Innovative Fabrics for Architectural Structures

Robert Cahill, Hiraoka (Australia) Pty Ltd.

Hiraoka & Co. Ltd have been producing textile products since 1902 and manufactured some of the earliest PVC coated polyester fabrics for tension membranes. In recent years the company has been exploring new technologies for improving the performance, functionality and visual impact of membrane fabrics.

Recent technical advances involve aspects of light transmission, UV and temperature control, and the availability of coloured/translucent fabrics to either blend in to or stand out in the surrounding environment.

It is quite possible to combine some, or all, of these technologies in the one fabric.

1. Semi Transparent Fabrics.

Most fabrics used for medium to large architectural structures are white. This is partly for aesthetics, light transmission, production advantages, etc. Typically a white PVC coated fabric for tension membranes will have a light transmission level in the range of 5-15%. This provides adequate light levels in many situations. The white surface also reflects a high percentage of solar radiation which may be important for temperature control within the structure. Nevertheless, there are a number of situations where it may be desirable to utilise a fabric with far higher light transmission capabilities.

The higher light level may fulfil functions such as improved natural lighting, reduction in energy usage, improved ambience and also for decorative effects. At night time the structure can also be lit from within with white or coloured lighting to create a glowing icon.

Applications where these fabrics could be utilised include shopping centre or hotel atriums, sport stadiums where light levels are critical for grass growth, structures with a southerly (shaded) aspect.

Over the past several years Hiraoka have manufactured some lighter weight transparent fabrics for a range of applications. These fabrics consist of a transparent PVC coating on a polyester base cloth. Light transmission levels are in the range of 40% to over 60 %, depending on fabric construction and the type of additives that may be incorporated into the coating. These fabrics have been produced with the main focus on maximising the level of light transmission and have tended to use a reasonably open weave base cloth. The open weave construction implies a lower fabric tensile strength.

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Some of these lower strength fabrics have been used in larger structures to increase illumination levels, or to provide some aesthetic benefit. Given their strength limitations they have been used in relatively short spans, unless supported on a framed structure. (See Figure 1, below)

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Figure 1. Fabric with 64% light transmission. Kirloskar Brothers HQ, Pune, India.
(Photo courtesy of MakMax Australia)

In some applications a small quantity of semi-transparent fabric is used to provide a visual focal point in the structure. (Figure 2, below) This effectively draws your eye immediately to this section of the structure. It also allows more natural light into the structure to create an open, airy atmosphere.

Figure 2. Semi-transparent fabric above central mast. Mildura Soundshell.

Generally, these sections of semi-transparent fabric have been physically separate from the main textile canopy due to strength and biaxial behaviour differences between the two fabrics. In some applications there has been the desire to combine white and semi-transparent fabrics in a continuous membrane, but concerns about the different biaxial behaviour leading to wrinkles in the membrane have limited this approach to date.

Hiraoka will now produce a range of high strength semi-transparent fabrics that utilise the same base cloth as their white architectural structure fabrics. These will be manufactured in Type 1, Type 2 and Type 3 grades of fabric. This permits the construction of larger scale transparent canopies or a combination of white and transparent fabrics in the one membrane to create an impressive aesthetic daytime appearance and a stunning visual impact at night.

There is a definite trade-off between the density of the base cloth and the amount of light that will pass through the fabric. The Type 1 fabric has a light transmission of 41%. The Type 3 fabric, which utilises a base cloth with higher weave count, has a light transmission of 30%. As a comparison, the white fabric has a light transmission of about 11%.

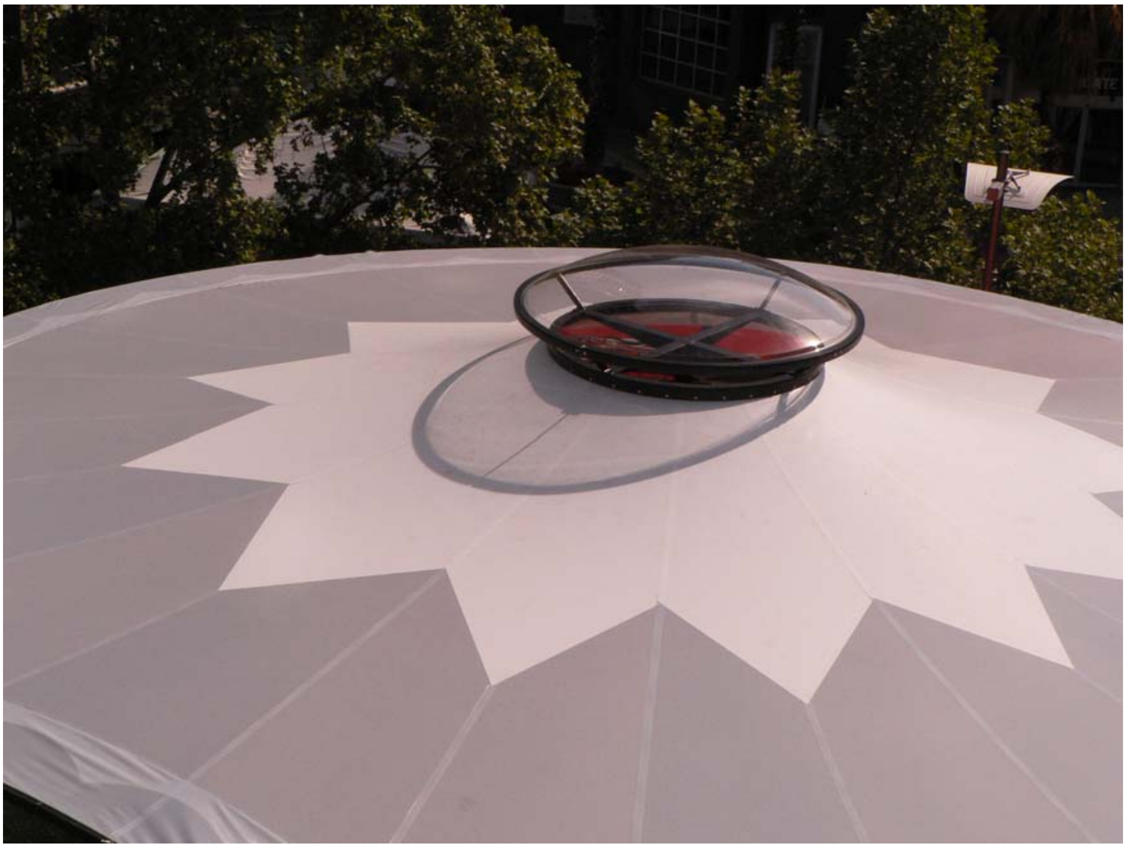
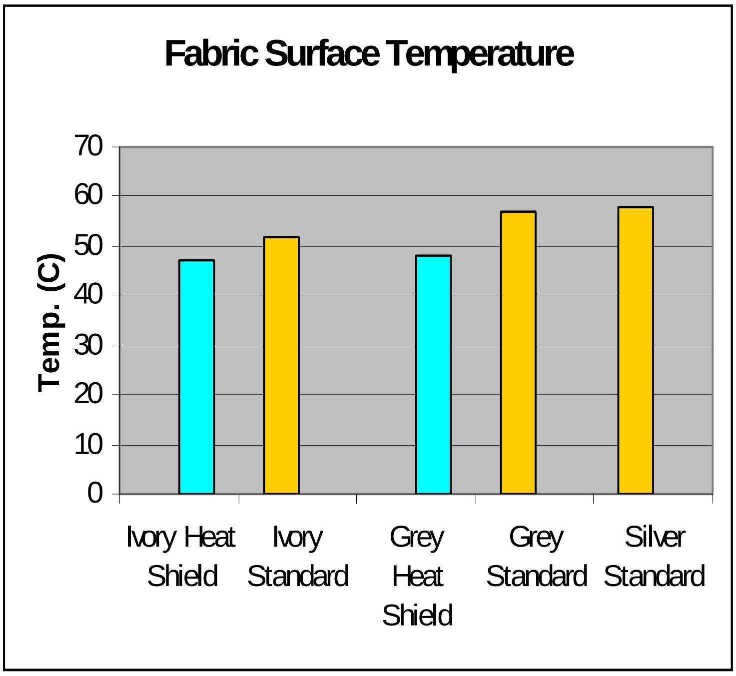


Figure 3. Combination of white and semi-transparent fabric. MIAF temporary performance venue.

2. Heat Shield

Membrane fabric surfaces absorb and transmit solar radiation. If you can alter the level of radiation that is absorbed and reflected you can reduce the solar heat gain through the membrane surface. This has significant implications for membrane design, air conditioning loads, and fabric



selections. The issue of heat loads is becoming increasingly significant in building design as we become more aware of the need to reduce energy consumption where possible.

Hiraoka have incorporated a nanoparticle additive into PVC coatings that reduces the amount of infrared radiation that is transmitted through the fabric. This additive does not significantly change the level of visible light transmitted, so there is no visible difference to the fabric.

In trials on enclosed small structures on a sunny day in summer conditions the temperature difference between the structure that incorporated Heat Shield and the standard structure was around 5 degrees C – based on a cream coloured fabric (see Figure 4, below). Fabric surface temperature was also measured using ivory and grey coloured fabrics with and without Heat Shield. Silver coloured fabric without Heat Shield was also included for comparison purposes (see Figure 5, below).
This incorporation of the Heat Shield additive has significant implications for comfort levels in a number of different types of structures. A large tent on a summer day can become uncomfortably hot. Many large tents require air conditioning to maintain a reasonable comfort level. The use of Heat Shield will significantly reduce the air conditioning loads in these structures.

Figure 4. Trial of fabrics with and without Heat Shield.

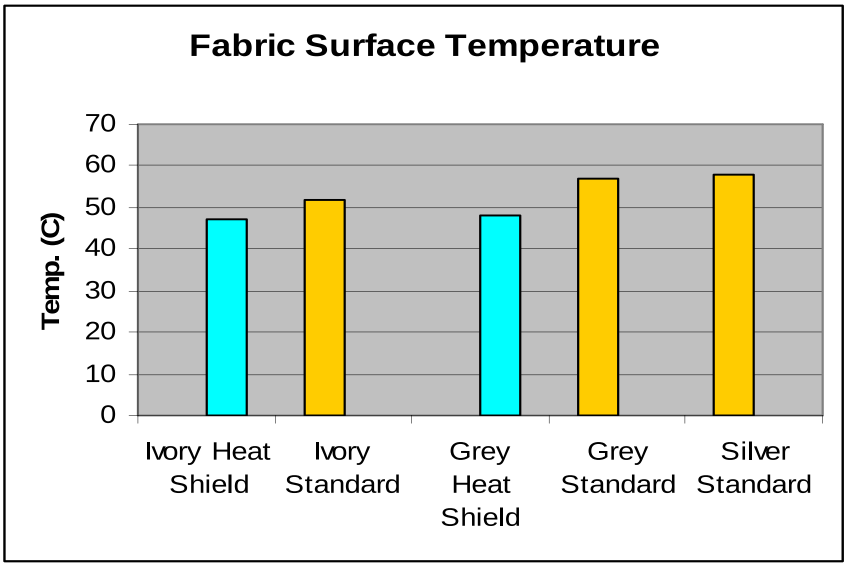


Figure 5. Surface temperature of Ivory and Grey coloured fabrics with and without Heat Shield.

These Heat Shield fabrics can also be used on structures that house animals – cattle feed lots, piggeries, etc. In these applications there is an improved productivity and improved animal welfare benefits derived from the use of these fabrics.

The Heat Shield additive also has significant implications for use in the semi-transparent fabrics discussed above. In normal circumstances, a transparent fabric will allow significant temperature gain due to the greenhouse effect. By incorporating the Heat Shield additive a semi-transparent fabric will have roughly similar temperature behaviour to an equivalent white fabric (within 2 degrees Celsius). This means that we can design and install structures that allow a large amount of visible light, but with little or no extra heat load.

3. Coloured, Backlit fabrics

In several countries there is a proliferation of awnings that utilise “backlit” fabrics. These fabrics have a coloured top surface to create visual impact in daylight and a highly translucent bottom surface to permit back lighting at night. Whilst this concept has been used for awnings for many years, the same concept has recently been applied to some high strength architectural fabrics to permit the construction of tensile structures with a high visual impact day and night. The finished structure effectively becomes a visual beacon or landmark in the local environment.

In Figure 6 (below) an example of this concept is being used on a structure at the front of a well known food franchise. This structure is quite visible from the adjoining freeway and is highly visible in daylight hours. At night, lighting directed upwards through the membrane allows an eye catching glow to attract the attention of passing motorists.

Figure 6. Coloured, backlit fabric for membrane structures. McDonalds, Florida.

This example shows what can be done with a bright colour for a highly commercial application. Several major corporations have particular colours that are strongly associated with their brand. I am sure that you can think of examples of fast food companies, petrol companies and other organisations that would benefit from the ability to emphasise their brand 24 hours a day. Similarly, a structure at a sporting stadium could utilise the home team's colours to create a landmark venue that is a beacon for night fixtures.

This concept does not need to be confined to bright commercial colours. A subtle, more artistic colour could also be used on a structure designed for broader public amenity. There are numerous architectural and artistic variations that are possible with this approach.

Summary

The three innovations in fabric technology discussed above can allow new designs in membrane structures that significantly alter the visual and functional boundaries of tensile architecture. Each of these design elements can, on their own, significantly broaden our design flexibility. When combined within the one fabric, there is the potential to produce architectural structures that offer exciting new levels of visual impact and performance.