CHAPTER 14:

A COMPREHENSIVE ANALYSIS OF FABRIC SUBSTRATE FORMATION

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INTRODUCTION

Substrate refers to the underlying material or fabric on which various treatments or coatings are applied. In other words, it is a foundation or base upon which the desired functional or decorative elements are added. In agreement with this definition, Wild, 2016 penned, A substrate is defined as the primary material upon which other materials are applied. In the case of fabric, a substrate is the base cloth upon which ink, paint or pigment are applied to create all of the glorious printed fabrics available to us today. The choice of substrate plays a crucial role in determining the final characteristic and performance of the textile product. It can greatly impact factors such as durability, comfort, aesthetics, and functionality. The substrate affects the properties of the fabric such as strength, durability and drape. The substrate used in textiles can be a wide range of materials including natural fibers like cotton, silk, wool, and linen as well as synthetic materials such as polyesters, nylon, acrylic etc. The substrate selection is based on intended application, desired properties and manufacturing process involved. Once a substrate is chosen, it undergoes various treatments and finishes to enhance its properties or impact specific functionalities. These treatments can include dyeing, coating, printing, laminating and lots more

Textile substrates are formed from yarns or fibre webs by several techniques including weaving, knitting, tufting, and

nonwoven formation. In addition, composites of textile substrates are formed by methods such as adhesive bonding, the formation of back coatings on fabric substrates, and flocking.

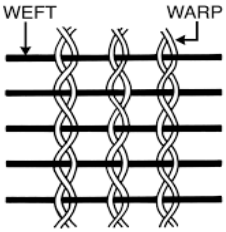
Substrate formation methods

The most common form of interlacing is weaving which involves interlacing two sets of yarns usually at right angles to one another. The warp yarns are fed into the loom and filling (weft) yarns are inserted into the warp using a shuttle or an alternative insertion technique. The yarns are held in place by the inter-yarn friction.

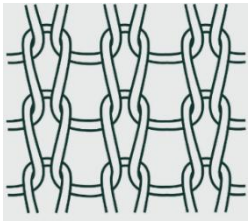
Another form of interlacing where the thread in one set interlocks with the loops of neighbouring thread by looping is called knitting. Knitting involves interconnecting yarns by looping them around one another. In warp knitting the yarns in a warp beam are looped over adjacent yarns in a zigzag repeating pattern to form a fabric, while in fill (weft) knitting a fill yarn is formed into a series of loops that are passed through the loops previously formed in the fill direction. The interloping of yarns results in positive binding. Knitted fabrics are widely used in apparel, home furnishing and technical textiles. Lace, crochet and different types of net are other forms of interlaced yarn structures. Braiding is another way of thread interlacing for fabric formation. Braided fabric is formed by diagonal interlacing of yarns. Braided structures are mainly used for industrial composite materials.

Other forms of fabric manufacture use fibres or filaments laid down, without interlacing, in a web and bonded together mechanically or by using adhesive to make a continuous interconnected web. The former are needle-punched nonwovens and the latter are spun bonded. The resulting fabric after bonding normally produces a flexible and porous structure. These find use mostly in industrial and disposable applications. Composites of textile substrates are formed by bonding two fabrics together by

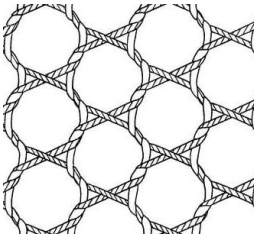
use of an adhesive to form a bonded substrate or backed substrate or by application of cut fibres to an adhesive-coated substrate to form a flocked substrate. Figure 1 shows the schematics of fabrics produced by the methods discussed above. All these fabrics are broadly used in three major applications such as apparel, home furnishing and industrial.



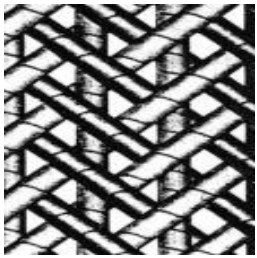
Woven fabric structure



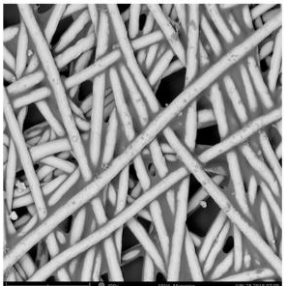
Knitted fabric structure



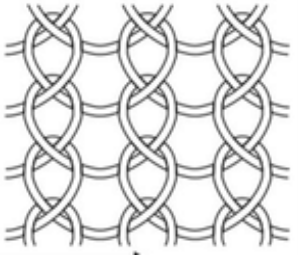
Netting fabric structure



braiding fabric structure



Non woven fabric structure



lace fabric structure

Elements of woven fabric structure

Basic woven textiles are composed of two components: warp and weft tows/yarns that are at right angles to each other in the plane of the cloth. The warp is along the length and the weft is along the width of the fabric. Individual warp and weft yarns are called ends and picks. The interlacing between the warp and weft yarn can be arranged in uncountable ways, resulting in endless weave architectures. Weaving is therefore referred to as interlacing warp and weft yarns perpendicularly.

Regular weave and Irregular weave

Regular weaves give a uniform and specific appearance to a fabric. The properties of the fabric for such weaves can be easily predicted. Irregular weaves are commonly employed when the effect of interlacement is masked by the coloured yarn in the fabric. Such weaves are common in furnishing fabric.

Weave structures

The repeating unit of interlacement is called the weave. According to Nwosu (2023), ‘weaves refers to the technique or particular way the patterns are achieved in the cloth through an interaction between the way the warp is threaded through the heddles on the harnesses or shafts and the order in which the harnesses or shafts are raised or lowered. There are many weave structures developed by weavers, but most of them were invented by a combination of three simple weave structures namely: plain weave or tabby, twill and satin Stout (1970) states that "weaves are classified according to the method of the interlacing of the warp and filling yarns and the number of sets of warp or filling yarns required". Thorpe and Larsen (1967) as cited in Ligom (2017) share the same view that plain twill and satin weaves are often considered as the basic weaves. Stout however explained that other weaves are largely

combinations or variations of the three basic weaves. Nwosu (2015) notes that weaves are consistent in formation, simple in themselves and few in variety.

Fundamental weave structures

Plain Weave

The plain weave, variously known as “calico” or “tabby” weave is the simplest weave. It is formed by yarns at right angles passing alternately over and under each other. Plain weave has the simplest repeating unit of interlacement and the maximum possible frequency of interlacements. Plain weave fabrics are firm and resist yarn slippage

Nwosu (2015) states that "plain weave is the simplest and universally known to weavers everywhere and that very high proportion of all weaving is done in plain weave". The author further adds that "plain weave could either be warp-faced, weft-faced or balanced". Hollen, Saddler and Langford (1979) report that "given the nature of interlacing in plain weave, it requires only a two harness loom for construction (one harness up and one harness down). As a result, there is no right or wrong side. Plain weave variations include; balanced plain weave, unbalanced plain weave and basket weave”:

The plain weave has the following characteristics:

- It has the maximum number of binding points
- The threads interlace on alternate order of 1 up and 1 down.
- The thread density is limited
- Cloth thickness and mass per unit area are limited.
- It produces a relatively stronger fabric

The principle involved in the construction of plain cloth is the interlacement of any two continuous threads either warp or weft in an exactly contrary manner to each other, with every thread in each

series passing alternately under and over consecutive threads of other series interlaces uniformly throughout the fabric. By this plan of interlacement, every thread in each series interlaces with every thread in the other series to the maximum extent, thereby producing a comparatively firm and strong texture of cloth. A complete unit of the plain weave occupies only two warp threads and two picks of weft, which is the design for that weave. Figure 2 shows plain weave in direct view and cross-section along warp and weft. The weave representation is shown by a grid in which vertical lines represent warp and horizontal lines represent weft. Each square represents the crossing of an end and a pick. A mark in a square indicates that the end is over the pick at the corresponding place in the fabric, i.e. warp up. A blank square indicates that the pick is over the end, i.e. weft up.

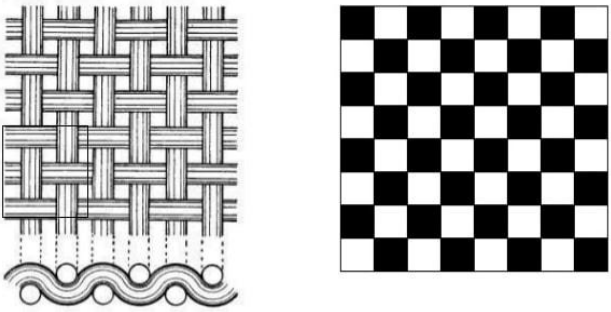


Figure 2: Plain Weave

Modification of Plain Weave:

The plain weave may be modified by extending it warp or weft way or both. The extension of the plain weave thus produces a rib effect. A warp rib results from extending the plain weave in the warp direction and a weft rib structure results from extending the plain weave in the weft direction. A matt rib results from extending the plain weave in both directions (Jara, 2013).

The chart below shows the derivatives/modifications of plain weave according to Jara, 2013

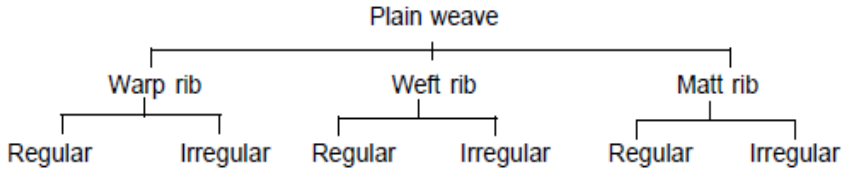


Figure 3: Plain weave modification

Warp Rib Weave:

These are produced by extending the plain weave in warp wary direction. Figure 3 shows the warp rib weaves constructed on regular and irregular basis. At A, B and C are seen regular warp rib weaves and at D, is shown the irregular warp rib weave. E and F show the interlacing of D and A respectively

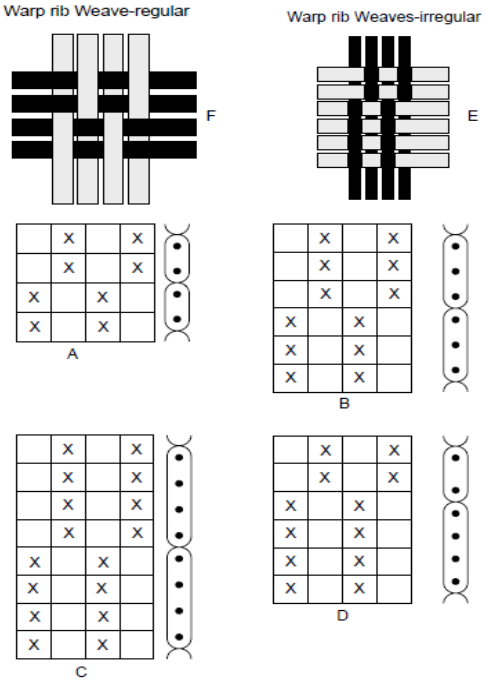


Figure 4: Warp Rib Weave

Weft Rib Weave

These are constructed by extending the plain weave in weft direction as shown in Figure 4

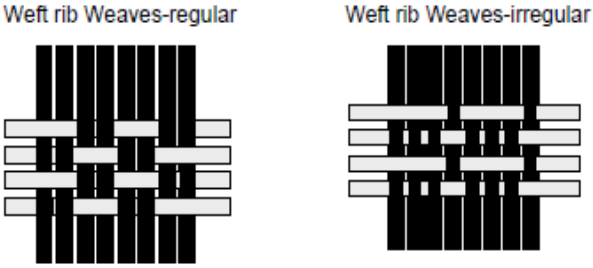


Figure 5: Weft Rib Weave

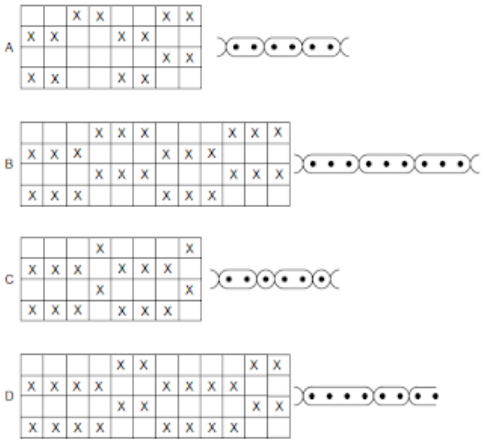


Figure 6: Weft rib weave

In both the warp and weft rib weaves, the appearance of the cloth depends on the respective thread settings, and to achieve good effects, it is necessary to weave a weft rib with a high number of picks per inch and a comparatively low number of ends per inch. Similarly the warp rib effect can be enhanced with a high number of ends per inch and a comparatively low number of picks per inch. The prominence of the rib can be increased by suitable use of

coarse and fine yarns. The dependence of all rib constructions upon the correct thread settings is marked. Rib weaves are used in gross grain cloths, matelasse fabrics, repp cloth which is extensively employed for window blinds in railway carriages and other vehicles, upholstering furniture, and cambric picket handkerchief

Matt Rib Weave:

These weaves are also variously known as hopsack or basket weaves. The matt rib structures result from extending the plain weave in both directions. On basket weave, Hollen, Sadder and Langford (1979) penned, 'Basket weave refers to weaves made with two or more warp yarns used as one, and with two or more fillings yarns used as one, placed in the same shed'. The most common basket weaves, according to the authors, are 2 x 2 and 4 x 4. Other combinations include 2 x 1, 2x 3, and so forth.

In case of regular matt weave, the plain weaves are extended equally in the warp and weft directions, where as in case of irregular matt weaves, the plain weave is extended unevenly or irregularly in the warp and weft directions. The regular and irregular types are shown in Fig.

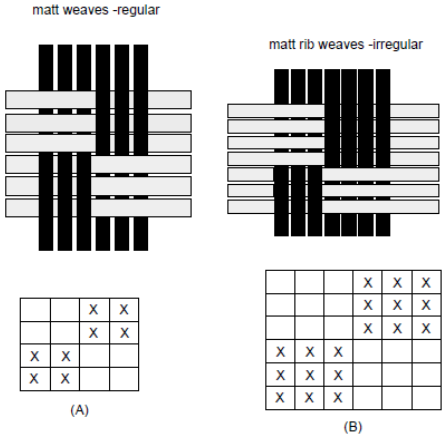


Figure 5: Matt weave

Characteristically, basket weaves are flexible and wrinkle resistant because they have few interlacing per square inch. Matt

weave finds extensive uses for a great variety of fabrics such as dress materials, shirting, sailcloth, duck cloth and lots more.

Textural stability of Plain Weave in relation to other weaves:
The firmness of any woven structure depends on the frequency of interlacing between the warp and weft threads. The greater the number of intersections the better will be the firmness of the cloth. Let us consider the case of two fabrics woven with identical warp and weft counts and thread settings. Consider that one is woven as plain weave and the other with any other weave such as twill, sateen etc. It will be seen that the latter will be less firm, and therefore of weaker texture than the former, because the threads composing it would be bent in a lesser degree than those of the plain weave, thereby causing them to be less firmly compacted. Thus it is important that the counts of warp and weft, the number of warp threads and picks per inch, and the weave, should be properly proportioned, in order to obtain the best results.

Range of texture produced in plain weaves:

The plain weave is produced in a variety of forms and textures, possessing totally different characteristics, which adapt it for specific purposes. The variety of forms in textures are produced:

- By causing a differential tension between the warp threads during weaving.
- By using various counts of yarn for weaving different types of fabrics,
- By using warp and weft yarns of different counts in the same fabric,

The term ‘texture’ is related to type of material, counts of yarn, relative density of threads, weight, bulk, feel during handle, and other properties. The range of textures produced in plain cloth is wide. An ideal plain cloth is one which has identical or similar warp

and weft constructional parameters. Plain weave finds extensive uses in shirting, suiting, cambric, muslin, blanket, canvas and lots more.

Twill Weave

According to Hassan 2023 definition, A weave that repeats on three or more ends and picks produces diagonal lines on the face of the fabric. The order of interlacing that creates a diagonal line of warp and weft floats to be formed in the fabric is called twill weave

Kureave and Audu, as cited in Ligom (2017) observed that twill weave is the type of weave in which the weft crosses two or more warp yarns before going under one or more warp yarns. This definition is rather simplistic in nature. Hollen, Saddler and Langford (1979) seem to be more elaborate and implicit in their definition of twill weave. According to them, twill weave is one in which each warp or filling yarn floats across two or more fillings or warp yarns with a progression of interlacing by one to the right or left to form a distinct diagonal line or wale. Joseph (1980) and Lyle (1976) look at twill as the second basic weave used in the production of woven fabric, characterized by a diagonal line achieved on the front and back of the fabric. Joseph (1980), Hollen, Saddler, and Langford (1979) indicate that twill variations are in the number of harnesses used. The simplest twill requires three or four harnesses. The more complex twills may have as many as eighteen (18) picks inserted before repeating, and are woven on a loom with a dobby attachment.

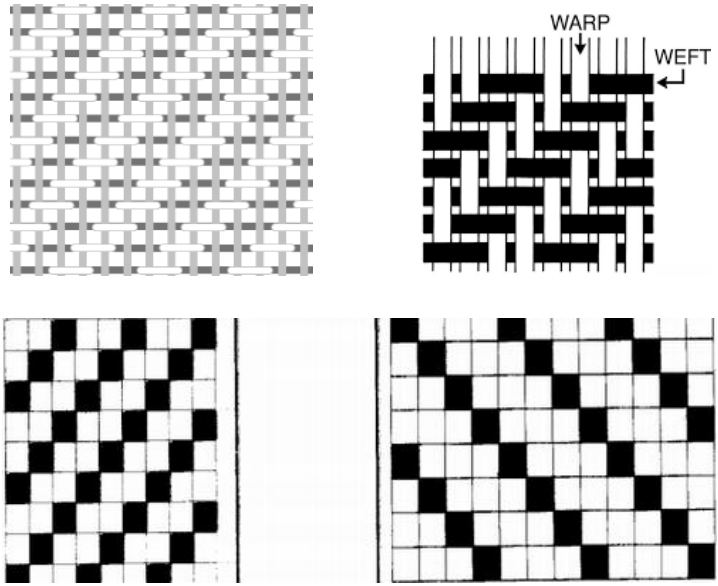


Figure 6: 2//2 twill weave. Source: Wood, 2006

Characteristics of Twill Weave

1. Produce diagonal lines from one selvedge to another.
2. Smallest repeat size 3*3
3. At least 3 heald shafts are required.
4. Generally, the straight draft is used (V draft/ Pointed draft, Broken draft).
5. Draft multiple of 2 or 3
6. Both sides are face sides, but their appearance is different.
7. Textured and Strong weave.
8. Less binding point than plain cloth.
9. Better wrinkle recovery.
10. Better cover thickness

Classification of Twill Weave According to:

1. **directions:**

- **Warp-way twill:** warp float run in the warp direction.
- **Weft-way twill:** weft float run in the weft direction.

2. **Twill line**

- **S-twill/Left hand Twill:** Twill line (Diagonal line) runs from the lower right corner to the upper left corner. Exp: 3/2 S, 2/2 S, 2/3 S etc
- **Z-twill/Left hand Twill:** Twill line (Diagonal line) runs from the lower left corner to the upper right corner.

3. Face Yarn

a) **Warp-face Twill:** A predominance of warp yarns is seen on the face of the fabric.

Exp: 2/1, 3/1, 3/2 etc. *[Warp up > Warp Down*

b) **Warp-face Twill:** A predominance of warp yarns is seen on the face of the fabric.

Exp: 1/2, 1/3, 2/3 etc. *[Warp up < Warp Down]*

c) **Double face Twill/ Even-sided Twill:** Predominance of warp & weft yarns on both sides of the fabric. [Warp up = Warp Down]

Exp: 2/2, 3/3, 4/4

4. Nature of Twill

a) Simple Twill:

Each warp end is raised **over** or lowered under only one pick in the repeat.

Exp: 2/1, 3/1, 1/2, 1/3 etc.

i) Simple Warp Twill: Each warp end is lowered under only one pick in the repeat. (Warp up > 1, Warp Down = 1)
Exp- 2/1, 3/1 etc.
ii) Simple Weft Twill: Each warp end is raised over only one pick in the repeat. (Warp up. =1, Warp Down >1)
Exp: 1/2,1/3 etc…

b) Expanded Twill:
Each warp end is raised over or lowered under more than one adjacent pick in the repeat. (Both warp up & map down will be more than 1)
Exp- 3/2,2/3,3/3 etc.

c) Multiple Twill:
It contains at least two warp twill lines or two weft twill lines of different widths in each repeat,
Exp- 3 4 8/ 2 3 2, 5 6 8/ 2 3 9

Uses of Twill Weave:
Generally, diamond, diaper and zigzag twill are used for making pillows, covers, screens, upholstery, bed sheets, towels etc. Again, continuous twill is used for making fabric for shirting, suiting and pantin (denim, gaberdine). It is used for making various types of ornamental cloth, other derivatives of twill weave are used. Moreover, hearing bone twill is used in the cloth of suits and overcoats.

Satin Weave
According to Hasan (2023), Satin weave refers to the construction of a weave where there is a weft thread that floats over at least 12 warps as well as under a single warp. The next weft gets woven in different warps over same the number.

Nwosu, 2023 opined that the satin and sateen weaves may be considered to be opposites of each other. They are characterized by their smooth lustrous surfaces due to warp floats in satin and weft floats in sateen. In satin weave, each warp yarn floats over four or more weft yarns (up to about 12) and interlaces with the next weft yarn. Interlacing progresses by one thread up, and by at least two threads either to the right or to the left. Alternatively, in a sateen weave, each weft yarn floats over four (or more) warp yarns and interlaces with the next warp yarn, with interfacings progressing two or more either to the left or to the right.

Hollen, Saddler and Langford (1979) have it that, satin fabrics are characterized by lustre because of the long floats that cover the surface. When warp yarns cover the surface, the fabric is a warp-faced satin and the warp count is high. Similarly, when filling floats cover the surface, the fabric is filling and the filling count is high. Satin weave, according to Joseph (1980), is characterized by long floats on the surface. These threads are caught under cross threads at intersections as far apart as possible for particular constructions. The author posits that adjacent parallel yarns do not interlace in a position of contact

The basic characteristics of satin/sateen weaves are:

- They are either warp or weft-faced weaves.
- Have no prominent weave structures.
- Only one binding point in each end or pick
- No continuous twill lines
- Have poor seam strength due to thread mobility
- More thread density is possible in warp and weft
- More mass per unit area is possible
- Have less binding points and more float lengths
- Use of move numbers (intervals of selection) is necessary to construct these weaves.

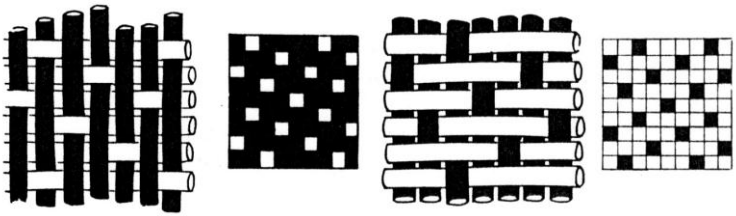


Figure 24: Sateen weave. Source: Errol Wood, 2012

Besides, satin weave needs more shafts in the part of weaving compared to other plain or twill weaves. Consequently, the cost of production increases. Satin weave fabrics notably are Brocade, Crepe-satin, velvet satin, etc. Meanwhile, the Sateen is a variation of the satin weave constructed with another type of yarn except for silk. It produces a smooth, glossy surface on the fabric due to the interlacing points covered up by the threads' floats.

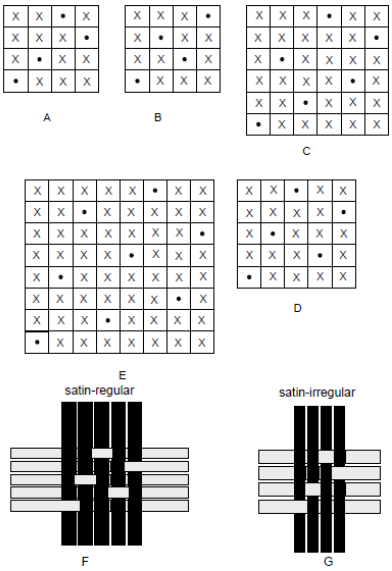


Fig: Example of Satin regular and irregular weave structure

Supplementary weft pattern weave: also called extra weft, pattern weft, supplementary weft, a structurally non-essential weft

used to add pattern to a ground structure. The supplementary weave can be of the warp or of the weft**.**

Supplementary warp pattern weave: also called the extra warp, pattern warp, supplementary warp that weaves in on the top of the background fabric or below depending on how it is treadled.

Compound weave: contains more than one weaves structure.

Modelling different weaves

The firmness of a woven fabric depends on the density of threads and frequency of interlacements in a repeat. Fabrics made from different weaves cannot be compared easily with regard to their physical and mechanical properties unless the weave effect is normalized. The concept of average float has long been in use, particularly for calculating maximum threads per cm. It is defined as the average ends per intersection in a unit repeat. Recently this ratio, known as weave factor has been used to estimate the tightness factor in fabrics.

Summary

Textile substrates are formed from yarns or fiber webs by several techniques including weaving, knitting, tufting, and nonwoven formation. In addition, composites of textile substrates are formed by methods such as adhesive bonding, formation of back coatings on fabric substrates, and flocking. Weaving is the most common method of forming fabrics. Basic woven textiles are composed of two components: warp and weft tows/yarns that are interlaced with each other to produce a layer. The three basic weaves, plain, satin and twill weave and their derivatives were discussed.

Questions

Name the main componetnts of Basic woven textiles

Explain twill weave in details

What are the characteristics of a twill weave?

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