Evaluation of Textile Materials
Prof. Apurba Das
Department of Textile Technology
Indian Institute of Technology-Delhi

Lecture-39
Evaluation of Low Stress Mechanical Properties of Textile Materials

Hello everyone, so our today's topic of discussion is low stress mechanical characteristic of fabrics. So this will be the last topic in this course evaluation of textile materials. So in this class today what we will discuss the 3 main characteristics which are related to the low stress mechanical characteristic, one is bending ok, bending on its own weight, bending of fabrics on its own weight like this is the fabric ok.

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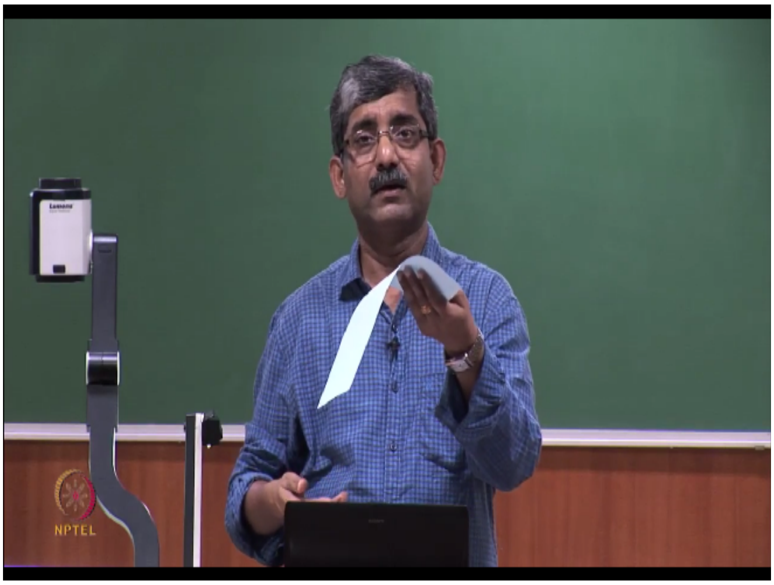

And if we let it hang and this like cantilever and as the fabric is flexible so it will bend on its own weight. So we will see the level of bending, see if a fabric is stiff it will not bend and as the flexibility increases this stiff point will bend gradually depending on the flexibility of the fabric. So that is one characteristic. Second is that the shear, the shear means when we apply force parallel to another x another surface ok.

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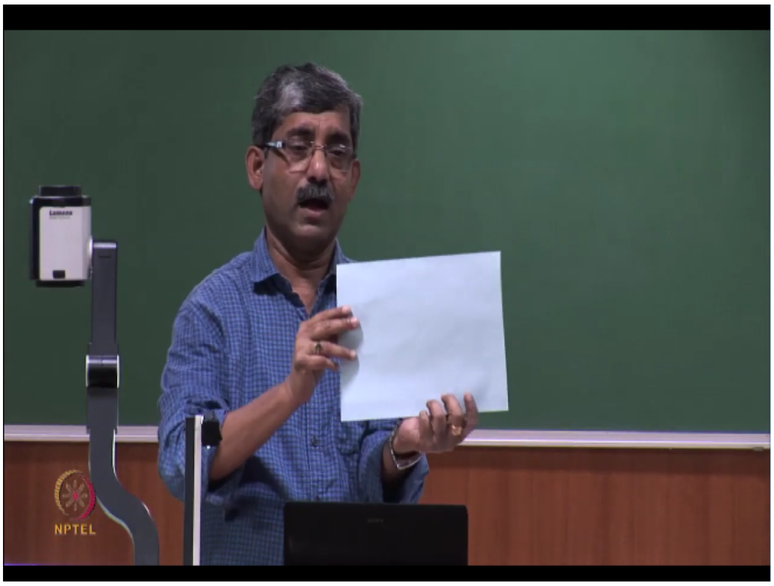

So that due to that force suppose this is the fabric and the fabric is actually griped at the bottom ok and then we are applying some force which is horizontal force and which is parallel to the other side. So if the force is applied then there will be the shear, so that shear characteristics will discuss here and this shear characteristics of textile materials which makes the textile material unique from any other sheet type material and any other flexible material.

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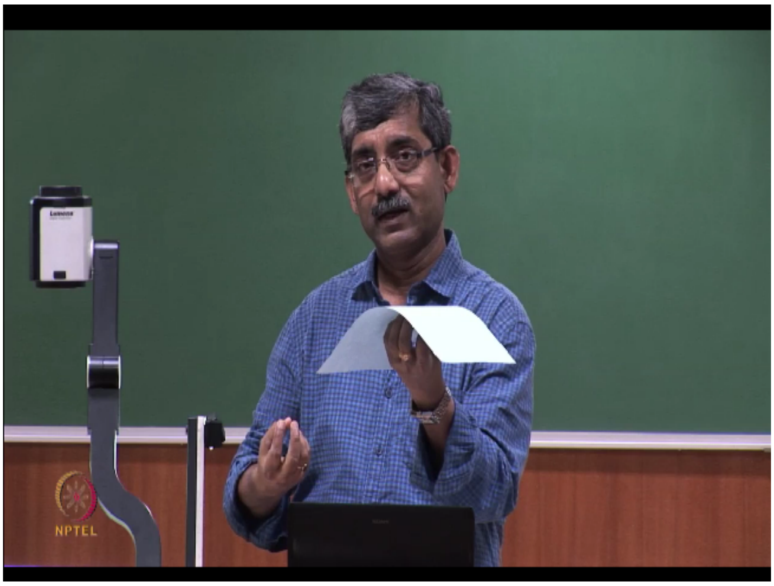

That we will discuss in detail and the bending and shear if we take together there will be another characteristic which is that its call drift. If we hang fabric so that the drift that due to that this drift characteristic fabric will actually hang and make a some actually fall it will have some look, so that characteristics is known as drift. This will discuss and this drift is actually related with the bending and shear characteristic of fabrics that how are that related this also we will discuss here.

And that will be the end of our course evaluation of textile material. Now first I will start with the bending characteristics. So low stress mechanical characteristics is our topic of discussion today.

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Now fabric handle if we see so far industrial fabrics performance characteristics are important ok, their performance characteristics means their tensile strength, abrasion strength. So this type of characteristics are important ok, their permeability ok. But for apparel fabric along with other characteristics the handle is extremely important which actually handle as you takes care of smoothness, roughness which is a surface friction type characteristic.

Stiffness, limpness characteristic that is our the characteristics of the bending and drapability ok. Drapability is combination as I mention the bending and shear characteristic. So this fabric handle is very important for apparel application. Now if we see the bending.

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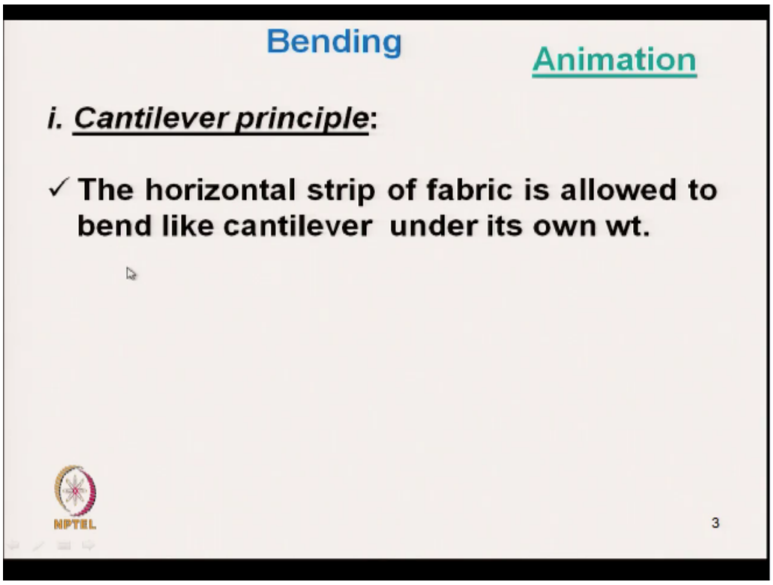

So bending is basically we can test bending characteristics of fabric in various ways and most widely used bending characteristic is the cantilever principle, measurement of bending is a cantilever principle where the horizontal strip of fabric is allowed to bend like cantilever under its own weight. So this is horizontal strip of a fabric and it is allowed to hang. So this is actually hanging and we will measured the tip of the fabric.

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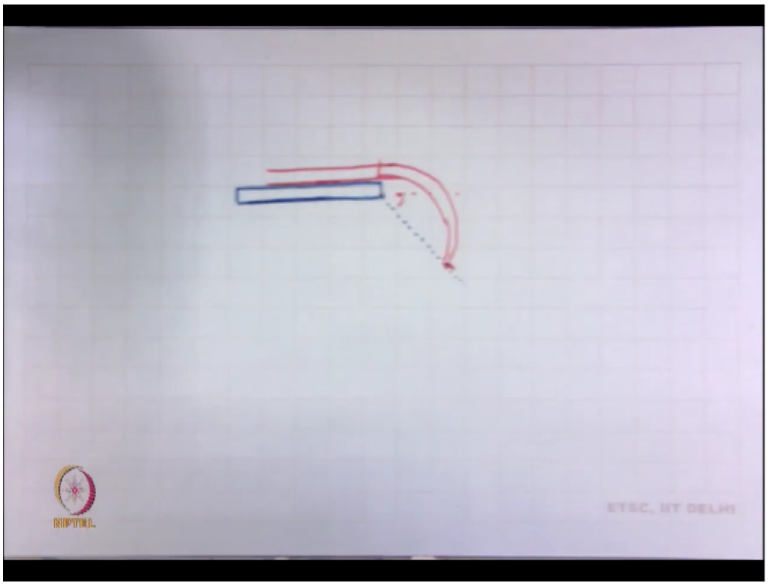

And when it is actually seen as a known angle at certain angle and from there we will try to calculate. Suppose this is a horizontal platform and we have certain angle ok, at angle we have certain we know this is a known angle and if we hang a fabric flexible fabric from this plate the tip of the fabric will make will it will hang and tip of the fabric will reach to a certain point of which is at which is making certain angle with the horizontal point.

And this distance total length of the fabric will be actually is a measure of fabric bending characteristics. So this is the principle which the instruments are Shirley bending strength tester is used this principle and this is a fabric.

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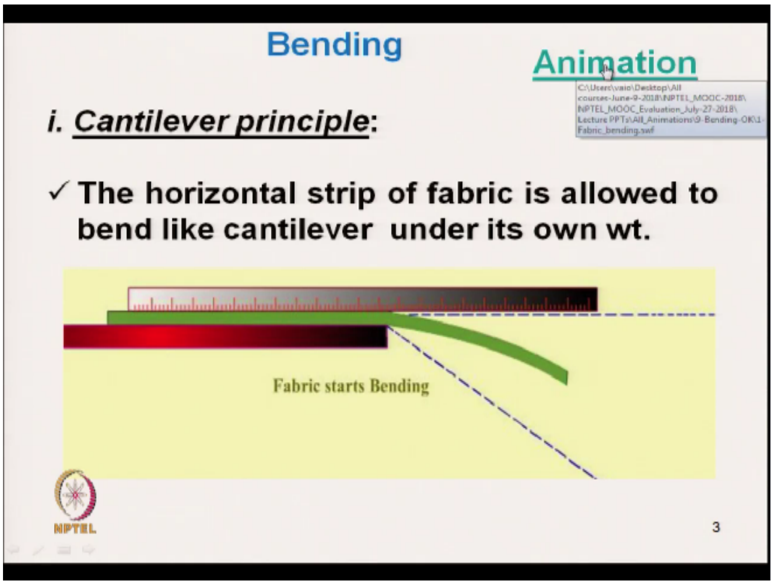

Now if we see this red colour it is a this is platform ok and green colour is a fabric sample specimen and the standard this scale is there where and then the fabric allowing the scale is actually pushed forward and gradually fabric will bend and bend up to a predetermined angle and when it touches with this line ok and then we can measure the length how much fabric length is being actually hang it is called overhanging length.

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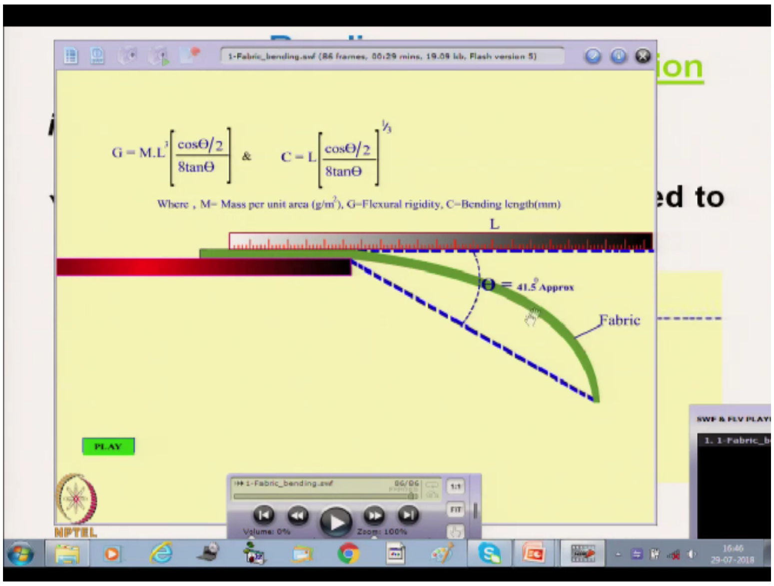

That length we can calculate directly from this scale ok. Now if you see the animation here this is the starting point where the platform end of platform the fabric and the scale are exactly in line with their coinciding and the fabric is actually we are moving the scale along the fabric is coming out and this is the standard line ok. This line I will come and at certain angle and this is hanging and its hanging and after certain time after hanging for certain time this point is reached and which is actually as per the standard.

This angle is 41.5 degree why is it 41.5 degree that I will discuss in detail and this angle this length is measured. This length is actually expressed in terms of bending length C and there is a relationship between this bending length and actual overhanging length, actual overhanging length and this is Lxcos theta/2/ 8tan theta power 1/3. So this is the relationship and this empirical relationship gives the value of bending length.

C is the bending length, L is the overhanging length and from by knowing this values we can calculate the this is a G flexural rigidity of fabric and M is the mass per unit area of fabric, L is overhanding length and this is a function of theta. So function of this angle. So this is the angle and for standard testing instrument and this value of theta is 41.5. Now so this is that, so ahh the overhanging length and the bending length may be different ok.

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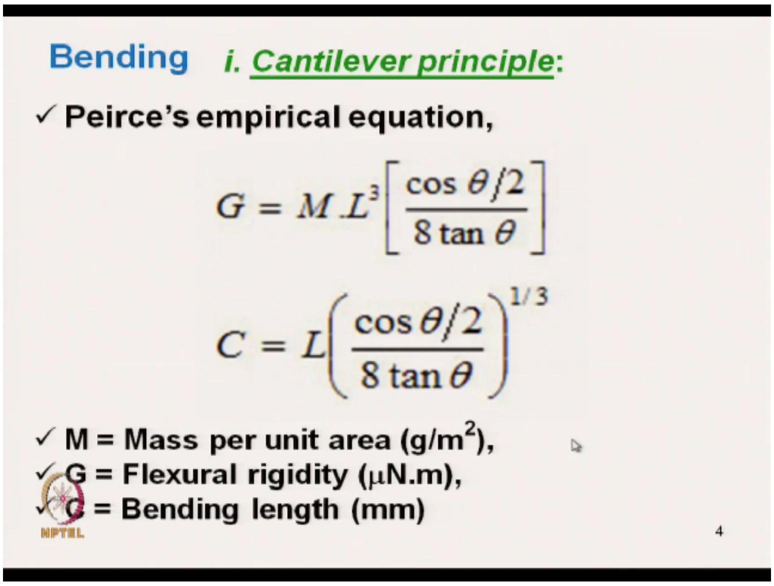

Now Peirce's empirical equation as I have shown earlier, so this are the 2 empirical equations which Peirce has actually proposed and where M is the mass per unit area of fabric gram per square metre and G is directly we can measure the flexible rigidity of fabric, flexible rigidity is micronewton x meter micronewton metre and this we can have ahh with other units also and C is a bending length.

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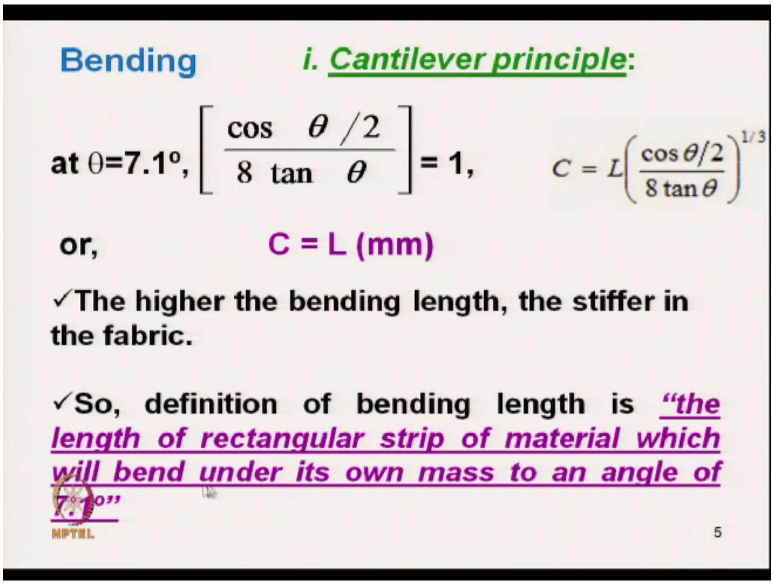

Bending length and bending length and overhanging length they are related with this this equation what this formula ok. Now in if we use the value of theta as 7.1 so if you use 7.1 as value of theta then cos theta/2/ 8 tan theta it will be equal to 1 ok for theta value 7.1 this value will be this that right side this function of theta will be as 1 ok that means C will be equal to L what does it mean.

So that means the overhanging length is equal to the bending length. So building length we can then define bending length so the hire bending length means the stiffer will be the fabric. So if we do we may now know the overhanging length but bending length is the characteristics because the bending length actually is although dependent on L but it is related with the theta.

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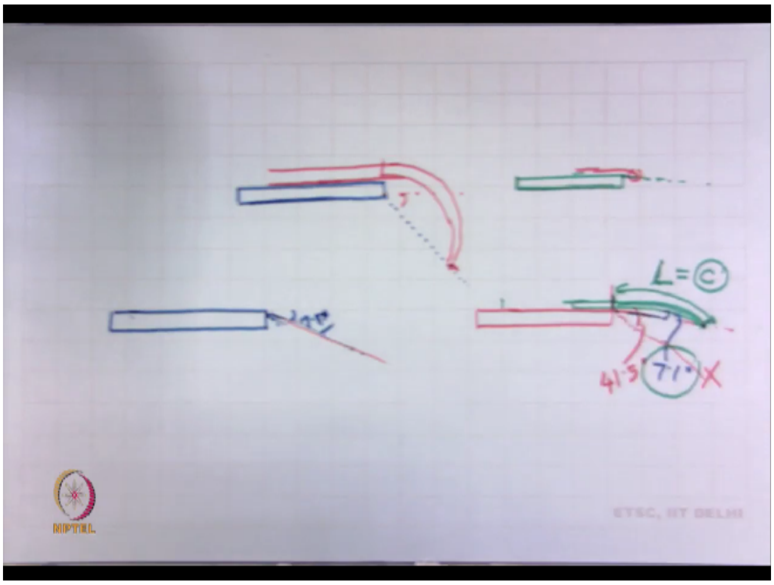

Now if we try to define the bending length it is the length of rectangular strip of material which will bend under its own mass to an angle 7.1 degree. Now so this is a platform ok, now what we are drawing we are drawing the length at angle as a 7.5 very small length so it is a 7.1 degree**.** This length, now this angle ok 7.1 degree angle I am drawing 1 line. Now here actually 7.1 would be much less than this.

So I can withdraw it again ok this 7.1, now this 7.1 degree, now if we now take fabric sample specimen rectangular fabric specimen and we are trying to it is hanging the tip of the fabric is touching is making touching with the line which is making 7.1. This is a imaginary line and this length whatever this overhanging length L, so L this is actually will be equal to C.

Now C is the bending length by definition, now if you want to calculate the bending length then it will be very simple we take an imaginary an line of 7.1 degree below the horizontal plate horizontal platform and we simply hang the length and which when it is actual tip is touching with that line imaginary line that whatever the overhanging length L will be actually it is it will be defined as the C which is the bending length.

But in normal in ahh the bending test bending testing instrument this 7.1 degree we normally do not use what we use, we use the value 41.5 degree that we have already explained. So in this animation of seen the angle is basically 41.5 degree. This is the angle in normal it is a in is it safe 41.5 degree ok. Now here why is it 41.5 degree and why not it is a 7.1 degree.

Now if it was 7.1 degree then our calculation would have been very easy whatever the value overhanging length it would have been equal just equal to the bending length but in problem with 7.1 degree is that fabric specimen actually there very limp. So there as there very limp so that it will make immediately within very short length it will make 7.1 degree ok. So ahh for very flexible fabric.

Suppose we take any say fine fabric, we are not talking about the stiffer fabric for any fine fabric or apparel purpose use, if we try to actually hang, when we hang and this will immediately reach 7.1 degree and there in that case measurement will be difficult. So that is why we do not use 7.1 degree as a that this angle, we use 41.5, the angle which is higher than this. This is say 41.5 degree.

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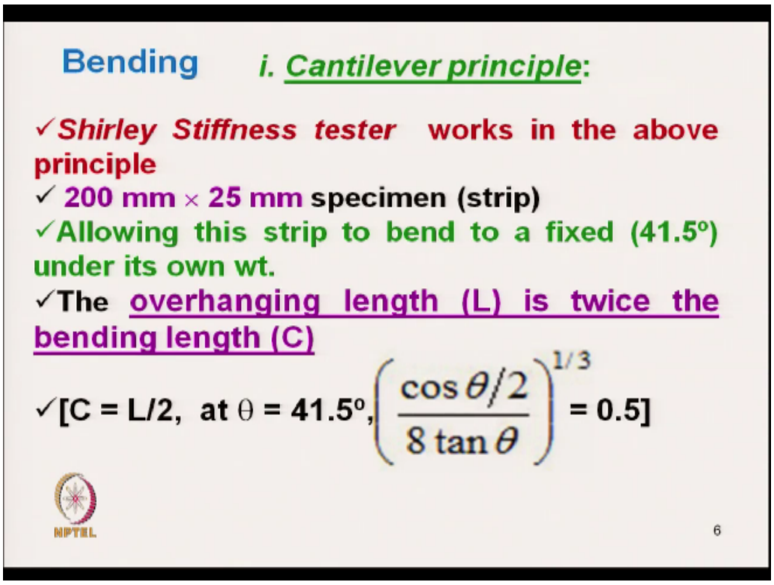

So that the overhanging length will be little bit higher, so that it is a measurable, you can measure that length and why it is 41.5 degree, this is because that Shirley stiffness tester it works in the same principle that is cantilever principle, the size of the specimen is 200 mm/ 25 mm width ok, allowing the strip bend to a fixed line ok the which is 45 degree below the horizontal line.

So that angle under its own weight and the overhanging length is twice that of bending length ok, why is it twice because in here if we use theta as when 41.5 degree in this equation so costheta/2/8 tan theta it is exactly 0.5 to the power 1/3, this value will give us a value which is 0.5 and why 0.5, 0.5 is a value which is easily measurable that means in Shirley stiffness tester the scale which we use which is actually the which shows directly the this value of this bending length we get the value directly bending length.

But the scale which is shown so in that in Shirley stiffness tester what we do suppose this is 41.5 degree Shirley stiffness tester and here what we see after the above this fabric we are placing we place the scale this is a scale and this is now let me draw once again, this is a fabric and how it is you talking about at angle 41.5, the fabrics have specimen which is show in green colour.

This is the fabric specimen and here the fabric had been pushed along with the scale this is the red colour it is a scale ok, the scale, now the scale if we see it is actually it is gauze and say millimetre and it is centimeter. Now if we see the scale here it is a it is centimetre 1 cm from here say which is 1 cm 1 cm like this. Now if we see carefully the scale the scale is exactly double the actual one.

Where the 1 cm swing it is actually it is a if you see the length this length is 2 cm length that means the factor 0.5 has been taken care of and here the scale is guessed in such a person directly you do not need to even divided by 2, so it is giving directly the value of the bending length. So this is the way. So here the whatever the scale is read a scale is reading is there this will be actually L/2 overhanging length/2.

If the overhanging length is a 10 cm, so it will directly it will have add so in incorporate the factor 0.5. So if it is 10 cm overhanging length in the instrument it will show 5 as a 5 cm as a reading which is directly which shows the bending length ok. Now this theta value with if we know that we can calculate the relationship between the bending length and this overhanging length ok.

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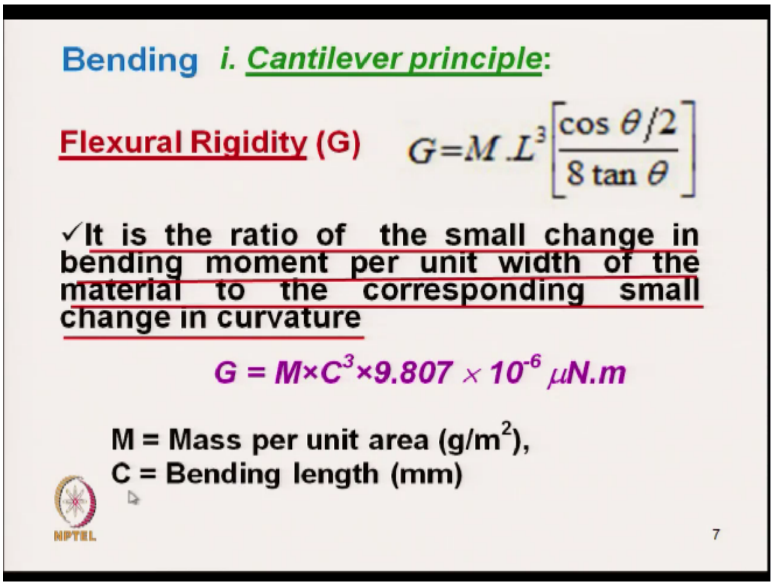

So flexural rigidity, it is we can also calculate by using this formula if we know the angle is known L is known ok and then mass per unit area if we can know. So in that case we can calculate L is actually is calculated if you know the overhanging length, it is the ratio of small change in bending moment per unit width of the material to the corresponding small change in curvature.

That is the basic definition of flexural rigidity of material ok and now this is the G value flexural rigidity if we know the bending length and the mass value mass per unit area. So that we can calculate the G value, G it is actually just converting this equation from ok mass per unit area M G is a bending length in millimeter.

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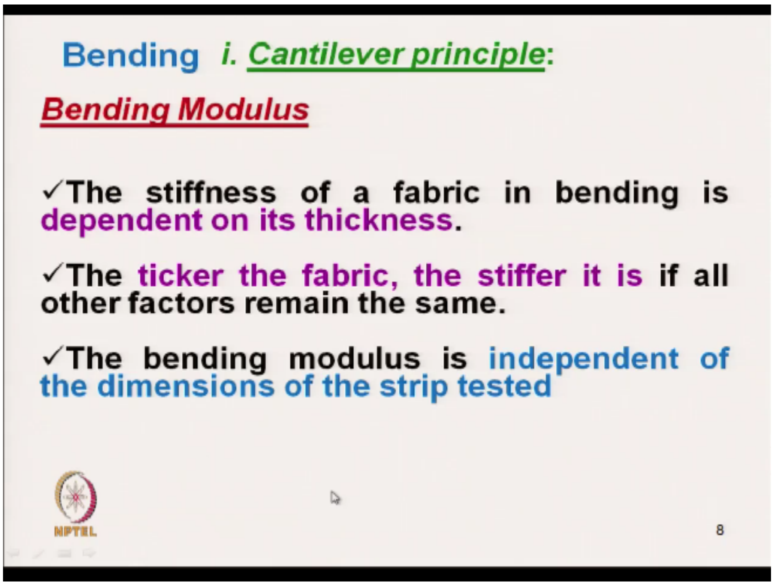

And bending modulus it is of the stiffness of a fabric in bending is dependent on the thickness. So we can compare we can actually get the value it is just for counter for comparison of fabrics different fabrics of different thickness. So we can use so the thickness of fabric the thicker the fabric the stiffer is the it is and if all other factors remain constant. So to compare the fabric of different thickness.

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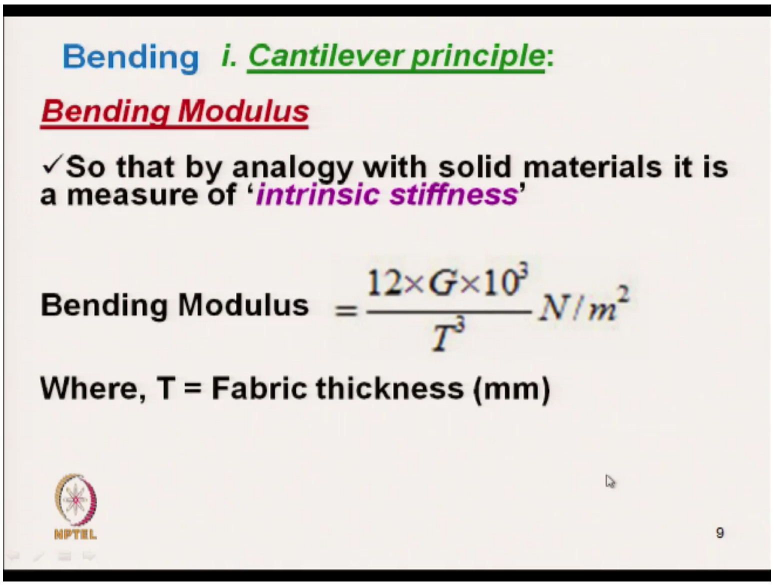

So we can get ahh another parameter which is bending modulus and the bending modulus is independent of dimensions of the strip tested and this is so that by analogy with the solid material it is a measure of intrinsic stiffness and which is nothing but this giving this formula where flexural rigidity is divided by T to the power q where T is the thickness of fabric and this is the formula 12G 10 to the power 3 by T cube, but T is in terms of millimetre it is in newton per metre so just conversion of unit.

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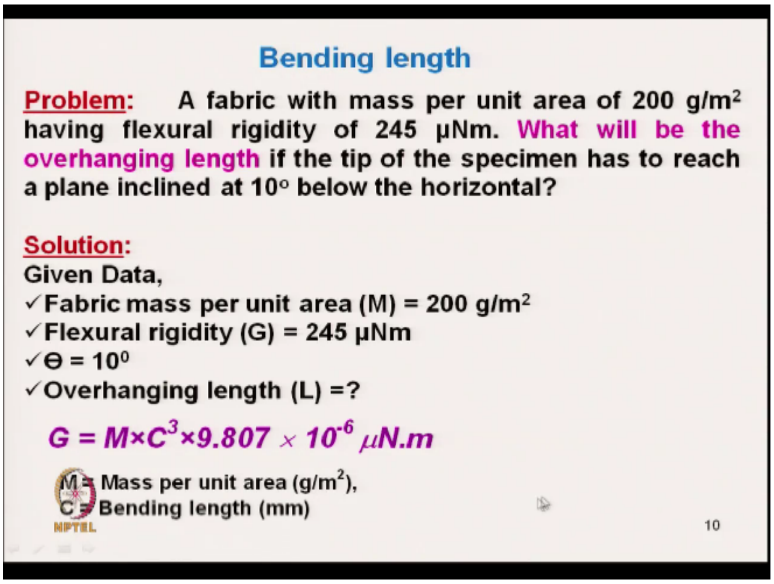

And will try to let us try to solve couple of numericals which are very simple just for getting idea about how this fabric mass per unit area and flexural rigidity are related just it. Now a fabric with mass per unit area of 200 gram/square metre having flexural rigidity of 245 micronewton metre. This is the flexural rigidity and what will be the overhanging length, that is the question.

If the tip of the specimen has to reach of plane inclined at 10 degree below the horizontal plane ok that is the and we know the fabric characteristics and we want to calculate the overhanging length. So this at the problems with sometime we need to know for some specific application. So what it is asked that we actually we gradually push the fabric and we allow it to hang on its own mass.

And on its own weight when it is hanging so it will actually gradually as we change the increase the overhanging length. So the angle will be gradually increased. So suppose here we suppose this is a platform we are using this is a overhanging length, now we want to know that at what overhanging length, this is the overhanging length the fabric will tip make an angle of 10 degree ok.

So in that case the other characteristics are given, the stiffness is with the mass per unit area is given and flexural rigidity is given and using the simple earlier formula M is given here. So flexural rigidity is given and our you know the angle theta and we have to calculate the L value. Now G is this is the formula G= MCx9.807*10 to the power -3. This is the formula we know and the mass per unit area is given.

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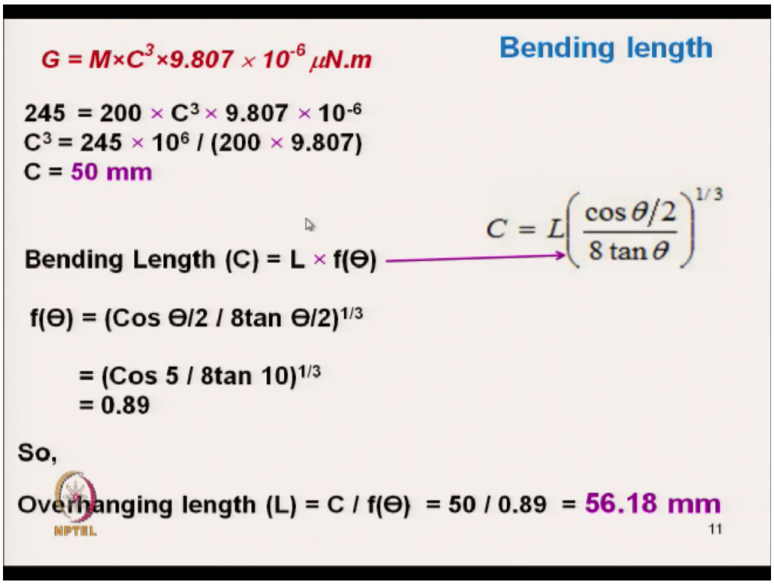

So C is the bending length ahh from where we can calculate the C value, the C value is it is a 50 is the C value what is that C,C is the bending length and we are here our requirement is that we have to calculate the overhanging length. Now from bending length we can this is the relationship so L is the overhanging length where bending length is equal to L and it is a function of theta and this is nothing but effects f theta is nothing but this other.

This cos theta/2/ 8 tan theta power 1/3, this is the function of theta and from where we can calculate the f theta, if theta is nothing but your tan 5/8 tan 10. So theta is basically this is 8tan theta not tan theta/2, 8 tan theta this is a formula. So tan cos 5/8 tan 10 ok power 1/3. So it is coming out to be 0.89, so if we get the ahh function of theta is F9 this constant this value if we get then we can calculate the overhanging length of this is that means it is of 56.18.

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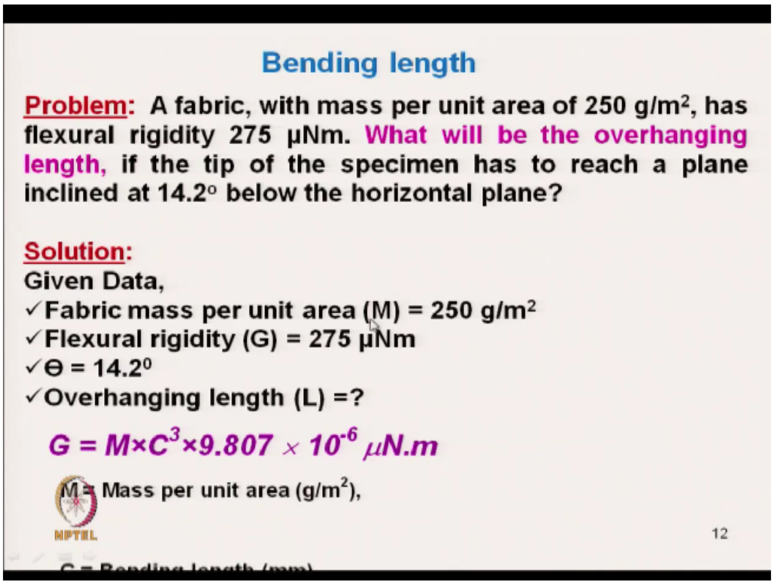

Now what does it mean, here the C value C value is related with the this is the flexural rigidity and 200 is the mass per 200 is mass per unit area and G is the flexural rigidity 245. Now here from this equation it is very clear that the as the mass for keeping everything constant, if we increase the mass per unit area then C value will drop and C if C value is reduced then the overhanging length will reduce.

That means keeping the fabrics flexural rigidity same, if we use heavier fabric then that fabric will actually simply hang quickly that means overhanging length will be less. But the for same fabric same mass per unit area if you increase the flexural rigidity that means directly the value of C will increase and overhanging length will increase, that means for same fabric same mass per unit area the overhanging length or bending length.

This actually the source directly the bending characteristics of fabric, now the same similar problem here it is a just data have change the mass is becoming 250 gram per square metre and the flexural rigidity has increased the mass has increased, flexural rigidity has increased and the angle required is 14.2.

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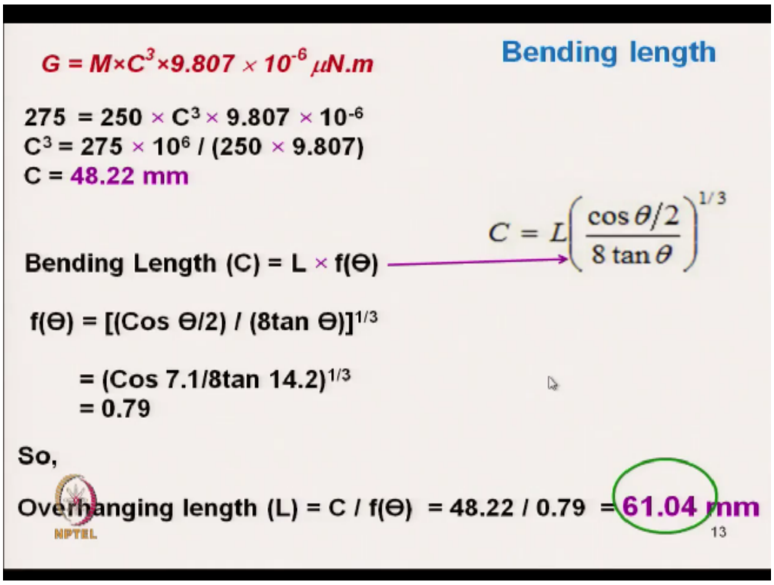

So that ahh at the same way we can calculate here and here in this case the C value is 48.2 to and the overhanging length is function f theta=cos theta/2/8 tan theta, so that we have we can use the theta value its 14.2 that means cos 7.1/8 tan theta tan 14.2. So this value is given 0.79 and we can calculate this is the overhanging length. So for given values we can calculate the overhanging length or the bending length ok.

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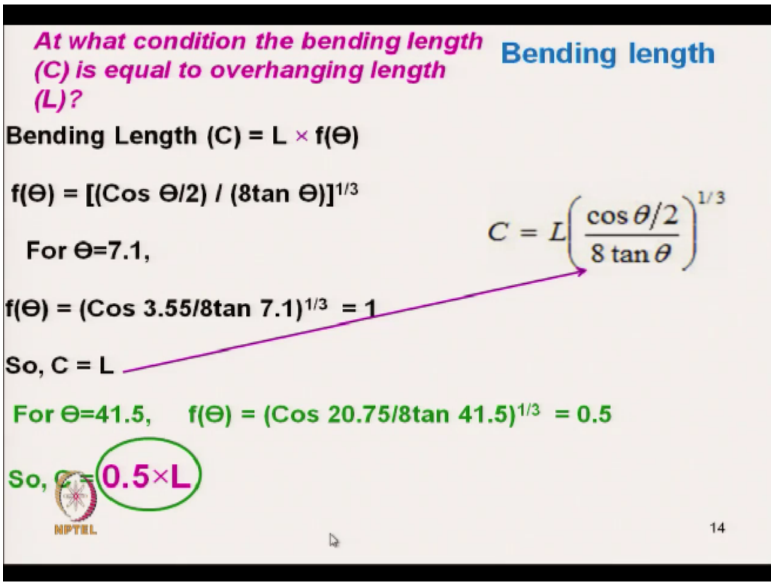

Now the problem we can solve we can use this equation and we can quickly get the bending characteristics because we if we calculate if we get the C value ahh the bending length that means it is indirect it is directly its showing the flexural rigidity of fabric and if we know the C value we can calculate the flexural rigidity by using this formula for certain give mass per unit area.

Now this is ok for normal fabric with the which are with certain stiffness, but when we think of a fabric which is very limpy fabric very flexible fabric. Now this fabric suppose this is having certain stiffness that is why its tip of the fabric is making certain angle and that angle it is making after certain overhanging length. But if we immerse in a fabric of knitted fabric knitted fabric highly flexible particularly white printed fabric plain white printed fabric.

It is flexible that means when we are trying to overhang it will not make any such car ok it is not bend it will simply follow fall through the platforms, so at any angle it will fall. So that means it is not possible to measure the bending rigidity by this cantilever principle. So there we require different principle of measurement, there are different types of principal. So this I will discuss now.

Before that if you ask at what condition the bending length C is equal to the overhanging length as I have discussed, so this if we see if we can make it unit then this will be the if theta is unit then bending length will be equal to 10. So this is possible only when the theta value is 7.1. So that the why we do not use 7.1 in the instrument that we have already explained.

So this is because and this is the condition if it is asked which condition at which condition C is equal to 1, that is only condition where theta becomes 7.1 ok and for machine instrument we use 41.5 because here its actual rounded how hallow which is 0.5 is reached ok, and this is the equation this is the relationship we used in almost all the cantilever type instrument that is 41.5.

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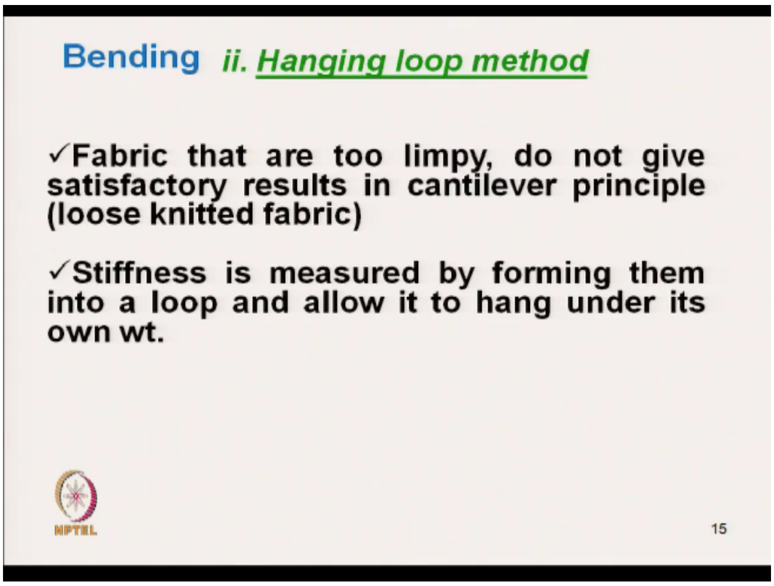

Now as I have explained this technique is used when where that the proper bending is actual that certain length will be required to bend ok but for very limpy fabric we request this is for Shirley and stiffness tester and for we use different types of techniques ok. This techniques are basically there are 3 different techniques and this techniques are the fabric that are too limpy do not give satisfactory result in cantilever principal.

So use knitted fabric, the stiffness is measured by forming them into loop so that is the hanging loop method ok and allowed it to hang under its own weight. That is the process of measurement because limpy fabric if we cannot use the straight cantilever principle. So there the length of the trip is say L suppose this is the strip and we have make made the leaf this is the L is the length of the strip.

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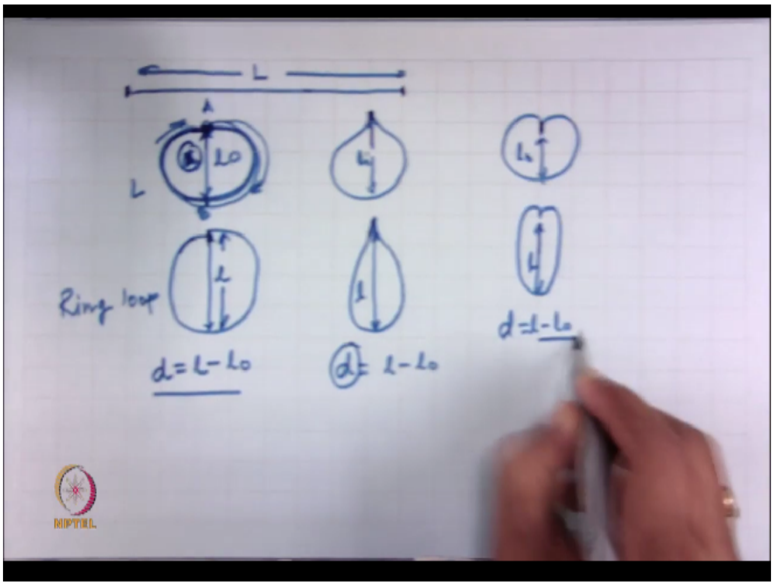

And we can form the loop in 3 different ways. Now this is the length of the fabric sample specimen, so this is L now we can form 3 different types of loops one is called the ring loop, this is the one end, this is end 3 and you are forming just we are making a ring and we are holding this part without any hold, so this is then perfectly circular ok and from this point ok we are making we are measuring the distance here with the extreme point.

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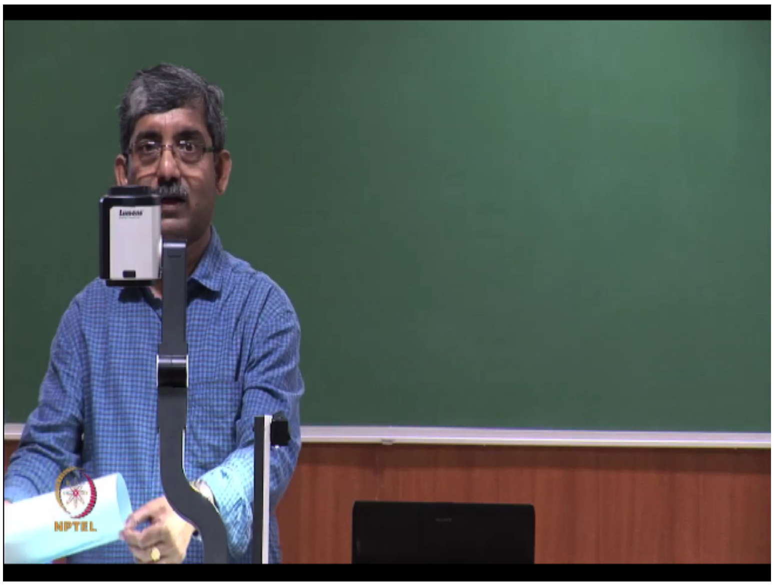

In this case this distance is nothing but diameter of the circle ok, now if we see this is the fabric and we are trying to make a ring forms, this is the ring forms ok you can this is the ring form and this ring ok this ring is nothing but it is a fabric ring, in this form we are forming the ring and the ring the length of the ring that is circumference of this length circle is nothing but L ok and this without any mass ok without any it were not hanging.

Now if and we have just form that this way ok ring and this ring once we are hanging we are hanging and this on its own mass there will be certain deformation of this ring. Now this ring will get deformed due to its own mass ok, this is a point day A point and now this extreme point B has been changed due to its mass there is a deformation and this is suppose this is the distance.

And here the diameter suppose this is the length L0 and here it is a length L so initial length L0 and after hanging this is the length L. So the total deviation defluxion is measured with d which is nothing but L-L0 ok. This is the ring loop ok, another type of formation we can make with the same length we can make in the form of pear the pear only this formation is known as pier loop ok.

Just we take the same fabric sample and we are making this type of ok, this is the piere formation and this initial distance from this point to this point we can measure as L0 without any deformation this is the length ok, distance now we are hanging it and on its own mass this will be hanged depending on the flexibility of fabric the distance will change.

And it will be like this is a function L is the formation and this deviation which depends on the flexibility of fabric L-L0 ok and as the flexibility increases this d this d value will increase this is pear loop ok another loop formation which is known as the heart loop we can form the fabric in the form of heart ok. This heart loop is there that we can measure ok and this heart loop from where we can measure the distance from this point extreme point.

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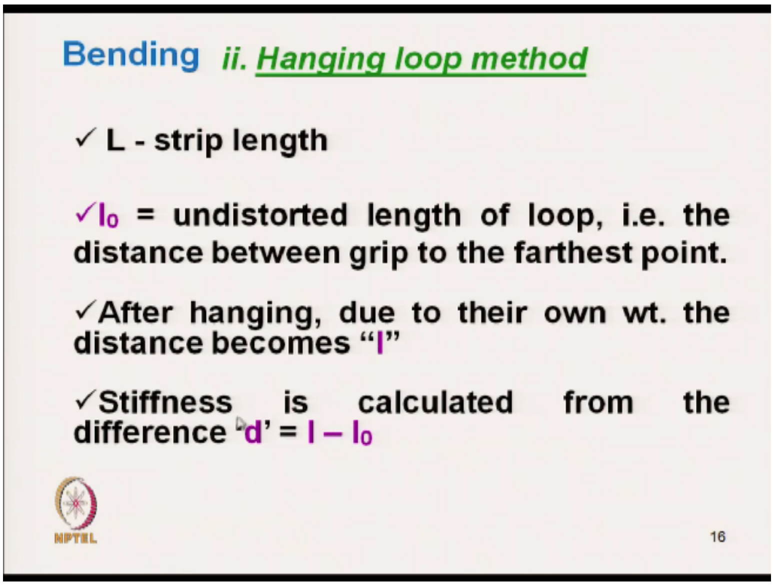

It is a L0 and on its own mass if it is deflected this will be L and d is L-L0 ok and accordingly we can use different formula, so L is the undistorted length of the loop from the holding point grip point to the farthest point and after hanging it has become L and d is deflection.

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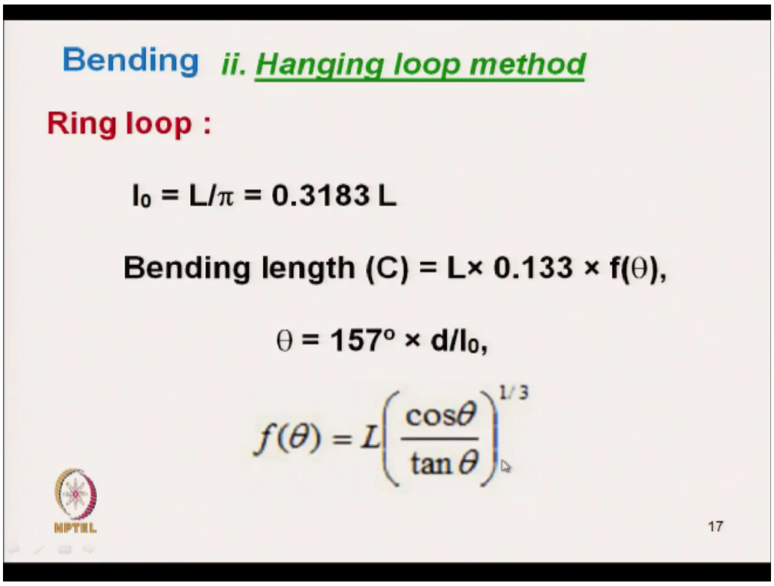

And using different formula for ring loop this is the formula standard formula is given some empirical formula and we can get theta value and we can calculate the bending length using this formula and similarly L this one.

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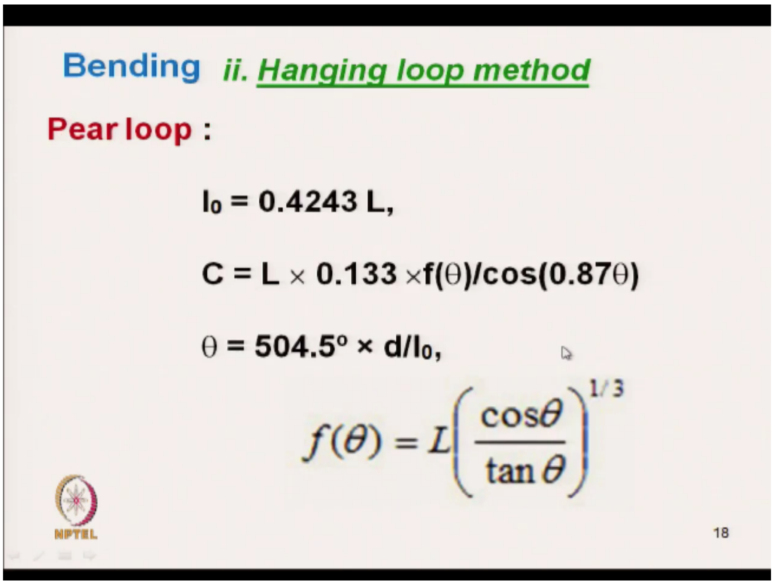

Similarly for pear loop this is the formula we can just use this formula directly we can calculate the C value where function of theta is this.

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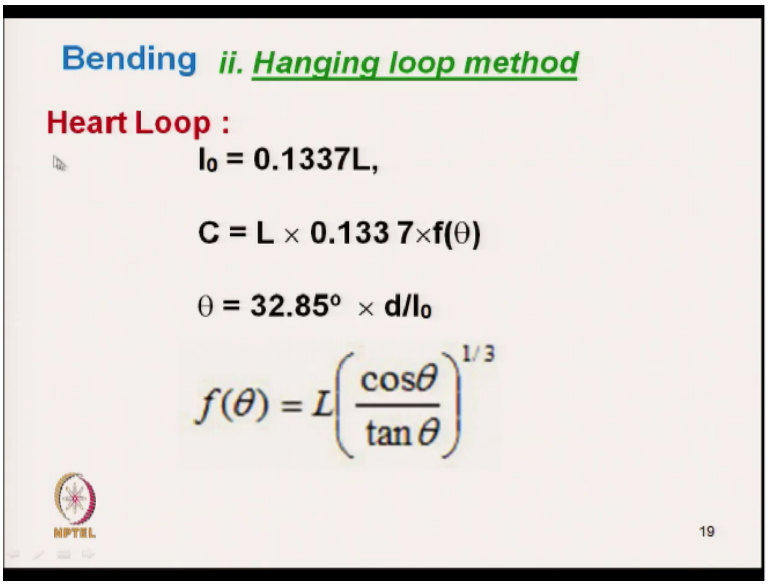

And heart loop this is the formula ok, so using this formula we can calculate the bending length for different types of loops ok. Now I will stop here in next we will start the shear characteristics, till then thank you.