A Review on: The ratio between applied stresses and resultant strain behavior of textile materials (yarn and woven fabric).

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Abstract:
Woven fabric structures have, on account of the manufacturing process, a characteristic waviness of the fabric threads are not uniform, weft and warp threads are curved depending on the weave type, weaving process, coating process and the tension rate. If tension forces are applied to such a fabric, then displacements of the fabric structure take place as a result of the alteration of the thread curvature, which are described as constructional strain. This phoneme is fitted better by a viscoelastic material. These property one of results of ranking of textile subject for end use. The relationship between applied stress and resultant strain contains a time-dependent element parameter. In stress-strain behavior of textile material we can get various, parameters like initial modules, yield stress, yield strain, region beyond the yield point, tests relevant to this phoneme, all pervious behaviors of textile material discussed in this paper. The main objectifies of this brief to clearly understand the fundamentals of deformation of textile martials under representation of stress to clarify the terminology the fabric structure and strain variation during deformation. We cannot confirm or deny the existence of a uniform stress behavior for one type of textile material, but this data is assumed to be categorized for each experiment separately. Exploration and examination in textile stress behavior require more and more experiment's trails and proof.

Key words:
Stress, Strain, Yield points, Initial modules, Time dependence.

الملخص:
تتعدد البنية الهندسية للأقمشة المنسوجة والناتجة من عمليات التصنيع والإنتاج المختلفة ، والتى بدورها تعمل على إيجاد تموجات لخيوط السداء و اللحمة ليست موحدة داخل المنسوج ، وترجع نسبة التموج على عدة عوامل منها ؛ طبيعة المادة النيسجية و نوع التركيب النسجى ، وعملية النسيج ومعدل الشدد الواقع عليها ، وعمليات التجهيز.، وبتطبيق القوى الواقعة على المنسوج فى تلك المراحل ، فإن المواد النسيجية يحدث لها إجهاد معين ناتج عن الجهد التى تعرضت إليه بمقدار معين حيث يتم تطبيق قوى معينة على مساحة معينة من القماش ، والتي تعرف بإسم خاصية الإجهاد. وتتضح هذه الخاصية بشكل أفضل بمواد النسيج ذو المرونة العالية، حيث أن هذه الخاصية هي واحدة من الخواص المحددة للإستخدام النهائي للمواد النسيجية. وتحتوي العلاقة بين الضغط الواقع على المواد النسيجية والإجهاد الناتج عن تلك الخاصية على العديد من العوامل التى تؤثر وتتأثر بها مثل مقدار القوة الواقعة، المنطقة المتأثرة بالأجهاد الواقع، معدل الوقت لعملية الأجهاد، سلوك المادة بعد الإجهاد، الإختبارات المعملية الازمة لقياس معدل الأجهاد للمواد النسيجية، وهذا ما سوف يتم تناوله بهذه الورقة البحثية. حيث أن الهدف الرئيسي من هذا الموجز هو فهم أساسيات تشوه المواد النسيجية تحت معدلات الإجهاد وتوضيح مدى تغير بنية وسلالة المواد النسيج تبعا لهذه الخاصية. ومن النتائج المستخرجة أنه يتطلب الاستكشاف والفحص في سلوك

الإجهاد النسيجي المزيد من الأختبارات حيث أنه لا يمكننا تأكيد أو إنكار وجود سلوك إجهاد موحد لنوع واحد من المواد النسيجية، ولكن من المُفترض أن يتم تصنيف هذه البيانات لكل تجربة على حدة تبعا لتصمميم التجربة الموضوعة للقياس.

الكلمات المفتاحية:
الضغط الواقع، الإجهاد الناتج، نقطة التأثير، عامل الوقت.

1. Introduction:

The elucidation of performance properties of woven fabrics have a salient effect on the fabric during wear and other end uses especially on evaluation of fabric response to the process of loading and the breaking point [90]. Moreover, when a fabric is subjected to a specific amount of strain, as far as the strain remains constant, the resultant stress owing to the mentioned strain reduces as time passes, due to the stress relaxation occurrence when wearing or testing, However, in textile materials the structure is not homogeneous; bending cannot usually be handle as of a layer series through the fabric [69].
The behavior of textile structures properties (yarn and fabric) under tension depend on their filament arrangements of cross section [75]. Tension is generated by an applied strain. As the generated tension acts on the helical structure, the yarn is compressed radially and a force normal to the filament surface is produced. The increase in the tension force is limited by the tensile strength of the filaments. Hence, many previous research works [7, 58, 99] have focused on the stress relaxation and strain behavior of fabrics. This point is considering one of Sub-addresses of fiber and woven fabric physics. Therefore; the study of geometric system of this two aspects which not independent, help to elucidate their behaviors [9].
In this review, the stress - strain behavior of textile materials was stablished. Starting with an overview on general structure of fiber and fabrics to the effects of variability on this phoneme for these material and the required tests relevant.

2. Definition of Stress, Strain and Stress relaxation:

2.1. Definition of Stress:

The behavior of a textile material under progressively increasing applied force is completely expressed by the load–elongation curve with its end-point breakage. The load measured in newton's or grams force and the elongation in centimeters. Elongation is normalized as fractional strain or extension percentage.
In most physical and engineering applications, load is replaced by stress, defined as:
Stress = load/ area of cross-section (N/m^2) [69].
In textile technology, materials often expressed by terms of their weight, or term of their bulk. The normalized force is termed the specific stress and is defined as: Specific stress = load / linear density N m/kg [44].
In consistent units, we have the following relation between stress f, specific stress σ and density ρ: $f = \rho \sigma$.
B. K. Behera and P. K. Hari. [2010], defined textile material stress behavior as: Stress is the internal resistance or the counter-force of a material to the distorting effects of an external force. The total resistance is equal to the external load. Stress (s) can be equated to the force (F) applied per unit. Stress $\sigma = F/A$.

Stress is expressed in three basic types of internal load (tensile, compressive and shear).They indicate three type of stress as in Fig.1 .Tensile stress is the stress in which the two sections of material on either side of a stress plane tend to pull apart or elongate as shown in Fig. 1(a). Compressive stress is subject to axial push acting normally across the section; the resistance set-up is called compressive stress. Compressive stress is the reverse of tensile stress as shown in Fig.1(b). Shear stress on a material is the result of by two equal and opposite forces acting tangentially across the resisting section as shown in Fig.1(c) the resistance set up is called shear stress[13, 79].

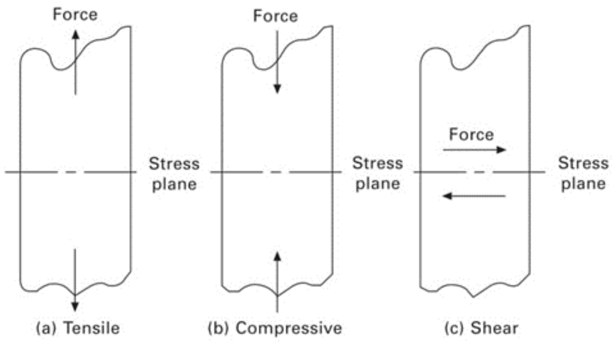


Fig.1. Types of applied stress.

2.2. Definition of Strain:

Strain, is the geometrical expression of deformation caused by the action of stress and is normally measured by the deformation per unit length; Strain is a dimensionless quantity [63]. Strain, whether tensile, compressive or shear, is always a number. There are different types of strain as described below [44]:

- Normal strain or linear strain**:** is a ratio of change in dimension to the original dimension. It is denoted by ε = change in dimension/ original dimension.
- Shear strain**:** is the angular deformation due to shear stress.
- Volumetric strain**:** the ratio of change in volume to original volume.

Tensile or compressive axial strain is accompanied by lateral strain. The lateral strain is a fraction of the linear strain and within the elastic limit bears a constant ratio to the linear strain [100]. The ratio of the strain value of the strain in the lateral direction to the strain in the axial direction is Poisson's ratio v which refer to following equation [18]:

$$\nu = -\frac{\varepsilon_x}{\varepsilon_y} = -\frac{\text{lateral strain}}{\text{axial strain}}$$

The negative sign accounts for the contraction of materials in the direction perpendicular to the applied stress.

As acknowledge, **The Poisson's ratio is one of the fundamental properties of any engineering material and presents an essential mechanical aspect of them. Sometimes the value of Poisson's ratio obtained for fabrics differs significantly from the other engineering materials, which results in the unique performance of fabrics when subjected to the tensile deformations** bearing in mind the flexible nature and the nonlinear behavior of fabrics during extension [70].

The Importance of Poisson's Ratio brighten up according to the considerable complexity of the fabric behavior from different mechanical aspects, interpreting and predicting their behavior are difficult when using fabrics in special exceptional cases their industrial usage, So that in this condition it's necessary to measure Poisson's ratio corresponding to the tensile modulus and its variation with the increase of strain to observe their behaviors [65, 69].

2.3. Definition of Stress relaxation:

Stress relaxation is, a time-dependent behavior in textiles, which occurs with the release of stresses when the textile is under constant strain over a period of time [91].Not only when a textile material is held stretched, its stress gradually decays, It may drop to a limiting value or may disappear completely., this phenomenon is known as relaxation, but also when the fibre is held extended at fixed length, the continued spontaneous breakage of crosslinks relieves the internal stresses in the molecular assembly and thus leads to the lowering of tension, which is termed stress relaxation. [95].

The viscoelastic nature of the constituent fibre is responsible for stress relaxation, and the irreversible deformation of fabrics could be the result of the inter-fibre friction which provides the fabric frictional stress during deformation. Stress relaxation will occur more rapidly at the high temperatures and moisture absorption will have a much greater effect [47].B. Gross. [1947], illustrate that Stress relaxation under constant strain goes parallel with strain retardation under constant stress and either effect can be chosen as the adequate basis for a discussion of the behavior of a viscoelastic body. The Stress relaxation phoneme can only be understood if the viscoelastic properties of textile materials are taken into consideration [24]. Studying the inelastic effects in textile fabrics enables us to understand and eventually predict important performance characteristics such as tension and force which refer to its stress- strain behavior.

3. Theoretical Approach:

3.1. Overview of fiber Geometry forces:

Fibrous materials which make up our clothing are compliant when compared with traditional materials because of their inherent nature and their resultant mechanical and physical responses to external stimuli. In another expression, fibers considers as a component for the textile systems which formed by inter fibre frictional forces only and derive their mechanical properties from the complex hierarchical structure of fibre, yarn and fabric construction [62, 85].

To clarify this point .,Peirce.[1973] , suggested that textile yarns may be assumed to be elastic and isotropic materials as they possess rigidity; their resistance to bending affects the form of the yarn in a fabric and has an a result on crimp property . Olofsson. [1965], assumed that the yarn will take shape produced by such forces and that the cross-yarn will 'flow' into the available space, the yarn takes up the shape of an elastica being bent by point loads acting at the intersections.

Hu.(2004), reported that each fabric consists of a large amount of constituent fibers and yarns, since , any slight deformation of fabrics will thus give rise to a chain of complex movements of the latter. This is very complicated subject, therefore both fibers and yarns behave in a non-Hooken way during deformation [86].

Due to, complexity of fiber structure, and for achieving particular properties, comes from different levels of its structure under tension values [1, 30]. There is several fiber shape [16,17] as shown in Fig.2.Each shape has different behavior from the stress and strain reflect from it.

A cotton fibre, which is not fully mature, before and after collapse **Trilobal Oct alobal Deep-grooved**
Examples of melt-spun fibre shapes.

Fig.2. fiber shape examples

To indicate the stress–strain curve distribution in fibres based on the idealized geometry for of twisted continuous filament yarns Fig.3. Illustrate that, the modeling goes from the strain distribution in fibres, which reduces approximately as $\cos^2\theta$, to give a contribution to stress reduced by a further factor of $\cos^2\theta$ through the axial component of tension and the oblique region on which the tension of the fibre act.. The ratio of yarn to fibre modulus is thus the mean value of $\cos^2\theta$, which is $\cos^2\alpha$ for the ideal helical geometry [38, 39].

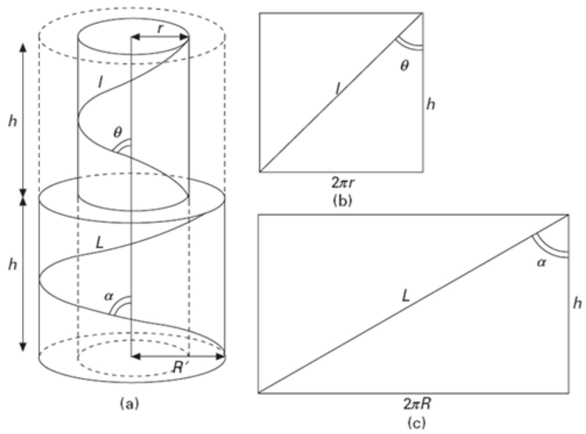


Fig.3.
(a). Idealized helical yarn geometry.
(b). and (c). Shown relations between helix angles θ and other quantities.

To assess the fabrics according to their physical properties the point (Thermodynamic relations) has been discussed in earlier studies and research [29, 52] for a long time to put the quantitative relations between swelling, moisture absorption and mechanical properties in fiber which derived to reach the coefficients of stress values for both fibers and fabrics. The equations as distinct from inequalities apply only to reversible changes, and they break down when there is hysteresis. The general equation may conveniently be derived, in the method proposed by Hearle [37, 38] in general, by considering a rectangular parallelepiped under stresses normal to its faces and swelling in directions parallel to its sides. This can be modified for other shapes and for other types of stress and deformation.

Morton and Hearl. [2008], modified the Hearle's equations to apply them for single fibers by consider a fiber to be a cylinder of irregular cross-section, as shown in Fig.4 with area A and length l, the forces on the fiber to be a tensile stress tension T. Fully equation reported in their book.

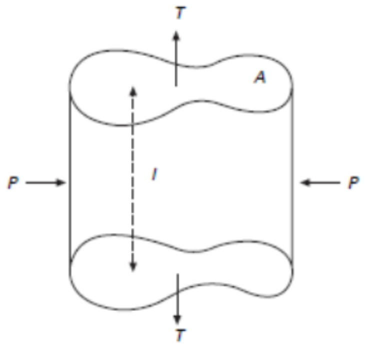


Fig.4. Stress Geometry forms on a fibre.

From this introduction and illustration the geometry of yarns, for designing textile fabrics with specific physical for industrial applications, a forces property is important. One of the most fundamental properties is the load-extension curve, which is determined by the properties of the constituent warp and weft yarns, weave pattern, yarn count, and weave density and so on. It is not in itself sufficient. There will be some effects that are due to the inherent properties of the structural arrangement, and the fibre properties may be modified by the presence of neighboring fibers [40]. The fiber properties in themselves do, however, give a limit to what is possible in a yarn or fabric. On account of variation of their cross section, the most studied and, in many applications, the most inherent mechanical properties of fibers are their behavior under forces and deformations applied along the fiber axis [21].

Various theoretical models have been developed for the prediction of the stress–strain properties of yarn structures. Research into the behavior of textile yarns using the force method was conducted systematically as far back as 90 years ago [37, 49, 53, 65].

Peirce. [1947], started with the structure-property relationship at by studying loading and derived geometric relationships between yarn spacing, yarn diameter, modular length and weave angle to understand the behavior of woven fabric on different deformation modes. He founded that, extension occurs in amorphous sections, where primary and secondary bonds expand and are extending with shears loads, when an external force stops acting at this point, much of the extent achieved will recover and the material will exhibit elastic properties. If continuous load occur, the plastic material is deformed, where long molecular chains are re-arranged reciprocally as a result of the disconnection of secondary bonds under forces as reported by (Hearl and backer, 1969).

Shanahan.(1978), also reported that ,the re-arrangements of the molecules' reciprocal position offer better possibility for material to resist additional loading. If the continuous loading a final break will occur.

B.K.Behara and P.K.Hari.[2010], indicate the yarn behavior in woven fabric by a model helps in predicting inter-yarn forces at the cross-over point, yarn path produced by the inter-yarn forces which spread across the contact region ,they discussing why the cross-section should vary in different woven fabric from circular, elliptical, racetrack or any other shape., they found that its depends on the yarn density in fabric. Its founded that there was some sort of force acting between the yarns in the intersection region as shown in Fig.5.and Fig.7

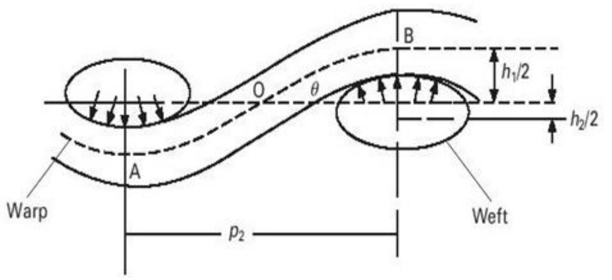


Fig.5. Yarn path produced by inter-yarn force.

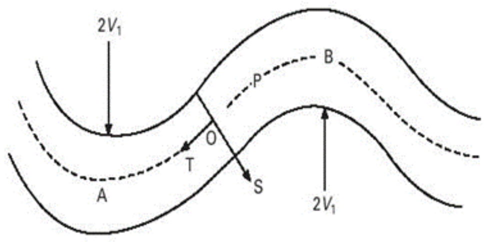


Fig.6. Yarn shape in fabrics.

In the concept fiber Stress geometry, the yarn will relax as function of time due to the visco-elastic character of textile materials [5, 10].

To indicate forces in ideal state may be expressed by Behara and Hari, as a tension, –T, and a shearing force, –S. These can be resolved as:

Horizontal force (–U = –T cos q + S sin q).

and a Vertical force (–V = –T cos q – S sin q).

Fig.7. indicate Forces acting on elastic state to the equation: $V_2=8B_2$ SIN Θ_2 /P_2^1.

However, $2V_1$ and $2V_2$ are the inter-yarn forces for warp and weft yarn in the repeat as shown in Fig.7. Their magnitudes have an important bearing on the cross-sectional shape and the deformation–recovery behavior of the fabric.

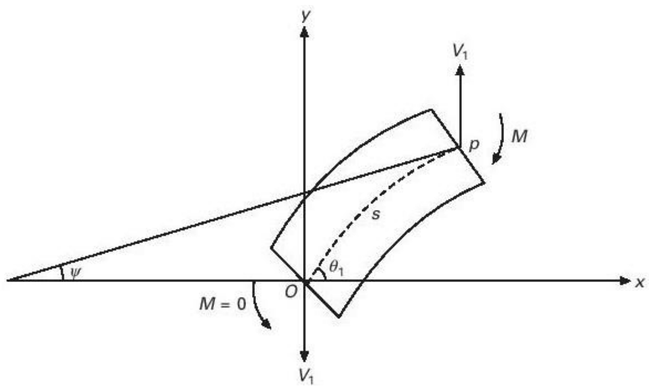


Fig.7. Forces acting on elastica.

There are major implications of these forces in the cross-over region [46]:

- The change in the yarn cross-section: the deformed shape depends on the force distribution. This has an indirect effect on the fabric cover, fabric thickness and deformation-recovery of the fabric due to resistance offered by the frictional force in this region.
- The yarn in the fabric will have two distinct regions whose properties will be very different. The yarn in the fabric will exhibit anisotropy for any deformation and recovery.

It is important to understand that bending rigidity of the yarn which indicates the precursor growth of inter-yarn force at the cross-over point and this is in equilibrium with an identical inter-yarn force from the cross-thread. The inter-yarn force values as determined above, helping in prediction the strains values in woven fabrics.

Anadjiwal. [1991], decided that the Stress behavior is predominantly influenced by yarn bending parameters especially at reasonably large loads when testing tensile and compression yarn property also influence in fabric stress behavior.

Fig.8. presented an example of different value of stress for cotton in different conditions where is (a) indicates the Structural features of cotton, which determine the tensile properties, while (b) indicates Stress–strain plots. Line A is for extension of the crystal lattice, lowered to B owing to its helical structure, to C by untwisting of reversals and to D by pulling out convolutions. The dotted lines (letters with primes) are for wet cotton [4, 54, 55].

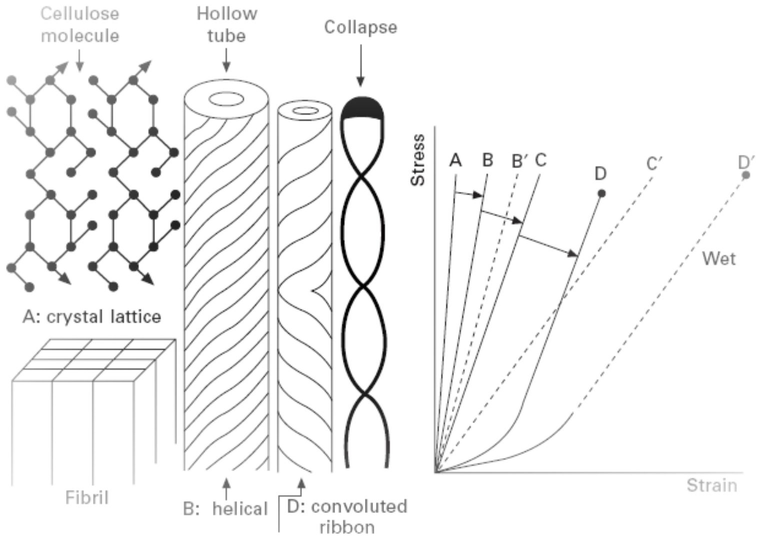


Fig.8. Different value of cotton stress behavior.

Fibers materials are increasingly subjected to higher straining levels during processing and end use .The interlacing of one set of threads with another in the fabric usually contributes to an accretion or growth breakdowns resistance of warp or weft direction [56].

It is important to take in consideration factors when studying stress- strain behavior of fibers such as twist and component, yarns regularity, their count, yarn crimping, and friction between longitudinal and transverse cross-section; all these parameters have a significant effect on fibers stress coefficient as perceive obviously in the conventional tensile strength test [97].

3.2. Overview of textile Geometry forces:

Woven fabrics are subjected to a wide range of complex deformations during usage**.** The mathematical modeling of the stress-strain relationship of woven fabric is a very complicated topic because it involves a large number of hypotheses, covering lack of expertise or the inability to articulate some of the relevant factors, this is generally considered among the most structurally sophisticated and hierarchical materials that we can control to satisfy particular performance and end use [66]. Textile structures are considered as special ‘knots’ or ‘links’ under the assumption that the constituting threads are smooth spatial curves. It is unpredictable deformations subjects as reported [Sergei Grishanov, 2009]

During last eighty years, many scientists have dedicated their theoretical analysis of strain and stress and its relationship with the mechanical properties of the fabric which are due to its breakage behavior. Hearl and Morton. (2008), described three ways of specifying breakage, or resistance to breakage: by the force, elongation or energy necessary; the breaking elongation gives a measure of the resistance of the material to elongation. It is thus important when a

specimen is subject to stretching, In comparing materials to see which is least likely to break, it is important to consider the conditions under which breakage would occur to indicate it's stress behavior, and then to decide which quantity is the appropriate one to use.
The first of several quantities related to the shape of the stress–strain curve is the initial modulus [50], which is equal to the slope of the stress–strain curve at the origin (after the removal of any crimp) as shown in Fig.9. This slope usually remains constant over the initial portion of the curve

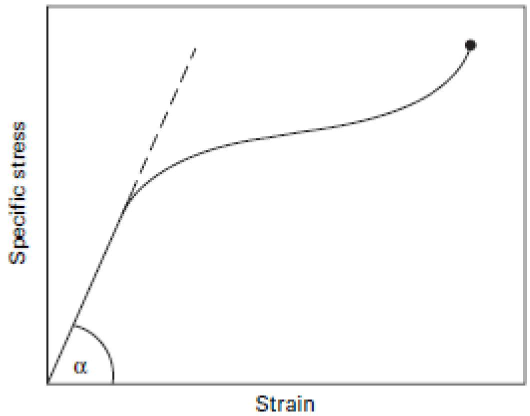


Fig.9 .Initial modulus = tan ∝.

There are two other moduli may be reported: the first is , tangent modulus is the slope of the stress– strain curve at any given position, It is relevant when materials are subject to cyclic loading. Plots of tangent modulus against strain are another useful way of showing the changes in extensibility as fibers are increasingly strained, as described by [Vangheluwe, 1992]. The second moduli is, secant modulus which stress/strain at any position on the stress– strain curve. Dynamic moduli are related to a property of elastic recovery of material and time dependence which will explain in section (4.9and 4.10).
The behavior of the load elongation in the woven fabric warp and the weft directions considered one of the factors affecting the amount of resistance to stress [11, 96]. The load elongation behavior and modulus can be deduced from the properties of yarn and cloth structure.
As Fig. 10. Indicate, a fabric may be extended in the bias direction at an angle ψ to warp. If there is an extension at an angle, we have to consider the shear behavior of the fabric as shown in Fig. 10.a. If the fabric is extended at an angle ψ. it will extend by rotating the members of the trellis relative to each other. The fabrics will simply swivel in to a new position as shown in Fig. 10. B.

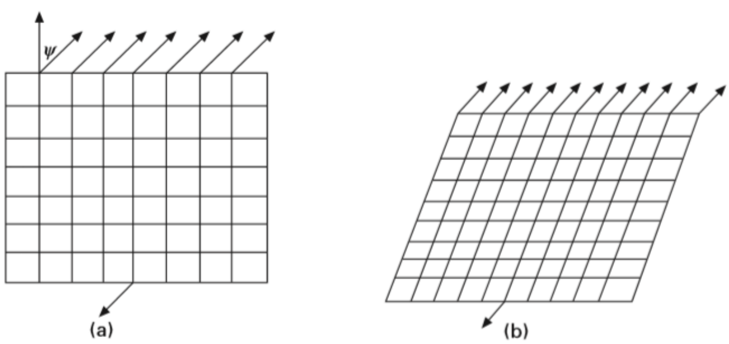


Fig.10. Force behavior in bias direction for woven fabric.

However, there is some resistance to this rotation of shear force action. It can be seen that the force applied will produce at the edges of the fabric an extension stress along warp and a shear stress as shown in Fig.11 [28, 30].

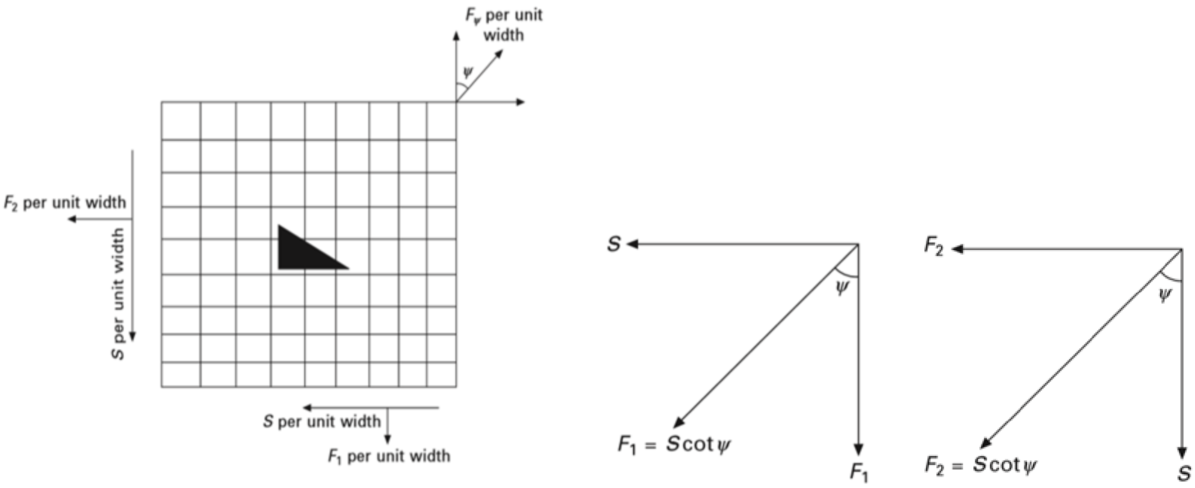


Fig.11. strain forces affect along fabric edges.

As shown in Fig.11: F1 and S will have a resultant in the direction of F.

and F1 = S cot ψ.

and F2 = S tan ψ.

Then consider a triangular element in the middle of fabric as shown in Fig.10. Then fig.10 will convert to Fig.11 and by suppose the length of the hypotenuse is 1.

Forces acting on the sides of the element. For equilibrium, resolving horizontally, we have the equation: S = F sin ψ cos ψ.

And if F is known at any angle ψ, than we know S, F1, and F2.according to the two following equation: $F_1 = F\cos^2\psi$. & $F_2 = F\sin^2\psi$.

Taking into consideration of the strain behavior. The applied force before and after deformation and its components are shown in Fig.12. and Fig.13. respectively.

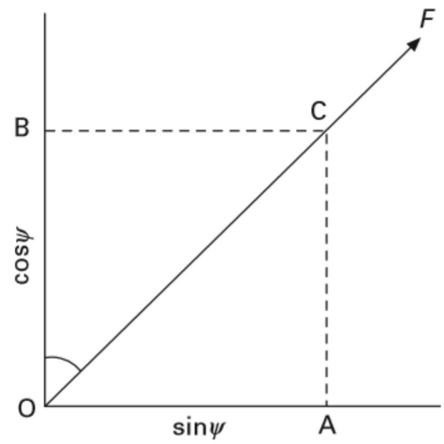


Fig.12. Strain behavior of woven fabric before deformation.

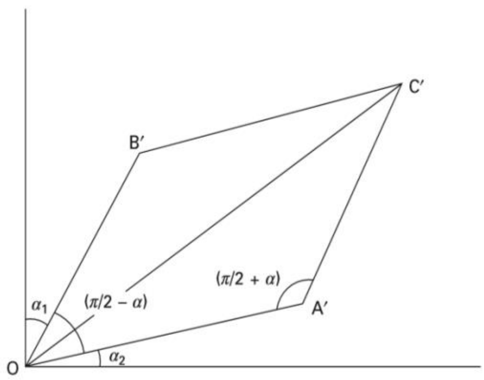


Fig.13. Strain behavior of woven fabric after deformation.

We can get many equations for calculating the strain $OA^/$ value as plotted in Fig.13 which equal to strain in OA direction which plotted in Fig.12.

Fig. 14. Indicate the general image of the stress–strain curve of a woven fabric which occur more in warp direction than weft direction. This behavior appears as a result of the repeated loading and unloading for woven fabric experiences during different manufacturing and processing [90, 97].

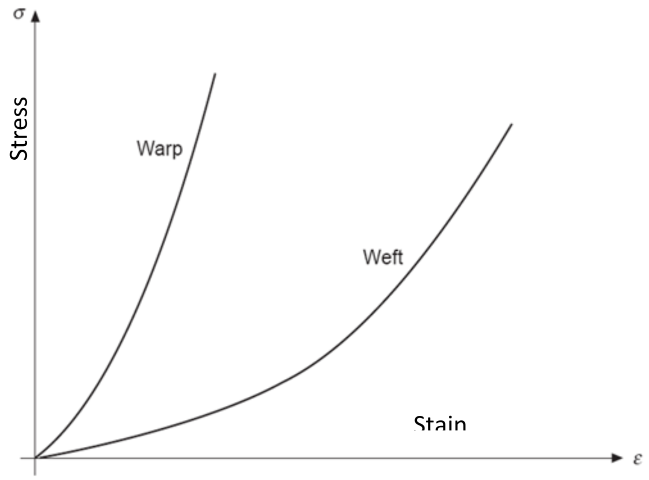


Fig. 14. General image of stress–strain curve.

The, (stress/strain) behaviors - (tension/extension) properties, of textile material are complications. Stress is not a single value function of strain, but depends on the particular factors referee on textile subject, historical mechanical property. The response is non-linear, inelastic and time dependent. Nevertheless, there are variations Factors that determine the results of stresses and strain in textile materials as following.

4. Factors determining the results of stresses and strain in textile materials:

4.1. The material and its condition:

The behavior of the textile material under stress depends on its nature whether it is from natural or not, and the arrangement of its composed molecules; these will vary not only from one type of fiber to another but also from one fiber to another and from one condition of the material to another. It can summarized as the condition of the material depends on its previous history, including the processes to which it has been subjected and the mechanical treatment that it has received, on the amount of moisture that it contains, and on the temperature [7, 13]. All these parameters effects must be taken into considering of the results reflect on stress and strain behavior and value for textile materials.

4.2. The arrangement and dimensions of the textile subject:

The dimensions of the textile subject **(**specimen) will, of course, have a direct effect on the results of value of stress. As example the breaking load of textile subject will increase in proportion to its area of cross-section, and its elongation will increase in proportion to its length. There indirect effects that we are more concerned in this point it is the length of specimen and its width .It can clearly show in tensile strength test which the breaking load of long lengths will be less than short ones [82, 85].

4.3. A Strength load (nature and timing):

The load necessary to cause breakage for textile material fibers or woven fabrics and it will vary with the speed of the test, a rapid test requiring a greater breaking load than a slow one. Thus the physical experiments require loads as tensile or tear determine the way in which the load is applied, whether it is by constant rate of loading(CRL), constant rate of extension (CRE) and (CRT) constant rate of travel [93] .

A textile material elongation is not a single-valued function of the load applied , because it depends on the time length for load and any previous loads have been applied. Thus, the stress values for the textile materials will vary. If a constant load is applied to a martial, it will, after its instantaneous extension, continue to extend for a considerable time and, if the load is great enough, it will eventually break [71].

Textile materials are complex subjects ,variable and probably unknown loading histories specially in evaluate the practical behavior of fibers, which is a subject to measure the constant force necessary to break a fibre and is given experimentally by the maximum load developed on related strength tests.The value of the specific stress at break is termed as tenacity or specific strength. Breaking length may also be used for comparing strengths on the basis area of cross-section; the stress at break is termed as ultimate tensile stress [50, 72].

4.4. Specimen's crimp and elongation at break:

It may be expressed by the actual, the fractional or the percentage increase in length, and is termed the breaking extension or break extension. The specimen's crimp affect in stress value when measuring strength value is normally pulled out by a suitable small tension in measuring linear density, and it can be removed by a pre-tension at the start of the test [12].

If a crimped fibre is inserted in the tester without any initial tension, the load– elongation curve will have the form shown in Fig.15. The origin of the curve may be put at A, where it diverges from the zero line, but this point is difficult to locate precisely. A better procedure is to put the origin at O, the extrapolated point corresponding to a hypothetical straight fibre. The crimp is given by AO and may be expressed as a percentage of the initial length. Studies of the methods of measuring and defining crimp have been made by [Betra. S. K., 1974].

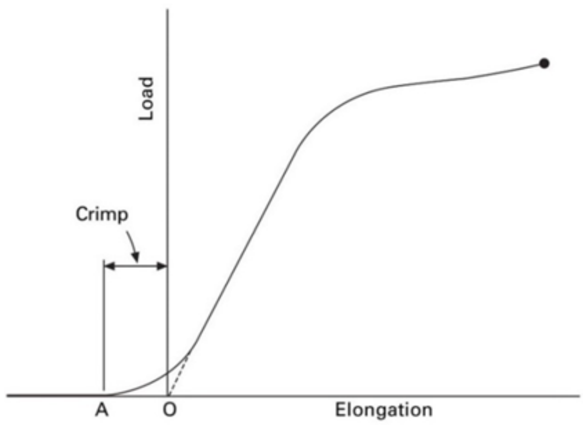


Fig.15. Load–elongation curve of a crimped fibre.

4.5. **Work of rupture**:

The total work of rupture of any particular textile specimen is proportional to its mass, independent of the actual values of linear density and length which determine that mass. Equation of: specific work of rupture = work of rupture/(linear density ×initial length).The units for this are joules. Specific work of rupture as shown in Fig.16. May be expressed in units of N/ Tex or kJ/g, and is given by the area under the curve of specific stress against strain [77].

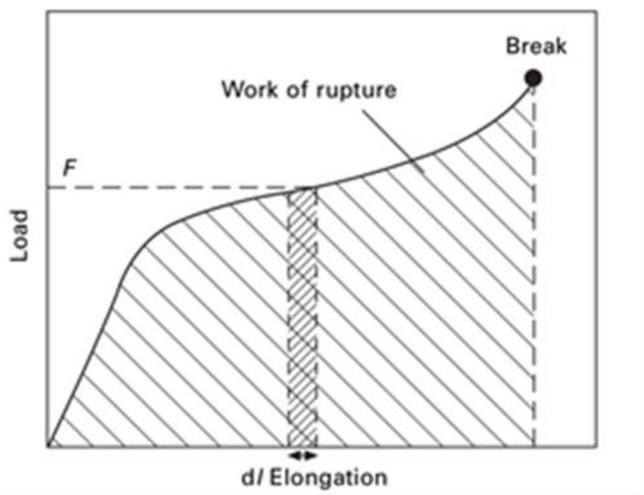


Fig.16. Work of rupture.

4.6. Work Factor:

In the ideal state, If the fibre which to be a subject force is proportional to extension - when stretched in two direction which obeyed Hooke's law (the real response of springs and other elastic bodies to applied forces) ,the load–elongation curve would be a straight line[61], as shown in Fig.17. The work factor will be 0.5. If the load–elongation curve lies mainly above the straight line, the work factor will be more than 0.5; if below, it will be less than 0.5.

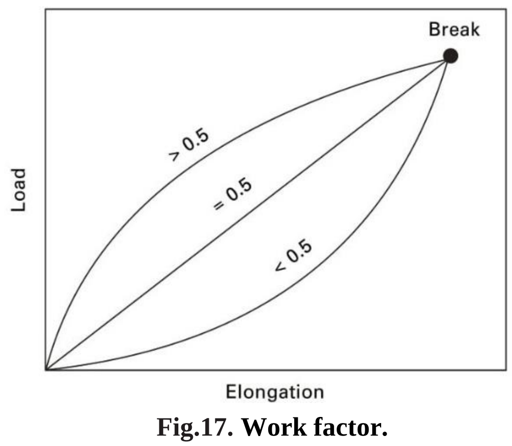


Fig.17. Work factor.

4.7. Initial modulus and other moduli (Yield point)**:**

To indicate the several quantities related the stress and corresponding strain when plotted on a graph constitute a stress–strain diagram for yarn and fabrics is the initial modulus, which is equal to the slope of the stress–strain curve at the origin (after the crimp removed). Fig. 18. (a) and (b) [19, 45,46] is the perfect graphic represent the stress-strain curve for yarn and fabric.

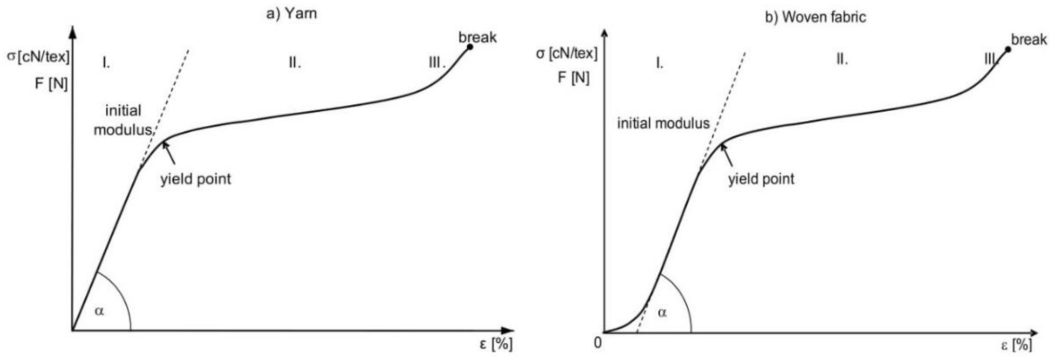


Fig.18. Stress-strain curve of yarn and fabrics

As shown in Fig. 18. The load-extension curve is divided into three zones [31, 48, 83]:

- (zone I) : The zone of elastic deformation or Hook's zone of both yarn and fabric:

If the extension occurs within the Hook 's zone, after relaxation the material will recover to its initial length .This area is also known as the linear proportionality or linear elasticity zone.

- (zone II) : The zone of viscoelastic deformation:

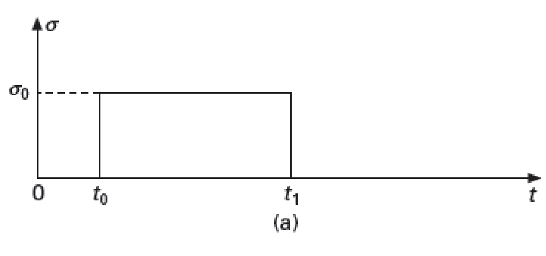
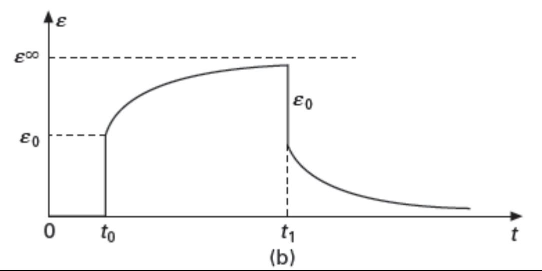
After the loading, the material recovers to its initial length after a certain time of relaxation. The Stress-Deformation relationship is not linear, the limit between the elastic and plastic deformation is the yield point, seen as a turn of curve on the stress-strain curve

- (zone III) The zone of permanent deformations: The material does not recover after the relaxation.

The definition of yield point [43, 81] is the stress beyond which a material deforms by a relatively large amount for a small increase in the stretching force. Beyond this stress, the material no longer obeys Hooke's law.

4.8 .Visco- elastic of fibres:

Textile fibres do not behave as linear elastic bodies but display a combination of the behavior of viscous fluids and elastic solids. For further clarification, if a constant stress σ_0 is instantly applied at time to a linear viscoelastic fibre as shown in Fig.19 then this will first cause an instant elastic strain ϵ_0 followed by a slowly increasing strain which approaches its ultimate value ϵ_∞. This increasing component of strain is the sum of the delayed elastic strain and the strain related to viscous properties of the fibre material. It can be said that in this condition the fibre material 'flows' as a viscous liquid, this effect is termed creep and produced by the rearrangement of molecules under the load applied. Once the load is removed the fibre slowly returns to its original length; this is typical behavior of the elastic material under stress [5, 14, 32] .

	
(a), a constant stress applied from time t_0 to time t_1	**(b), an elastic response at time t_0, creep from time t_0 to time t_1, and recovery after time t_1.**
Fig.19. Creep and relaxation behavior of a linear viscoelastic solid	

There are linear and non-linear approaches to modelling the viscoelastic properties of fibres [23, 33]:

- In the case of linear approach, the viscosity is defined by Newton's law which states that in the liquid shear stress is proportional to the velocity gradient: $\tau = \eta = \frac{\partial v}{\partial y}$

Where η viscosity, V is velocity and y is the direction of the velocity gradient.

- In application to linear viscoelastic solids it is assumed that the stresses related to strain and strain rate produce a combined effect resulting in a simple model of viscoelastic behavior in the form: $\tau = G\gamma + \eta \frac{\partial v}{\partial t}$.

These two equations in fact describe the viscoelastic behavior of the Kelvin–Voigt Model and it can be applied to viscoelastic behavior of textile material by dividing more equations for each case [3].

4.9. Elastic recovery of material:

Elasticity has been defined by the 'American Society for Testing and Materials' as 'that property of a body by virtue of which it tends to recover its original size and shape after deformation'.

Elastic recovery, It is the property of a material by which it tends to recover to its original size. In another expression: the behavior on removal of stress is only a special case of the general phenomenon of hysteresis as reported by (Grishanov and Omelchenko , 2009).

The results of elastic recovery of textile subject, will not fall on a single line during a cyclic change of stress or strain [42].After a few initial cycles, the subject becomes conditioned and the results tend to fall on a loop [42,64] as in Fig. 20., the curve explains that the energy is used up by internal friction and therefore the material is heated up and can be heated.

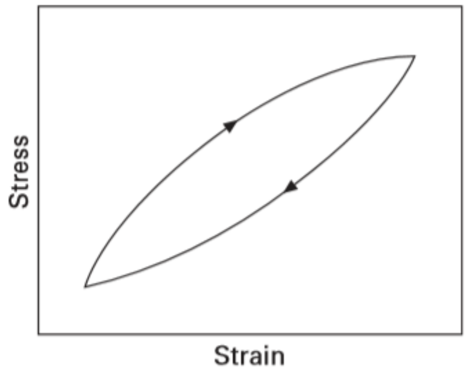


Fig.20. Hysteresis loop curve.

When textile materials are stretched by forces below the breaking strength level, and then they are allowed to recover, they do not return to their original length immediately. The duration of the application of the force and the time allowed for the recovery [69].

Farrow. [1956], uses the following equation to measure ,how much a material recovers its original length after deformation: Elastic recovery = (recovered extension/ imposed extension)×100.

A deformation from elastic recovery may be divided up, as shown in Fig.21. into an elastic part, which is recovered when the stress is removed, and a plastic or permanent part.

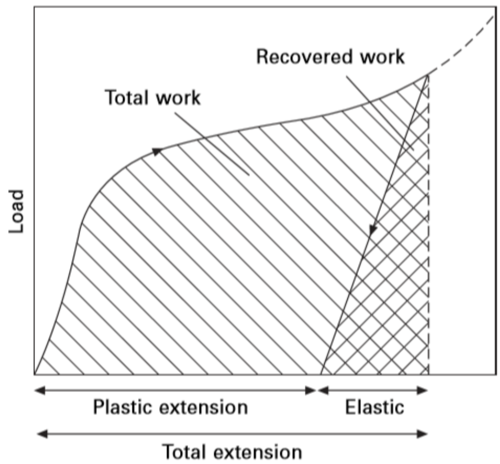


Fig.21. Elastic and plastic extension.

It was found experimentally in previous studies [34] that the recovery percentage steadily decreased with increasing extension of the material up to the yield point where the recovery decreased sharply. Guthrie and Kimar .[196 1] , measured the elastic recovery of fibers it will be seen that the elastic recovery is less at the higher humidity at small strains, but at larger strains it is greater for a number of the materials.

Most of the textile material, they are neither the plastic material nor elastic material they work under viscous elastic. So, it will actually come back, but it may not; there will be definitely some deformation. If it is extended beyond the yield point, but if it is extended within broken region, then it will come back. That is why for most of the low stress mechanical characteristics of textiles works under within the Hook's law.

Considering that, there are different applications of textile, not only in technical textiles but also in the daily apparel which recovery affect on garments dimensional stability, which changes with differs of stress characteristics. So on even with the different technical application, we must know the elastic recovery characteristic of textile material.

4.10. Time dependence effect:

In pervious stress-strain explanation's in section.2. , it have seen that stress is load is increasing and strain is taking place, but in the term time dependence effect , the material is loaded once and it is a kept at that loading condition for a long time. So, this type of situation is they are in most many technical applications like in geo textile for any applicants where the material is under constant load for long time.

When a yarn or fabric is extended by a given amount and then held at that extended length, the time dependence is seen. If the force required to do this is monitored, it is found to rise to a maximum value immediately and then decrease slowly with the passage of time. This phenomenon is known as relaxation of stress [21].

Even textile materials do not act as strictly elastic materials in the initial straight line region of the force extender curve [21]. Their behavior is better fitted with a viscoelastic model, since the relationship between the stress applied and the resulting strain contains a time-dependent element as plotted in Fig.22.

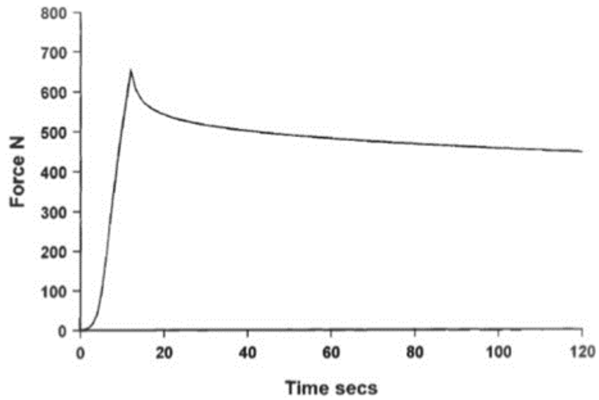


Fig.22.The decay of load with time.

The importance of know the strain time and strain behavior, is clearly appear in determining the load fixed required for using specially, in geotextiles under the ground it is continuously loaded, so we must know the strain characteristics; so that we can predict whether it will fail or not.
In addition to this characteristic of time dependent extension, results from it also known as the creep phoneme.

4.11.(creep- secondary creep) amount:

Textile materials may exhibit an appreciable amount of creep. The instantaneous extension is followed by creep due to the effect of applying a constant load to textile material whether it fiber or woven fabric for a given time and then removing this load, the removal of the load results in an instant recovery, followed by a further partial recovery over time, which leaves some unrecovered extension. On other explanation, the removal of load gives rise to an instantaneous recovery, followed by a further partial recovery with time, which still leaves some unrecovered extension [92].This is known as creep phoneme**.**
Therefore the total extension may be divided into three parts [98]: the immediate elastic deformation, which is instantaneous and recoverable; the primary creep, which is recoverable in time; and the secondary creep, which is non-recoverable.
This three type in extension of textile material due to creep phoneme had an impact and affect for its behavior of stress property whereas at low stress, creep is due to localized molecular rearrangement, which may or may not be recoverable. At high stress, molecules slide past one another in non-recoverable deformation.one of parameter affect in term creep of stress behavior of textile materials known as (secondary creep) as shown in Fig.23., and Fig.24. It refers to the time-dependent part or (time scale) of the recovery curve is identical with the primary creep curve. If the same load is applied again after recovery, the rate of creep is lower than that in the first test on the specimen; the primary creep occurs at its initial rate, as it was before, but the secondary creep resumes at the rate it left off [31].
To be more clearly, the secondary creep phoneme gives rise to the major part of the permanent extension of a textile subject and is usually negligible below the yield point. Thus a comparison of the amounts of secondary creep that occur in various fibers and fabrics after particular loading histories is given by the figures for inelastic extension for every textile material separately [6, 99].

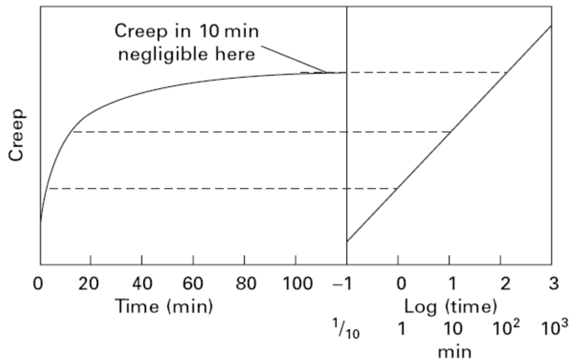
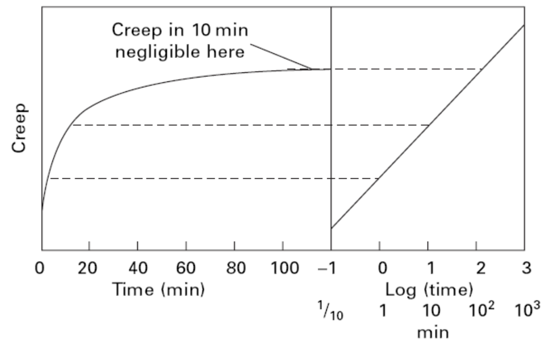
	

Fig.23creep and secondary creep curve depending on timescale.	**Fig.24 extensions curves over a wide range of times**

With, previous brief explanation of the elements affecting the stress - stress values of textile materials, we concluded that there are many factors affecting the values of this phenomenon on textile, due to its highly anisotropic, so that their mechanical properties including strengths are a function of stress direction. Wherefore, line production of woven fabrics and garments with high quality requirement is now a major issue facing in this industry; Objective measurement of fabric mechanical properties especially the stress behavior is being used as an aid to the process and buying control of fabrics in the apparel industry.

From this point of view, there are many tests relevant to determining coefficients and values of stress- strain behavior of textile material. It will be briefly mentioned below with describing its relates to stress behavior of textile material.

5. Testing connected to stress- strain behavior of textile material.

Fabric mechanical tests relevant to measure textile subjects under loads which these conditions similar to actual fabric deformation can be examined by different tests. Many factors of stress behaviors in textile material influence, directly or indirectly with many tests, but we will mention the most important tests related to the stress phoneme in this paper. Tensile, tear, shear, and bending tests are covered explanation to determine the fabric stress behavior as following:

5.1. Tensile property- Tensile Strength (Breaking Strength):

Tensile strength test of textile subject is defined as a maximum load that it will endure without breaking when subjected to uniaxial tensile loading [35]. Tensile tests are often used to determine the tensile strength, braking length, elongation, modulus of elasticity, proportional limit, reduction in area, yield point, yield strength.

It is necessary to define the shape o f a tensile when a woven fabric is subjected to tensile deformation. To identify the stress-strain curve of woven fabrics; described as the fabric undergoes a loading and unloading cycle. This cycle can be described, in which the fabric specimen is extended from zero loads to the maximum stress of (500-1000) gf/cm by using different apparatus. A typical example of a stress-strain curve derived using the KES kawabata evaluation system of fabric [51] for measurement of tensile and shearing characteristics apparatus is shown in Fig.25, Because of de-crimping and crimp-interchange the initial area has a low slope for this curve, the slope then rises steeply until it reaches its height, the extent of the stress-strain curve can have determined by yarn crimping degree and the relative ease of yarn distortion [12, 20,25].

If the fabric undergoes a cyclical loading process, it is first stretched from zero stress to a maximum (loading) and then the stress is fully released (unloading). There will be a residual strain, εo, as textile materials are viscoelastic in nature. The recovery curve will never return to the original, due to the presence of residual strain. This is the hysteresis effect, which denotes the energy lost during loading and unloading cycle and its means that a deformed fabric cannot resume its original state [26, 48].

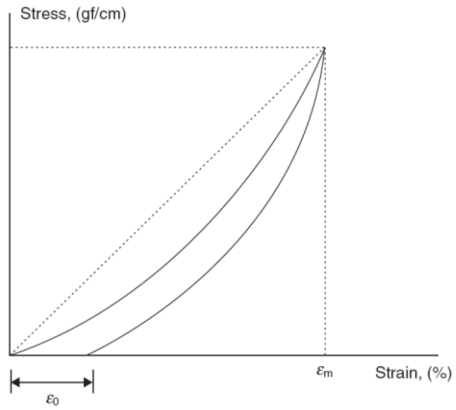


Fig.25. Loading and Unloading Cycle in the Tensile Stress-Strain Curve

The main purpose of a tensile test is a versus elongation load curve which is then converted into a stress versus strain curve. Research and scientists [7,31,32,42] who study stress- strain behavior of textile material under tensile test are dividing the load and elongation by constant values, the load-elongation curve will have the same shape as the stress-strain curve., and experimental trails gathered on each substance has its own unique stress curve. A typical model for stress-strain curve [84] is shown in Fig.26. If the true stress, based on the actual cross-sectional area of the specimen, is used, it is found that the stress-strain curve increases continuously up to fracture.

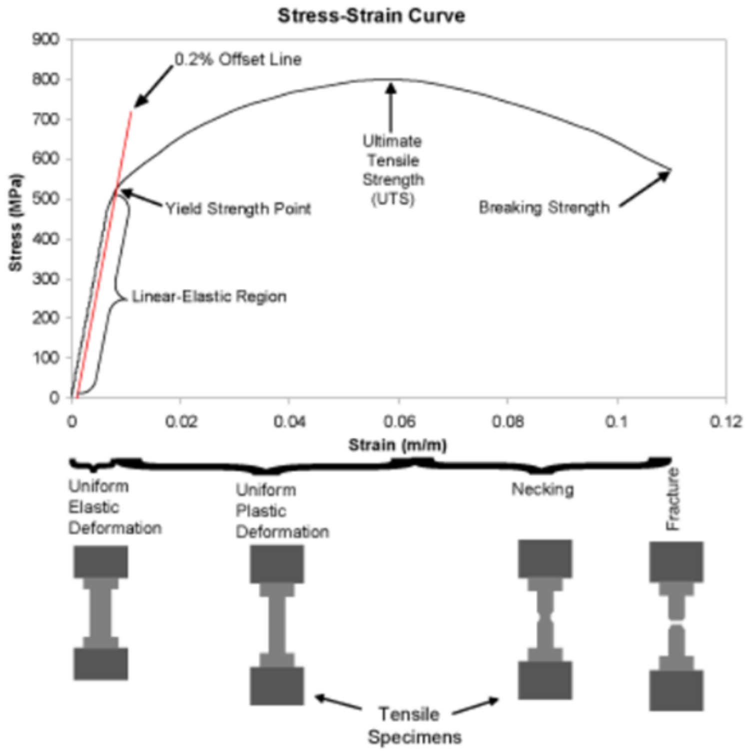


Fig.26. A typical engineering stress-strain curve of tensile test.

The tensile properties of woven fabrics are particularly prominent effect on fabric performance and many others during wear and other finishing uses. Thus, fabric response assessment to the loading tensile in both the loading process and the breaking point should be considered. Hence, many previous research works have focused on the tensile and stress relaxation properties of fabrics in different parameter of experiments trails, all experiments were agreed upon each material has its own unique stress-strain curve. [45, 87,96]

The stress –strain behavior of textile subject under tensile tests depended on various parameters as indicate in section .4.annd consider one of the most important test to determine the Coefficient of (stress- strain) behavior of textile materials. The tensile behavior of a textile fabric would be identical to that of its constituent yarns if all yarns were uniform in their tensile properties, and if the interactions between the two perpendiculars yarn systems were negligible. Unfortunately, in reality, these two factors are too significant to be excluded; this complicates the otherwise very straight forward relationship, as reported by [Ning Pan, 2015].

5.2. Tear strength:

Fabric tearing can define as the consecutive bering of yarns or collections of yarns laterally a stripe done a fabric [48]. J. Thanika and Vu-Khanh. [2018], reported that the tearing process of textile materials is an energy absorption phenomenon.

Tear strength is the tensile force required to start, continue or propagate a tear in a fabric under specified conditions. During tearing test, The Del area containing energy dissipation process appears due to various dissipative mechanisms: yarns tension and yarns slippage. When dissipated energy ∂W is greater than the energy required to create a new tear surface, the crack propagates into the textile materials [36].

The equation to calculate of tearing force T which has been proposed by [H.M. Taylor,1959, is following : $T = f(Snt\ f / f_s+2)$., where f_S is the slippage force, f breaking force, n number of yarn ,crossing points, S spacing between the yarns , t filling yarns density.
Fig.27. (a, b). Show respectively, Schematic representation of tearing force assembly and loading-unloading tearing force–displacement curve.

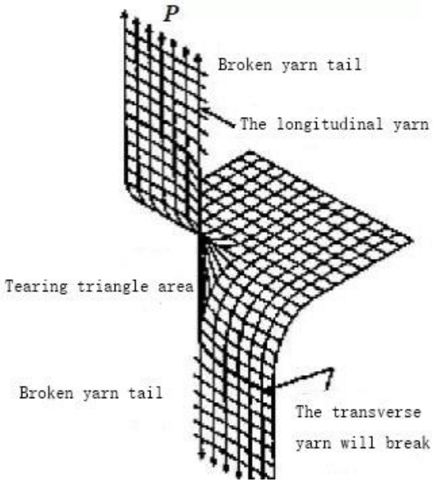


Fig. 27. a.Tearing force assembly.

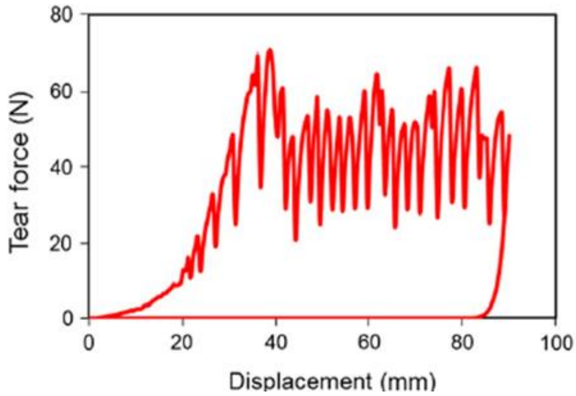


Fig.27. b. Loading- unloading tearing force displacement curve of the tongue tear

For more indication, In the case of tensile loading, all the yarns in the direction of loading share the load; in tear loading only one, two or at most a few yarns share the load. Not only in the breaking strength embrace the force required to break a large number of yarns simultaneously, and is less affected from yarn and fabric parameters. But also the tearing strength is considerably affected by changes in yarn and fabric structural characteristics [20].
Morton. (2008), examined the strength of the fabric in relation to the properties of the yarn and the structural density of the fabric. If a load is applied to a woven fabric and the yarns are straight with non-crimp, full load will be faced in tension at complete strength. However, If the yarns are crimped or bent, the initial load will be consumed in straightening bent tows and subsequently take up load leading to low strength materials. It demonstrated that the relationship between the breaking force and slippage force of a yarn has an important effect on the variation of strain energy density of fabric materials. It indicates that the slippage force and yarn breaking force are very close [77].
The knowledge of tearing work in textile is useful for explaining the effect of fabric characteristics and strain energy density and provides a useful tool for the in-depth study of tearing resistance, not only for fabric materials, but also for coated fabrics, as well as other types of textiles, in particular knits and nonwovens, to give a reasonably direct assessment of serviceability than the tensile strength and a fabric with low tearing strength is generally an inferior product. So that tearing strength is one of the most important properties for assessment stress behavior of textile material for end use.

5.3. Shear property:

The shear behavior of a fabric determines its performance properties when subjected to a wide variety of complex deformations in use [2]. Cusick, G. E., and Grosberg and Park. [1961], used a qualitative method to describe shear properties with a model which are based on the concept

of Low-Stress Mechanical Properties of Fabrics. They indicated that the hysteresis produced during shearing is determined wholly by the frictional restraints arising in the rotation of the yams from the intersecting points in the fabric.
The uniaxial tension of a bias-cut fabric specimen is relatively simple and may be carried out on any extensometer. Shear properties are important not only for fabrics and/or clothing but for textile composites as well. Shear characteristics of woven fabrics can be explained by two terms fabric., Shear rigidity (G) and Shear hysteresis at two angles (2HG and 2HG5) with the KESF instrument [67].
Until now, it has been known that a general empirical stress-strain curve for shear illustrates the characteristics in Fig. 28. [59]. Deformed at low strain levels, the shear stiffness is initially large, as in the OA region, and decreases with increased strain. The shear behavior in this region is controlled by mechanisms of friction, and the widely accepted model definition is that the incremental stiffness is due to the sequential movement of frictional components. The mechanism starts to break as soon as the tension is high enough to resolve the smallest of the frictional constraints at the intersection regions and the incremental stiffness falls, this is the AB region. At particular amplitude of stress, the incremental stiffness reaches a minimum level, that is point B, and remains almost linear over a range of amplitudes, with slopes thought to be regulated by the deformation of the so-called 'elastic elements' in the fabric. It is generally observed that shear stiffness increases with increasing strain, above a relatively low level of shear strain (5 ° –10 °). Incremental stiffness starts to grow again at amplitudes greater than a certain amount C, and the closed curves increase in width with increasing amplitudes of the shear angle. It seems that this is due to steric hindrance between the two twisted intersecting yarns, resulting in transverse yarn distortion, or riding up the intersection, or both [36 ,68].

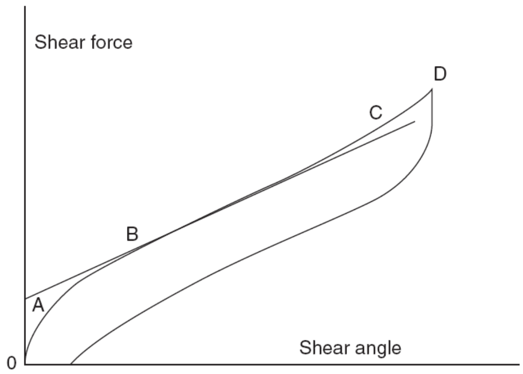


Fig.28. Stress–strain curve of woven fabric during shear deformation

In addition to the above factors, Shear angle is considered is one of the main criteria for characterizing fabric formability, this property helps fabric to undergo complex deformations and conform to body shape. Shearing angle affects draping, flexibility and woven fabric handle too [30, 80].
Constantly, the shear behavior of woven fabrics is: an important characteristic in fabrics whose end-use is for apparel purpose. Large shearing strains resulting from low shear stress are necessary to fit a fabric which lies in a single plane to the various three dimensional surfaces required when forming the cloth into a garment; This is due to the behavior of the woven fabrics during complex deformations, their shear behavior is most influential [87].

5.4. Bending property:

Bending hysteresis is the energy loss within a bending cycle when a fabric is deformed and allowed to recover, denoting the difference in bending moment between the loading and the unloading curves when the bending curvature is fixed[15] . The bending properties of a fabric are determined, applied, yarn-bending behavior, in turn, is determined by the mechanical properties of the constituent fibers and the structure of the yarn. The bending property affects the fabric bending rigidity of the product, and the fabric's longitudinal compressibility before buckling. The bending properties of fabrics govern a substantial part of their performance, such as hanging and drape, and it was considered an essential part of a complex fabric deformation analysis [57].

The relationships among yarn-bending behavior (the constituent fibers and the structure of the yarn), the weave of the fabric and the finishing treatments to determine the bending properties of a fabric are highly complex [43]. Fabrics are very easy to bend. Their rigidity is usually about 1/100 that of tensile deformation. A large number of parameters are required to express bending properties bending properties in a closed form is very difficult. As example it should to know the relationship between fabric bending rigidity, the structural features of the fabric, and the tensile/bending properties of the constituent yarns. It must be measured empirically or determined through the properties of constituent fibers and the yarn structure empirically calculated or determined by the properties of the constituent fibers and their yarn structure. For apparel and domestic textiles (such as curtains, table cloths, and upholstery), deformation under conditions of low stress (such as, bending, tensile and shearing) is considered of great practical significance due to its end use [82].

Bending behavior of a woven fabric can be characterized by bending rigidity (B) and bending hysteresis (2HB). Bending rigidity is the resistance of a fabric to bending, which can be described as the initial moment-curvature derivative. The bending rigidity equation[73] B is B= ¼ wc^3, where w is the weight of the fabric in grams per square cm and c is the bending length [73].

Figure.29. illustrates a typical bending curve for a woven fabric. For this curve, it is normally thought that there is a two-stage behavior with a hysteresis loop under low-stress deformation. Firstly, there is an initial, higher stiffness nonlinear region, OA. Within this region, the curve shows that the effective stiffness of the fabric decreases with increasing curvature from the zero-motion position, as more and more of the constituent fibers are set in motion at the contact points. Secondly, there is a close-to-linear region, AB. When all the contact points are set in motion, the stiffness of the fabric seems to be close to constant [60].

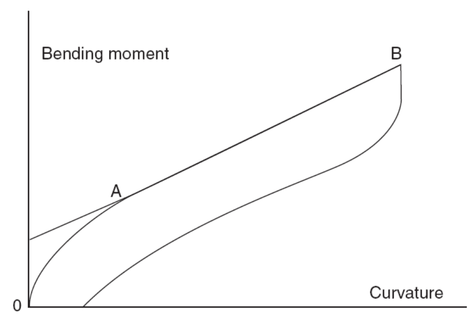


Fig.29. Typical bending curve of woven fabrics.

All this indicator above of bending property implies that bending stiffness and bending hysteresis are not independent, but have a linear relationship to the stress –strain behavior of textile material.

The importance of deformations under stress values for fabric such as tensile strength, bending, and shear rarely occur separately in practice but are invariably combined in a complex manner during fabric tailoring, wear and other end use [89]. These elementary fabric mechanical properties are generally believed to relate to such important fabric characteristics as drape, handle, tailor ability, creasing, wrinkling, and shape-retention properties; consequently, their study represents an essential part of a rational scientific approach to the design and application of apparel and domestic textiles [81].

Conclusions and further research trends:

Fundamental and experimental investigations of the structure and stress behavior properties of fibre and textile assemblies have been one of the major topics in textile. Textiles material are numerous and diverse, with different systems on its mechanics which closely related to forces. Fibres are the main building blocks in the production of textile materials. The physical and structural properties of fibers can, to a great extent, define the properties of the final product which includes yarns, threads and fabrics**.** The final properties of fabrics depend more or less on many various technical and technological parameters, which should already be adjusted during the design phase of a fabric [94, 98]. Detailed knowledge of these relationships is particularly important for achieving specific performance characteristics in textile industry specially at medical and technical applications. The relationships can be established by carefully well- planned experimental trials, theoretical studies based on its stress- strain behavior. In such way, the production will be more efficient and the desired final properties of the fabric will be attained, related to its type and end-use. However, it is impossible to precisely predict all physical properties of fabrics; textiles have been used for many areas because of their unique characteristics to apply to these areas properly and optimally. Meanwhile, a deep-down understanding of the structures and mechanic forces as stress and strain of fabrics is require

Presumably, the existence of a permanent stress behavior for one type of textile material cannot be confirmed or denied; The empirical stress-strain curve relates the applied stress to the resulting strain and each material has its own unique stress-strain curve. Therefore, attempts must be made to predict the results to study applied stresses and resultant strain in different parameters for textile materials under the actual conditions of use from experimental results obtained under different conditions. As a matter of fact, this is can be best done if the experimental conditions are as simple as possible to have enough care and reliability in order to eliminate the source of errors and reach more precise results for the propriety of stress and it should assumed to be categorized for each experiment separately. Additionally, it should intromission computer-aided design (CAD) and computer-aided engineering (CAE) techniques and simulation to predict the textile material forces due to its complex geometry.

Eventually, Stress – strain behavior of textile material is study a slick engrossing, that redefine how fibroes and fabrics are produced. Coupled with the analyses of the effects of stress phenomena on fabric physical properties in textile research area, this brief account reveals that such a comprehensive investigation could furnish a basis for the prediction of fabric complex deformation, understanding fabric stress-strain behavior and help lead to a more technological approach for the constructing fabrics to give specifications and clothing production.

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