Criteria for Fabric Selection for Shade and Tensile Structures

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INTRODUCTION:

This paper will deal primarily with comparative assessments of solid fabrics for shade and tensile structures.

However, some attention will be paid to mesh fabrics given their increasing use, particularly in shade sail applications.

Common criteria in fabric selection exist for these two broad categories of fabrics – function, permanence, aesthetics and cost efficiency.

The selection process must be matched to the needs of each shade or tensile structure project. We have categorised 5 main structure types to demonstrate the importance of accurate matching of fabric types for specific applications.

The five categories are:–

1. Air Structures.
2. Marquees / Tents.
3. Clear Spans.
4. Tensile Structures.
5. Sail Shades.

1. AIR STRUCTURES:

These are essentially, air inflated or air supported buildings – inflated beams with pneumatic cushions, modular shapes – domes and bubbles. The most commonly used material in these structures is a type 1 P.V.C. coated polyester fabric, which is fabricated as the outer skin. A lighter weight version e.g.: 400 GSM is used as the inner liner.

2. MARQUEES AND TENTS:

In pole tents, fabric is draped or hung rather than tensioned. Polycotton canvas for domestic tents is common with P.V.C. coated and laminated polyester fabrics used for party hire and event marquees.

Some tents include various tensile structure characteristics such as Hoecker's gull wing structures, which do not use guys and utilise tensioned fabric.

3. CLEAR SPAN STRUCTURES:

These differ from traditional marquees by having a clear space beneath the fabric, free of poles and other supporting obstructions.

They typically use Type 1 P.V.C. coated polyester fabrics where the fabric is pulled taut through channels in the frame's ribs.

4. TENSILE STRUCTURES:

The relatively minimal visual support system is what typically distinguishes tensile structures from other fabric buildings.

Tensile structures are curvilinear so the fabric membrane must accommodate curvature to resist applied loads. In this type of structure fabric selection takes on critical proportions, given the increased load the fabric has to carry and hence the structural integrity demanded of it.

Structural integrity is designed into tensile structures by Engineers who understand the capacities of coated fabrics of varying specifications. At this juncture a brief description of “architectural” coated fabrics is appropriate. The most commonly specified coated fabrics fall into 3 categories – Type 1, Type 2 and Type 3.

Type 1:

Typical Weight 650 GSM+

Typical Tensile Strength (DN / 5cm) Warp 270, Weft 270.

Commonly used in inflatable structures, marquees, tents and clear spans.

Optional blackout versions where total opacity is required are available for buildings such as circus tents, cinemas, laboratories or marquee rooves where high temperature, high humidity conditions apply. These fabrics can achieve solar reflectance values of over 80% and heat absorption values of less than 20%. Opaque fabrics may be specified where visibility reduction is important e.g.: soiling or pollution on a structure surface will not be noticeable from within the structure even with a strong upward light source. High tensile meshes may correspond to a membrane Type 1 category. Due to their high strength (DN / 5cm) Warp 300, Weft 300, they are used for large tensile structures, sun protection sails and wind breaking walls.

Type 2:

Typical Weight 1000 GSM+

Typical Tensile Strength (DN / 5cm) Warp 420, Weft 400.

Most appropriate for large tensile structures or those with a life expectancy of over 15 years.

Type 3:

Typical Weight 1250 GSM+

Typical Tensile Strength (DN / 5cm) Warp 570, Weft 520.

Used for very large, long life permanent tensile structures.

In selecting from this fabric classification Engineers will also assess their needs with respect to tear strength, biaxial elongation and constructional stretch, insulation properties, adhesion and weldability.

In addition to physical or mechanical properties, Engineers and Specifiers also look for other important dimensions in architectural fabrics:–

1. Resistance to U.V. and weathering degradation
   i.e.: protection of the fabric coating and in turn the substrate.

   P.V.C. fabrics are susceptible to dirt and soiling adhesion. Acrylates and other lacquers were developed to extend fabric life by reducing surface tackiness, slowing the process of plasticiser migration, whilst adding an extra U.V. barrier.

   In recent years developments in fluoropolymer lacquers have produced barrier coatings such as P.V.F. polyvinyl fluoride (Tedlar) and P.V.D.F. polyvinylidine fluoride (Fluotop).

   P.V.F. and P.V.D.F. offer additional protection against weather chemical corrosion and U.V. attack. These new enhancement coatings on P.V.C. fabrics genuinely improve cleanability and prolong the fabric life to a greater extent than is possible with acrylic lacquered surfaces.

Other significant technical requirements are:–

2. Flame Retardancy.

   Fabrics must conform to AS.1530 Parts 2 and 3.

3. Resistance to wicking, mould and mildew.

   Treatment of polyester yarn can reinforce resistance as can biocides or bacteriostats used in P.V.C. coating formulations.

4. Aesthetics.

   High gloss finishes which derive from both the coating and lacquering processes enhance the appearance of a tension structure. The ongoing cleanliness and cleanability of a structure relates directly to the fabric selection issue.

5. Cost.

   Coated fabric costs should be assessed in the context of expected performance for each fabric type under review.

6. Light Transmission.

   Various levels from highly translucent to total blackout can be specified.

BASE FABRICS:

Polyester, because of its strength, durability cost and low shrinkage is the predominant substrate used for membrane structure fabrics.

Nylon is more costly and more prone to shrinkage and elongation. Woven Fibreglass coated with PTFE or silicone provides outstanding durability.

Silicone coated Fibreglass is less expensive than the PTFE coated Fibreglass, but lacks its reflective qualities or low heat absorption.

PANAMA WEAVE (2X2):

Is a very commonly used substrate for direct vinyl coating and essentially applications driven e.g.: used more for tension structures than for marquees.

PLAIN WEAVE (1X1):

Also suitable for direct coating, but usually found in lower specification coated fabrics and laminates where strength attributes are less important.

OPEN SCRIM:

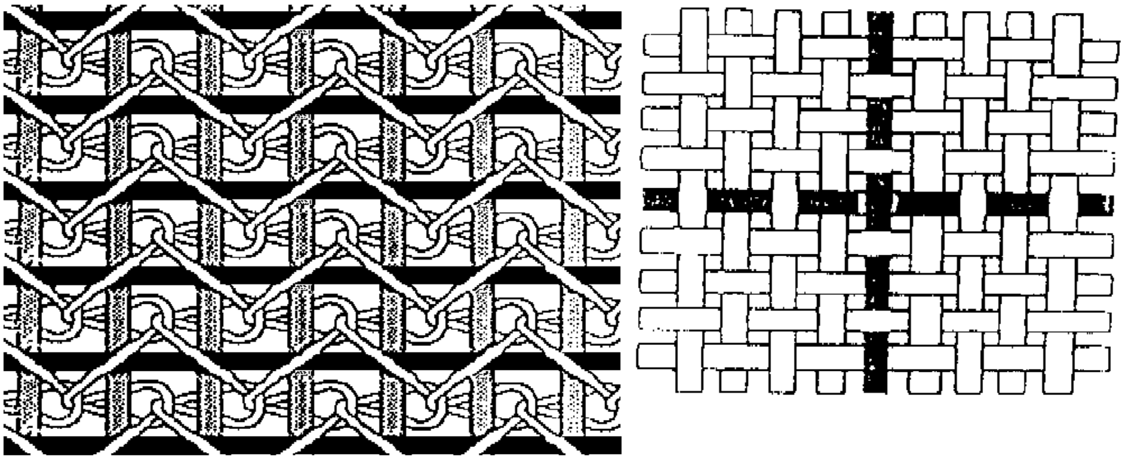
Is the lowest cost woven fabric and is suitable for lamination or melt coating.

WEFT INSERTED WARP KNIT:

Plain weave polyester has been replaced by weft inserted warp knits in many cases. This is especially so for vinyl laminates due to lower cost and superior dimensional stability. (Refer to Diagram 1). However, bond strength is sometimes poorer compared to woven scrims.

The key differences are that in a waft inserted knit fabric the weft yarn is laid on top of the warp yarn. A mesh of fine yarn holds the 2 layers together. In a woven fabric the weft and warp yarns are interlaced.

Diagram 1:



WIWK **Woven**

FURTHER COMPARISONS:

For small to medium scale tension structures the most commonly used material is polyester base cloth (either Panama Weave or Weft Inserted Warp Knit) Coated or Laminated with P.V.C.

For large membrane structures such as sports stadia fabrics such as woven Fibreglass coated with polytetra fluorethylene (PTFE) or Teflon as it is generally known, predominate.

PTFE resins are chemically inert and confer high resistance to ultra violet radiation and chemical pollution, plus excellent cleanability. High strength comes from the woven Fibreglass core fabric. Teflon / Glass fabrics also provide excellent flame retardancy. However, they have some disadvantages in terms of flexibility and ease of assembly compared to P.V.C. coated polyesters.

Silicone coated Fibreglass is used to a much lesser degree. Its main advantages are good light transmission, durability, and lower cost. However, fabrication is difficult with special glues needed, also the surface is sticky as no surface treatment is applied. P.V.C. laminated fabrics are the least expensive of the fabric options. Laminates usually consist of vinyl films over woven or knitted polyester or nylon scrims. Coated fabrics typically use a high count, high tensile base fabric coated with a bondable substance for extra strength. The fabric can be further enhanced by laminating, lacquering or printing.

One fabric manufacturing process, the Precontriant method, places the base fabric under tension before and during the coating process. The result is that yarns in both directions of the weave have identical characteristics giving the fabric markedly enhanced dimensional stability. (See Diagrams 2 and 3).

Apart from lower initial cost, the main advantage laminated fabrics offer is in surface design. Fabricators can generally draw from a wider range of different coloured films, stripes or patterns.

The weights of laminates, or coated fabrics, are not the sole indicators of strength, whilst the chemical composition, amount and distribution of coating determines abrasion resistance and weatherability.

Diagram 2:

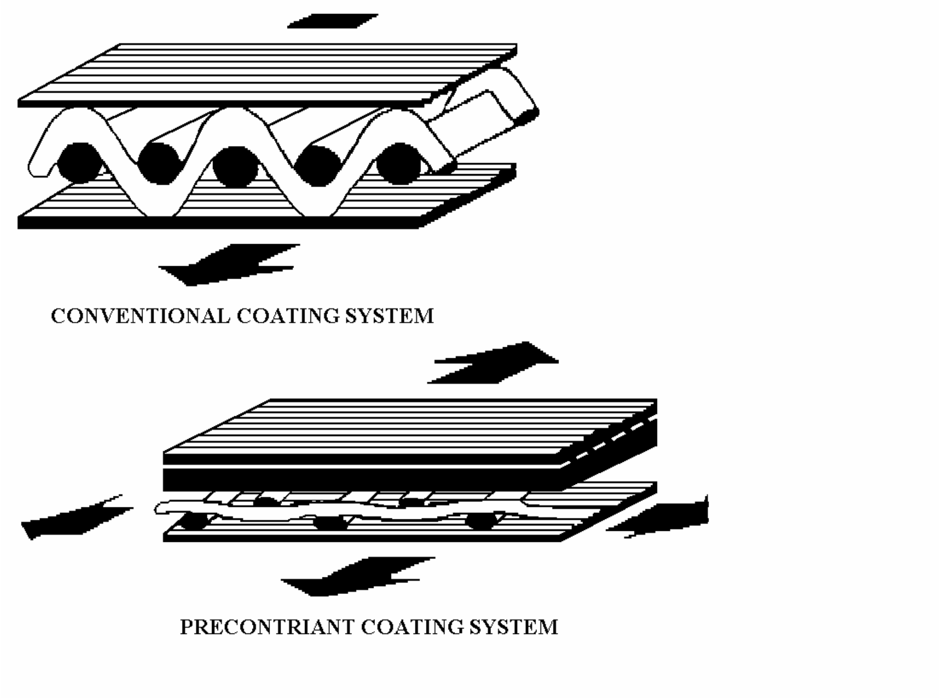
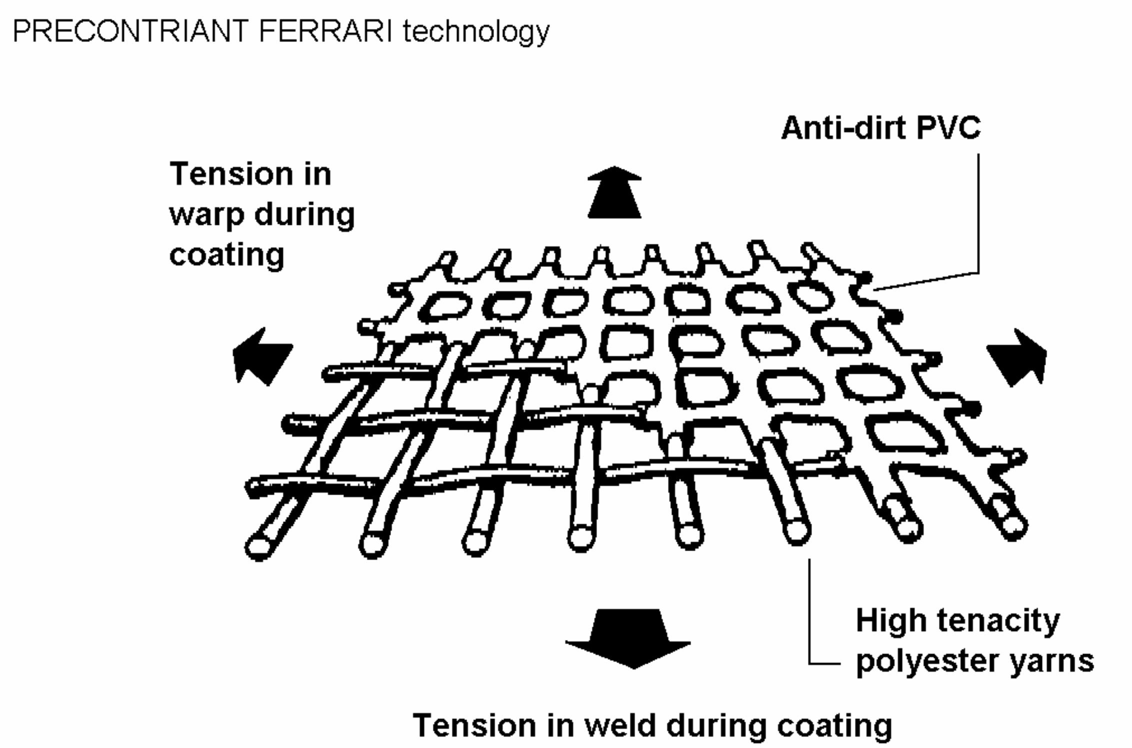


Diagram 3:



5. SAIL SHADES:

This group of structures represent somewhat of a diversion from the sailmaking craft. Yacht sails are designed to harness the wind, to capture the breeze, whilst shade sails should be designed to be as wind negative as possible. Diverse shapes and sizes abound in this increasingly important area of sun protection.

Where protection from rain is also important, solid fabrics (Type 1) are used, but mesh fabrics generally predominate.

The options available are:–

(1) P.V.C. Coated Polyester Meshes – 2 Types.

1 – 1 Soltis type meshes produced by a similar method to P.V.C. coated fabrics, but where the manufacturer controls the deposition of the vinyl coating such that the base fabric is sealed whilst still allowing air to permeate. This style of product achieves good life expectancy and exceptional dimensional stability.

1 – 2 Vinyl encapsulated polyester yarn woven on special looms. Wide colour and texture options are achievable and cost is less than for Type 1. Dimensional stability is, however, lower.

Both types can offer high quality performance incorporating ultra violet inhibitors in their polymer resins and bacteriostats for mildew and mould resistance.

They are generally resistant to colour fade, soiling and abrasion. Weave construction can be configured to enhance shading co–efficiency, tear resistance and other desirable physical characteristics. These meshes can be fabricated by sewing or H.F. Welding and do not fray, unlike traditional woven fabrics.

(2) Shadecloth (U.V. Stabilised).

Two main types:

2 – 1 Woven. These are made from polypropylene or polyethylene, are light weight and relatively inexpensive.

2 – 2 Knitted. This construction offers a bulkier feel, non–fray characteristic, higher abrasion resistance and higher life expectancy when compared to woven shadecloth.

Large areas can be spanned for commercial applications, such as exhibition areas, parking lots, cattle feed lots, crop protection, hail protection for car storage areas etc.

A FINAL PERSPECTIVE

A Specifier could reasonably base their fabric selection on the issue of how long the fabric is expected to last in a particular structure, in a particular environment.

Different types of fabrics will last varying amounts of time, depending upon U.V. exposure, weather, including humidity, photo chemical pollution etc.

A light weight P.V.C. laminate, without any protective lacquer coating might only last 1 – 2 years in a harsh environment, whilst a heavy duty purpose designed coated fabric with P.V.F. coating might last 20+ years.

Another criterion is whether the structure is static or mobile. The more mobile the application e.g.: hire and even marquees, the less appropriate a laminated fabric would be. The high level of flexing associated with constant erecting and dismantling increases the risk of delamination, but that same laminate may be appropriate for a small scale stand alone shade tent or a market umbrella, where short term cost factors are overriding considerations.

Finally, the amount of money allocated to a project has a bearing on fabric selection. However, replacement cost, fabric life span and structure aesthetics should not be ignored in identifying value factors.