LSAA Technical Symposium

Solid Fabric and Shade Cloth Materials – Engineering and Other Properties



Textile Materials for Architectural Structures

Overview

Architectural fabrics are playing an increasing role in the Australian and global built landscapes.

Textile clad light structures deliver superior design, aesthetic, cost and build time advantages over traditional construction forms.

In a world where Environmentally Sustainable Design and Embodied Energy are fast becoming the key driving forces of modern Architecture these benefits are now more compelling than ever.

Overview (cont...)

Fabrics facilitate advances in architectural design by virtue of:

- Environmental Sustainability
- Energy Efficiency
- Structural Strength
- Cost Efficiency
- Aesthetic Effects
- Low Maintenance
- Space Extension
- Longevity
- Durability
- Flexibility and Portability
- High Performance
- Shade and Light Diffusion
- Extreme Temperature Resistance
- Flame Retardancy

Infinite Variety

Structures can be created in a variety of forms, sizes, spans, colours and even graphically printed giving infinite variety and freedom of creativity.


Manama - Bahrain


Shopping centre Plymouth - UK

Limitless Applications

From stadia to a school yard, from desert to the arctic no application or environment is beyond the scope of Architectural Textiles.


Faro stadium - Euro 2004 Portugal


Grand Canyon view point USA

Textile Selection

There are diverse forms of architectural textiles. Selection criteria relates to:

- Suitability for Structure Function
- Wind Load Resistance
- Life Cycle Expectations
- Design Expression and Aesthetics
- Desired Level of Light Transmission
- Desired Level of Solar Heat Gain
- Building Codes
- Economics – Relative Costs
- Maintenance
- Waterproofness

Types of Fabrics

Today we focus on 4 of 5 main types of architectural textiles:

- P.T.F.E. — Polyethylene Tetrafluoride on Fibreglass base fabrics ("Teflon coated fibreglass")
- P.V.C. / P.V.D.F. / P.E.S. — Polyvinylchloride with Polyvinylidene Fluoride on Polyester base fabrics
- E.T.F.E. — Ethylene-tetrafluroethylene ("Foils")
- H.D.P.E. Shadecloth — High Density Polyethylene
- Silicone Coated Fibreglass — (not covered)

1. PTFE "Teflon coated glass"

Skilled Park Gold Coast Queensland

1. PTFE "Teflon coated glass"

Millennium Dome London

1. PTFE

- Manufactured by coating woven fibreglass yarn with a PTFE ("Teflon") emulsion.
- The heavy grade fibreglass used is stable, non-combustible and resistant to chemicals and UV light.
- Provides a high level of light diffusion.
- Possesses high tensile strength and has good dimensional stability.
- PTFE is chemically inert.
- Forms a weather-tight barrier.
- Highest cost balanced by highest durability and longest life.
- Not yet recyclable.

PTFE CHARACTERISTICS (typical)

Weight	Thickness	Tensile Strength	Elongation	Light Transmittance
1380 gsm	800um	450daN/3cm	10 %	11 %

2. PVC / PVDF / PES

Gerland
stadium
Lyon - France

Car Park, Brisbane

2. PVC / PVDF / PES

Hotel Foyer
Cairns

Lake Pontoon
New York state

F1 Kuala Lumpur - Malaysia

Arts Festival Melbourne

Australian Textile projects win worldwide recognition

Shade to Order - Newcastle Airport

Port Douglas Sailmakers - Cairns

Exporting Australian Textile skills – Mumbai Airport -Makmax

2. PVC / PVDF / PES aka PVC composite

- PVC – long chain polymer with chloride molecules attached.
- PVC is the most widely used plastic in the world after LDPE.
- PVC fabric production consists of multiple coatings: Adhesives, Primers, main coat of PVC on a high tensile polyester fabric with a top coating of PVDF.
- Polyester base cloths offer strength, durability and low shrinkage.
- The PVC protects the polyester from aggressive UV and adds aesthetic qualities and flexibility.
- PVDF top coatings improve cleanability and longevity.
- Attractively priced and easy to fabricate. Fully recyclable.

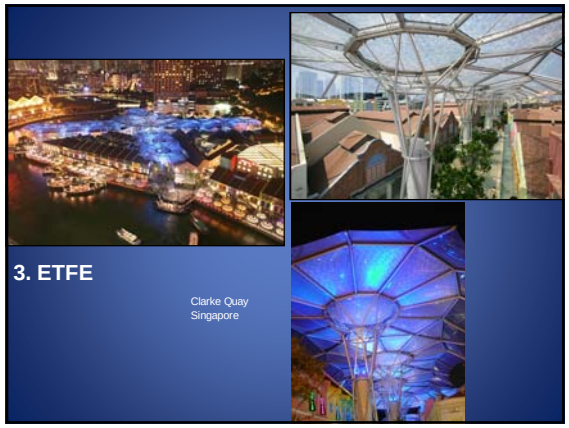
TYPICAL PVC TEXTILE CHARACTERISTICS BY CLASS

Class	Weight	Tensile Strength	Tear Strength	Coating
Type 1	750 gsm	300/280 daN/5cm	30/28 daN	PVC PVDF
Type 2	1050 gsm	420/400 daN/5cm	55/50 daN	PVC PVDF
Type 3	1050 gsm	560/560 daN/5cm	80/65 daN	PVC PVDF
Type 4	1350 gsm	800/700 daN/5cm	120/110 daN	PVC PVDF
Type 5	1500 gsm	1000/800 daN/5cm	160/140 daN	PVC PVDF

Architectural Grade PVC textiles conform to World Fire Retardancy Standards including AS 1530

1000daN/5cm equates to 20 tonnes of tension per metre – Type 5
Type 2 approx 8 tonnes / metre

1 metre width of Type 5 fabric approx 2mm thick can carry 10 empty Defenders



3. ETFE "Foils / Film"

- A high performance lightweight film manufactured by extrusion technique
- Transparent, Durable, Flexible, Self Cleaning, Non Adhesive, Energy Efficient.
- Landmark Projects: Beijing Watercube (2008 Olympics), Munich's Allianz Arena (2006 World Cup).
- Invented in 1970's by Dupont.
- Estimated to be 30% more energy efficient than traditional glass.
- 1% the weight of glass with the ability to support 400 times its own weight
- Recyclable, with an expected life of 20 + years.
- Low emissivity with the ability to select levels of light transmission.

ETFE FILM CHARACTERISTICS

Weight	Thickness	Tensile Strength	Elongation	Light Transmittance
175 To 438 gsm	100um to 250um	>=45Mpa	>= 400%	90 %

At 45 Mpa, 1 metre width of 0.1 mm thick foil can carry 4.5 kN. This restricts applications to smaller spans (small radius of curvature as per the "bubbles" of the Watercube).

Knitted Shadecloth

- Shadecloth is a light weight industrial textile commonly used for outdoor protection. It uniquely offers a combination of UVR protection with a breathable finish providing an ideal cover for the harsh Australian environment.
- Commercial shadecloth is manufactured by knitting high density polyethylene. This is generally UV stabilised yarn that has exceptional tensile strength.
- Woven shadecloth is no longer used in structures.

HDPE Knitted Shadecloth

- Knitted from filaments of High Density Polyethylene.
- High UV performance coupled with high tensile strength.
- Raschel knit (lockstitch) construction provides resistance to tearing and fraying.
- Ideally suited to moderate tension, modular shading applications requiring light-weight materials.
- Finds service in a wide variety of shading applications.
- Flexibility through wide width and broad colour range.
- Lowest cost with lower engineering input requirements.

3 Construction Methods used

- 100% Monofilament
  - Commonly used in the manufacture of heavy duty shadecloth. Typically has exceptional tear and tensile strength.
  - Can be very heavy when installed over a large span requiring additional tensioning
  - Depending on the knit will generally have low UVR block levels
  - Typical applications: Car parks and large commercial structures

3 Construction Methods used

- Monofilament and Tape
  - Most common type of manufacturing method
  - Tape insert provide high levels of UVR block
  - Monofilament provide strength while tape insert provides increased UVR block. Tape provides no strength.
  - Monofilament is HDPE and tape is LDPE
  - Typical applications: Schools, playgrounds and domestic shade sails

3 Construction Methods used

- Monofilament with oval monofilament insert
  - Recent technology proving to be effective.
  - Provides exceptional strength and high UVR block
  - Heavy weight product

HDPE CHARACTERISTICS (typical fabric 200gsm)

	WARP	WEFT
Breaking force	80 daN /5cm	215 daN /5cm
Breaking extension:	84 %	63 %
Tear resistance:	17 daN	28 daN
Bursting force (Steel Ball):	mean 1861 N	
Bursting Pressure:	mean 3000 N	

Cloth construction – lock stitch with filler tape for shade factor

Front surface | Back surface

Polyethylene Yarn

- High-density polyethylene has a linear structure which provides better tensile properties – the result is a stronger yarn and stronger shadecloth
- Polyethylene has a high strength to weight ratio and does not absorb liquid – greater stain resistance.
- Polyethylene is affected by ultra-violet light however UV stabilisers are used to prevent UV degradation.
- UV stabilisers can be affected by halogens (e.g. Chlorine, Bromine, Iodine, Fluorine).
- Flame retardants may be added to polyethylene to improve the flame retardancy characteristics of the yarn.

Threads

- Thread is a relative low cost item used in the fabrication of shade sails yet it is often overlooked as an integral part of a successful installation.
- 3 common types of thread
  - Polyester/Cotton blended thread
  - Polyester thread
  - PTFE thread

Characteristics of Threads

- Polyester/Cotton Threads
  - Typically used in upholstery and trim
  - Not compatible with extended UVR exposure
  - Not recommended for shade sails
- Polyester Thread
  - Good initial strength and reasonable UVR expectancy
  - Can be solution dyed providing excellent colour-fast characteristics
  - Can hydrolyse in humid, hot conditions
  - Susceptible to alkaline chemicals

PTFE Thread

- Similar initial strength to Polyester however it does not degrade over extended periods of UVR exposure hence extended manufacturers warranties
- Highly resistant to most chemicals
- Very expensive thread but still relative low in the overall fabrication of a shade sail or structure
- Fast becoming the product of choice for large shade sails fabrication

Sewn connections used for attaching (possible) edge webbing "cables"
Local corner attachment reinforcement
Edge pockets and joins in rolls of shadecloth

Good fabrication practices, quality control are important as the choice of thread.

Webbing

- "Shade Sail Webbing" generally has the following characteristics:
  - Width: Commonly 50mm
  - Installations: Typically used on a smaller shade sails around the perimeter for reinforcing however some fabricators use webbing in the perimeter pocket instead of a stainless steel cable.
  - Made form 100% Polyester – stretches to about 10%
  - UV Stabilised
- Webbing sewn splices need to be tested

Edge Cables and Attachments

- For shade cloth panels
  - Use standard stainless steel cables and fittings
  - Need adjustments for length on cables
  - Prefer use of swaging to wire rope clamps

Materials - Conclusions

- Need to have a knowledge of the types of fabric and shadecloth
- UV protection in coatings or the yarn/filament for shadecloth
- Don't skimp on threads, webbing, seams

Textile Materials - Summary

- We have presented only a modest sampling of the extraordinary scope of Architectural textiles.
- We saw that matching the appropriate Architectural textile to a given project is multi criteria dependant
- Textile structures present compelling evidence of the enhancement potential for built landscapes based on cost and time efficiencies as well as social and environmental benefits.