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

Lecture No-20
Evaluation of Tensile Properties of Textile Materials (contd.,)

Hello everyone, we will continue with the topic that we are discussing the effect of rate of loading on tensile characteristics.

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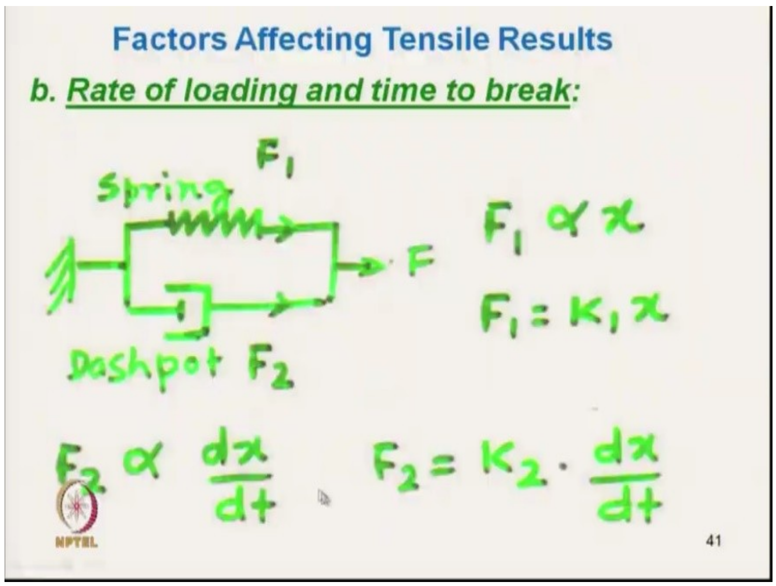

So, as we have discussed that due to viscous elastic nature as we increase the rate of loading the tensile load, tensile strength increases.

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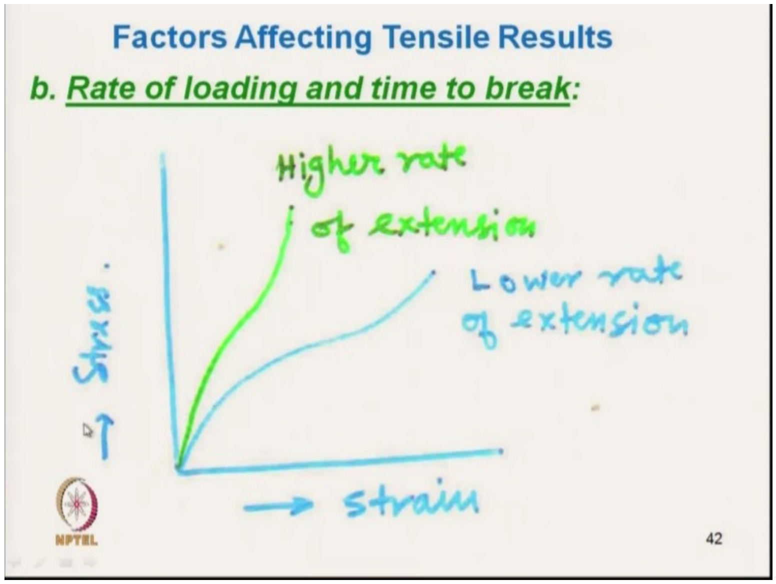

So, this curve shows that at lower rate of extension the stress developed by the fibre or yarn is lower, whereas at higher rate of extension it is higher.

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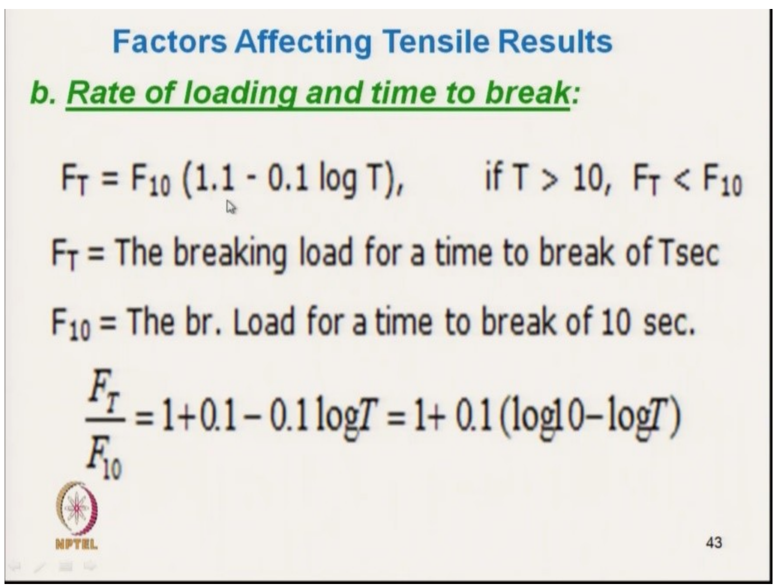

Now we will discuss with the help of the empirical equation. This is the empirical equation where it is FT = F10 is * 1.1 – 0.1 log T here log 10 is with the base 10. So, where FT is the breaking load for a time to break of T sec if the T is more than 10, then if T will be less than F10. Where F10 is breaking load for a time to break at 10 sec, so in standard testing condition the time to break it is mentioned okay.

It is fixed. So we have to set a rate of loading in such a fashion that the material, the specimen breaks at 10 secs. So that is why, that, that is called it is a F10. And if the rate of loading or the rate of extension in, is in such a fashion it is in lower rate of loading that means that time required to break will be high okay. The time required to break will be higher than 10, because when we are having lower rate of loading, or lower rate of extension the time required will be higher.

In that case, the FT, FT that is breaking load will be lower than earlier. So that this is due to the viscous elastic nature of the material and the empirically this can be shown by this formula. Now what we have to do we will just try to rearrange this equation nothing else. So FT /F10 = 1+ 0.1, so 1.1 has again been divided into 1+0.1 so in this way if we just rearrange 1+ 0.1 log10 – logT.

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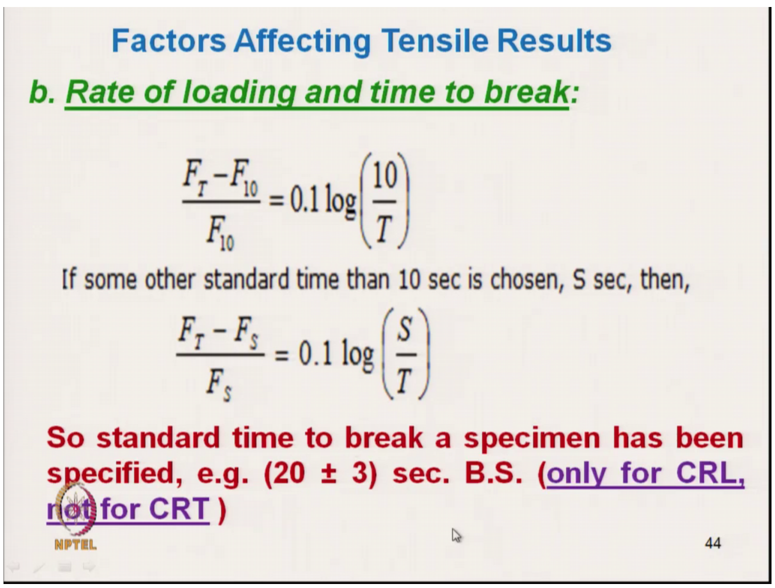

So again this is can be rearranged here in this fashion. Finally what we are getting FT – F10 / F10 = 0.1 log 10 / T, okay. This is for the standard time, reference time of 10 sec. Now, if we want to generalize for any other time than 10 seconds, so any standard time it may be 20 sec it may be any other time. So, 20 sec so if it is the so that is the in some standard time other than 10 sec is chosen, S sec will be then, the breaking time is S sec. In that case, FT – FS / FS will be = 0.1 log S / T.

This is the standard equation, so from there if we know the time to break by changing the rate of extension. So, if we know the time to break then we can calculate the; and if we know the breaking stress, breaking strength at a particular time then we can calculate the, the breaking strength of other time. So if the change the change in rate of extension or rate of loading we can predict the strength of material by using this empirical formula.

So the standard time to break a specimen has been specified. So the standard time is 20 + - 3. And it is only for CRL, this standard time is only for CRL not for CRT. What is CRL constant rate of loading type instrument not for constant rate of traverse type okay, this breaking load, breaking time is specified. This breaking load, breaking time is specified.

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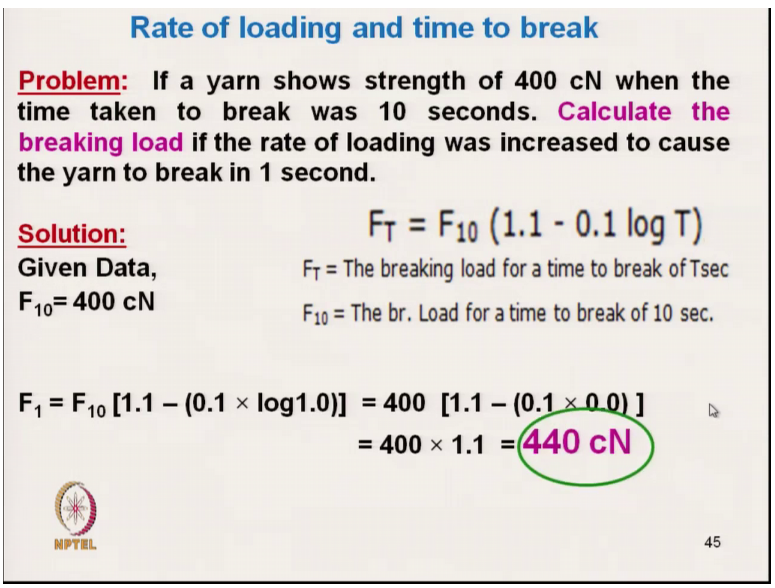

Now let us try to do some, solve some simple problem. Problem is that, if a yarn shows strength of 400 cN when the time taken to break was 10 seconds. Okay. So, at time to break the 10 seconds, the strength is 400 cN. Calculate the breaking load if the rate of loading was increased to cause the yarn to break at 1 second. So, earlier it was 10 sec now rate of loading has been increased okay and it is breaking at 1 second.

So you will use this formula straight way so initially it was F10. F10 was standard so we will put the value 1 here it is the time to break. So in that case we can simply calculate Ft is the breaking load for a time to break of T sec. F10 is the breaking for a time to break at 10 second. And F10 is given it is 400 cN. And from there we can calculate the F that is for 1 sec, F1 we can calculate that means T is 1 that means log 1. What is log1? Log1 is 0.

So, this will become 0. So, F10 * 1.1. So F10 is 400, 400 * 1.1. This 1.1 so it is coming out to 440 cN. So, when yarn was breaking at 10 second time, the strength was, the breaking strength was 400 cN. And when if we increase the rate of loading is increased in such a fashion it is breaking very quickly within 1 second. In that case, same yarn will show the strength of 440 cN.

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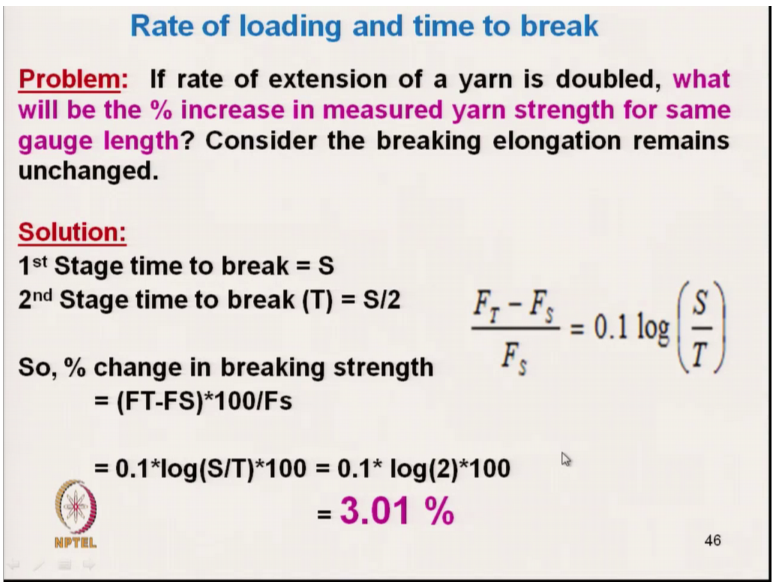

Now, let us try to solve another problem. The problem is that if the rate of extension of a yarn is doubled, here doubling the rate of extension. What will be the % change, % increase in measured yarn strength for same gauge length? So what we are doing, we have same gauge length where changing the rate of extension. Rate of extension is changing now consider the breaking elongation remains unchanged.

So breaking elongation is not changing. What we want to know is percent increase in breaking strength and the rate of extension is doubled. Now, so here in first stage time to break is S okay? And in second stage time to break T will be = S/2. Is that clear? Because, gauge length is same and we are increasing the rate of extension to double. So initially and there is a breaking elongation is unchanged, breaking elongation is same.

So, gauge length is same so in that case the first case slower case the time to break was S second. And when it has been doubled that means yarn will break at half of that time. It has become S by 2. Now we have to use this formula. Here this formula it is a, it is doubled S by T means S by S by 2. S by T it will become 2. S by T will become 2 that mean 0.1 log 2. This is the value.

And what is required? Percentage increase in measured yarn strength what is that? FT - Fs by FS * 100, straightaway we can calculate so percentage change in breaking strength is nothing but FT - Fs by Fs * 100. So this left hand side if we multiply by 100 then we will get percentage increased in strength. So that means 0.1 log of 2 * 100.

So this value will give us the percentage increase in breaking strength or percentage change in breaking strength. So it is coming out to be 3.01%. So that is how you can calculate the; because here in the numerical the strength value is not given. But what it is asked, the percentage increase. okay? From there we can calculate the percentage increase its coming out to be 3.01%.

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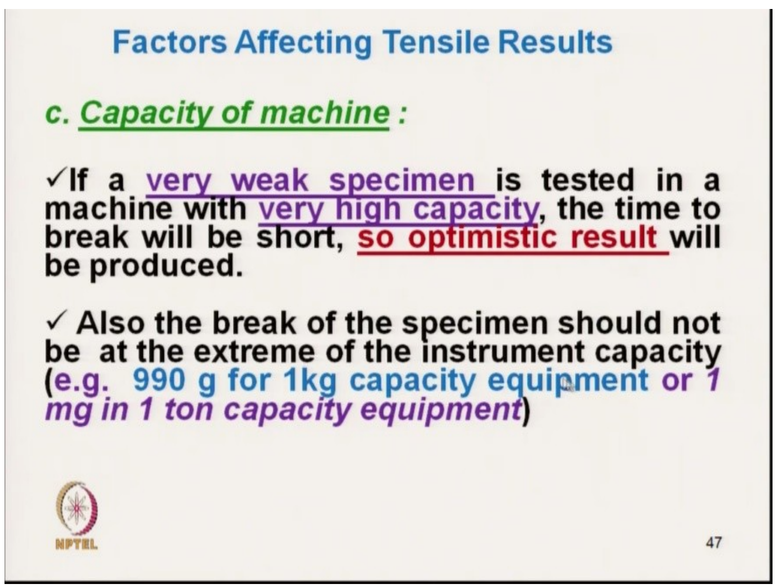

Now next factor which affect is the capacity of machine. Now if a very weak specimen okay, suppose you are testing out a very fine fibre. A single fibre, a cotton fibre, a single one denier filament with a machine of very high capacity, one ton capacity machine in that case that very high capacity, in that case if we one first important, first thing is that we may not get that result but if at all we get the result we will get the optimistic result.

Because it will break with a short time, immediately it will break because the machine capacity is very high. The time to break will be short. So you may get an optimistic value. Also the break of the specimen should not be at the extreme of the instrument capacity. So, capacity of the machine so is a 990g for 1 kg equipment. So 1 kg maximum equipment if we use a yarn whose strength is say 990g say its gram force. So in that case it may give wrong result okay that result will get affected.

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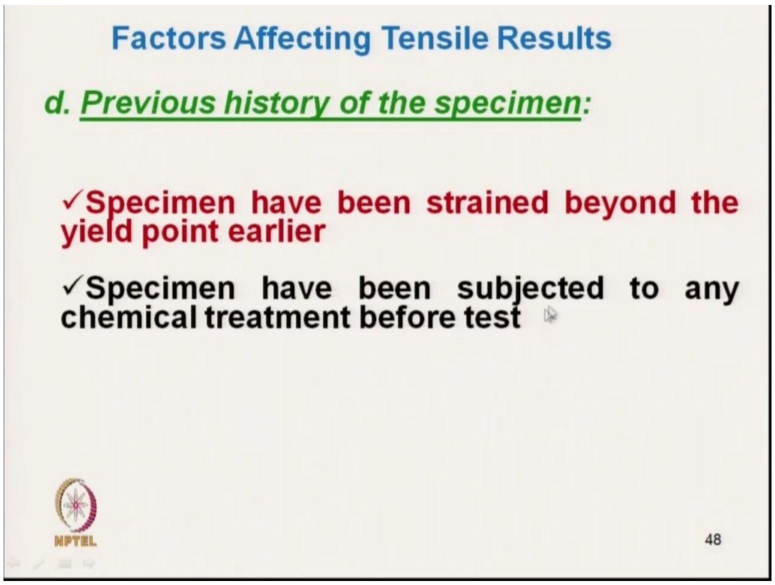

Another factor, which is the previous history of the specimen that also affects the tensile result specimen have been strained beyond the yield point. Suppose one specimen, which has been in previous case. It has been strained beyond the yield point. In that case it has got already deformation. Okay. So that if the same, that sample is tested again, that will affect the test result. Specimens have been subjected to any chemical treatment before test.

Okay so previous history you must know. Then only we can test otherwise, if the specimen has been treated chemically okay it has been scared or if it is bleached that may affect the test result. We must be very clear.

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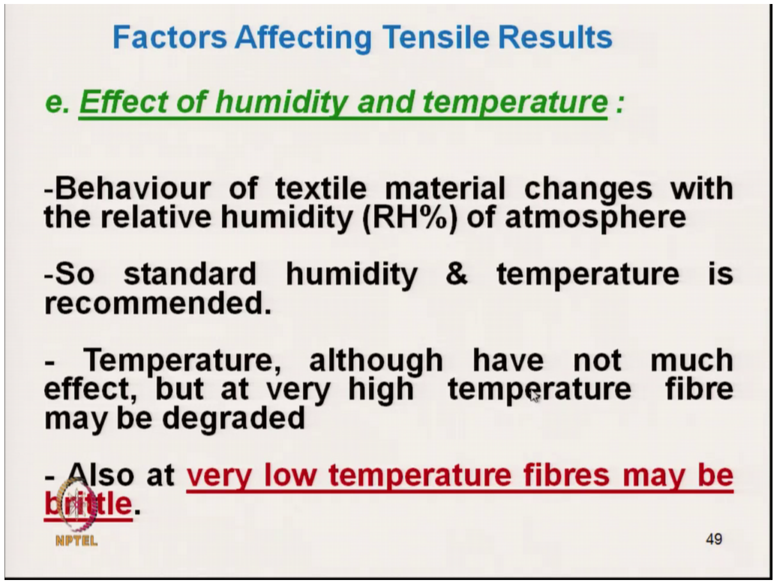

So, effect of humidity and temperature, behavior of textile material changes with the relative humidity that we have discussed earlier also. So, standard humidity and temperature is recommended. And temperature, so temperature, although have not much effect, but at very temperature fibre may be degraded or at very low temperature fibres may be brittle.

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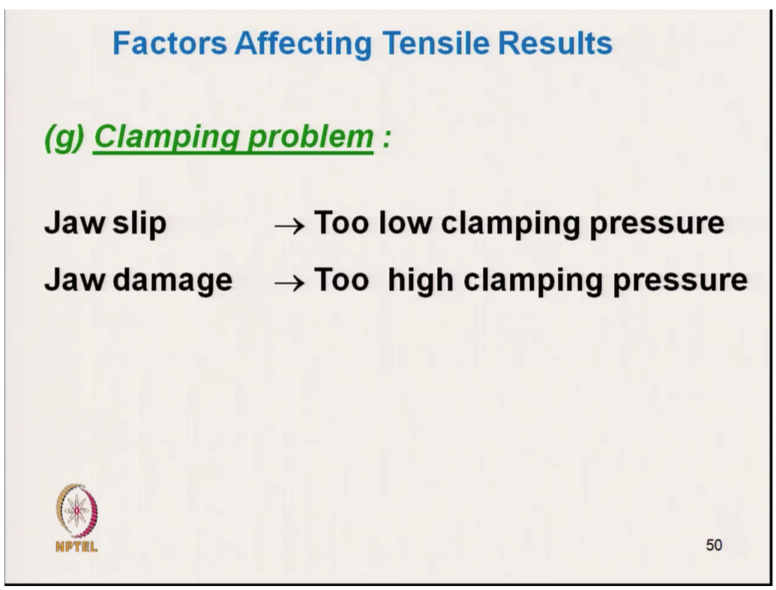

Clamping problem, so the clamping problem improper clamping will result different result, jaw slip is there. Jaw is not proper, so too low clamping pressure. So in that case jaw slip will occur so that unnecessary; so the high extension value and if there is a jaw problem, jaw is damaged so in that case the material will get damaged in the jaws. If there is high pressure, high clamping pressure material can get damaged, that will affect the result. So that is why, clamping has to be perfect it does not affect the test result.

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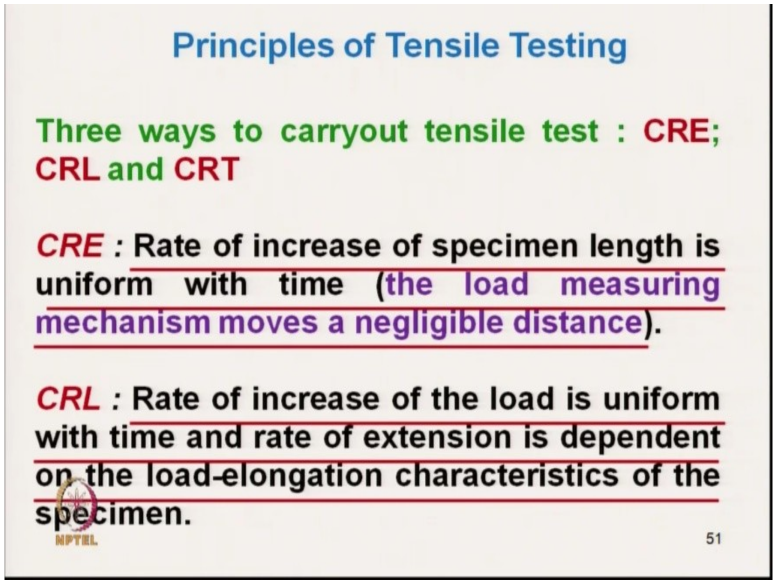

Now there are three different principle of tensile testing, this you must understand very clearly these processes are CRE Constant Rate of Elongation, constant rate of loading and constant rate of traverse. So what is constant rate of elongation where rate of increase in specimen length is uniform with time, so the one jaw will be fixed and another jaw will move at constant speed so that rate of increase of the specimen is uniform. Other jaw will at a constant speed.

The load measuring mechanism moves a negligible distance. So other side of the jaw if that moves that will be negligible. So, for all practical purpose other jaw will be fixed. CRL that is constant rate of loading, here the rate of increase of load is uniform. So, load increases that constant rate with the time. And the rate extension depends on the load elongation characteristics. So rate of load, rate of extension will definitely change but that change is depending on the load-elongation characteristics that we will discuss it later.

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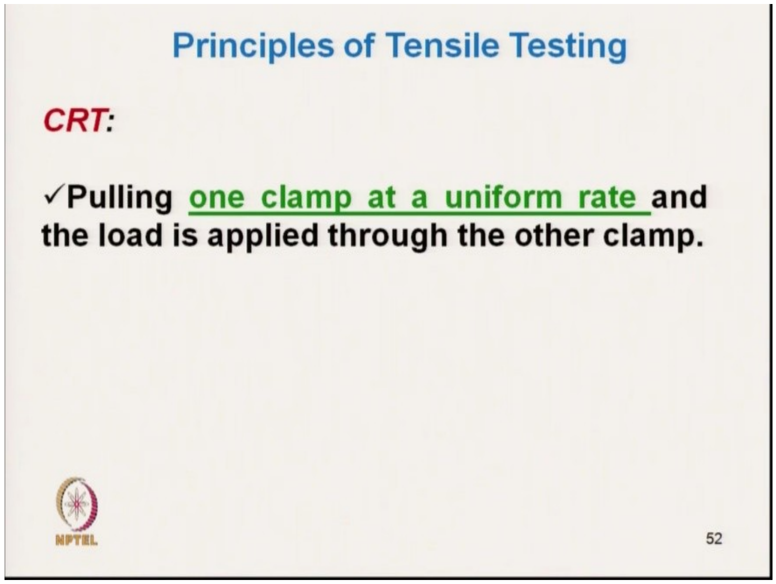

Now, CRT is actually, pulling one clamp at a uniform rate okay now CRT and CRL sometime is confusing.

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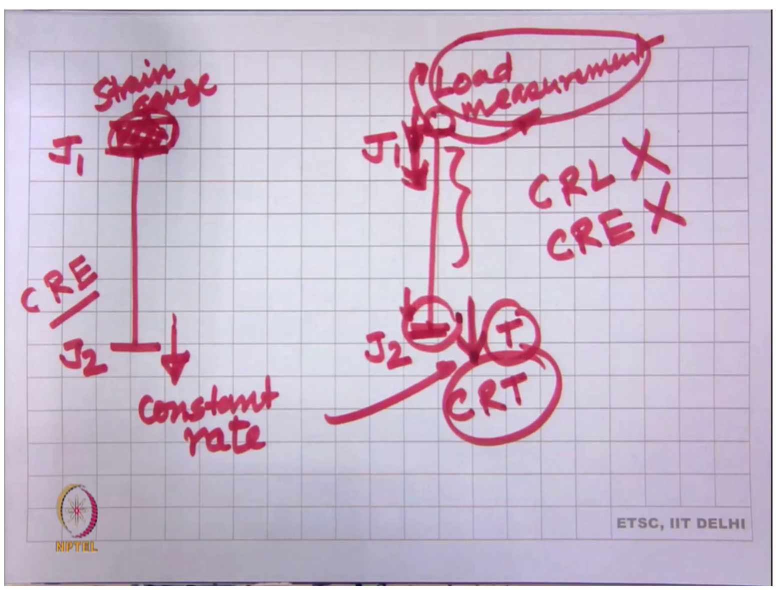

This is jaw 1 and this is jaw 2, which is movable jaw, moves at constant rate. It moves at constant rate. Now for all practical purpose, if the load measuring arrangement is such that the movement of this jaw is almost fixed it is almost 0, because when the jaw 2 is moving so the load will be measured by the other jaw. This jaw if it is almost fixed like if we measure by strain gauge okay, strain gauge then the movement of this jaw we can neglect.

In this case, we can call it is as CRE constant rate of elongation. Because, the material will elongate at constant rate but for other type of tensile equipment where this is jaw 1 and jaw 2. Jaw 2 is moving at constant rate, okay this is moving at constant rate again. But this the load measurement, can be only done if this jaw moves. With the movement of this jaw this load measurement system will get signal then only it will show the load.

Because load measurement system is a function of the displacement of movement of this jaw so in that case, what happens; the extension this jaw is moving, this jaw is also moving so the extension is not constant. Okay, extension is not constant and also here the rate of extension is not constant and here increase in load is also not constant. So this is not CRL and also it is not CRE constant rate of extension it is not constant rate of extension. But one thing is, here this movable jaw actual this both the jaws are moving, driver jaw which is driver jaw moves at constant rate.

Okay, so it travels at constant rate that is why this principle is known as CRT. That is in this the jaw, driver jaw will move at constant rate of traverse but actually the extension will change and it is not; it will not impart load at constant rate. So, it is a different method which is known as the constant rate of traverse.

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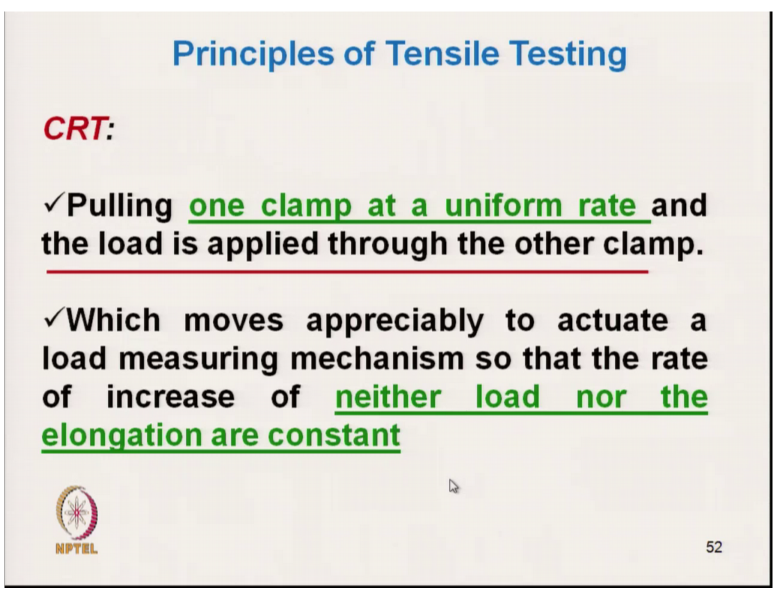

So pulling one clamp at a uniform rate load is applied through the other clamp through the movement of other clamp. One must be very clear here load is applied by the movement of other clamp that is why is called CRT principle. This means the other clamp which moves appreciably it is not negligible it move appreciably to actuate a load measuring mechanism so that the rate of increase is neither load at constant rate nor at the constant rate of elongation.

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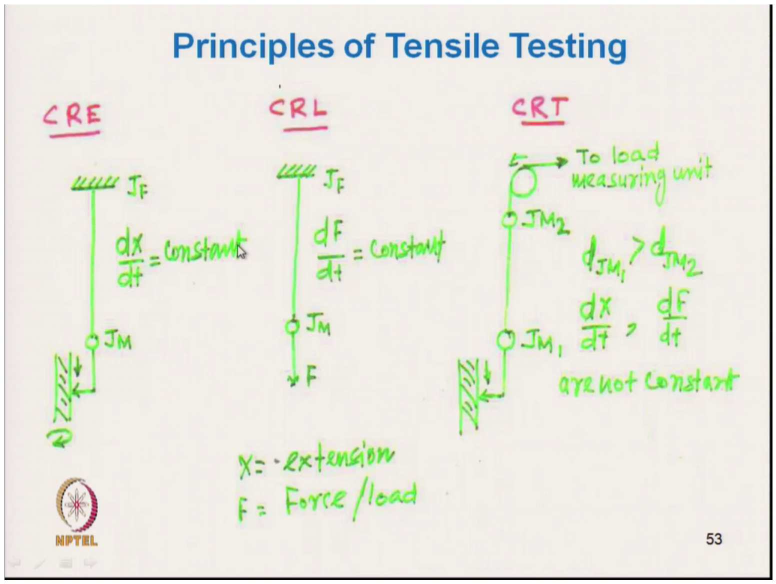

Okay, now these three pictures will give idea, here it is a fixed jaw, it is movable jaw and it is driven by some arrangements some screw arrangements. Okay, like some UPI machine, this jaw fixed jaw here some load an arrangement is there. But effectively there is no movement, so it is moving at constant, dx/dt is constant that is a CRE principle. Here the jaw is moving in such a fashion that force, rate of increase in force that is df/dt loading is increasing in constant rate. And CRT as we have discussed disowned the jaw 1 is moving at constant rate but jaw 2 is also moving actuate the loading mechanism so that is why it is the constant rate of traverse. Okay?

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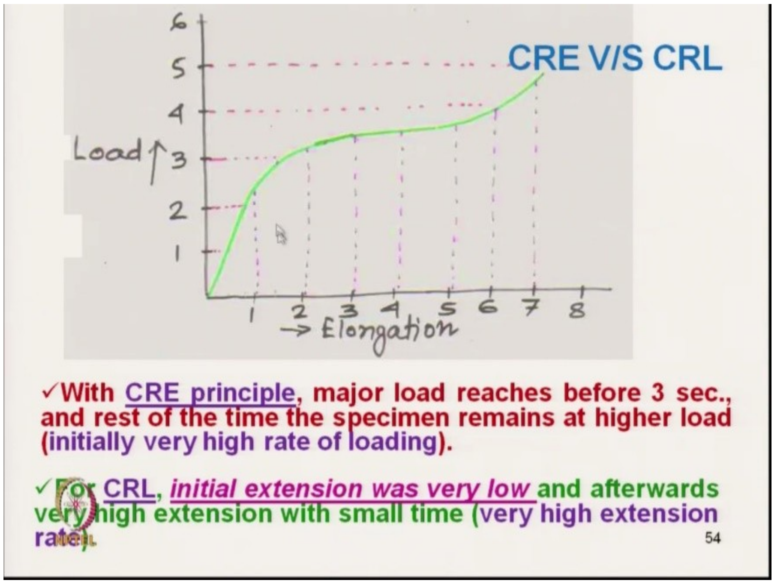

Now, let us see what happens to the rate of loading, constant rate of loading or constant rate of traverse if one is fixed. Now try to see here, now with the CRE principle, Constant rate of elongation this is the curve. This is the standard curve. Now let us see CRE principle or CRL principle the curve is same. Now suppose the instrument is working at CRE principle, Constant rate of elongation principle that means this is the constant rate of elongation.

That means, in 1 Sec this is the elongation, 2, 3, 4, 5, 6 in this way it is extending. Now here in 1 sec the extension is say, up to this point. Or 2 sec this point, 3 sec here, we will see the maximum extension is taking place within the 2 or 3 sec. whatever maximum so this is maximum loading is taking place within the 3 sec. Loading on the specimen, so major load which before 3 sec majority of the load. Remaining say 5, 6 sec the material is under high stress condition, okay. And the rest of the time, the specimen remains at the high load condition.

That means initially the loading is at very high rate. With initially 3 sec, the loading taking place, maximum loading is reaching. So, when the specimen; when the testing is taking place in CRE principle its rate of loading at initial stage will be very high. After that for long time, the rate of loading is very slow, okay. So that means if we see up to 2 second it has reached 3 it has reached 3 loading, loading 3.So, but rest 6, 7 second it has increased another 2. Okay, another 2 unit. So that rate of loading initially it is very high but after that rate of loading is very low.

Initially if you see rate of loading 3/2 it is 1.5 say it is the rate of loading but after that next say say 6 second it is; it has increased 2 units, that means 2/6 so 1/3, so rate of loading has reduced after that. And if it works in CRL principle we will see in CRL principle, initially the extension was very less. Initial up to 3 sec the extension was up to say 1.5 okay, but after that next 2 sec extension is from 1.5 to 7 so large extension took place within 2 sec. So, for CRL principle, initial extension; rate of extension was very low okay, but afterward, the rate of extension has increased to a greater extent.

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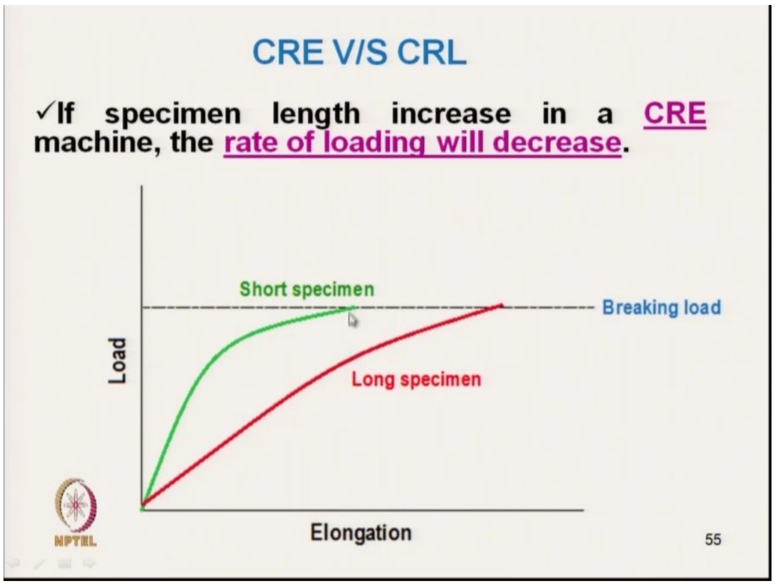

Now so effect of specimen size on CRE principle if the specimen length increases in a CRE Machine the rate of loading will decrease. That means this is the; suppose the machine breaking load of the specimen is say fixed. So, this is the breaking load point and a short specimen will have this much of extension, this is the extension of the shorter specimen. For longer specimen it will get extended and the elongation will be up to this point. That means if this works in CRE principle that means the maximum load will reach for short specimen earlier than the long specimen. That means, if we use short specimen the rate of loading will increase and vice versa if we increase the length of the specimen, rate of loading will decrease.

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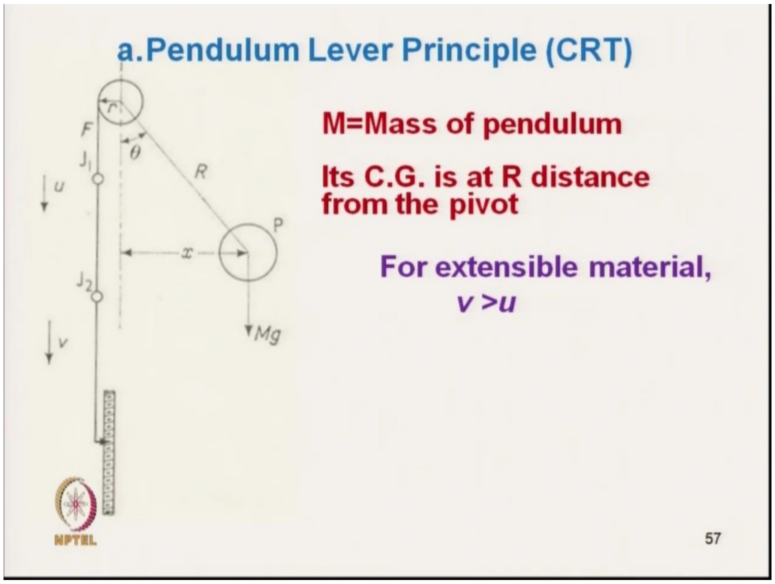

Now, we will start the methods of measurement of tensile characteristics. There are different methods of measurements. And we will discuss the method of measurement of fibre bundle and yarn fabrics. First we will discuss the pendulum lever principle (CRT). This principle is used for measuring the yarn strength even for the single yarn we can test or maybe it is normally used for lea strength ok. This is the pendulum principle. Now, I will draw, I will show you the exact principle here.

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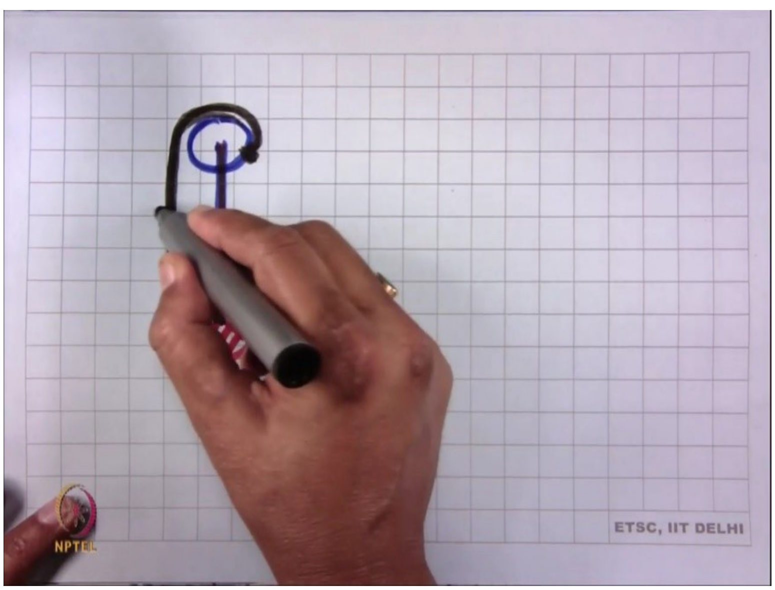

Here we will see this is the pully, okay and with the pully, the loaded pendulum is actually hanging. This is the pendulum. Now, on the pully here one string, okay this is strip displaced, metal strip is actually placed here flexibly. Which is fixed somewhere here, it is not wrapped it is actually fixed here and it is wrapped here and then it is not like a bell pully here it is fixed. Now, if we apply load and it is fulcrum here, centre of the pully. Now, if we apply load downward as it is fixed here this will try to move in this way.

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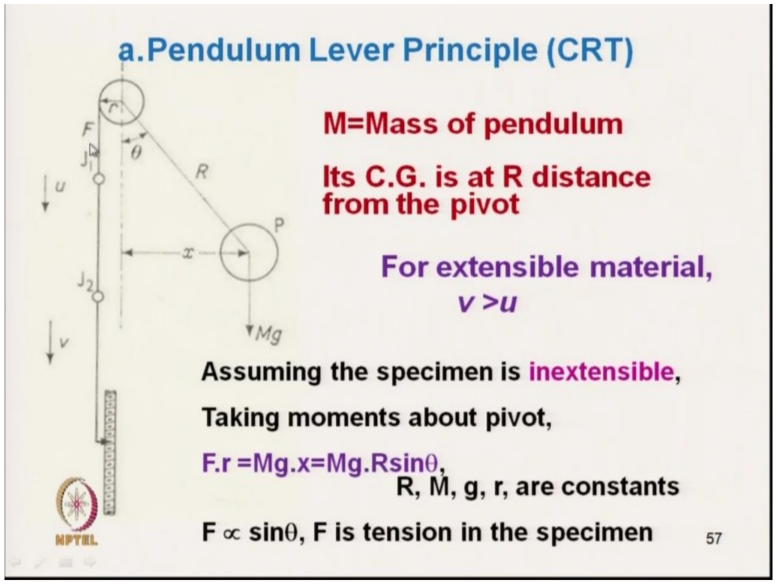

And this is fixed and there will be this moment and this one if it is pulled then this is actually freely rotating. This is free to move, so and if it is pulled down this one will try to rotate anti-clockwise and this total pendulum system will move towards the anti-clockwise movement, okay towards the right ok this side it will move ok. That is the principle here. Now here this is the arrangement okay, so the mass of the pendulum is M and its center of gravity is at R distance from the pivot point. This is the R distance from the pivot point.

Initially, this pendulum is vertical at this position. Now once we apply force F, this pendulum will get deflected, okay. As it is the; this is the metal strip there which is fixed due to that this will be pulled here. Now for extendable material these motions, the speed here speed of jaw, is moving at the speed of v and aperture is moving in the speed of u. So, for material extensible so v larger movement is more than the upper jaw movement. Now we assume that the specimen is inextensible and we can take the moment above the pivot point, this is the point pivot. Now force, what is the force, which is actually acting on it, the force F is acting downward. And due to the mass of the pendulum which is moving downward, which is acting force downward.

Now, this force due to the yarn through the material this force F, it woks it actually tends to rotate this disc, this pulley anti-clockwise, this moment. And the moment due to this pendulum mass it tries to rotate in clock wise direction and it always tendency to move clockwise direction and these two movements are balanced. So, the anti-clockwise movement about the pivot is F * R, R is the radius of this disc. Okay, and the clock wise moment Mg is the force exerted by the pendulum of mass M, Mg * this distance.

What is this distance, if the deflection is theta, deflection of the pendulum is theta and R is distance so it will become R sine theta, So, the net momentum will be Mg R sine theta, so this is the; in balance condition it will be always balanced about the pivot. So in this equation R is constant for a particular instrument, M is constant because the pendulum that is pendulum bob weight is constant for a particular experiment, g is constant r is constant that is the radius of the pivot disc is constant.

These are the constant terms. So if we are using all this constant terms, then we can tell this force exerted okay, on the material is directly proportional to sin theta, okay. F is the tension on the specimen that increases with the sine theta.

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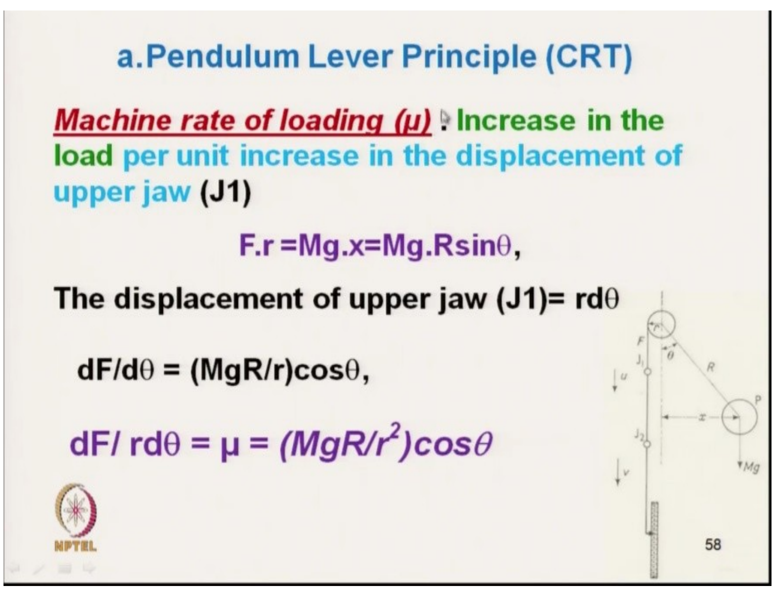

Now, there are 2 terms, in this instrument one is called machine rate of loading, another is that time rate of loading ok. The machine rate loading is that, expressed in terms of Mu it is the increase in load per unit for increase in the specimen for displacement of upper jaw. So, unit displacement of upper jaw what is the increase in load. So, we can refer earlier equation Fr Mg R sin theta, and displacement of upper jaw that is J1. If we know the deflection d theta and rd theta is the circumferential displacement ok rd theta is the displacement of upper jaw.

So, in that case, the ratio dF/d theta if we take differentiation dF/d theta will become that is r if we bring to the right side that will become MgR/r and sine theta will become cos theta. That is after differentiation it will become equation will become this and if we multiply 1/r both the side that will become dF/rd theta which is nothing but the Mu, machine rate of loading, dF/rd theta = mu= MgR/r2 cos theta r becomes r square because we are multiplying that by 1/r and this multiplied by cos theta.

Now this is the machine rate of loading, now at starting point when the machine rate of loading when the theta is 0 in that case theta is 0 that means it will be 1 in the starting point and as the theta goes on increasing that this rate of loading will gradually reduces.

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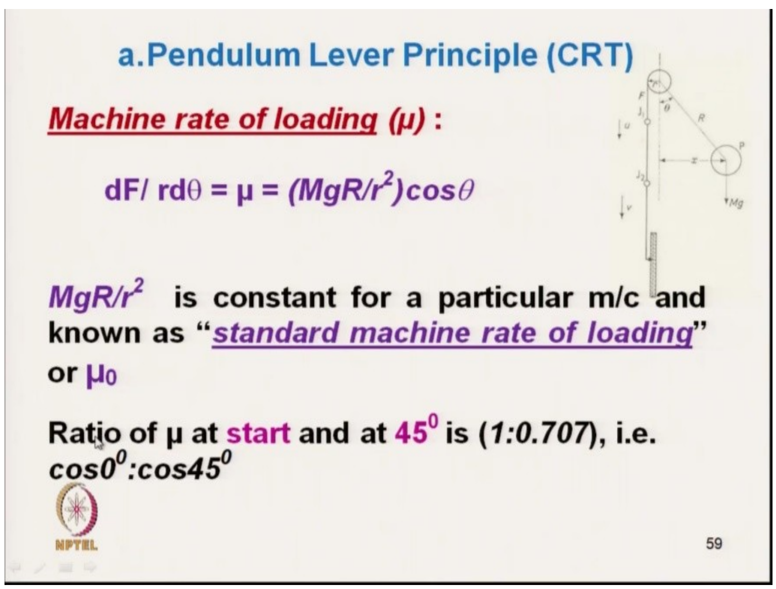

So, this is the machine rate of loading dF/rd theta and this value is constant value and that is constant all is value are constant value for particular machine and it is known to be standard machine rate of loading so this value MgR/r 2 small r square is called standard machine rate of loading one can calculate and the ratio of Mu at the starting point and at 45 degree consider at 45 degree then it will become it is the ratio of cos 0 by cos 45 degree so it has become 1 : .707 that means here rate of loading in this machine in this instrument reduces gradually with the deflection so rate of loading at the starting point is machine and reduces gradually with the deflection with the time.

And one can ask to calculate what is the ratio of rate of loading with the starting of and after certain deflection so we can calculate only the ratio between cos 0 to cos 45 that angle, this is machine rate of loading.

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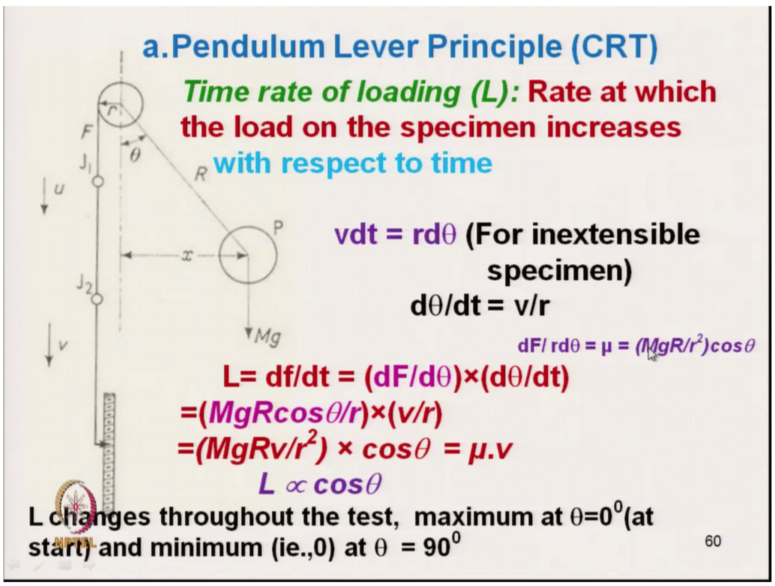

Another it is called time rate of loading. The time rate of loading is the rate at which specimen increases with respect to time. Earlier with respect to deflection, with respect to the movement ok, here with respect to time, with the time how the rate of loading increases. So, if we see vdt for any if we assume the material is inextensible, that means there is no extension which means the lower jaw movement and upper jaw movement the speed of lower jaw and speed of upper jaw remains constant, v=u, that means, vdt is the total movement of the lower or upper jaw which = rd theta is the deflection. Rd theta is the actual movement of this jaw.

So, vd theta =; vdt = rd theta ok from there we can calculate d theta / dt = v/r this we will use later so you must remember that d theta / dt where calculated for in-expandable material that is become v/r and this was the earlier formula we have seen d theta df/r d theta = Mu that we have seen for the machine rate of loading. Now L=df/dt that is L, what is L the time rate of loading it is df dt, the rate of load of the specimen of increase in time.

So, df rate of load increase with increase in time df/dt is the L value, df/dt we are just rearranging df/d theta * d theta/dt. So, df/d theta we already calculated earlier that is the machine rate of loading so df/d theta will become, so Mg R cos theta/r from there we can calculate multiplied by v/r. This is vr d theta dt already seen is equal to v/r, it is coming out to be the MgRv/r 2 * cos theta ok that means nothing but Mu*v ok. We have seen rate of loading, this again time rate of loading is proportional to cos theta.

If we want to know the relationship between the machine rate of loading and time rate of loading, so it is Mu time rate of loading = machine rate of loading multiplied by v ok, v is the velocity of the specimen, velocity of the jaw. Here that assumption is that it is clearly extensible, there is extension if you know the rate of extension or extensibility we can modify this equation. L is proportional to cos theta again.

Similarly the time rate of loading also reduces with time, initially the time rate of load is maximum. So, L changes throughout the test and maximum at 0 degree and minimum at 90 degree if the deflection is at 90 degree normally almost all the practical purposes it never reaches at this point.

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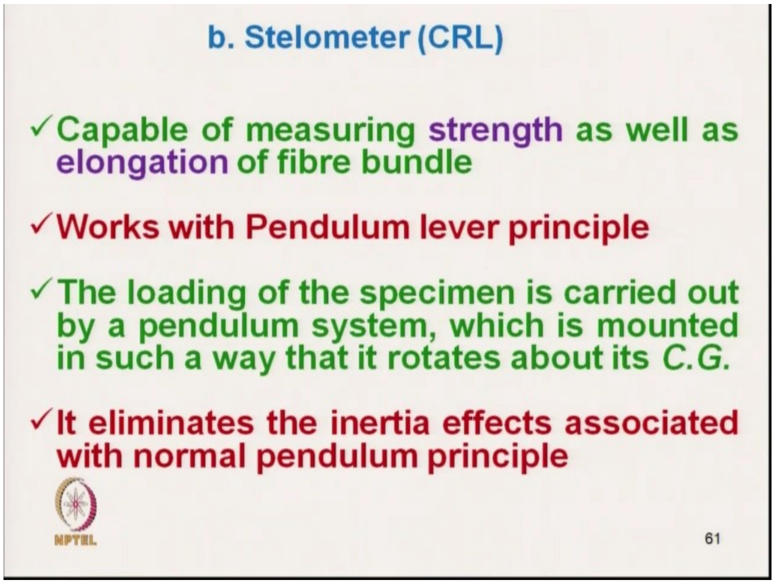

Now we start and discuss another instrument which is Stelometer. Stelometer is a principle again it works in pendulum principle, but stelometer is used for fibre bundle, earlier we have seen that is pendulum principle. Here stelometer also works in pendulum principle. It is capable to measuring strength as well as elongation of fibre bundle. So, it can be measure the fibre bundle strength and elongation can be measured. It works with pendulum lever principle ok.

The loading of the specimen is carried out by a pendulum system, so in the earlier system also we have seen it is loading is carried out by deflection of pendulum ok here also deflection of pendulum actually by deflection loading is actually applied which is mounted in such a way that it rotates about its centre of gravity. So, pendulum the design is such that it rotates about its centre of gravity if it is released.

It eliminates the inertia effect associated with normal pendulum principal. In earlier case we have seen that the pendulum it moves but there due to the high rate of extension actually inertia effect will be there. initially it is observed pendulum will not move due to initially extension there it is not showing the load. These are the initial effect of the pendulum ok. We can see here.

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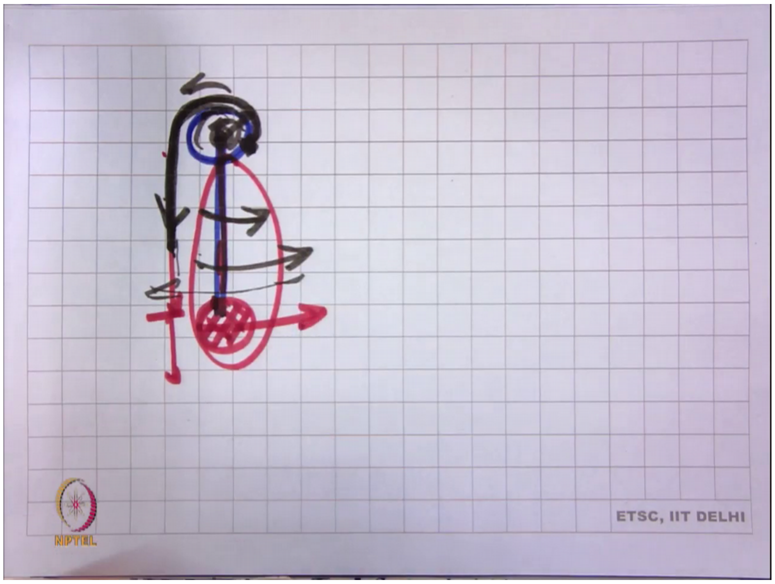

So in earlier method what we have seen, when the jaw starts moving, this pendulum due to its inertia so it will not; although there is movement but due to its inertia it is not moving, it takes time. So that is inertia effect here is eliminated in stelometer ok.

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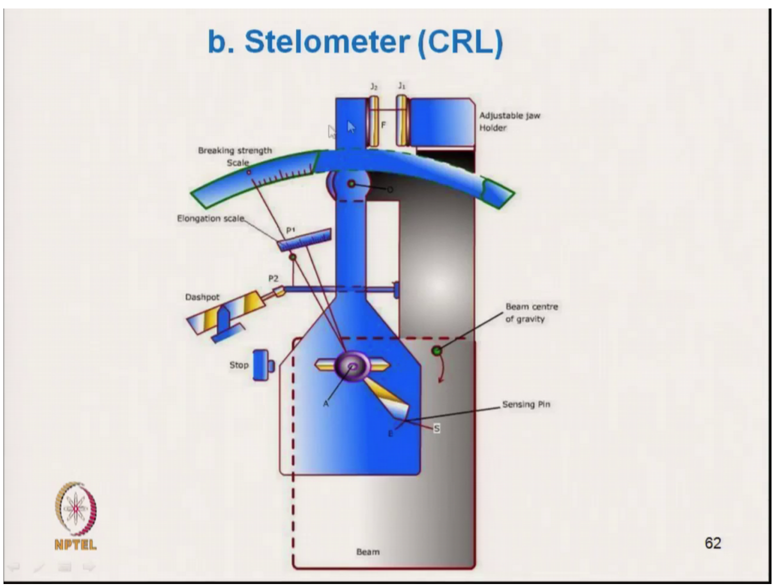

So this is the actually diagram of stelometer. Now, it has got two distinctly separate components. Now, we must try to understand here.

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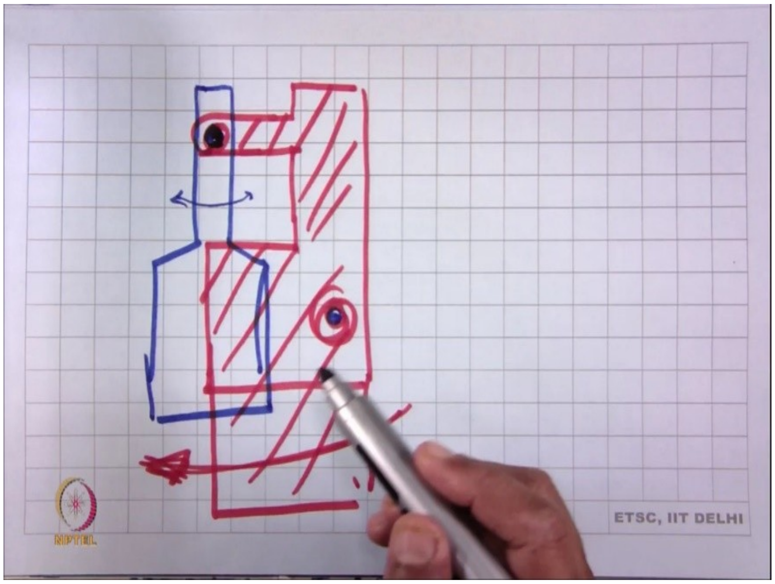

Now two components are there. This is one structure okay red one is heavy one, big size. This red one is a beam and blue one is pendulum okay. Now, here it is pivoted here at that point ok. Center of gravity of pendulum is somewhere here. This is the center of gravity of pendulum. Now, for the time being, we just, we just eliminate the, this pendulum blue color. This beam is there and it is the pivoted at this point ok. It is the pivot point. Now what will happen if it is released? Initially it is vertical so if it is released what will happen? The tendency of the beam will always to rotate clockwise direction because its center of gravity is here. Design is such that its center of gravity is here.

Okay, so it will try to rotate in this direction. Now, here the pendulum is hanging, this pendulum is freely, this can rotate freely along this pivot point. Now what will happen, if nothing is here? In this condition we release this; this is actually fixed by some stop arrangement. There is some stop arrangement. Now, this stop arrangement if we release here what will happen, this pendulum will try to rotate simply rotate and what will happen to this, the beam will rotate, what will happen to this pendulum if we release this stop arrangement, the pendulum will this beam will rotate clockwise but the pendulum will be remain in that point, in the vertical position.

Because it is just hanging pendulum simply hanging on the pivot point, okay so, nothing will happen. This will simply rotate and this will tilted in such a way centre gravity is below this. It will simply be hanging, and this pendulum will remain, in vertical position. Now, the condition is that it is stopped here, here all sample is here. We have fibre bundle is put here, this is the fibre bundle. Now what will happen, now we will release, stop arrangement then what will happen here pendulum, this beam will try to rotate clockwise due to its mass and center of gravity and pendulum will try to be there in vertical position.

But as this fibre's are there this total beam it is heavier than pendulum is much heavier than pendulum it will try to pull the pendulum here. Through this fibre mass this beam it will try to pull the pendulum and pendulum will rotate in clockwise direction also along with the beam okay. And till the point because, as it is moving upward the load will increase that we will come, that we will discuss. But till the point it will follow the beam when it is reaching it breaking point, as soon as reaching its breaking point, then pendulum will be released.

And another point is that if there is no extension, suppose material is 0, if the material is inextensible material, in that case the pendulum will follow exactly the beam. But if the material has got some extension the pendulum will follow little bit at higher rate move little bit ahead and this will also follow but it will at lack behind. This difference in movement we can measure, we can actually identify and that is nothing but extension of the bundle ok. Now, the principle is very simple it is very simple. Now we have to balance the moment this beam will have a balance, this the beam which is actually, a beam of center of gravity.

This beam will have movement, clockwise movement and this pendulum will exert a anti-clockwise movement. Okay, and this the stop arrangement of the beam.

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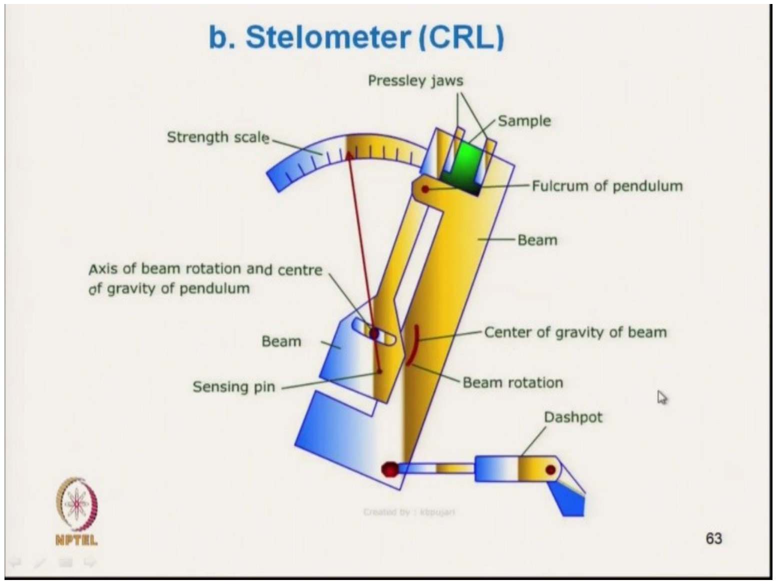

Once you release the stop arrangement, this is the situation. As we have discussed this is the sample, here it is the fulcrum point ok, this is beam, and this is center of gravity of beam, okay. Here it is the dashpot, it can control the movement and the sensing point and there is a scale ok. And it is called the Pressley jaw. In Pressley system, jaw is used, the same jaw is used here. Okay, Pressley strength system I have mentioned earlier also.

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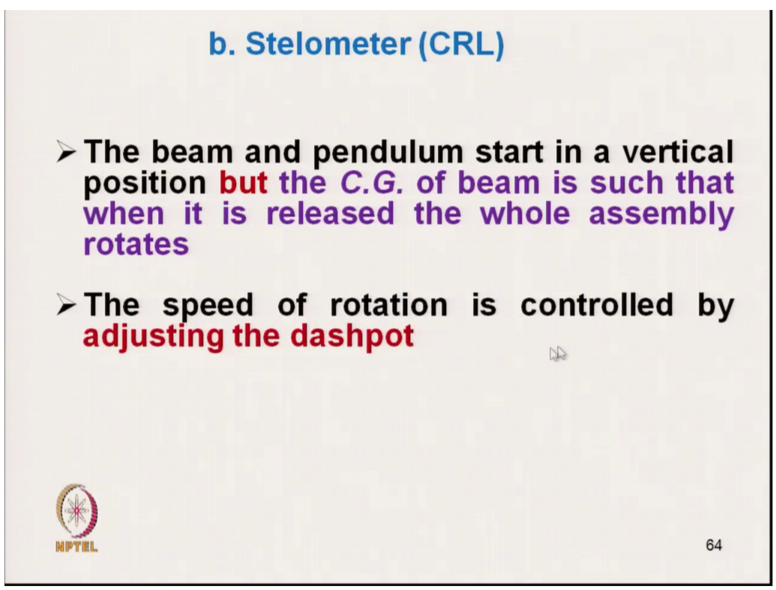

Now let us see balance of movement. The balancing of movement is that the beam and pendulum start in a vertical position but the center of gravity of beam is such that when it is released the whole assembly rotates, clockwise. The speed of rotation is controlled by adjusting the dashpot. We can adjust the dashpot, so that the speed of rotation is controlled.

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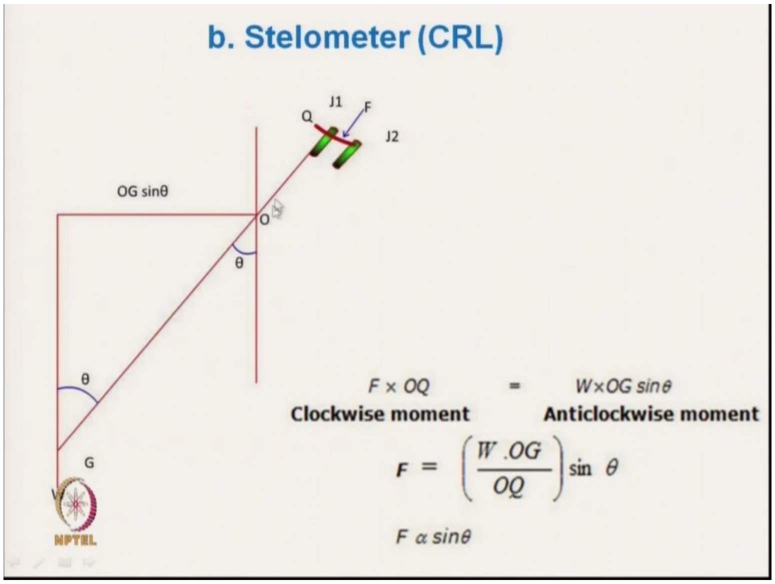

So, this is the way. Here this is the fibre ok, here force on the fibre. Force on the fibre * this OQ, OQ is the distance that is a clockwise movement, clockwise movement by beam clockwise movement by its beam distance from the fulcrum point to the jaw it is OQ. That is the force on the fibre, that is the clockwise movement by the beam and anti-clockwise movement by the pendulum which is W is the mass of mass of pendulum. And OG is distance ok from center of gravity to pendulum to the pivot point this is the center of gravity of the pendulum point. And it is this is OG sin theta because theta is the deflection.

So, we can see that F is proportional to the sin theta. That means, here the loading is proportional to the sin theta it increases with the sin theta as sin theta increases.

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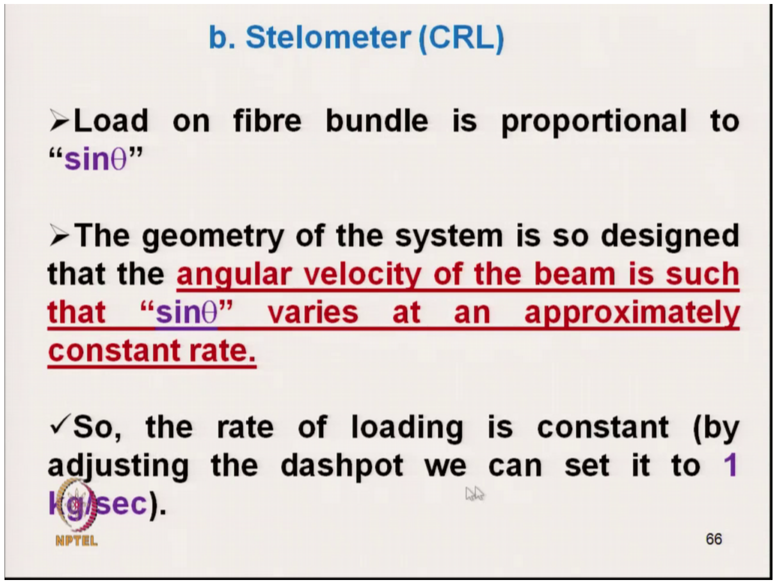

So, the load from the fibre is proportional to the sin theta. The geometry of the system the total geometry of the system is kept in such a fashion that angular velocity of the beam is such way that sin theta varies at an approximately constant rate that is very important here. So, designing is such that the angular velocity is in such a fashion that sin theta increases at constant rate. So, if we can keep sin theta increasing rate of change of sin theta at constant rate.

Then we can claim that the instrument works in a constant rate of loading principal ok. So, the rate of loading is constant, and we can adjust the dashpot to certain extent so we can adjust load at any rate of loading so 1 kg/sec or any rate of loading, so we can increase the dashpot ok.

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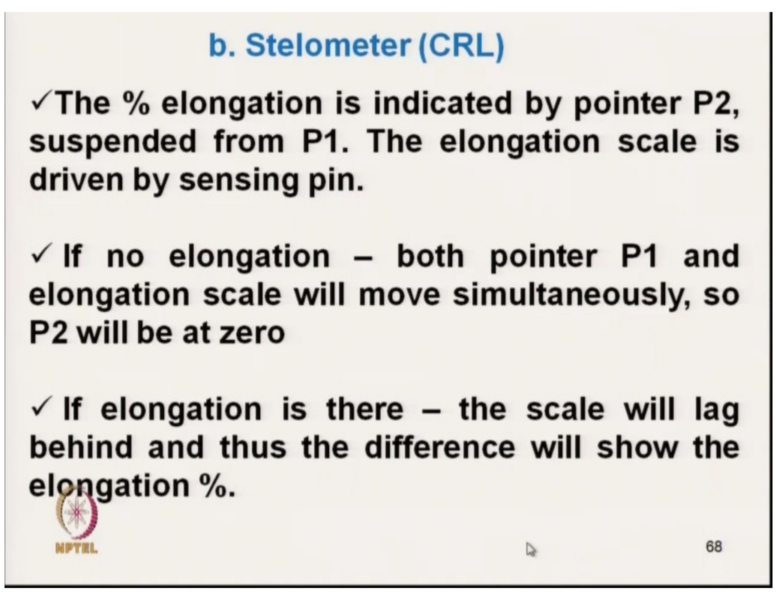

From there elongation percent can be calculated ok, by the difference between pointer 1 and pointer 2 as I explained. If there is no elongation both pointer 1 and pointer 2 will move together and show zero point. And if there elongation the scale will lag behind and thus the difference will be shown as elongation okay. And next class, we will discuss another principle, which is beam balance principle, and there will be many other principles till then, bye. Thank you.