Design of Machine Elements – I

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Lecture No - 29

Design of Springs

good day today we continue our lecture on design of springs and this is a lecture number twenty-nine

now you see that for the helical springs we had already learnt about the stresses about the deflections and nomenclatures the other design parameters what are required to be determined for a total design of an helical spring

so what we do today that we take up a small design problem on helical spring and we will solve that problem so that we'll have a good revisit to the all what we have learnt in earlier lectures about the helical spring

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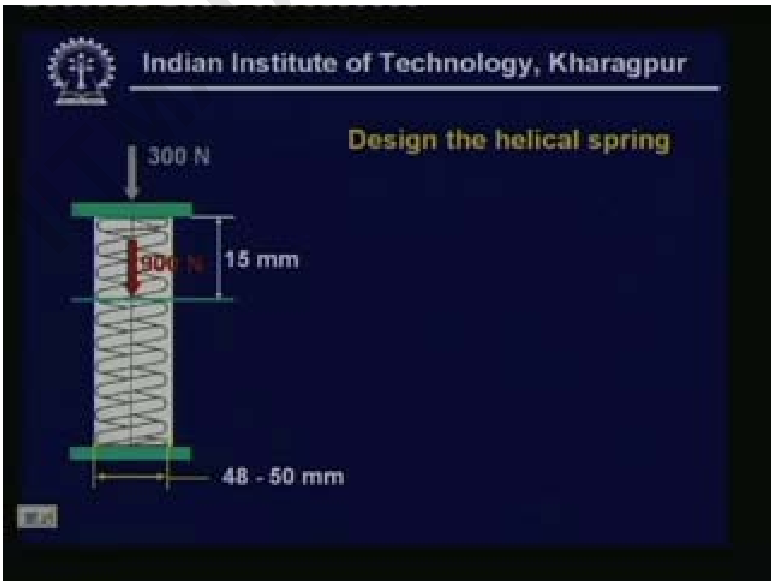

now the problem is defined here

you can see that a helical spring has been taken which is acted upon by a load of three hundred newton and nine hundred newton respectively that means it is working under a variable load and {fa} (00:02:12) for which the spring deflection will be around fifteen mm

and other situation is that for some design requirement the spring outside diameter should not exceed fifty mm as a matter of fact it should be within forty-eight to fifty mm

so with this particular design problem let us start today's lecture to solve the problem

in general when we start the problem then first of all we have to think of what we have to think of a spring material we have to think of the spring dimensions and the most important to start with is a spring index because a spring index gives you the ratio between the coil diameter and the wire diameter

now as because a we can have a variety of choice of the spring index we have to start somewhere normally the spring index can vary over over a large length say starting anything between three to twelve or so

however normally it is a good practice if we start the design with somewhat around six or seven but anyway it is not the final answer ah but one can start approximately designing the spring with a spring index c or value six

because you know if the spring index is is more then what is happening the curvature effects will be lesser whereas if you are having a spring index to be in a lesser side then the curvature effect will be higher

but at the same time what will happen the larger the diameter of the spring wire then lesser will be the stress in the spring wire and vice versa

however to find a unique solution to a design problem one has to resort to a trial and error method which is normally unavoidable in all design problems

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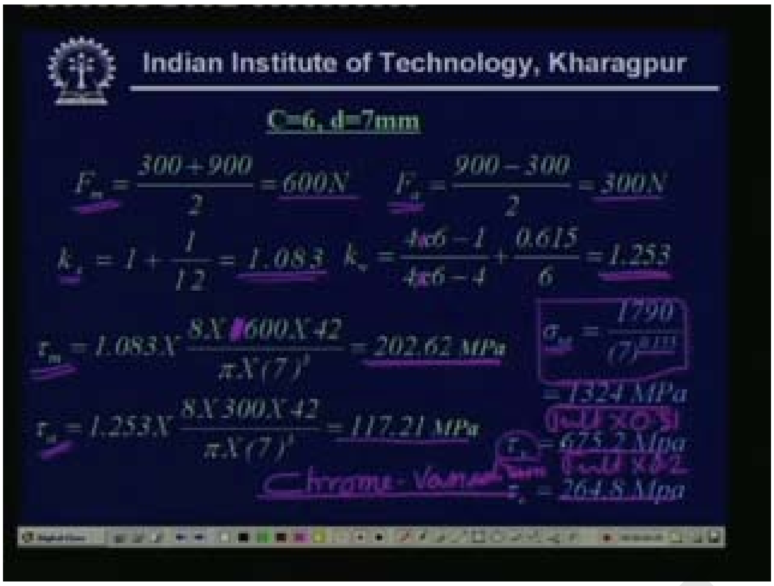

so in this case we start the problem with a design ah [Noise] with C equals to you can see C equals to six and it's a corresponding diameter we are considering to be wire diameter to be seven mm

now what is the basis of choice of this particular C equals to seven and D equals to seven mm because you can see then the capital D will be coming out to be forty-two and you add to that the wire diameter so that comes out to be forty-nine and so this comes very much within the limit

so our basis of choosing the wire diameter seven comes from the fact that we have to restrict ourselves the outside coil diameter within a value of forty-eight to fifty so with this we take up the C equals to six and D equals to seven

now you know this problem is a dynamic problem i mean it is the spring is acted upon by an variable load so there are two situations coming into picture one is the average the mean stress Fm and another is a stress amplitude Fa

so in this situation what we are doing that Fa comes out to be six hundred newton and this comes out to be three hundred newton after calculation

now we know the stress concentration shear stress concentration K factor Ks will be given as ah one over this particular one by two C that is twelve one point zero eight three

and Kw is four into six minus one four into six minus four plus point six one by six which comes out to be one point two five three so we get the value of mean shear stress that is tau m is one point zero eight three there is a this will be six hundred please note down

so eight into F into the capital T divided by the pi D cube the standard formula what we have learnt earlier so that gives you the value of two hundred two point six two mega pascal

and ah stress amplitude in the similar manner comes out to be something like hundred seventeen point two one mega pascal

now the {caam} (00:07:57) the question comes about the what will be the material of the spring and what should be the corresponding strength values

so we have seen that in this order of a criteria we require the material strengths like {sig} (00:08:18) tau tilt point and tau endurance limit and both of these can be derived from other from the data base from the design hand books or we can have the relationships what we have learnt during the spring design

so here ah we choose a material that is ah i am just writing over here the we choose a material let it be chrome vanadium

so we choose a material chrome vanadium so if we choose a material as chrome vanadium then immediately we know that the relationship for ultimate strength comes out to be one seven nine zero by this D to the power zero point one five five

so you please refer to the earlier material property lecture and from where you get a formula and and indices value of a and this value of m so that gives you a value one three two four

and ah again if you go back for the relationship of sigma ultimate to sigma tilt point then you'll be finding out this tilt point is sigma ultimate multiplied by zero point five one for chrome vanadium and endurance limit is sigma ultimate multiplied by point two

so if you get these are the two values what you get from this calculation

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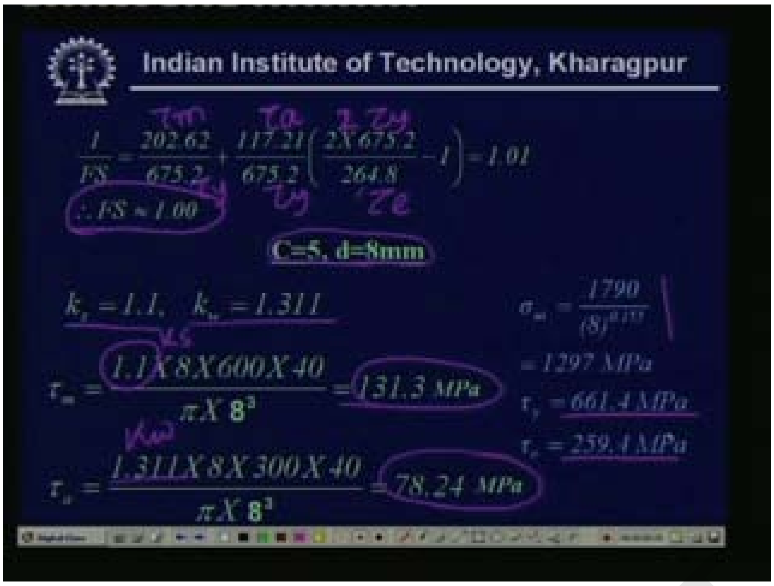

so once you find out the material property then what we can see that we substitute this values into the equation of

what is this comes out to be this you know this comes out to be tau mean by taw ilt point tau stress amplitude by taw ilt point twice of taw ilt point this is two tau ilt point this value and this is tau endurance that gives you a value of factor of safety as one

so the design do not have any factor of safety this is just a word utilizing the material property and getting the answer for the spring dimensions

so ah it is better that normally for any design of the springs we go for a factor of safety which should be more than one and in the facility of one point two five three ah may be one ah i mean one point five or so it will be better so that's it end

we take up the next iteration where we consider the C equals to five and d equals to eight mm this choice is obvious because C seven and d six will be giving us the more stress on the wire there by the factor of safety will again decrease

so let us go for the higher one and ah just by following the similar procedure as ever we find that this is Ks is one point one

Kw is one point three one one and we multiply the mean stress by Ks and the stress amplitude by K wall correction factor that we have already learnt earlier and this gives a values of this nature

and in the same way with using the chrome vanadium steel we get for this case a tow ilt point and tow endurance value is something like this

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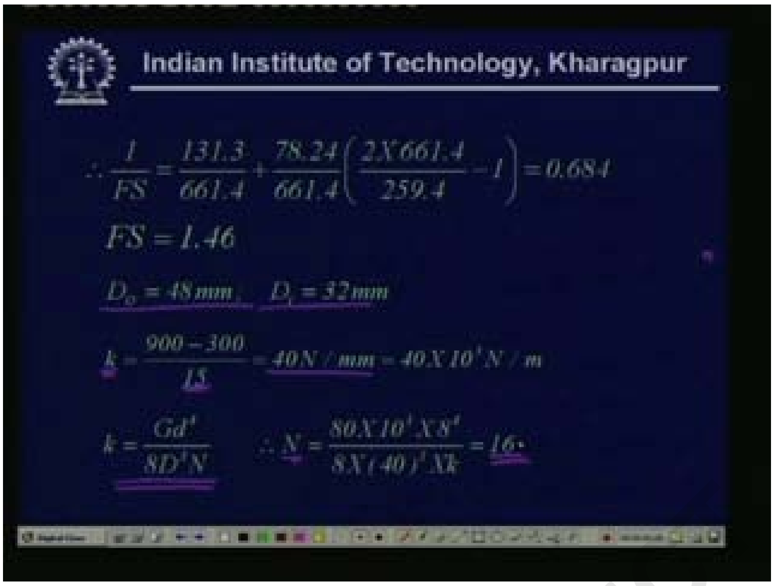

so if we put this to the formula then what we get we get we get this values as yes this values we get as point six eight one up and i guess a factor of safety comes out to be about one point four six

so it is very near to one point five and ah this factor of safety is quite suitable for the design and we accept the value of C to be five and D to be eight mm okay

so what we get the capital D comes out to be forty and outer diameter comes out to be forty-eight so obviously this is well within the limit prescribed and we can select these dimensions

so once we select these dimensions then we find out from the standard results ah the standard formula what we have learnt earlier that D zero comes out to be forty eight D i thirty-two mm

so what is this particular spring stiffness k or this ah spring rate spring constant whatever you may call it so nine hundred minus three hundred by fifteen that was a displacement ah for the load of nine hundred to three hundred

so we get the value of k as this much so in terms of newton meter we get it this way so basically what we are getting is the slope something like this if it is three hundred if it is nine hundred we get a fifteen so that is a slope which is the fifteen mm is your displacement

so force displacement curve from where we get the value of stiffness so once we know the value of stiffness then what we can find we can find out we can find out the value of number of turns value of number of turns can be obtained from this relationship so number of turns comes out to be sixteen then we come back to the idea that once we find out this number of turns so this number of turns you know will be what we call as number of ah

excuse me we go back to the earlier slide [Noise]

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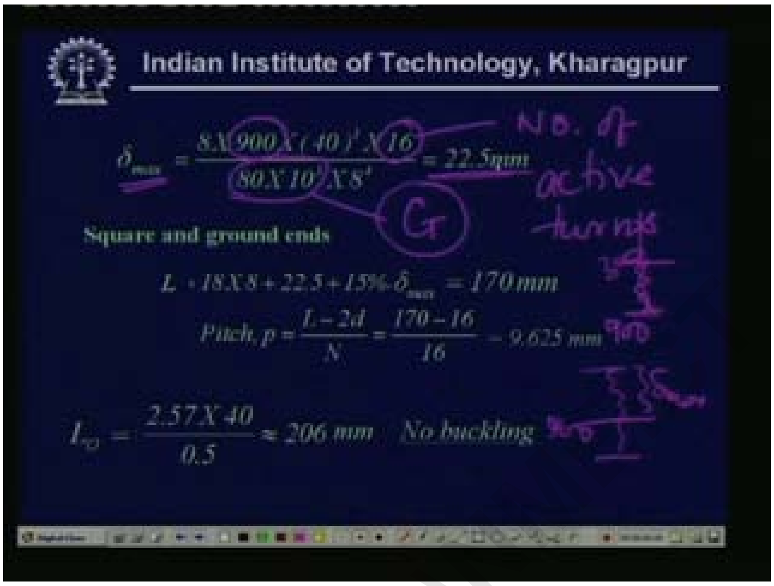

okay so this comes out to be the case this one this sixteen is number of active turns

so once we get the number of active turns then we have found out the maximum delta this this is the deflection of the spring that comes out to be twenty-two point five

please note that we have assumed e ghty into ten to the power three ah this amp as the value of G this is nothing but the value of G for the steel material can be assumed

now here you understand the load is nine hundred because ah if because the spring was somewhere in between squeezed from three hundred to nine hundred this is three hundred this is nine hundred it was squeezed in between

so if you leave it then if you leave it something is like that then you put the entire nine hundred then this comes out to be your delta max

so it is under nine hundred what is happening so that delta max we are computing to be twenty-two point five

so once we get this delta max then what we get

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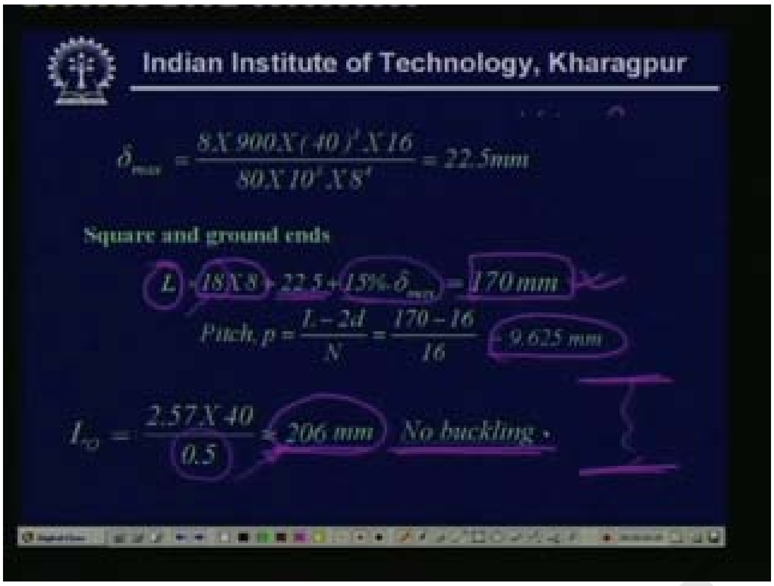

we can find out ah for an square and ground end coil that is an assumption

so ah ah just one second this should be squared and ground ends so for this type of spring you have seen earlier this is the spring it is flattened and grounded at the top and bottom also

so for this type of spring what we get that we get the value of free length this is a solid length while going the solid length

if you just go through for the square and ground end chart you will be finding out this is the total number of coil eighteen that is sixteen plus two into eight is dia

this is the delta max and we have assumed certain fifteen percent of the total one to consider as an clash allowance and that gives us approximately and value of one seventy mm

so once you know the free length to be one seventy mm then pitch comes out to be from this formula as nine point six two five

now we come down to the check for the buckling so we have seen that the check for the buckling is ah two point five seven this is this is the limiting value for d is the capital D divided by the end condition

in this case the end condition comes out to be over the plates and so it is point five and that comes to be around two zero six

so i urge upon you to just see look to the formula we have derived earlier from where you find that this value is coming out two zero six mm whereas the value of the free length of the spring is one seventy mm so obviously there should not be any buckling

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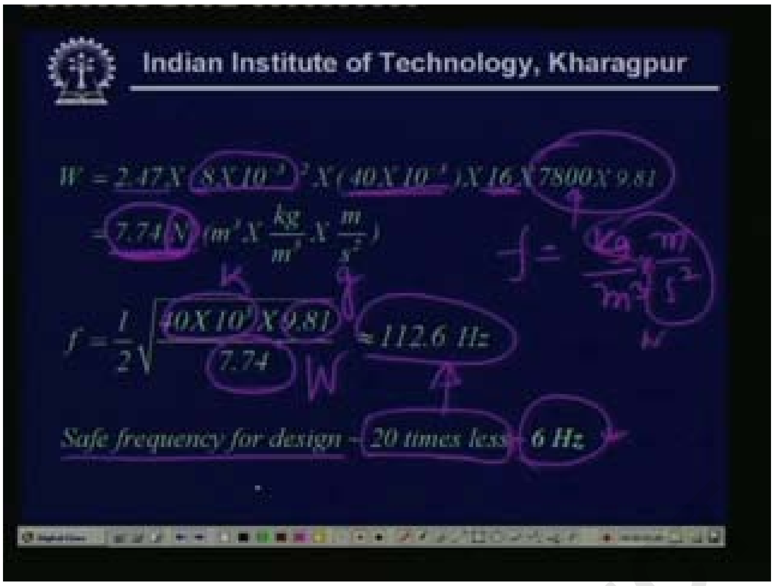

so we go back to the case that what should be the frequency behavior that means what is the critical frequency of the spring ah springs so that the spring do not have any surging tendency

now in this case we know the weight of the spring should be first computed to find out the formula of the frequency and that formula you will you remember it as half as written over here

ah i think i can just tell over here this is a spring rate K this is g and this one is your W the weight of the spring total weight of the spring

so you can see we have found out two point four seven then this is D square so that is a D square of pi by cross sectional area pi by four d square and this comes out to be pi D and the total one

so this mean dia of the coil then the total number of active turns and this comes out to be your ah this is your density Kg per meter cube and this is just to make in unit of meter per second square so this is the G value so Kg meter per second square will give you the newton

so that is the thing so once you get these values as the weight comes out to be around newton meter cube Kg per meter cube meter per second square so meter cube is meter square into meter meter cube so the unit comes out to be seven point seven four newton

so this one ah one thing you should be very careful about this units okay so while dealing with this Si unit you know the force should come out the weight means it should be a force unit so that is newton so once you put these values it comes out to be hundred and twelve point six hertz and that means what [Noise] that this is the frequency

so we understand the safe frequency for design should be at least twenty times less than this frequency okay ah because if you take up twenty times less then what happens that not only the first mode all other harmonics for the frequency ah i mean up to say around ah twenty ah harmonics you can take care of okay

so that comes out to be approximately six hertz so the spring is safe times less then what happens that not only the first mode all other harmonics for the frequency ah i mean up to say around twenty harmonics you can take care of okay so that comes out to be approximately six hertz

so the spring is safe ah that means spring frequency for design ah so that means while you are applying ah in actual application it should be around six hertz so that gives you the total design of a helical spring

so i i hope that you understand that by this particular problem what we have done

we have taken more or less all the aspects that what we have learnt ah in helical springs starting from the stress equation the correction factors wall correction factor and shear stress factors the material choice material strength choice

then the choice of spring index and then ah um then you you have seen that we have used a sort of a criteria that means invariable load design then you have checked for the buckling you have checked for the frequency that is the surging of the spring

so more or less we have seen that all the situations what we have learnt has been taken care of by this particular problems so ultimately the values what we have computed right now ah in different stages are the typical spring design parameters for the given problem

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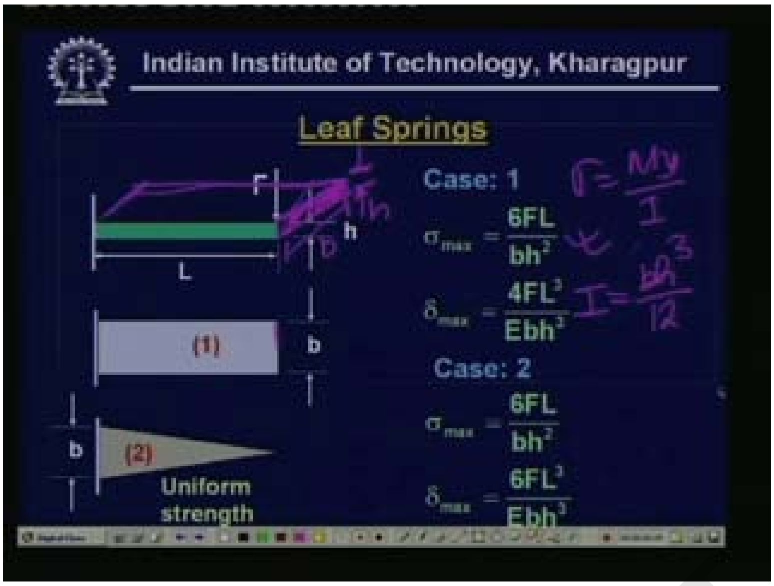

now we ah we go back to the another aspect that is what we call as a leaf springs

so ah after we have learnt about the helical springs let us come and concentrate our idea that how we take up the design procedure for the leaf springs

now basically if you consider a leaf spring ah ah it is nothing but simply you know if you take a string material and just put a put a uh load over there and then ah what will have it will just deflect and if you just take over the load then it will just go back to its original position

something like that ah um ah now in the sports you have seen the diving uh situations at when the swimmers they dive from the diving boards down onto the swimming pool you have seen the diving board just have a oscillations like that that is a simply a springing action so that is basically a leaf spring

so this leaf spring when you put it into a form ah in some form and that particularly when you see in the rear wheels and the front wheels of the {aut} (00:24:48) automobiles means mostly the buses and trucks then ah those are the leaf springs what we actually designed

but the fundamental principle lies over the fact that simply a steel material if you just put a load it deflects and if you remove the load then it goes back to its original position it is as simple as it is

so ah considering the fact that what i have just told you let us look at the board you can see this is a simple situation of a leaf spring that what is called a diving board swimmer is standing over here and he or she is going to jump well here there is no question of jumping a load is continuously falling over here so from our ah fundamental ideas i mean the basic courses we know that in this case the stresses will be a bending stress is what you know it is sigma equals to My by I

so if we put these values then we get a stress value of this one please note that in this case if i extend it is an three dimensional somewhat a this thing now this is your b and this is this is your h okay

so this is the b what you can see if you look from the top then this is the width portion b ah sorry this is the b and this is the h so correspondingly if you are having then moment of initial I comes out to be bh cube by twelve so this we are utilizing

so once in utilize once you utilize this concept then all equations are clear to you

similarly if you have the delta max means a defection while the deflection will be maximum obviously the T the defection will be maximum and this deflection is again given by this expression

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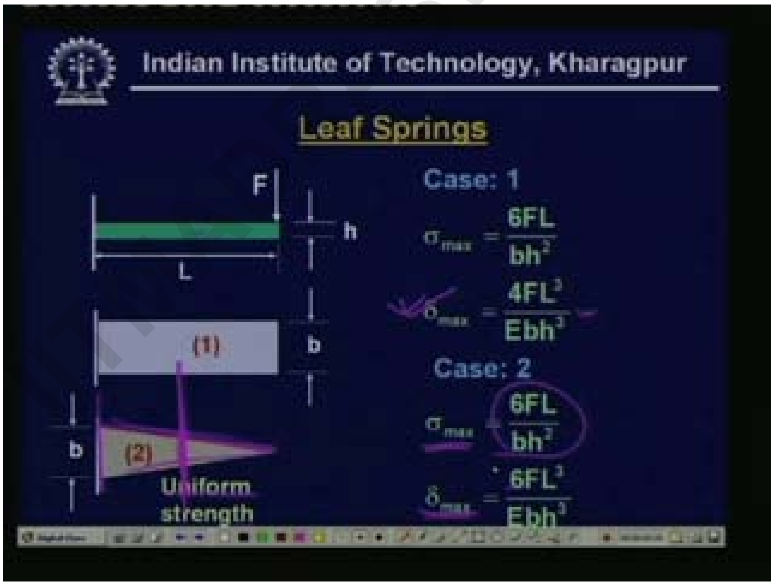

now in the second case you can see that instead of using ah cross section having ah same cross section we are taking a triangular sort of situation

then the beauty of this particular type of triangular section what is being shown here is that we call this is an uniform strength so this is very easy that means if you are putting an load F equals to here somewhere at the meet section what do you expect that the bending moment will be Fl by two and area will be what is this one this width will b by two so bh cube means b by two and other h cube will come into picture

so immediately you can see the stress what has been calculated sigma max equals to this much will be the same what it is at this location whatever it is this location but that is not the case over here

so if we have a shape like this then what is happening that you are having that stresses at any locations will be the same and that is what we call as an ah uniform strength leaf of an uniform strength

however in this particular case what is happening that ah the although the this particular one once you just look at the board although the strength is what we call as an uniform strength cross section but only thing is that that maximum delta is obviously larger than what we have obtained in the case one

now if its if it is larger then this gives one additional advantage you know from the this particular design point of view what is this advantage that always we'll be having ah more resilience okay

the resilience of the spring will be more you know the resilience we have ah we have learnt in our earlier course it is a that energy stored energy per unit volume that is amount of energy stored per unit volume so it will be having more resilience because it is having a more deflection

at the same time what is happening that is the material requirement for this uniform strength beam is much less compared to what we get for an beam of an un-uniform cross section

so non uniform cross section and gives you an uniform strength and lesser material and more resilience so this is in one way it is better ah design than in {caa} (00:29:48) ah in comparison to what we get for an uniform width beams

so in leaf spring design people normally choose this type of uniform strength ah a uniform strength situations so these situations are normally taken up

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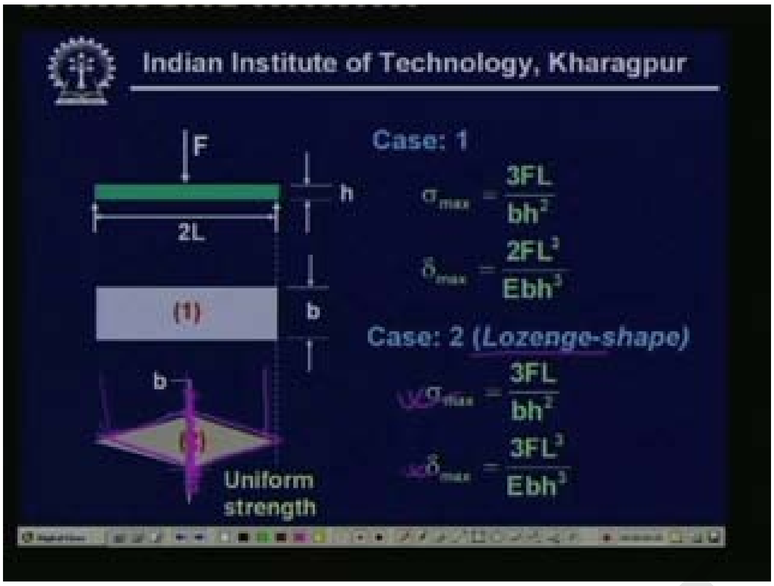

now if you take the second case then [Vocalized-Noise] in the similar manner we consider a simply supported beam for which these are the stress and deflection equations in the same way the simply supported beam as if this is the central zone fixed up and two cantilevers working

so in that particular case you are having a stress of this nature and delta max of this nature and this shape this type of diamond shape it is called a lozenge shape the idea is the same

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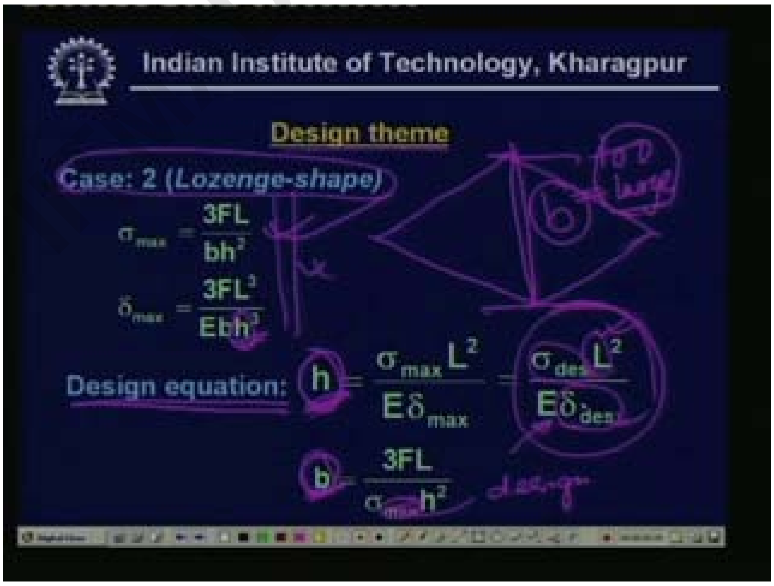

now what is a design theme just look into this slide that you can see and the design theme is something like this for the sake of explanation just the case two of what we just learnt earlier has been chosen but anything any one case you can take either for a cantilever or a simply supported here we have taken up a case what we just learnt earlier

now just solve for the h solve for the h divide this equation by this ah this equation and um i mean then what is sigma max by this one comes out to be what that these design equation if you just eliminate h out of these two equations so h comes out to be sigma max E delta max into L square

now this sigma max you replace by a sigma design that what we do normally in the design okay the material the sigma max what is coming out to be will be the maximum amount of stress what we can expect in the design

so in the design what should be the delta max if the design you to consider E is the material property and the value should be chosen for the type of spring spring material you are going to use and the length is the characteristic length of the spring ah is also under your choice

so once you have these values this this particular design parameters are known to you then you find the value of h once you get the value of h substitute back in this in a equation then what you get suppose in this equation if you substitute back you get the value of b

well now here i think ah uh one should use the instead of max it is better you use the design okay sigma design the same thing what you have used so b equals to three FL sigma design by h square so that gives you the value of h and value of B

so for a given load and given length of the spring you know what should be the leaf thickness and leaf weight that’s all so this is the simple way of thinking a design for the leaf spring

so once we find out the value of h and b then one has to think in this line see the b value what you obtained considering this aspect that means you got something like this

then this b with values of sigma deflection and L this is the b what you you have obtained can be too larger dimension okay it can be a too larger dimension to accommodate in a in a ah machine assembly

so in that case the requirement comes into picture and that is what we'll be just looking in the next slide

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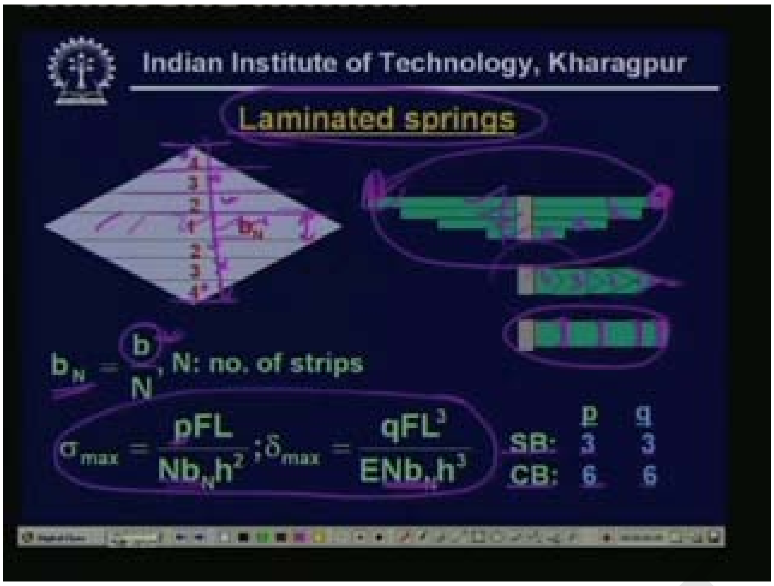

so this is what is the concept of the laminated springs

what you can see that just in the earlier slide we have seen that we could {di} (00:34:45) design

what we can see that we have just designed this value of b what i was telling is too big to accommodate in certain cases

so what we will be doing is that instead of going for this large width one can resort to a ah tricky way that you make out make the stripes like this okay this is one stripe

now once you have taken it out then this one this two and two makes another one three and three makes another one and this four and four makes another one put one after other one below other

so this is basically one then this it is coming out to be two then this comes out to be three and this comes out to be four and if you have cut it like that then this is the one this is the two this is the three and this is the four

so you view from the top i have only drawn one side okay this one side of this one is being drawn that is that is one two three four

so what is the idea you can see the width of each section bN is basically b divided by N in this particular case N comes out to be around four and you do not have any changes in the equations except for the fact that this b in the earlier equation is just changed in this fashion

and this is the case a pq that constants this is for the simple beam simply supported beamthis p and q comes out to be three three for cantilever beam this comes out to be six and six so this is the basic equation remains same if except for the fact that this Nbn nearly replaces the width b and advantage

the advantage is that instead of this large width of the b it reduces to a width of this particular situation where everything remains the same

however ideally what happens is please look into the this board once again that ideally we do not have these type of very short pages because you can see that whenever the load comes over here if it is so sharp then it can't it won't have any load bearing capacity

so normally what is happening that ah you you you can think of little bit of blunting of this sides okay something like this you can have or simply you can keep the edge as straight cut pieces

well for such modifications what happens suppose this modification is being done over this one then normally what happens the stress equations do not change much but the change comes into the certain aspects of the deflections okay

because you are changing some amount of i mean basic shape you are changing from what you got the shape for the case of uniform strength

so pure triangle is not getting impure triangle but it is having an truncations at the tip

but anyway ah by such modifications you do not lose much but you will lose ah you'll gain in the turns of the strings and other things ah for the particular leaf springs

so this is what we call as a laminated spring that means these are all the laminations that what you are providing

so now i think that you have seen such kind of springs being put under the automobile wheels and where you can see that this are normally it will be clamped and the wheel will be somewhere here um and ah this particular one will be carrying the wheel and these are the attachments okay

so i we will come down to those situations these type of springs also you will be seeing below the ah i mean the wagon the wheeler wagon ah wagons which is carrying the loads you will be finding out these type of leaf strings are sometimes put in the wagon

however ah normally nowadays more and more automobiles and other things are going for helical springs because these leaf springs are normally not very well suited for varying considerations

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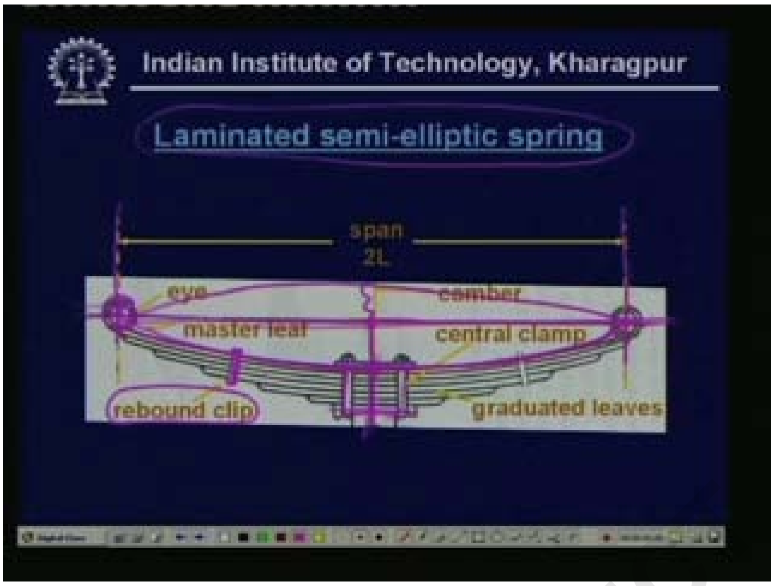

okay this is what i was trying to talk about the laminated spring so this laminated spring has got ah this is the main line

so this is what we call the top one as the master leaf so ah this is the eye for attaching with the automobile bodies or something like this

the amount of beam that is being given is called a {caa} (00:40:56) camber and these are the central clamp and ah here the bolts are also there bolted to this one this is called central bolt and these are all graduated leafs what we are getting this things

now these are called rebound clips now what is this rebound clips the rebound clip is mostly required that whenever certain amount of loading coming over from here comes over the spring

this rebound clip helps to shares some loads called the master leaf to this graduated leaves and this particular one is a central clamp and this central clamp has got a central bolt to fix up so that has got a some tendency to weaken up the springs

but anyway ah ah as because the clamp is having sound width over here that takes of the total ah weakening effect by this particular clamps and a and another thing is that this camber what is this camber is being provided

see what is happening that this camber is provided in one sense that whenever the load comes that under the action of maximum this is called a positive camber under the action of the maximum load when this spring deflects at the most it can take up a spread portion sometimes if it goes in the other way then we call that will be a negative camber but normally this happens very rarely and designs are fully made that this particular one the camber ah is such that at the most it goes like this

so this is what we call the span of the laminated spring

so this is called an laminated semi-elliptic spring and this is the one what you see in automobiles

so we know [Vocalized-noise] this is the master leaf rebound clip the region of rebound clip to share the loads then the graduated leaves and central clamp eye okay

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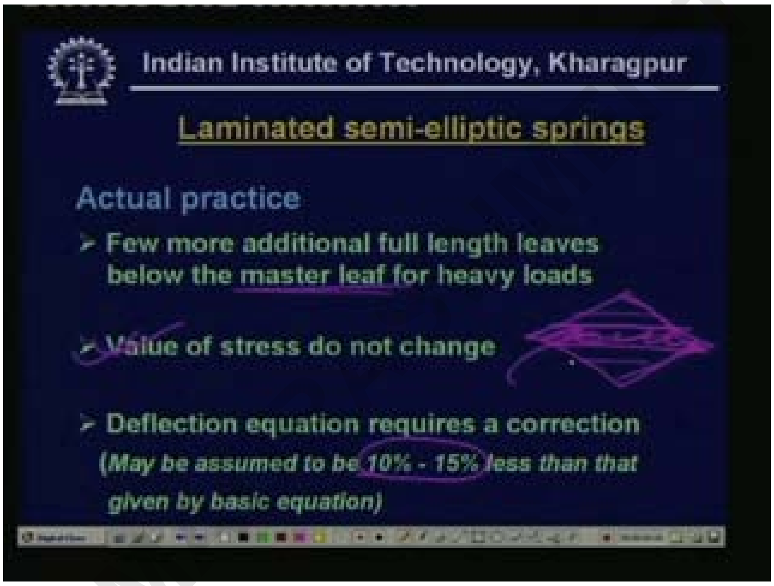

now actually this laminated semi-elliptic spring do have the following materials one is a plain carbon steel chrome vanadium steel chromium nickel molybdenum spring silicon manganese spring so these are the typical materials what are being used for a design under leaf springs and standard sizes of the leaf spring are given over here

the width is twenty-five to eighty mm i think it one one should write mm in steps of five mm thickness two to eight mm in steps of one mm and ten to sixteen mm please note down this is mm ah in steps of two mm so these are the standard sizes of a leaf spring

and next we would like to discuss something about the actual practice

what is actual practice is this that we have seen that this particular shape of the leaf is being cut into this one isn't it and that is put into there as a lamination so the top one which is a middle one we call as the master leaf but normally what we know is that few more additional full length leaves below the master leaf for heavy loads in actual practice this is not only one master leaf

we may be having one or two more full length leaves placed below the master leaf as ah we have seen in the actual loosened shape plates

so it is an deviation so actual design should have only one master leaf as per the simplification {wha} (00:45:33) i mean as per the design procedure but in reality to take up more heavy loads we do have more full length leaves

now what it happens that for that matter the value of stress do not change please note that the value of stress do not change but what happens that just by virtue i mean just by putting some additional full length leaves what you get is that the deflection equation changes

it requires certain amount of correction why you understand because the stiffness is changing the stiffness of the spring is changing

so ah in general you can consider that this deflection is somewhat ten to fifteen percent less than what is given by the basic equation

but ah one can also compute by a formula that what should be the actual deflection by putting of by putting some additional full length leaves under the master leaf

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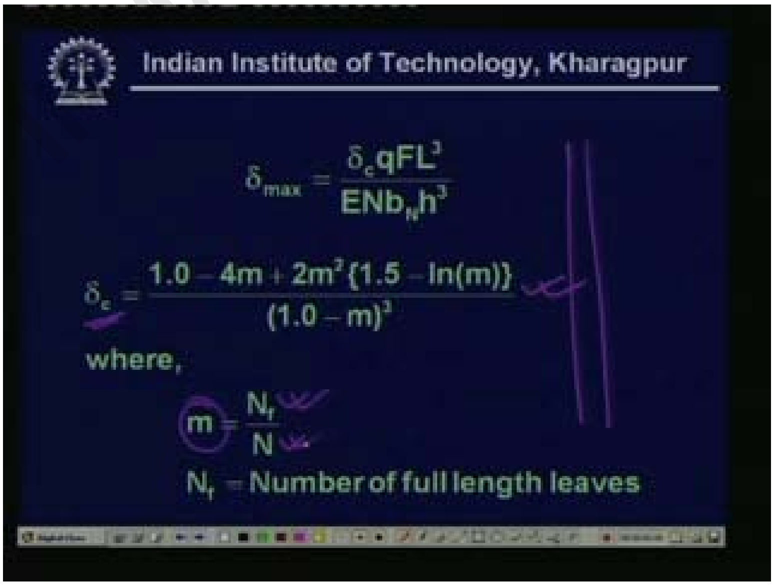

so let us see what is that expression for see this expression of delta max is a is are {equ} (00:47:00) this idea is this is a delta max you know the Q value it will be six or three depending upon whether it is an cantilever beam or ah this particular one is the ah simple beam

however [Vocalized-Noise] a normally this laminated springs what we are designing is something thought of an double cantilever centered at the middle

anyway ah our idea was to find out what our idea was to find out that what should be the correction by putting the full length leaves below the master leaf

so the correction comes out to be this one this delta c given by this particular formula one minus four m two m square into one point five minus ln means log to the base E and m and one minus m cube where m is a ratio given by number of full leaves to total number of ah number of full length leaves by the total number of leaves what you are using in the spring

so this equation may be utilized for finding out the correction in deflection coming or arising due to the fact that you are having some full length leaves below the master leaf

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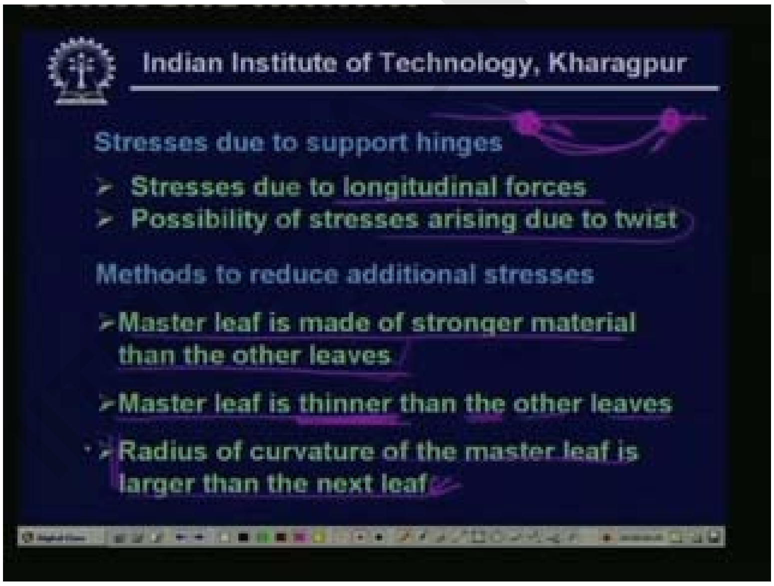

now if we look to another aspect that the stresses due to support hinges as you have seen that all the laminated leaves are connected at the eye to the support

so from the support some longitudinal forces do come into picture onto this leaf springs and there is an possibility of stresses arising due to twists

so what is a disadvantage so the disadvantage for such additional longitudinal force is and the twisting affect that just what ah i have told you is that the master leaf actually gets more and more stress compared to what you are having for the graduated leaves so one has to find out some ways so that the stresses in the master leaves are reduced okay that means the master leaf stresses should be reduced compared to other stresses arising due to what due to affect one as a longitudinal force another a possible twist

what are the methods to reduce these additional stresses the methods are something like this the master leaf is made of stronger material than the other leaves okay

this is one way that means if you make up a stronger material then obviously the stresses it will be able to take up more

another way is that you make the master leaf thinner that means the master leaf is made thinner than the other leaves that you are considering

so if you make it thin then obviously what is happening that stresses will reduce at extremes because your Y is changing Y is reducing but anyway ah that is also not a that is also one possible way

but what people do is the other one the radius of curvature of the master leaf is larger than the next leaf what this means what this idea means for which let us go to the next slide

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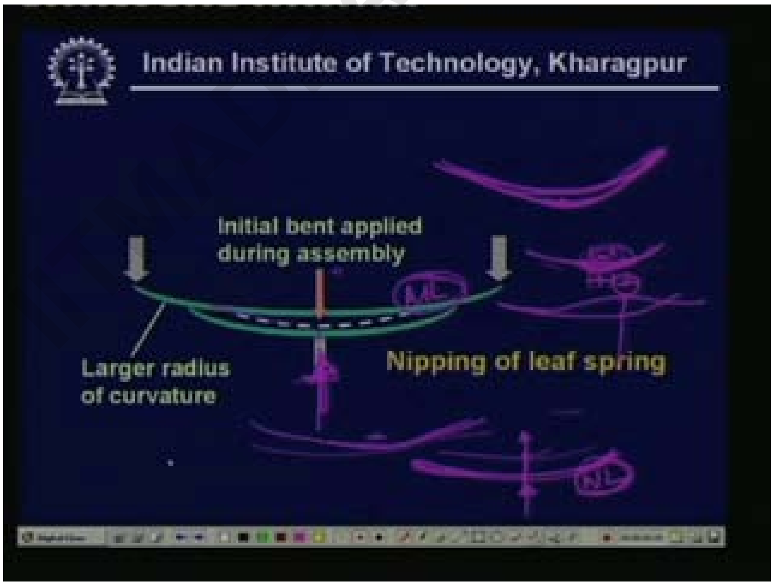

see this is a figure that has been mentioned over here is [Noise] just ah hold on i am just coming down to the on this idea so here we come [Vocalized-Noise]

now as i was telling you that this is the master leaf and this is the leaf just beneath the master leaf so what you will do you give this master leaf an initial bent okay first of all you can see the largest radius of curvature this is having a large {rad} (00:53:31) large radius of curvature compared to this one so obviously there exists a gap between this master leaf and a next leaf and what you apply an initial bent during assembly

how you apply the initial bent during the assembly just by putting the central bolt if you tighten the central bolt then gradually the master leaf will bent inward and just have a look at the board

the master leaf will bent inward if we having a gradually tightening in this way and this will be coming closer to this one

so what you are having is that the master leaf had a curvature of this nature and you are making it more bent you are making it more bent that means what you are doing is that you are incorporating you are incorporating the more stress onto this one

you you ah you got the point so this was this particular one if you are having an bent then what will what it will create

how you are applying the bent as i told you just by putting the clamp over here just you tighten the bolt from the both sides it will come closer come closer and closer and so that is what you get

now [Vocalized-Noise] if you are bending it by this amount then what is happening that this is getting stress means it is having a more compressive strength negative and this is having more tensile strength

and what is happening to the this one this one was like this it was having some stresses and this particular one is trying to flattened out more that means it will have a tendency of a this particular one will having an tendency of a what ah opening out stress

that means it is going it is going to more stress in these directions well ah i will come down to this particular part later on

so once you get a bent shape like this it is creating some amount of initial stress onto it

now you {ish} (00:56:10) look into a situation once you in actual practice once you given heavy load over that one then this bent shape will be trying to put a some sort of shape like that may be because it will be pushed up like that so it is gradually going towards the tension side and it was actually a negative so it has to overcome the negative and go to the positive side of stress

so that means what is happening due to the loading it will first relieve the stress and then get stressed and in this situation what is happening that this particular one what you are having just by pulling it inside

i am talking about the next leaf this is the next leaf okay NL i am just writing next leaf this is the master leaf this is ML and this is NL so next leaf is what it means it has already got a pull like that

so when a load is coming over then it is getting again an additional load like that so what is happening if it were some stress say if it is going like that some stress will be what is happening that this is going towards this plus

so if it going more towards plus then the stress is getting adding added up okay

so in this case the next leaves will be more stressed but the master leaves gets the stress relief just by application of the load

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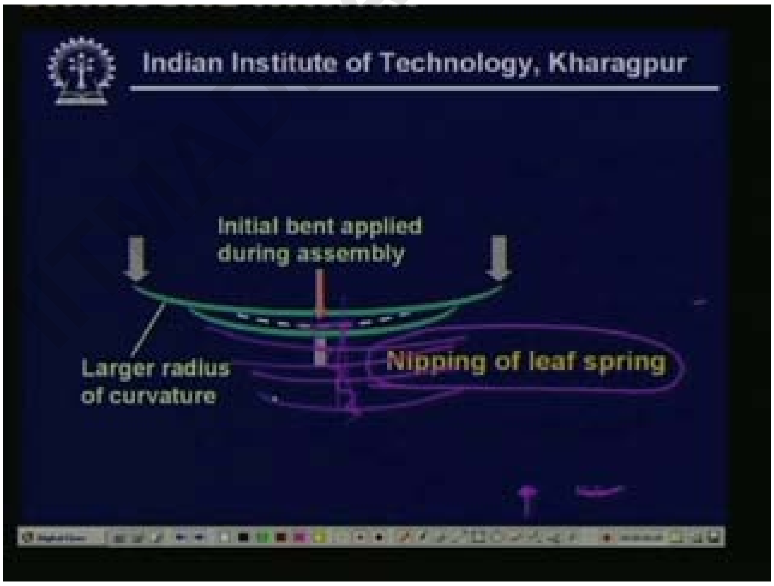

so this is what we consider as the nipping of leaf spring as a matter of fact what happens you know that not only the leaf spring i mean next leaf all the leaf in between the leaves of the automobile springs

that means if we consider over here then all the leaves will be having certain amount of this nipping so that certain amount of nipping so that what you are having that there is certain amount of gaps all will be ah stresses will be uniformly distributed and certain amount of dirt accumulation in between the leaves also can be cleared so this gives the total design consideration for the leaf spring

so very quickly if we just have a ah revisit to the leaf spring then what we get that first of all the design is a simple leaf just look at a board

simple leaf spring coming over here you get the equations designed theme is you divide this by this get the value of h and the value of B you laminate the width put into the laminated form and then ah this is the actual elliptic spring

so the materials of the spring you know the standard weights are given over here and in actual practice what we do we has been told and the lastly that a nipping of leaf spring is required

so this ends our lecture on design of springs

thank you