replaced with younger plants and these have quickly grown to be equal in size to the existing trees, and are far more stable.

Maintenance processes are regularly reviewed to ensure they are consistent with the desired outcomes.

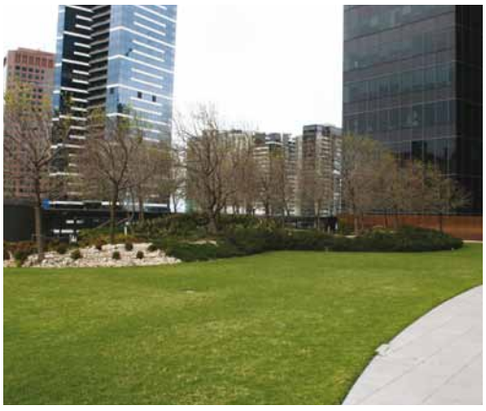
Results and reflections

Overall, the Freshwater Place management team is extremely happy with the aesthetic and social benefits of the green roof. The useability of the space gives the building a unique edge and adds value to the property.

The green roof is a well used space, particularly in the warmer months of the year. The barbeques are in constant use throughout the summer and the lawn is a popular place for picnics. The vegetable gardens are maintained by residents, who enjoy the social aspect of growing produce together.

Reflecting on the lessons learned over the last nine years, the management team has advice for anyone considering a green roof project:

1. Green roofs have their own challenges due to the unusual nature of the site, so it is best to keep the design simple.
2. Green roofs are not 'set and forget'. It takes some time to get the plants, irrigation and maintenance right, so be prepared to make adjustments as you go along.
3. Monitoring the green roof components and plants is essential for establishing a successful green roof. The monitoring should be regular and not reactive.



Manchurian Pear trees are a feature on the Freshwater Place green roof

Case Study

Minifie Park Green Roof

Location

290 Belmore Road, Balwyn, Victoria

Completion Date

December 2012

Cost

$306,000

Area

440m² on a new building

Description

The roof is on a one-storey building in a park. There is no public access but the roof slope of 2 to 3 degrees means it can be viewed from ground level. The green roof includes a range of indigenous plant species to promote the use of local flora and provide habitat opportunities for fauna.

Introduction

Minifie Park Early Learning Centre is a council-owned, community-operated childcare centre located in North Balwyn, an eastern suburb of Melbourne. It was built to replace an older building.

Council decided to include a green roof as an integral part of the new facility. The purpose of the green roof was to provide thermal insulation and help the building blend in to the surrounding parkland.

The project received funding from Melbourne Water and the Victorian Adaptation and Sustainability Partnership to support the incorporation of water sensitive urban design features into the building.

The building was designed by the architectural firm FMSA and built by Behmer and Wright. The green roof was designed and constructed by Junglefy.

Design and components

The roof has a weight loading of 170 kg/m². A gutter guard has been installed in the box drains, and leaf traps in downpipes to prevent them from blockage by pine needles from an overhanging tree. There is 400 mm wide unplanted perimeter zone to keep the areas around drains clear of vegetation.

Kalzip® aluminium standing seam roof sheeting was used for the roof deck. It was installed over a steel-framed portal structure – a building frame with pitched rafters. The standing seam system was a key element in Junglefy's tender for the work, because its successful use on green roofs is well documented, and Kalzip was prepared to provide a 10-year warranty on the waterproofing. This is the first Australian green roof installed over this type of lightweight roofing system to Junglefy's knowledge. The Kalzip® roof system is intrinsically watertight so a waterproofing layer or protection layers were not installed.

The drainage layer was ZinCo FD40, with water-retention capacity. A ZinCo Filter Sheet SF was also installed.

The growing substrate was Junglefy's proprietary Victorian mineral mix. It was delivered in 5,000 kg capacity bags, lifted by crane and installed through a hose

The building sits low in a park, meaning the roof can be easily viewed from street level

attachment, and applied 100 mm deep. The large single substrate bag could be moved around the roof and greatly reduced the installation time compared to using multiple smaller bags. The substrate was covered with a layer of jute netting to provide weed control and protection from slipping due to gravity and wind forces. Plants were installed through cuts made in the netting. A layer of substrate was installed over the top to reduce the potential for wind uplift.

The Early Learning Centre has an additional bare roof area of approximately 300 m^2. The green roof is irrigated with water collected over all roofs. Captured water is stored in an interconnected network of six tanks, with a total capacity of 24,000 litres, in the ground level plant room at the lowest point of the building. The modular tank system offers adaptability for current and future use: one or more tanks can be removed for repair or replacement without any need to interfere with the building structure and surrounds.

The irrigation system has 'back to base' control with sensor-driven monitoring from an inbuilt weather station enabling irrigation cycles to be missed during rain events exceeding a specified threshold. The system used is standard for parks and gardens irrigation throughout Boroondara. Water is pumped up to the roof from ground level and delivered to the plants through a KISSS Below Flow Flat capillary system. Initially, irrigation delivery was patchy across the roof causing uneven plant performance and the loss of a small number of plants, but adjustments to the system have resolved this issue.

The plant palette was a mix of low-growing Victorian perennial grass and herb species typically found in grassy/creek-line woodland (the likely original vegetation on this site). The herbs flower in spring and autumn, providing colour interest through a significant part of the year. Proposed additions include the planting of taller grasses to conceal the ventilation shafts.

Junglefy's custom-designed aluminium edge restraints separated vegetated and non-vegetated areas of the roof.

Planting stock was contract-grown by Australian Ecosystems, provided as tubestock, and inspected at the nursery prior to delivery. Planting took place in November, after a delay. As a result, hand-watering was necessary over summer, to ensure the plants were well established.

Maintenance

Junglefy has maintained the roof since planting. The intention had been that roof management would move to the City of Boroondara. However, due to Junglefy's experienced management and competency to work at heights, they have been sub-contracted by the City's Parks and Gardens team, and continue to maintain the green roof on a monthly basis. This arrangement has simplified management for the City of Boroondara.

The potential for acidification of the growing medium from the needles shed by a nearby overhanging pine tree is a source for concern.

Performance evaluation of the green roof plantings is being undertaken by the City of Boroondara.

Plant nutrition is provided as eight to nine-month low phosphorus controlled-release fertiliser applied at half the recommended rate.

Costs

Total cost was $306,000. This included:

- design and preliminaries $180,000
- green roof installation and plants $126,000

The total building cost was $3.5M.

Results and reflection

Insulation properties were a major driver for the inclusion of a green roof in the building design. An anecdotal story from builder Behmer and Wright's site manager suggests that the green roof contributes to thermal comfort for users: after the green roof substrate was installed in winter, the builders elected to spend their lunchtimes in the facility as they found it was warmer than the site office.

Monitoring of energy consumption for heating and cooling will reveal whether usage is lower than would be predicted for a building of this type without a green roof.

The City of Boroondara and the users of the Minifie Park Early Learning Centre feel very proud of the redevelopment and its green roof. The positive experience at Minifie Park has made Council enthusiastic to pursue future green roof projects. Council says that the local community has responded well to the green roof, seeing the views of vegetation as far superior to a bare metal roof. The design objective to create a connected visual experience between the building and the park has been met. The green roof demonstrates that a modern building development can be sympathetic to its surroundings.

Plant species used
Austrodanthonia racemosa Slender Wallaby Grass
Austrodanthonia setacea Bristly Wallaby Grass
Poa morrisii Velvet Tussock Grass
Poa morrisii Velvet Tussock Grass
Bulbine bulbosa Bulbine Lily
Chrysocephalum apiculatum Common Everlasting
Chrysocephalum semipapposum Clustered Everlasting
Dianella revoluta Black-anther Flax Lily
Einadia nutans Nodding Saltbush
Linum marginale Native Flax

1 *Sheets of drainage cells were cut to fit the width of the roof profile. Image: Junglefy*
2 *The unplanted perimeter zone prevents plant roots from growing into the drainage pipes*
3 *Native grasses on the green roof blend into the surrounding parklands and provide habitat*

Case Study

Victorian Desalination Project Green Roof

Location
Lower Powlett Road, Wonthaggi, Victoria

Completion Date
2012

Cost
$4,000,000

Area
26,000m² on a new building

Description

The Victorian Desalination Project green roof is the largest in the southern hemisphere. It covers a number of buildings of the process plant, ranging in pitch from 3.5 to 20 degrees. The undulating slopes of the roof are designed to limit visibility of the industrial buildings from the surrounding public areas and link to the nearby coastal landscape.

Introduction

The Victorian Desalination Plant provides for desalinated water to be delivered from the private sector to the State Government owned water authorities. The plant is capable of supplying up to 150 billion litres of water a year to Melbourne, Geelong and via other connections to South Gippsland towns.

The aesthetic focus of the project was to soften the visual impact of the process plant buildings. Several other objectives were also considered in design of the green roof, including, ecological restoration of the area, thermal performance of the building, minimising the noise impacts from the desalination process plant and protection of the roof from the harmful effects of solar radiation.

The Victorian Government's private sector partner, AquaSure, consists of Suez Environnement, Degremont, Thiess and Macquare Capital Group. The Theiss Degremont Joint Venture was the design and construct contractor for AquaSure. The green roof design delivery was provided by ASPECT Studios, with technical design, installation and maintenance by Fytogreen.

Design and components

With a saturated dead load of 143kg/m² plus live load, the roof is designed for maintenance access only.

The building is a steel frame structure with a timber ply roof deck. Waterproofing layer is Sika Sarnafil. A foam resin developed by Fytogreen was used as an underlay, trapping water and nutrients and helping the plants to grow. The drainage layer is a 20 mm Atlantis® Flo-Cell™ with a Bidim® A14 geofabric to filter sediment run-off.

The extensive green roof substrate mix was provided by Fytogreen and installed to a depth of 80 mm. The majority of the roof was constructed on a slope of less than 15 degrees and did not require any sheer protection. However, about 650 m² of the roof was installed on slopes greater than 15 degrees and Geoweb® Cellular Confinement System was used to stabilise

Graphic depiction of the design shows how the green roof blends into the surrounding environment

the substrate and vegetation. The 150 mm deep Geoweb® cells were installed over four days, with anchoring tendons running through every second row of cells to secure the system in place.

Due to the strong winds to which the green roof is exposed, a system of stainless steel hold-down netting was required in the areas subjected to the highest wind speeds. These winds create a twin vortex effect where the combined lateral forces and vertical uplift would risk dislodging the substrate ballast layer. The primary function of the mesh was to mitigate the insurance risk during establishment when the mulch layer was exposed. As time goes on it is expected that the plants will ameliorate wind uplift.

A sub-soil irrigation system was designed for the green roof by Netafim™ and installed by Fytogreen. The automatic drip system includes a weather monitoring station to ensure irrigation frequency and volume is appropriate. Data is collected on the amount of rainfall and the level of evaporation. Water for irrigation is captured from a 3.7 ha collection area and stored in a 0.5 megalitre pond. In addition to the captured storm water, 600 litres of process sampling water per hour is available from the desalination process plant.

The Fytogreen design for the green roof was carefully considered to ensure consistency with the coastal character, and to meet the ecological objectives of the project. Species selection focused on plants that are locally indigenous to the area using seed that was collected within 40 km of the site.

Given the site's exposure to the elements in a windy and temperate coastal environment, testing was undertaken prior to construction to ensure that the species chosen would thrive in the conditions. Fytogreen established a test roof on a nearby site in 2009 to determine which species would respond well to the wind and variable temperatures, and to test planting patterns that would enhance the health of the plants.

Plants are fertilised using Osmocote® low phosphorus 12 to 14-month controlled release fertiliser. Application rates are adjusted as deemed necessary.

Maintenance

Fytogreen has a five-year contract to carry out any maintenance required for the green roof. Given the high profile of the project and the community expectations around aesthetics, the contract specifies standards for maintenance. This includes a requirement that vegetation cover must be at least 95 per cent, with no more than five per cent weeds. Fytogreen visits the site as required, to ensure these maintenance obligations are met. Visual inspections of plant health are important to ensure irrigation and nutrient levels are adequate.

Plant species used
Acaena novae-zelandiae Bidgee-widgee
Actites megalocarpa Dune Thistle
Apium prostrata Sea Celery
Ficinia nodosa Knobby Club-rush
Carpobrotus rossii Pigface
Correa alba White Correa
Correa reflexa Native Fucshia
Dianella admixta Spreading Flax-lily
Dianella brevicaulis Coast Flax-lily
Dichondra repens Kidney Weed
Disphyma crassifolium ssp. *clavellatum* Rounded Noon-flower
Gonocarpus tetragynus Common Raspwort
Goodenia ovata Hop Goodenia
Lomandra longifolia Basket Grass
Olearia axillaris Coastal Daisybush
Rhagodia candolleana ssp. *candolleana* Seaberry Saltbush
Senecio spathulatus Dune Groundsel
Stylidium graminifolium Grass Triggerplant
Tetragonia implexicoma Bower Spinach
Threlkeldia diffusa Coastal Bonefruit
Ozothamnus turbinatus Coast Everlasting
Chrysocephallum apiculatum Common Everlasting

Results and reflection

The opportunity to develop an indigenous plant palette for such a large scale green roof has demonstrated the way the natural ecology evolves and responds to the site conditions and the development of microclimates as the vegetation matures.

Some of the initial planting stock struggled to survive the windy conditions on-site. However, Fytogreen anticipates that the existing vegetation will provide protection for new plants that grow from self-sown seed, allowing them to establish more strongly on the roof.

Fytogreen points out that the requirement for irrigation water should not be underestimated, and it is important to be mindful of the client's expectations in terms of the roof's appearance. The aesthetic value may become a higher priority than designing for minimum water use. Recovery of irrigation run-off enables 80 per cent of the water to be re-used and ensures that water sensitive design principles are maintained without compromising plant performance and appearance.

The vast size of the green roof planted with Australian natives leaves a positive impression with all visitors to the site.

The inclusion of the green roof on the Victorian Desalination Project was an inspired gesture that added to the acceptance of the project by the local community and the wider public.

ASPECT Studios reflects that because this roof was constructed in the absence of a formed Australian green roof design standard it is a testament to the innovation and skill of the design and construction team. Initially viewed as a risk, the green roof has proven to be one of the most successful elements of this challenging project and represents the growth of the green roof industry in Victoria.

1 *Irrigation pipes are embedded in the upper level of the growing media, above filter sheet and drainage layers*
2 *Plants were propagated offsite and delivered to the green roof for installation*
3 *Plants were well established by December 2013*
4 *Non-vegetated zone around the edge of the roof*

All images in this case study are courtesy of ASPECT Studios and Fytogreen

Case Study

Burnley Biodiversity Green Roof

Location

Burnley Campus, The University of Melbourne , 500 Yarra Boulevard, Richmond, Victoria

Completion Date

February 2013

Cost

$13, 930

Area

49m² on an existing building with heritage considerations

Description

The green roof is located above ground floor offices on a concrete roof deck with a 1 degree slope. The roof is accessible only to authorised staff or students with Working at Heights certification; however, it can be viewed from the first floor hallway window.

The Biodiversity Green Roof features:

- Victorian grassland plant species in a shallow scoria-based growing substrate
- a range of landscaping materials (sand, gravel, ash, rubble) and features (logs, rocks, hollow twigs, roof tiles, terracotta pots) to create habitat opportunities for birds, lizards, insects and other invertebrates
- a small ephemeral pond and shallow creek bed, that are supplied by rainfall run-off from the roof above

Introduction

The University of Melbourne has a campus in Richmond, near the Yarra River, focusing on horticultural research and education. The main building was constructed between 1946 and 1949 and is protected by a Heritage Overlay, and the entire site is listed on the Victorian Heritage Register.

The northern end of the roof of the main building has been developed into a Biodiversity Green Roof as part of the larger scale Green Roofs Project, which also includes a Demonstration Roof and a Research Roof on the same building. A design team from HASSELL worked with the University to provide design solutions to assemble the roofs. Junglefy constructed the roofs. A planning consultant was hired to navigate through the planning process and clarify which permits were required.

The Biodiversity Green Roof was developed as a part of the larger Burnley Green Roofs Project to encompass demonstration, education, extension and research. The Biodiversity Green Roof provides students and visitors to the University with an example of the design and features of a non-irrigated, shallow depth green roof designed for habitat.

Design and components

The roof has a weight loading of 150 kg/m².

Replacement of waterproofing was avoided by patch repair of existing waterproofing: the estimated cost saving was $2,000. Components include ZinCo SSM45 protection mat and high-density polyethylene (HDPE) root barrier, a ZinCo FD40 drainage layer and ZinCo Filter Sheet SF. A scoria-based growing substrate was delivered by crane in 1 m³ bulker bags, and installed to a depth of 100 mm.

A 400 mm wide unplanted perimeter zone keeps the area around the edge of the roof clear. Aluminium edge restraints separate vegetated and non-vegetated areas of the roof. Scoria aggregate was installed in the non-vegetated areas of the green roof.

The Biodiversity Roof receives run-off from two downpipes that drain the roof area above it. One is directed into the pond and ephemeral stream, the other enters a buried drain pipe that travels along the long axis of the roof. This allows lateral seepage of water into the substrate, and supports plant species with higher water needs, such as Kangaroo Grass *(Themeda triandra)*. Drainage off the roof is achieved through two drains on the northern perimeter of the building.

There is no irrigation system on the Biodiversity Roof. It is watered infrequently by hand-held hose during hot weather or prolonged periods without rain.

The plant palette consists of Victorian perennial grasses, herbs, and one species each of an orchid and a fern. These species are typically found in grassland and woodland, and some are known sources of food and nectar for insects. Plants provide colour and interest through a significant part of the year. Tubestock (grown in the Burnley campus nursery, with a small number of plants purchased from Victorian indigenous nurseries) was planted in February 2013. The roof was hand-watered through autumn to promote establishment.

Plant species used				
Herbaceous perennial herbs		**Grasses and grass-like forms**	**Orchid species**	**Fern species**
Arthropodium milleflorum Pale Vanilla Lily	*Linum marginale* Native Flax	*Austrodanthonia carphoides* Short Wallaby-grass	*Microtis unifolia* Common Onion-Orchid	*Cheilanthes austrotenuifolia* Green Rock Fern
Asperula conferta Common Woodruff	*Lobelia pratioides* Poison Lobelia	*Austrostipa scabra* Velvet Tussock Grass		
Brachyscome basaltica Swamp Daisy	*Marsilea drummondii* Common Nardoo	*Chloris truncata* Windmill Grass		
Brunonia australis Blue Pincushion	*Microseris lanceolata* Yam Daisy	*Dichelachne crinita* Longhair Plumegrass		
Bulbine bulbosa Bulbine Lily	*Pelargonium rodneyanum* Magenta Storksbill	*Lepidosperma concavum* Sword-sedge		
Calocephalus citreus Lemon Beauty-heads	*Podolepis jaceoides* Showy Podolepis	*Lomandra filiformis* Wattle Mat-rush		
Calotis anthemoides Cut-leaf Burr-daisy	*Ptilotus macrocephalus* Green Pussytails	*Themeda triandra* Kangaroo Grass		
Chrysocephalum apiculatum Common Everlasting	*Ptilotus macrocephalus* Green Pussytails			
Cullen tenax Emu Foot	*Rumex dumosus* Wiry Dock			
Dianella revoluta Black-anther Flax Lily	*Rutidosis leptorrynchoides* Button Wrinklewort			
Eryngium ovinum Blue Devil	*Selliera radicans* Shiny Swamp-mat			
Eryngium vesiculosum Prickfoot	*Senecio quadridentatus* Cotton Fireweed			
Helichrysum rutidolepis Pale Everlasting	*Stylidium graminifolium* Grass Trigger-plant			
Hypericum gramineum Small St. John's Wort	*Veronica gracilis* Slender Speedwell			
Leptorynchos squamatus Scaly Buttons	*Vittadinia cuneata* Woolly Vittadinia			
Leucochrysum albicans var. tricolor Hoary Sunray	*Wahlenbergia communis* Tufted Bluebell			

Scaly Buttons (Leptorhynchos squamatus)

*Hoary Sunray (*Leucochrysum albicans *var. tricolor)*

Blue Pincushion (Brunonia australis) *with visiting Hoverfly*

Maintenance

Staff maintain the Biodiversity Green Roof: this takes about one hour per month. A photographic record of weed species is maintained to monitor those that germinate on the roof. Timely removal of these plants before they set seed prevents them from becoming more widespread. Plant nutrition is provided as eight to nine-month low phosphorus controlled-release fertiliser, applied at half the recommended rate.

Costs

The following table details outline the indicative cost of the Biodiversity Green Roof. As it was installed as part of the larger Burnley Green Roofs Project, with works carried out simultaneously (for example, substrates for all green roofs were lifted by crane on the same day), there were economies of scale for design and installation. However, for this case study, costs are provided, in the table, for a stand-alone 'design and build', as the scale of this roof was small and simple in relation to the overall Burnley project.

Component	Cost
Preliminary costs: design, project management, etc.	$3,000
Repairs to existing waterproofing	$1,500
Protection Mat SSM 45	$250
Root barrier	$100
Aluminium retaining edge (33 linear m)	$3,580
FD40 drainage	$1,100
Filter Sheet SF	$120
Scoria-based growing substrate (10 cm depth)	$680
Scoria aggregate installed on non-vegetated perimeter	$350
Labour cost of installation including crane fees	$1,020
Labour cost of installation including crane fees	$630
Plant production/ purchase costs	$600
Materials collection and planting	$1,000

Results and reflection

Nine months after planting the vegetation is still quite sparse, although this is likely to fill in, particularly as the grasses self-sow over time. Plants were grazed by possums living in a pair of Italian Cypress trees (Cupressus sempervirens 'Swane's Gold') that were growing adjacent to the building. The trees were removed during 2013 because possum nesting and grazing caused irreparable damage to the trees' canopies. The rooftop plants recovered well over spring.

Australian ravens and magpies visit the roof to bathe in the pond, and also bring food to consume on the roof. Spiders have colonised the tree debris, and an ant colony has moved into the rocky substrate near the end of the stream. Burnley staff members have commented on their enjoyment of the colourful grassland species planted outside the first floor window.

Kangaroo Grass established strongly on the Biodiversity Green Roof. Source: Leanne Hanrahan

Bundles of sticks are installed amongst the vegetation to provide homes for native wildlife. Source: Leanne Hanrahan

Case Study

Kangan Institute Green Roof

Location

Docklands Campus, Kangan Institute, Harbour Esplanade, Docklands, Victoria

Completion Date

November 2012

Cost

$56,000

Area

250m² on a new building

Description

This water-efficient green roof is designed as a space to provide amenity for staff. The area is not open to the general public. Decking and seating is provided. The roof is built on a concrete roof deck with 1.5 degree slope, it is above the third storey.

Introduction

The Kangan Institute Automotive Centre of Excellence (ACE) is located in the Batman Hill Precinct of Melbourne's Docklands. The building holds a 5 Star Green Star rating. The building houses a 2,000 m² area of automotive workshops, and 1,200 m² of specialised training and office areas.

The green roof is located adjacent to the administrative offices, and over the learning suites, which will benefit from reduced heat loads.

The green roof was designed by ASPECT Studios, in collaboration with Gray Puksand Architects. Robert Bird Group provided structural and civil engineering services.

The green roof was installed on the concrete roof deck of the new concrete-framed building.

Design and components

The roof weight loading is 200 kg/m². Roof drainage is achieved through a series of in-floor sumps, with overflow risers installed along the bottom of the roof slope.

The drainage layer is Atlantis® 20 mm Flo-Cell™ drainage cell, with flow across the roof to perimeter drain. The filter sheet is Bidim® geotextile, Grade A14. For waterproofing, Waterproofing Technologies' Enviro HP1200 was used. This is a two-component, spray-applied, flexible polyurethane membrane. A leak detection system was not installed.

As HP1200 waterproofing treatment is rated as root-resistant (through a testing procedure specified and assessed by CSIRO), a root barrier was not required. Separation sheets of low-density polyethylene (LDPE) were installed to protect the waterproof membrane during construction.

Stormwater run-off was captured to irrigate the green roof, as well as toilet flushing: one point was awarded under Green Star's WAT-3 criterion for the required measurable reduction (by 90 per cent) in potable water consumption on the site from these initiatives. Fytogreen Australia designed and installed the irrigation system. Irrigation is delivered through a Netafim sub-surface dripper system. This is water-efficient, programmable and automatic enabling the duration and frequency of irrigation cycles to be adjusted.

ASPECT Studios developed the planting design, which consists of low water use herbaceous and succulent perennials: all have performed strongly.

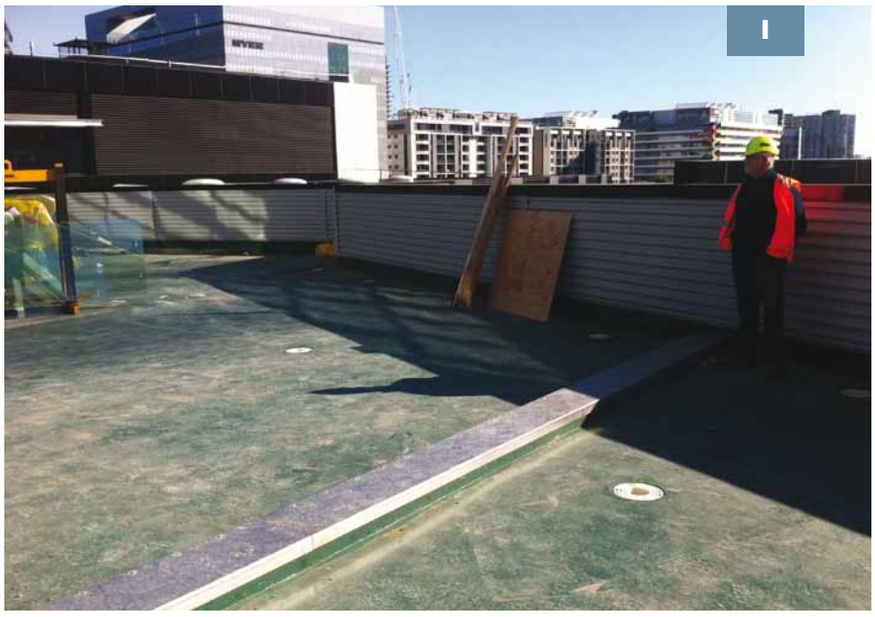
Plant species used
Anigozanthus 'Ruby Velvet'
Carpobrotus edulis
Crassula capitella 'Campfire'
Dianella caerulea 'Cassa Blue'
Dianella caerulea 'Little Jess'
Lomandra longifolia 'Tanika'
Poa poiformis 'Courtney'
Sedum palmeri

Maintenance

Establishment maintenance was provided for eight weeks after planting. The green roof was then managed by the Kangan Institute maintenance team. Plant nutrition is provided as 12 to 14-month low phosphorus controlled-release fertiliser applied at half the recommended rate.

Results and reflection

The garden has suffered somewhat from a lack of maintenance. A maintenance strategy is now being developed. Bird control has been needed as seagulls have been nesting in the garden after being disrupted from nesting elsewhere on the building.



1 Roof deck with waterproof membrane prior to flood testing. The raised strip is a major structural movement joint which required specific attention to maintain waterproofing 2 Views of the green roof at planting 3 Views of the green roof 10 months later 4 Anigozanthos 'Ruby Velvet' contributes a striking element to the green roof planting scheme at Kangan Institute

All images in this case study are courtesy of ASPECT Studios and Fytogreen

Case Study

Growing Up Rooftop Garden

Location
131 Queen St Melbourne, Victoria

Completion Date
July 2010

Cost
$219,000

Area
200m² on an existing building

Description

The roof space is surrounded by a 1.2 m high balustrade above the 8th floor of the building. The rooftop garden total area is 200 m², with planter boxes occupying 48 m², and a central 'hill' area of 43.5 m².

A trafficable zone expands and contracts around a central landscaped hill to create a number of gathering spaces of various scales and orientations. Bound by edges of seating and planting, inhabitants are surrounded by greenery.

About half of the 131 Queen Street roof area is occupied by plant and machinery: this is screened and separated from the accessible roof garden area by a picket fence.

An additional 38 m² green roof space (not publicly accessible) was installed above the lift motor room. This is part of an Australian Research Council Linkage Project Grant carried out by The University of Melbourne's Green Infrastructure Research Group, to investigate the performance of plants on green roofs in a variety of growing substrates.

Introduction

131 Queen Street is managed by Quayle's Owners Corporation Managers. The building was constructed in 1896 and the tenants include a range of private and public organisations. It was intended that the rooftop garden be used by building tenants for lunch and recreational breaks, meetings, workshops and classes, as well as special events.

The Growing Up roof was built after the Committee for Melbourne ran a design competition for a green roof. The Committee identified three potential CBD rooftops and ran the competition to demonstrate how a "vibrant, innovative and contemporary urban green space" could be created on a rooftop. Safety, maintainability, and durability were key considerations for assessment of entries in the design competition.

Bent Architecture won the design competition with its "Head for the Hill" submission, based on the roof at 131 Queen Street.

The builder was Better Projects Australia and engineers were Clive Steele Partners. The University of Melbourne provided guidance on substrate and planting design.

The project budget was $200,000, with additional in-kind support provided by sponsors; for instance, VicUrban (the State Government's former development agency, now Places Victoria) provided a project manager to oversee construction and ensure that partners' objectives for the project were met.

Timber decking, mosaic seating and permeable paving treatments are some of the functional and decorative features used

Design and components

The roof's weight loading is for a dead load of 300 kg/m2 and a live load 150 kg/m2. Total carrying capacity is 100 people. The weight loading precluded the original design from being realised, which was a hill with a large volume of soil and a mature tree growing on it. Instead a sculpture tree was constructed, centred over a column, and covered with wisteria to provide shade in summer and allow sun penetration onto the roof in winter. A hill was made from recycled, expanded polystyrene covered with a small volume of substrate and succulents.

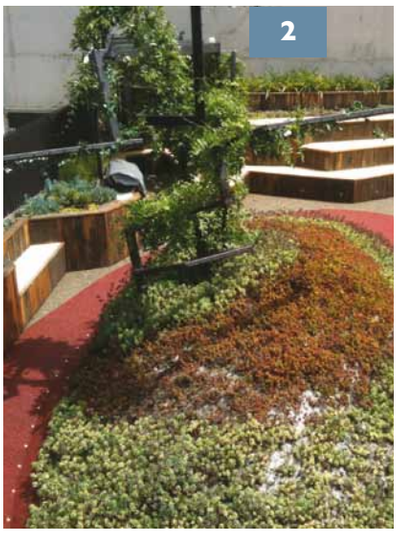
Drainage outlets along perimeter walls lead to concealed downpipes. The roof deck is steel framed with precast concrete roof slabs and sand cement screed over to create fall from the roof to drainage outlets.

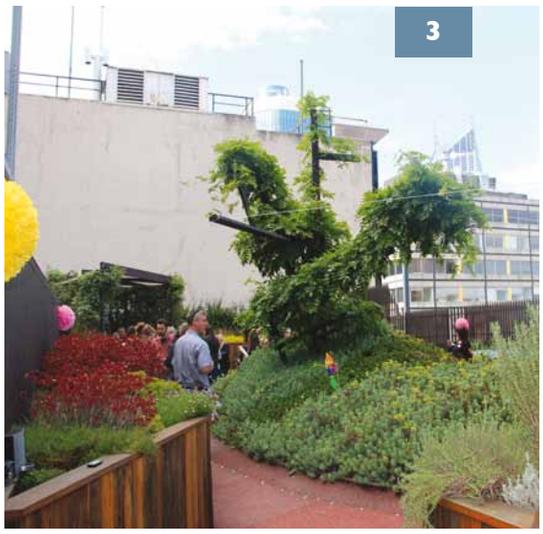
A new Polyseal Enviro 800 Pur Top-coat polyurethane waterproofing membrane was installed over the existing membrane. This carries a seven-year warranty. Elmich VersiCell® structural (weight-bearing) drainage modules were installed underneath pervious paving material. The open drainage layer allows free flow of water through to the waterproofed roof deck. No changes were made to the pre-existing drainage points. ZinCo Filter Sheet SF was used over the drainage modules.

The growing medium (saturated bulk density 750 kg/m^3) was mixed by Debco to a recipe specified by The University of Melbourne's Green Infrastructure Research Group. Growing medium is used at depths of 200 mm in shallow planter boxes, and 400 mm in deep planter boxes. The same growing medium is used on the 'hill' at a depth of 200 mm over most of its face, although the depth increases to 400 mm depth at the top and on the western face of the hill, to allow for the expanding root system of the Chinese Wisteria. The build up of the hill is created from recycled expanded polystyrene blocks, overlaid with an Elmich VersiWeb® 200 mm deep cellular confinement system to contain the growing substrate. The hill is covered with geotextile, and plant root masses were installed into slits cut into the fabric.

The substrate and plant selection was made with consideration of the Growing Up team's desire to install a sustainable green roof that did not require irrigation. However, after project handover, the building owners installed a drip irrigation system for use particularly during harsh summer weather conditions. Captured rainwater is supplied to the productive garden and perimeter planters, but the hill zone is flourishing without irrigation.

Plants were supplied in a range of sizes, from tubestock, and 14 cm through to 30 cm containers from members of the Nursery and Garden Industry Victoria. The University of Melbourne's Green Infrastructure Research Group grew most of the succulent plant species that were installed as tubestock. A total of 1,664 plants were installed.





1 *The Growing Up roof garden at completion*
2 *Two years later*
3 *Three years later*

Images in this case study courtesy Diana Snape Photography, for Bent Architecture.

Plant species used					
Grass-like	**Culinary herbs**	**Climbers**	**Succulents**	**Trees**	**Shrubs**
Lomandra confertifolia 'Little Pal'	*Origanum vulgare* Oregano	*Passiflora edulis* Passionfruit	*Sedum pachyphyllum*	*Citrus limon* 'Meyer' Meyer Lemon	*Banksia spinulosa* 'Birthday Candles'
Anigozanthos flavidus Kangaroo Paw	*Rosmarinus officinalis* *R. officinalis prostratus* Rosemary (upright and prostrate forms)	*Wisteria sinensis* Chinese Wisteria	*Sedum xrubrotinctum*	*Olea europaea* European Olive	Hairpin Banksia cultivar
Dianella tasmanica Tasmanian Flax-lily	*Thymus vulgaris* Common Thyme	*Aphanopetalum resinosum* Gum Vine	*Sedum mexicanum* Mexican Stonecrop		
Themeda australis Kangaroo Grass	*Salvia officinalis* Culinary Sage	*Pandorea jasminoides* 'Alba'	*Aloe* 'Always Red' *Aloe* 'Gemini'		
		P. jasminoides 'Lady Di' Bower Vine cultivars	*Kleinia repens* Chalk Sticks		
		Clematis glycinoides Forest Clematis	*Lampranthus deltoides*		

Maintenance

The garden is maintained once a month by a horticulturalist, and the building management team carries out some maintenance in between these scheduled visits.

Plant nutrition is provided as eight to nine-month low phosphorus controlled-release fertiliser, applied at half the recommended rate, as required.

Results and reflections

The rooftop has been popular and is used throughout the year as a social space by the building occupants. The rooftop can be booked for functions and is open annually to the public as part of The Committee for Melbourne's 'Melbourne Open House'.

Substrate installation

Costs

Component	Cost
Timber and metal work (including planter boxes, seats, pergola, roof lift, access ladder, fencing and sculpture)	$135,850
Building preparation works (including scaffold, handrail, crane)	$14,500
General construction items (including roof access anchors, signage, light, power and plumbing and upgrades for Building Code of Australia compliance)	$35,608
Permeable paving	$23,220
Ronstan cables	$2,000†
Plants	$5,000
Rainwater tank & pump	$2,500
Elmich green roof system	in-kind*
Growing media	in-kind‡
Plants	in-kind[n]

† Further structural rod & cable systems for green walls and landscaping and cable systems for balustrades and railings were provided at cost price by Ronstan Tensile Architecture, a sponsor of Growing Up

*The green roof system and labour for installation was provided as in-kind support by sponsor Green Roof Technologies, this had an estimated value of $60,000

‡ Provided as in-kind support by sponsor WeBlow

[n]Provided by sponsors Proteaflora, Aloe-Aloe Horticulture, Merrywood Plants and Majestic Plants, this had an estimated value of $8,500