4 Providing shade

There are numerous types of shade systems, incorporating natural or built components, or a combination of these. The following sections describe the major factors and considerations for each of these approaches.

Built shade is designed and constructed of manufactured components, unlike natural shade solutions which use trees, large shrubs, vines and ground covers to block direct UVR and absorb indirect UVR.

A comprehensive shade strategy will most likely incorporate both built and natural shade solutions.

Personal shade

Personal shade includes the beach cabana or umbrella. While cabanas generally offer good protection, umbrellas offer limited protection from indirect UVR, due to their small size and open design. In addition, some products use shade fabrics that do not provide adequate protection from direct UVR.

Nevertheless, the worth of such structures should not be discounted as a means of personal UVR protection, provided other personal protective measures are also taken.

Natural shade

The use of natural shade can be one of the most effective and aesthetically appealing ways of providing shade. Vegetation offers seasonal variations in perfume, colour and sounds. Many species produce colourful flowers or have attractive foliage or bark, some make good habitats for wildlife and many species can be used to screen unwanted views, give wind protection and provide privacy.[1] Other materials cannot accomplish these things as well as vegetation can.

The use of vegetation for shade also has a number of environmental benefits including:

- less need to use non-renewable resources (used in many building materials)
- energy saved in comparison with built shade systems, which often have high embodied energy (this is the sum of all energy used to produce a material, product or structure including extraction and processing of raw materials, manufacturing, assembly and transportation)
- fewer disposal problems as plants generally act as nutrients during decomposition

Other environmental benefits can be gained by using indigenous (or local native) plants for natural shade. Their use is important for flora, habitat and genetic conservation. Local native plants are also suited to local conditions and therefore require less maintenance. If non-local or overseas plants are used then care must be taken to ensure they will not become environment weeds (see section on the use of indigenous (local native) plants.

[1] Correy A. Landscape design dilemmas: Australian native trees and solar access conflict. *Landscape Australia*; May 1992.

The following table shows some of the many benefits of trees in an urbanised area:

TABLE 3. Some general and specific contributions of trees to urbanised sites

Landscape values
- A sense of scale
- Softening of built landscape
- Focus and directed sight lines
- Linking & unifying landscape
- A buffer to unwanted noise
- Variety of colour, form, texture & pattern
- Variations in shade and light
- An emphasis to seasonal change
- A contribution of fragrance

Recreational benefits of trees
- Passive recreation
- Linking of human generations
- Links to parklands
- Human physical health
- Human psychological health

Conservation values
- Create & preserve habitat
- Preserve flora and fauna
- Conserve genetic resources
- Maintain wildlife habitat

Education and interpretation
- Local natural history
- Gardening and horticulture
- Wildlife/vegetation relations
- Environmental appreciation

Climate amelioration
- Shelter from the wind
- Shade/thermal insulation
- Temperature modification
- Humidifying the air
- Filtration of polluted air
- Interception of rain fall
- Reduced run-off & water turbidity
- Alter effective precipitation
- Reduction in glare

Environmental values and amelioration
- Production of oxygen
- Fixing of carbon dioxide
- Reducing erosion
- Protecting watersheds
- Altering windflow patterns
- Noise abatement
- Re-odorising air
- Modifying ambient temperature
- Purifying the air

Economic benefits
- Increased property values
- Improved investment
- Greater levels of tourism
- Utilisation of tree products
- Carbon balance benefits
- Effective use of water

Source; Compiled from Grey and Deneke, 1978; Anon, 1989; Harris, 1992; Finnigan, 1994.

Selecting trees for shade

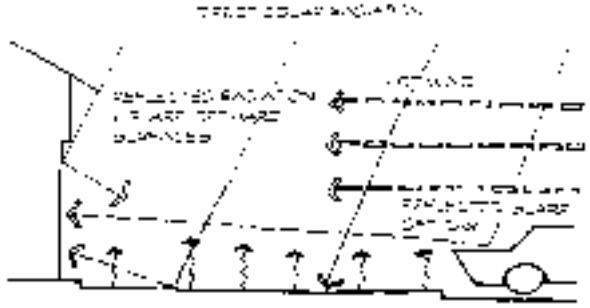
The effectiveness of natural shade depends on the density of the foliage. Foliage and timber will block direct UVR, but gaps in the canopy will allow UVR to penetrate. The size of the canopy (of a tree or group of trees) is also an important consideration. The larger the canopy diameter, the greater the opportunity for protection from scattered or reflected UVR. The height of the branches from the ground can also influence the effectiveness of natural shade, with low branches providing better protection[2].

It should be noted that introducing complete, or even partial shading by vegetation may affect the viability of existing under-storey vegetation. The landscape of shaded areas, as a result, may need to be treated differently to that of non-shaded areas.

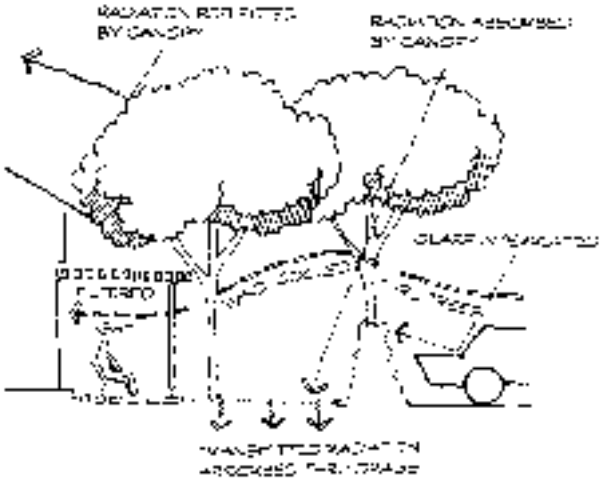
Landscape planning and design

Vegetation (including trees, shrubs, vines and ground covers) should be considered an essential part of shade planning and site design, as they possess many qualities, which enhance outdoor spaces. In addition, people intuitively associate trees with shade when seeking relief from the heat of the sun. It therefore makes sense to place a high priority on the strategic use of trees and planting to provide shaded areas.

In providing natural shade, there are a number of landscape planning and design issues that should be considered. The main issues are discussed on pages 37 and 38.



without planting



after planting

note

Most local councils have tree planting policies and policies for the protection of ‘significant trees’. They may also actively encourage residents to plant trees. Telephone your local council for more information.

2 Parsons, Pet al. The shady side of solar protection. *Medical Journal of Australia* 6 April 1998; 168.

the surrounding environment

Planting should be consistent with, and sympathetic to, the scale and character of the surrounding environment. Considerations include existing vegetation, townscape character, the cultural heritage value of existing planting, buildings/smaller built items and their setting as well as the landscape identity of the locality.

local conditions

Local conditions (eg soil, climate, aspect and land-use history) will influence the species of plants that will be suitable for a given location. Unless the environment has been significantly altered, local conditions will suit indigenous (local native) plants which grow naturally in the area. Advice on local conditions should therefore always be sought before selecting plant species and where possible indigenous plants should be used.

Information on local conditions and suitable plant species can be obtained from local councils, the South Australian Indigenous Growers and Revegetators Association (SAIGRA), Urban Forest Biodiversity Program (for the metropolitan area), Mount Lofty Ranges Catchment Program (for the Mount Lofty Ranges), Greening Australia (all areas including regional) and local nurseries.

planting patterns and location

It is important to consider site usage patterns when selecting and positioning planting so that shade is provided at the desired time of year. For example, if a venue is used mainly in summer, locate shade trees or vines to provide good summer shade.

If you wish to create continuous shade along a pathway, plant trees close enough together to create a visual and physical avenue effect at maturity. If you wish to create shade for areas where people congregate, plant trees in groups with spacing that allows their canopies to overlap at maturity. An alternative approach would be to use a trellis covered with a fast growing, dense foliage climber.

long term effects on the built surrounding environment

The long term effects of the planting on the surrounding built environment should be taken into account. For example, planting near or over services may cause problems and in some cases may be illegal.

Similarly, the root systems of trees can cause the uplifting of nearby footpaths. The placement of root barriers between the roots and the path is one way of preventing this. Reactive soil conditions are an issue in many parts of South Australia, and so the distance of vegetation from buildings must be carefully considered.

note

A listing of toxic plants is provided in Corkery L. Playspace—Handbook for planning outdoor play environments. See Bibliography.

note

See Chapter 2, Sun facts, for information on the UVR reflectance of different ground surfaces.

risk management considerations

Risk issues should be considered in relation to the main site users. For example, risk issues in public places are very different to those in domestic sites.

If children predominantly use a site, for example, it is important to avoid plants that have high toxicity ratings, spiky branches, or that drop fruits or seeds. Avoid species that are more likely to drop their branches than others. Shrubs that branch clear of the ground can provide play areas under their foliage. Dense and low planting provides hiding places and may compromise security.

designing ground surfaces to control indirect UVR

As ground surfaces can be a major contributor to indirect UVR at a site, the selection of surface materials with low UVR reflectance is an important consideration.

Grass is commonly used as a ground surface. However, some of the potential problems associated with this surface are the significant amounts of water required; the needs for considerable maintenance (particularly for grass lawns); and problems associated with fertiliser run-off into waterways. It should be noted that water usage for this purpose could be reduced by planting species of trees which will partially shade the grass. Indigenous ground covers, trailing plants or low shrubs can be used to cover large areas which are not required for walking or sitting; or under trees where grass will not grow.

In areas where water is limited and costly, or supply is not assured (or where grass and planting is difficult to maintain) fine loose stone such as decomposed gravel or graded local stone can be used. This approach will still allow for water penetration to the roots of nearby shade trees. In addition, a well-draining compacted surface such as this will not form mud in wet weather, or blow around as dust during dry weather.

The use of Indigenous (local native) planting[2]

what are indigenous plants?

In general the term 'indigenous' refers to those plant species which naturally occur in a given region (ie. 'local native' plants). In relation to using indigenous plants for natural shade or revegetation projects, indigenous plants are those that have been grown from locally collected seeds or cuttings for replanting back into the area of origin.

why is their use important?

In most areas of South Australia remnant natural vegetation is under threat from a wide variety of pressures. By planting local native plants we contribute to the conservation of natural flora of a region and provide habitat for birds, mammals, reptiles and butterflies that are totally dependent on natural vegetation for their continued existence.

By using only locally collected seed to grow plants we maintain the natural variation that may exist between different populations of the same species. Variations of the same species can be found in plant form, flowering, growth rate, frost resistance and drought tolerance. By using seed that is NOT locally collected, we risk hybridisation with local plants, leading to the loss of this variation (genetic diversity) and the eventual demise of the distinct local population.

what are the other benefits of using indigenous plants?

There are also many benefits from using local native plants. Local native plants are well adapted to the local conditions, including soil and climate. Thus, plants grown from locally collected seed should result in greater long term survival rates, will generally only require watering upon planting and will not require fertiliser and other soil treatments.

Use of local native plants also provides excellent opportunities for learning about our little known indigenous plant heritage and can bring a renewed sense of pride into the local community.

Many introduced plants from overseas or other regions of Australia have the potential to escape into bushland and completely overwhelm indigenous plant and animal communities. Many of our existing garden plants have already escaped and threaten our native bushland, but by planting local native species you reduce the risk of this happening in the future.

2 South Australian Indigenous Growers and Revegetators Association (date unknown) *Introducing a great new natural resource for SA. SAIGRA.*

Built shade

Built shade comprises all shade systems that are constructed, as distinct from natural shade. One advantage of using built shade systems, especially permanent systems, is that they can often be used for a number of purposes besides providing shade. For example, a shade structure could be used to collect rainwater for irrigation; or a structure could support photovoltaic cells, (either as a mounted array or as a laminated roofing material) for the generation of electricity.

Built shade systems can be either stand-alone structures, or systems which are incorporated into existing buildings and other facilities. They can be categorised as follows:

- **permanent systems**
- **demountable systems**
- **adjustable systems.**

Permanent systems

Permanent systems are considered to be those which last for at least 10 years. Their structure commonly comprises a roof with associated supporting structure and sometimes side protection, to reduce the effects of indirect UVR.

It is very important that permanent roofing systems are durable as they need to withstand the harshest of conditions, eg exposure to sun, rain and wind uplift. From an environmental and economic point of view, regular maintenance of these systems is essential to ensure their long life span, thus reducing the need for replacement of materials.

The component parts of a permanent system should either be cheap and easy to replace, or they should have a life span equivalent to that of the main parts of the structure. There is no point having a metal roof with a useful life of 60 years, that needs to be replaced after 10 years, because the supporting structure or fixings did not last.

Permanent systems are likely to gain more favourable consideration from funding bodies which provide capital works subsidies.

Demountable systems

Demountable systems are likely to be a more practical and cost-effective alternative to permanent structures where:

- shade needs are infrequent
- temporary shade is required at varying locations
- a permanent structure is incompatible with the range of activities that take place at a site.

Some demountable systems can be adapted for use in a variety of situations such as above tiered seating as well as over large flat surface areas. Some can be placed on a variety of ground surface conditions such as sand, grass and pavement.

Demountable systems may be designed in modular forms that can be extended or contracted depending on the circumstances. This may consist of a lightweight framework and fabric infills which provide overhead cover, as well as walls where they are required. Alternatively, they may comprise tent-like forms, such as large marquees or lightweight tension membrane structures.

The demountable system should be easy to erect and dismantle. Complex assemblies are time consuming and increase the risk of incorrect installation. For example, tension membrane structures are quick to erect because the canopy is in one piece. Structures using conventional materials usually take longer to erect because there are more components and fixings.

Demountable systems need to be strong enough to withstand the wear resulting from frequent transportation, assembly and dismantling. The availability of suitable storage facilities is essential to maintain the product in good condition. Their temporary nature means that they are less likely to be subject to vandalism.

Adjustable systems

Adjustable systems range from very simple devices to those which use sophisticated technology. They offer a high degree of flexibility, allowing protection levels to be modified according to the time of day or season, and to satisfy a variety of user needs. They can be either permanent or demountable.

Adjustable shade systems should be easy and convenient to operate. For example, if operation is time-consuming, difficult or requires specialist attention, use of a device may be discouraged. It should also be easy to operate in storms when prompt dismantling of the structure may be necessary.

Components such as pulleys and cables should be corrosion resistant; use of stainless steel is recommended where possible.

Adjustable shade systems are usually attached to a permanent structure and fall broadly into the following two types:

- retractable devices such as canvas awnings
- louvred devices.

retractable devices

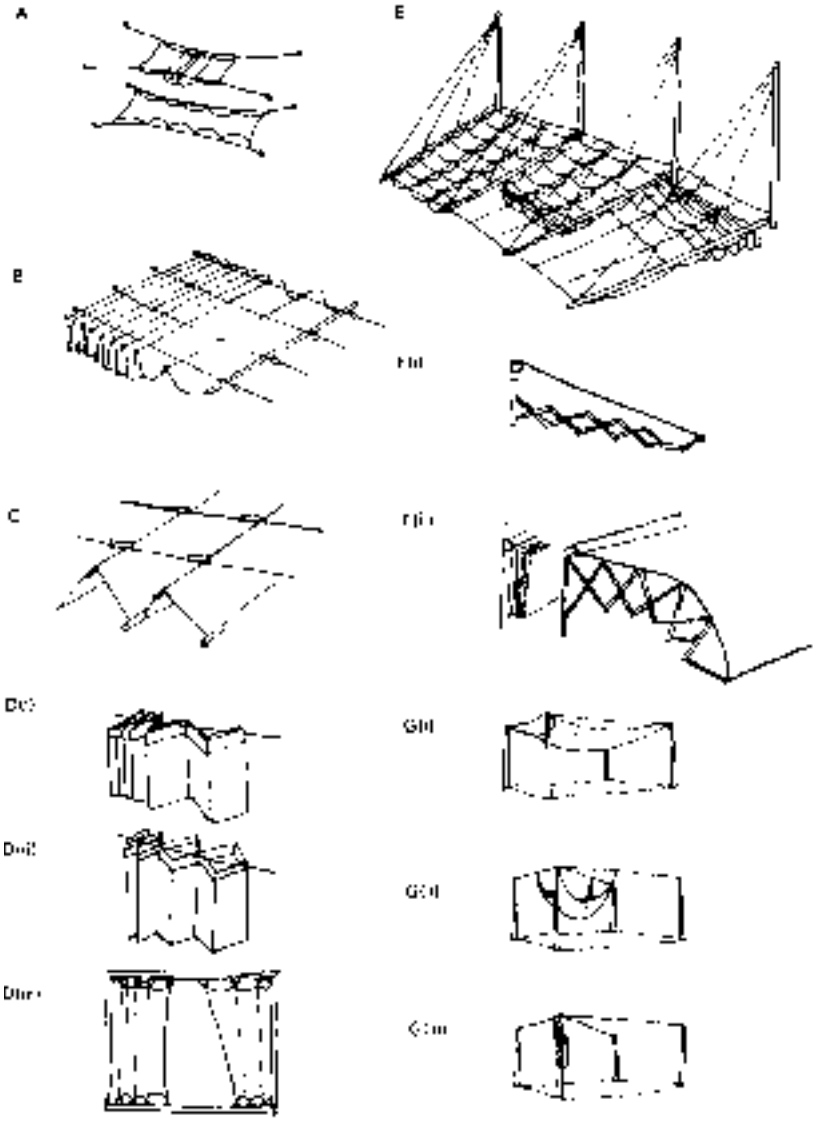
These can cover large areas and can, in some cases, offer rain as well as UVR protection. The most common of these is of the fabric ‘roll-out’ type. One simple form is the fabric awning, cantilevered or supported by a pergola-like frame. Fabric awnings can also be supported on folding or telescopic arms, which allow adjustments to achieve the required vertical shadow angle. These devices are available in manually operated or motorised form.

Where fabric canopies are tensioned on extension, it is important that they are as taut as possible. This is because movement and flapping of the canopy will reduce the life span of the device. The canopy should be able to be tightened and adjusted as the fabric stretches over time.

It is also important to ensure that the canopy can be adequately stored when retracted. Folding back into a well-ventilated box will extend the life span of the device and prevent accidental damage.

Built shade

There are positive and negative environmental impacts associated with retractable devices. The negative impacts include those resulting from the manufacture and disposal of plastic and other synthetic materials commonly used in canopy devices. On the other hand, only a small volume of material, and therefore less embodied energy (See Glossary), is required to produce the canopies.



examples of retractable devices

Diagrams A, B and C are examples of linear systems that consist of a folding canopy which is supported or suspended from tensioned wires or a solid frame.

Diagram D is an example of vertical shading which can be used to block reflected and scattered UVR.

Diagram E illustrates a type of retractable awning which is thought to have been used on a large scale to shade seating areas of amphitheatres in Roman times.

Diagram F demonstrates how adjustable awnings can be used to extend overhangs on existing buildings.

Diagram G is an example of a canopy that retracts in one piece; retraction can be achieved by a simple system of pulleys and rope or wire.

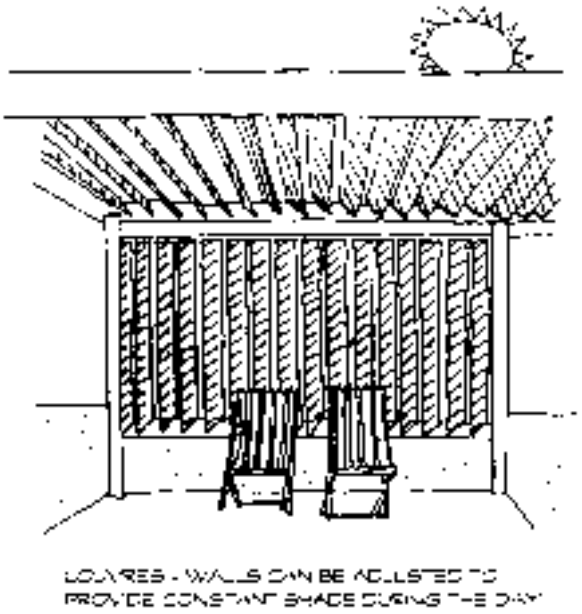
louvred devices

A range of manually adjusted louvre roof systems are commercially available. These systems offer a high degree of control and flexibility for shading of outdoor areas. They can be adjusted to totally exclude the sun's rays or to create partial shade. Most louvre designs have the added advantage of providing protection against rain.

The louvre blades are usually an aerofoil design, fabricated in pre-painted steel or aluminium. Other materials can also be used for the louvre blades. For example, corrugated polycarbonate sheet could be used in situations where UVR protection and ventilation are required, without excluding warmth and light. Louvres of expanded metal mesh could be used where waterproofing is not a priority.

If the louvres are placed vertically, the louvre wall can be an effective wind deflector, or wind gatherer, in addition to providing protection against direct and indirect UVR.

Also available in the marketplace are louvred roofs which open and close automatically in response to sensors triggered by wind, rain and solar radiation.



louvered walls and roofs

Components of built shade

Built shade consists of:

- the supporting structure, which is required to maintain the shading element in position
- the primary shading element, ie the material that comprises the canopy or roof.

The properties of the shading element, such as mass and span, will strongly influence the design of the required supporting structure. For example:

- relatively lightweight materials such as metal or translucent roof sheeting, which are capable of spanning up to 1.2 metres, will require less supporting structure than a roof of terracotta tiles, which are significantly heavier and require supporting battens about every 300mm
- a project that uses structural fabric or shade cloth as the primary shading element will require less supporting structure than metal roof sheeting, as fabrics are lighter and span greater distances when in tension
- solid fabrics such as canvas or reinforced PVC do not allow wind to pass through in the same manner as open-weave shade cloth, and therefore require supporting structures which can resist a much higher level of wind loading.

This relationship between the shading element and supporting structure is significant in determining the functional performance of built shade. Short-span structural systems necessarily result in a high number of supporting columns. While in some situations this may not present a problem, locations such as school playgrounds require shaded areas substantially free of columns. The design brief should define the requirements of the area to be shaded, and the designer should ensure that span characteristics of the supporting structure comply with the requirements of the brief.

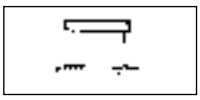
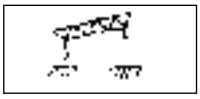
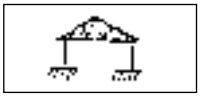
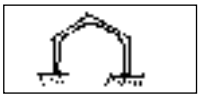
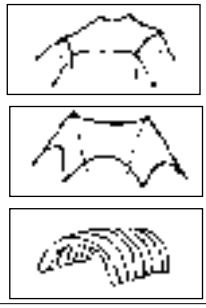
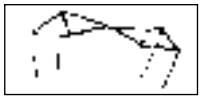
The final cost of built shade is also significantly affected by the relationship between the shading element and supporting structure. Selecting a cheap material for the shading element will not be cost-effective if an extensive and costly structure is required to support the selected material. In order to achieve the most cost-effective outcome, the designer must select materials and structural systems that together provide the optimum solution for the brief.

In planning built shade, the required life of the shade structure should be determined and designed for. The post-life use of the materials, ie how they may be re-used, recycled or disposed, should also be considered and designed for.

For all built structures, large or small, it is essential to seek professional structural advice and certification from a qualified structural engineer. This certification is required for building applications and will ensure structural integrity and safety.

note

See page 76 for more information on the design brief.

structure	diagram	suitable material	typical span	notes
beams		steel timber concrete	up to 30m up to 15m 7–20m	span is dependent on the type of material used and the design of the beam
girders		steel timber	up to 20m up to 18m (non-laminated)	
trusses		steel timber	8–15m	span is dependent on design of truss
portal frames		steel timber concrete	up to 80m up to 50m 20–40m	an integrated frame, form can be designed to suit need
space frames		steel	dependent on type of system used	
arch structure		steel, timber	large spans of up to 90m	
tension membrane structure		steel	dependent on type of system	three main types: 1 cable—cables tension membrane 2 tent—membrane stretched over supports and anchored to ground 3 air—tensioned by air pressure in/under membrane
tension stay structure		steel		roof of structure is partly suspended by same structure

structural systems for long spans [3]

3 Elder A. *A handbook of building enclosure*. London: The Architectural Press, 1974.

supporting structure

The supporting structure required to maintain the shading element in position consists of two elements:

- the footings
- the support system.

The function of the footings is to convey the loads on a structure to the ground. In addition to the load resulting from the weight of the structure, wind can cause significant uplift forces on lightweight structures. For this reason, footings need to be strong enough to hold the structure in place.

There are different types of footings to suit different site conditions. The type chosen is dependent on the superstructure, soil conditions and loading conditions, eg wind.[4] The existence of underground services may influence the type of footing used and its positioning.

The support system, ie columns and beams, holds the roof canopy in place. When selecting a support system a number of factors should be considered including:

- foundation conditions
- span to be covered
- nature and magnitude of loads on the structure, eg wind and weight of building materials
- aesthetics (also in regard to possible future alterations)
- proposed erection method as well as flexibility in use
- fabrication costs
- environmental considerations such as:
  - its embodied energy
  - the lifespan of the structure compared to that of fixtures and canopy materials
  - suitability of support structure for additional uses eg water collection/ photovoltaic array
  - the possibility of re-using the materials at the end of the structure's life (especially for long life materials), and the ability for material to be disassembled or recycled to minimise waste.

primary shading element

There are five main categories of materials which can be used for the primary shading element.

standard building materials

These include:

- metal or tile roofing
- timber
- concrete
- masonry
- other conventional building materials.

Significant advantages over other materials are their assured long life, non-combustibility (except for timber), waterproofing and resistance to vandalism. Given their long life, it is often possible to source these materials second hand, which reduces the need for the manufacture of new materials.

However, standard building materials are characterised by straight line geometry and, unless creatively and carefully designed, can lack aesthetic appeal.[5] They also require a substantial supporting structure.

rigid translucent materials

These include:

- treated glass
- polycarbonate
- acrylic
- fibreglass sheeting.

These materials block direct UVR while allowing the transmission of heat and diffuse light. They are most suitable for structures intended for winter UVR protection. Being waterproof, they also offer rain protection and can be used to collect water.

It should be noted however that many rigid translucent materials, especially the plastic-derived ones, carry a number of environmental costs.

4 Stroud Foster J. *Mitchell's advanced building construction — The structure*. London: BT Batsford Ltd, 1963.

5 Davis BT. *Shade roof systems for open deck car parks, playgrounds and similar areas*. Paper presented to Membrane Structures Association of Australasia Conference; Auckland, New Zealand, July 1–2 1993.

It is therefore recommended that rigid translucent materials only be used where some other environmental benefit can be achieved, for example, where their use may offset or reduce the need for artificial lighting or heating.

Rigid translucent materials are typically supported at relatively close centres (approximately one metre) on metal or timber framing and may also require safety mesh immediately below sheeting. Relatively high maintenance is required, both for cleaning and inspections of gaskets and fixings. If correctly installed, sealed and maintained, their life span is medium to long term.

structural fabrics

Examples of structural fabrics include canvas or PVC coated polyester. Being tightly woven, they exclude most UVR. Structural fabrics can be easily demounted and used elsewhere, need less support structure than do permanent fixed systems and require far less material for the shading element itself. Some structural fabrics, however, are non-recyclable and so will contribute to landfill at the end of their life.

Like translucent sheets, structural fabrics are combustible. They require regular maintenance, including cleaning, to retain light transmittance.

knitted or woven fabrics

Knitted or woven fabrics, such as shade cloth, act as a physical barrier to direct UVR, with little transmittance through the yarn, but 100% transmittance through openings in the fabric structure. Different colours and fabric densities provide different levels of protection. For example, a two-tone cloth may have different ratings for each colour. If the material is tightly stretched during installation, the holes in the fabric may expand and allow more UVR to penetrate.

Shade cloths are generally rated in terms of a 'cover factor' which indicates the amount of light blocked. While the correlation between the blockage of light and UVR is high, it is not an accurate measure of UVR protection.

However, many manufacturers/suppliers have had their shade cloth rated for UVR transmission. These ratings may vary from less than 50% to more than 90%.[6]

As the life span of shade cloths is usually short (due primarily to their susceptibility to weathering), they are often used as an interim measure while natural shade is growing. Life span can be extended by designing to allow for progressive tightening to offset stretching.

From an environmental perspective, these materials are generally lightweight so, like structural fabrics, they require less support structure than do permanent fixed systems. However, as it is generally not economically viable to recycle most of these materials (especially those that utilise a number of different material types, eg PVC coated yarn), their disposal will usually contribute to landfill.

Some important points to note about shade cloth include:

- It may be characterised by poor durability if used in a location subject to windy conditions.
- While a relatively inexpensive shade option, care needs to be taken to ensure that the fabric selected provides at least 94% protection from direct UVR.
- It is often rated as providing 'up to' a certain level of protection eg up to 95% protection. It is necessary to ascertain the actual protection offered as a minimum, not as a maximum.

other materials

Although shingles, thatch, brush and lattice are now less commonly used than conventional materials, they have the potential to be used creatively in modern settings. They can provide very effective barriers to direct UVR, are biodegradable and can often be locally sourced, sometimes from the site itself.

With proper design, installation and maintenance, the life span of a structure made from these materials can be greatly increased. However, they are often more labour intensive to install and maintain.

6 NSW Cancer Council. Review of Shade Materials (unpublished).

Selecting shade materials

When selecting materials for the primary shading element, the following issues need to be considered:

- suitability for proposed design
- ultraviolet protection factor (UPF)
- desired level of light transmission
- desired level of solar heat gain
- waterproofing qualities
- environmental consequences
- wind resistance and structural implications
- ease of replacement
- maintenance requirements
- life span of UVR protective qualities
- particular properties
- relative cost
- compliance with Building Code of Australia requirements (if applicable), eg regarding flammability.
- risk assessment of each material
- susceptibility to vandalism.

UPFs explained

The ultraviolet protection factor (UPF) is a scale developed by the Australian Radiation Laboratory (ARL) to rate the UVR protection provided by materials. The term UPF was chosen to distinguish it from the SPF scheme for sunscreens, though the protective categories are directly comparable. A material's UPF rating is based on the percentage of UVR transmitted through the material.

In 1996, Standards Australia and Standards New Zealand jointly published a standard for sun protective clothing (AS/NZS 4399:1996).[7] The standard describes the testing methods and labelling requirements for UPF rated clothing. Although the standard applies only to personal clothing, the ARL has stated that for non-clothing items such as tents, awnings and umbrellas, it would be reasonable to attach a label stating the UPF rating of the fabric, as long as it is clear that the rating applies to the fabric only. The ARL states that this may involve a disclaimer to the effect that the UPF rating only applies to the material used in the construction of the item and not to the item as a whole.[8]

The following table is based on the UPF Classification System as it is presented in AS/NZS 4399:1996. The table relates UPF to the percentage of UVR transmitted and absorbed by materials.

UPF range	% UVR absorbed	% UVR transmitted	Protection category described in Australian Standard
15 to 24	93.3 to 95.8	6.7 to 4.2	Good
25 to 39	95.9 to 97.4	4.1 to 2.6	Very good protection
40 to 50+	97.5>	<2.5	Excellent protection

note

Appendix C contains detailed information on the qualities of different shade materials.

7 AS/ NZS 4399:1996 *Sun protective clothing — Evaluation and classification*. Standards Australia and Standards New Zealand.

8 Gies PH. Letter to Australian Radiation Laboratory clients. October 1996.

Tension membrane structures

Tension membrane structures (TMSs) are increasingly being used in shade projects. Despite this, they are often the type of structure with which people are least familiar.

Comprising reinforced structural fabrics which are supported at the perimeters with edge cables, TMSs require minimal structural supports. TMSs are a cost-effective option where shade is required for large areas which need to be column-free.

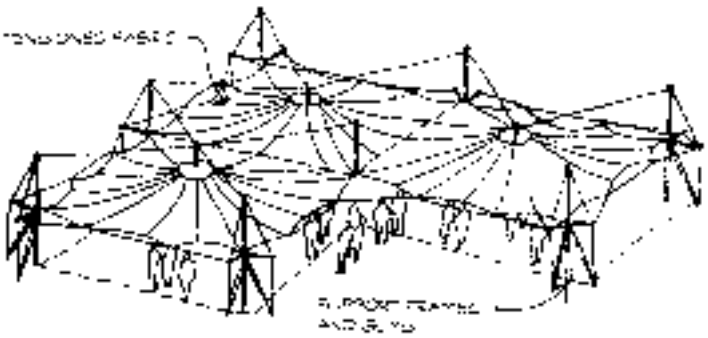
The structural efficiency of a TMS is directly related to the degree of curvature in the fabric. The fabric resists wind-load exerted upon it by a combination of tension and curvature. The tension is usually carried by edge cables which can develop and withstand large tensions.

There are a number of issues relating to TMSs that should be noted:

- Due to the large tensions, it is often difficult to attach TMSs to existing buildings, especially those with timber frames or non-reinforced brickwork or blockwork.
- If using a complex curved TMS, consideration needs to be given to the shade created to ensure that it is appropriate to the need. For example, the commonly used hypar is a double-curved surface which is formed by twisting a square shape, so that it has two high corners diagonally opposite each other, and two correspondingly low corners. However, the upward sweep of the surface means that, unless the structure is meticulously oriented, little protection is achieved from direct and indirect UVR.
- Care should be taken to ensure that the curvature of the TMS is suitable for minimising indirect UVR.
- Regular forms of TMSs may lead to excessive noise levels. Complex or irregular forms, or the use of soft ground surfaces underneath the structure, may help to avoid this.
- Because TMSs require little supporting structures and are lightweight, less materials are needed, which is an environmental benefit. However, these materials often have negative environmental impacts associated with their use of non-renewable resources, manufacture and disposal.

  For small areas, off-the-shelf TMSs may produce good results, provided that the item is of good quality and that care is taken with orientation.

  The design and construction of TMSs is a specialist area. A list of specialist design firms can be obtained from the Lightweight Structures Association of Australia.



an example of a tension membrane structure

note

See Appendix B for contact details for the Lightweight Structures Association of Australia.

Off-the-shelf structures

Off-the-shelf structures are those which are pre-manufactured for assembly on any site. While some purchase contracts provide for supply only, others provide for supply and installation. In the appropriate situation, off-the-shelf structures can provide a readily available, cost-effective method of shade provision.

Prospective buyers of off-the-shelf structures should determine the shade needs of the site prior to approaching suppliers. Unless a Shade Audit has been conducted, it is impossible to determine if an off-the-shelf structure will meet the requirements of the design brief.

It should be remembered that shade suppliers will not necessarily offer independent advice and may not offer advice beyond their own product range. Given that these products are pre-designed, it may also be difficult to find a product that suits all the requirements of the particular site.

If the decision is made to purchase an off-the-shelf structure the following issues should be considered: [9, 10]

- ensure the structure meets the requirements of the design brief:
  - Will the structure provide the type of shade required at the right time of day, at the right time of year?
  - Does it allow for the type of activity taking place near or under it, eg are columns too close to play equipment?
  - Does it provide an adequate amount of shade for the number of potential users?
  - Will it affect lighting levels during night-time use?
  - Does it enhance the attractiveness of the surrounding environment?
  - Have potential sources of damage been considered, eg vandalism, storms, strong winds?
- ensure canopy material provides at least 94% protection against direct UVR transmission. Ask to see test results of the material's UVR transmission levels.
- check that the level of protection claimed for the product is guaranteed for its lifetime.
- ensure the structure does not contribute to hazardous situations, eg placement of guy ropes may result in trip hazards.
- ensure the structure is certified by a qualified structural engineer.
- inspect examples of previous work done by the supplier. If possible, talk to previous clients about how the product has performed over time.
- if the contract is for supply and installation, ensure that the price quoted includes engineering certification of the installed structure including footings.

note

The method for conducting a Shade Audit can be found on page 60.

9 Alexander–Gabrielson M. *Swimming pools — A guide to their planning, design and operation*. Illinois: Human Kinetics Publishers Inc, 1987.

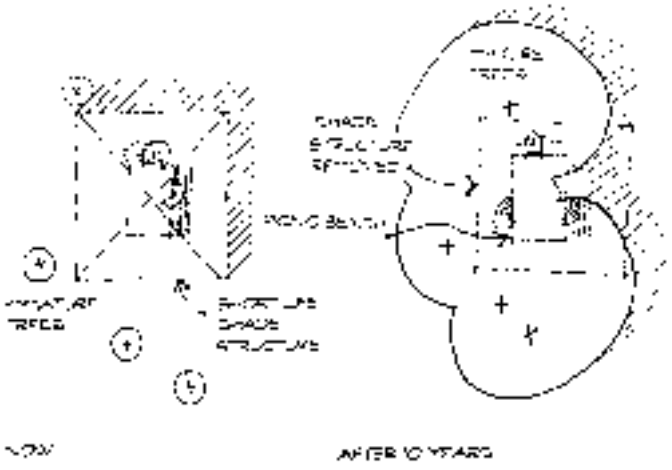
10 Brisbane City Council, Department of Recreation and Health. *Tender documents for supply and delivery of shade structures* (unpublished).1993.

Combinations of natural and built shade

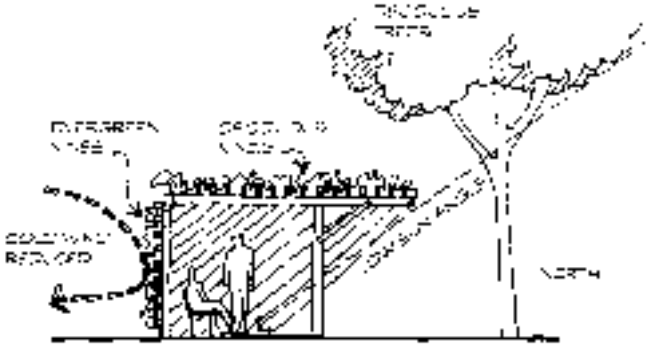
Systems combining both natural and built shade will potentially exhibit the advantages of both. This approach may be particularly appropriate for settings such as picnic areas, school playgrounds and spectator zones at playing fields.

Natural and built elements can be combined to provide effective shade in several ways:

- Vegetation can be used to improve the comfort levels afforded by shade structures. For example in summer, plants can be used to channel breezes through a structure. In winter, they can be used to provide windbreaks.
- 'Short life' built structures can be used to provide UVR protection until vegetation planted for shade purposes matures. The structure should have a life of 6 to 10 years to allow for a reasonable degree of maturity of shade trees.
- Structures can be used to support shade-producing vegetation. For example, a vine-covered overhead pergola or a lattice screen, interwoven with climbing plants, can be particularly appropriate during summer.



combining structure and vegetation to meet short and long-term shade needs



a vine-covered pergola