Design of Machine Elements – I

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Lecture No - 07

Compound Stresses in Machine Elements

good day

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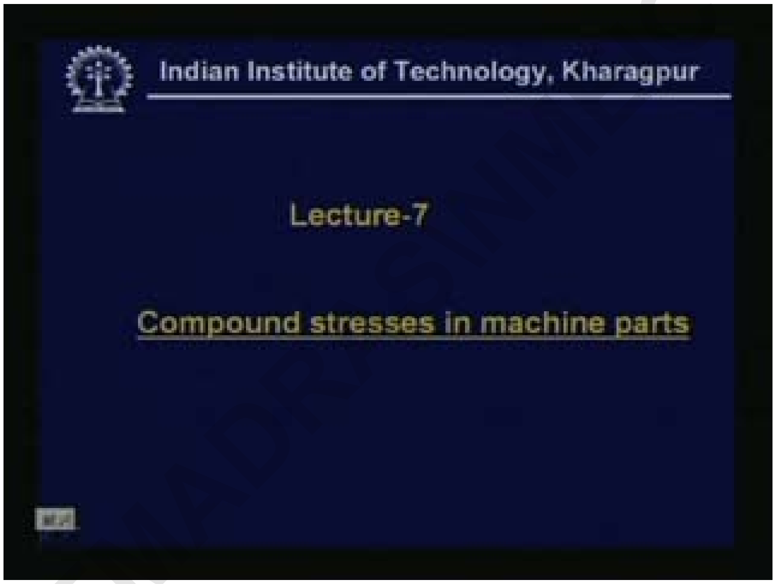

today we start our lecture number seven and this deals with the compound stresses in machine parts

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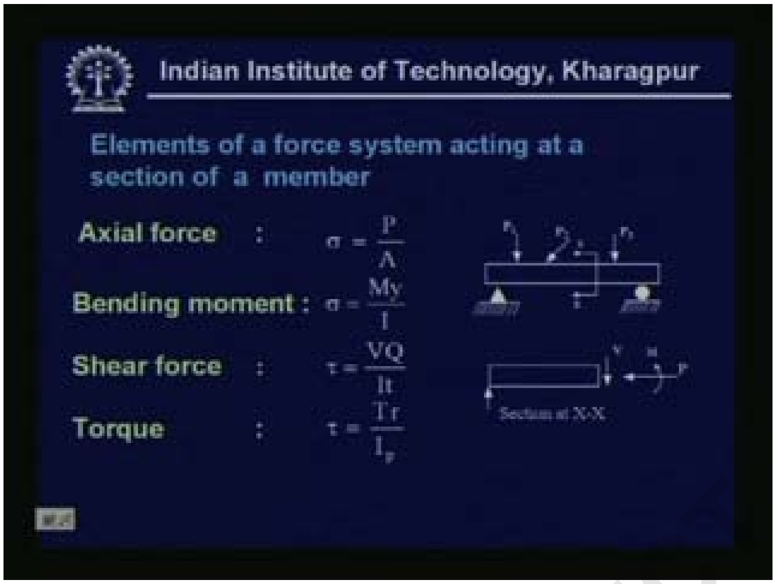

if we see our earlier lecture then we have learnt that the elements of a force system acting at a section of a member are normally

axial force that we are given by sigma equals to P by A

bending moment sigma equals to My by I

shear force VQ by It please note that ah we can have this t is the thickness what we consider there as b also the width of the section same thing here it is has been written as t

ah although this particular ah beam acted {up} (00:01:38) upon by loads P one P two P three etcetera ah and uh do not have any torsion acting onto it but still we have written down the equation for the torque ah {ss} (00:01:54) that means which gives the shear stress is Tr by Ip

in in short what we mean to say is that this is a say recapitulation of all the forces that we normally ah come across when the machine member is subjected to varieties of loads

now today we will be considering the name suggests as the combined stresses means if all these type of various type of stresses arise at a point in the machine member then how we combine them together to get some ideas that what is the effect of all the stresses that is coming onto the machine member

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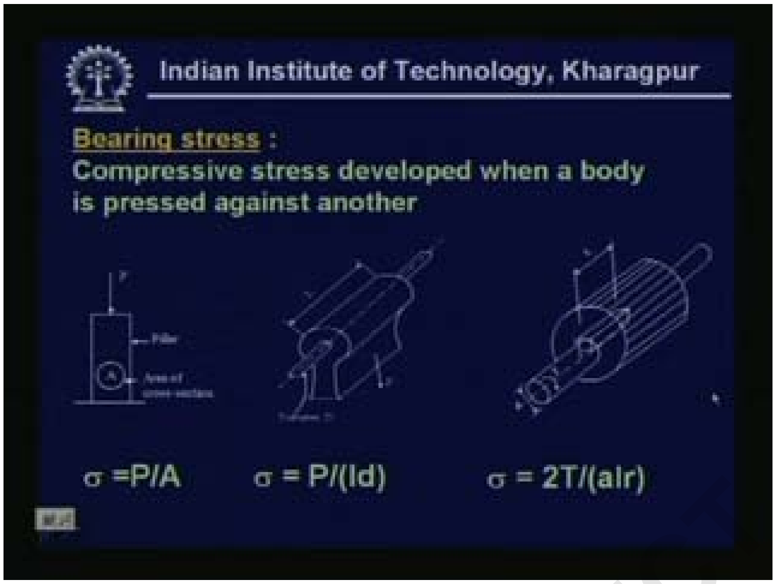

now ah apart from the stresses what we have discussed in the last class or other last two classes there are also other two categories of stresses

one is called bearing stress now this stress as you can see is defined as the compressive stress developed when a body is pressed against another

now here we have seen three examples that first of all you can see a simple ah circular member which we have defined as an pillar having an area of cross section A is getting pressed over another body say fluid or something like that under an action of load P

then um what we call that is that at this juncture or at this location the body is pressed so thereby the bearing stress sigma here we are calling as sigma equals to P divided by A

please note that ah if we had written a expression for compressive stress that means if i have written an expression for compressive stress then what you can see is that

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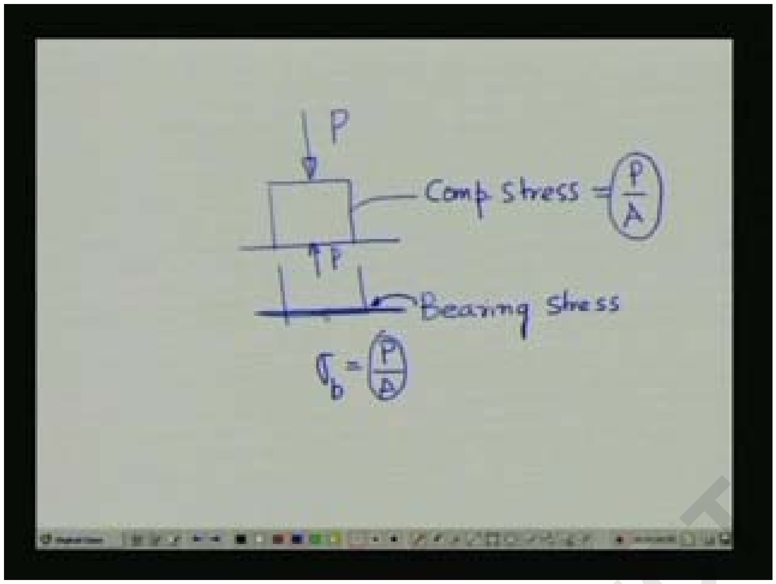

the same figure the same figure if we draw and it is loaded by an force P then at this we are getting what we called as the bearing stress at this location and that is being given as P by A

now if we have a cut at any location here and if you have taken an free body diagram then what we would find out

that this particular body would have again come under a load P like that and in that case the compressive stress is again defined as P by A

so this compressive stress having the magnitude is P by A and this bearing stress bearing stress is also having a magnitude P by A

then please note that when we call a bearing stress then it is only where the contact is taking place between two different machine elements whereas compressive stress is nothing but an internal stress

so here lies the uh somewhat a difference between an compressive stress and bearing stress although in certain cases the expressions for the stresses might be looking um the same

now in the same way if you look into the second figure then what you are getting

we are getting that this is a shaft going inside a hole having an length l and this is pressing the shaft this particular member is pressing the shaft with an load P

therefore what is this thing

in that case the bearing stress sigma is written as P divided by length l into this particular diameter {ob} (00:06:22) diameter of this particular shaft okay

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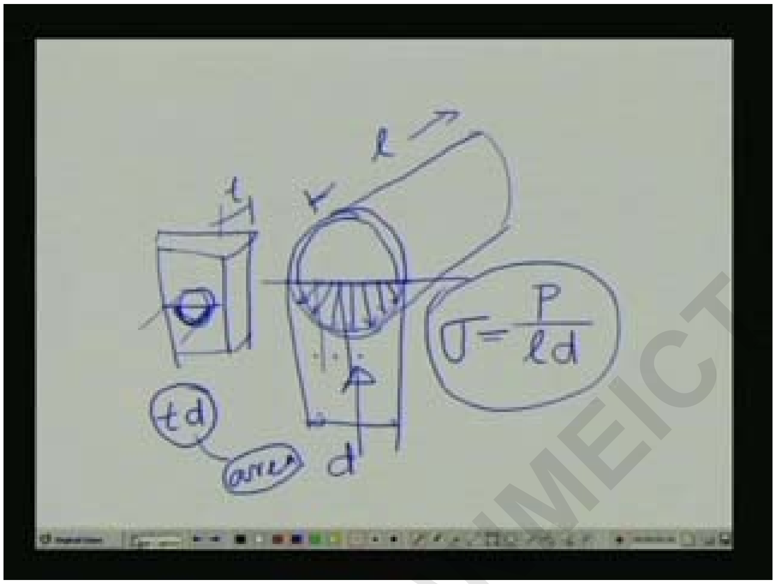

now that means what we are mean to say is that if we are considering this that means whenever there is a hole if we (( )) (00:06:37) at the shaft inside that means if you are (( )) (00:06:48) holes something like this and a shaft is going then we assume the contact to be taking here and the it is only the projected force that we are interested

that means although we can we can see that this particular one if we look to the actually the situation once again we can represent that somewhat a perpendicularly the forces are acting like this

but what we are taking all these force projections something like in the normal direction means all the forces in their normal directions

so thereby in that particular expression we found sigma b i think it is was written as sigma it doesn't matter ah with the same thing we mean to say equals to this load divided by this is the length l that is coming into picture

and this is l and we always use this is the diameter so this is the projected diameter d

so this becomes a bearing stress in case of the circular hole so you remember whenever there is an circular hole and we are having an contact of the shaft just described we always take the area as the length and the projection

so if it had been a small plate of thickness t suppose you having an small {pash ups} (00:08:33) thickness t and we are having an shaft inside like that

then what is the projection

here also we will be considering t into diameter of the shaft this is the projected area so this is the area to be considered for the bearing stress [Noise]

so if we look at the third one then we can see that our shaft is again going inside a bush and it is locked what we call as (( )) (00:09:12) key and the {shark the} (00:09:15) and this the shaft is transmitting a torsion t or the torque t

so in that case we can see the sigma the bearing stress arising on to this key is given as 2T by alr [Noise]

what is this actually signifies

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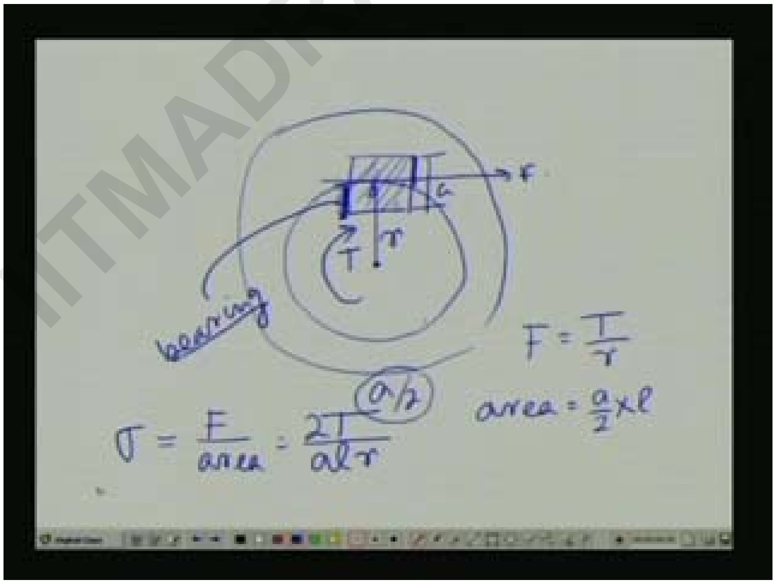

that once again we can see that if we are having this one then if we look into this figure the shaft is there

this is actually t and so it is acted upon by a torque t so what is happening

so we are having the radius this is r so what is the force applied

suppose which we considering force then force equals to T divided by r and then in this particular case you can see if you are applying load like this then this particular shaft is having tendency to rotate so obviously the shaft will be pressed over here by the key and it will be pressed over here on to the bush

so this is the area where you get a bearing so entire dimension was given as a so this length is basically a by two

so what is the total area

the area is equals to a by two multiplied by what you are getting is the total length i suppose it was given as l

so you are getting bearing stress sigma equals to force again divided by area that comes out to be T two goes up alr

so this is the precisely how we get the bearing stresses in this manner

now we have shown you just a three examples so there could be any more examples for this one where you can where in the machine design whenever you see a contact between two machine elements are taking place then what you do

you consider what is the force acting on to it and correspondingly you divide it by the area of contact and that will give you the bearing stress

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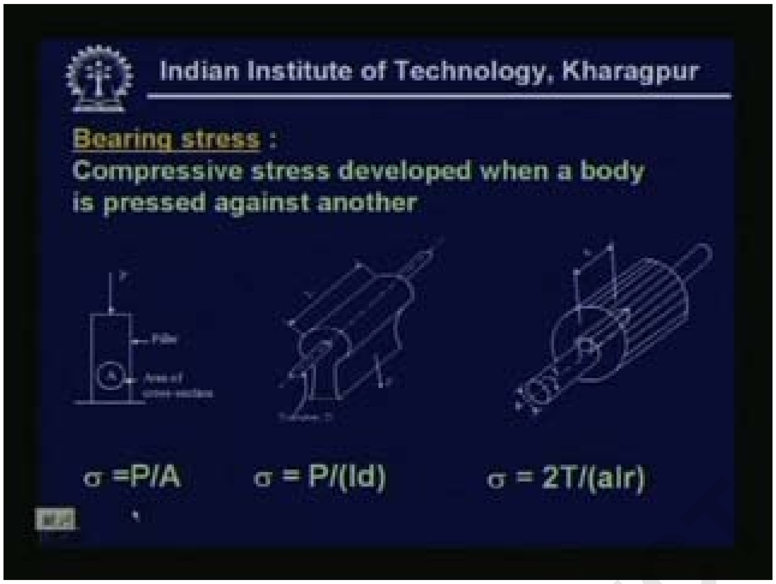

so this is one kind of stress what we have seen is called an bearing stress and which is just purely coming due to the contact between two machine elements

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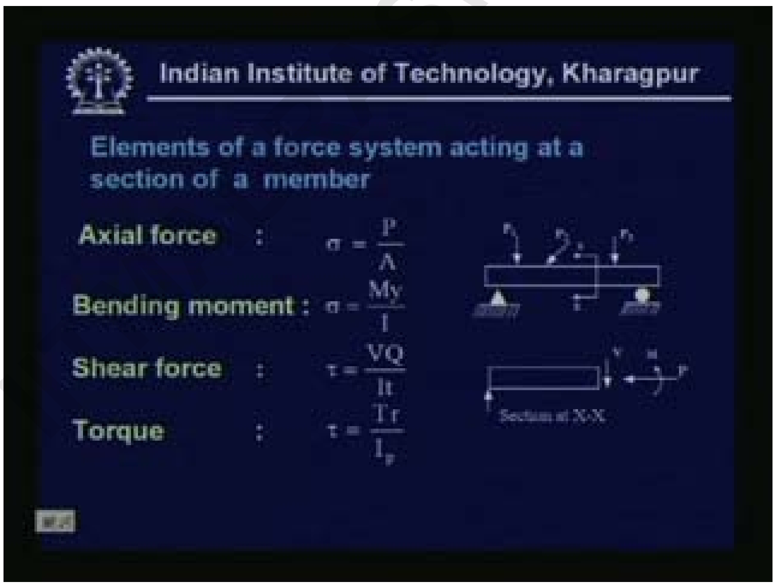

now if we ah {e e} (00:12:19) and this one the forces what we have seen that is already we have seen earlier that these are the forces ah these are the forces acting onto the machine elements creating all {tuska} (00:12:30) all types of stresses what has been given here are all the internal stresses basically

so we go back to the digital class once again just one sec

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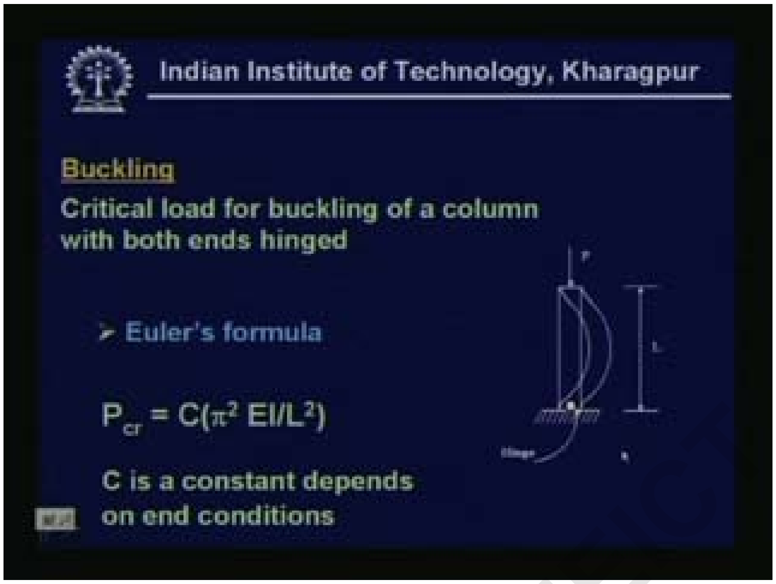

so another form of the stresses is is called the buckling now what is buckling

we won't be discussing much about the buckling only thing we would like to say at this moment that it is a some sort of a stability sort of thing where the stress and other things are not coming into picture

basically when you are having a very long slender column and acted upon by a vertical load as shown in the figure just it is given an p then you can see that the slender column can have a tendency of bending like this and which we call as an buckling [Noise]

now in this case ah there is an famous formula ah called Euler's formula is there to find out a critical load which is given by this expression

where C is a constant depends on end conditions means this is hinged and ((free end)) (00:14:00) both end could be hinged both end could be fixed on {sh} (00:14:03) {vay} (00:14:04) various types of ah end conditions depending upon that one you can have a value of C

and other thing this is known to you this is ah E is a young's modulus I is the moment of inertia L is the length as it is defined over here

now the basic idea of this P critical is that when the P is more than P critical this P is more than P critical then you just if you give a slightest push from either this side or this side then what will happen the column will completely fail

but if the P is less than the P critical then would giving an slight {deformash} (00:14:47) i mean slight push at this side and again if you just take withdraw the force that side ward force then what will happen

the column structure will again regain to its original position

so this is some sort of stability which comes into picture whenever we ah design a machine element having a slender whenever we are having an slender column like that

one of the example you will be learning later on ah could be say ah screw for a screw jack requires to be designed for a buckling load

this was just an one example i am trying to give you

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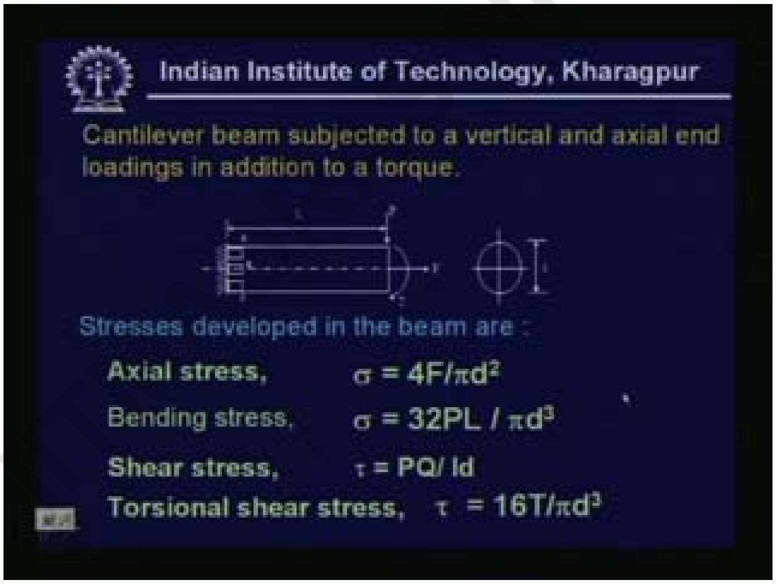

now here we take up one example of a combined how a combined stress can occur in a beam

you can see that this is an cantilever beam and it is acted upon by an load p over here at the end having an length l it is acted upon by an tensile load for f and a torsion which is if i view from this side it is in a clockwise direction we are viewing from this side

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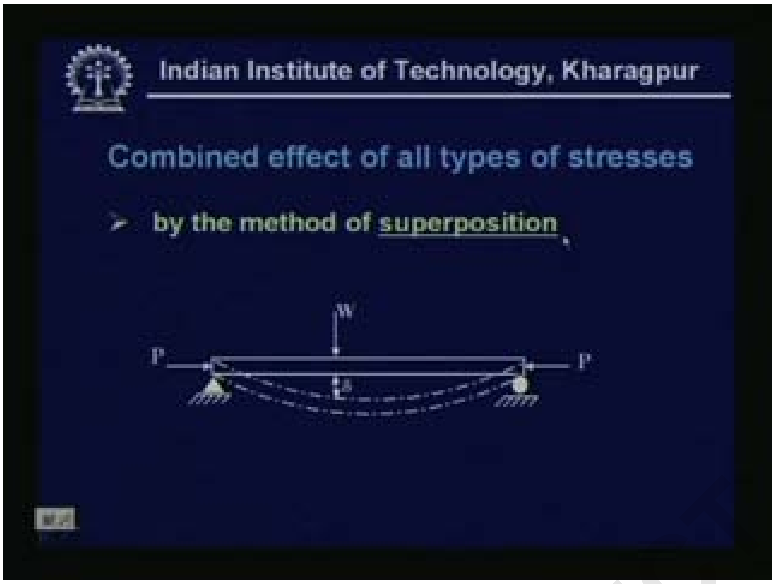

then it is coming out to be in the clockwise direction [Noise]

so in this case what is happening that you are having ah the {ss} (00:16:10) stress is which could be calculated as we have seen earlier

now in this example you can see the actual stress is sigma is P by A so obviously this has got the force by pi d square ah by four so this gives you the idea

now bending stress we have learnt was by My by I now if you put substitute the values of the M

so P multiplied by L that's we are trying to consider the section just at the end because we know that maximum bending moment will be occurring when L is a maximum okay

so that is a distance is the L maximum and we will be getting the bending moment at the end as P into L

so if you substitute all the values then we get an expression for bending stress as given over here

similarly the shear stress we know VQ by i ((b)) (00:17:11) in this case what is happening that we will be having the maximum shear stress at a diametrical location over here and that is coming out to be how much

that this is P means this is the P load so that shear stress V will be coming as P

Q we have defined that first moment of {na} (00:17:31) area about the neutral axis and so that means this will be the area for which you get the moment about a neutral axis will be Q divided by moment of inertia above the neutral axis and d is the diameter of the shaft [Noise]

and torsional shear stress was how much

Tr by IP and again if you substitute all the values of respective R and uh ah IP etcetera then what you get

you get an expression of the shear stress as sixteen T by pi d cube

now what you can see in this figure is that you have selected some four locations this is a so ah this is an a location this is b location this is c location and we can call this as the d location

so what are the stresses that will be coming at all these points

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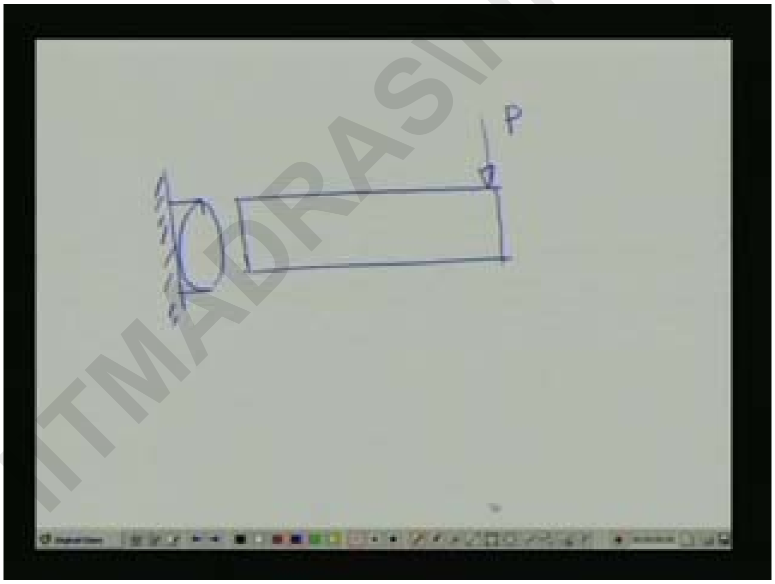

now if we look to this thing then let us have an idea that what is the concept

we had got a P over here and then just at the end if we take a section like this then it is an circular member we are getting okay just a cut section we have considered

ah uh if i to be more precise then let me do one thing

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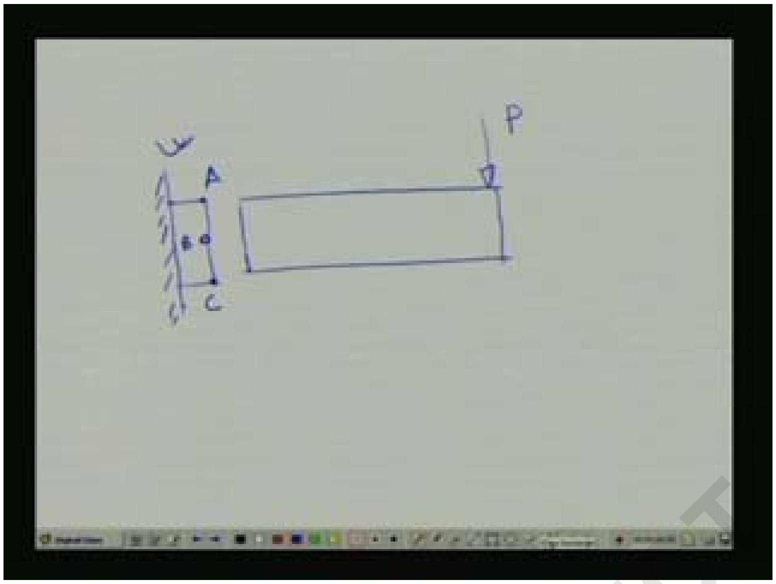

means this is the view what you are getting all right

that means this point is A whereas assume that this is almost at the edge

this is B location this is C location and D is onto the other side

so if we just draw and expanded view of this one then what we can see

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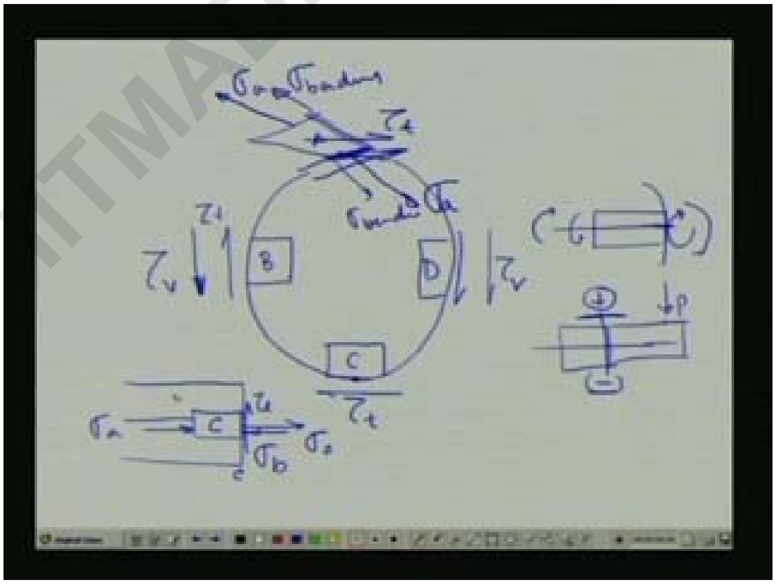

we can see that this is the this is the view and we are considering an element A this is an element A so if we consider the torsional stress so we have seen the torsion was in which direction

torsion was in clockwise direction so onto this phase it is anti clockwise so obviously onto this phase clockwise shows shear stresses due to torsion if we write down this T

this is D this is B and this is C comes out to be in this manner

and if we look to the vertical sheer stresses then what is happening

we are having this is a shear stress due to the vertical load this is a shear stress due to the vertical load now what will be the shear stress due to the vertical load at this point

it will be zero because the q is zero over here similarly this is the vertical load over here will be also zero

ah this was tau t and this was also tau t

now if we look to the bending situation then what is happening

that you are getting some sort of [Noise] situation that this particular bending stress if you are considering over here then it is coming out to be an ah it is it is it is in the axial direction okay

so if we are considering this one this phase if you see this is the phase we are seeing that is this is the element is it okay this is the total element

A if we consider if you are looking the same thing so onto to this element what you can see

is that that this is the shear stress going like this and this is due to a sigma axial this is going like this sigma axial and what about the bending

now if it is bending like this in this manner it is bending like this manner [Noise] so what will be happening

that you will be if you look for the shaft it is acted upon by load P somewhere here we have taken the section here this is the section here so this will be a tensile and this will be a compressive [Noise]

so obviously if we look to the element A then what is happening

that in addition to that we will be having an imposed a sigma bending on the both the sides this is sigma bending similarly onto this phase which ah as a matter of fact we cannot see like because this it is the cut section so we have to see the surface that means if we look at the surface that means if it is C where here rotate it so C comes over here okay it was here we just give a rotation C comes over here

so that means what you are getting

this is sigma axial sigma axial and you are having a sigma bending in an compressive manner and shear stress it goes as it is okay this is the shear stress because v was not there

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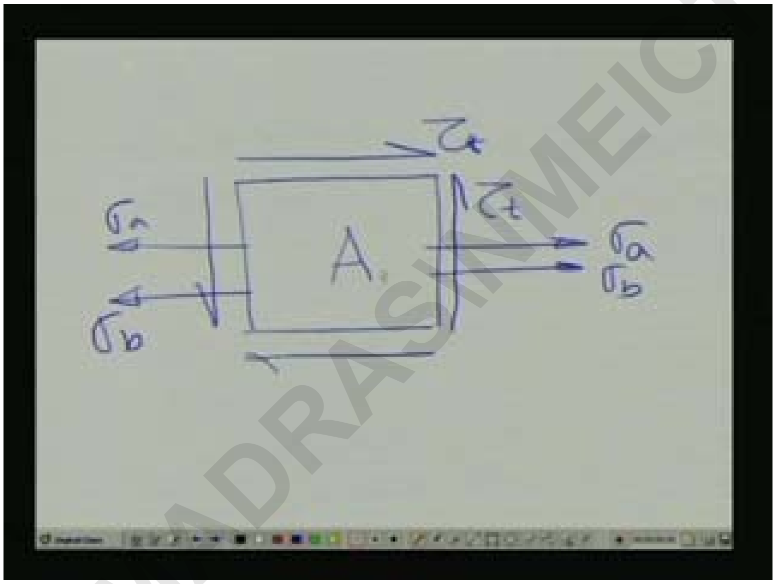

so in this manner if we consider the just one element A then what we get

we get this particular element acted upon this is the element A acted upon by an shear stress tau shear stress tau you know that these two stresses will be complementary in nature

and we will be getting this one is sigma axial and this is sigma bending similarly we will be getting here the sigma axial and sigma bending

so this is the entire state of stress at this point A

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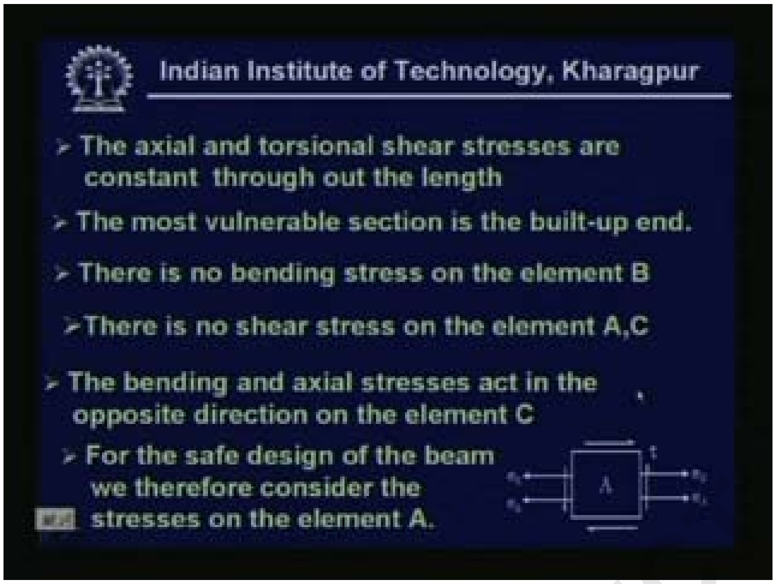

now if we go back to this figure and we see the summation what we have learnt from that example the axial and torsional shear stresses are constant throughout the length because it is irrespective of the section

now the most vulnerable section is the built-up end that already we have discussed because of the fact we will be always having the most bending moment at the built-up end [Noise]

there is no bending stress on the element B why

because the element B falls onto the neutral axis that so the fibers neither have any tension nor any compression

there is no shear stress on the element A and C

the bending and axial stresses act in the opposite direction on the element C that we have already observed

so for the safe design of the beam we therefore consider the stresses on the element A

so what we have learnt

that means when there is a machine member acted upon by several loads first of all we have to find out looking at the free body diagram which is the most critical section

now once you have found the critical section as it has been mentioned in this point two that we are having the most vulnerable section is the built-up end so you mean in that that way you can find out which is the most vulnerable section and for that matter you can find out the stresses at that point ah to be more precise stresses at that section

now once you find out the section there are several points onto the section and in that circumstances again you have to find out which point onto the particular section has got the most stresses

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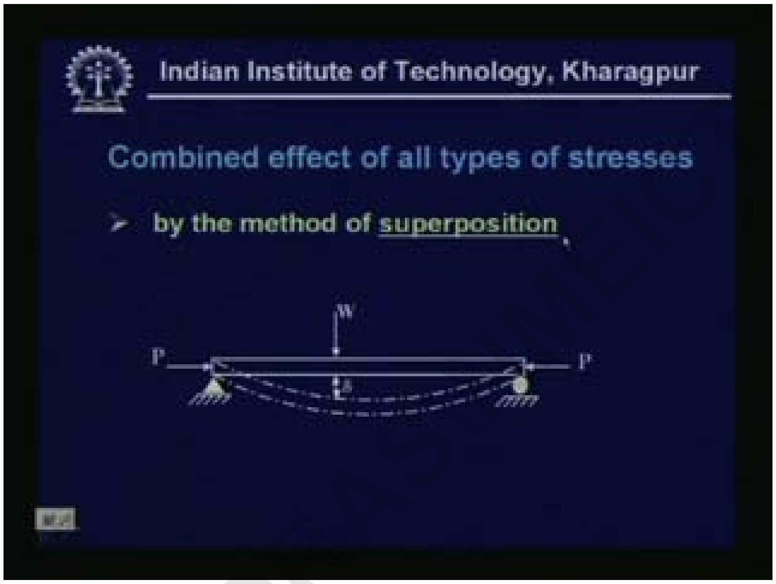

and that we have found out here that element A is the most vulnerable stresses

so now we {un} (00:27:00) to would like to find out that what is the combined effect of all types of stresses

the method what we know is called the method of superposition means you superpose one stress over another stress

now in this superposition what you understand is that you can superposition like type of stresses meant all the normal stresses can be combined together in the similar manner all the shear stresses also can be combined together

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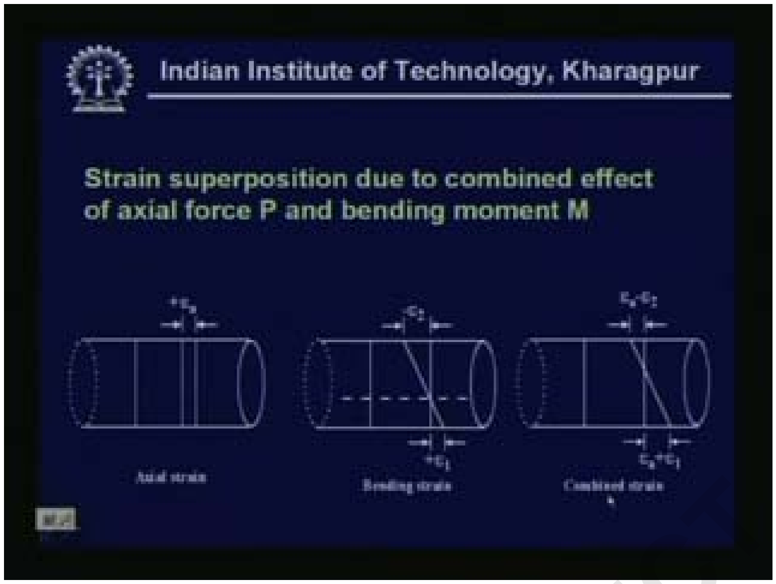

now the genesis of this particular superposition lies in the fact that the strain superposition due to combined effect of axial force P and bending moment M this is one just an example that if you are having axial force P and a bending moment M

why this example has been chosen

because axial force creates a normal stress and bending stress also creates a normal stress

now as because in design what you have what you know

that mostly all our stresses will be very much within the yield stress limit thereby the amount of strain will be very small

so it is possible that this superposition theory holds good that means it is possible to superposition all these type of stresses

so ah looking from that aspect we find that say just by putting an axial load we are having an axial strain epsilon A and

and we know if it’s having an bending i suppose if you are having a you can see the bending here is compressive here is tensile that means you are applying an bending moment in {ss} (00:28:50) in such a way [Noise] that means looking from this side you are applying here is a clockwise and here is an anticlockwise manner [Noise]

now what is an imposed effect

sigma epsilon A minus epsilon two and you are having this strain epsilon one plus epsilon two

so ah you can see the distribution of this particular bending strain and axial strain combined together comes out to be small amount of magnitude of the total strain will be less here compared to the magnitude of the combined strain what you were getting over here

so from this once we know the strain pattern obviously the stress pattern will be obtained as we have seen earlier from the ah from the stress equations we can find out the stresses and that also can be combined together [Noise]

but the basic idea is that you were summing up the deformations [Noise]

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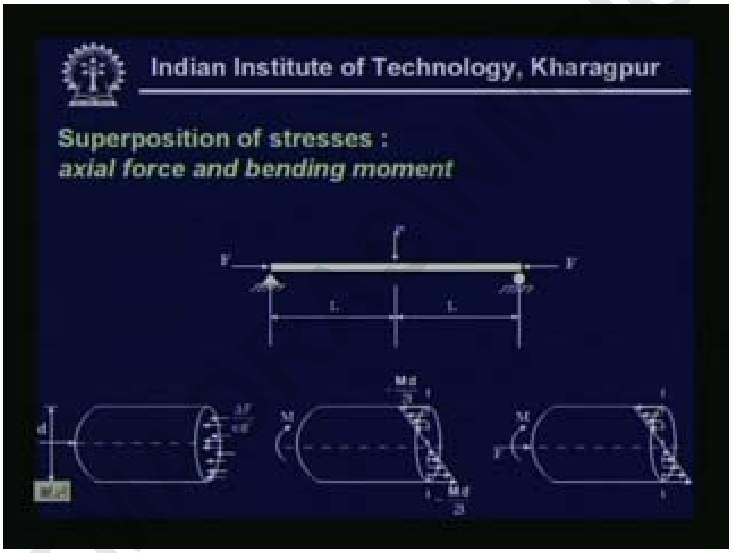

now here also an example we are seeing [Noise] that axial force and bending moment is acting onto a beam [Noise] how the bending moment this load P is creating an bending moment and this force is the axial force the similar one as we have seen for the strain there will be an uniform stress of delta f by pi d square

and what will be the bending moment

My by uh My by I so that is Md by two is the y and I is the moment of inertia about the neutral axis

so this is the bending moment distribution you can see an uniform distribution these two magnitudes are same and uh what you can see that this magnitude is superimposed so we are getting an added ah these together will be the composite load

so that is this is an total minus and I the next one is the plus and minus

so that means you are getting an effect of this manner [Noise]

so that the next stress will be what

delta f pi by d {ss} (00:30:59) by pi ah d square and uh ah i think this will be four actually [Noise] and ah this will be Nd by two I

so if you add up these together then you will get the total stresses add up means the algebraic summation

so ah what we can see is that ah ah this is this actually should be four f by pi d square so just make a correction please okay [Noise]

ah now we go back to the next slide

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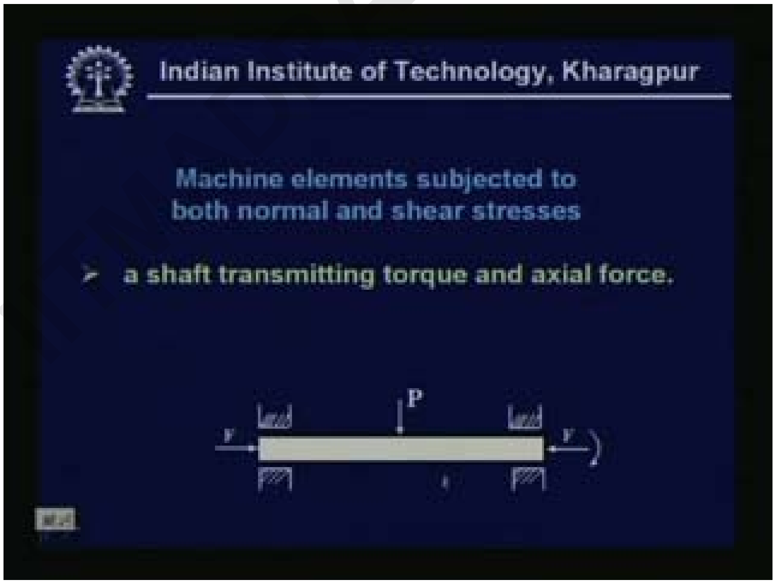

here we take an another example ah shaft transmitting power where we are having the shafts are placed on to the bearings there could be axial loads and and this is the torsion that is the power transmission is taking place [Noise] and the actual load of the machine member or something ah is there and for which we are getting an equivalent is getting a load P [Noise]

so any element or any section if you consider any section over here than any section if you take and similarly if you take an elements like this [Noise] then what you get

you will get this particular type of stress elements what we have seen earlier and that will consists of what

the stresses of normal stress kind and as well as the shear stress kind

now the question is that we had learnt that if we are having axial stress {axia} (00:32:43) stress due to axial force and bending moment both are normal stresses we can add up

similarly we can add up the shear stresses arising due to torsion and shear stresses arising due to what

due to the shearing direct shear or direct shear means the shear stress due to bending

then what about that this effect of ah effect of both the stresses means namely the normal stress and the shear stress acting at a point on the machine element what will be the combined effect

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to learn that this particular combined effect what we understand is that

we have to we have to use an idea which is called transformation of plane stresses

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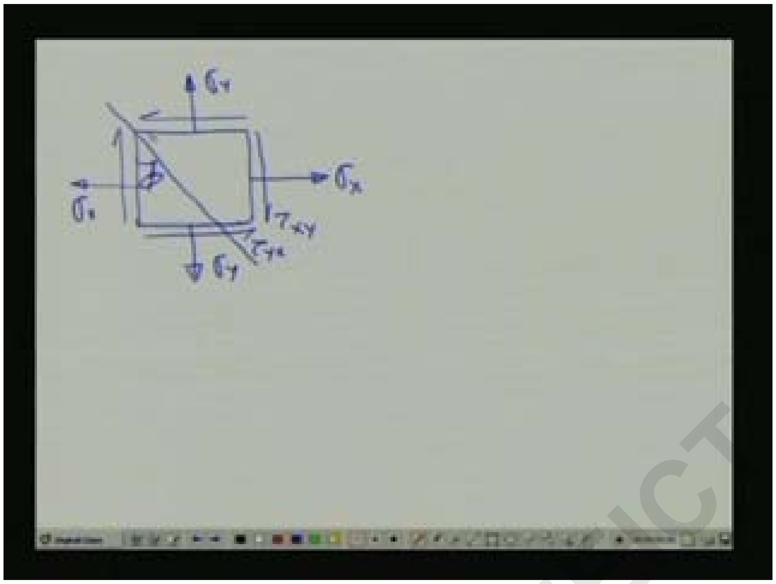

now to give an idea of the transformation of the plane stresses let us use an idea what we can find out here is that [Noise]

we have {ss} (00:33:51) take up let us take up ah element

let this element be acted upon by a stress sigma x stress sigma y

now this is tau xy this is tau yx

this is we are having sigma y what should be the stress

this will be to have the equilibrium you know the stresses has to act in this this manner

now this is an element this is these we call just like an element A or what we understand this could be ah element B what we have just taken up in this particular ah what we call examples we have this could be any element

now one important situation comes into picture is that if you are having this type of combination of sigma y and tau xy i mean the shear stresses and the normal stresses

then we have to find out the combined effect of sigma and tau

not only that we have to also find out that if at that particular point at any other orientations what is the stress [Noise] that means what is {meants to bys} (00:35:35) what is meant that this element is being acted upon by this {sig} (00:35:41) by this loads we know these loads

but if i if i make a cut plane cut through an some angle say here i have just given as phi then what will be the stresses at this locations

so there could be an possibility that although here we can see sigma x of some magnitude at some other plane obviously the sigma x will change its magnitude and those magnitudes could be larger than the sigma x what we can see apparently for this plane [Noise]

now this uh will create what

this will create a situation that at any particular cross sections what we can have

that you can have a stresses of different kinds

and similarly it holds good for the shear stress that if we can see a shear stress acting onto this plane in this manner for any other orientations or for any other orientation or any other plane the shear stress also can take up a value which could be much larger than this value or which could be also lower than this value

so let us examine and find outs what physically it means [Noise]

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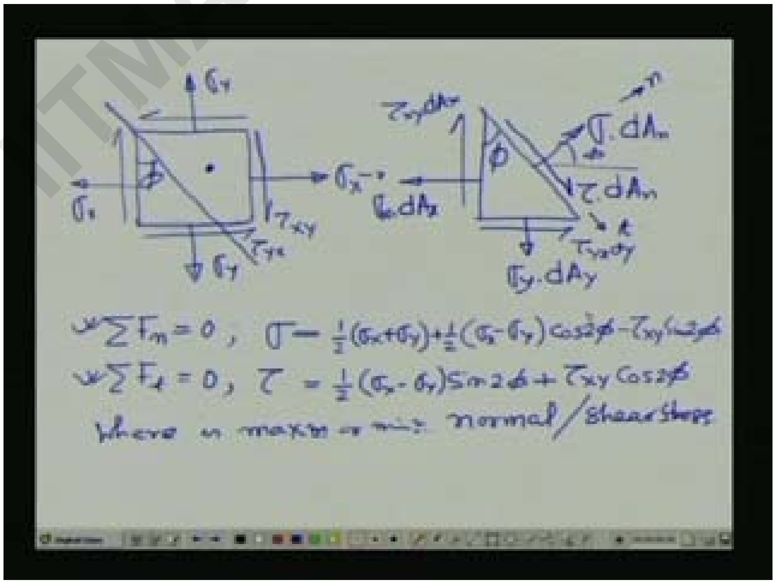

now um what physically it means is that if i take a cut let us draw the this particular cut portion free body diagram okay

this comes out to be something like this

this angle is phi this angle comes out to be how much

sigma normal because it is a normal direction means we are considering this plane and we considering ah something like onto this plane we are considering sheer stress tau and these direction we are calling as an tangential direction [Noise]

so this is the {fo} (00:37:57) this is the sigma y direction [Noise]

now now without drawing any other figure let us do one thing

let us put the values of the write down this force values onto the plane directly

what is the force acting onto this plane

this will be just sigma into dA what is this

normal area

what is the force acting due to the shear stress

this is tau into d ah um um hum sorry sorry just tau into dAn the force here acting as what

sigma y into what is the corresponding area

the corresponding area we consider as dAy shear stress here will be as tau yx into dy

similarly what we get the force in these direction is tau xy into dAx this one is coming out to be tau hum not tau this is comes out to be sigma x into dAx this product

i think we have covered all the forces [Noise]

so if this is the angle phi then obviously these angle is also coming out to be phi [Noise]

so if we consider if we consider the force balance that means sum of forces in the normal direction equals to zero just doing little bit of algebra

[Noise] what we can write down

the value of sigma comes out to be how much this sigma comes out to be half sigma x plus sigma y plus half sigma x minus sigma y [Noise] into cos two phi minus tau xy sin two phi

similarly summation of forces in tangential direction equals to zero means that shear stress tau equals to half sigma x minus {sig} (00:40:58) sigma y into sin two phi plus tau xy cos two phi

now while writing these equations please note that we have taken these shear stresses in these directions to be positive means on to this x this is x plane it is positive

if we chose any point within the body this shear stress is creating an clockwise moment so that clockwise moment is an positive one so this is clockwise moment this is positive this is positive this is taking into a negative direction so [Noise] we are having ah negative stress

and this is also a negative stress because it is creating an counter clockwise movement [Noise]

under this situation or under these notations we give the force equilibrium equations like this [Noise]

now as you have been talking about that where is the where is maximum or minimum normal oblique shear stress where is maximum normal oblique shear stresses means [Noise] which is the location we would like to find out

now for that matter what we can do

simple mathematics we can just simply take the derivative of this ah normal stress and the shear stress with respect to the angle and thereby we can get the required relationship

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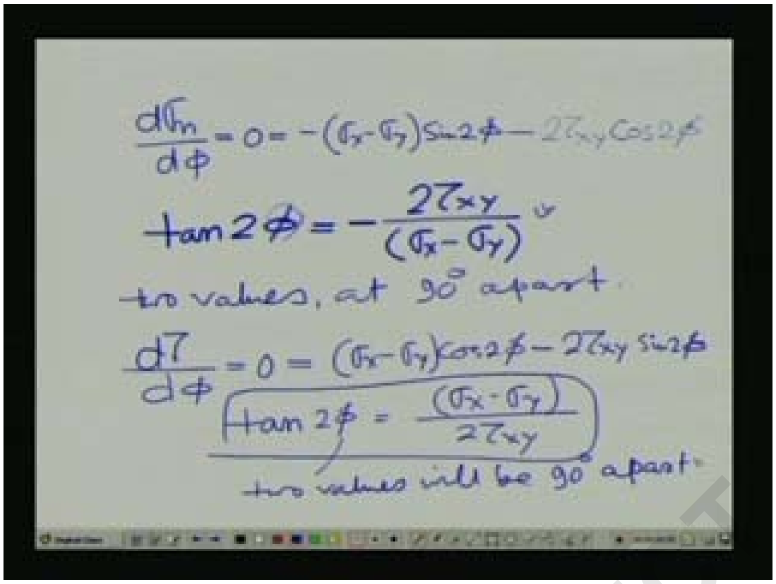

so this relationship if we find out then we get that d sigma n by d phi you know equals to zero if we equate it

then we get minus sigma x minus sigma y ah sin two phi plus we get ah then we we are getting this is as sin two phi minus

just one second and this will be minus two tau xy cos two phi

so this gives you an idea that this is coming out to be the idea that means tan [Noise] so what we get

tan two phi equals to [Noise] minus of this tan two phi comes out to be minus of two tau xy sigma x minus sigma y [Noise]

so this relationship what we are getting is a tan two minus tan two phi two tau xy sigma x minus sigma y [Noise]

now of course we are having two values of phi we can see that we are having this phi we are having two values at ninety degree apart

so these are the two values we will be getting at ninety degree apart

and in the similar manner ah we can find out also these values for the delta sigma n by delta phi [Noise] now ah one thing we can we can see that if we have just gone through that expressions what we have seen earlier that

under these conditions these conditions if you have just see that it is equivalent to the expressions what we have written for what the expressions what we have written for the tau shear stress tau

so that means what is you can say that

whenever the values of the normal that means {thes} (00:46:05) normal stress or maxima or minima in that particular conditions we will be getting that shear stress values are coming out to be zero

because these expression these expression is exactly the same as the shear stress expression what we derived just early [Noise]

now we can see that delta tau by delta phi once again if we equate to zero and write down the similar expressions then what we get

we get sigma x minus sigma y cos two phi sigma y minus sigma y cos two phi minus two tau xy sin two phi

so what we get we get that tan two phi equals to simply coming out to be sigma x minus sigma y divided by two tau xy

so this is the condition for which we get the maximum shear stress

again also these two values will be these two values will be ninety degree apart that means

if you have noted down this one i am just erasing the screen

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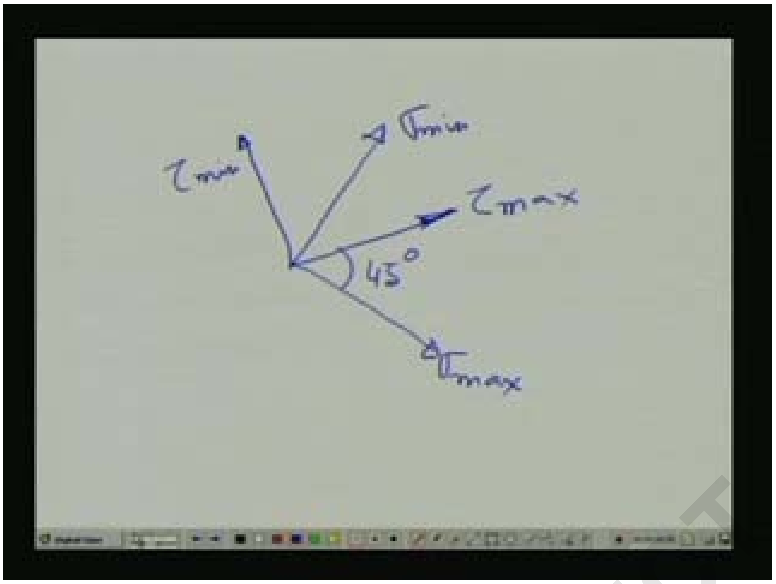

that means suppose we are having the idea is something like this that we are having two values of angle any angle which gives you say this is sigma max and obviously ninety degree apart we will be having the sigma ((mean)) (00:48:08)

and if you are considering the shear stress values then this could be your tau max again it is ninety degree you are having the tau min so this angle will be forty-five degree okay

so this is the idea that means whenever you sigma max that forty-five degree apart tau max now the similar way you get for the other results

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now if we go to this transformation of stresses then what we have seen that

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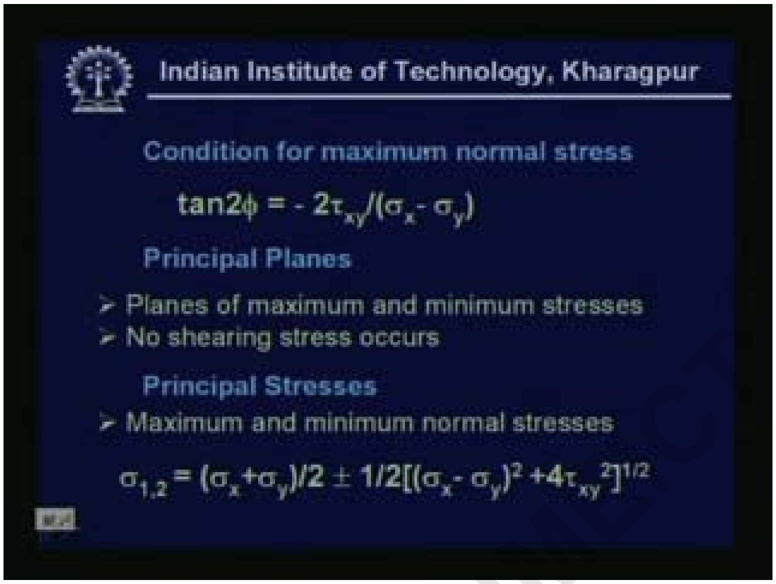

condition for maximum normal stress what we have just derived tan two phi is this one

principal planes the planes of maximum and minimum stresses and no shearing stresses occurs that you have just remember that the planes of maximum and minimum stress is no shearing stress occur and principal stresses maximum and minimum

normal stresses are given by the relationship one and two one means the maxima and minima by this expression means that if we put this condition into the main expression then we will be getting and the relationship for the principal stresses in this manner

so this are called the principal planes and these are called the principal stresses what is the principal planes

where you are having the maximum and minimum stresses and no shearing stress

and the corresponding values of the principal stresses are given by this expression

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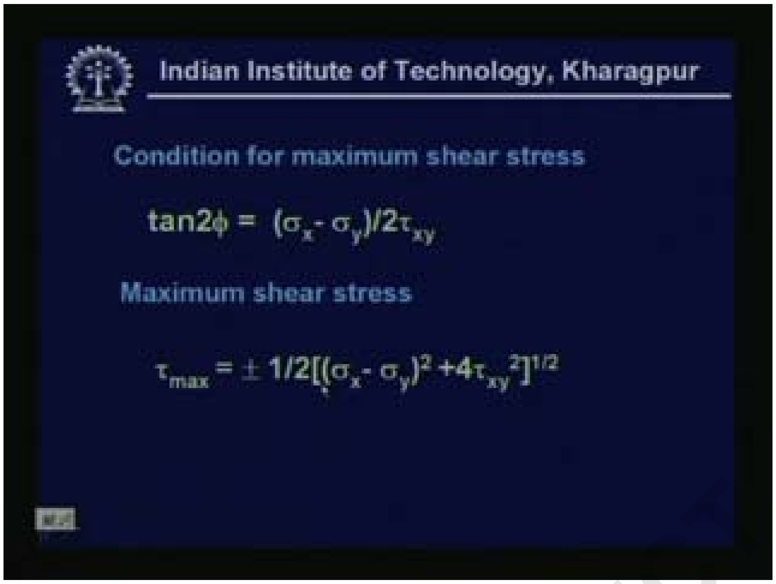

in a similar manner what you are having

the condition for maximum shear stress is as tan two phi equals to this one and the corresponding value of maximum sheer stress is coming out to be this particular tau max

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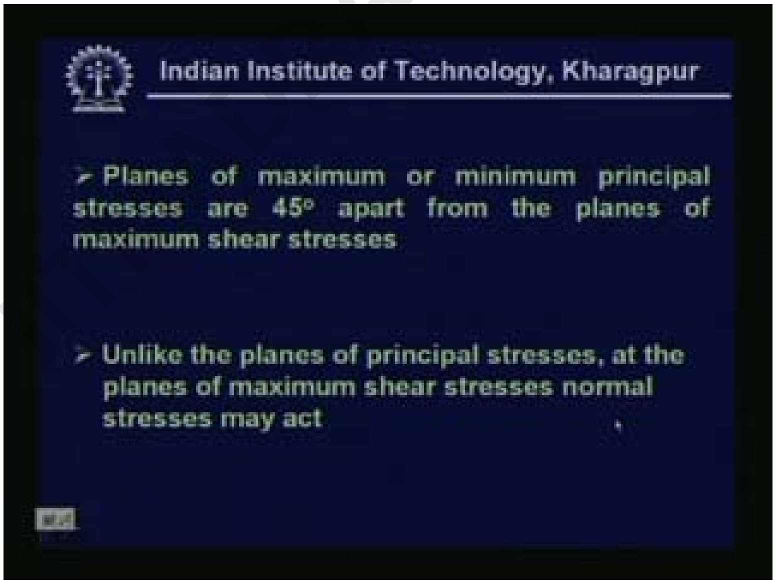

now if we go we can see the planes of maximum or minimum principal stresses are forty-five degree apart from the planes of maximum shear stresses

unlike the planes of principal stresses at the planes of maximum shear stresses normal stresses may act

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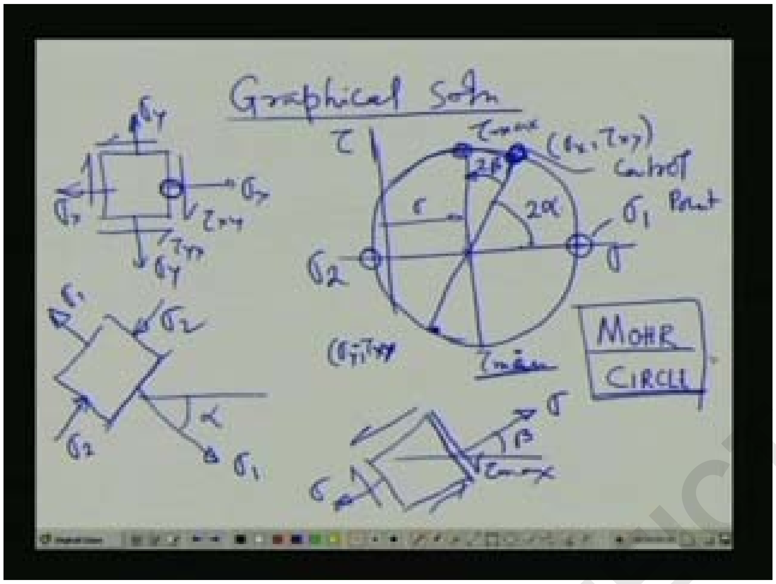

now in this respect one of the important ah situation comes out to be that a graphical solution

now in this graphical solution if we look this as an element as we have seen earlier without going for this is a sigma x this is sigma y sigma y sigma x then tau xy tau yx in the same manner you get

here you plot a sigma axis and tau axis

first you plot the values for this one what is this one

sigma x positive and tau x positive because it is creating this clockwise so this is the positive

this value sigma y and this tau y is negative assuming sigma y to be less than sigma x then this point is sigma x comma tau xy

and uh this particular one if we consider this one then we can find out this value as sigma y comma tau yx or minus tau xy anyway you can write it down

you join these two line then draw a circle these are the values sigma one sigma two principle stresses you can see no shear stress and these are the values tau x tau i min

what is the angle this always you call as control point

uh from control point how we are reaching this point by say two alpha so we draw a line come by here alpha just make it half then these gives the value of sigma one i mean orientation of the sigma one as well as the value of the sigma one you can deduct from here

so obviously this comes out to be a negative side so this comes out to be sigma two this is the orientation

what is the orientation of the tau max

you can see say this is two beta so from here you just go by an line beta so this gives you the sigma this value sigma corresponding to this one is where you are getting the sigma

so you can complete that element

and onto this phase tau max is positive so its direction is this way this is tau max

so tau min will be ah just one second so tau min will be this way so this is gives you the facts so this is sigma okay

so this way of plotting a graphical solution you can get it by plotting this is called Mohr Circle

so this is a very useful way that if you wish to use an graphical solution then also you can do it as i have described it here

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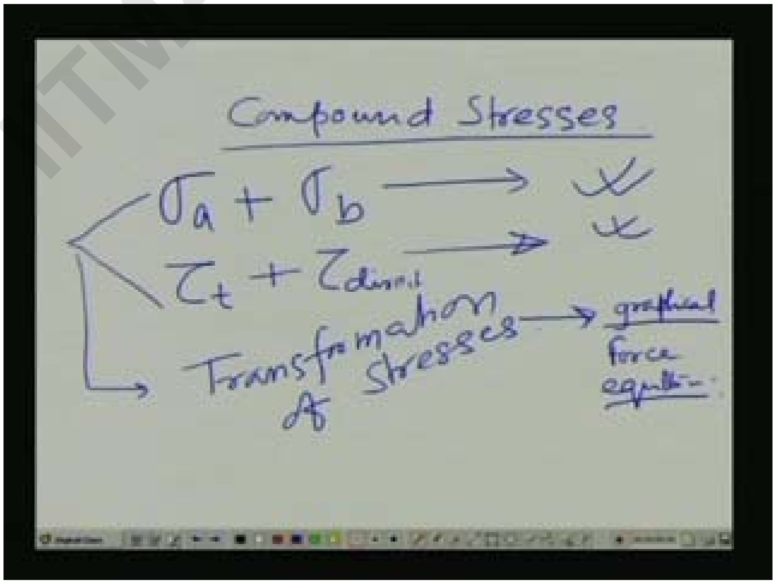

so we understand that to conclude that is today's lecture what we can say that we have already learnt what

the compound stresses okay compound stresses we have learnt

means sigma axial plus sigma {ub} (00:54:50) bending you can do it correct

then tau torsion plus tau direct or something like that what you call you can do it

then you add up how you do it

by transformation ah stresses

this transformation of stress can be done how

that is in addition to one is the graphical just we did at the last by graphical method or by by force equilibrium equilibrium you can get this particular value

so from force equilibrium and graphical solution ah you can get the values of the transformation of stresses [Noise]

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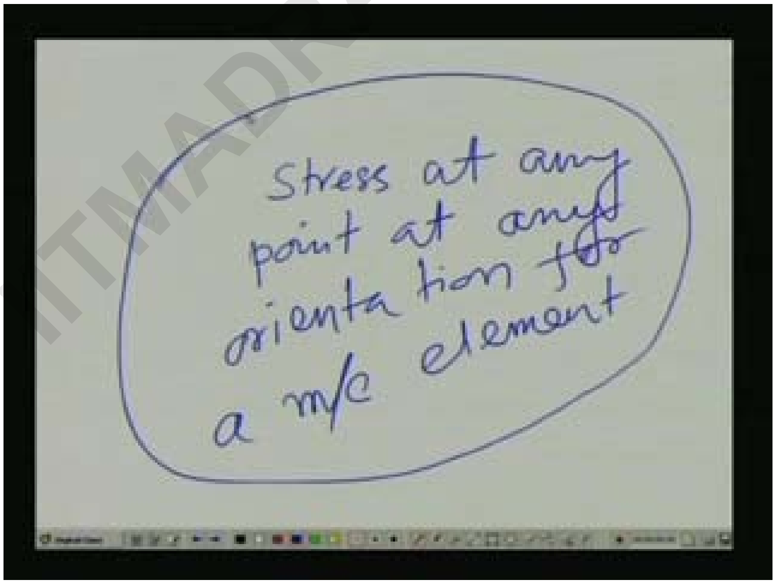

once you get the values of transformation of stresses then what you know

that you can find out stress at any point at any orientation for a machine element

this is a very useful information we will be carrying out for the design of the machine elements thank you

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good day

ah today as you have seen that we are going to discuss about the design for strength

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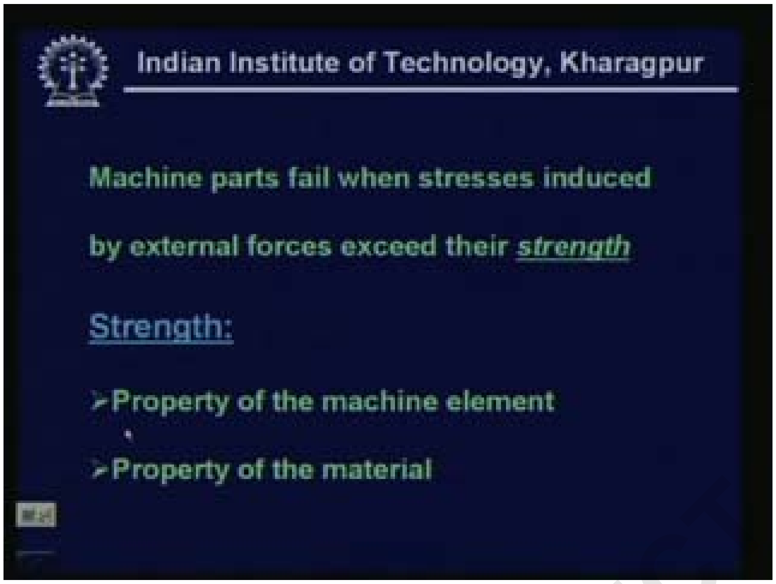

now we understand that when a machine part fails when stress is induced by external forces exceed their strength so this is very quite understandable

now the only thing is that that we have to look that what is the meaning by the word strength

the strength means one you have can notice is that the property of the machine element

now what do you understand by the property of the machine element

means suppose ah this is a machine element and which has been designed to take up some external loading onto it

so once it has been designed that further it is put onto a machine member or it is simply lying on to the table or somewhere else it is always going to have that strength for which it has been designed

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see i have chosen a material chalk a simple chalk has been chosen and we apply a pure torsion on to the chalk

just you can see that if i apply a pure torsion then it is little hard so just see it has broken

can you see the broken portion how it has failed so it has just failed in the situation ah this forty-five degree line i mean i mean this both the way it is a forty-five degree line

so what is happening

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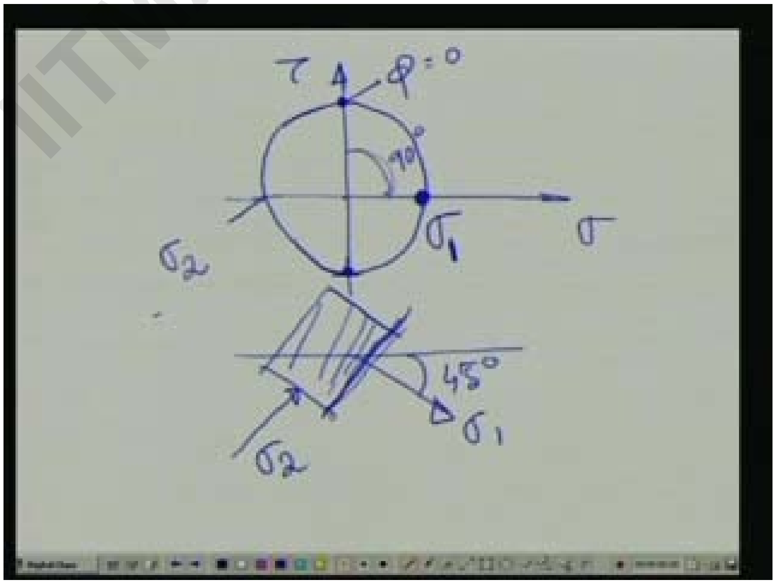

if you consider this forty-five degree line can you not see it it is resembling the same forty-five degree line what we have drawn onto this particular plate over here okay

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so this is what is one small model i wanted to show you now i just have an explanation

just see it once again now this particular plane

okay this is the plane you can see onto this this is the plane where you can see ah a failure and correspondingly this is the plane where you can see the failure and this is all at forty- five degree as i have drawn onto this ah

but