# Quadrant II – Notes

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**Name of the Presenter:** Suvarnagouri Y

**Notes :**

**Properties of Textile Fibres**

The second step in the process of learning textiles is to know how to qualify a material for a specific use. In order to do so the product must possess some essential characteristics or properties. It is generally agreed that the essential qualities or primary properties of a fibre like length, strength, flexibility or pliability, cohesiveness or spinnability and uniformity are adequate. Other properties may be desirable in all fibres but they are not essential. So they can be termed as secondary properties. These may improve the quality of textile fibres and thus get the consumers' satisfaction.

Secondary properties include: Physical shape, lustre, density or specific gravity, absorbency, electrical conductivity, elasticity, elastic recovery, pilling, hand, feltability, thermal behavior, the resistance to biological organism and resistance to chemicals and other environmental conditions. The following is the detailed information about the characteristics of textiles fibres.

**Physical properties**

**Length:** Textile fibres are available in different lengths. Filaments are long continuous fibres of indefinite length measured in yards or meters. Staple fibres are the short fibres and are measured in inches or centimeters and range in length from ¾ " to 18". All natural fibres except silk are staple fibres. Man-made and synthetic fibres are all filament fibres. They are made as filaments since their length can be controlled when the fibre forming solution escapes through the holes of a spinnerette . Sometimes filament fibres are also cut into staple length to produce certain desirable qualities. In order to cut the filaments into staple length, several thousands of filaments are taken in the form of a loose rope or strand, often made crimpy and are cut to produce staple fibres ranging in length from 1" to 5". The rope of fibres is also refered to as ‘Fibre tow’.

Fibrous materials must possess greater length than the diameter. This is referred as length to width ratio. A minimum ratio of 100:1 is considered essential. Majority of the fibres have greater length than the diameter.

**Strength**: Strength is the second primary property of all textile fibres. In order to be serviceable, all fibres must possess this quality. The strength must be adequate for processing or spinning into a yarn and further making into a fabric. Fibres may vary in strength and the strength within a fibre may not be uniform throughout. It depends upon mainly themolecular structure of the fibre.

The strength of a fibre is defined as the ability to resist stress & is expressed in grams per denier. Denier is equal to the weight in grams of 9000 meters of filament. Fibre tenacity may vary from fibre to fibre. It may be as low as 1 gm/denier in acetate and as high as 8 gms/denier in glass. Strength can also be measured in pounds / sq.inch. This is referred as ‘tensile strength’. The strength of a fibre can never be confused with strength of yarn or fabric since it is possible to produce very strong and durable materials from weak fibres. The yarn or the fabric strength is controlled by many other factors which are discussed in the related chapters.

A strong fibre is durable, has a better tear strength and resists sagging and pilling. The tenacities of some selected fibres of consumers' interest are given below.

**FIBRE TENACITIES**

**Under Standard Conditions ($70^0$ F & 65% RH)**

1. Cotton - 4.0
2. Silk - 4.5
3. Wool - 1.5
4. Rayon - 1.5 to 2.4
5. Acetate - 1.2 to 1.5
6. Nylon - 4.5 to 5.9 (High tenacity fibres– 5.9 to 9.2)
7. Polyester - 4.4 to 7.8
8. Glass - 7.0

Glass ranks first in tenacity than the other fibres. Next comes Nylon and Polyester. Some of these fibres loose or gain strength when wet. A good example for loss of strength during wet condition is Rayon and for gaining strength is cotton.

**Flexibility or Pliability**: It is also one of the important primary properties. Many natural fibres are available without this quality. So they are qualified for textile use. Certain degree of flexibility or pliability is necessary for a fibre to be used as a textile fibre. A textile fibre needs to be bendable. For example a glass rod cannot be bent without breaking, but a glass filament can be bent easily. This property is essential to create yarns and fabrics that can be creased, have the quality of drapability, ability to move with the body and should allow for the free movement and also be comfortable. A stiff fibre will make stiff fabrics, which cannot be used comfortably.

**Cohesiveness or Spinnability**: Cohesiveness is the ability of the fibres to stick together during spinning. The cohesiveness in fibres may be due to the longitudinal contour or the cross sectional shape that enable them to adhere together. The surface or the skin structure of the fibre may also influence cohesiveness. For example, wool fibre possesses scales on the outer skin of the fibre which help in interlocking fibres while spinning. If the surface or shape of a fibre do not contribute for cohesiveness, the same can be compensated by using filament yarns. As filaments are present throughout the length of the yarns, there is little necessity of having the ability to stick. So this cohesiveness is often conveniently replaced by spinning quality. Polyester is having the lowest cohesiveness but it can be made into staple yarns by using less percentage of cotton and later burning it through carbonising process.

**Uniformity**:In order to produce fine yarns, uniformity in the raw material is required. Fibres that are used to produce yarns need to be similar in length and width, in spinning quality and in flexibility. All man-made and synthetic fibres are uniform since they are made through artificial processing. But in case of natural fibres, it is not so. Fibres differ is many aspects, and so it is not possible to produce very fine materials in natural fibres unless some extra  is done.

**Physical Shape:** The physical shape of the fibre is an important factor in determining many of its properties. It includes the surface contour (smooth, rough, serrated), the shape of the cross section and the width and length of the fibre. The shape of the cross section influences certain factors such as lustre, body and hand. The surface contour in turn influences cohesiveness, resiliency, loft and thickness. It contributes to resistance to abrasion, Pilling and comfort factors such as absorbency and warmth. The cross sectional shape can be changed for all artificial fibres unlike natural fibres as the fibres are moulded though spinnerets.

**Density:** Density is the mass of a unit volume of material. It is expressed as gms/cubic cm or pounds per cubic foot. The specific gravity of a fibre indicates the density relative to that of water at 4oC. All textile fibres are heavier than water except olefin fibres. Only these fibres float on water. Cotton, wool fibres are heavy and nylon is comparatively lighter. The lower the density the more the covering power. A pound of wool and a pound of nylon weigh the same but the fibres are more in nylon than in wool. High-density results in heavy fabrics, low density results in light weight fabrics.

A lightweight fibre helps a fabric to be warm without being heavy. Acrylic fibres being light comparatively are wool like in appearance and are used extensively instead of wool to produce light weight sweaters & blankets.

**Lustre:** Lustre is the amount of light reflected from a surface. It is more subdued than shine. Light rays are broken up into many short rays unlike the shine in which the light ray is reflected back wholly without any breaks. The lustre is due to smoothness, fibre length, flat or lobal shape. It determines the fibres natural brightness or dullness. The natural fibre silk has the high lustre and cotton is the dullest natural fibre. All man-made fibres are produced with lustre controlled. It is not always desirable to produce bright fabrics. So the lustre is controlled by the addition of pigments such as titanium dioxide in spinning solution. The lustre in natural and man-made fibres can also be improved by various finishing techniques. For example the lustre in cotton is improved by mercerization.

**Absorbency:** Generally textile fibres have certain amount of water as an integral part of the fibre. All most all textiles fibres are naturally hygroscopic (i.e they pick up moisture from air). But the amount of moisture the fibres absorb may differ. Absorbency in the ability to take in moisture and moisture regain is the percentage of moisture a bone-dry fibre will absorb from the air under the standard conditions of temperature and moisture. Fibres that absorb water easily are known as hydrophilic (water loving) fibres. Natural protein and vegetable fibres, rayon and acetate are hydrophilic fibres. Fibres that have difficulty in absorbing water are known as hydrophobic fibres.

Many synthetic fibres are hydrophobic in nature. The absorbency of glass fibre is ‘0’. The absorbency of a fibre is due to the hydroxyl groups present within the fibre and the amorphous molecular arrangement. The fibres having crystalline arrangement are generally hydrophobic.

Absorbency is an important factor in all textile fibres especially those which are used for apparels as it influences many other fabric properties such as comfort, warmth, water repellency, static build up, dyeability, shrinkage, wrinkle resistance etc. It is easy to wash a hydrophobic fabric as it does not absorb stains and it dries quickly.

Among the textile fibres the natural protein fibres silk and wool are the most absorbant of all fibres. Next comes the natural and man-made cellulosic fibres.

The absorbency of a textile fabric is controlled by the type of yarn and fabric construction and also by finishing. For example: in cotton, the absorbency is increased by kier boiling, mercerization and napping. Pile construction increases the area of absorption.

**Elasticity:** Elasticity is defined as the ability of fibres to return back to original shape after being stretched. Elastic recovery is the ability of fibres to return from strain and is expressed in percentage. If a fibre returns to original length after stretching to a specified length, it is said to have 100% elastic recovery.

Elasticity is required in fabrics when subjected to stretch during wear. This property is influenced by the side chains & cross linkages between the molecules. If strong bonds are present in between chains of molecules, the fibre tends to return to its original length. If the bonds are not strong it can’t recover to its original length but takes up the new shape. Thus creases appear on the material. Some fibres show immediate elastic recovery, and some fibres may show delayed elastic recovery. For example, the creases on a silk material disappear if hung overnight. Wool, silk, viscose and nylon are having good elasticity. Cotton and acetates have poor elastic recovery. Polyester has moderate elongation but has good elastic recovery. It is apparent that both the elongation and elastic recovery are considered together in evaluating fibres, yarns and fabrics.

**Abrasion Resistance:** It is the ability of fibres to withstand the rubbing or abrasion it gets in everyday use. All fabrics irrespective of the enduse are subjected to rubbing of some kind during wear. The fabric has to withstand rubbing, otherwise the fabric will show signs of damage and become unsightly. The resistance may be due to the tough outer layer and flexible molecular chains of the fibre. The size of the yarn also influences the abrasion resistance. Thick yarns resist abrasion than thin yarns. Yarn uniformity is also important as irregular yarns are abraded more easily than uniform yarns. Smooth fabrics with compact yarn arrangement are less susceptible to damage by abrasion than those with irregular surface in the low count.

Nylon has excellent resistance and acetate and glass have very poor abrasion resistance when compared to silk & wool. Cotton has better abrasion resistance. This is an important property, as it influences the durability and increases the resistance to splitting.

**Hand:** Hand is the way a fibre feels. It can be only detected by feeling it in between fingers. The hand varies due to the cross sectional shape, the length and diameter, the flexibility, the compressablity, resilience, surface contour of the fibres, surface friction and thermal characteristics of fibres .

The hand and drape of a fabric are inter dependent. The hand of a fabric may vary from very pliable to very stiff, from very soft to very hard, from very limpy to very springy, from rigid to high degree of stress, form very smooth to very rough, from slippery to harsh, from very cool to very hot and from wet to dry.

The hand of a yarn and fabric should not be confused with the hand of a fibre. It is possible to produce smooth yarns from rough fibres and vice versa.

**Pilling:** Ball like structures are often observed on polyester and nylon materials after few washes which make the material unsightly. Pilling is nothing but the balling up of fibre ends on the surface of fabrics. It is one of the disadvantages of staple fibre fabrics. In natural fibres the balls cut away from the fabric easily but synthetic fibres are so strong that they do not break away rapidly from the fabric. So the strength of fibres is a basic factor in the problem of pilling. Pills usually occur in areas that are abraded or subjected to abrasion during wear. Usually at the armpits of garments and back and lower edge of sarees, pilling can be seen. It can be made better by removing pills. But it is almost impossible to remove pilling from synthetics unless it is given singeing finish. In this the fabric passes through gas flames, so that the balls are burnt off. In order to inhibit the formation of pills on materials, they are given special finishes known as anti pilling finishes.

To prevent pilling close fabric construction is recommended. Tightly twisted yarns and longer staple fibres are helpful in preventing pilling. Fulling of wool, resin finishes on cotton are anti pilling finishes.

**Loft and Resiliency:** Loft is the ability of a fibre to spring back to original thickness after being compressed. Resiliency is the ability of a fibre to bounce back to shape following compression, bending or similar deformation. Wool and silk fabrics are more resilient. They can be deformed, crushed or wrinkled during wear but they come to shape upon hanging. Elastic recovery is an important factor while evaluating the resilience of a fibre. Usually good elastic recovery indicates good resiliency.

**Chemical properties**

The reaction of fibres to various chemicals is helpful in use and care of fabrics; chemical reactivity is the effect of acids, alkalies, oxidizing agents and solvents. The fibres react differently to various chemicals and these are explained under each fibre. The dyeability of fibres comes under chemical properties and it is also discussed under each fibre.

Biological & other properties

Biological & other properties such as ageing resistance, sunlight resistance, resistance to moths, mildew and microorganisms play an important role in determining the performance of fabrics in use and care.

**Molecular Structure of Fibres**

As any other matter, textile fibres are also having chemical structure. The chemical structure of fibres is different from one another. For example: Cotton fibre is made up of cellulose which consists of hydrogen, carbon & oxygen. The way in which the chemical elements are arranged is what makes cotton different from polyester, which has the same chemical constituents. The chemical structure affects fibre properties such as strength, elongation, resiliency, density, moisture content, sunlight and ageing resistance, dye absorption and electrical behaviour.

The fibre morphology refers to the molecular arrangement of fibre. The molecules in fibres are in the form of chains. These are known as polymers. Polymerization is the process of joining together small molecules known as monomers. The longer the chains, the higher the degree of polymerization.

The arrangement of molecules in these fibres can be described in terms of molecular orientation and amorphous regions. When the molecules of fibres are parallel to each other and also parallel to the longitudinal axis of the fibres, the arrangement is said to be highly oriented structure. If the molecules are arranged in haphazard way or at random, it is termed as amorphous or low oriented structure. A crystalline structure occurs when the fibre molecules are parallel to each other but not necessarily parallel to the fibre axis.

In a single fibre, it is common to find both amorphous & crystalline regions and fibres vary in the proportion of oriented, crystalline and amorphous regions. The molecular arrangement of natural fibres is difficult to change except in cotton where the molecules tend to decrystallise by mercerization finish.

The man-made & synthetic fibres when extruded through the spinnerette consist of only random arrangement but when they are stretched they become thin and tend to take oriented structure. It improves the strength, elongation, moisture absorption, abrasion resistance & dyeability of fibres.

The properties like elasticity, strength etc are also dependent on the strength of the bonds between molecules. These molecular chains are held together by cross-links or inter chain attractions or bonds such as Hydrogen bonds & Vander walls forces. Hydrogen bonds are stronger than Vander walls forces even though both are found in crystalline arrangements. Hydrogen bonding occurs when the positive hydrogen atoms show attraction towards negative oxygen or carbon present in another chain. Thus the molecular structure of fibres is an important factor that affects the properties of fibres.

The molecules are held together in a chain like formation within a macromolecule by strong electronic force known as valence bonds. For example cellulose, which is the base of cotton, is formed by the polymerization of small, simple molecules in to a larger complicated macromolecule.