Guide to Reinforcements

While composite materials owe their unique balance of properties to the combination of matrix and reinforcement, it is the reinforcement that is primarily responsible for such structural properties as strength and stiffness. The reinforcement is the principle load carrying member of the composite and determines its electrical properties and coefficient of thermal expansion.

The most frequently used fibrous reinforcements are fibreglass, aramid, carbon and to a lesser extent polyethylene and boron. Fibres are prepared for processing either as a continuous filament, known as unidirectional fibres (UD), or as continuous filaments woven into a fabric.

Fibre Properties

Fibreglass — The most commonly used fibre due to its low cost, light weight, high strength and non-metallic characteristics. E-Glass is the most widely used variety offering a high strength-to-weight ratio, good fatigue resistance, outstanding dielectric properties, and excellent chemical, corrosion & environmental resistance. S-Glass is a higher strength fibre offering slightly lower density.

Aramid — Known by the trade names Kevlar® and Twaron®. These fibres combine extremely high toughness and energy-absorbing capacity, tensile strength and stiffness with low density. They suffer from relatively low compressive strength.

Polyethylene — Known by the trade names Dyneema® and Spectra®. They offer similar energy absorption characteristics to aramid fibres, but at a much lower density. Their cost is higher however and polyethylene begins to lose its mechanical properties at a fairly low temperature (80°C).

Carbon — Offer very high strength and stiffness combined with a low density. Cost is higher than that of fibreglass. These fibres are available in several forms – high strength (HS), intermediate modulus (IM), high modulus (HM), and ultra high modulus (UHM).

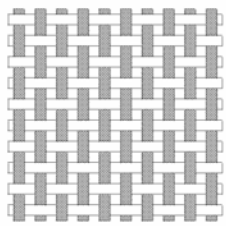
Boron — Boron fibre has a higher strength and stiffness than HS carbon. Their cost is very high and they are difficult to handle being very stiff and brittle.

Fabric Weaves

Fabrics consist of fibres in at least two directions. Fibres running along the length of a roll are called warp fibres, while those running across the width are called weft fibres. These fibres are interlaced with each other in varying configurations to give different fabric styles.

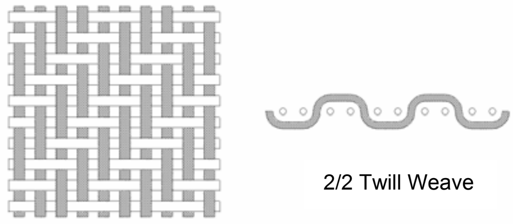
Plain Weave — A plain weave fabric is where warp fibres are interlaced each time they meet weft fibres. This is achieved by the fibres alternatively passing above and below each other.

The resulting fabric is very stable, however it can prove difficult to distort and conform to sharp profile changes.



Twill Weave

In a twill weave the fibres pass over and under a number of fibre bundles, e.g. a 2/2 twill would have fibres passing over two bundles and then under two bundles. Adjacent parallel fibres are offset by one fibre bundle which creates a "herring bone" or diagonal pattern in the cloth.

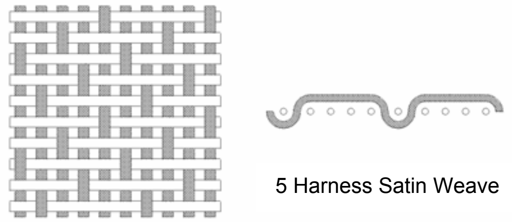


2/2 Twill Weave

Twill weave fabrics have a much more open weave that lends itself to being distorted or draped to conform to more complex shapes. This weave style is fully balanced and therefore does not require inverting in a multi-ply laminate.

Satin Weave

The construction of a satin weave fabric is such that a fibre bundle passes over a number of fibre bundles (the exact number depending on the satin weave) and then under one fibre bundle.

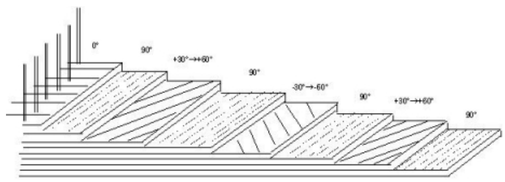


5 Harness Satin Weave

This produces a much flatter fabric that is more easily distorted or draped to suit complex shapes. Due to its construction, satin weaves are unbalanced (fabric with one side consisting of mainly warp fibres, whilst the other is mainly weft). The result of this imbalance can be distortion in the item being manufactured. It is normal practice when using these fabrics to invert half the plies within the laminate and so produce a symmetrical laminate.

Stitched Multiaxial

These fabrics consist of several layers of unidirectional fibres in different orientations, 0° , +45° , -45° , 0° . These layers are then stitched together to form a fabric that can be handled in very much the same way as a woven cloth.



Stitched multiaxial fabric, can be obtained in heavier aerial weights which are not practical/economical with woven cloth. They exhibit excellent drape and can conform to complex shapes quite easily with the added advantage of building up the laminate thickness rapidly. The disadvantage of multiaxials is that care needs to be taken to ensure a balanced laminate is obtained, and the weight/thickness of the fabric can make it difficult to tailor around fine details.

Further information can be obtained from;

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