Experimental Stress Analysis
Prof. K. Ramesh
Department of Applied Mechanics
Indian Institute of Technology - Madras

Lecture - 15
Determination of Photoelastic Parameters at an Arbitrary Point

We have been discussing on transmission photoelasticity, and we have said that you need to have stress optic law to relate the fringe patterns observed to stress information. And to plug in the stress optic law you need to get fringe order, and in order to get fringe order we need to have appropriate optical arrangements. We have looked at plane polariscope; we have also looked at circular polariscope.

And I said one of the convenient means to quickly identify the fringe order is in white light, so in white light you see a color code.

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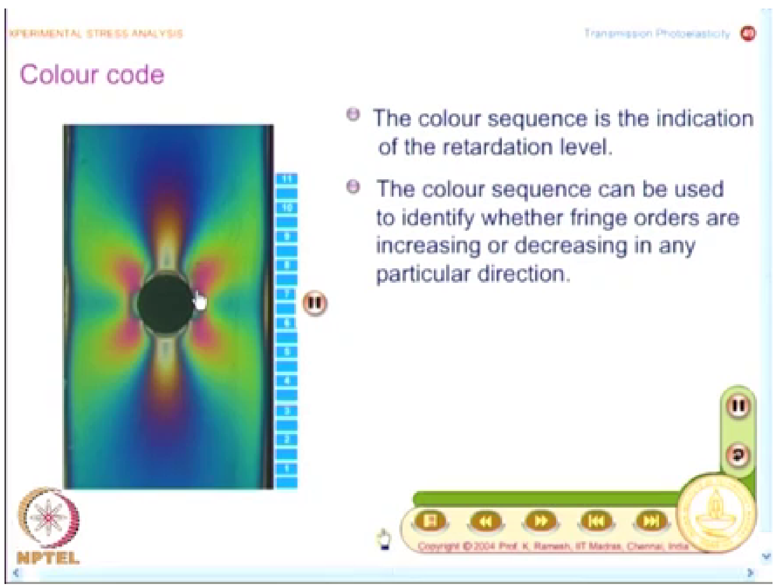

And what I have here is the problem of a plate with a hole, and you have this as a stress concentration region, and I have color of black here, then you have white and then it moves out. And you see a rich play of colors and the play of colors given indication, what is the gradient of the fringe variation? Here it is 0, here it is 1, so from 0 to 1 it increases in this direction.

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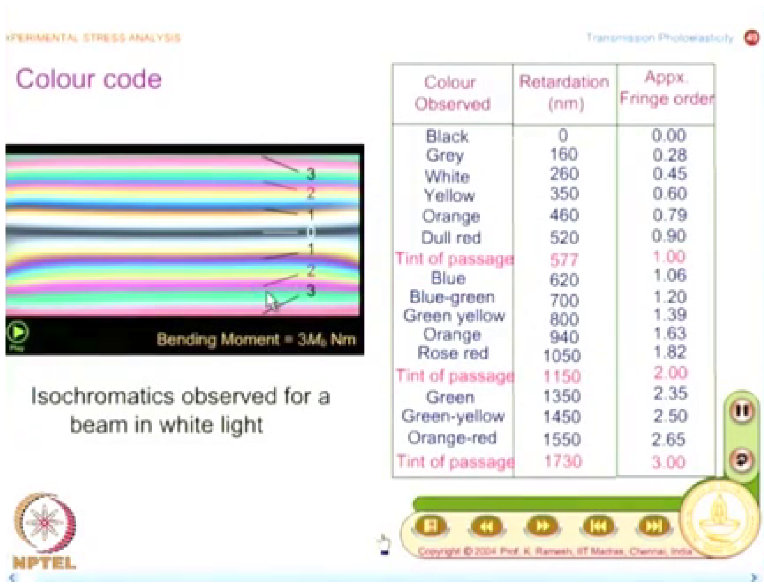

And we also looked at the color code wherein we identify for each of the colors an approximate value of retardation, and I have the color code up to fringe order 3 and what you have was dull red to blue transition you have a tint of passage, and you label that as fringe order 1, and the corresponding retardation is about 577 nanometers. The second transition happens between rose red and green that is what you have here this is your fringe order 2.

And if you look at the retardation it is double that of 577 closely. Then you have another tint of passage between orange red and then green, and beyond fringe order 3 the colors tend to merge though it is not shown in this picture, the picture stops at fringe order 3, beyond fringe order 3 the colors merged it is very difficult to associate a particular color to a fringe order beyond fringe order 3, and this gives a fairly good idea when it is black I have fringe order is 0.

And when it is blue red transition you have fringe order 1, and rose red and green transition you have fringe order 2. Similarly, you have orange red and shade of green which is fringe order 3, you can tune your eyes to get this and you can have a picture of how these fringes look like. So you have the variation here, and this gives as an indication how to find out the gradient direction in conventional photoelasticity color was primarily used to find out the gradient more than quantitative estimation.

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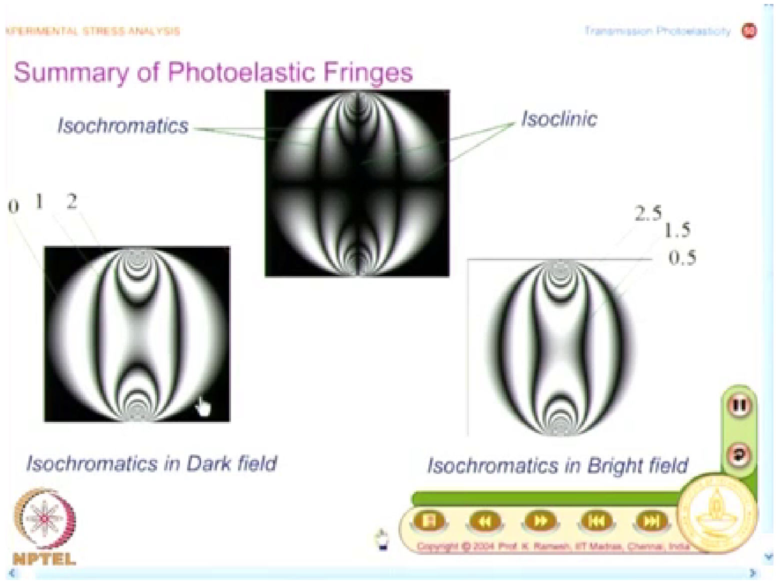

And we have also looked at a summary wherein we saw what we had as fridges in plane polariscope, and what we had as fringe in circular polariscope. In a circular polariscope you have dark field as well as bright field, and because the way the model is loaded and also from theory of elasticity solution the outer boundary fringe order is 0, this was also scenes in color code when we have looked at circular disc in color we had shade of grey followed by black on the boundary.

So this is fringe order 0, and this is about application point, so you know the fringe gradient directions from 0 it goes to increase towards this, so by knowing the 0th fringe order and the gradient in the direction it increases or decreases it is possible to label the fringes, we have not really looked at the nuances of fringe order labelling. If somebody gives you a black and white photograph it is extremely difficult to label the fringes, it is not a simple task.

On the other hand, if you have a isochromatic recorded in white light, you can comment on approximate value of the fringe order and also the gradient by looking at the color visually. If you go to 3 fringe photoelasticity you can also give quantitative data, but with visual interpretation you can only say the gradient comfortable, the numbers maybe erroneous. Now what we will have to look at is in all problems we may not want to know the fringe order at every point in the domain.

What I have is I have fringe order 1 here I may a point in between for which I need to find out the fridge order.

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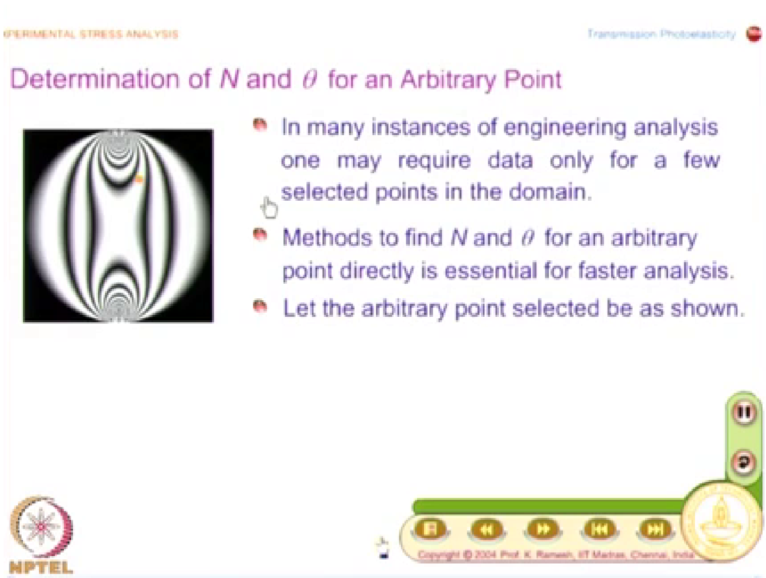

Now we need to find out how to do this experimentally, so the focus is how to find out determination of N and theta for an arbitrary point. And what is shown here is I have a circular disc and diametrical compression, dark field arrangement, I have 0, 1, 2, 3, 4 and so on. This is to illustrate suppose I have a point which lies between fringe order 2 and 3, I want to know the fringe order at this point of interest, and this is what key form my design scenario.

Then it is enough I find out fringe order at this point or few selected points in the domain, I need not go and find out and use the complete whole field information this I emphasize earlier, experimental methods particularly optical techniques give you whole field information from my design point of view you may not require all that information, you may want to know information only at few selected points.

Particularly, when you go for stress concentration problems you would like to estimate the stress concentration factor, in that case you may want to know, what is the maximum stress? And what is the average stress? So you may want to find out fringe order at these 2 locations. So in addition to looking at whole field information there are also requirements where you have to find out fringe order at selected points.

So methods to find N and theta for an arbitrary point directly this is the key point is essential for faster analysis, and you already know suppose I want to find out N and theta. For N I can go to a circular polariscope, for theta I have to necessarily go to a plane polariscope, and in fact determination of theta at any arbitrary point is for more simpler and straightforward then finding out N and arbitrary points.

So first what we look at is we look at how to get theta, then we will go on find out how to get the fridge order N? Now for the same point I want to find out the theta.

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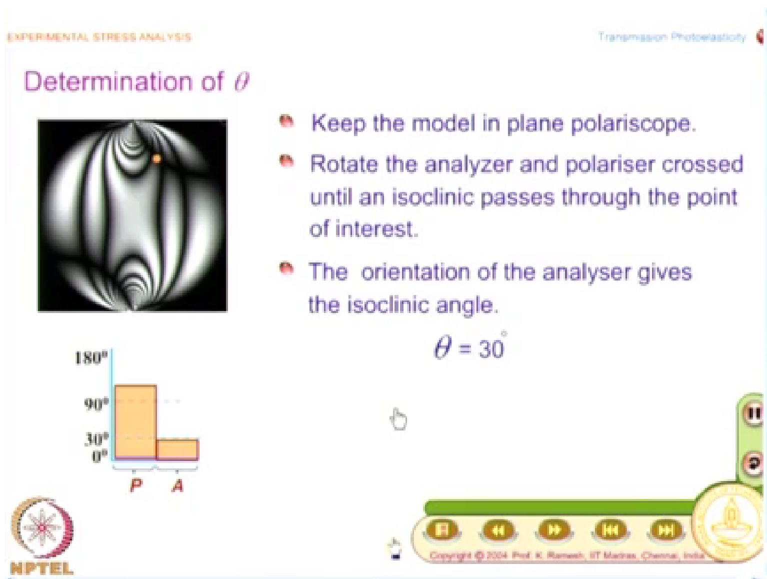

So what I do here is I go to plane polariscope and I rotate the elements until the isoclinic passes through the point of interest, so it is very simple what I need to do is I need to mark the point on the model, then I keep the model in the plane polariscope keep rotating the polarizer analyzer combination crossed you want to keep them crossed and then rotate, and you stop at when an isoclinic pass through the point of interest.

And what you will have to keep in mind is since you are going to do it visually, you know you have to look at the model perpendicular error or parallax has to be avoided, and you also see compare to an isoclinic fringes very broad, so some amount of human judgement is involved in stopping when to identify isoclinic passed to the point of interest. And there could be a error in the determination of this, this is if you are very careful you can do it + or - point 5 degrees.

If you are casual you may end up with an error of + or - 2 degrees, so if your eye is tuned and if you look at the model perpendicularly and also stop at a point where the intensity is fairly minimum, then you will be able to give an accuracy of the order of + or - 0.25 degrees, even visual inspection you can do that, and that procedure is summarized here. What I have explained is summarized here.

So keep the model in a plane polariscope rotate the analyzer and polarizer crossed until an isoclinic passes through the point of interest, the orientation of the analyzer gives the isoclinic angle, because we have labelled the analyzer angle with respect to the horizontal, and that itself directly gives what is the isoclinic at the point of interest, a 30 degree isoclinic is passed through here, and this is pictorially represented in this diagram.

So you will always find the angle of polarizer analyzer are separated by 90 degrees indicating that they are crossed, and we have stop this crossed position of polarizer analyzer, when analyzer has reach 30 degrees this, has passed through the point of interest. So the value of theta at this point after looking at the analyzer you find it is 30 degrees. And it is simple suppose I want to find out for another point mark the point and find out when does the isoclinic fringe passes through it.

Then stop it find out the analyzer and you get the isoclinic angle as simple as that, the only difficulty is because the isoclinic fringe is very broad your involvement in interpretation and stopping the crossed polarizer analyzer combination is crucial in deciding the accuracy. In modern days you replace your human eye with an electronic camera and you do intensity processing and you are in a position to enhance the accuracy, so determination of theta is fairly simple.

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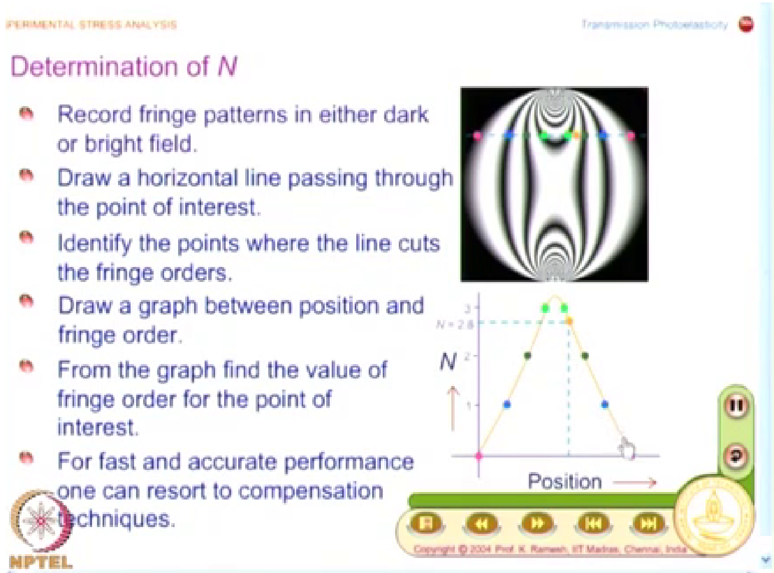

Now we move on to find out how to get fringe order N, so now I know for which point I want to find out fringe order, we have deliberately taken this point not lying on any one of the fringe orders. In this case I have taken it between fringe order 2 and 3, and this is dark field recorded image, suppose you are given a choice you have to find out the fringe order and this is the data available how will you proceed?

If you want to improve the accuracy you need to have as many data as possible a simplest thing is try to fit a curve of variation because I know the fringe order at selected points, and if I know fringe order selected points join them, and this point lies in between that so you can find out from the graph what is the fringe order at the point of interest. Suppose, I have sufficient number of fringe orders, even recording the dark field alone would be sufficient.

If you do not have several data points you can record a dark field image, you can record a bright field image, so you have additional data points and from that you can find out what happens at the point of interest, draw a graph and that is what precisely we will do. And in this case even a dark field images sufficient because suppose I take a line along this passing through the point of interest it would cut several fringe orders.

So the simplest way to do is you record the image and then post process the data, so what I am going to do is draw a horizontal line passing through the point of interest, so I have several points that this cuts, So what I have to do here is I have fringe order 0, 1, 2, 3 this is 3, then 2, 1 and 0. This I have been able to find out because I know for sure in the case of circular disc, the outer boundaries 0th fringe order this information is known, so I can count it as 0, 1, 2, 3.

And now I want to find out please order on a point which is lying in between fringe order 2 and fringe order 3, so what you need to do is you need to draw a graph and then identify what is the fringe order at the point of interest, and that is what is shown in this slide, so what you do is identify the points where the line cuts the fringe orders, draw a graph between position and fringe order and that is shown below I have the position and I have the graph drawn.

From the graph find the value of brings order for the point of interest, and it depends on how good you have drawn the graph, and how well you have located this points, your accuracy is dictated by that, and here it turns out to be fringe order at the point of interest is 2.8 that is what you get here. But if you want to have real improvement you need to resort to what are known as compensation techniques, see here what you do is you have to take a picture draw a line and then find out the fringe order.

Suppose, I eliminate even taking the picture and drawing the graph, then I will have a much better technique and that is what you do in compensation techniques. So once simple approach is plot graph and do it, and if you want to improve the performance and also improve the accuracy you have to resort to what are known as compensation techniques. And we will see, what are compensation techniques?

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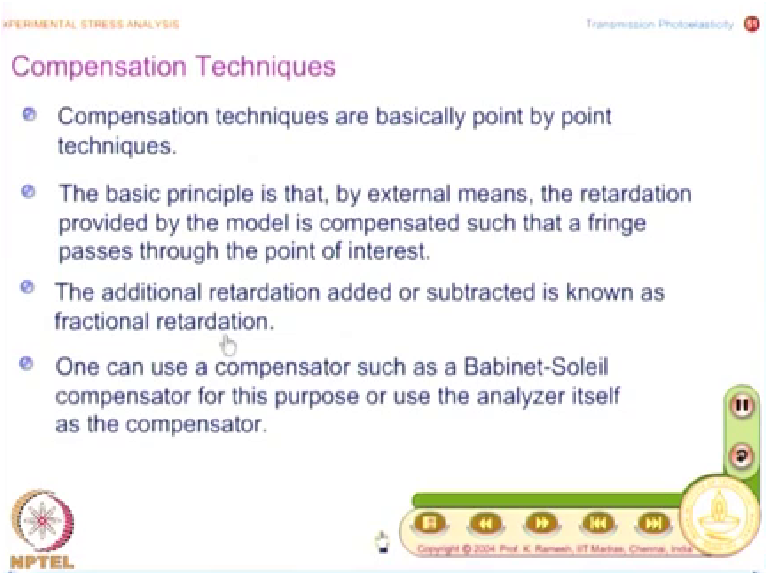

See the moment you have come to the compensation techniques, you have to go back and then see how we evaluated the retardation matrix, in a Jones calculus representation we have indicated a retarder by a matrix, and I have also said we are adding or subtracting retardation with respect to the reference axis, the reference axis at the point of interest coincide with the principal stress direction, this is very important.

I emphasized even at that point you need to find out in which axis you add or subtract retardation, this is very key point the moment you come to compensation technique even a optical method becomes the point by point, because we have in general said we have a fringe pattern observed you get the whole field information, if you are able to interpret from that photograph well and good.

The moment I will go to a compensation technique whatever I do pertains to the particular point of interest, I may see in a process of compensation methodology I may still see some fringe contours away from the point they do not have physical meaning, the physical meaning is attached only to the point of interest this will become clear when we will look at the technique and how we do it. So do not think a whole field technique always gives whole field information.

The moment you employ a compensation technique you reduce this to a point by point method, so this is what you have compensation techniques are basically point by point techniques. And what is the principle, by external means the retardation provided by the model is compensated such that a fringe passes through the point of interest, see we have also done a logical development of fringe formation both in a plane polariscope and circular polariscope.

We said when the model behaves like a full wave plate in a dark field, the light is cut off at 0, 2 pi, 4 pi retardations, at other points you had a shades of brightness you know from dark fringe to you also go to bright fringe, so you have intensity variation why that intensity variation comes? Because at those points the model was not behave like a full wave plate instead of a plane polarized light coming out you have a elliptically polarized coming out in the case of a plane polariscope.

So all the light is not cut by the analyzer, so you see some light now in compensation technique you find out what is the fractional retardation we need to add or subtract at the point of interest, so that with the compensating device at the point of interest the retardation =0, 2 pi, 4 pi, 6 pi, this is basis of compensation techniques, but for me to apply compensation I should know the principal stress as directions at the point of interest this is the prerequisite.

So the principle is you make it with the compensating device that retardation at the point of interest equal to a full wave plate. In the case of dark field if we employ a dark field, if we employ a bright field you can also have intermediate values. And this is what we have so the basic principle is by external means the retardation provided by the model is compensated such that a fringe passes through the point of interest.

And the moment I bring in compensation see I also made a statement that in photoelasticity you get only positive fringe orders, this refers to total fringe orders sigma 1-sigma 2= N S sigma/T or N S sigma/H because sigma 1-sigma 2 is always positive, N is always positive but when I do compensation the compensation can be positive or negative we should not confuse these 2 because at the retardation may be >2 pi I may slightly reduce it and bring it to 2 pi.

So I have to compensation as negative value, it may be slightly <fringe order 1, I may add compensation to increase it to fringe order 1, so the moment I come to compensation techniques.

First is, it is the point by point methodology, second whatever I compensate has a sign attached to it do not confused this with sign of the total fringe order these are 2 different issues, because such confusions you know can come.

So this is what you have here, the additional retardation added or subtracted is known as fractional retardation, so we call this as fractional retardation and fractional retardation can have a sign attached, and in many instances how to find out the sign is crucial. In fact, the whole of digital photoelasticity the sign was ambiguous and this has really taken almost a decade to solve this issue it is not trivial.

And you are doing a conventional photoelasticity you have lot of heuristic information available to you to fix the sign, the moment you go to computer processing this has to be done intelligently and that has been achieved now. So what you find here is the fractional retardation will have a sign and that you have to find it out precisely, and there are many compensation techniques available, one can use at compensator such as Babinet-Soleil compensator for this purpose.

Or one can also use analyzer itself as a compensator, see when you normally developing a technique you identify that there is an issue and this needs to be sorted out, so the first solution will only be sort of a first approximation you may want an additional gadget to help you, so if you look at Babinet-Soleil compensator it is an additional piece of equipment which need to be attached to a polariscope then find out the compensation.

On the other hand, as techniques developed people also device without an additional element can we do something with the optical arrangement itself go back to equations and find out whether you could improve upon and find out one of the elements itself and behave like the compensator. So that is how you have analyzer itself is being used as a compensator, this has a special name you have a person invented it, so you have all that as Tardy's method of compensation.

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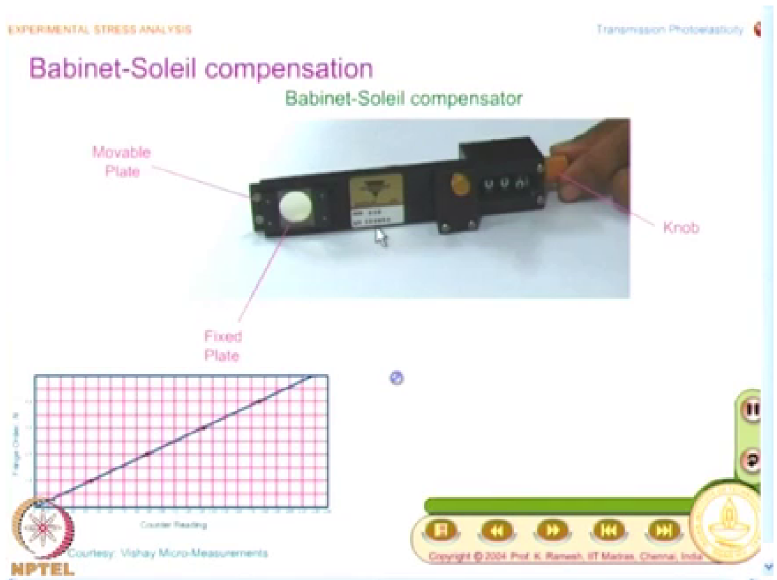

So what we will do is we look at Babinet-Soleil compensator as well as compensation by using the analyzer, and you have readymade equipment's available for Babinet-Soleil compensator, and you can see here I have a window and I have another plate that is coming out, so I have a fixed plate and I have a another plate which moves and you can also see that there is a counter. So this is the commercially available Babinet-Soleil compensator this is from Vishay measurements group.

And what you have here is I have 2 elements, one element is stationary, other element moves. This can be rotated by rotating this nob and the counter value will change, you need not sketch this you just observe this later I have a simpler sketch which you can note it down. And what you have is when they supply a compensator like this they also supply a calibration graph, so this graph goes with the compensator this is supplied by the manufacturer himself.

So what is that you need, when you want to look at the compensation see you have read elaborately what is the retardation plate, what are wave plates? Wave plates you know by changing the thickness if you have a crystal plate by changing the thickness you can adjust the retardation, and if I want to have + and - this is also possible. So the physics behind the Babinet-Soleil compensator is I have a provision to adjust what is the effective thickness of the compensator.

One could be positive, one could be negative there are many combinations possible, one could be tapered, so essentially what you are doing is you are trying to adjust that fractional part, so that at the point of interest model behaves like a full wave plate.

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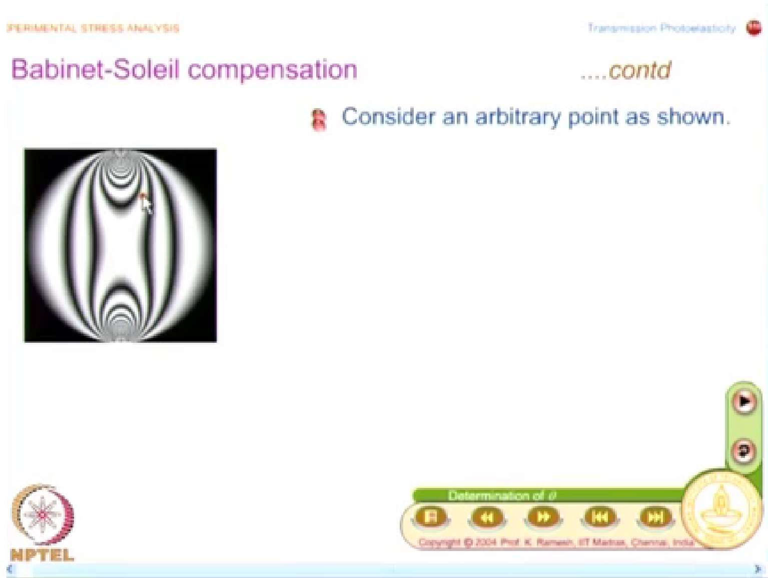

And this is very interesting and how do we go about, see what I have is I have kept the same point which we have found out the fringe order by plotting a graph earlier, and we will find out fringe order for this point by using Babinet-Soleil compensator. See when we went and drew the graph you did not want to find out the isoclinic at the point of interest, what you did was you simply took the photograph then drew the line and then identify points where the line cuts the fringe order then you plotted a graph and picked out what is fringe order at the point of interest.

If you adopt that kind of a method there is no need to find out the isoclinic angle at the point of interest, but that method is time consuming and also depends on the accuracy with which you have picked out other data points. On the other hand compensation technique, I do not have to take a photograph imagine in old days when they had to take a film developed the film and then make a print only then they will be able to do it.

Now you have a digital camera instantly you get the pictures, even processing the picture is not a big issue now, you have several image processing routines also have come picking out this data is very simple, but now with advancements and imaging why do you go and work on a conventional approach people thought that they will work on intensities that is how digital photoelasticity has developed. Even the basic philosophy in processing the data has changed.

But nevertheless you need to know how you can do a conventional approach that knowledge helps, this also helps in verifying whether your digital photoelastic algorithm is giving you the correct result, because you should always have a secondary method to check because once you bundle everything as a software it is a black box, whether it is finite elements or whether it is experimental mechanics if you are going to ultimately use as a software you should never use it as a black box.

You should know how the software has been developed, and you should also have methods which helps you to verify whether the software is turning out correct results, so from that point of view also finding out the fringe order at any arbitrary point using a compensation technique is useful. Do not think that digital photoelasticity with press of a button I get all the fringe orders, then why I need to find out and learn compensation technique.

Even to verify some of those algorithms may fail at some places, there are limitations in any development there are limitations. So what you have here is I need to find out the fringe order at this point of interest the moment I go for any compensation technique I need to know the isoclinic angle at the point of interest.

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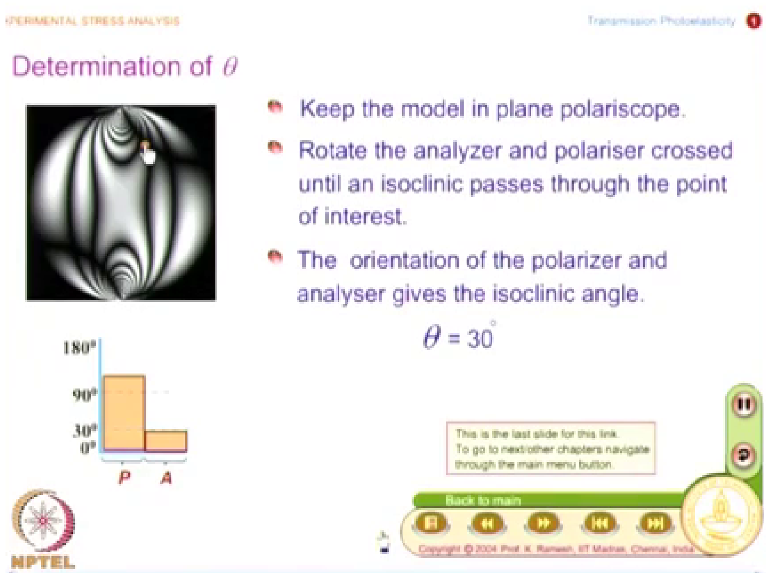

And how do I get the value of theta, and for this point we have already seen, I am just recapitulating it. So we found that the 30 degree isoclinic pass through the point of interest, so I have theta at this point of interest is 30 degrees, this information is needed for me to align the Babinet-Soleil compensator at the point of interest to introduce compensation, understand this. Interestingly, even in digital photoelasticity I need to get theta at the point of interest and then only go to fringe order N.

Though in a conventional approach I can find out theta separately and N separately, the moment I come to compensation techniques I need to find out theta also at the point of interest and then only apply compensation, the same philosophy is extended in digital photoelasticity also. And you will also have to keep in mind when you are looking at compensation technique, when I do the compensation which fringe order has move and fill the point of interest.

I am telling you in advance, so that when the animation comes you observe this certain points, first thing is it is applicable only to the point of interest even though I see fringes elsewhere they have no physical meaning this you have to keep in mind. And second observation is which fringe order has moved and occupied whether it is a higher fringe order has moved to the point of interest or lower fringe order has moved to the point of interest, this you have to keep in mind. So now what we see is we have identified theta at the point of interest.

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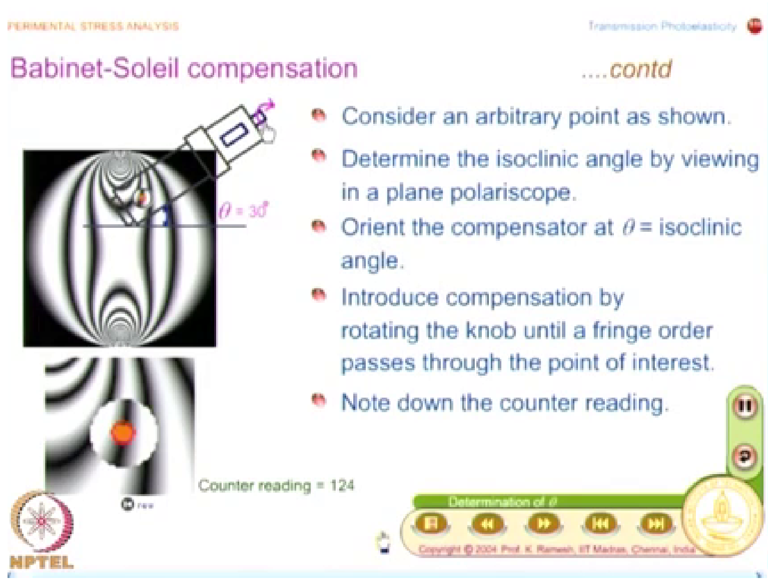

Now we go back and then see how do I use this information, so we have determined the isoclinic angle by viewing in a plane polariscope, and what I need to do is orient the compensator at theta=isoclinic angle. So that is what you see here, so what I see here is you see this very carefully, I have oriented this compensator axis at theta =30 degrees, this is where I used this and I think you need to sketch this figure, I will give a slightly complete figure here.

So I have the fringe pattern, I have to align this compensator at the angle of the isoclinic at the point of interest, because this compensation has to be done along the reference axis at the point of interest, the reference axis turns out to be principal stress direction at the point of interest, and principal stress at the point of interest has been determined from the isoclinic angle. So now I align the compensator with that angle.

Then whatever the compensation I do it is possible for you to obtain the calibration between the counter reading and the compensation added or subtracted it as simple as that. And what I have shown here is the compensator export and this is the field of view here, the field of view is very small in case of a Babinet-Soleil compensation, so what you see here is only within this field whatever the interpretation, even within this field only at the point of interest the interpretation is valid.

Though you see a fringe background, they have no physical meaning when I apply the compensation, right now compensation is not applied, right now only I have aligned, even when I have aligned it there is a base compensation is available until I rotate the nob and then make this fringe to move to the point of interest, I will not know what is the way to interpret the data. Now what I will do is I am going to rotate the nob in such a manner a fringe passes through the point of interest.

So that it is what is shown you are rotating this nob and you have this in the field of interest, I have a fringe that passes through the point of interest, and we would have a enlarge view of this and I will do the compensation again, are you able to see when I do the compensation, here which fringe order is move to the point of interest, higher fringe order is moved to the point of interest and I see a fringe here.

Do these branches have any physical interpretation? They do not have any physical interpretation, I see a fringe so that is why I said in all optical techniques interpretation of recorded data is very crucial just because you see a fringe I cannot say this was fringe order 3, so in all this point fringe order is 3, you cannot conclude that way. What we have made observation is higher fringe order is moved and occupied this position.

So that means what I have done is I have done the compensation in a manner whatever the fringe order is in this case the fringe order3, so 3- that compensation will give the fringe order at the point of interest. So you get the heuristic information what is the sign that you should attached to the fractional retardation, suppose fringe order 2 has moved then you need to add, fringe order 3 has moved so you need to subtract.

So whether to add or subtract depends on what observation you make at the point of interest, this will become very important when I go to Tardy's method of compensation. The Tardy's method of compensation I can rotate it clockwise or anticlockwise, and in the counter they have very user friendly, you have rotate it in one manner whatever the reading that you get you are in a position to you are in a calibration chart you are in a position to find out what is fringe order at the point of interest.

That is a way the calibration slightly done differently but the physics is same, you have to know in all compensation techniques whether a higher fringe order is moved and come to the point of interest or a lower fringe order has moved to the point of interest. And in this case the animation clearly shows a higher fringe order has moved to this point of interest, and when I start with you know because in a Babinet-Soleil compensator the field of view is only this.

The other fringe are not affected, other fingers are like what I have in the regular dark field, they still hold the interpretation as dark field fringes, in this region the interpretation is valid only for the point of interest. For illustration I have some big circle, actually it is the center of the circle, so whatever the interpretation, data interpretation is applicable only to the point of interest when I apply compensation technique.

Even though I see resemblance of fringe elsewhere, they do not hold interpretational value to the physics of the problem. In this case because of the field of view is only restricted to this these are still dark field fringes do not worry about it, they are still dark field fringes and you can attach to 0, 1 I mean this is 1, 2, 3 all those valid, within this region only for the point of interest you must attached the retardation whatever the fractional retardation attaches only to the this point of interest.

So this is how you do the Babinet-Soleil compensation, so I stop the rotation of the nob until a fringe passes through the point of interest, and you need to note down the counter reading. And in this case the counter reading turns out to be 124, so is the idea clear? When I go to a compensation technique I need to know I need to mark the point of interest in some manner.

Then I need to find out the principal stress direction at the point of interest, align the compensator axis along the principal stress direction then rotate the nob until a fringe masses to the point of interest.

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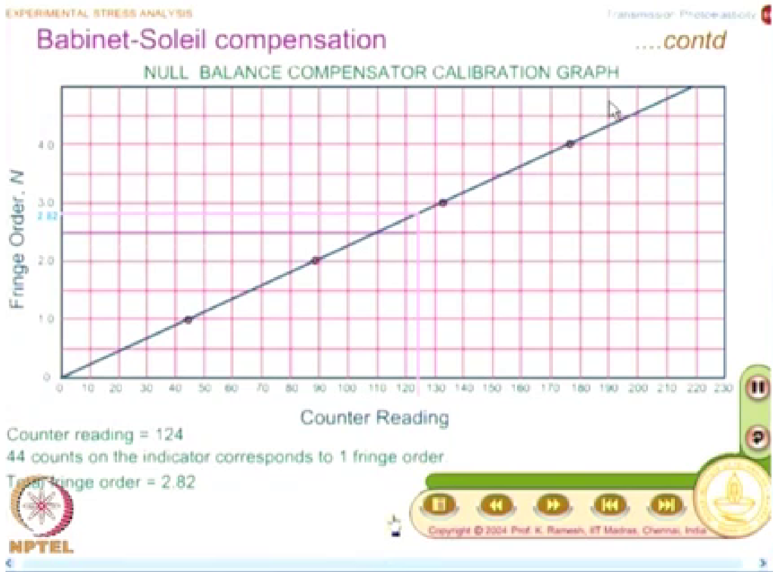

In a Babinet-Soleil compensation they have made the calibration in a manner you find out the counter reading you are in a position to use the graph supplied by them, so this gives the null balance compensator calibration graph, now I have the counter reading is 124, I simply go in this graph and find out what is the fringe order, I get this fringe order as 2.82. So this is far more accurate than finding out based on plotting your graph and here I do not need to plot a graph.

I have the calibration than just by noting the counter reading, you make a sketch of this graph that is just you do not have to put all these find values, you just show the shape of this linear variation and you have fringe order 1, 2, 3, 4. And if I know the counter reading it is possible for me to find out from this graph what is the fringe order, so it is easier for you to do this, we have this as 2.82.

And this is supplied by the manufacturer he gives you 44 counts on the indicator corresponds to one fridge order, this is for the particular piece that is supplied, so this may vary from batch to batch or piece to piece, and this will be supplied by the manufacturer.

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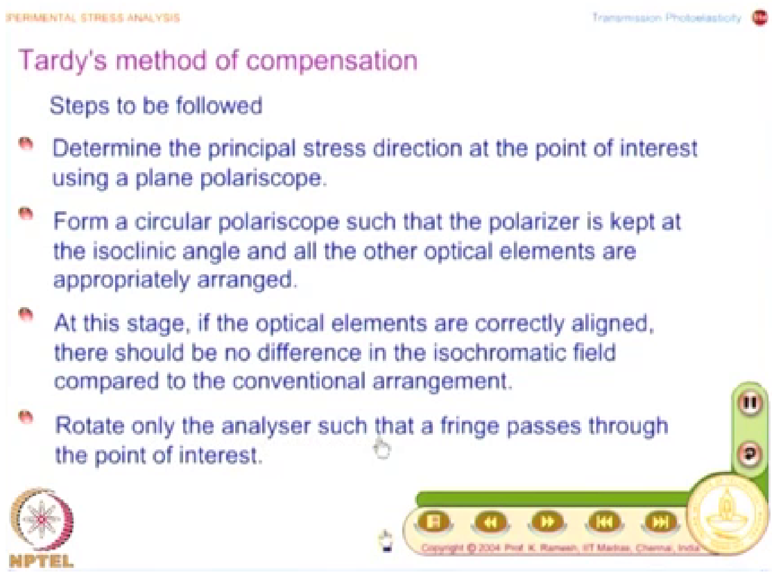

And what I am going to look at is we have also said one can find out compensation not by having an external element, but by simply handling the analyzer and this is known as Tardy's method of compensation, and I am going to only list out the steps today and we will see the mathematical development later. As before you have to find out the principal stress direction at the point of interest using a plane polariscope.

Then what I need to do is I need to form a circular polariscope such that the polarizer is kept at the isoclinic angle and all the other optical elements are appropriately arranged, see this is the very very important step, in case of Babinet-Soleil compensation what we saw? We found out the principal stress direction and we took the Babinet-Soleil compensator and aligned it along that axis it was 30 degrees.

So you have the disc and then you put it like this put it at the 30 degrees in that particular point of interest, the alignment was fairly simple. Suppose, I want to use the analyzer itself as a compensator, then I need to rotate the entire polariscope to that angle of the isoclinic angle, so that means the fringe field should not be affected. Here, again we will send this circularly polarized light impinging on the model.

Then circularly polarized whatever the light that comes out of the model is analyzed by the second quarter wave plate and analyzer that would form the reference axis, and this one of the verification is whether you rotated all the elements appropriately is to verify after rotating all this isochromatic fringe should remind same it should not have any distortions or any changes that ensures that you have rotated all the optical elements appropriately.

So it is very similar to keeping the compensator at the isoclinic angle at the point of interest, then the next step what you do is simply rotate the analyzer, rotate only the analyzer such that a fringe passes through the point of interest. And what I have said is summarized if the optical elements are correctly aligned there should be no difference in the isochromatic field compared to the conventional arrangement.

This is the check, because you know when you have polariscope where you have to rotate each of the optical elements they have to be rotated carefully maintained the parity between the individual elements because we want to have polarizer and quarter wave plate separated by 45 degree, and you need to have the slow axis at 135 horizontal, now it becomes appropriately with respect to the basic isoclinic angle, so you need to keep that parity quarter wave plate should be crossed.

Now I have been basics whatever the analyzer axis I will take that as a base and what I need to do is I need to rotate the analyzer until a fringe passes through the point of interest. Now what I will do is you will be surprised that whatever the angle that I rotate is crucial that itself will give you what is the value of the fractional retardation, and that sign how will you attach whether the higher fringe order is moved to the point of interest, lower fringe order moved to the point of interest.

In fact, in conventional photoelasticity this is very strong heuristic information, because you visually see a higher fringe order comes or a lower fringe order comes and occupies this, so you attach the sign and in fact you will be doing this as part of your laboratory exercise to find out the material stress range value you need to find out the value of fringe order as accurately as possible so you resort to a compensation technique.

So what you have here is the optical elements are currently aligned, there should be no difference in the isochromatic field compared to the conventional arrangement that you should verify and rotate only the analyzer such that fringe passes through the point of interest.

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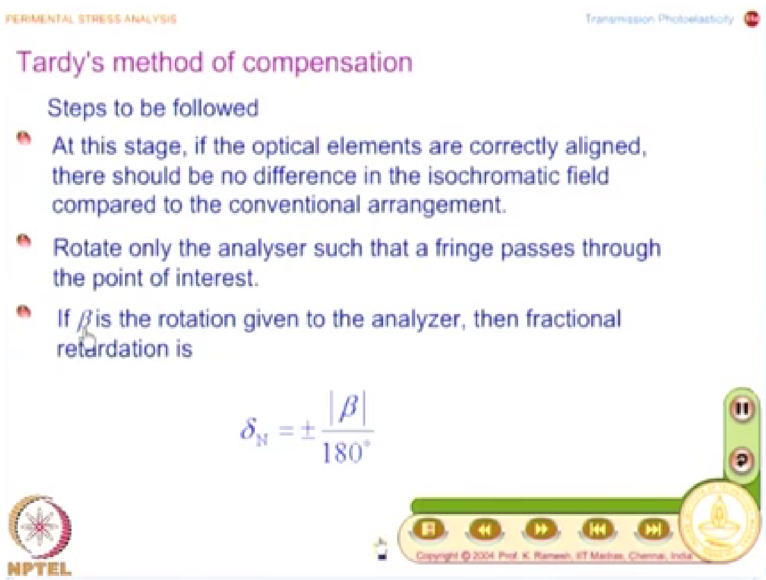

And what you finally have is I have this as suppose I have rotated by angle beta, then you have an expression the fractional fringe order delta N expressed in terms of fringe orders is given as + or – beta/180 degrees. So in the Tardy's method of compensation your focus is to find out the angle beta that is necessary to keep the analyzer, so that a fringe passes through the point of interest and beta is also referred from isoclinic angle reference.

And you have this as beta by 180 degrees and this sign comes from your observation of higher or lower fringe order passing through the point of interest. See now as engineers you need not have to believe my words, you have to go back and then get into Jones calculus repeat these steps and find out whether whatever the statement that I have made that analyzer behaves like a compensator you can verify.

In fact, we will take it up as part of discussion in the class tomorrow, and in this class what we focused was we looked at briefly what we saw as color code, I said color code is very useful in conventional photoelasticity to identify the gradient of fringe whether the fringe order is increasing in that particular direction or decreasing in the particular direction color code is very, very useful.

And I said black is 0th fringe order, and then blue red transition is fringe order is 1, and red green transitions is fringe order 2 and if eye is tuned it is easy for you to identify the fringe order 0, 1, 2 you can comfortably identify, 3 there will be little difficulty but there is distinct change in color between 1 and 2 that is easy for you to identify. Then we said in many problems of practical interest it is not necessary that you need to find out fringe order at every point in that model few selected points are sufficient.

And in fact for you to directly find out the fringe order compensation techniques are the ideal, but when I want to employ the compensation technique even to find out the fringe order only, I need to calculate and find out what is the isoclinic angle point of interest and then only move on to find out the fractional fringe order they are interrelated. Suppose, I want to take a photograph and then processes it and find out the fringe order I do not need isoclinic angle.

Because there you take a photograph and then draw a line passing through the point of interest if you have sufficient number of points signed them appropriately and from the graph you will be able to get the value but that consumes time. On the other hand, compensation techniques give you instantly what is the fringe order at any point of interest, and in fact compensation techniques are useful even to verify the result from your digital photoelastic algorithms.

Sometimes these algorithms fail at certain locations if the gradient is high or if you have discontinuity and so on, you need to have verification by secondary technique where compensation technique really do a great help and we have seen 2 methods of compensation. One is Babinet-Soleil compensation which is an external compensator we have seen how to use it, and we have also looked at analyzer itself of a circular polariscope being used as a compensator.

We have only looked at the steps, because there are 2 issues involved, you need to know how to apply Tardy's method of compensation, the basic procedure. And you need to have a proof to convince yourself that this basic procedure is quite alright, and this is what we will take it up tomorrow, but I would like you to look at trigonometry identities, and also matrix multiplication brush these fundamentals and come to the class, thank you.