     

# Built Sunshade in

# New Zealand Public Spaces

six case studies 2016

A research report commissioned by
Health Promotion Agency New Zealand

Christina Mackay *Architect*

## Commissioning

The research was commissioned by Health Promotion Agency (HPA) and supported by Victoria University of Wellington.

## Disclaimer

This research has been carried out by independent parties under contract to HPA. The views, observations and analysis expressed in this report are those of the authors and are not to be attributed to HPA.

## Acknowledgements

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## Ethics Approval

This research methodology and process was approved by the Human Ethics Committee, Victoria University of Wellington (Application 23159).

## Author

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# ABSTRACT

New Zealand has the highest rates of skin cancer in the world. Internationally, the provision and use of shade is considered a key strategy in the prevention of skin cancer, but there has been little research undertaken on how well shade canopies in public spaces provide UVR protection for their users. This research examined six public shade canopies in six different locations in New Zealand which opened in 2014 and 2015. Firstly, the principles of designing for UVR protection are explained. Secondly, based on interviews with local government planners, public health professionals, facility managers, architects and sun-shade designers, each case study reports on the project initiation process, the project brief and feedback on the performance of the shade structure. Using information from site surveys, the UVR protection provided at the centre of each canopy is estimated. Key learning points from each project are identified. The findings present insight into possible initiation processes and designs for future 'sun-safe' public spaces in New Zealand.

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# EXECUTIVE SUMMARY

## Background

New Zealand has the highest rates of skin cancer in the world. Our country includes many fair-skinned people, is subject to relatively high ultraviolet radiation (UVR) levels in a temperate climate and the outdoors is deeply rooted in our lifestyle. Internationally, the provision and use of shade is considered a key strategy to reduce overexposure to UVR and thereby reduce the incidence rates of skin cancer. In our cities and towns, Local Government has a role in providing communal spaces that are protected from damaging UVR and in promoting the use of shade. In 2014 and 2015, several new public projects that included a shade component were completed. Using a case-study format, this investigation aimed to understand: how these 'shade' projects were initiated, how they are used by the public as well as the level of UV protection and thermal comfort that they provide. The findings present insight into possible initiation processes and designs for future 'sun-safe' public spaces in New Zealand.

## Methodology

Possible case study projects were identified in conversation with HPA and the CSNZ network and through a review of recent architectural journals. The six sites were selected to achieve a variety of venues and locations within New Zealand. Background and feed-back on each site was gathered through semi-structured interviews with the client, the designers and the venue managers. Each site was surveyed using photographs and the project drawings and specifications. This information was used to prepare diagrams illustrating shading of direct UVR and estimations of the exposure to diffuse UVR. An approximate Protection Factor (PF) was estimated for the central point of each canopy.

## Findings

Findings from the six case studies are summarised as follows -

**The Pavilions, Britomart, Auckland**

The Pavilions were designed as a temporary commercial project to attract shoppers to a collection of eight retail stores and a cafe. The shade under the translucent canopies, softened with greenery and vines, is a popular and well-loved meeting place. Over the central café dining space, a translucent white membrane gives shelter from the rain, hot summer sun and provides a 100% barrier to UVR. The circulation spaces on either side are covered with clear PVC. The film transmits maximum daylight (and UVR) to a site which is shaded for much of the year by neighbouring tall buildings. With a protection factor of PF 15+ at its centre, the central canopy gives excellent UV protection for a very long lunch.

**Eat Streat, Rotorua**

Initiated by Rotorua Lakes Council, Eat Streat was a central city revitalization project. The canopy design for covering an existing street was the result of an architectural competition. Over the central walkway, a timber framed 'V' shaped clear polycarbonate canopy transmits light and warmth but shields UVR. On either side, retractable canopies can be extended to give café patrons shelter from the rain or the sun. These are owned and operated by each outlet. The overhead canopies and geothermally heated pavements create warmth during the cool winter evenings. At its centre, the shade gives a UV protection factor of PF 15+ and creates a safe and comfortable 'alfresco' experience.

**Lido Pool Shade, Palmerston North**

In response to a long history of pool users receiving sunburn at the Lido Aquatic Centre, in 2014, health promoters and professionals, community groups and the Palmerston North City Council worked together to implement more shaded areas. Proposals to cover over the terraced embankment beside the 50m outdoor pool were invited from several shade-sail companies. Under the central decorative sail UVR protection is estimated to be approximately PF 5. This low level is typical of small sails where large areas of open sky can be viewed from underneath. This means that pool users need to rely on personal sun protection. For all day swimming sports and weekend recreation, shade could be designed to give all day protection by shielding more direct and diffuse UVR.

**Kamala Pavilion, Wellington Zoo**

The Wellington Zoo Trust developed this multi-purpose pavilion in a ‘hub’ precinct at the heart of the Zoo grounds. The intriguing design, inspired by reptile skin, creates an outdoor feel by the use of a translucent UVR protective membrane roofing and raw concrete. The pavilion is used as an events venue as well as shelter for Zoo visitors to rest and eat lunch. For winter events, zipped-up PVC blinds and under-floor heating keep the space warm. In summer, the low open façade faces east and restricts direct sun. The outlook to wooded hills allows for only a little open sky to be viewed. The pavilion, at its centre, has a UV protection of PF 15+.

**Ruataniwha Kaiapoi Civic Centre Canopy**

The 2015 Civic Centre was an 'anchor rebuild' project following the 2011 Canterbury earthquake. The canopy space is at the centre and heart of the town. It acts a grand entrance to the Civic building while providing a large outdoor shaded and sheltered public space perfect for casual meeting and for civic events. The double height canopy is formed of white painted fixed mild-steel louvres angled to provide 'light and bright' summer shading. It is open to the welcome Canterbury relatively low rainfall. With additional shading from surrounding buildings and trees, the centre of the 12.5m deep 'verandah' is well protected from summer UV with an estimated protection factor of PF 15+.

**Hagley Oval Pavilion, Christchurch**

The 2014 Cricket pavilion was another 'anchor' project in the rebuilding of Christchurch. The Canterbury Cricket Trust Board proposed forming a new cricket oval with a surrounding spectator embankment and a pavilion in Hagley Park. The pavilion provides facilities for members, officials and players. A tensioned architectural PVC textile canopy soars over the terraced seating. The fabric blocks UVR from the direct morning sun but the seating is open to diffuse UVR from the sky. Seats at the centre of the covered terrace have an estimated protection factor of approximately PF5. Despite the large monolithic canopy, spectators on the terrace need to use personal protection and/or retreat indoors to the function room on the upper level.

## Learning points from the six case studies

Shade was successfully used for outdoor public space making; alfresco dining, social, gathering and recreational spaces.

The shade projects were initiated in various ways: by community action, Council policy, city revitalisation initiatives, facilities management and/or commercial agendas.

Rotorua Lakes and Palmerston North City Councils, used sun-protection policies to support the initiation of public shade projects.

In Auckland, Rotorua and Wellington, designers considered shade for UVR protection as secondary to the need for shelter from the rain and/or wind. Designing canopies for all weather allows the amenity to be used day and night and all year around.

In the drier climate of Canterbury, rain protection was less valued. The louvered pergola at Ruataniwha Kaiapoi Civic Centre creates an attractive civic 'outdoor room' which is well shaded from summer sun.

The multi-purpose and multi-use of many canopies and pavilions contributed to their cost effectiveness. The Kamala Pavilion at Wellington Zoo is used as an events venue but also as a shelter for Zoo visitors to rest and eat their lunch. The canopies at Eat Streat provide shelter from rain, sun and the cold night sky, but in the evening they are a canvas for decorative coloured lighting.

The four urban outdoor dining and/or event spaces achieved shading with a protection factor of PF15+, making them suitable for year round all-day UVR protection. This high level of protection was a result of the specification of shading materials shielding direct UV and also the shielding of diffuse UV by surrounding hills, trees and/or buildings, as well as by the canopy design itself.

Canopies at the swimming and cricket venues, used for all day events, offered lower UVR protection of approximately PF5. This was largely a result of the flat open sites and of the high sides of the canopies which protected sightlines and/or views. Users are subsequently exposed to significant diffuse UVR from the open sky. At these venues, people need to rely on personal protection when they are under shade. In order to lower public risk of UVR over-exposure, events could be rescheduled to times with lower UVI levels.

The public will use shade if it is warm and comfortable. At each climatic location, especially in spring and early summer, air-temperature can be too cool for comfort. The spaces were heated by various strategies; orientating openings to the east so concrete flooring could heat from the low morning sun, using a transparent or translucent shading material which transmits the heat of the sun but not UV, and introducing geothermal and gas radiant heating. Further research is required to understand the optimal heat transmittance of shading materials for different locations in New Zealand.

For the hot summers of Auckland and Christchurch, architects chose shading materials which transmitted little or no heat, such as architectural textile and painted mild steel. Spaces were also cooled by opening the sides to breezes.

Comparison of the case studies highlighted the complex issues in creating sun-safe environments at summer pools. These pools are used when UVR levels are extreme, often by scantily clad teenagers for all-day swimming sports and weekend recreation. Small shade sails typically provide low protection. The provision of PF 15+ shade which would give all-day protection should be high priority for outdoor pools in New Zealand.

All the projects were creative and innovative in their design. They not only provided shade for UVR protection, but they enriched public and community life in New Zealand.

# INTRODUCTION

In 2000, Cancer Society of New Zealand (Inc) published *Undercover – Guidelines for shade planning and design* (Greenwood, Soulos & Thomas, 2000). Since then, there has been increasing awareness of the need to provide sun-shading in public spaces to prevent UVR over-exposure. In 2014 in the USA, *The Surgeon General's Call to Action to Prevent Skin Cancer* positioned the aim to 'increase opportunities for sun protection in outdoor settings' as Goal number 1 (US Department of Health and Human Services, 2014). Over the last 3 years in New Zealand, several projects have been built to shade public spaces. However, the success of these projects in providing UVR protection for users has not been investigated.

The aims of this case study research are:

- To understand the role of territorial authorities, lobby groups, building owners and/or designers in initiating shade in public spaces.
- To assess the design and UVR protection of recent built shade in New Zealand public spaces.
- To understand issues associated with the provision of shade in public spaces.

*Report format*

In order to present the reader with a general understanding, the report firstly outlines the principles of sun-shading for UVR protection. Secondly, the research methodology is explained. Thirdly, the six case studies are presented, in order of geographical location from north to south. At the end of each case study, key learning points are identified and summarized in the Executive Summary.

*Research limitations*

As the research was commissioned in winter, when UV levels are too low to assess UVR protection factor (PF) using a UV meter, PF factors were estimated as explained in *Research Methodology*. Each case study included site surveys and interviews with territorial authorities, designers and building managers. No surveys of users were undertaken.

# PRINCIPLES OF SUN-SHADING FOR UV PROTECTION

Background on key aspects of prevention, diagnosis and treatment can be found in the 2014 Australasian publication, *Sun, Skin and Health* (Slevin, 2014). The provision of shade is a key prevention strategy. In order to design effective outdoor shaded space, the following factors need to be understood; how different skin types react to the sun, the seasonal and daily patterns of UVR intensity for the geographical location and how UVR exposure is comprised of direct, diffuse and reflected UVR. In order to shield the direct sun, seasonal daily sun-paths must be plotted and the shading material carefully chosen. Finally, outdoor areas need to be thermally and visually comfortable if they are going to be used. The overall design and use of different materials can modify the microclimate significantly.

## Skin Type

It is important to understand your and your family's skin type and the time it takes for sunburn to occur at different UVR intensities. *Figure 1* illustrates this in relation to the UV Index (UVI). UVI is an international standard measurement of the strength of ultraviolet radiation at a particular place and time.

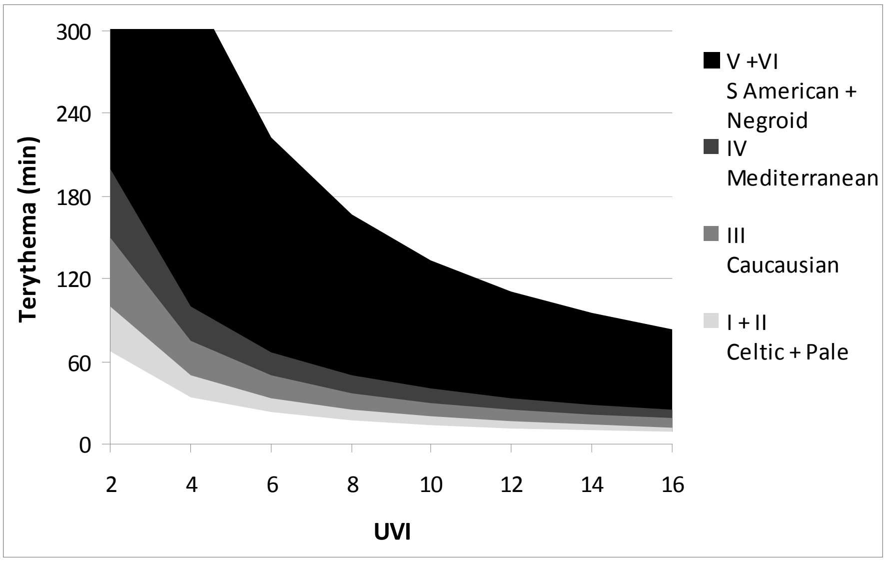



*Figure 1: This graph illustrates how different skin types (as defined by Fitzpatrick in 1988) react to increasing intensities of UVR. $T_{erythema}$ is the time (in minutes) it takes for 'redness of the skin' to appear. (Copyright: Author)*

The role of any form of sun protection is to block or filter UVR to safe levels for the person or people involved. The World Health Organization (WHO) recommend that sun protection is required when UVI > 2. At UVI 2, the $UVR_{eff}$ in standard erythmal doses (SED) would be 1.8 SED per hour. Generally 2 SED is sufficient to cause erythema or sunburn in people with sensitive skin. This level is aimed at the needs of the fairest skin type group.

## Seasonal and daily UV levels

The following charts in *Figure 2* are useful in determining when it is necessary to avoid direct sunshine in different New Zealand locations. It is important to remember that the UVI levels in these charts are an estimation of the 'maximum potential hazard' on a cloudless day in an open location (equivalent to a flat plain). Hills, forests and buildings can reduce UVR exposure significantly by shielding diffuse UVR as described in the following section.

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Auckland | 10 | 8 | 7 | 4 | 2 | 1 | 2 | 2 | 3 | 6 | 8 | 9 |
| Wellington | 9 | 8 | 6 | 3 | 1 | 1 | 1 | 2 | 2 | 5 | 7 | 8 |
| Christchurch | 8 | 7 | 5 | 2 | 1 | 1 | 1 | 1 | 2 | 4 | 7 | 8 |
| Central Otago | 8 | 7 | 5 | 2 | 1 | 1 | 1 | 1 | 2 | 4 | 6 | 8 |
| Invercargill | 7 | 6 | 4 | 2 | 1 | 0 | 0 | 1 | 2 | 3 | 5 | 6 |

Mean UVI (including clouds)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Auckland | 13 | 11 | 7 | 4 | 2 | 2 | 3 | 5 | 6 | 8 | 11 | 13 |
| Wellington | 13 | 9 | 6 | 3 | 2 | 1 | 2 | 4 | 5 | 8 | 11 | 12 |
| Christchurch | 12 | 8 | 5 | 3 | 1 | 1 | 2 | 3 | 4 | 8 | 10 | 11 |
| Central Otago | 10 | 8 | 5 | 2 | 1 | 1 | 1 | 3 | 4 | 7 | 10 | 11 |
| Invercargill | 8 | 7 | 4 | 2 | 1 | 1 | 1 | 2 | 3 | 5 | 9 | 10 |

Peak UVI (cloudless)

*Figure 2: NIWA data (from 2002 to 2007) from five locations in New Zealand. (McKenzie, 2008)*

# Direct and diffuse UV

We receive UVR from two main sources outdoors. Direct UVR is radiated directly from the sun, in sunshine. Indirect UVR includes diffuse (or scattered) UVR from the hemisphere of the atmosphere (the visible sky) and smaller amounts of reflected UVR off buildings or ground surfaces. When the sun is high we receive slightly more direct UVR than diffuse UVR and when the sun is low we receive less direct UVR than diffuse UVR. However, in the design of shade it is useful to consider that

**in an open field situation a person will receive on average approximately 50% of UV from the direct sun and 50% from diffuse UV reflected from the hemisphere.**

For practical purposes, the diffuse UV can be considered to be equally distributed around the hemisphere. So if the UVI level is predicted to be UVI = 10, it could be predicted that a person would receive approximately UVI = 5 from the direct sun and UVI = 5 from diffuse UV reflected from the hemisphere of the open sky as illustrated in *Figure 3* below.

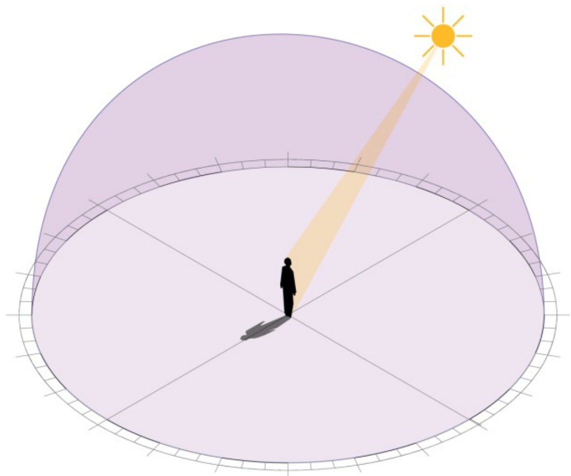


*Figure 3: In an open landscape a person will receive approximately 50% UV exposure from direct sunshine and 50% UV exposure from diffuse UV reflected from the hemisphere of open sky.*

The amount of UVR exposure of a person standing in the shade can be estimated by observing the solidity of the shading material and the proportion of the sky hemisphere that can be seen. For example, consider a person was standing in the shadow of a wall on a flat plain.

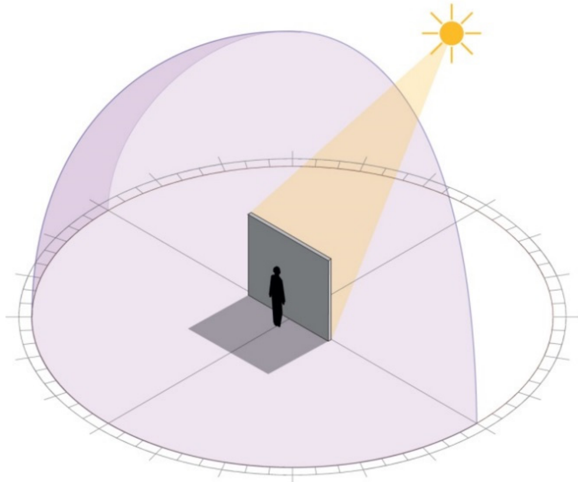


*Figure 4: A person standing in the shadow of a wall will receive approximately half the hemisphere of diffuse UV only.*

As illustrated in *Figure 4*, the person is receiving no direct sun and they can see only approximately half of the hemisphere of the sky. If the UVI in the open is UVI 10 then the person will be exposed to approximately half of the diffuse UVR (UVI 5) which is UVI 2.5.

Protection Factor (PF) is a concept used to describe the UVR protection provided by fabric or sunscreen. In the same way the shade provided by the wall (illustrated in *Figure 4*) is reducing UV exposure by 4 times (e.g. UVI 10 to UVI 2.5) and could be considered to have a protection factor of PF = 4.

$$\text{PF (protection factor)} = \frac{\text{UVI (in open)}}{\text{UVI (under shade)}}$$

Where there is shade provided from buildings or trees, choosing to '*walk in the shade'* for short walks is an effective strategy for daily life. (At UVI = 2.5 at fair skinned person will receive sunburn in just under an hour).

Living in a city and urban environments such as downtown Wellington can provide even more protection from diffuse UV. Verandas and tall buildings can reduce the view of the sky (and therefore exposure to diffuse UV) significantly. This is illustrated in *Figure 5* on the following page.


*Figure 5: In this view of Willis Street in Wellington, the view of the sky would be less than 1/5 of the potential sky hemisphere. At UVI = 10, a person in the street shade would be exposed to less than 1/5 diffuse UVR = 1/5 x UVI 5 = UVI 1.*

Conversely, diffuse UVR can seriously undermine the protection given by an umbrella. Consider a person reading a book under an umbrella in an open landscape as illustrated in *Figure 6*. It is an activity that might be enjoyed for an hour or two.

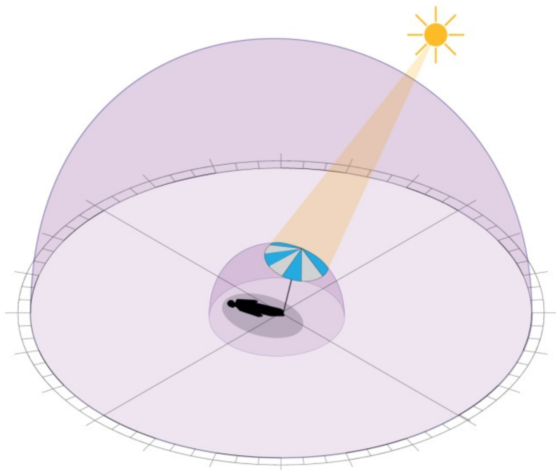


*Figure 6: In open situation, a beach umbrella might shield direct UVR, but it provides little protection from diffuse UVR.*

By calculating the surface area of the umbrella as a proportion of the hemisphere of the visible sky, a 1600mm diameter umbrella would only shield 13% of the diffuse UVR. If the UVR in the open was UVI 10, and the material of the umbrella blocked 95% of UVR, the UVR exposure under the shade would be UVI 4.7. A fair skinned person would experience sun-burning in less than 30 min. In this example, while the umbrella fabric had a UPF of 20 (the fabric blocks 95% of UVR), the protection factor (PF) of the umbrella canopy was only PF 2.1. (UVI 10 divided by 4.7).

If the umbrella were situated on a beach, the effective UVI level underneath would be even higher due to the **reflected** UVR off the sand.

## Reflected UVR

Generally most materials in the natural world absorb UVR. The darker the material the more the UVR is absorbed, in the same way as a dark painted wall absorbs the heat of the sun. Darker coloured fabrics transmit slightly less UVR than lighter coloured ones of the same type. A grass play-ground could have 0.8 to 1.2 % reflectivity. The reflectivity of new concrete could be 15.8%; it is only 9.2% when it is aged (McKenzie and Kotkamp, 1996). Dry sand and snow can reflect up to 18% and 20%. A light coloured wall would reflect heat, light and UV as well. At these levels, reflected UV is unlikely to significantly affect the protection factor of a shade canopy in the home environment.

Reflected UVR is critical to consider in outdoor recreational areas especially in the ski-fields or at the beach. In these settings you would expect to be well protected with clothing, sunscreen and sunglasses.

## Sun paths

The design of shade structures is considerably more complicated as it is important to understand the different paths of the sun throughout the year. Sun paths for different locations vary according to the movement of the sun around the earth.  The following diagram, *Figure 7*, illustrates the seasonal variation in Wellington.

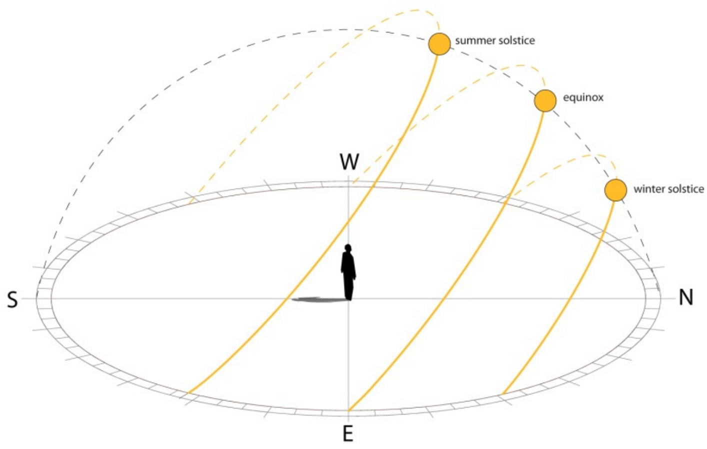



*Figure 7: Diagram showing the seasonal sun-paths 42° latitude near Wellington. In the tropics the sun paths are more directly overhead and have little seasonal variation.*

Detailed sun-path charts for different locations in New Zealand are available from various websites and even mobile phone apps. Most architectural drawing software can plot building and canopy shadows for any geographical location throughout the day and the year.

The aim of good sun protection is to shield the direct sun when UVR levels are above UVI 2. While diffuse UVR is relatively constant, the angle of direct sunshine is constantly changing both vertically and horizontally.

## Screening UV

Shading materials need to be chosen with care, as people can assume that all shade is the same. Solid materials provide a 100% UVR barrier and for perforated materials the percentage is proportional to the solid area.
Fabrics provide varying degrees of protection; mainly due to the openness of the weave. Generally dark colours absorb more UVR and therefore create a slightly better barrier but usually this is not significant. Horticulture woven shade-cloth offers poor protection. Before selecting any material, it is important to check the manufacturer's specifications for UVR transmission.

Solid materials such as metal, wood or clay roof tiles block UVR 100%. Normal glass filters only part of the UVR erythemal range, but the interlayer of laminated glass (used in overhead glazing and car windscreens) is a 99% barrier. As UVR degrades most materials, coatings are used to protect the base material but in practice they can protect people as well. The coating on polycarbonate sheeting does this. Some uncoated clear PVC's often offer little protection (and break down quickly). ETFE (ethylene tetrafluoroethylene) translucent film has been used to cover sports stadiums. This material transmits a high percentage of UVR allowing grass underneath to grow. In summary, if you are considering using transparent or translucent shading materials the technical specifications need to be checked carefully. Transparent roofing can be appealing as it gives UVR protection that is light and warm.

Green landscaping can also be designed to shield spaces. Dense tree canopies provide the best barrier to direct UVR. Outdoor 'walls' of hedges or vine covered trellis can shield diffuse UVR. In more temperate zones, deciduous trees or vines can allow the low UVR winter sun in, to warm the surrounding surfaces and the occupants. Local advice is required to select the most suitable trees and plants for different climates.

## Thermal comfort

In New Zealand, there are times when the air temperature is too cool for comfort, when the UVR levels are above UVI 2. In this situation, solid dark shade would be cold and would not be used. Transparent roofing together with screening of cool sea breezes can create safe and warm spaces. In high summer, fabric or timber screens can be placed under the translucent roofing to shield the space below from the sun's radiant heat.

A 2014 study presents charts of when 'warm shade' is required for five New Zealand locations. (Mackay, Sandford, & Hall, 2014)

## Permanent versus temporary canopies

Buildings are built to withstand high wind loads. This requires engineered foundations, structural elements and connections and usually involves considerable expense. In domestic situations, temporary light weight shade sails and umbrellas can work well. They can be simply demounted if strong winds are forecast.  In public and community situations this monitoring is difficult and permanent solutions are generally more suitable.

## Appropriate levels of UVR protection

The aim of UVR protective shade is to create a situation where people can enjoy the attributes of the outdoors – fresh air, warmth and breezes but be protected from UVR over-exposure. The goal is to prevent sunburn and eye damage.  The protection rating (PF) needs to appropriate for the proposed period of use, the UVI levels of geographic location and the skin types (and/or personal protection) of the users. Satisfactory protection for mid-day and whole day use is provided when the protection factor of a shaded location is above PF15 (Parsons, 1998). This can be achieved by using a 100% UVR barrier to shield direct UVR <u>and</u> screening 87% of the 'sky view'. In many situations filtered screening, natural vegetation or openings to a view are desirable for aesthetic reasons. Any amount of 'sky view' which allows in diffuse UVR will reduce the protection factor (PF) rating, but small areas are not significant.

# RESEARCH METHODOLOGY

Possible case study projects were identified via the network of Cancer Society of NZ branches and through a review of recent architectural journals. The six sites were selected to achieve a variety of venues and locations within New Zealand. Background and feed-back on each shade project was gathered through semi-structured interviews with the client, local council staff, the designers and the venue managers.

## Project initiation, implementation and feed-back

Each local Territorial Authority was contacted to confirm if their policies included sun-shading for UVR protection. The building owners and/or managers were interviewed about the design brief as well as the initiation and implementation process of the project. Architects and designers were interviewed concerning overall design considerations and sun-shading strategies. Building managers and/or site staff were interviewed on any issues with the installation of the shade structures and their ongoing maintenance. All interviewees were asked to report on any feedback that they had received from the general public.

## Assessment of the UVR protection of the shade canopies

Firstly, the level of UVR protection required was estimated by assessing the UVR protection requirement and obtaining maximum UV levels in summer.

*UVR protection requirement*

The managers of each facility confirmed the typical pattern(s) of use of the canopies; the time of day and the duration of occupation.

*UVI levels*

NIWA data on annual UVI levels was sourced for different locations (McKenzie, 2008). The most protection will be required when the UVI levels are at the maximum (i.e. at solar noon in mid-summer). Secondly, each canopy and its setting was surveyed to assess how well it protected its occupants from direct UV and diffuse UV.

*Site and context*

The site, location and orientation was identified on Google maps. The site was surveyed using photographs and measurements.

*UVR protection*

As site surveys were undertaken in June, UVR levels were too low for accurate measurement using a hand-held UV meter. Therefore by using the UVR transmittance of the material shading the direct sun and the proportion of open sky viewed (diffuse UVR), the protection factor was estimated for the shade at 1m above the ground at the central location of each canopy or pavilion.

*Shading material*

Where available specifications for UVR and heat transmittance of the shading materials were sourced from the project building specification and/or the material supplier.

*Shading of direct sun*

Using site measurements and/or the plans and drawings obtained from the designer or building owner, simple 3D digital models were constructed. Using Revit software sun-paths were plotted at 10pm, 1pm and 4pm in mid-summer and at 11am, 1pm and 3pm at the equinox and in mid-winter. Results are illustrated in plans and perspectives.

*Shielding of diffuse UVR*

Exposure to diffuse UVR from the open sky was assessed for the central point (at 1m above the ground) under the canopy or pavilion.

The size and position of the ‘sky view’ was assessed on site and/or using construction drawings. At each site, visual angles were measured to the top and bottom of ‘sky views’ (using a mobile phone app for measuring slope). Angles were measured from 1m above the central point under the canopy to top of surrounding buildings, trees and hills. Where the horizon was undulating, an average line was taken. In some cases, horizontal and vertical angles from the central point to the opening were measured from construction drawing plans and sections. This process defined one or more 'sky views' as illustrated in *Figure 8*. By using spherical geometry, the proportion of the hemisphere exposed to view, the 'sky factor', was calculated using the following formula.

Sky factor* = (sin a° - sin b°) x (c°/ 360°)

*The 'sky factor' is the proportion of the hemisphere of the open sky that can be seen at a specified point under a shade canopy.

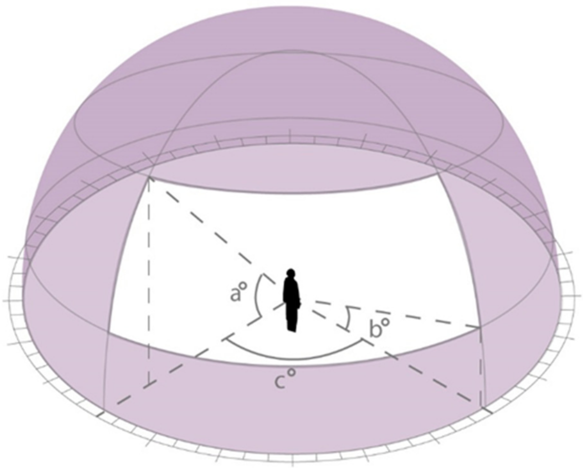



*Figure 8: The sky factor was calculated by measuring angles a°, b° and c° from 1000 above the floor at the central point under the canopy to view(s) of the open sky.*

*Protection Factor (PF)*

The protection factor (PF) of the shade <u>at the central point of the canopy</u> was estimated using the UV transmittance of the shading material and 'sky factor' using the following formula.

PF (approximate) (under shade) = 1 / (UVR transmittance (of shading material) x 0.5 + sky factor* x 0.5)

$$PF_{(approximate, \ under\ shade)} = \frac{1}{\text{UVR transmittance}_{(of\ shading\ material)} \times 0.5 + \text{sky factor}^{*} \times 0.5}$$

## Thermal comfort

A shade canopy is likely to be used if it creates a thermally comfortable environment. A 2012 study correlated available NIWA temperature and UV data for five New Zealand locations; including Auckland, Wellington and Christchurch (Mackay, Sandford & Hall, 2014). The resulting charts illustrate an estimation of when 'warm shade' and 'cool shade' are likely to be required in each location. Using this knowledge, the design and materials of each case study site were considered, at a basic level, in terms of how the temperature of the space was able to be modified throughout the seasons. Full understanding and assessment of the thermal performance of the canopies would require complex site measurement and analysis.

# CASE STUDIES

## Case study 1: The Pavilions, Britomart, Auckland

| | |
|---|---|
| *Address:* | Britomart Precinct, Auckland |
| *Owner:* | Cooper and Company |
| *Designers:* | Cheshire Architects Ltd |
| *Local Government:* | Auckland Council |

### Background

The site of the Pavilions is within the Britomart precinct in downtown Auckland. Cooper and Company are involved in developing the nine city blocks, as an urban renewal project, for the Auckland Council. The site of the Pavilions is ear-marked for a multi-storey development. In 2014, it was being used as open car-parking servicing the surrounding shops, bars and restaurants and a weekend market. Britomart had become a lively night-time venue, but it was quiet during the daytime. As pop-up shops had been successful in Christchurch following the earthquakes, Cooper and Company decided to 'activate' the area using temporary commercial buildings.

The design of the Pavilions, aimed to attract day-time shoppers, particularly women, to eight fashion and specialty boutiques centred round an 'anchoring' café/restaurant with outdoor dining.

*Figure 9: above*

## Context

A tower building blocks the site from a harbour view and sunshine from the north. On the south side, the site opens onto the Te Ara Tahuhu pedestrian walkway which links to Britomart Transport Centre to the open space of Takutai Square.

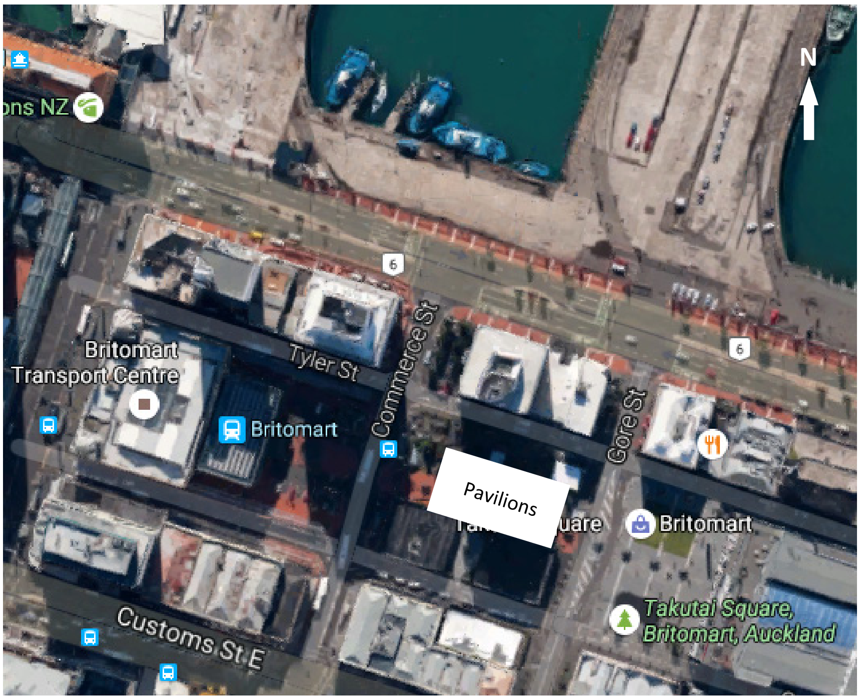



*Figure 10: The location of the Pavilions within the Britomart Precinct.*

## Description

As a temporary building with an expected five year lifespan, the construction needed to be low-rise, simple and economical. As a destination, the design needed to be appealing and unique; not just another shopfront in a strip mall. Cheshire Architects achieved this by creating an open and welcoming 'urban garden' with three high light-filled canopies. These act as an over-grown 'verandah' to the collection of small scale boutique shops. They use simple steel gable trusses, a feature common in the adjacent historic warehouses. Wall and columns are clad in natural timber slats which form a trellis for vines.

*Figure 11: A winter view from the Te Ara Tahuhu pedestrian walkway illustrates the three gable canopies with different roofing.*

To suit Auckland's high and frequent rainfall, the architects firstly conceived the canopies as open rain umbrellas, rather than sun umbrellas. However, they work as both.

In response to the shadow of the neighbouring building on the north side, the two side canopies are roofed in a transparent film which transmits maximum daylight and sunshine. In contrast, the central dining area canopy uses a white translucent membrane. From their past experience, the architects knew that this material would appear 'light and bright' in the summer sun but shield the heat of the sun. It would provide 'cool shade' for long summer lunches.

*Figure 12: As can be seen by the shadows, the translucent architectural textile gives good quality shade for the diners but it creates a light and airy feel.*

## Project feedback

The lightly shaded pavilions with their decorative gardens have become the 'most loved part of Britomart'. In contrast to the Transport Centre and Britomart square, they are on a human scale and well 'furnished' with seating and planting. In 2014, Cheshire Architects Ltd received a New Zealand Institute of Architects Local Award for the design.


*Figure 13: The clear PVC roofing on the two side canopies works well in letting in maximum light to the circulation spaces (especially in the winter).*

Auckland is known for its 'horizontal weather', and the space under the canopies is not used on cold windy wet days. The gaps at the end of trusses allow the rain to be blown through. Café patrons need to brave the weather to reach the indoor café via the open walkway. The architects explained that the design was not intended to be a perfect solution for all weathers.

In Auckland, it would be possible to enjoy the lunchtime winter sun at its low UV levels of UVI 1 – 2. Unfortunately, as the site is over-shadowed by neighbouring buildings, this is not possible. On winter days and evenings, the café provides knee rugs and radiant gas heaters to warm their patrons.

## UVR protection

*UVR protection requirement*

The pavilion canopies are used mainly by two groups of people.

Firstly, shoppers who pass through the side canopies, from the open walkways in the Britomart area. High UV protection in these spaces is not necessary for such brief occupation. In Auckland, from September to April, when UVI reaches 3 or higher, daily personal sun protection of hats, clothes and/or sunscreen is recommended.

The second user group are café patrons who may relax under the central canopy for one or two hours during the day. The group needs UV protection.

*UVR levels in Auckland*

UVI can reach UVI 13 on a clear day in the mid-summer.

The protection factor required for a two hour lunch would need to be above PF 12.

*Shading material*

The central pavilion uses architectural PVC textile Serge Ferrari – Precontraint 502 (Code 502-8102 – EN 14501 rating = TS10 RS76 AS14). It has an 8 year warranty (baytex.co.nz) and shields 100% of UV. It is able to be recycled when the pavilions are dismantled.

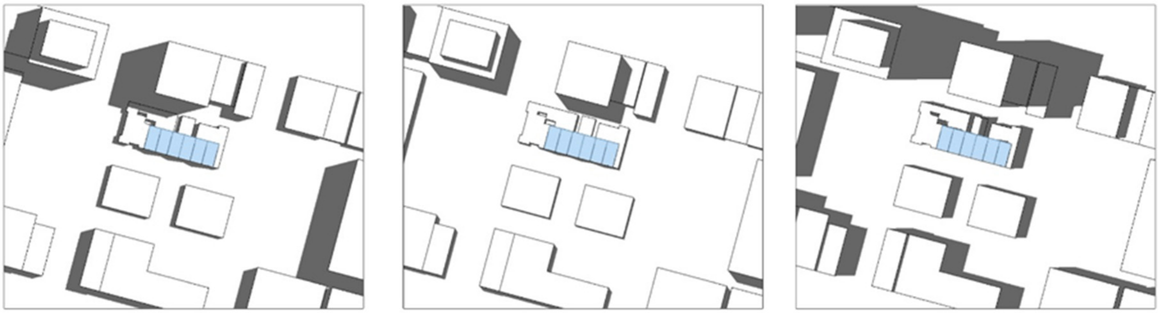
The side pavilions use a clear PVC membrane. (Its exact specification is not known). However clear PVC is only used for roofing in temporary or short–life situations. Clear PVC transmits a high proportion of high UV, heat and light. As evident at the Pavilions, UVR radiation breaks down the PVC and it becomes cloudy. In the short-term, this cloudiness is likely to reflect and refract the sun's heat, light and UVR thus providing some UVR protection. Nevertheless, after a few years it will deteriorate and need to be replaced. For this reason, PVC often has a limited life guarantee of only 5 years. (http://www.psp.co.nz/translucent-roofing/corrugated-sheeting/sunlite-translucent-pvc)

Clear PVC would be unsuitable for shading the dining area. In high summer the diners could overheat and could even get sunburnt while enjoying lunch. Yet the material is an appropriate solution when used over a temporary circulation and garden space as it gives warmth, maximum light (and UVR exposure) to passing shoppers.

*Shielding of direct UVR*

Shadow from surrounding buildings

As previously mentioned, the downtown site is surrounded by high buildings which restrict the direct sun. In *Figure 15*, area plans show how much the site is in shade over the duration of a year. In mid- summer, sun falls on the canopy roofs between 10am and 4pm. At the spring and autumn equinox, they are partially shaded. In mid-winter, the area receives very little sunshine.



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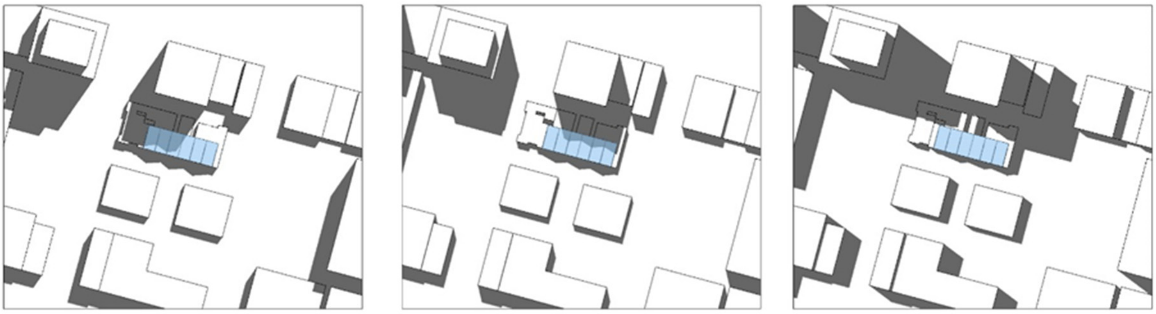

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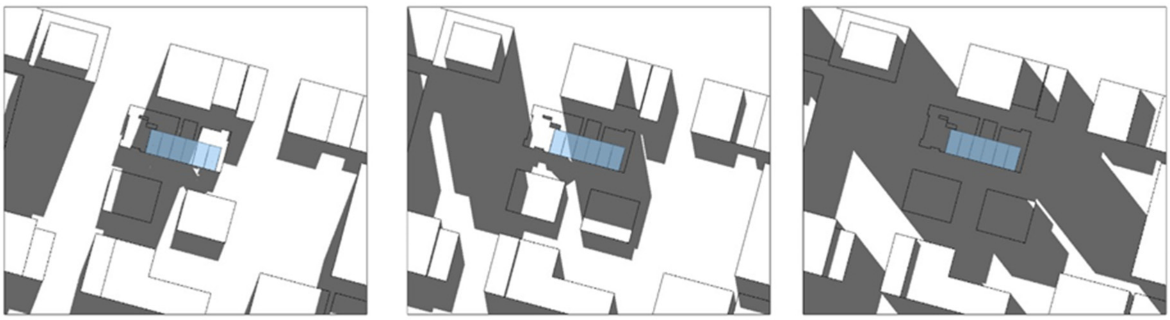


MID-WINTER *20 June* *11am* *1pm* *3pm*

*Figure 14: Shadow from surrounding buildings. (The location of the Pavilions is highlighted in blue.)*

Canopy shadow

In *Figure 14* below, perspectives illustrate the daily pattern of shadow across the year. In mid-summer, the central canopy creates full shadow at lunchtime. At 10am and 4pm, it creates half shadow, but the sunshine is being somewhat filtered through the PVC roofing. For six months of the year over winter the dining space is in full shade.

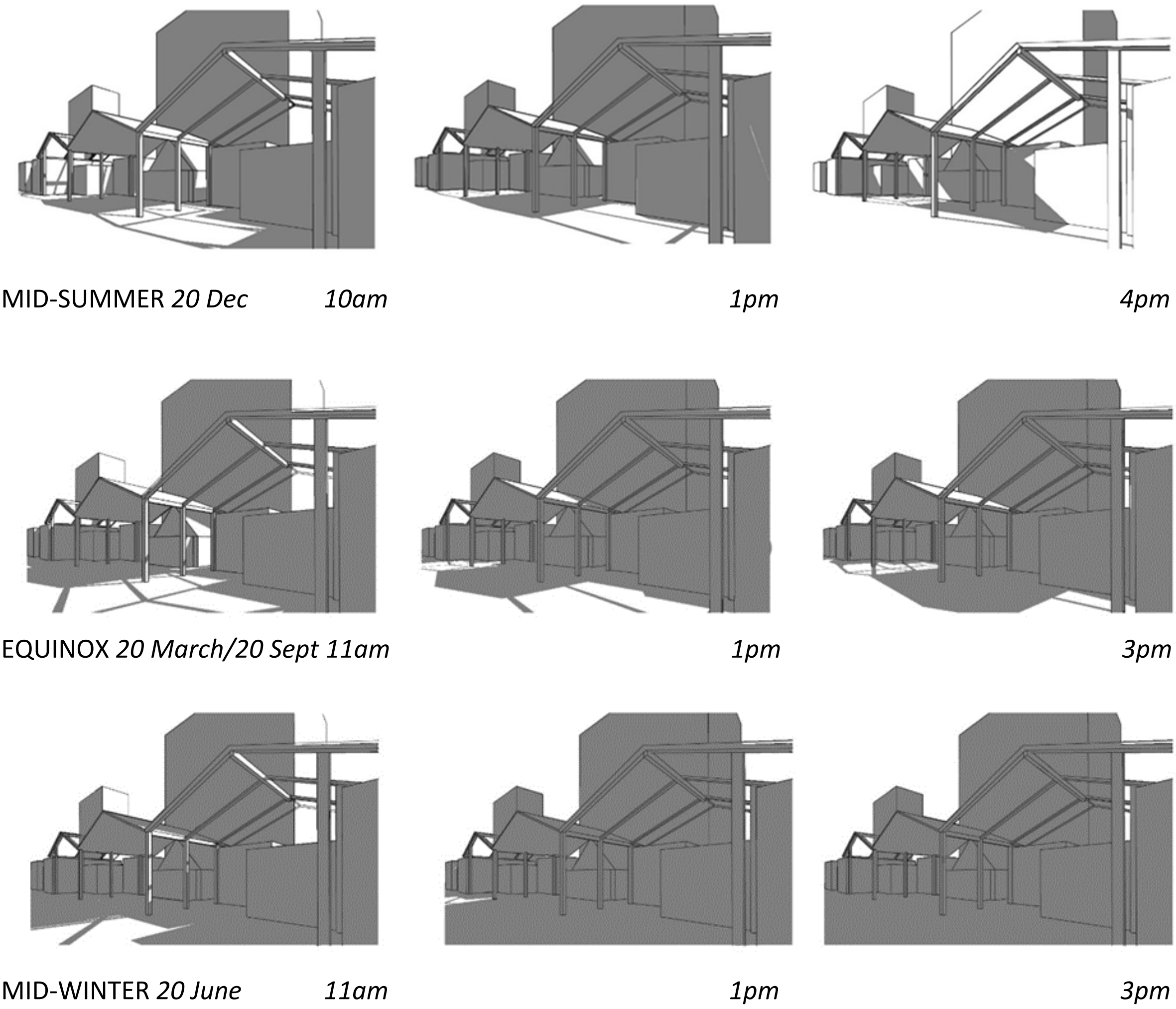



*Figure 15: Shade under the canopies at different times of a year.*

*Shielding of diffuse UVR*

*Figure 16: This collage panorama, taken from the centre of the central pavilion, illustrates how little open sky can be viewed (and therefore how little exposure the diners have to diffuse UV).*

The proportion of open sky viewed from the centre of the central canopy is estimated at 0.05. (This includes the view of the through the clear PVC)

*UVR Protection Factor*

$$\text{PF estimated (under shade)} = \frac{1}{\text{UVR transmittance (of shading material)} \times 0.5 + \text{sky factor} \times 0.5}$$

= 1/ (0 x 0.5 + 0.1 X 0.5) = 1/0 + 0.05) = 1/0.05

= PF 20

The high level of protection is achieved by several factors

- by the use of a roofing membrane that is over 99% UV barrier
- the ‘sky view’ in all directions is limited due to the walls of the surrounding boutiques and the height of the surrounding inner city buildings.

## Thermal comfort

The chart below suggests that the use of roofing which blocks the heat of the sun is likely to be necessary for summer cooling.

| | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9 | 4 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 |
| 10 | 4 | 4 | 4 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 |
| 11 | 4 | 4 | 4 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 |
| 12 | 4 | 4 | 4 | 3 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 |
| 13 | 4 | 4 | 4 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 4 | 3 |
| 14 | 4 | 4 | 4 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 4 | 3 |
| 15 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 4 | 3 |
| 16 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 |
| 17 | 4 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 19 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

- UVI<2 + temp <18 C - requires warmth but not UVR protection
- UVI<2 + temp >18 C - requires neither warmth or UVR protection
- UVI>2 + temp <18 C - requires warmth and UVR protection
- UVI>2 + temp >18 C - requires UVR protection + maybe cooling

*Figure 17:*
*Chart of estimated shade types to suit different times of the day during the year in Auckland (Mackay, Sandford and Hall 1).*

From September to December, 'warm shade' is likely to be welcomed by café patrons. Further analysis and on-site monitoring of temperature, humidity and wind speed would be required to determine the amount of heat transmittance that would be ideal for year round use.

**Key learning points**

- The height of inner city buildings shield diffuse UVR and reduce UVI levels.
- Canopies can be effective 'umbrellas' for the rain as well as for the sun's heat and UVR.
- The use of transparent and translucent films can modify sunshine, daylight and heat of the sun.
- The combination of built and natural shade can create attractive and appealing urban space.

# Case study 2: Eat Streat, Rotorua


*Address:* Tutanekai St, Rotorua

*Owner:* Rotorua Lakes Council

*Designers:* ARTO Architects

*Local Government*: Rotorua Lakes Council

## Background

Rotorua Lakes Council have a policy of 'Shade Creation' to 'provide for shade in public open spaces'.

Eat Streat opened in March 2014. This $2 million project pedestrianised and covered an existing street with many restaurants close to Lake Rotorua. The concept was part of an inner city regeneration project initiated by Rotorua Lakes Council. The aim of the project was to remove automotive traffic from the street and create an alfresco dining area that people could enjoy 365 days of the year; a space that was warm in winter and cool in summer, with shade from the sun and shelter from the wind.

The Council obtained the design for Eat Streat by the process of an open architectural competition. It was won by Arto Architects, a local firm.

## Context

Tukanekai Street was a typical wide open street with verandahs over the pavements and street car-parking along its edges. The buildings on either side were mainly single storey and a mix of ages.


*Figure 18: City plan showing the location of Eat Streat*

## Description

ARTO's design proposed a clear glazed canopy over a new public walkway down the centre of the old street. Open at each end, it frames the view shaft up Tukanekai Street from the centre of the city to the lake. When approaching from the lake, it acts as a gateway and entrance to the city.

*Figure 19: View of Eat Street towards the lake*

Each café has their own opaque waterproof (and UV protective) retractable canopy which extends from the edge of the original street verandah to the new frame of the ‘V’ shaped central glazed roof. A gap in between allows heat to disperse in the summer and also give a sense of openness and the outdoors. The incorporation of decorative screens, at each end of the ‘streat’, act as wind breaks.

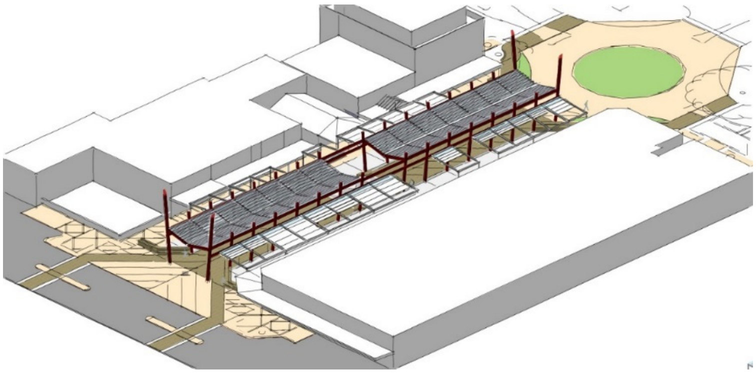


*Figure 20: An aerial view illustrates the central walkway and retractable canopies.*

In support of local industry, Rotorua City Council has a ‘timber first’ policy which required the structural support for the canopy to be constructed in timber. This significantly influenced the design aesthetic. In order to provide comfort for patrons in the evening and on wintery days, the pavement under the retractable canopies is heated geothermally.

*Figure 21: Decorative lighting is used to enhance the canopy in the evening.*

## Project feedback

ARTO architects and Rotorua Lakes Council project team reported that this innovative project was a ‘learning curve’. This new concept required a lot of research and development; of materials, products and construction as well as liaison with the public, property owners and café operators.

Eat Streat has proved to be commercially successful. It is a vibrant restaurant and social environment for locals and tourists alike. It has not only revitalized a central city street but has attracted other bars and restaurants to the surrounding area. In 2015, APR Architects (now ARTO Architects) received a New Zealand Institute of Architects – Waikato/Plenty of Plenty Public Architecture Award for the design.

The motorized retractable canopies are owned by the each business. Their average cost was $20,000.  Rotorua Lakes Council arranged the purchase of the canopies and also provided finance to allow the owners to pay them off over time. Every café bought a canopy.


*Figure 22: The retractable canopies extend outwards from the front of each restaurant to the central walkway.*

## UVR protection

*UVR protection requirement*

Eat Streat is used by various groups of people. Pedestrians, walking from the lake to the city centre, pass through. They are moving from an open area where daily personal sun protection of hats, clothes and/or sunscreen is recommended for the warmer months. Café patrons who may relax at the restaurants and bars for one to four hours throughout the day. The space is also used for events such as the start of car rallies, cycle events and jazz festivals.

*UVR levels in Rotorua*

UVI can reach UVI 13 on a clear day in the mid-summer.

The protection factor required for a four hour lunch would need to be PF 15+.

*Shading material*

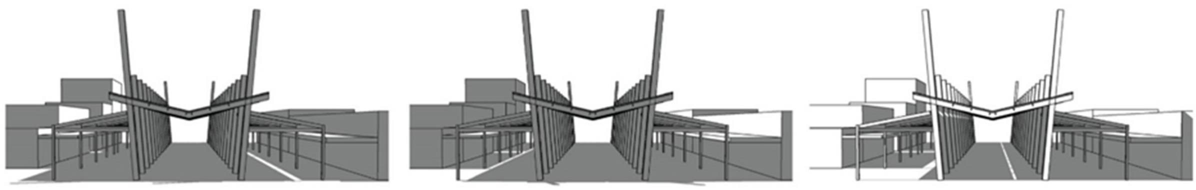
The central canopy is roofed in clear polycarbonate. Polycarbonate sheet has a protective layer which is a 100% barrier to UVR.

The motorized retractable canopies were sourced from Australia. The Italian textile is water-proof and rated at 100% UVR protection.

*Shielding of direct UVR*

Retractable Canopies Closed

As illustrated in *Figure 23*, in summer, only small strips of direct sun enter the space when all the retractable canopies are extended. Sun enters through the gaps at each side of the central canopy. Diners can easily move to avoid these rays of sun.



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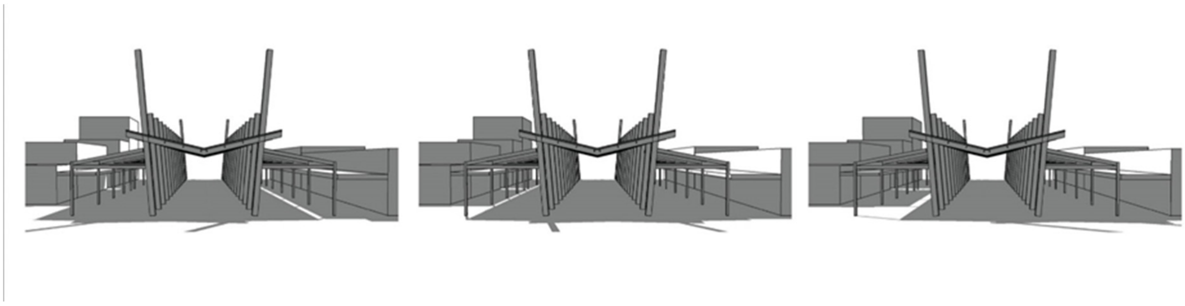

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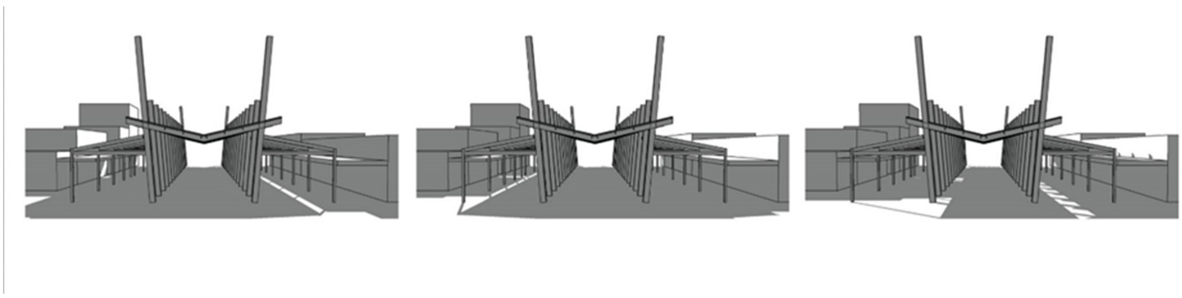
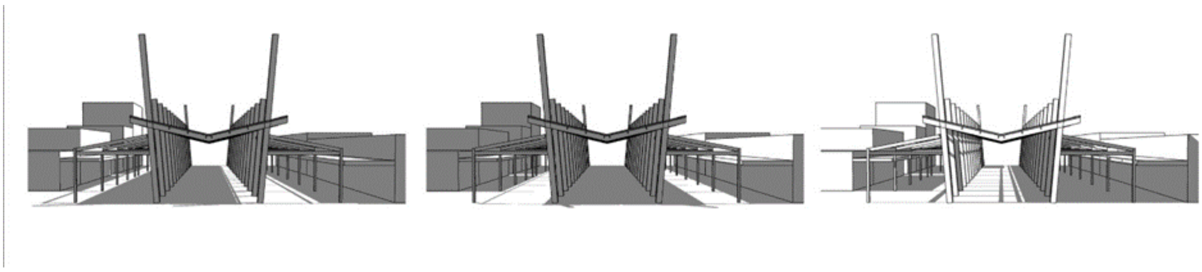


MID-WINTER *20 June* *11am* *1pm* *3pm*

*Figure 23: Pattern of shading of the central polycarbonate canopy and the retractable canopies when they are fully extended.*

Retractable Canopies Open

As illustrated in *Figure 24*, when all the side canopies are retracted, wide strips of full sun enter the dining areas throughout the year. Restaurant owners are in control of extending the canopies when needed for rain or sun protection. In order to maintain adequate UVR protection, to suit the time of day and time of year, operators would need to be aware of UVI levels and also cooperate with their neighbours.



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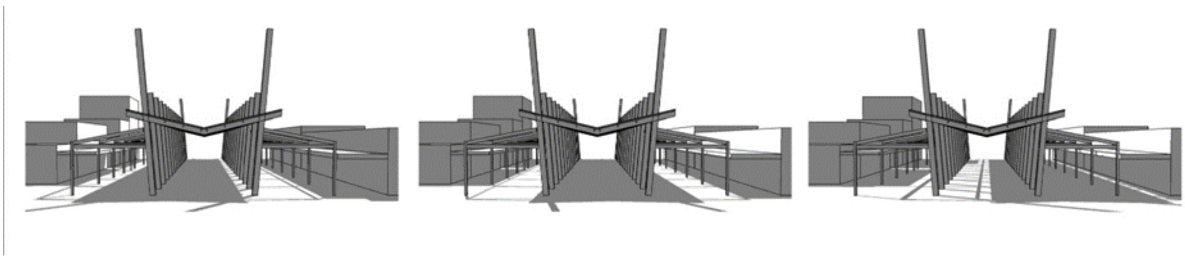
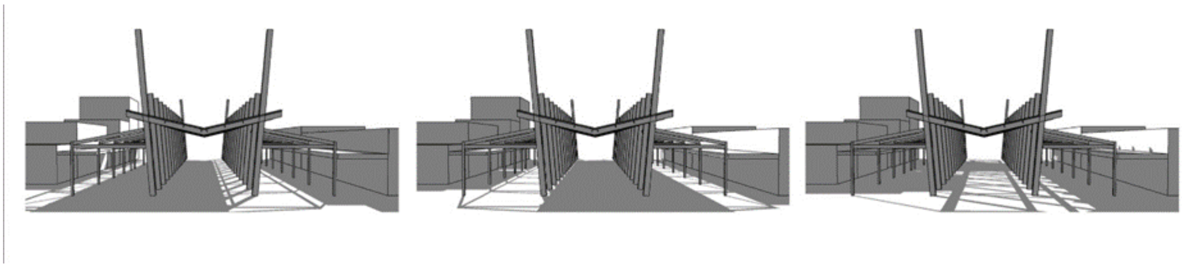


EQUINOX *20 March/20 Sept 11am* *1pm* *3pm*



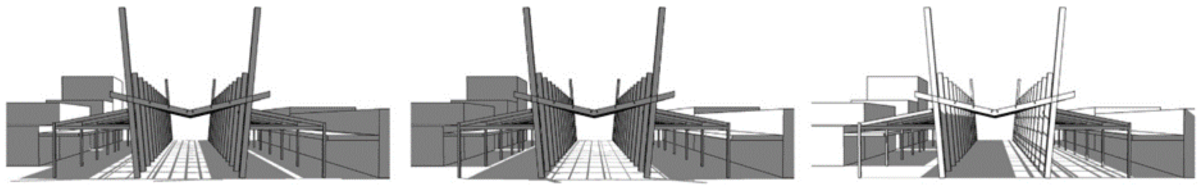
MID-WINTER *20 June* *11am* *1pm* *3pm*

*Figure 24: Pattern of shading of the central polycarbonate canopy when the retractable canopies are open.*

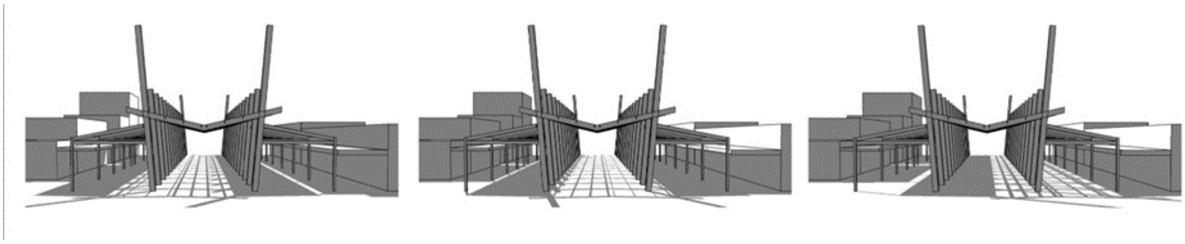
'Warm' shaded areas

The clear polycarbonate roofing for the central canopy shields UV but transmits light and heat from the sun. The following diagrams illustrate where 'warm shade' falls.

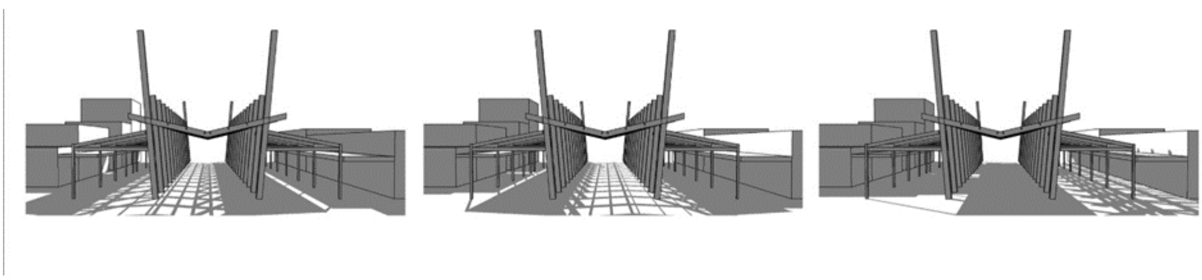
The clear roofing means the walkway is always light and bright. On hot summer days, there is plenty of cooler shade provided by the side canopies. In spring and autumn, areas of the dining space are warmed by the sun, but protected from UV. In the winter, if the retractable canopies are closed for rain protection, the clear polycarbonate works as a roof light.



MID-SUMMER *20 Dec* *10am* *1pm* *4pm*



EQUINOX *20 March/20 Sept 11am* *1pm* *3pm*



MID-WINTER *20 June* *11am* *1pm* *3pm*

*Figure 25: Pattern of sunlight through the polycarbonate roofing (when the retractable canopies are fully extended.*

*Shielding of diffuse UVR*

The proportion of open sky viewed from the centre of the central canopy (with the retractable canopies closed) is estimated at 0.08.

*Protection Factor*

The PF In the centre (when the retractable canopies are closed -

$$\text{PF estimated (under shade)} = \frac{1}{\text{UVR transmittance (of shading material)} \times 0.5 + \text{sky factor*} \times 0.5}$$

= 1/ (0 x 0.5 + 0.08 X 0.5)

= 1/0 + 0.04)

= 1/0.04

= PF 25

The high level of protection is achieved by several factors

- by the use of a roofing membranes that block over 99% of UVR.
- the 'sky view' is limited to the view at each end and the narrow strip of sky seen between the different roofing.

## Thermal comfort

A chart for estimating when warm shade might be required is not available for Rotorua. The nearest location for which information is available is Auckland.

| | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9 | 4 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 |
| 10 | 4 | 4 | 4 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 |
| 11 | 4 | 4 | 4 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 |
| 12 | 4 | 4 | 4 | 3 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 |
| 13 | 4 | 4 | 4 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 4 | 3 |
| 14 | 4 | 4 | 4 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 4 | 3 |
| 15 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 4 | 3 |
| 16 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 |
| 17 | 4 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 19 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

UVI<2 + temp <18 C - requires warmth but not UVR protection

UVI<2 + temp >18 C - requires neither warmth or UVR protection

UVI>2 + temp <18 C - requires warmth and UVR protection

UVI>2 + temp >18 C - requires UVR protection + maybe cooling

*Figure 26: Chart of estimated shade types to suit different times of the day during the year in Auckland (Mackay, Sandford and Hall 1).*

At this site, in cooler weather and evenings, the paving under the outdoor tables is heated geothermally. Heat from the sun is not required for comfort. In the summer, restaurant patrons can choose to sit in the 'warm shade' under the polycarbonate or under the cooler shade provided by the PVC textile canopies. Gaps between canopies allow air flow and prevent excessive heat building up.

## Key learning points

- Well-designed canopies, that provide protection from the rain, wind and sun, can revitalize public space and promote day and night use, all year around.
- Local Government can take a leading role to initiate, facilitate and manage public shade initiatives.
- Retractable canopies, owned and operated by restaurants can provide varying levels of UV protection to suit the time of day and time of year.
- Shaded spaces can be warmed by other heat sources, such as geothermal.

# Case study 3: Lido Pool Shade, Palmerston North

| | |
|---|---|
| *Address:* | Lido Aquatic Centre, Palmerston North |
| *Owner:* | Palmerston North City Council |
| *Pool management:* | Community Leisure Management |
| *Designers:* | Shade Systems, Dargaville |
| *Local Government:* | Palmerston North City Council (PNCC) |
| *Shade advocates:* | Community Health Advocate,<br>Cancer Society (NZ) – Central Districts<br>Dr Louise Reiche, Dermatologist |

## Background

In 2010, in response to a Manawatu Cancer Society submission on the need to adopt sun protection policy covering Council responsibility in shade planning, community event management and outdoor work employment, Palmerston North City Council (PNCC) introduced a sun protection policy as part of their district plan. This has enabled the Parks and Property Manager to undertake shade initiatives within the project works programme.

In 2013, the local Cancer Society Community Health Advocate, with support from a local dermatologist, prepared a submission to the draft Palmerston North City Council annual plan 2013/2014 recommending the implementation of 'shade placement for outdoor areas and a sun awareness campaign for patrons and outdoor staff of the Lido Aquatic Centre'. For generations, there had been an issue of children and teenagers becoming sunburnt when frequenting the 50m outdoor pool. There was an onus on kids, families and schools to provide their own sun protection.

The submission was supported by statistics of pool use and skin cancer reporting for the region as well as the findings of a survey of 230 pool users and families. 94% of the interviewees considered there was a need for more shade. The most popular shade priority was for shade sails over the embankment next to the 50m pool.

PNCC management used funding from 'safety improvement to reserves' to initiate the project. (The Local Government Act, 2002 Amendment Act 2012 includes '*avoidance of mitigation of natural hazards'* as a Local Government service).

The 50m outdoor pool is open from October to April and is heated to 25°C, using a gas boiler. It is used by around twelve local high schools and intermediate schools. In February, they come for their swimming sports day, often from 9am to 3pm. Some schools are well prepared with hats and sunscreen, but some are not. Pool management presently supply sunscreen and hats. The Cancer Society provides sunscreen at community and school outdoor events and sun protection education for pool staff. Students also come for swimming lessons at other times. After-school clubs use the pool for swimming lengths. Adults also frequently use the pool in the mornings and at lunchtime.

The Lido Aquatic Centre includes a 25m indoor pool, a hydro-slide, out-door family pools, play equipment and a dive pool. The Council invited design and installation proposals for the whole site from several shade sail companies. Shade sails can be a relatively economical solution for providing shade and they involve less compliance costs as shade sails under $50m^2$ do not require a building consent (NZ Legislation, 2004). PNCC worked with the selected supplier to refine the design. Due to budget constraints only the shade on the embankment adjacent to the 50m pool was built.

The project team decided to provide spectator shade over the concrete terraces. The supplier provided 3D analysis of the pattern of shade from direct sun created on the terraces and perspective drawings.

The canopies were opened in 2014.

## Context


*Figure 27: The alternately blue and white shade sails are positioned along the embankment on the NW side of the 50m pool*

The 50 m pool is situated in an open grassed area surrounded by trees. On the northwest side an embankment and a stepped concrete terrace provides good views for spectators.

Some existing shade was provided by low canopy over a bench seat attached to the fence at the top of the embankment.

*Figure 28: The existing shade canopy along the fence provides minimal UV protection.*

## Description

Shade is provided by nine square tensioned fabric sails on galvanised mild steel posts. They are positioned over the stepped concrete terrace at a height to allow clear views of the pool from the seating along the fence behind.

*Figure 29: A variety of fixing heights of the sails and fabric colour gives an appealing decorative effect.*

## Project feedback

All those interviewed reported that the blue and white sail shades were well received by pool users. They are used during school events and by recreational swimmers and families. However, during swimming sports there was not enough good quality shade to protect all the spectators and sunburn was still occurring. Also, many students chose to sit in the direct sun.

The pool manager reported that on weekends teenagers tended to congregate around the dive pool. Therefore, pool staff still needed to erect temporary sun umbrellas in this area. There is still no additional shade for competitors waiting to swim, for pool attendants or for the swimmers in the pool.

*Figure 30: A view of a canopies being used on a school swimming sports day.*

The pool manager understands the shade sails are likely to last for 15 years. The suppliers advised that the sails should be left up all year, as it is difficult to remove and replace them because of the tensioning in the sails.

At Lido Aquatic Centre, shade sails are presently used to cover part of the 'family' pool where small children play. The pool manager reported that the cool shade provided by the sails prevented the water from heating up and that pre-schoolers often shivered without the sun's heat. (This is a situation where a transparent shading material could provide 'warm shade' to warm both the toddlers and the water).

The possibility of using natural shade was also discussed. PNCC councillors had expressed their preference for funding 'green shade'. Pool management confirmed that leaves from the deciduous trees on the north-west boundary did not create a problem, as the March to April leaf fall was at the end of the summer pool season.

## UVR protection

*UVR protection requirement*

School swimming sports are held over six hours from 9am to 3pm, usually in the month of February. On summer weekends, teenagers can spend six hours at the pool. As the swimming pool is in the open air, the use of sunscreen and/or protective clothing is recommended and promoted by the Cancer Society and the pool management. Shade adds to this protection and it can help remedy poor sunscreen application. However, over-exposure to UVR is cumulative, so even low UVR levels of UVI 2 will cause skin damage in 1 to 4 hours *(refer to Figure 1).* For all day use in summer, ideally, shade needs a protection factor of PF15+.

*UVR levels in Palmerston North*

UVI can reach UVI 13 on a clear day in the mid-summer.

Protection for a six hour pool visit, over the middle of the day, should be PF15+.

*Shading material*

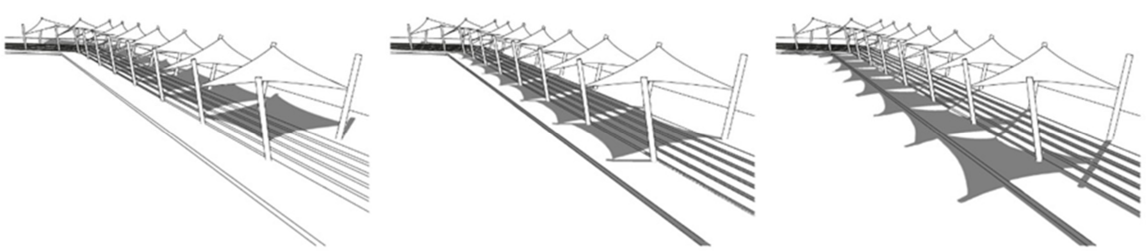
The shade sails use a material Monotec 370 series. The blue fabric blocks UVR 85.9% and the cream fabric blocks UVR 85.2%. Shade Systems reported that these percentages are calculated while the fabric is 'under tension' and not in the loom state position (as calculated by some fabric manufacturers). The difference can be significant.

The fabric has a 15 year UVR warranty.

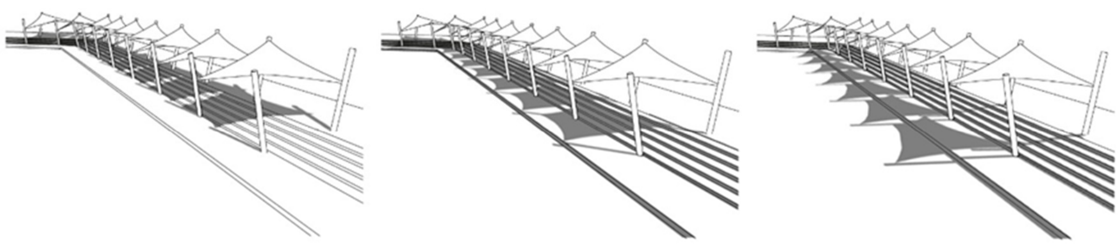
*Figure 31: The sky can be viewed through the weave in the 85.9% UVR blocking fabric.*

*Shielding of direct UVR*

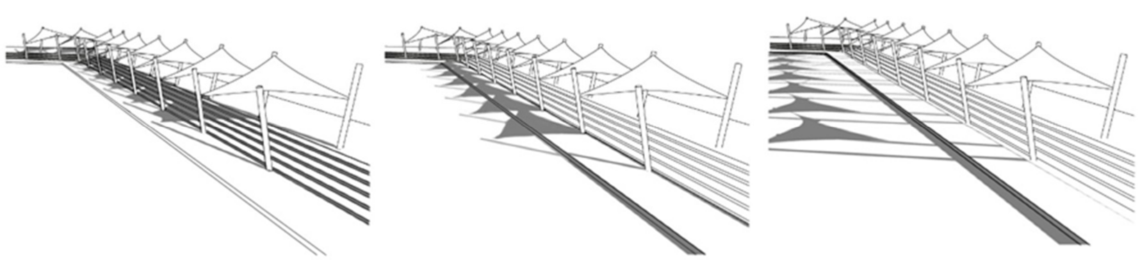
The 50m pool is open from October to April. The diagrams in *Figure 32* illustrate that during this summer pool season, the sails shade the terrace steps from morning to around midday. In the afternoon, the terraces are increasingly exposed to full sun and completely exposed by 4pm in mid-summer. The diagrams also illustrate how the direct sun penetrates the gaps in-between the undulating sails.



MID-SUMMER *20 Dec* *10am* *1pm* *4pm*



EQUINOX *20 March/20 Sept 11am* *1pm* *3pm*



MID-WINTER *20 June* *11am* *1pm* *3pm*

*Figure 32: Pattern of shadows cast by the shade sails.*

*Shielding of diffuse UVR*

The area under the shade is relatively open to the sky (and to diffuse UVR) for several reasons. Palmerston North is a flat city. The sails have been positioned at a high level to retain spectator views. The undulating effect of the sails exposes areas of the sky between the sails.

By observation and geometric calculation, when sitting under the centre of middle shade sail approximately 0.24 of the hemisphere of the sky is visible.

*Figure 33: This view illustrates the openness of the shade to the sky (and to diffuse UVR)*

*Protection Factor*

The shade sail fabric has a UVR barrier rating of 85.2% (cream fabric) and 85.9% (blue fabric).

The protection factor (PF) of the shade at 1000 above the step under centre of the middle sail on the concrete terraces is

$$\text{PF (approximate) (under shade)} = \frac{1}{\text{UVR transmittance (of shading material)} \times 0.5 + \text{sky factor*} \times 0.5}$$

$$= 1/ (0.15 \times 0.5 + 0.24 \times 0.5) = 1/ (0.08 + 0.12) = 1/0.2$$

$$= \text{PF } 5$$

The low level of protection is caused by three factors -

- the flat landscape is very open to diffuse UVR from the sky
- the use of a shading material that transmits 14 - 15% of direct UVR.
- the amount of open sky in view between and around the sails.

What does a protection factor PF 5 mean for pool users?

If the UVI was 12, the effective UVI under the shade sail would be UVI 12 divided by 5 which would equal UVI 2.4. At UVI 2.4, a fair-skinned person would begin to experience the effects of sunburn in about 60 minutes (refer to *Figure 1*). This shade is suitable for a quick dry off after a swim; however, for all day use, PF5 is not sufficient. Students would require full personal protection for swimming sports held over the middle of the day when UVR levels are highest.

This shade provision may also give users a false sense of security. They might assume that because sails are built to provide shade, they will offer good protection for extended use, but this is not the case.

The protection factor PF 5 is estimated for the centre of the central sail. If someone was sitting in the shadow of a sail, but not underneath it, they would see more sky and therefore have even less protection.

Issues in providing suitable shade at open-air swimming pools have been identified and discussed in Australian research (Gies et al., 2013).

## Thermal comfort

Due to unavailability of NIWA data, a chart for estimating when warm shade might be required is not available for Palmerston North. The Wellington chart *(Figure 34)* is the closest available, although summer temperatures in Palmerston North can be higher. (In early 2016, air temperatures in Palmerston North reached over 30°C.)

The chart suggests that *'warm shade'* would be valued in Oct to Dec and Feb to April.

| | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| 10 | 4 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| 11 | 4 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 |
| 12 | 4 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 |
| 13 | 4 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| 14 | 4 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| 15 | 4 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| 16 | 4 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 |
| 17 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 19 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

UVI<2 + temp <18 C - requires warmth but not UVR protection

UVI<2 + temp >18 C - requires neither warmth or UVR protection

UVI>2 + temp <18 C - requires warmth and UVR protection

UVI>2 + temp >18 C - requires UVR protection + maybe cooling

*Figure 34: Chart of estimated shade types to suit different times of the day during the year in Wellington (Mackay, Sandford and Hall 2).*

## Key learning points

- Public outdoor swimming pools are high risk environments for UVR over-exposure and therefore sun protection needs to be carefully managed by local councils and pool management.
- Shade sails are often specified in these settings but, in the open, small shade sails typically provide low protection.
- Shaded environments with sun-protection PF 15+, could be designed for all day use by shielding both direct and diffuse UVR.
- Public outdoor pools are highly appreciated public facilities, especially for teenagers. Public investment in making these spaces delightful, comfortable and sun-safe could add significantly more value.

# Case study 4: Kamala Pavilion, Wellington Zoo

| | |
|---|---|
| *Address:* | Wellington Zoo, Wellington |
| *Owner:* | Wellington Zoo Trust/ Wellington City Council |
| *Management:* | Wellington Zoo Management |
| *Designers:* | Assembly Architects Limited, Arrowtown |
| *Local Government:* | Wellington City Council |

## Background

The pavilion was initiated by the Wellington Zoo Trust as part of a 10 year re-development project to create a 'hub' precinct at the heart of the Zoo grounds. The proposal included a food outlet and multi-purpose visitors' pavilion. As the site was exposed to the prevailing northwest wind and rain, the pavilion was firstly conceived to create a dry sheltered 'outdoor' space.

The brief to Assembly Architects described a space that would attract and host events, such as weddings, conferences and public lectures, but also function as a shelter for school groups and zoo patrons to rest and to eat their lunch. The design needed to appeal to a wide range of people and the construction needed to be robust and durable.

*Figure 35: above*

## Context

The pavilion is situated at the Hub, at the centre of the Zoo grounds. The open side of the pavilion faces east to a view of trees on the neighbouring greenbelt.

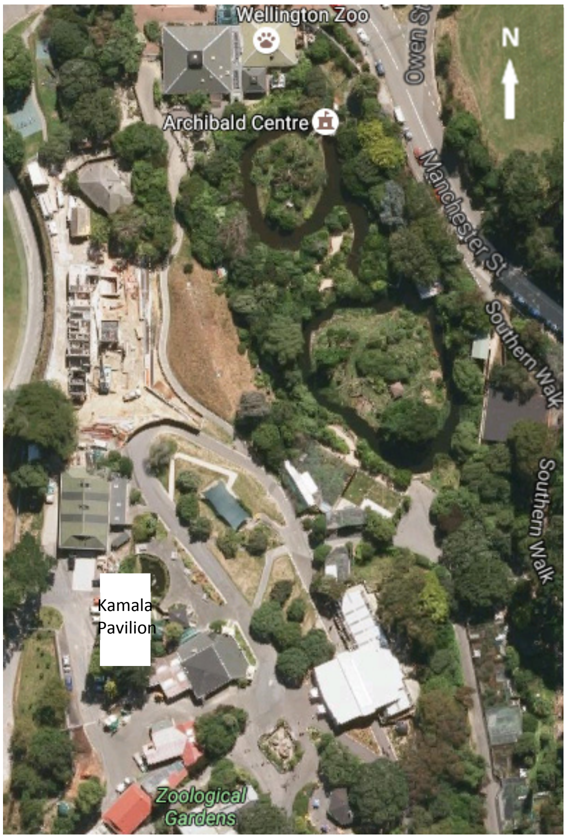



*Figure 36: Location of the Kamala Pavilion within the Zoo grounds*

## Description

In the design of the 'tunnel' shaped pavilion, the architects were inspired by the skin of reptiles at the zoo. They worked with engineers to design a structural, yet decorative, curved framework to support the translucent membrane roofing. The roof is supported by concrete slab walls at the north and south ends and columns along the east side. On rainy and/or windy days, clear PVC roller blinds can be zipped up to close the open façade. The pavilion floor and terrace are natural finished concrete slab.

*Figure 37: The afternoon sun is filtering through trees to pattern the membrane roofing*

The pavilion also has under-flooring heating to provide comfort for scheduled events in the winter. It takes 24 hours to heat. A mobile gas fired blower heater is occasionally used in winter to heat the space quickly.

*Figure 38: An image the pavilion exterior taken soon after it opened. When the blinds are rolled up the space becomes a large verandah.*

## Project feedback

Wellington Zoo Management report that the pavilion is well used both day and night all year and is well appreciated. Staff love the patterning of the tree shadows through the translucent roofing and the sense of outdoors it creates. The ‘blank canvas’ has worked well to create a multi-purpose space used by a wide variety of people of all ages.

*Figure 39: The pavilion interior on the winter’s day in 2016. The PVC blinds are closed. In order to increase the seating capacity, the picnic tables have been replaced with durable outdoor tables and chairs.*

Staff reported that the pavilion does not over heat. The entry door and roller blinds can be opened up to allow cross ventilation. The under-floor heating works well for events. The space can be cold (although sheltered from the wind) at times in the winter, but Zoo visitors are dressed for the weather.

The roll-down transparent PVC blinds can emit drafts underneath and flap noisily in strong winds. Zoo managers are currently considering other door systems. Although the pavilion is appreciated as an ‘outdoor space’, this creates unanticipated issues. Rust proof chairs were needed to cope with Wellington’s salty sea air. The outdoor space attracts birds and spiders, but surfaces can be easily hosed clean again.

The clever design of the pavilion has attracted its use. An advertisement was filmed in the space and the design has received several architectural awards. As a multi-use space the project has been affordable. Zoo management confirmed that investment in an events centre alone could not be justified. On a daily basis, it doubles as a visitors' all-weather shelter.

## UVR protection

*UVR protection requirement*

The pavilion is used by two main groups of people.

Firstly, people visiting the Zoo animals who usually spend two to four hours walking around the open pathways. In Wellington, from September to April, when UVI is 3 or higher, personal sun protection of hats, clothes and/or sunscreen is recommended. The pavilion is providing respite shelter from the full sun for typically 20 – 30 min when they eat their lunch.

The second group may attend a conference or a wedding in the space and may not choose to wear sun protection because they expect to be indoors. These people need the pavilion to provide complete sun protection. An event might last up to 6 hours.

*UVR levels in Wellington*

UVI can reach UVI 13 on a clear day in the mid-summer.

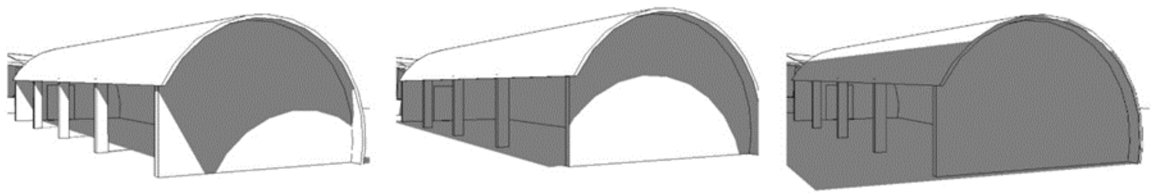
The protection factor required for a six hour event is PF15+.

*Shading material*

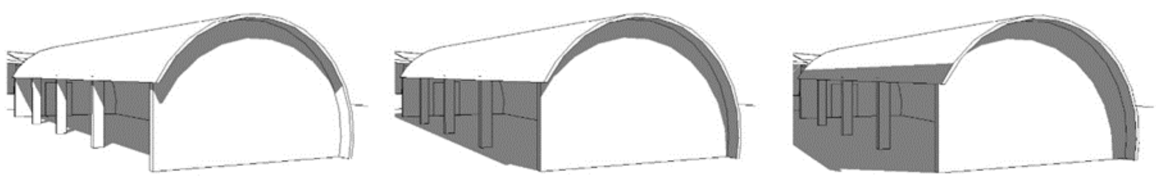
The architects originally specified a translucent membrane typically used for horticultural purposes, Durashelter greenhouse film. As illustrated in *Figure 36,* the film's translucency allowed the afternoon sun to glow through the membrane and highlight the shadows of the trees behind. The membrane was an adequate barrier for UVR protection but soon after the pavilion opened a tree branch fell through the membrane. It was replaced with a more opaque white architectural PVC textile, which typically create a 100% barrier to UVR.

*Shielding of direct UVR*

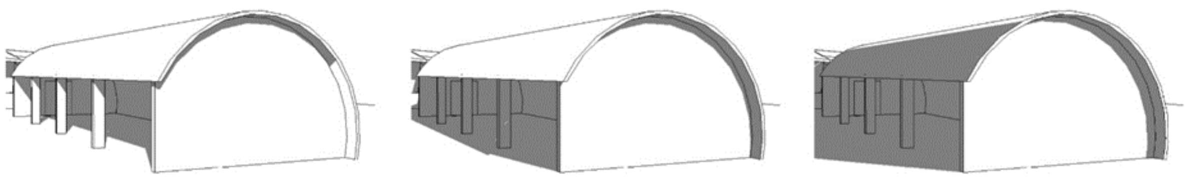
The pavilion is open on one side only; the four 2.2m high openings orientate towards the east. These factors mean that just a small perimeter strip of direct sunshine enters the pavilion in the morning (as illustrated in *Figure 40*).



MID-SUMMER *20 Dec* *10am* *1pm* *4pm*



EQUINOX *20 March/20 Sept 11am* *1pm* *3pm*



MID-WINTER *20 June* *11am* *1pm* *3pm*

*Figure 40: Pattern of shadows cast by Kamala Pavilion*

*Shielding of indirect UVR*

*Figure 41: This collage panorama, taken from the centre of the central pavilion, illustrates how little open sky can be viewed (and therefore how little exposure the diners have to diffuse UVR).*

At the centre of the pavilion (with the blinds rolled up) the proportion of the sky in view was estimated using geometry as 0.04.

*Protection Factor*

The performance factor (PF) calculated at the centre of the pavilion is -

PF approximate (under shade) = 1 / (UVR transmittance x 0.5 (of shading material) + sky factor x 0.5)

= 1/ (0 x 0.5 + 0.04 x 0.5) = 1/ (0.0 + 0.02) = 1/0.02

= PF 50

The high level of protection is achieved by several factors

- by the use of a roofing membrane that is a 100% barrier to UVR
- the pavilion is closed off from diffuse UVR from the north, west and south
- the 2.2m high openings on the east side face a view of trees and hills. Only a small view of the open sky can be seen from the interior.

## Thermal comfort

The following chart illustrates the type of shade required at different times of the day during the year in Wellington.

| | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| 10 | 4 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| 11 | 4 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 |
| 12 | 4 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 |
| 13 | 4 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| 14 | 4 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| 15 | 4 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| 16 | 4 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 |
| 17 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 19 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

- UVI<2 + temp <18 C - requires warmth but not UVR protection
- UVI<2 + temp >18 C - requires neither warmth or UVR protection
- UVI>2 + temp <18 C - requires warmth and UVR protection
- UVI>2 + temp >18 C - requires UVR protection + maybe cooling

*Figure 42: Chart of estimated shade types to suit different times of the day during the year in Wellington (Mackay, Sandford and Hall 2).*

The chart suggests that 'warm shade' is ideal for the Wellington region, although some cooling (or solid shade) may be needed in January. The original specification of a translucent membrane (rather than its opaque replacement) was possibly best suited to create warm shade for most of the year.

The pavilion design also blocks cold southerly winds and in the winter it captures the low morning sun. The sun penetrates underneath and warms up the concrete floor. This stored heat will slowly be released during the afternoon and therefore warm the occupants.

## Key learning points

- Pavilions can be more cost effective by being multipurpose and designed to be used in all weathers and seasons.
- Creative and appealing architecture can encourage people to use shade.
- Translucent roofing which glows in the sun and silhouettes trees behind can create a connection with the outdoors.

# Case study 5: Ruataniwha Kaiapoi Civic Centre Canopy

| | |
|---|---|
| *Address:* | 176 Williams Street, Kaiapoi |
| *Owner:* | Waimakariri District Council |
| *Designers:* | Warren + Mahoney Architects Ltd |
| *Local Government:* | Waimakariri District Council |

## Background

Kaiapoi is a small town located 17 km north of Christchurch, close to the mouth of the Waimakariri River. The town has a populaton of around 10,000 and is a service centre for the surrounding rural area.

The town lost its council facilities and library in the 2011 Canterbury earthquake. The re-build project, which opened in January 2015 was an ‘anchor’ project in the town’s recovery.

## Context

The site is at the nexus of the main street and the river, the most pivotal place in the town. In summer, the view to the river is filtered by a row of large deciduous trees. A open grassed space, named McAlister Square, previously existed  the location of the new canopy.

*Figure 43: above*


*Figure 44: Location of the Kaiapoi Library and Service Centre with its canopy positioned along the street edge*

## Description

The canopy is effectively a two- storey pergola, constructed of painted mild steel with fixed louvres. The canopy has a solid roof leading from the street to the front entrance.

*Figure 45: A view of the canopy from across Williams Street showing the waterproof roof leading to the main entrance.*

The idea of a canopy was not in the original brief supplied to Warren and Mahoney Architects. As the design for civic centre evolved, the value of creating a large 'out-door room' infront of the building and in the centre of town was recognised. The Council found the funds, within other budgets to 'make it happen'.

The canopy serves several functions. As a grand entrance to the building, it makes a civic statement. As a covered 'town square' it hosts people to sit, to meet with friends and to participate in civic and community events.

## Project feedback

Council staff report that the people are 'wowed' by the building and the design of its light and bright canopy. In the winter, the space is sheltered from the prevailing easterly winds and warmed by the low sun penetrating underneath. In summer, the louvres block the hot sun on days that can reach 35°C in the shade. The open louvres (and the paving and seating underneath) are washed by the rain. This was considered an attraction to the architects and the council staff, as Canterbury has low annual rainfall and rain is welcome.

The space under the canopy is utilised all year round. In the opening day, 250 people were seated to hear the mayor speak. Other communal events, for example out-door movies, have been suggested the space. Its steel framework is designed to be strong enough to support temporary art installations. It is a permanent shade canopy that requires no annual maintenance.

The design won an 2015 New Zealand Institute of Architects local award – public architecture.

## UV protection

*UV protection requirement*

On a daily basis the canopy provides a space for locals to meet, sit and chat and perhaps eat their lunch for 20 – 30min.
On other occasions, it could be used for a community or civic function commonly lasting two hours.

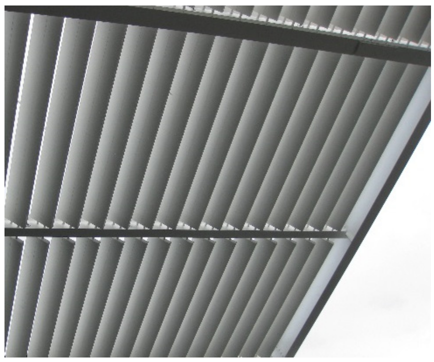
*UV levels in Kaiapoi*

UVI can reach UVI 12 on a clear day in the mid-summer in Canterbury.
The protection factor required 2 hour event would need to be above PF 10.

*Shading material*

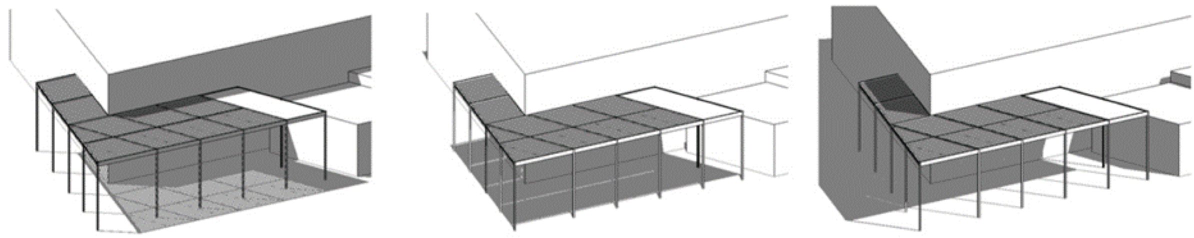
The canopy is comprises of fixed louvres. To provide good sun-shading of plaza and building façade, the architects analysed sun-paths to calculate the optimal angle and orientation of the blades.

*Figure 46: The white painted louvres shield the direct and most diffuse UV but they also reflect daylight to give the 'ceiling' a light and airy feel.*

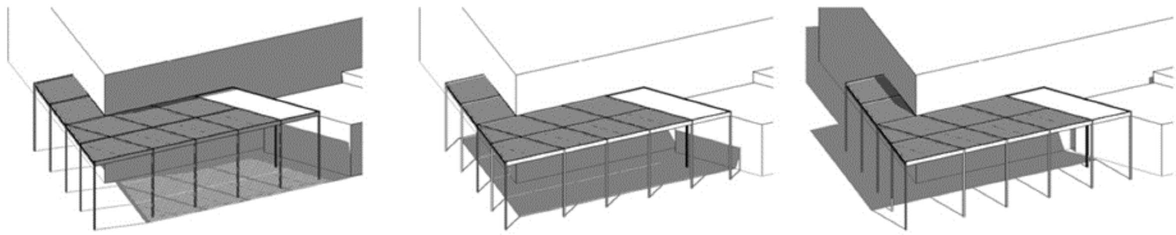


*Shielding of  UV*

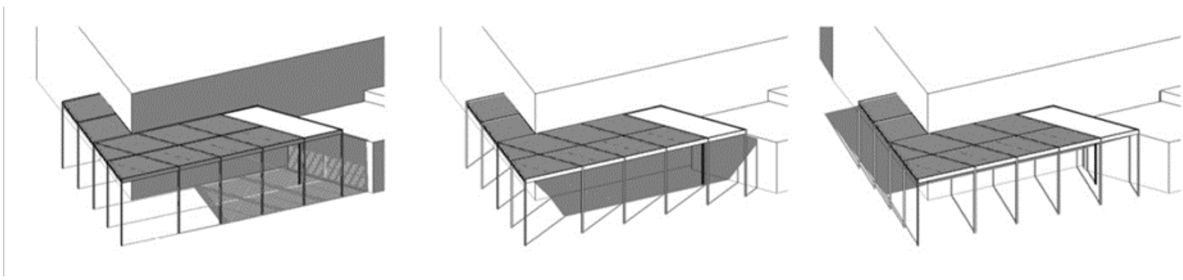
The diagrams in *Figure 47* illustrate that the louvres create solid shade over the whole plaza at 1pm in mid-summer, when UV levels are high. In winter, locals can enjoy sitting in areas full sun with the canopy overhead.



MID-SUMMER *20 Dec* *10am* *1pm* *4pm*



EQUINOX *20 March/20 Sept 11am* *1pm* *3pm*



MID-WINTER *20 June* *11am* *1pm* *3pm*

*Figure 47: Pattern of shadows cast by the louvres throughout the seasons.*

As illustrated in *Figure 48,* at 10am in mid-summer, when a maximum of UVI 4 is predicted (Mckenzie 13), the louvres shield approximately 60% of both direct sunshine and diffuse UV. At this time, at the centre of the canopy, UV exposure is estimated to be under UVI 2. UV 1 – 2 is a suitable level of UV protection for UVI levels at this time of day.

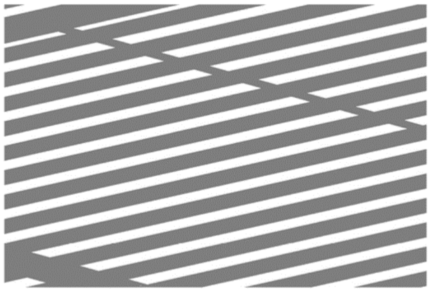


*Figure 48: Pattern of the shadow under the louvres at 10am in mid-summer, when the louvres are providing approximately 60% shade.*

*Shielding of diffuse UV*

The 6.5m height of canopy makes it open to the western sky. People seated at the outer edge of the canopy will be exposed to a greater proportion of open sky but the 12.5 m depth of the canopy shields people sitting closer to the building.

*Figure 49: Collage panorama from the entranceway looking towards the buildings across the street.*

At the centre of the canopy the proportion of the sky in view is estimated, using geometry, to be 0.1.

*Protection Factor*

In the shadow of the canopy, the performance factor (PF) calculated at the centre of the canopy is -

$$\text{PF estimated (under shade)} = \frac{1}{\text{UV transmittance (of shading material)} \times 0.5 + \text{sky factor}^* \times 0.5}$$

$$= 1/ (0 \times 0.5 + 0.1 \times 0.5) = 1/ (0.0 + 0.05) = 1/0.05$$

$$= \text{PF } 20$$

The high level of protection is achieved by several factors

- by the use of a solid angled louvres positioned to shield the direct sun during the middle of the day.
- the civic centre building blocks sun and sky to the east
- the surrounding two storey buildings and trees restrict the view of the sky.
- the 12.5 m depth of the 'verandah'

## Thermal comfort

The following chart illustrated the type of shade required at different times of the day during the year in Christchurch.

| | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 |
| 10 | 4 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| 11 | 4 | 3 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 |
| 12 | 4 | 4 | 3 | 3 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 |
| 13 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| 14 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| 15 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| 16 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 |
| 17 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 19 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

UVI<2 + temp <18 C - requires warmth but not UVR protection

UVI<2 + temp >18 C - requires neither warmth or UVR protection

UVI>2 + temp <18 C - requires warmth and UVR protection

UVI>2 + temp >18 C - requires UVR protection + maybe cooling

*Figure 50: Chart of estimated shade types to suit different times of the day during the year in Christchurch (Mackay, Sandford and Hall 2).*

Canterbury has hot summers when solid opaque materials, which shield heat and UV are useful. In the spring, transparent roofing might help warm the space, but the penetration of the morning sun will heat the concrete paving which will be slowly released during the day.

## Key learning points

- Civic scale outdoor canopies can create appealing and attractive public space
- In drier climates, rain protection maybe not valued.
- Open louvres can be designed to shield both direct and diffuse UV effectively.
- Solid louvres painted white appear light and bright.

# Case study 6: Hagley Oval Pavilion, Christchurch

| | |
|---|---|
| *Address:* | 63 Riccarton Avenue, Christchurch |
| *Owner:* | Christchurch City Council/ Canterbury Cricket Trust |
| *Management:* | Vbase |
| *Local Government:* | Christchurch City Council |
| Designers: | Athfield Architects Ltd |

## Background

Cricket has been played on the oval in Hagley Park since 1866 although in recent years, test matches were held at Lancaster Park. These facilities were badly damaged in the 2010/2011 Canterbury earthquakes. The Canterbury Cricket Trust Board (CCTB) proposed the re-development of the grounds with a new pavilion on the Hagley Park site, as an ‘anchor’ project in the rebuilding of Christchurch. The proposal included forming an embankment (a sloping terrace for spectators around the cricket oval) and the design of a pavilion with facilities to accommodate players, officials, CCTB members and guests and covered tiered seating for 440.

The redevelopment of the oval and the building of a pavilion on the open green space was controversial so during the resource consent process restrictions were placed on the siting of pavilion and the size of the canopy.

The pavilion opened in 2014.

## Context

The location of the pavilion was dictated by land ownership and issues in gaining resource consent for constructing any new building on Hagley Park. The only available site was on the south-west side of the oval, therefore the spectator seats face north-west. This orientation is not ideal as much of the terrace seating is exposed to full sun in the afternoon. Extension of the canopy over the boundary of the cricket ground was not possible due to resource consent constraints and test cricket rules.

*Figure 51: The perspective by Athfield Architects illustrates the proposed design. The Pavilion is sheltered by existing trees to the south- east.*

## Description

*Figure 52: A view of the pavilion from the oval.*

The terraced seating curves around the cricket oval and backs onto storeroom and service spaces at the lower floor level. This open terrace also leads up to a function room and spaces for players and match officials on the upper floor which can be opened up with large glass sliding doors. The tensile architectural textile roof spans over the building and the terraces. To create an air-tight climate control space the function room has a second inner skin of tensile fabric.

*Figure 53: During a cricket match both the outdoor seating and the indoor function space are available to members, cricket officials and invited guests.*

## Project feedback

The opening of the pavilion, with its soaring curved canopy, was greatly celebrated as part of Canterbury's recovery from its earthquakes. The pavilion won the New Zealand Cricket Venue of the Year 2015 and the design won an NZIA Canterbury Architecture Award 2015 and the LSAA (Lightweight Structures Association Australasia) Award of Excellence 2016.

The venue managers reported that during day-long cricket matches, players, members and officials using the pavilion tended to stroll around. If the full sun on the seating area is uncomfortable, patrons can easily move up to the fully shaded interior of the function lounge. The function room on the upper level, although initially primarily designed (with its single-skin membrane roof) for summer use, has become a popular venue for events throughout the year. The public appreciate its unique design and the beautiful setting in the park.

The architects reported that the tensile canopy had performed well in high winds. The white architectural textile requires to be cleaned annually by a specialist maintenance crew. It is accessed via a standard mobile elevated working platform.

*Figure 54: A spectator's view of the Oval at a cricket match*

While patrons of the pavilion have access to shade, as with all typical test cricket grounds, the 8,000 spectators must rely on personal sun protection. They use sunscreen, hats and long-sleeved shirts, as sun umbrellas would obstruct views of the pitch. Tents for food and drink outlets are provided at the back of the embankment.

The venue management are aware of the risk to spectators of UVR over-exposure during all day cricket matches. In conjunction with the cricket associations, they take a proactive approach to mitigate this risk including the free provision of sunscreen to spectators. There is a long tradition of timing cricket matches over the hottest time of the day and re-scheduling all matches to the afternoon and evening would require a significant change in cricket customs and culture. Some day/night matches for shorter forms of the game (including Twenty20 and ODI games) have taken place at Hagley Oval using temporary demountable lighting. Resource consent approval is reportedly in place for permanent lighting towers, but funding to install these has not yet been achieved.

**UV protection**

*UV protection requirement*

Cricket matches last all day.

Ideally for all day protection shade should have PF 15+.

*UV levels in Christchurch*

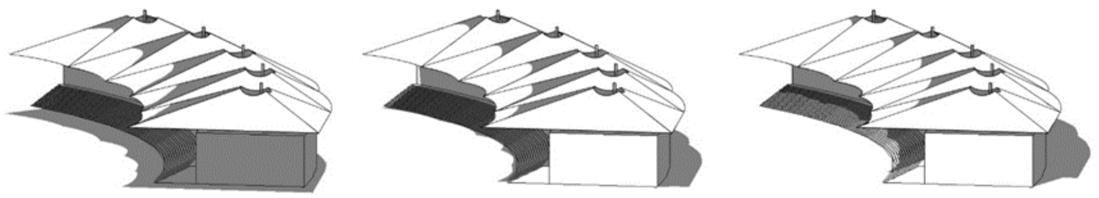
UVI can reach UVI 12 on a clear day in the mid-summer.

*Shading material*

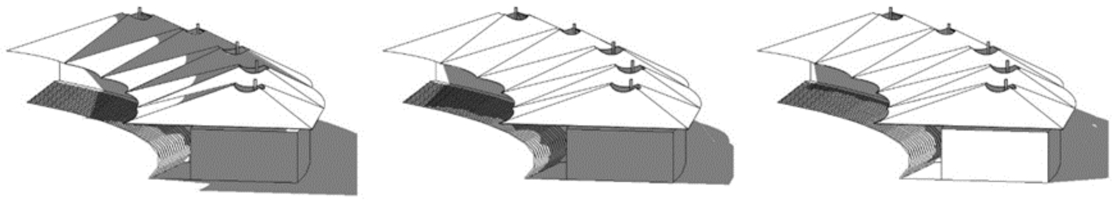
The pavilion canopy roofing is architectural PVC textile Serge Ferrari – Precontraint TX 30. It has a design life of 30 years. The material shields 100% of UV, and transmits 6% of the sun's heat and 5% of visible light.

*Shielding of direct UV*

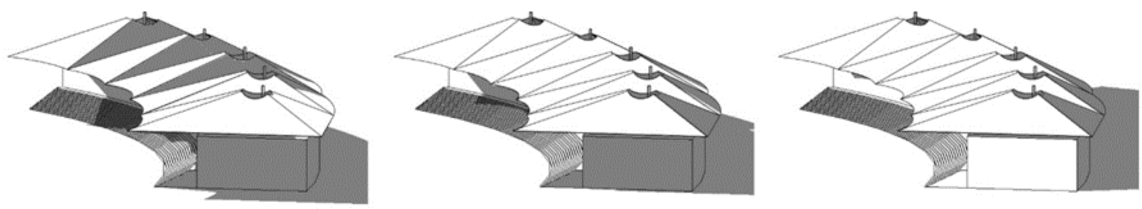
The diagrams in *Figure 55* illustrate that over summer, when cricket matches are scheduled, the outdoor seating is well-shaded in the morning up to 1pm. As the sun moves around the lower seating starts to receive direct sunshine. By 4pm, approximately half the seats will be in direct sun.



MID-SUMMER *20 Dec* *10am* *1pm* *4pm*



EQUINOX *20 March/20 Sept 11am* *1pm* *3pm*



MID-WINTER *20 June* *11am* *1pm* *3pm*

*Figure 55: Pattern of the Pavilion canopy shade*

*Shielding of indirect UV*

*Figure 56: This panorama collage (taken from the centre of seating in the centre of the pavilion) illustrates how open the exterior seating is to the north-west sky*

At this position the proportion of the sky in view is estimated using geometry to be 0.4. In contrast, the function space behind is highly protected from UV.

*Figure 57: This panorama collage (taken inside at the centre of the function space) illustrates how little open sky can be seen.*

*Performance factor*

The performance factor of the canopy shade is dependant of whether it is in direct sun or shaded from direct sun.

In the morning, the estimated performance factor (PF) of the shade at the centre of the terrace at the centre of the canopy is estimated as PF 5

$$\text{PF estimated (under shade)} = \frac{1}{\text{UV transmittance (of shading material)} \times 0.5 + \text{sky factor*} \times 0.5}$$

= 1/ (0 x 0.5 + 0.4 X 0.5) = 1/(0 + 0.2) = 1/0.2

= PF 5

In the afternoon, when the seating is in direct sun the estimated performance factor (PF) of the shade at the centre of the terrace in the centre of the canopy is estimated at PF 1.4.

$$\text{PF estimated (under shade)} = \frac{1}{\text{UV transmittance (of shading material)} \times 0.5 + \text{sky factor*} \times 0.5}$$

= 1/ (1 x 0.5 + 0.4 X 0.5) = 1/(0.5 + 0.2) = 1/0.7

= PF 1.4

These low levels of protection is occur because -

- Even though the architectural roofing membrane is a 100% UV barrier the wide open site receives high levels of diffuse UV
- The orientation of the covered seating allows a direct sun to penetrate in the afternoon.

## Thermal comfort

As illustrated in following chart, a shading material which blocks heat from the sun (such as the architectural textile specified) is likely to be keep spectators under canopy cooler in January, February and March. From October to December, spectators are likely to welcome more heat from the sun but they are able to keep warm by dressing to suit the cooler shade.

| | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 |
| 10 | 4 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| 11 | 4 | 3 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 |
| 12 | 4 | 4 | 3 | 3 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 |
| 13 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| 14 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| 15 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| 16 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 |
| 17 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 19 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

UVI<2 + temp <18 C - requires warmth but not UVR protection

UVI<2 + temp >18 C - requires neither warmth or UVR protection

UVI>2 + temp <18 C - requires warmth and UVR protection

UVI>2 + temp >18 C - requires UVR protection + maybe cooling

*Figure 58: Chart of estimated shade types to suit different times of the day during the year in Christchurch (Mackay, Sandford and Hall 2).*

## Key learning points

- Site situations can sometimes dictate less than ideal sun-shading solutions. This can be resolved by giving users different opportunities to seek shade.
- Personal protection is likely to be the base-line for all day outdoor sports. Shade can make the outdoor experience more comfortable.
- Timing of cricket matches later in the afternoon and evening could reduce UVR exposure.

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# FIGURES

All figures were sourced from the author's collection except for the images listed below.

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*Figure 9:* Source: http://aaa.org.nz/wp-content/uploads/2013/06/5.-BRITOMART-PAVILIONS-SCREEN-760x506.jpg

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*Figure 43:* Source: http://www.visitwaimakariri.co.nz/content/plugins/operator/images/400x400scale/42C8E6C8-FDBB-4C39-78DE64130BB3739B.jpg

*Figure 44:* Source: map data ©2016 Google, script by Author

*Figure 51:* Source: Athfield Architects

*Figure 52:* Source: http://www.christchurchconventions.com/venues-and-event-services/venues/vbase-hagley-oval-pavilion/

*Figure 53*: Source: Athfield Architects

*Figure 54:* Source: Athfield Architects