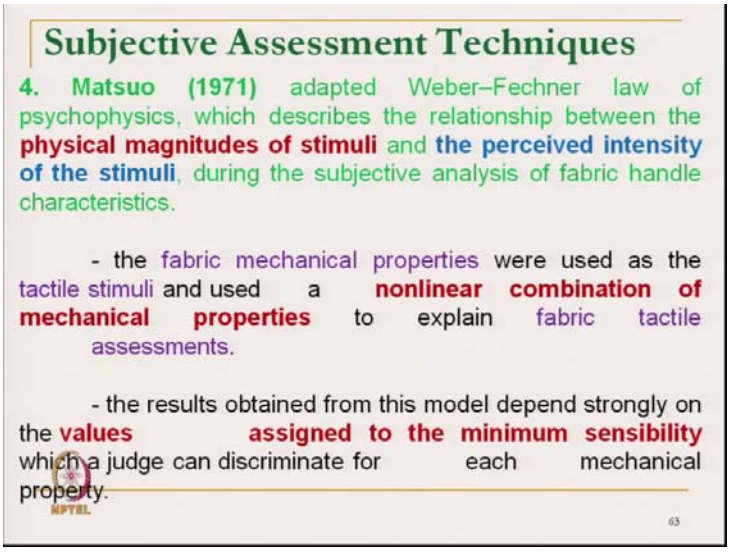
**Science of Clothing Comfort**
**Prof. Apurba Das**
**Department of Textile Technology**
**Indian Institute of Technology, Delhi**

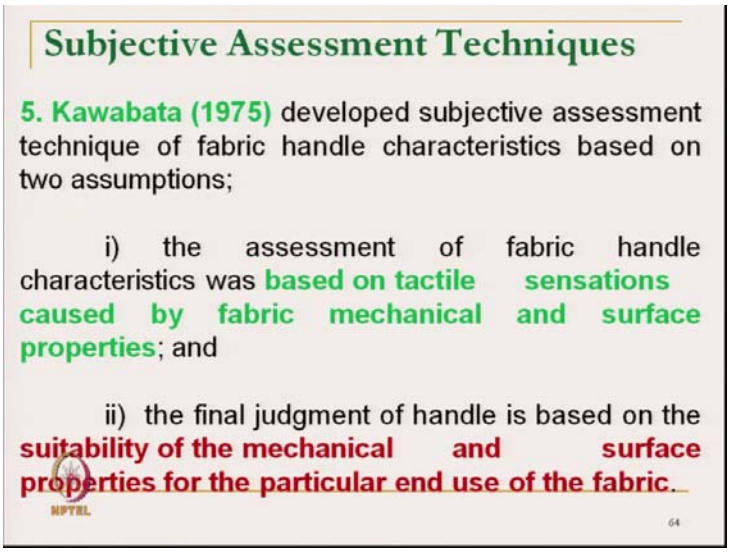
**Lecture - 17**
**Tactile Aspects of Clothing Comfort (contd…)**

(Refer Slide Time: 00:28)



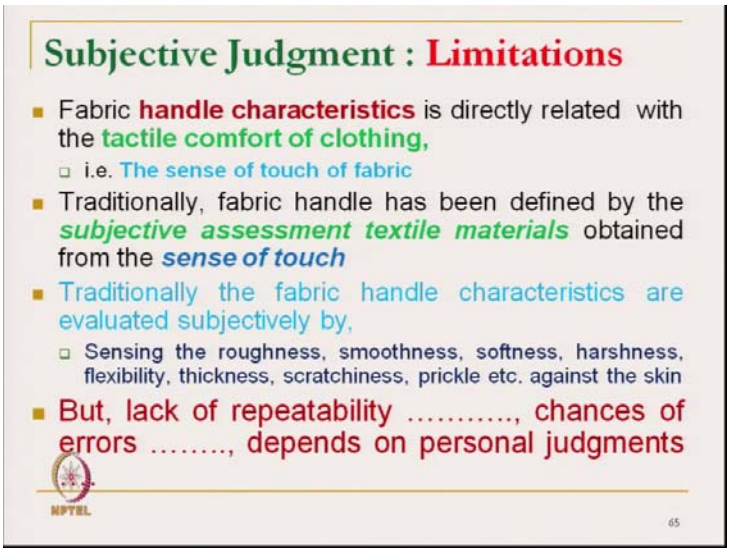

Hello everyone. So, we will continue with the measurement techniques of tactile responses of fabrics. So, we are continuing with subjective assessment techniques. After the technique proposed by Matsuo, who adapted Weber's and Fechner's law of psychophysics.

(Refer Slide Time: 00:44)




Next, technique is by Kawabata, who has developed the subjective assessment technique. The assessment of fabric handle characteristics was based on tactile sensations caused by fabric mechanical and surface characteristics. And the final judgment of the fabric, the handle judgment is based on the suitability of mechanical and surface property for a particular application ok, because that particular application that may be, may not be actually suitable for other end use for a particular fabric. Suppose, for a particular application, we may need a stiff fabric for other application, we may need all together different aspects.

(Refer Slide Time: 01:56)

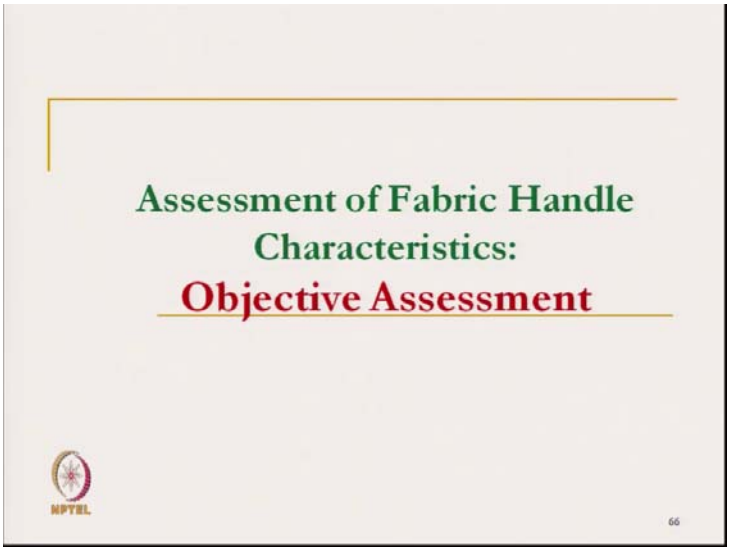


So, the final judgment is based on the particular application. So, all this subjective judgment they have got their own limitations. So this, although this gives directly it is correlated with the tactile comfort of clothing, like a sense of touch, but they have their limitation. So, this sensations of roughness, sensation of smoothness, softness, harshness, flexibility, thickness, scratchiness, against the skin that we can directly sense.

But main problem is that it is a lack of repeatability, and chances of error, and it depends on judge; person to person. So, even a particular fabric it is for a person, I may perceive a particular fabric differently at different mental conditions psychological condition, so that actually creates problem. This subjectivity depends it & it changes with the environment.

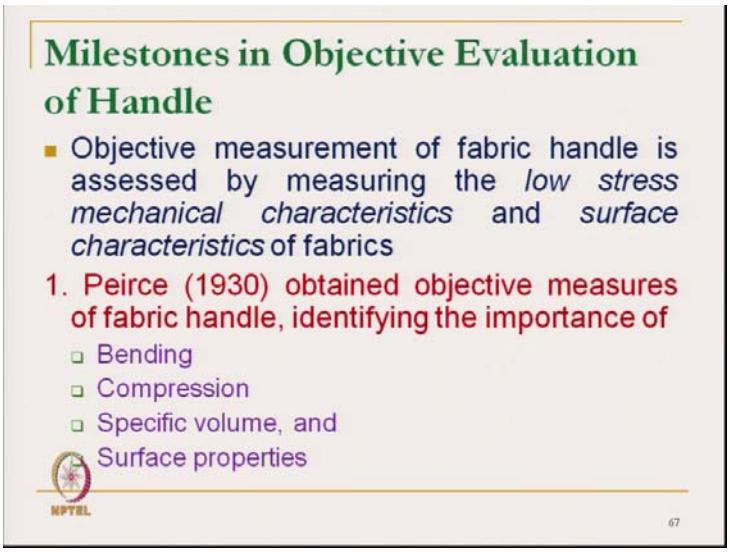
Although it is actual sensation, but getting a standard value is difficult. If my physiological condition changes, I will perceive a fabric differently. This is actual subjective responses, but the repeatability is not there. We cannot give a particular value. We cannot reproduce the value, particular fabric. So, to reproduce or to get a standard value irrespective of the judgment, irrespective of the perception, we need a measurement technique, which is objective in nature.

(Refer Slide Time: 03:44)



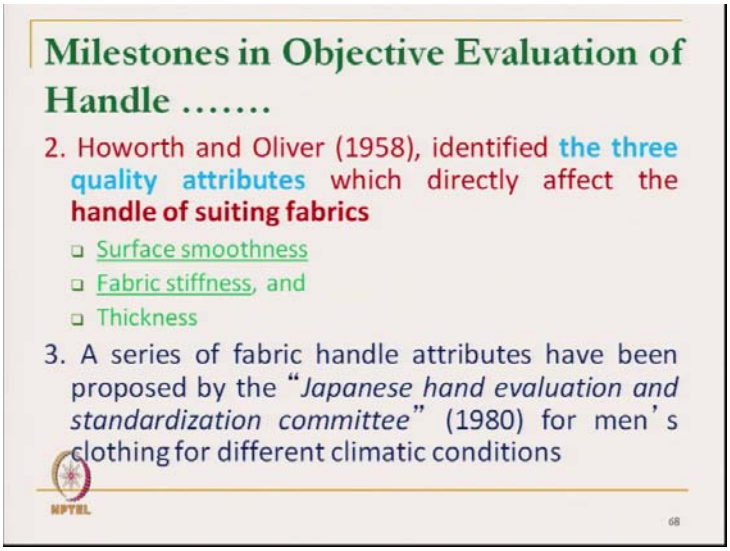

So, now we will discuss the different objective measurement technique for fabric tactile responses or fabric handle related characteristics.

(Refer Slide Time: 03:53)



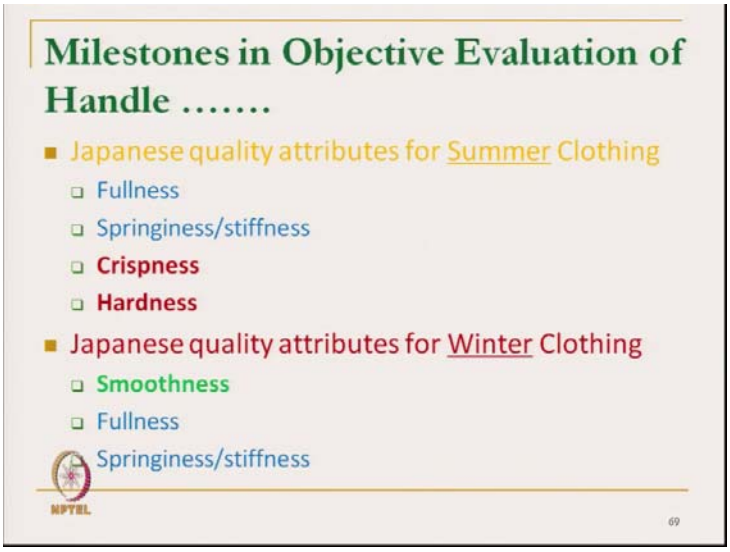

It is actually proposed long back by Peirce in 1930s. And Peirce identified the fabric tactile responses, various tactile characteristics of fabric, which directly sends tactile responses. These are bending, compression, specific volume, and surface property. So, Peirce in 1930s long back, he proposed that if we measure bending stiffness, if we measure compressional characteristics or specific volume of fabric or surface characteristics that these things will give our tactile responses.

(Refer Slide Time: 04:49)



Then in 1958, Howorth and Oliver identified three attributes for suiting fabric. These are surface smoothness, fabric stiffness, and thickness. These are all measurable. So, objectively if we can measure these characteristics, we will get the tactile response. Actually, we can guess the tactile responses of fabrics.

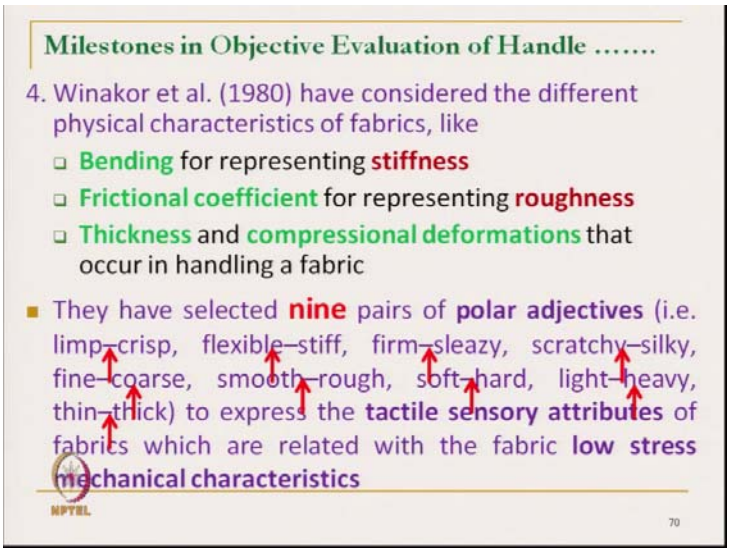
(Refer Slide Time: 05:22)




Next in 1980s, so Japanese team, they have come up with different attributes for one is for summer clothing. And other set is for winter clothing. They have actually devised, different objective aspects like fullness, if we can measure the fullness or springiness, stiffeness, crispness, and hardness. So this four characteristics are directly related with the summer clothing. And the winter clothing, they have come up with surface of smoothness, fullness, and springiness.

These three aspects are related with the winter clothing like springiness and stiffness. These are common for both summer and winter. Fullness is common for summer and winter. But, smoothness in winter, what they have proposed that in winter clothing, we actually need smoothness characteristics. We have to measure smoothness characteristics for at least for winter clothing. Similarly, for summer clothing, the crispness or hardness, they are important. They measure the crispness or hardness.

(Refer Slide Time: 06:52)




Then Winakor et al in 1980s after that Japanese, they have proposed. They have come up with the wide range of characteristics, wide range of feel. So, and they have correlated with the fabric characteristic like bending. If we measure the bending rigidity, it will give idea about the stiffness of fabric. Whether the fabric is stiff or limp, we can get idea about by measuring the bending rigidity of the fabric.

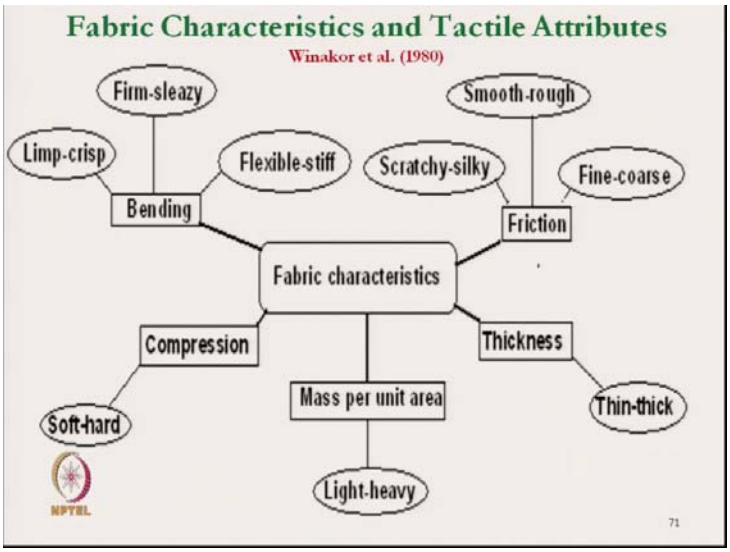
Similarly, if we can measure the frictional coefficient, what they have proposed, we can measure the roughness characteristics. If you measure the thickness and compressional deformation, so then we can measure the fabric handle rigid factors characteristics.

So, they have proposed nine actual pairs of polar of adjectives. And they have actually found that these are related with some of the fabric objective mechanical characteristic. So, this nine pair of polar adjective are, whether the fabric is limp or crisp, is it flexible or stiff. So, these are the subjective responses. We can tell whether the fabric is limp or crisp, is it flexible or stiff, is it firm or sleazy, is it scratchy or silky. So, these are the terms. So, polar adjectives, so that though person who is perceiving the sensation. This type of tactile sensation, we can actually get.

Fine or coarse, is it the fabric is fine or coarse. Smooth or rough, soft or hard, light or heavy, thin or thick. So, these are actually expert, they sense this tactile sensory attributes. And they are related with the low stress mechanical characteristics. And this group, they have actually proposed that you can correlate with the low stress mechanical

characteristics of the fabric. There are various mechanical characteristics. And they could actually find all nine adjectives, these are all this tactile attributes are related with the mechanical characteristics.

(Refer Slide Time: 10:02)



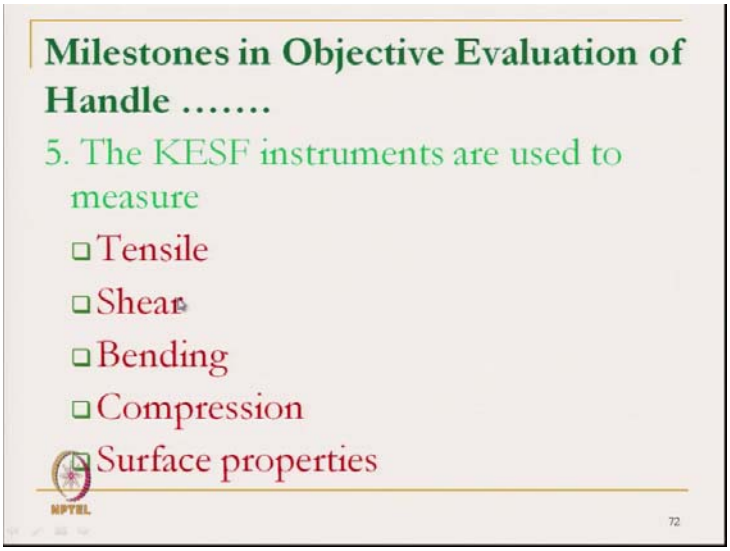

Let us see, how they are related with the mechanical characteristics. Now, try to see limp or crisp, firm or sleazy, flexible or stiff, these attributes tactile attributes are directly related with the bending rigidity. If we can measure the bending of fabric, that they have fabric characteristics that if we can measure the fabric bending characteristics, we can get idea about this polar attributes.

Scratchy or silky, smooth-rough, fine-coarse, they are related with the fabric frictional characteristics. So, if we by measuring the frictional characteristics, we can get all this characteristic idea, but frictional characteristics will not only help in this aspect. What type of friction, is there, any stick slip, is there any what is the frictional curve characteristic, curve nature of curve. μ will give some idea, but whether the fabric is fine or coarse.

This type of characteristics we can get by detailed analysis. Thick and thin; definitely by thickness; fabric heavy or light; definitely by measuring the mass per unit area and soft and hard, it is by compressional characteristics. So, if we measure the bending, friction, thickness, mass per unit area and compression, these are the mechanical characteristics

by physical measurement, we can get the value and we can actually, we can propose, we can get idea about this tactile responses.

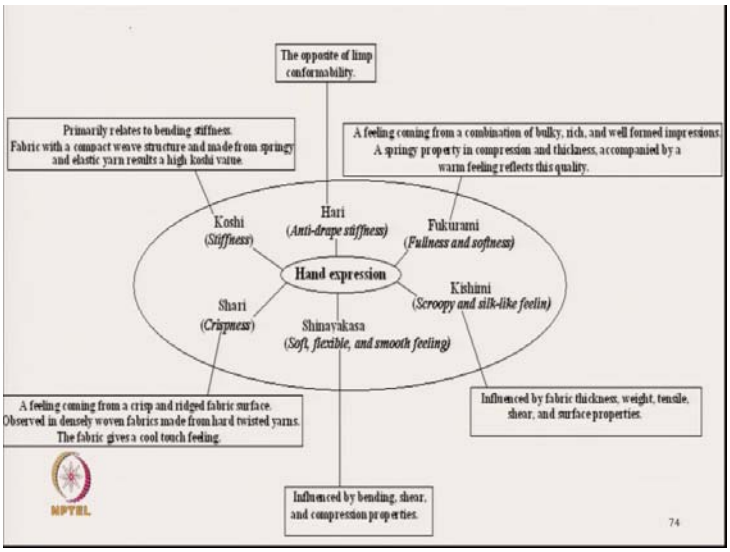
(Refer Slide Time: 11:50)




Next measurement is objective measurement is the Kawabata instrument, which is most popular, very popular instrument of objectively measuring the fabric handle characteristics. So, Kawabata system, it measures the tensile characteristics, low stress mechanical characteristics. It is not up to end point, up to the breaking point; it is at low stress mechanical characteristics.

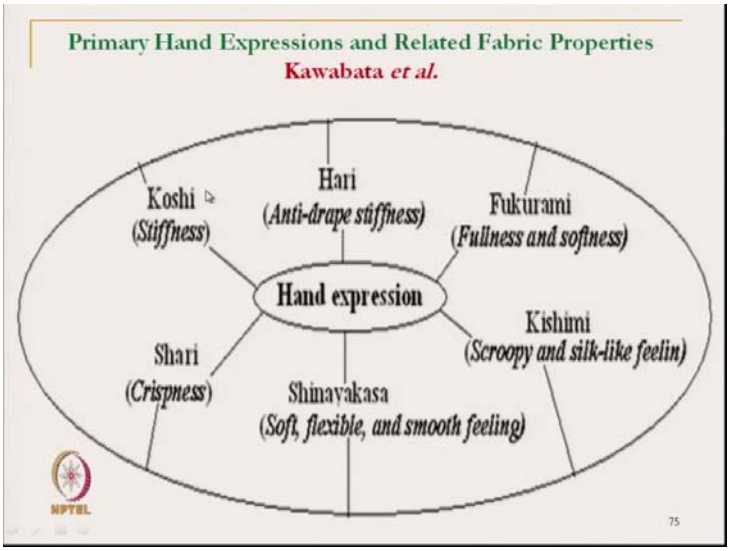
The tensile characteristics, it measures shear behavior, bending rigidity, bending characteristics, compressional characteristics, and surface related properties. So, it has got four different test modules. We will discuss one by one in detail. In module one, it measures the tensile and shear related characteristics. Then it is a bending, compression, and 4th one is related, it measures the surface related characteristics. So, Kawabata again like earlier; Kawabata also gives idea about the fabric handle related characteristics or fabric tactile characteristics correlated with the fabric mechanical, low stress mechanical characteristics.

(Refer Slide Time: 13:26)




So, what he has proposed, he has proposed six different terms like Koshi, Hari, Fukurami, Kishimi, Shinayakasa and Shari these six characteristics. These Japanese term they are related with the fabric low stress mechanical characteristics directly.

(Refer Slide Time: 14:06)




So, let us discuss in detail. Like Koshi, it is the hand expression is Koshi. It is related with the stiffness. It is directly not stiffness. It is not the exact stiffness. It is feeling of stiffness, it may be a Koshi we cannot directly say, it is stiff or limp. Higher stiffness will

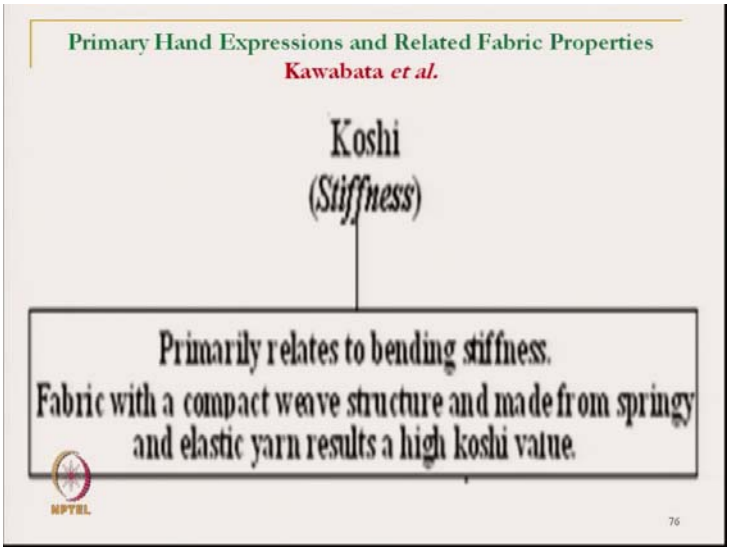
give you higher Koshi value, but it is not, we cannot say, it is a directly it is stiff, it is a feeling of stiffness. Now, it is a tactile feeling of stiffness, it is a Koshi.

Similarly, Hari is an anti-drape stiffness, again it is a stiffness. But, Koshi and Hari, they are different, it is a anti-drape stiffness. We have to actually get the expression. So, and see there is a difference between Koshi and Hari, but this difference we cannot express. We have to actually feel, and by that feel, we can get different characteristics. And you can measure the Hari that and we will discuss one by one. We will discuss different research study, then we will get clear idea. And these handle related expressions directly gives us as the tactile responses.

Fukurami, it is a fullness and softness. It is not the softness alone, it is a fullness. Some fullness characteristics. Kishimi, it is a scroopy silk like feeling. It is not smooth, it is not pure smooth. It is a silk like scroopy feeling, some harshness, some softness, some smoothness, this type of feeling, it is Kishimi. Shinayakasa, it is a soft, flexible and smooth feeling.

Like this, Fukurami is softness, and Shinayakasa softness they are different. It is softness along with the flexibility, along with the smoothness. If we get some combined feeling, it gives the Shinayakasa. In crispness, this is the crispness. It is it is not the softness, it is not the smoothness, some crispy feeling. Like some particular fabric if we touch, it gives some crispy feeling, so that is Shari.

(Refer Slide Time: 17:24)



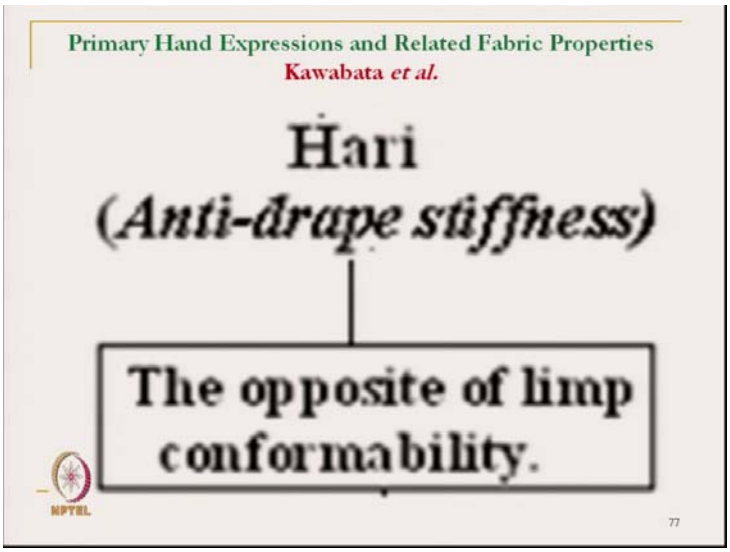
Now, let us see to get this value how, what are the handle or low stress mechanical characteristics related with this Koshi value or this type of values, like Koshi. What we have seen, it is a stiffness. It is primarily related to with the bending stiffness. It is not only, it is a primarily bending related. Now, if we try to get idea about the Koshi, not the stiffness. It is a fabric with a compact woven structure made from springy and elastic yarn result a high Koshi value that is type of stiffness we are talking about.

If we develop a fabric with a stiff yarn like we are developing a fabric with stiff rod with an open structure, it gives stiffness. It is like this stiff material, this will not give high Koshi value, this is not the Koshi value we are talking about. The Koshi is different suppose, let us see a fabric wear produced say from same warp and weft.

And same yarn we are using, now imagine that we are increasing the ends per inch, picks per inch gradually. Keeping the fabric same, keeping the yarn same, suppose it is a woven fabric. A fabric with lower ends per inch and picks per inch, gradually you are increasing and it has become compact, high ends per inch, and picks per inch. Almost same thickness, same yarns we are using. And it is stiffness will gradually increase as we increase the ends per inch and picks per inch.

And that we can say it is Koshi value is increasing. The type of stiffness it is increasing, due to the increase in view structure, compactness of the view structure, and with that compactness. Now, we are introducing one springy and elastic yarn. Like we are using elastane coarse spun yarn and we are giving a compact structure like denim; with the compact denim, with elastane yarn stretchable denim, that type of stiffness is Koshi value. It is not the stiff fabric; it is that type of higher stiffness value. It is a Koshi value. Suppose a cloth, we are giving a starch treatment.

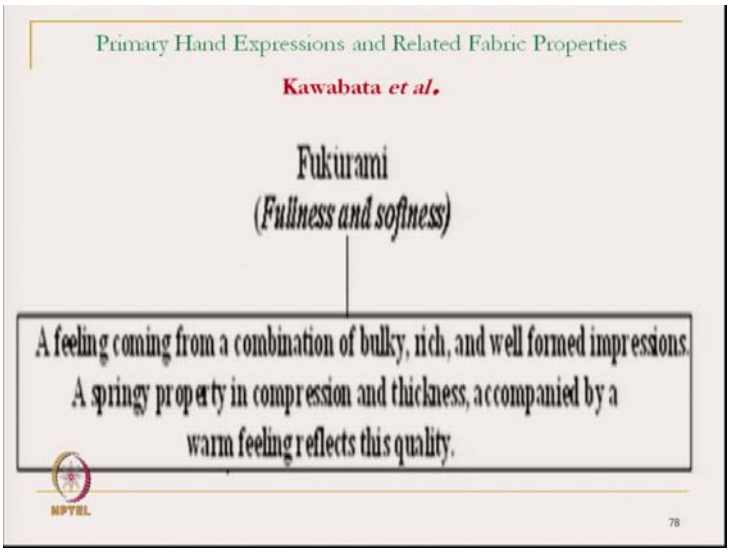
(Refer Slide Time: 21:13)




A cotton fabric given a starch treatment, it becomes stiff that does not mean, we are increasing the Koshi value. Koshi means, Koshi softness will be there, but it is a feeling is like that. It is a like Hari. It is anti-drape stiffness basically it cannot conform to our body, it is opposite to limp conformability. Like a fabric, which is actually taking the shape is not like cushion cover or maybe a sofa cover. It is conforming to the shape of the particular furniture or anything any cover.

If it easily conform to that shape that basically, it is that type of it is called less Hari value. And if it does not conform to that shape, we can say it is Hari value is high that means, it is not directly related to the only the bending rigidity. It is related with the many other characteristics. And Kawabata and his group, they have proposed that these are related with the combination of all more than one low stress mechanical characteristics with the different level of importance.

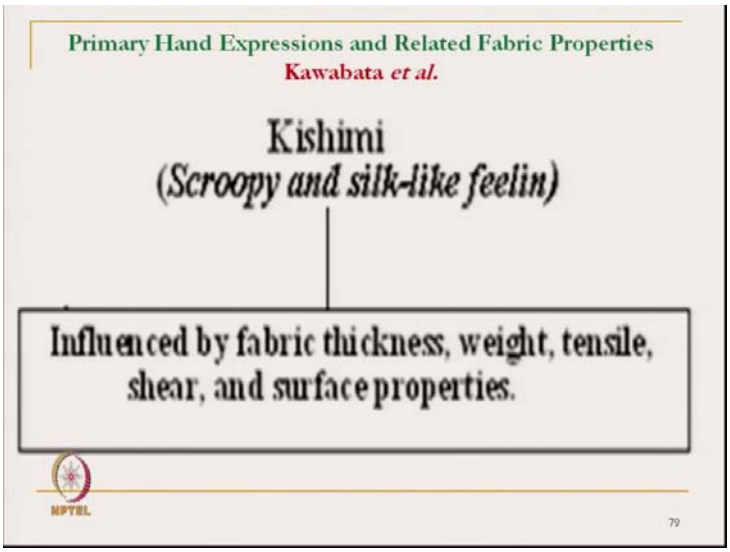
(Refer Slide Time: 22:37)




Fukurami, it is a fullness and softness does not mean that it is a fabric, which is soft will give higher Fukurami value. It is a feeling, it is a tactile sensation. A sensation coming from a combination of bulk, rich, and well formed impressions that means, it has to be a bulk and rich value and well-formed impression. And springy property in compression and thickness accompanied by warm feeling that actually reflects this quality.

It is not only the compression, it has to be springy in nature that means, resilience should be there. The warm feeling should be there, so that that type of feeling is actually Fukurami. It is a fullness it is a richness. Well formed impression that means, it has to come back; springiness, so that gives the Fukurami value, so that means, if we measure the compression, it is the not the only idea. So, it may be related with the bending, it may be related with other things.

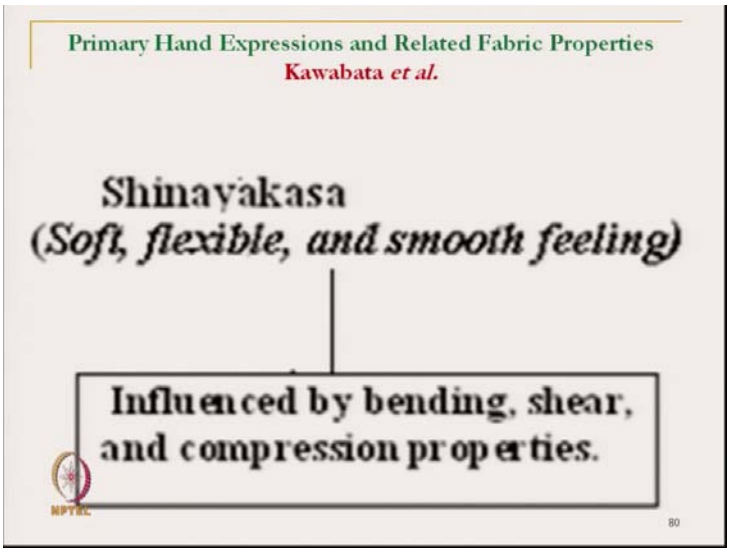
(Refer Slide Time: 24:03)




Next one is Kishimi. it is a scroopy or silk-like feeling. So, it is related with the fabric thickness, weight, tensile, shear. So, both tensile characteristics, shear characteristics, and surface property. So, this will give us the value. So, if we keep everything constant, so a tensile characteristics, like tensile elongation or shear characteristics change.

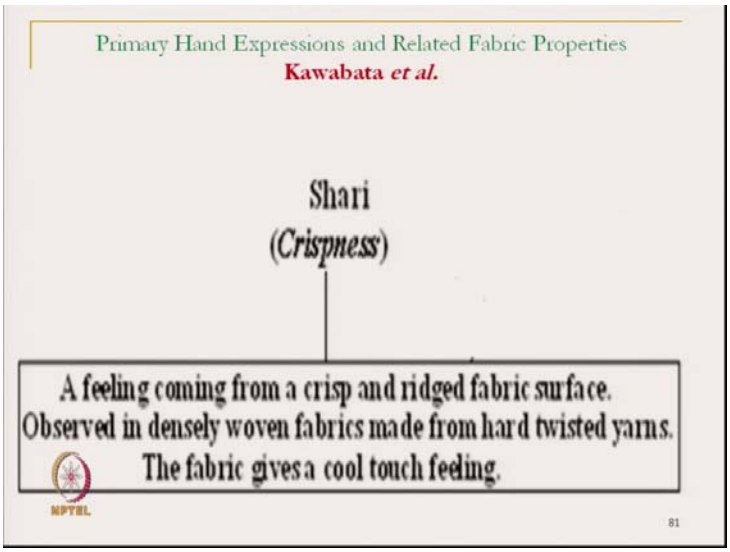
Then, this Kishimi value will change, that means, Kishimi value. If it is a function of the fabric thickness, weight, tensile, shear and surface characteristics, but their importance relative importance may be different, but they are related. If we take a silk fabric, it may not be the scroopy always, so that scroopy and silk like feeling. So, if we touch the fabric, we will tell this is the silk fabric, we can make out. So, if we we wear some silk cloth, we can we can tell that was silk fabric, so that type of feel feeling is called it is a scroopy feeling.

(Refer Slide Time: 25:32)




Shinayakasa, it is a soft, flexible, and smooth feeling. So, it is not the only characteristic, we can say it is a surface related characteristics, It is a bending related characteristics, shear related characteristics, so that that type of feeling it is a Shinayakasa. It is influenced by bending, shear compressional characteristics. Like if we have higher shear, if we change the shear, it is total characteristics will change.

(Refer Slide Time: 26:08)

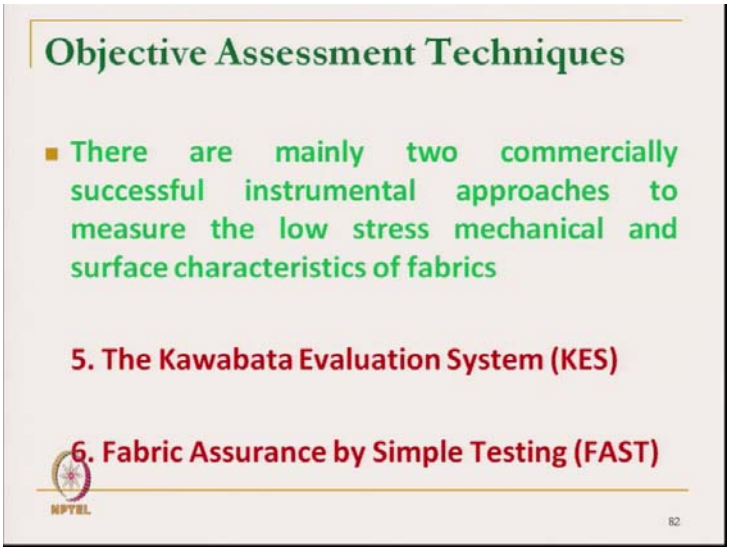



Shari; it is very commonly used, crispness in a fabric. A feeling coming from a crisp and ridged fabric surface, it is not smooth surface. If we actually move our finger, it should

be some crispiness. Some crispy sound should come that we can tell its crispiness. It is observed in densely woven fabrics made from hard twisted yarns, So, if we develop a fabric with a soft yarn; very low twisted yarn, low twisted open structure yarn, that type of feeling, it will not give our scroopy feeling.

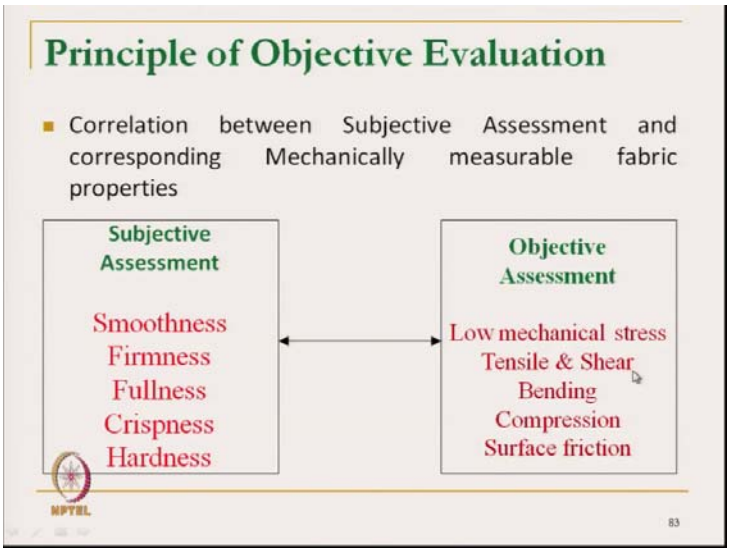
Now, if we keep on increasing the yarn density with a soft yarn, this will give some soft feeling, that will not get that type of scroopy feeling, some rigid structure. The fabric surface that we will not get, but if we twist, if we make a yarn with say hard twisted yarn, like crepe fabric we know georgette type of fabric, different high twisted fabric. If we touch, we will feel some crispy touch, it is talking about that type of feeling. And it gives a cool touch feeling.It gives some special feeling, which is Shari, some special crispiness.

(Refer Slide Time: 28:07)




So, there are two commercially successful instrument setups are available. These are for measuring the low stress mechanical characteristics and surface characteristics of fabric. These are Kawabata evaluation system, as we have mentioned and fabric assurance by simple test, fast measurement. So, we will discuss details about the Kawabata systems one by one. And then, we will discuss fabric assurance by simple test method fast techniques.

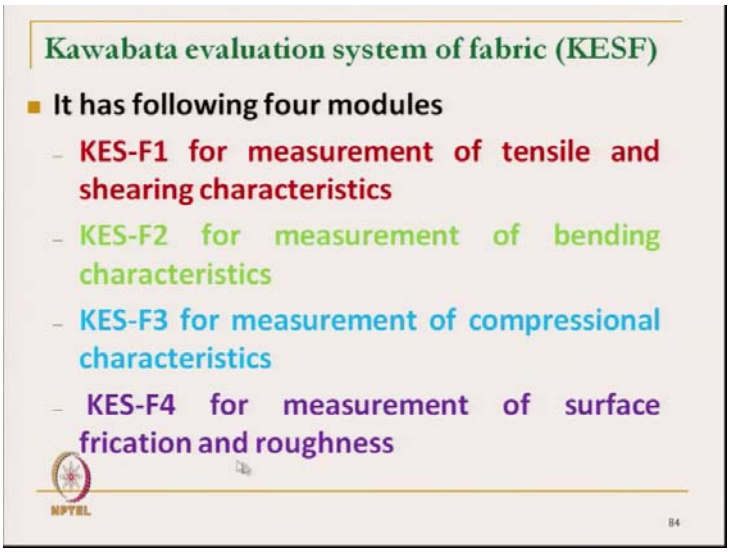
(Refer Slide Time: 28:47)




So, this subjective assessment of fabrics, it is smoothness, firmness, fullness, crispness, hardness they are directly related with the objective assessment of fabrics. So, if we can measure, the low stress mechanical characteristics objectively like tensile and shear, bending, compression, surface roughness, surface friction, all these characteristics, objective characteristics are directly correlated with the subjective assessment, that is subjective response of the wearer like tactile. These are the tactile responses.

Now, whether the fabric is smooth or rough, they are related with this criteria. Firm fullness, they are related with this criteria, but the importance of this criteria maybe different little bit. Crispness are related with all this criteria. And the Kawabata and his team, they have developed equation statistical equation to measure, to correlate these objective parameters with the subjective.

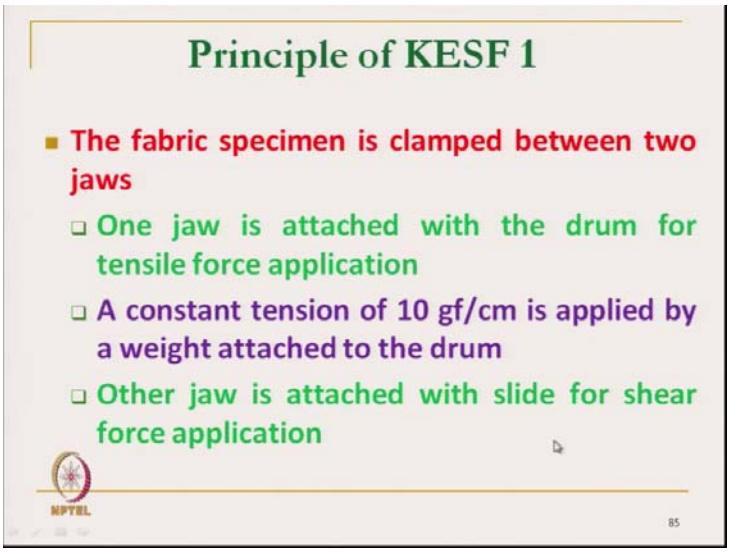
(Refer Slide Time: 30:08)




So, KESF they have actually, it is four modules of measuring the low stress mechanical characteristics. So, Kawabata evaluation system for fabric (KES-F1) which actually takes care of the tensile low stress measurement of tensile, and shear characteristics. KES-F2 it measures the bending related characteristics. Fabric bending related characteristics.

KES-F3 it measures the compressional related characteristics. The compressibility of a fabric recovery related characteristics. It is measured by KES-F3 technique and KES-F4 for measurement of surface friction and roughness characteristics. So, these four techniques and it gives all this four techniques, they give wide range of large number of parameters. And, if we correlate all these parameters with the subjective assessment or tactile responses we can get some standard equations for a particular fabric.

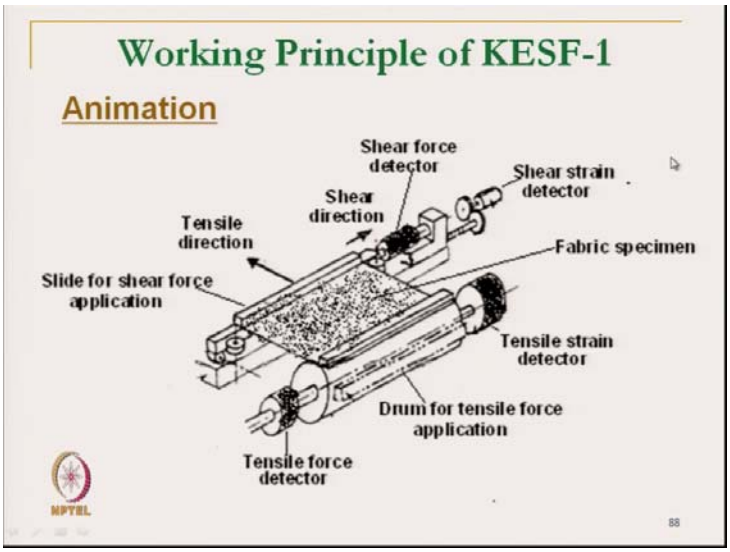
(Refer Slide Time: 31:32)




So, fabric specimen in KESF1 system the fabric specimen is actually clamped by two jaws. There are two jaws in KESF1. We measure two techniques, two principle parameters. One is tensile related characteristics and other is fabric shear related characteristics. So, here the fabric sample is clamped between two jaws. So, one jaw is actually placed on a rotating drum. And another jaw is a transversely sliding jaw, it is slider. So, one jaw is attached with the drum for tensile force application. So, as the drum rotates, it applies the tensile load. And this drum rotates clockwise and anti-clockwise.

And a constant tension of 10 gram force per centimeter is applied by actually attaching a weight on a drum, so that constant tension, in initial tension is applied that is 10 gram force per centimeter. So, depending on the width of the fabric sample, the tension we can change, to keep this; this is the low at lower level of a tension so, to keep the fabric in straight condition. So, as I have mentioned the other jaw is attached with slide that slide moves laterally to impart the shear force.

(Refer Slide Time: 33:36)




The picture gives the working principle of this instrument. Here this is the fabric sample fabric specimen, which is actually there are two jaws. This is one jaw, which is attached with the rotating drum. This drum when it rotates clockwise, it extends, this gives extension to the fabric sample and gives the tensile load. And during recovery, it gives the recovery.

Now, the difference here in Kawabata system and with other tensile or other measurement technique is that here. It works at low stress mechanical characteristics, lows at low stress level. And it keeps the totality (Refer Time: 34:37) totality means, it gives that extension and recovery.

It actually records the value of force and displacement during extension, and also during recovery. So, it is a true for shear, true for a bending; it is true for compression also. Now, here as it is rotating clockwise, it gives the extension. And during it is anti-clockwise movement of the drum, it is reverse; recovery curve is achieved.

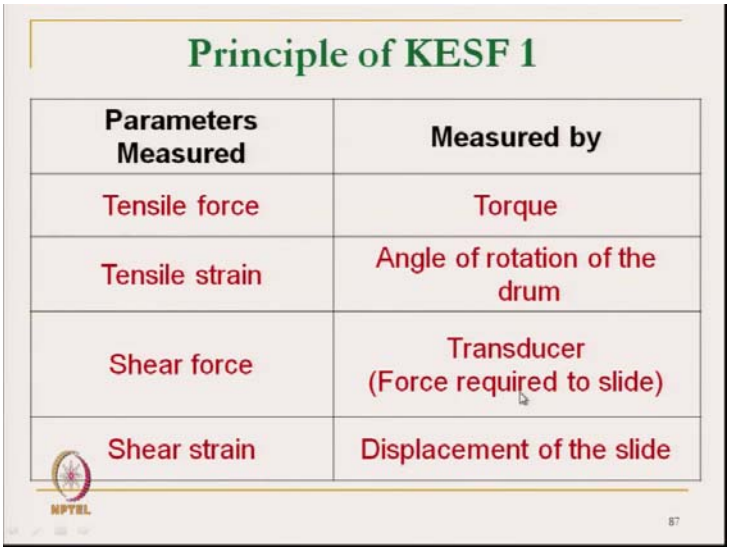
Similarly, the shear is achieved by this slider. This is the slide for the shear force application. This slider moves laterally like this, when it moves this direction, there is a shear and during return it comes back ok. So, during this lateral movement, it gives the shearing.Now, the rotation of drums, it is actually connected with some gear arrangement. And it is connected through the tensile force detector. It is a torque sensor

through this torque sensor, it gives the amount of force to rotate the drum, which is indirectly, which gives the force to extend the fabric.

So, this tensile force is detected by this sensor here and what about the tensile extension? This extension here is detected by the rotation, amount of rotation of this drum. And that is sensed by the tensile strain detector. Actually senses the angular rotation. So, this two sensor gives the tensile force and stress and strain.

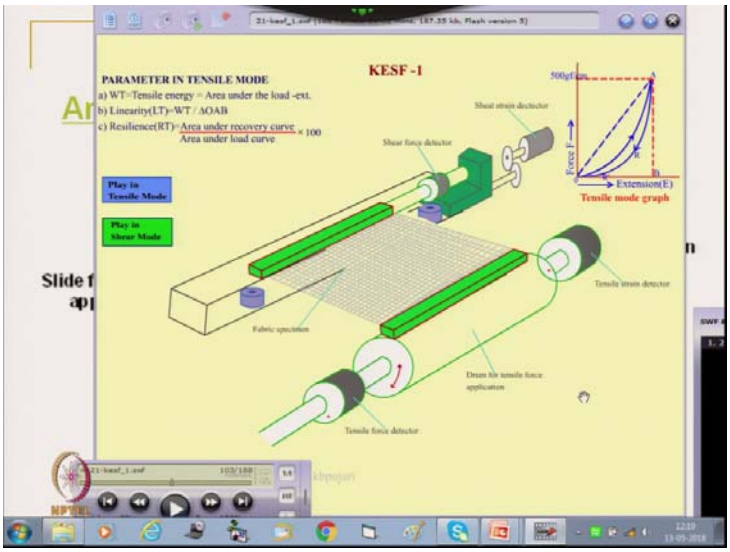
The sensation signal from this two sensor gives the tensile curve. Similarly, the slider movement gives the shear, it helps in shearing the fabric. And this shear force detector means the amount of force required to rotate to slide, amount of force required to slide this slider is sensed by the shear force detector. And the amount of sliding is detected by the shear strain that is the angle of rotation is directly proportional to the amount of slide. So, strain sensor and shear force sensor gives the shear stress strain curve.

(Refer Slide Time: 37:50)




So, from this, so shear the tensile force is measured by torque sensor. Tensile strain is measured by the angle of rotation of the drum. Shear force is measured by the transducer, force required to slide. And shear strain is the displacement of the slider. So, displacement of slide is measured by the angular rotation of this slider. This is slider angular rotation of the detector. So, from there, we can get the shear strain.

(Refer Slide Time: 38:33)




Now, let us see the animation. Now, first we will play for the tensile characteristics. So, this is the drum. So, for tensile characteristics, when we measure, so in this instrument, it works only one at a time. We cannot work both normally. Actually this is when tensile characteristics, we will measure, this drum will be activated, drum will rotate, but slider will be stopped. So, let us see.

Now, the drum has started rotating clockwise. Now, tensile force is detected by the tensile force detector. And now it is coming back drum is rotating started rotating anti-clockwise direction and it is coming back. And at this point, it has come back its original position. Now, the tensile total cycle is completed. Now, we can see here, the important fact is that this technique as we have mentioned, it takes care of the loading and unloading characteristics, total characteristics.

So, from this curve tensile, and loading and unloading, we get different parameters. So, all these parameters from loading and unloading we get different parameters. And from shear, we get a different parameters. So, from loading curve, we can measure the tensile energy, area under the curve, linearity of the curve and resilience. Similarly, for shearing we get set of characteristics. So, these characteristics and all the parameters; so, there are different test parameters and there are different settings.This we will discuss in next class. And we will continue with this Kawabata evaluation system measurement.

So, thank you for this day.