Evaluation of Textile Materials
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Lecture-40
Evaluation of Low Stress Mechanical Properties of Textile Materials (contd…)

Hello everyone, so we have reached almost at the end of this course evaluation of textile material. In the last class we have discussed the bending related characteristics and how to measure the bending behavior of textile material. And cantilever principle is the most popular most widely used principle and if the fabric is very flexible like knitted fabric and we have mentioned.

We can use other methods of measurement that is heart loop method , ring loop method and pear loop method as we have already discussed or limpy fabric like lose knitted fabric.

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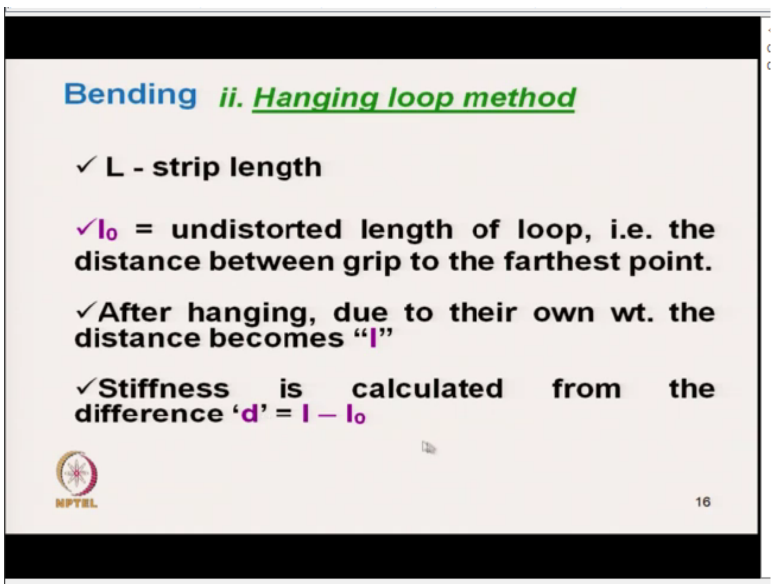

And L is the length of strip, L0 we have discussed it is undistorted length of loop that is distance between grip and the farthest point. And after hanging on it is own weight the distance there will be some distortion. And the distance becomes l, l is more than l0 and the deflection that is the stiffness is calculated based on the difference d is l-l0, so we have discussed.

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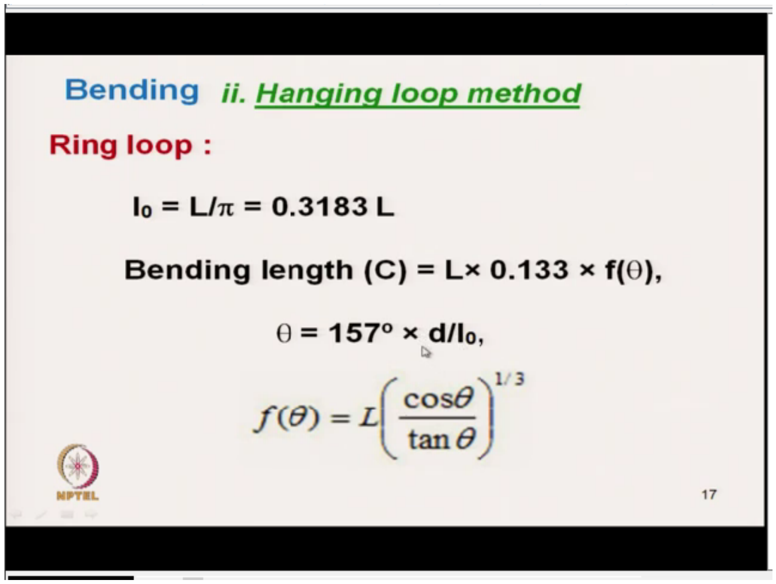

And this for ring loop l0 is nothing but there is the distance from one point to another point grip point to for that is nothing but diameter ok. Diameter of the loop and which is L/pie, so this is the way we can express ok. And from by if we know the l0 value and if we know the deflection d the difference then we can calculate the bending length using this formula where function of theta is l cos theta/tan theta to the power1/3,

So, here using this function of theta for a theta equal to here in case of ring loop the theta is 157*d/l0. And if we know this value deflexed only we should know the deflection if we simply **we** if we know the deflection value as in the last class we have mentioned and we can calculate the bending ok.

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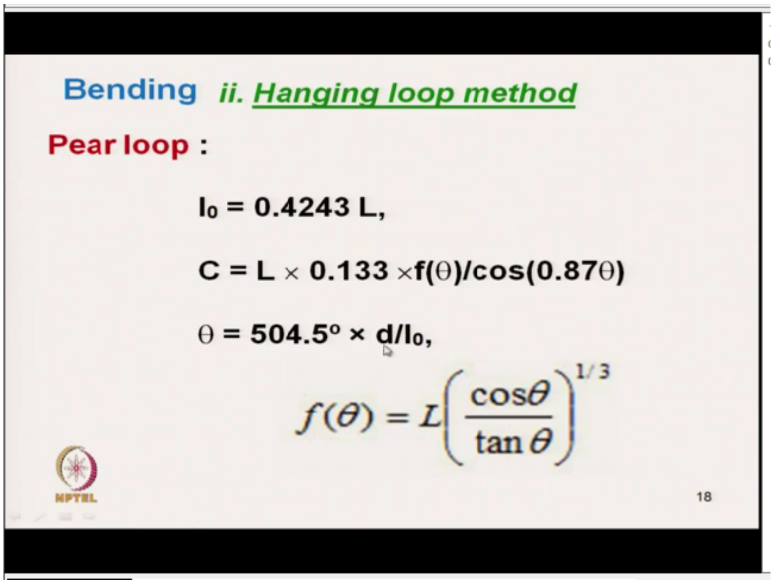

Similarly for pear loop if we know the deflection only deflection and function of theta is same here, and then we can calculate the bending length.

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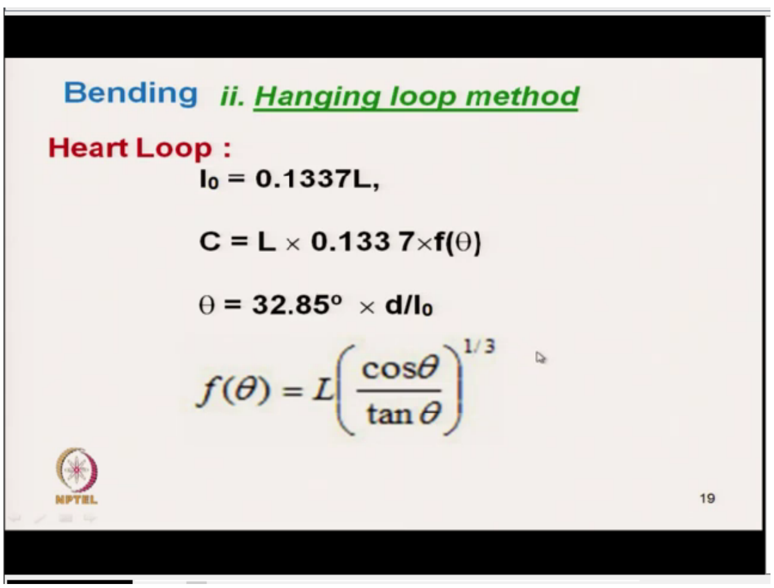

Similarly for heart loop ok using this formula now the next characteristics is shear characteristics.

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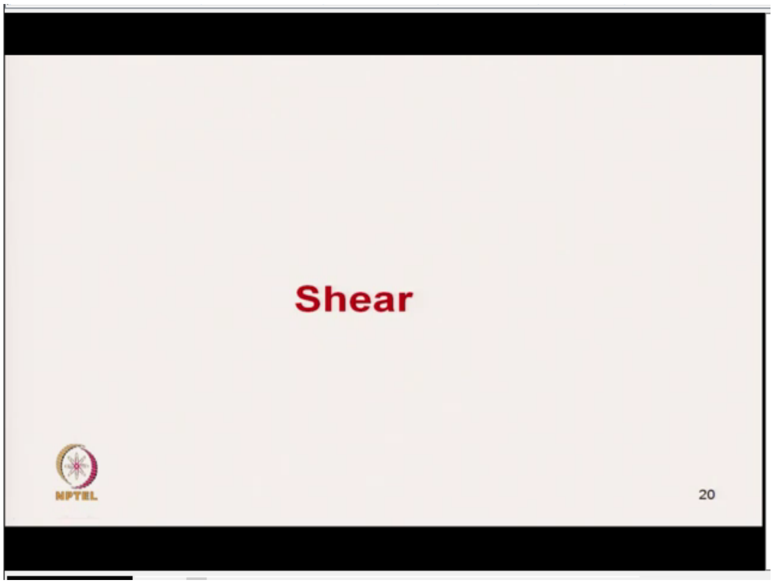

Now shear is a characteristics which is unique for textile material we can actually incorporate all other characteristics in any flexible material.

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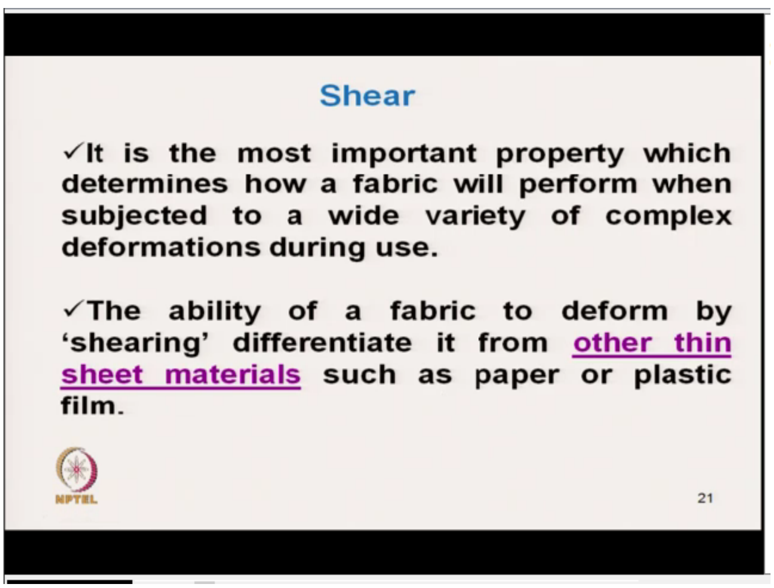

So, it is the most important property which determines how the fabric will perform when subject to wide variety of complex deformation during use. Suppose my cloth, my shirt when I actually move the fabric the characteristics of the fabric is that it takes it changes the shape according to my body movement. So, that makes my actually feeling it is comfortable otherwise what will happen? The ability of a fabric to deform by shearing it differentiate from other thin material.

So, that fabrics characteristics it is only uniqueness is that it is flexible and the it has got less shear stress ok. So, it can deform easily by shear that means whether it is a woven or knitted.

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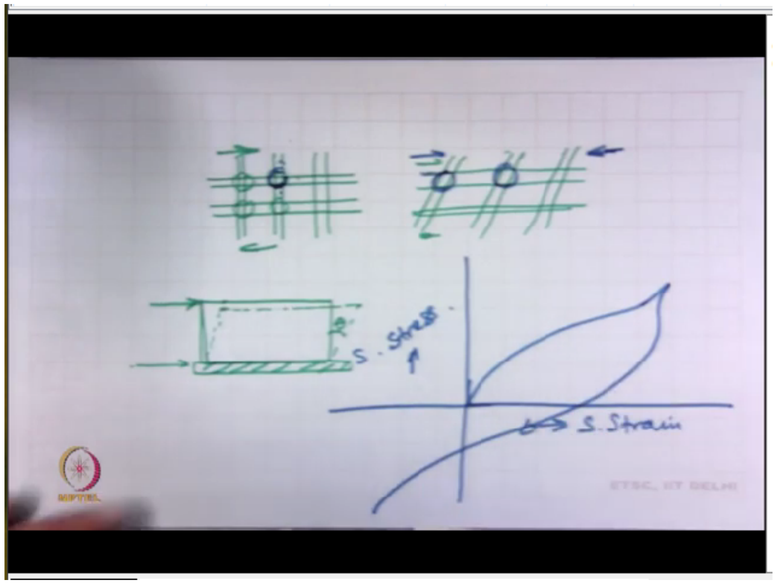

Suppose these are the warp yarn ok, so weft yarn and these are warp yarn. Now when we deform when we apply force ok this yarns will get deform very easily there will be because there is no actually positive binding. So, they will deform easily due to its inherence fracture, now if it is asked instead of textile material instead of say woven fabric or knitted fabric. We use any polythene sheet, so for any polythene sheet the we can incorporate any characteristics.

Suppose if you ask the polythene sheet in if I am making a short from a polythene sheet you may ask it is not say it is not permeable, so I can incorporate permeability by punching the holes ok. Then one may ask that it is not that flexible, I can definitely have polythene sheet with high flexibility even we can incorporate observance we can incorporate everything we can incorporate but one thing we cannot incorporate it is shear characteristics.

Because the polythene sheet any other thin sheet material if even very flexible sheet material, if we prepare our clothing that will have some other characteristics. But it will not be able to actually deform according to my body movement, so that makes the textile material unique ok. So that is the characteristic which is known as shear characteristics.

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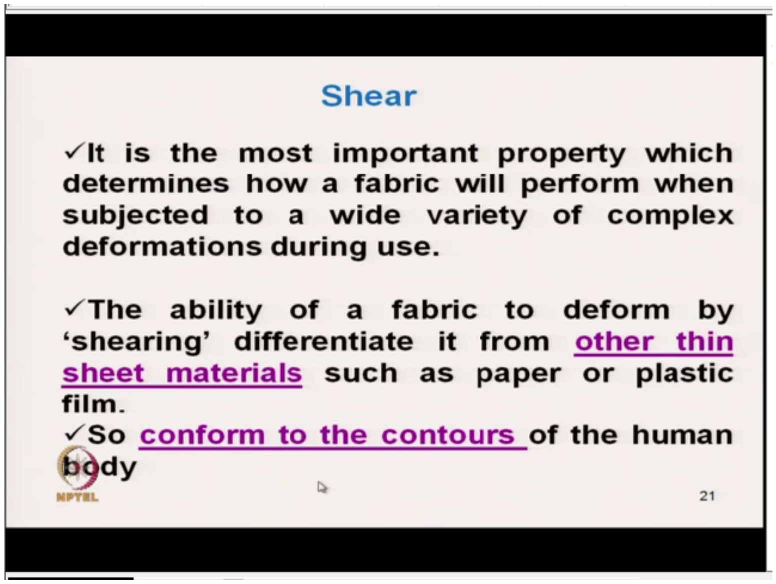

So, it does not confirm those see sheet material does not confirm to the contour of the human body and that textile material only do that.

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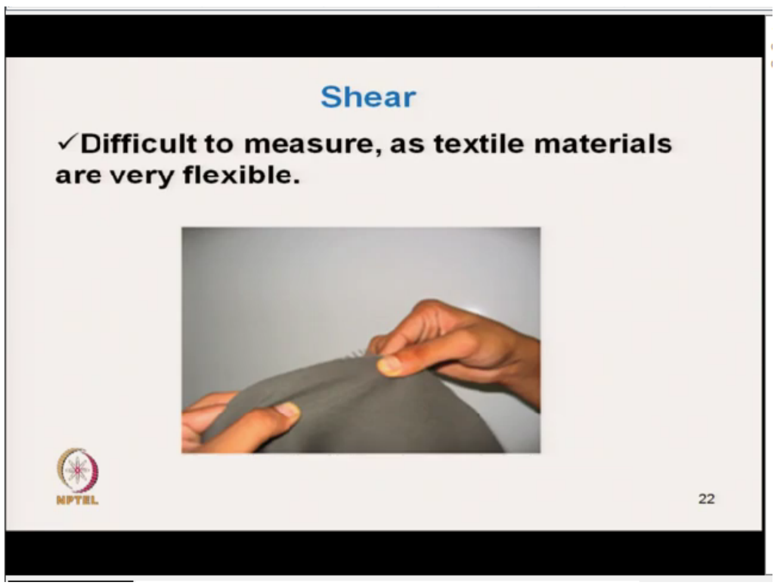

So, it is difficult to measure, so shear characteristics it is very difficult to measure. Because it is flexible, for any sheet material shear characteristics measurement it is not that difficult ok. It is basically when suppose there is a material any other material stiff material. And we are gripping in this is the 1 grip point ok. The material we are gripping now we will apply 1 force, so with this which is parallel to the base ok.

And with this force if there is any deformation, suppose this is the deformation it is deformed. Then we can measure the shear characteristics this theta the tan of this theta tan theta is the shear strength and we can measure the force to deform, so then you can calculate the shear stress. So, but for textile material as it is very flexible this type of measurement is very difficult ok.

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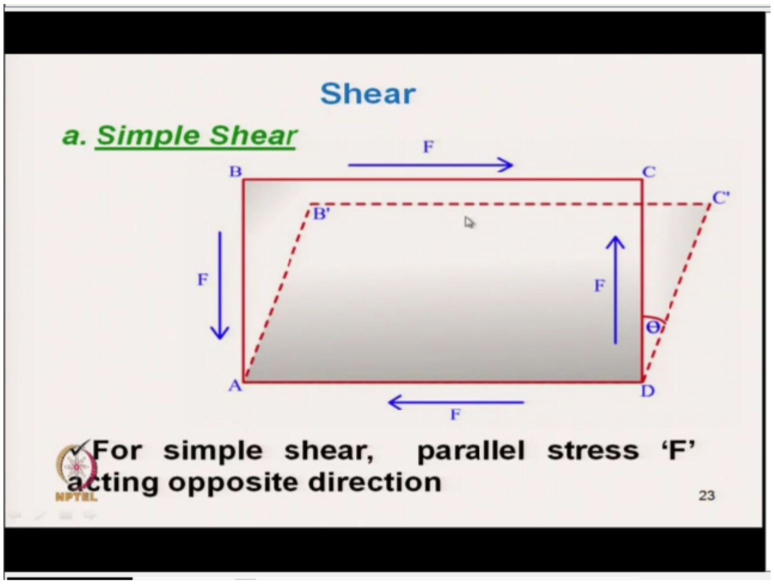

Now, so this is the simple shear, for simple shear parallel stress F is actually acting of in opposite direction that may this may be horizontal direction or may be vertical direction.

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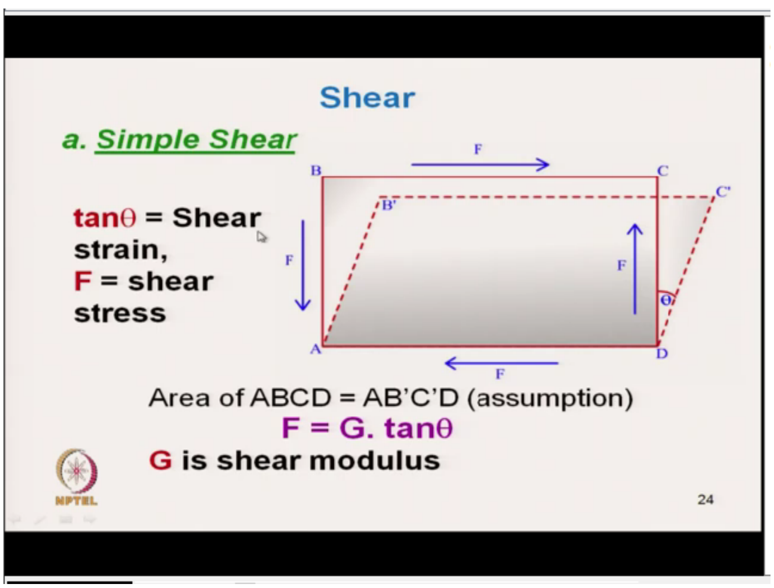

And where we can measure the angle of deformation theta and tan theta is shear strain and F is shear stress. Here assumption is that the initial that area of rectangular shape ok material the after deformation the area is same. So, here the G is the shear modulus we can calculate by the ratio of shear stress and shear strain. The G is nothing but the ratio of F by tan theta but the main problem is with the textile material and to test shear characteristics of textile material. We have to just we will use the same principle but we will modify the setup, the modification here is the 2 if any textile material if we try to shear.

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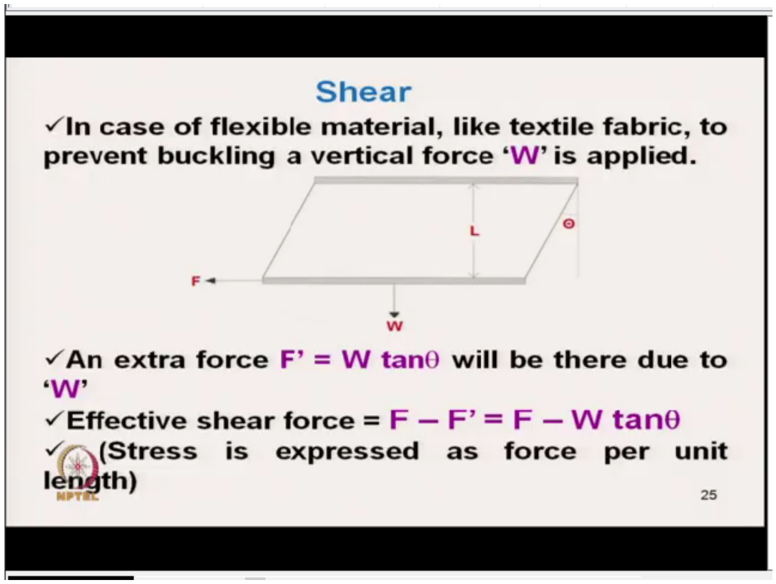

Before shear due to its high flexibility this fabric will buckle, this buckling will take place, so that buckling just to avoid this buckling prevent this buckling 1 vertical force is added applied extra vertical force W is applied. So, that the widthwise there is no buckling this becomes straight, so that extra force we have to apply in addition to F we have to apply an extra force just to have the W thus to actual balance the W.

We have to apply extra force F' which is equal to W tan theta when tan theta is the angle of shear. And this force is due to W and then the force required for only shear the fabric we can calculate by subtracting this W tan theta from total force required F. So, this will be F-W tan theta which is basically required to shear the fabric. And this stress is expressed in terms of force/unit length of the fabric, so if this is the length and we can calculate.

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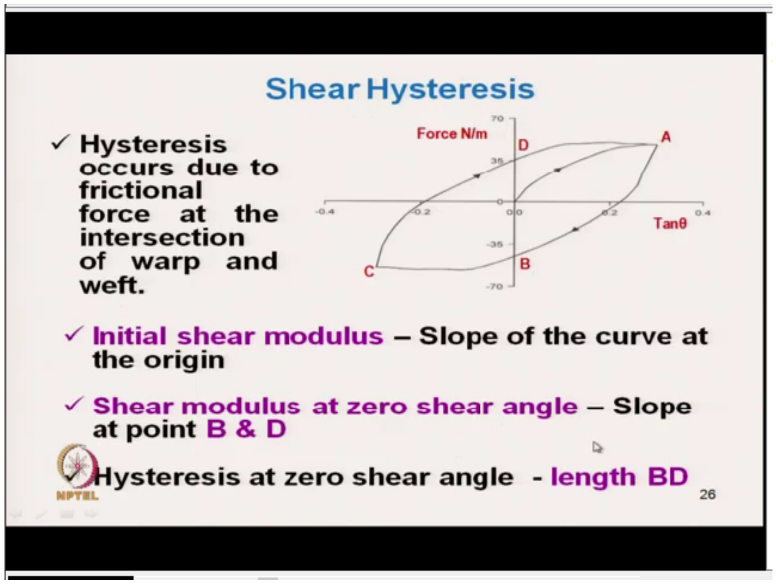

Now what is shear hysteresis?. Now shear hysteresis is that say suppose this is a fabric initial stage. Here at the initial stage although there is no from positive binding. But the fabric to yarn to yarn the warp yarn to weft yarn, this yarn to yarn friction will be there ok. This the shear force when it is actually deform there will be frictional sliding. That means suppose this is the force and what we are doing we are trying to deform ok.

Now the due to that frictional sliding we need some force, so, that is called that is the shear stress we need shear stress just to have some frictional sliding between the yarn ok. The yarn will this initial form and after that this will actually this is in this sheared form ok. Now that is how it is, so this is a shear strain and here it is a shear stress ok. Now this is ok after that and we can calculate the shear modulus and other now where once it is a coming back suppose after the deformation.

It is we are again trying to come back, so in that case the when it is a shearing it is coming back it will not follow the same path. Here we have to have this will follow a different path due to the frictional locking of this yarn ok. Now here this is and this difference is known as the shear hysteresis now the hysteresis occur due to frictional force at the intersection point of warp and weft ok.

Now where it is going and then it will come back and from this point again if we want to have without any too much the shear strain we have to apply certain force ok that is how it is the curve is like this. The initial shear modulus is that shear that slope at the initial parts. If we take the slope measure the slope that is the initial shear modulus, shear modulus at zero shear angle what is that?

At zero shear angle what is the shear modulus? So, the slope at point B and at point D. If we take the slopes, so we will get the shear modulus there will be 2 values. So, this will be the slope at the shear at zero point for this 2 values we contain we can take the mean of this and also hysteresis at zero shear angle. So, the difference between D the distance between B and D it is the hysteresis. So, from there we can calculate the shear stresses which is basically due to the frictional contact.

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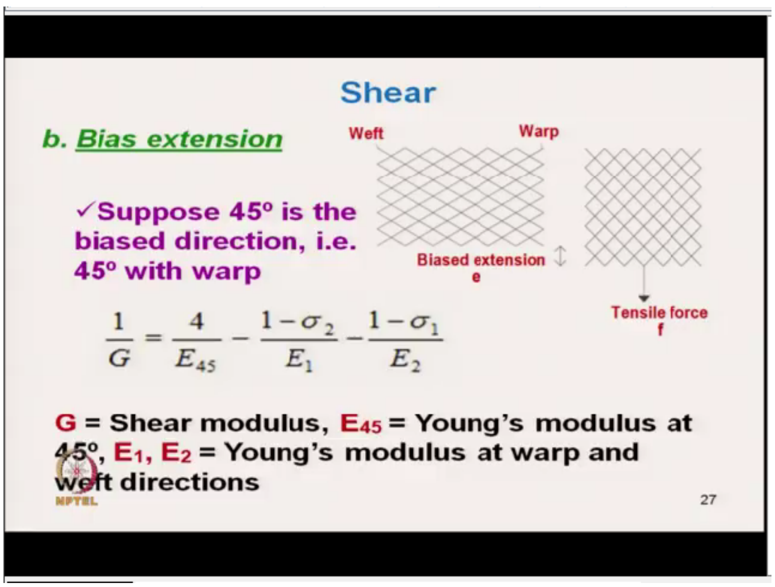

Now shear can also be measured by bias extension, so this technique this principle is used in FAST instruments ok. And the principle here is that we cut the fabric in the bias direction not in along the warp or weft we cut the fabric in 45 degree bias direction with warp ok. Now we will use this equation which is 1/G equal to 1/E45. So, 4/E45-1/ this sigma2/E1-1/sigma 1/E2. So, what are these values G is the shear modulus of the fabric and E45 is the young's modulus at 45 degree that means at 45 degree.

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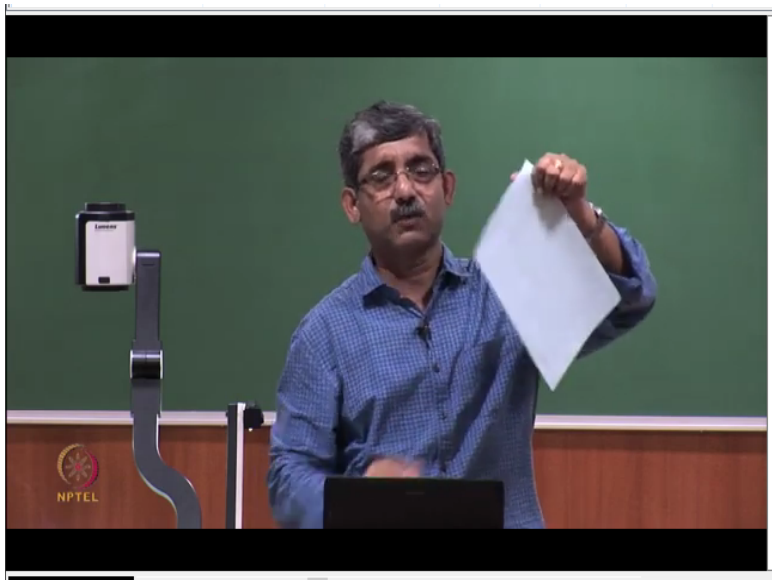

Suppose this is the fabric at work wise there will be certain young's modulus the because the yarns are at parallel condition there will be high young's modulus at weft direction also it will be higher. Because yarns are parallel but once we make we measure the shear modulus at say young's modulus at certain angle that means at 45 degree angle. The threads will have very less modulus because it will deform very easily.

So, that is why E45 and E1 and E2 are the young's modulus in warp and weft direction. Now if we see and that sigma 1 and sigma 2 these are the bias's ration in warp direction and weft direction. So, the relationship is between the shear modulus the biased angle young's modulus E45, E1 and E2. And if we see that here the E1 and E2 will be much higher than E45, so that is modulus at bias direction is it is very less.

Because the threads will simply actually take their action because the shear stress is less ok that is why in this equations as E1 and E2 are very high the initial (()) (17:56), we can eliminate this for simplicity we can eliminate this terms this second and third term in the equation. The equation will be simplified for all practical purpose we can use this that will be 1/G=4/E45 that the G=E45/4. If we can measure the young's modulus at 45 degree angle and divided by 4 will get the shear modulus.

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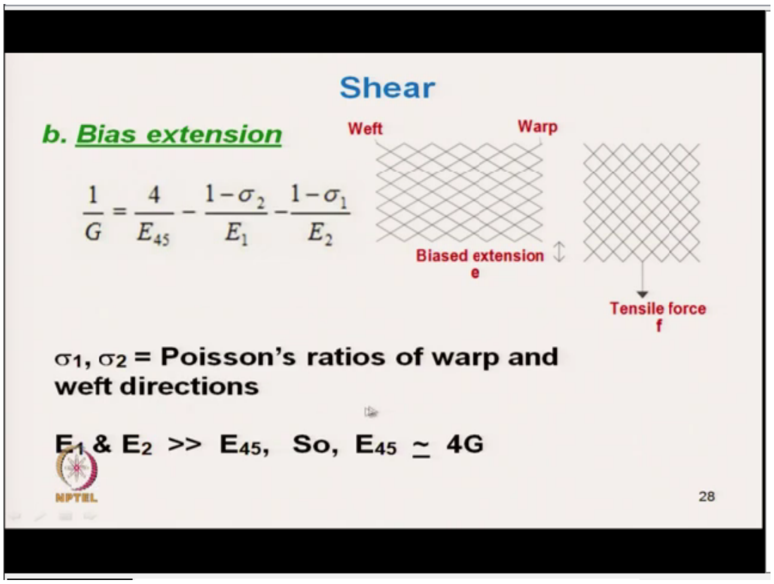

So, this is the equation, so E45 is almost equal to 4G ok. So, the sigma1, sigma 2 are Poisson's ratio. And here we can calculate the young shear's modulus of the fabric.

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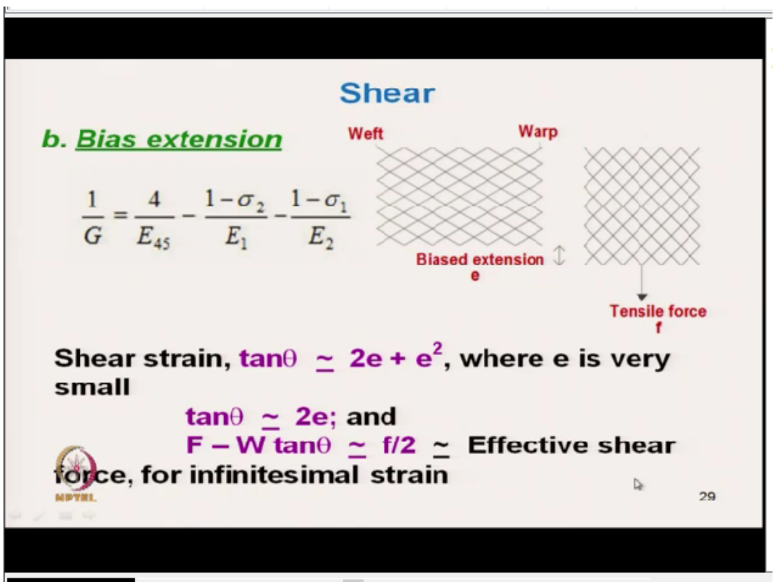

And the shear strain tan theta is related in the fashion like 2e+esquare where e is the biased extension by the force T. If we apply T force and then will have the biased extension, so that is tan theta we can measure. So, where it is a (()) (19:16) it is very small ok infinitesimal strain. So, that is e is very small if we take the e as a very small value this e square will be small, so that e square we can actually eliminate.

So, this will be tan theta almost equal to 2e ok, so this value is 2 tan theta 2e, so if we measure the e bias extension value, so we can calculate the tan theta and f/2 tensile force. So, that is tensile force/2 which is the effective shear force, so that is shear force and shear strain we can calculate using this formula for very small deformation. We if we deform at higher value then there will be other this equations will not be actually valid.

Now we will discuss another characteristics as I have mention which is actually re-linked with the shear and the bending characteristics ok and which is drape.

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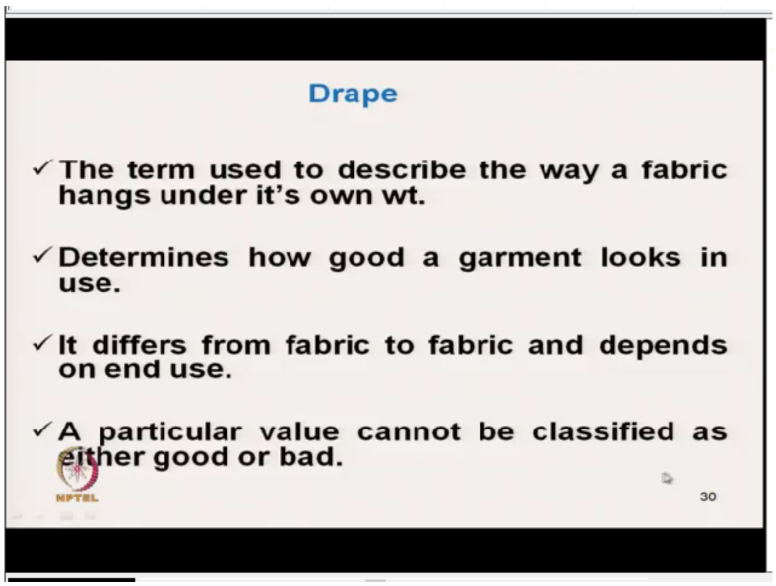

And drape the term is used to describe the way a fabric hangs under it is own weight. So, if we actually if we hang the fabric this fabric under it is own weight, how the fabric will get actually will hang will make some profile. That shows the drape characteristics and it determines how good a garment will look like. So, it is not only the garment for any other fabric like our cottons or any other fabric which actually requires a fall.

And that appearance is actually dependent on drape characteristics and it deforms from fabric to fabric and depends on the end use which is important. The drape like strength textile material with higher strength means it is better like uniformity which is more uniformity it is better that means CV% or U% lower U% is better. But here in drape we cannot see tell that higher drape coefficient had drape value is better or not ok.

Though that depends on the end use drape coefficient or drape value is just an indication we cannot tell the whether the fabric is good or bad that depends on the end use of the fabric. Once we need the stiffer fabric that means the drape will be different will be hydrant and if we need a flexible fabric that will be lower drapes. So, we cannot compare the value ok we cannot tell that higher drape value is always good. A particular value cannot be classified as either good or bad, so it depends on the end use like this is the drape ok.

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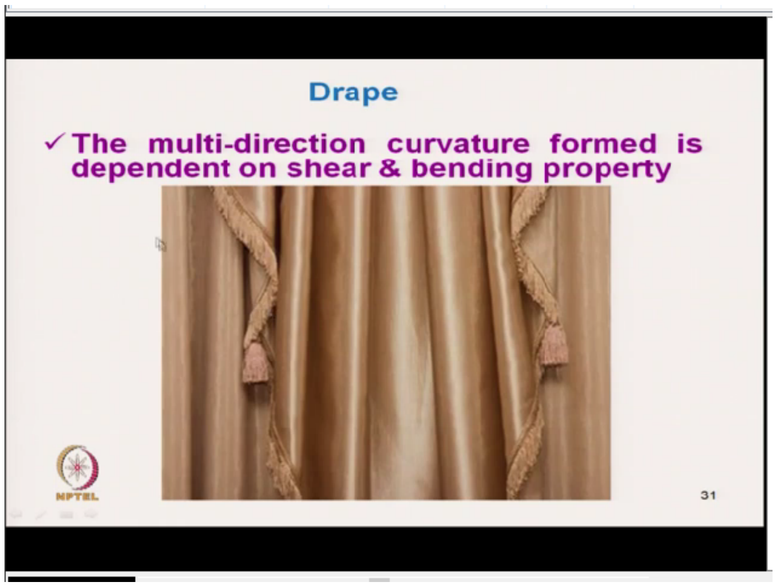

It is a multidirectional curvature which is formed ok and which depends on shear and bending property. And if we take this 2 properties together then it forms a drape and which shows it is a loop how pleasant the fall of the fabric will be.

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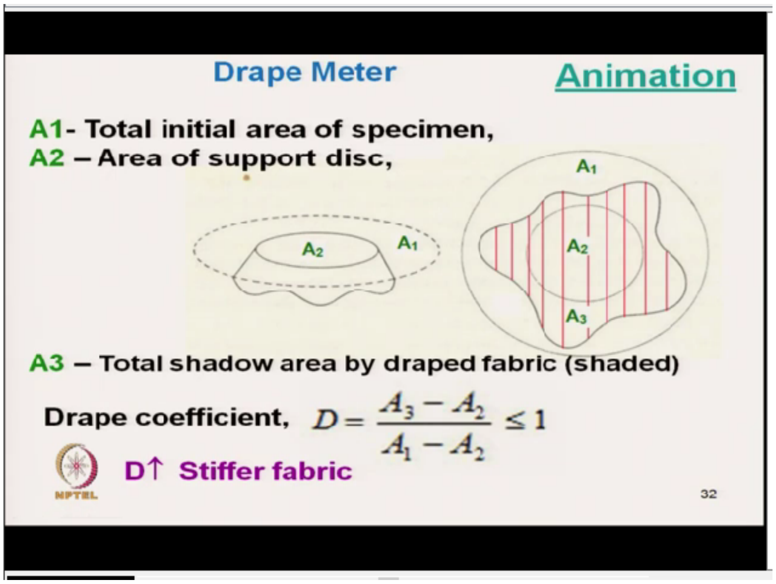

Now the measurement is done by using the drape meter where this is the a fabric ok fabric specimen without any with it is normal circular fabric space and A1 is the total area of the specimen we have cut the fabric and as it is flexible. Once we are placing the fabric with on a support disc of a certain known area A2. Then what will happen on it is own mass the fabric will start hanging.

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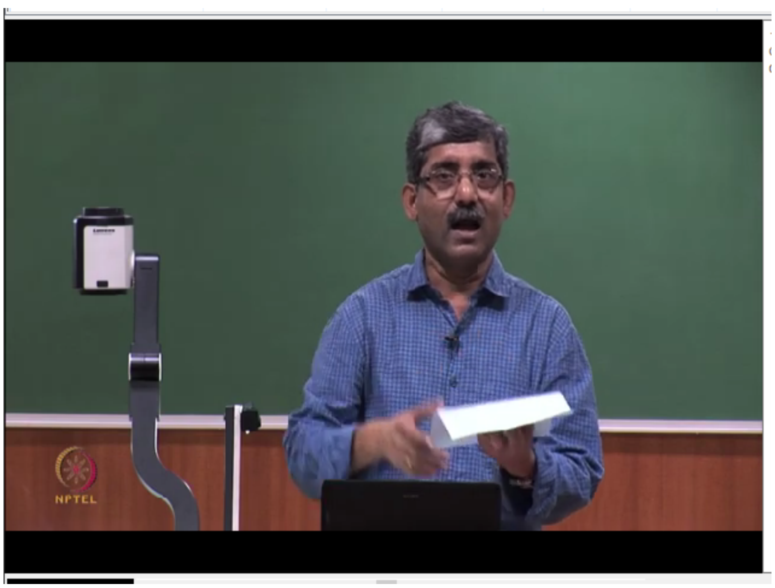

This fabric will hang and the projected area we can whatever projected area, this circle is the actual area of fabric A1, A2 is the support disc. And once we are hanging this will make a projection this A3 is the shaded portion is the total projected the projection total shadow area by draped fabric ok. And the projected area is that it A3-A2, A3-A2 is the which is actually projected from the support disc ok.

And then if we know all this values because A1 is known because we cut the fabric A3 is A2 is known. Because we know the area of the support disc only thing is that we have to calculate we have to measure the area of this shadow. And if we know that then we can calculate the drape coefficient, drape coefficient D is A3-A2, A3-A2 means projected area divided by A1-A2 that means the difference between the area depends on area between the actual fabric and the support disc.

So, if we know this value and then we can calculate the drape coefficient, now as the fabric gets stiffer the drape coefficient will be high. Suppose a fabric with the which is totally lengthy, it does not have any projected area, so what will happen the projected area that means ok A3 will be equal to A2. In that case, so that this portion this A3-A2 will be 0, so the drape coefficient for that fabric will be 0.

Now in place of fabric suppose we use cardboard ok, cardboard means that A3 will be equal to A1 ok because there is no drape at all. So, A3 is equal, so A1 is A3 is replaced by A1. In that case if we see numerator and denominator becomes same, so D value will be 1. So, that means the for any practical purpose, the drape value it is ranging from 0 to 1 for totally stiff fabric it is 1 the totally lengthy fabric it is a 0 ok.

So, that way we can have knowing the drape coefficient value we can actually come to know whether the fabric is stiffer or not ok. Now let us see the principle of this instrument here actually from top light beam is falling. And if we and this is the type of shadow at the bottom there is a shadow. This shadow we can trace and if we can measure the area and that area is actually from that area we can calculate the drape coefficient.

Now area measurement sometime it is very difficult, so that if we can trace and we can cut the fabric and we take the mass. And if know the actual mass/unit area of paper that from that we can calculate the area of the projected portion, now if we see the animation here.

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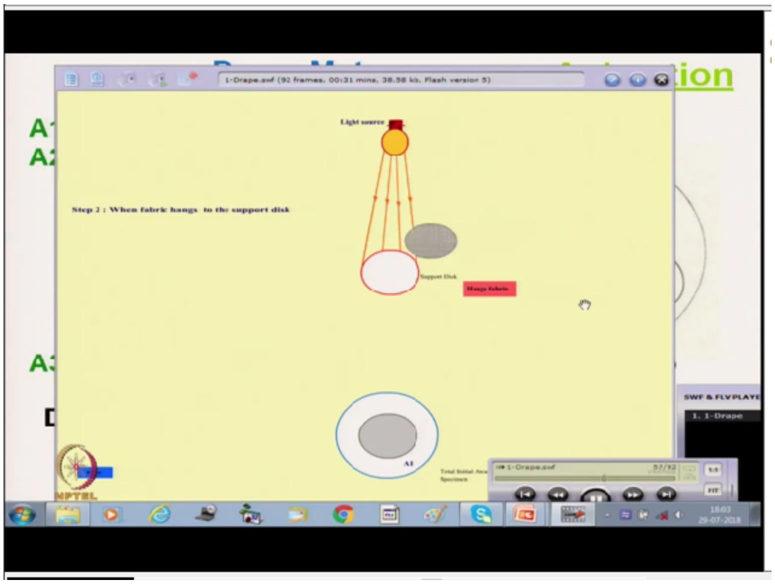

This is the support disc ok the stepper when there is no fabric ok and then we are trying to get the shadow of this support disc this is the shadow of the support disc ok that will. Next is that the hanging the fabric we had now placing the fabric on it. We are placing the fabric, fabric is hanging and now we are getting the shadow of the fabric.

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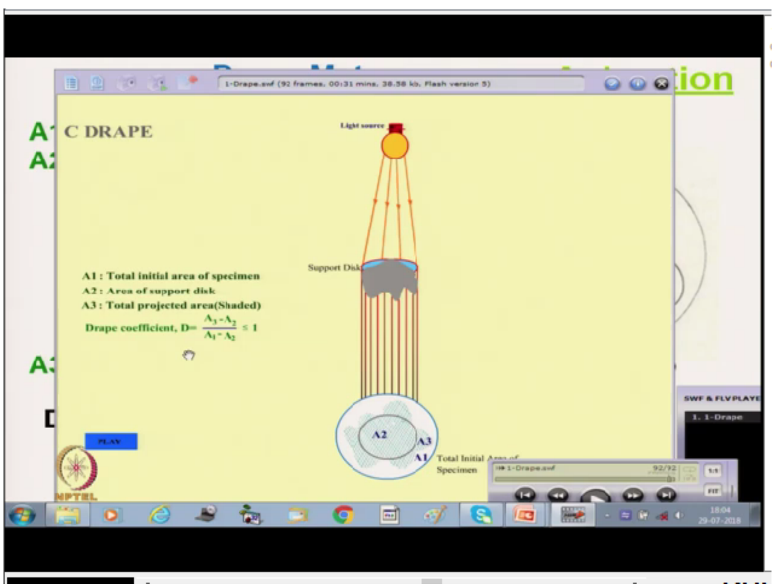

And we are calculating the drape coefficient now main problem with this system is that the light which is actually diverging. And actual area whatever we are getting it is not the actual area of the fabric projected area it has been actually enlarge this area is enlarge. So, that is why the sometime this keeps error value depending on the length of a distance from the light source ok.

And what we can do to eliminate this problem we can have 1 system where light is not diverging time.

Light will ne projected just exactly in parallel beam of light will be projected, then we will get the exact value of the fabric area.

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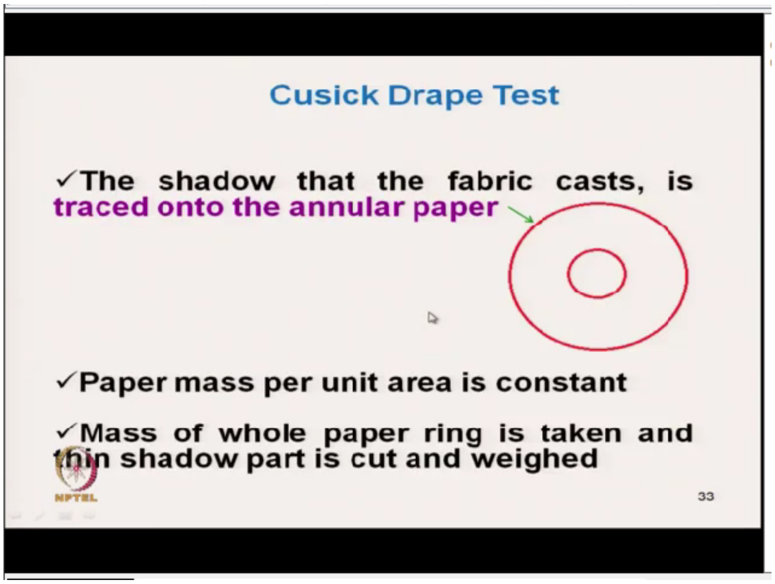

And that it is done by the Cusick drape tester ok Cusick drape tester is that the shadow that the fabric cost is traced on a annular paper where this is an annular paper. And the shadow we actually whatever it is casting it is that shadow we are just cutting out. Now this in this annular ring this is paper of known mass per unit area. So, mass per unit area of the paper is constant and this inner it is a whole this is the size of the support disc.

This is the support disc size and this is the size of the fabric ok and the shadow shaded portion we can trace and we can simply cut and then we can take the ratio. And mass of the whole paper ring is taken and the shadow part is then cut out and weight, so first the mass is taken then shadow part is taken ok.

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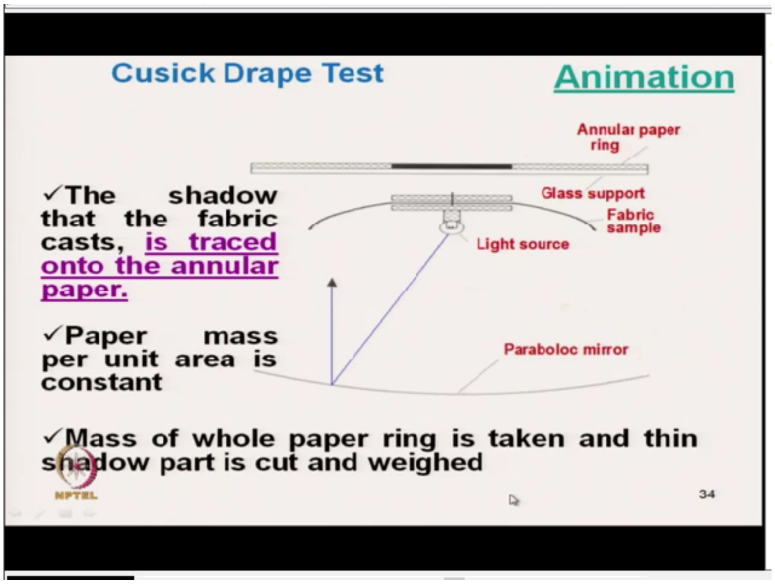

Now we see and then let us compare with other earlier process now if we take the mass of the whole paper that means what we are trying to take A1-A2 that is denominator we have taken the total annular ring ok. And when we are taking the mass of the total shadow portion and this cut out this portion the shaded portion. Then what we are trying to take it is a A3-A2 ok because this is the actual paper is annular, this is hole is there.

So, this projected length projected area we are taking because the paper the mass/unit area is constant. So, the ratio of mass is showing the ratio of the area, so here in this method if we simply take the trace the shadow and take the mass then it will be perfect it. And this the annular ring size is exactly as the size of the fabric because and size of the initial sample and as the light beam is projected a parallel light beam.

So, there is no divergence, so there is no extends that the enlargement is not there, so exact size is we can measure ok. Now the principle is the shadow that the fabric cast ok is traced on a annular paper. So, this is the annular paper is placed here above this here it is a the support plate ok support plate is here. And this area the annular the diameter of this annular paper is equal to the area of this support plate ok.

Now the paper mass/unit area is constant mass of the whole paper is taken and thin shadow part is cut out and weighed. Now if we see the animation and before that let me explain here, now the light source is at the bottom and here it is a parabolic mirror ok. It is a basically concave mirror is there and from light source light is divergent different source light divergent light is falling and then it is basically it is parallel light is being actual reflected.

And once it is a parallel light is reflected the this is the fabric profile and exact shadow of the fabric will be placed here ok and this exact shadow the paper the annular ring paper is placed on a glass support. So, why is it glass? because it should be transparent, so that it can light passes through and shadow can be is visible and we can simply trace ok and the from there we can calculate the mass.

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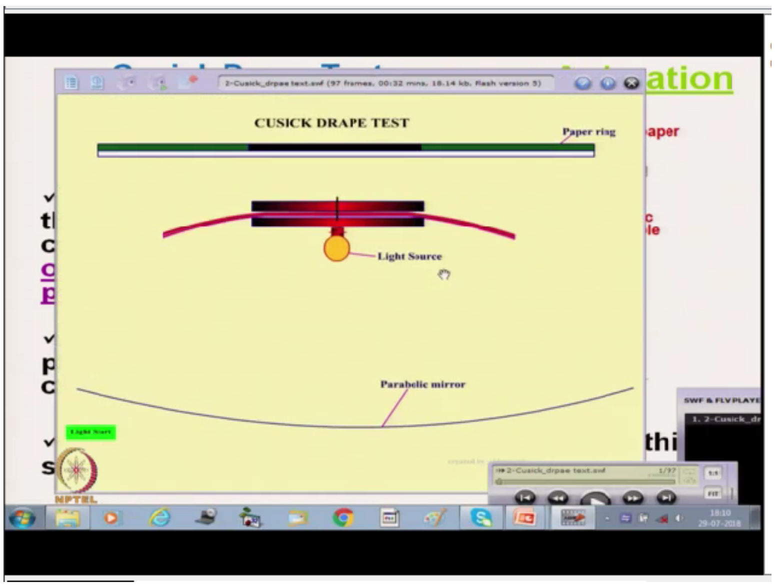

Now the light is actually falling the fabric sample specimen is just behind the light. It is not direct light is falling now it is now getting reflected and parallel light is getting reflected ok.

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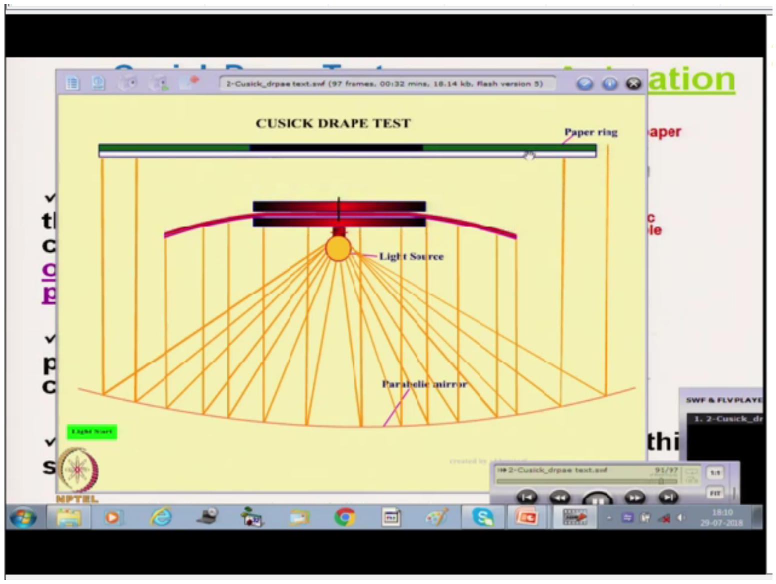

Now as the light beams are exactly parallel, so that there is no divergent the shadow we are getting here we are tracing here which is exact shadow of the fabric. And we take the difference ratio of the mass we will get the drape coefficient and expressed. And we can express in terms of factor also or we can express in terms of % by multiplying by 100.

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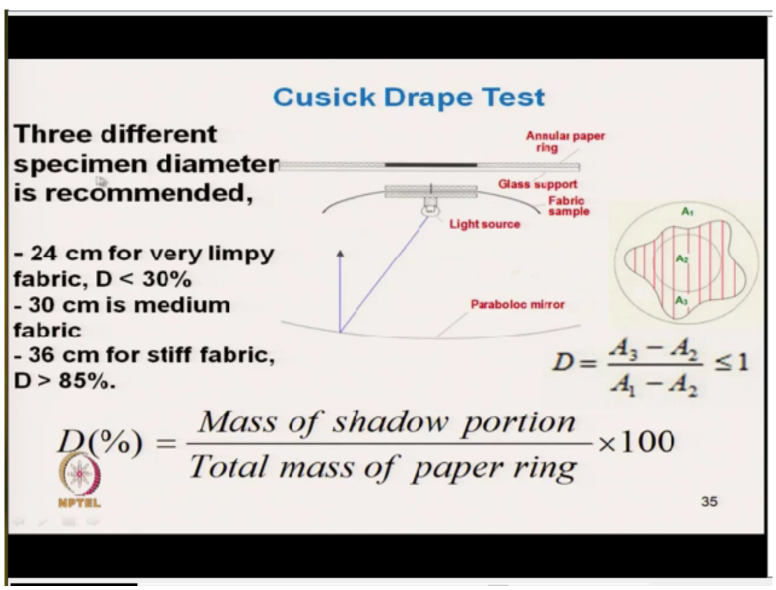

And 3 different specimen diameters is recommended ok when the fabric drape coefficient is very small. So, less than 30% 24 centimeter for very limpy fabric ok, for medium fabric is 30 centimeter and for stiffer fabric 36 centimeter. So, these are the various fabric sample diameters are given and then the drape coefficient we can measure ok.

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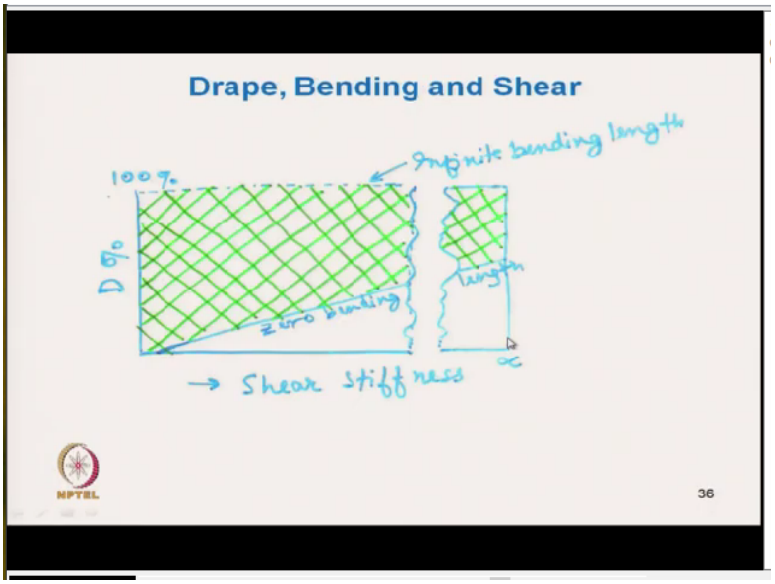

And last part is that there direct relationship diagram shows the relationship between shear stiffness, drape coefficient, drape % and the bending length. Now try to see one by one suppose a fabric is having zero shear stiffness. This is the zero shear stiffness ok, at zero shear stiffness if the fabric bending length that is bending length means it is highly flexible and the imaginary there is a zero shear stiffness there is a in that case the drape coefficient will be zero.

So, there that means it will simply fall as I have mentioned earlier zero drape coefficient. Now for say zero shear stiffness. If we increase the bending length we are increasing the bending length that means drape coefficient will increase. Now how do we achieve this type of situation now let us assume a situation where we have a fabric.

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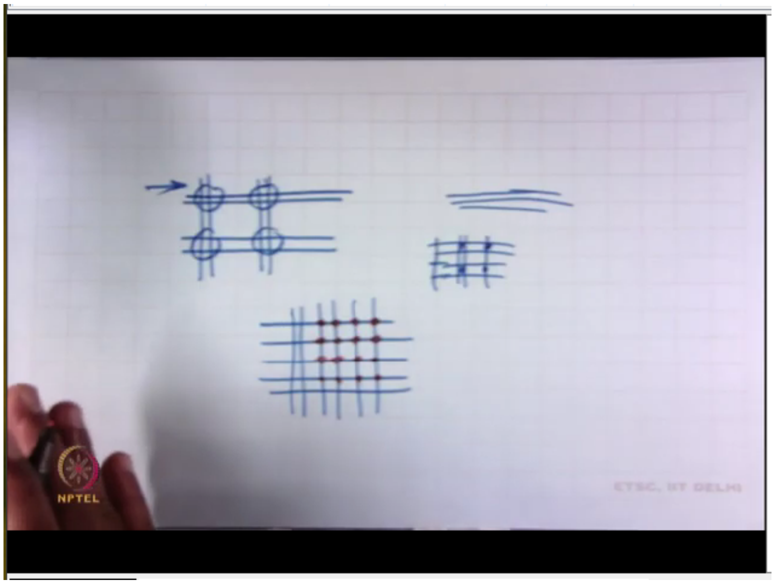

We have made a fabric with say rods highly polished extremely polished rods we are placed OK and this there is no friction there is a zero friction, zero friction between the rods. In that situation imaginary if we apply force, so there will be no shear stress, so that will this will simply slight there is no shear stiffness. But as the rods there are rod we can see we can assume the rods are highly stiff that means there is a infinite stiffness that means it will never bend ok.

So, bending stiffness is very high but shear stiffness is it is very low, in that case again the fabric will have 100% drape coefficient. Here the curve shows this picture shows that the fabric with say high **s** infinite bending length that means very bending length. And the shear stiffness even if it is 0 if we take the y-axis then bending drape coefficient as the bending rigidity increases from say 0 to infinite ok, then the drape coefficient will gradually increase.

Similarly suppose bending length is 0, means the fabric bends easily very flexible. But if we increase the shear stiffness gradually that means there is no the movement we are blocking. So, we can assume a fabric with zero bending length highly flexible bending length. But there actually there movement has been blocked ok, so, if we take a fabric with the very flexible fabric highly flexible fabric ok.

But what we are doing? We are actually knotting the this where actually we can assume the fabric with highly flexible. So, there is no bending rigidity very flexible fabric but what we have done? We have put gums at each and every we have joined we have actually this ends at this point. So, what will happen? This will not have any shear ok shear strain will shear stress will be high, so in that case but the fabric is highly flexible.

In that case the fabric will have certain values of the drape coefficient, so that is how this graph shows here the shear stiffness. If we increase gradually even if the bending length is 0 still the drape coefficient will increase. So, that means highly flexible fabric will not result the 0 very flexible very good look very good fall. In addition to the flexibility we have to incorporate the shear characteristics, if yarn cannot actually move fast each other then there will be higher drape coefficient.

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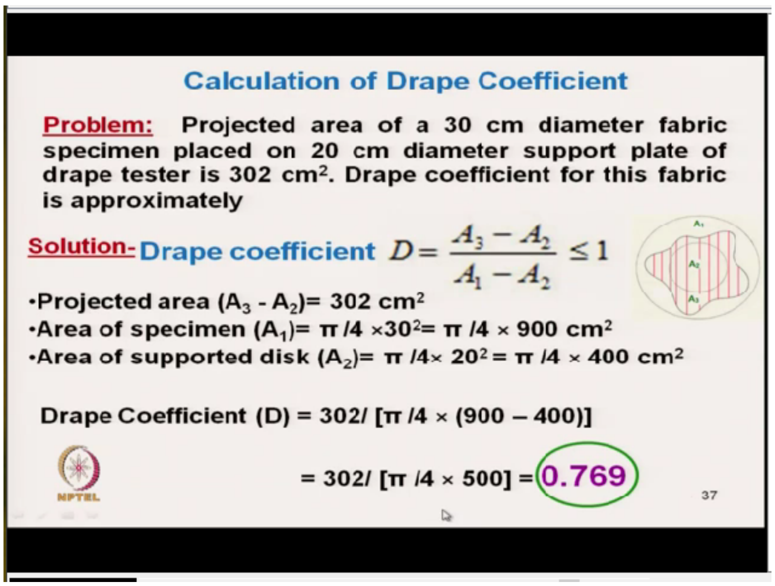

So, the problem here to calculate drape coefficient is that projected area of **3** 30 centimeter diameter fabric specimen placed on 20 centimeter support plate of drape tester is 302 centimeter square. Drape coefficient of fabric what will be the drape coefficient that means what is the projected area, projected area is means the shadow area-the area of the support disc that is the projected area.

Drape coefficient is known and the projected area is given which is nothing but A3-A2. This is given ok and A1 is the fabric specimen this 302 this is the 302 is the A3-A2 and diameter of fabric is given 30 and diameter of a specimen holder is the 20, from there we can calculate the

A1-A2. So, A1 it we can calculate, so projected area A3-A2 is 302 directly given specimen area is calculated pie/4 30 square that is pie/4 900 square centimeter.

And area of support is calculated pie/4 400 square centimeter and from there we can calculate the drape coefficient is 302/ the difference in this 2 areas. So, the drape coefficient is coming out to be 0.769 that is 76.9% is the drape coefficient.

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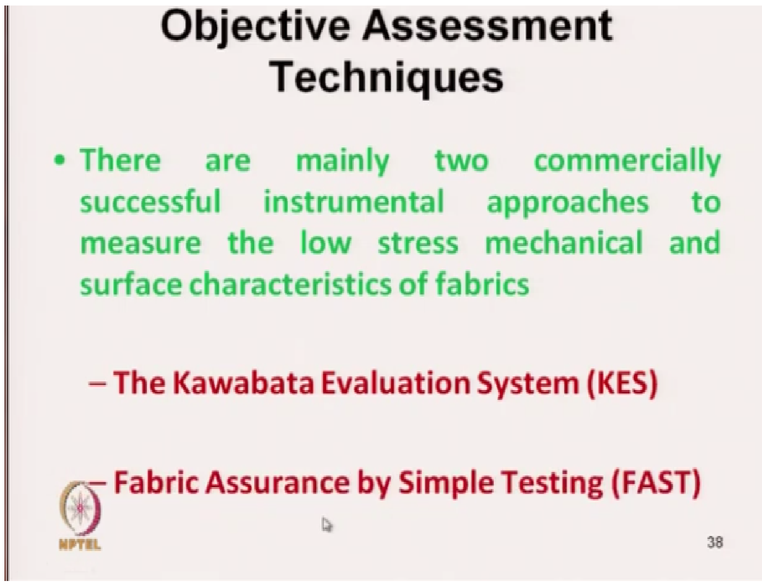

And in addition to this there are standard techniques the total systems of measurement of objective assessment of fabric handle. So, there are 2 instruments set of instruments are available commercially available ok and this those instruments the set of instrument measures the low stress mechanical and surface characteristics of fabrics, these are the Kawabata evaluation system for fabrics another is that fabric assurance by simple testing.

And in this course we will not discuss the detailed analysis or details of this instrument will just mention and in you will learn in the higher course. There will be another course that is the advance testing of textile material that course it is this things will be discussed.

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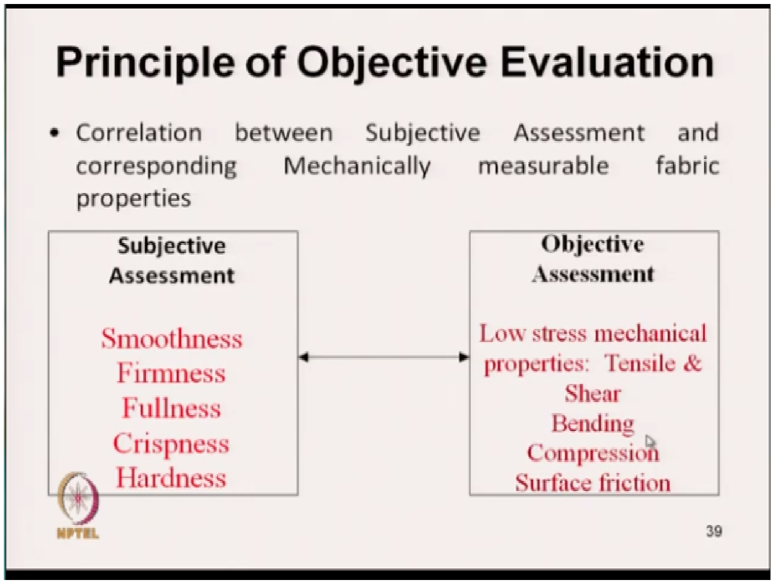

And the principles are the correlation between the subjective assessment and corresponding mechanical measurable fabric properties are that the subjective assessment tells the smoothness, firmness, fullness, crispness, hardness. These are the subjective assessments of the fabrics and those can be correlated with the objective assessments the low stress mechanical properties of fabrics ok.

The tensile characteristics, tensile and shear characteristics, bending strength, what we are try doing here. We will not actually it is not the high load will not be applied only the low stress mechanical characteristics will be evaluated here and the compression and surface characteristics will be measured.

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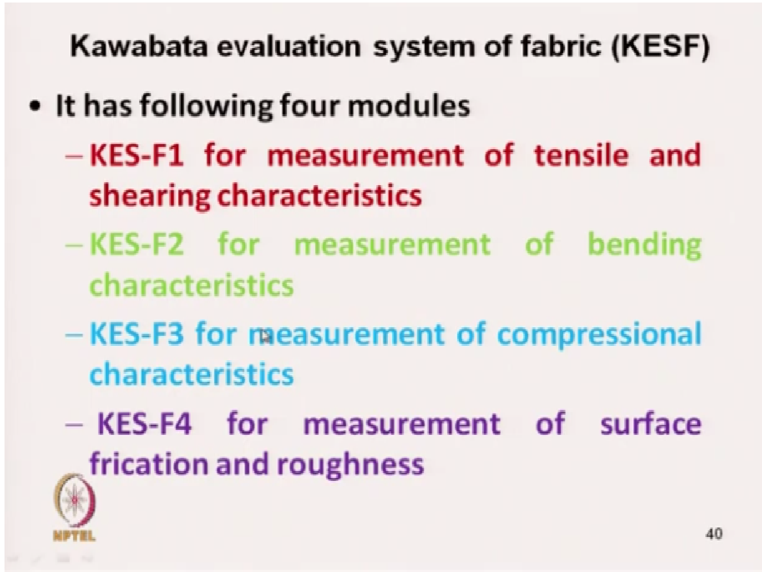

And there are 4 modules in Kawabata system KESF 1 or FB 1 for measurement of tensile and shear characteristics. The module 2 for measuring the bending characteristics module 3 measures the compressional characteristics and module 4 which measures the surface roughness and friction characteristics, so this 4 modules are there.

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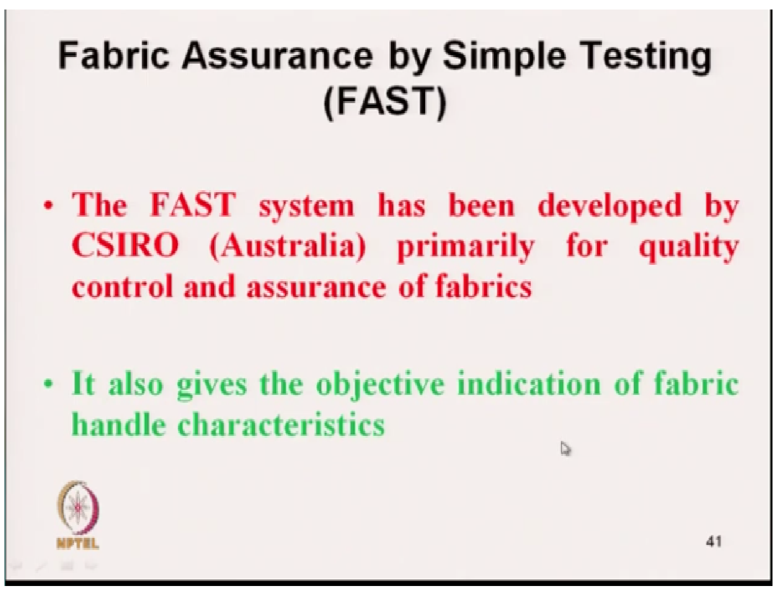

And similarly the FAST fabric assurance by simple testing which is developed by the CSIRO Australia and there the it gives the objective indication of fabric handle characteristics.

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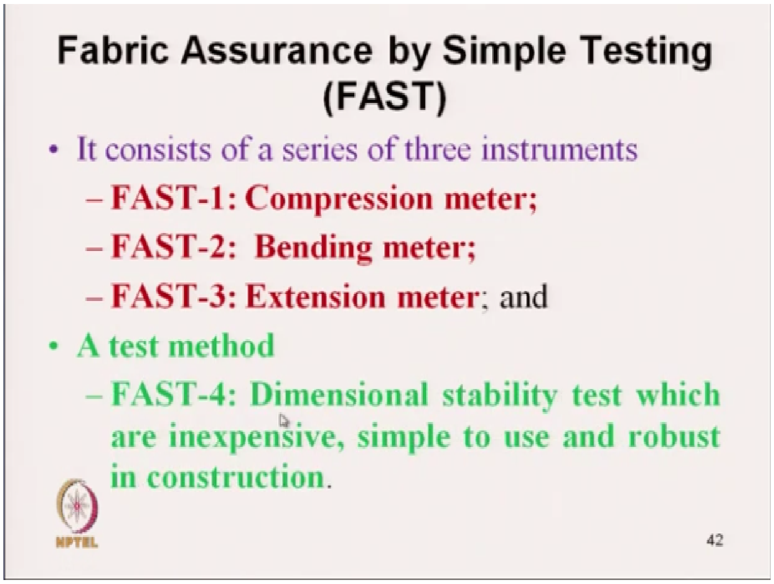

And there are basically 3 series of 3 instruments and 1 test method, so instrument FAST 1 is the compression meter which measures the compressional characteristics of fabric. Second one is the bending characteristics of fabric bending meter which actually works in the same principle of the Shirley instrument we have expressed we have explained here. FAST 3 measures the tensile and shear characteristics ok.

That is extension meter and FAST 4 is nothing but 1 test method which is which measures the dimensional stability of fabric and also hygral expansion ok. So, this all this detail will learn in other course and with this we will finish this course of evaluation of textile material and here we have discussed the all the characteristics from starting from fibre loose fibre, yarn, fabric ok and we have now come to know that different evaluation technique.

And they are implications how to actually interpret all this data ok that we have discussed this course will help you in your understanding in evaluation of textile material and till then thank you.