Experimental Stress Analysis - An Overview

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Lecture – 2.2
Visual Appreciation of Field Information – Part – 5

Let us continue the discussion on Overview of Experimental Stress Analysis.

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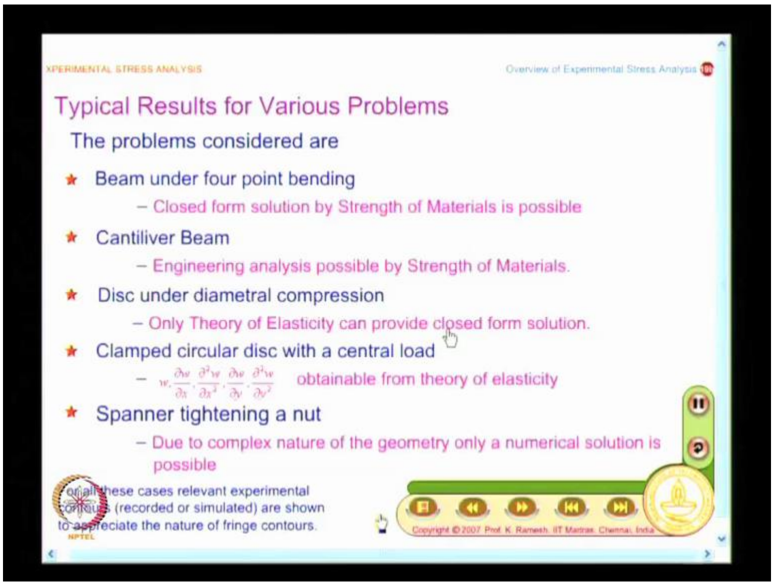

We have discussed in the last class, the problems considered are Beam under four-point bending, Cantiliver Beam, Disc under diametral compression.

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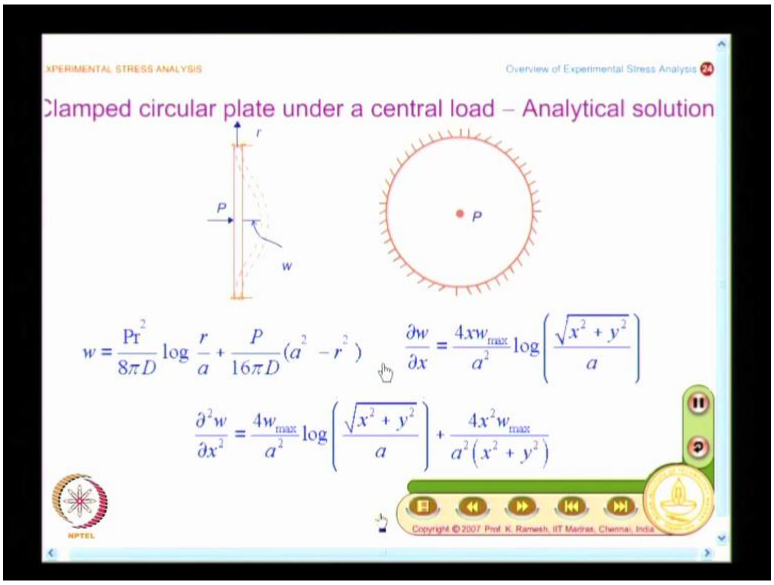

And the next problem what we would take on is, we would take on the problem of a Clamped circular plate under a central load. And what I would appreciate is I have this clamped circular plate, this is clamped at all around the periphery and it subject to a central load. In fact, in the kind of problems where they do out of plane displacement they take this as the bench mark example and using this only they testify their methods.

What you have here is your expression for w out of plane displacement, you have the expression for dou w by dou x, you also have the expression for the curvature dou square w by dou x square. In all this cases you have logarithmic term appearing in this, the expressions are definitely complex and you would be able to find out this from a study on theory of plates, where you have sufficient theory is developed to find out how to get this expressions.

And essentially, when I want to go and find out whether I have a speckle interferometry working all right I would not take a circular disc under diametrical compression, but I would rather take a clamped circular plate with a central load to test even my experimental setup. So by doing that I would be able to get that information. Similarly, what I have here is I have shown the slope in direction x you can also have the slopes in direction y.

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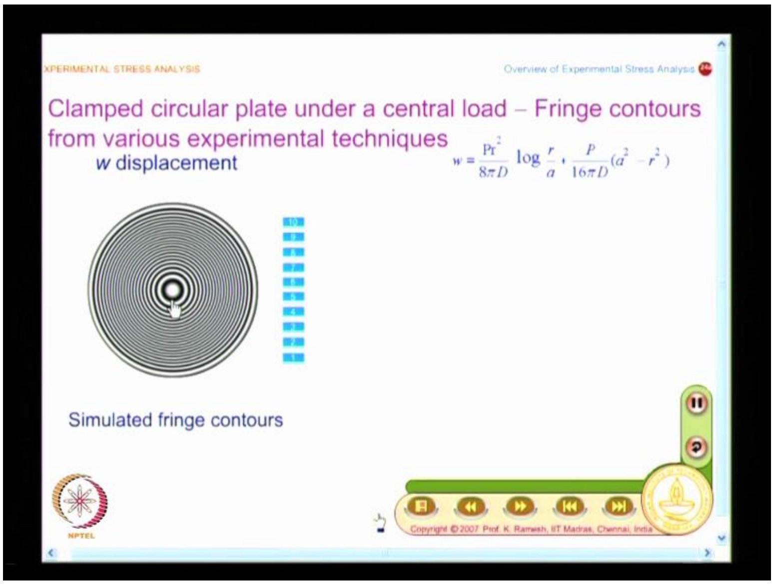

And when I go and find out I get this pattern like this. So what I have here is, I said nature is so good that it gives you. So I have simulated fringe contours, I have concentric circles nature is so good. In the case of beam under bending, you saw horizontal lines. In the case of clamped circular plate, you see beautiful circles. This is again a function of load apply, so you have concentric circles that they come and this is what you have. As a load is increase you have more and more circles.

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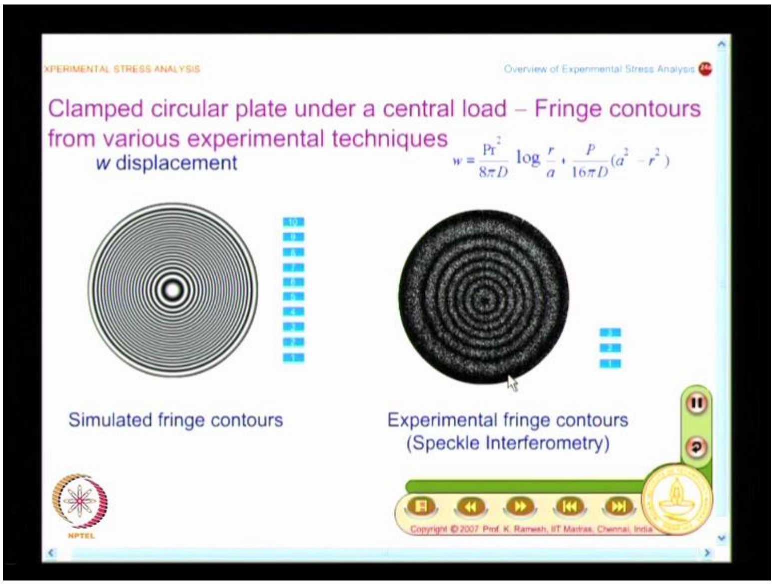

And what you find is, if I want to go and look at an experiment I can get this from speckle interferometry. I will magnify this and show this, here you do not find the fringes as clearly marked dark and white, you have secular pattern and these are called Correlation fringes.

Here again it is a function of the load applied, I can apply the load 1, load 2, load 3 and so on and you do not have the level of contrast that you have in the case of photoelasticity. What is the advantage here, you are able to get out of plane displacement by whole field technique, but they do not have high contrast. So, if you look at any of this speckle interferometry methods they spend lot of time on filtering. On the other hand, photoelastic fringes have very high contrast and you need to do less post processing then what you can do in the case of speckle interferometry. This is the fringes you have, and this is again function of load also make a neat reasonable sketch of this. Suppose, I want to go and see, how do the slope patterns look like and the slope pattern patterns looks like this.

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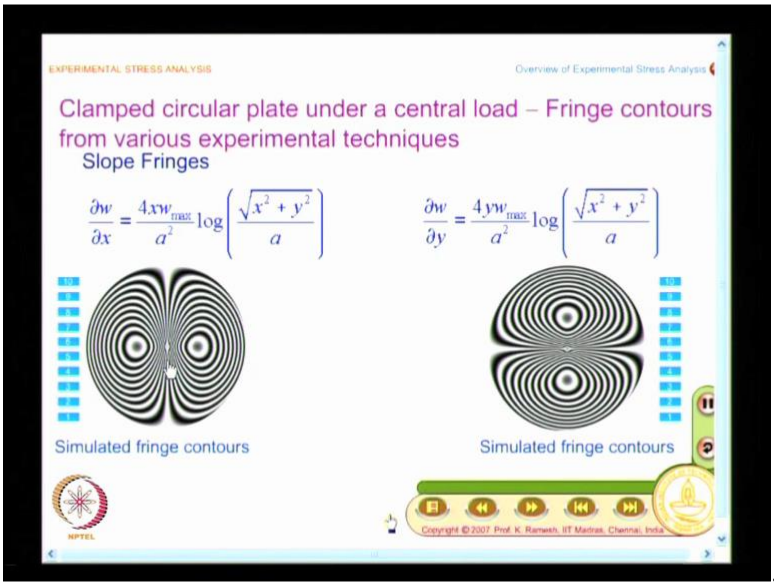

Slope fringes are like this, you have the expression here and you have the expression of slope in the direction x slope in the direction y and this is how the fringe patterns you have. What you have here is, I have and when I increase so you could say people also say this as butterfly fringes. They look like the wings of a butterfly and they call this as Butterfly fringes. Particularly in the case of non destructive testing when I want to do a honey comb panel testing, any delamination you would be able to find out easily if you see butterfly you should not feel happy, you feel disturbed that there is a delamination. If the butterfly pattern why they call it is, in the case of commoners you know they do not want to say that it is dou w by dou x contours they simply say it as butterfly fringes. You have a similar situation when you have the slope in the y direction also. So these are called butterfly fringe pattern. This you have a look at it and it is orient in a different direction and that is what you have.

Now, what you look at is, suppose is there any experiment which can reveal. These are all stimulated contours I have the expression here I have the stimulated when I increase the load I get that.

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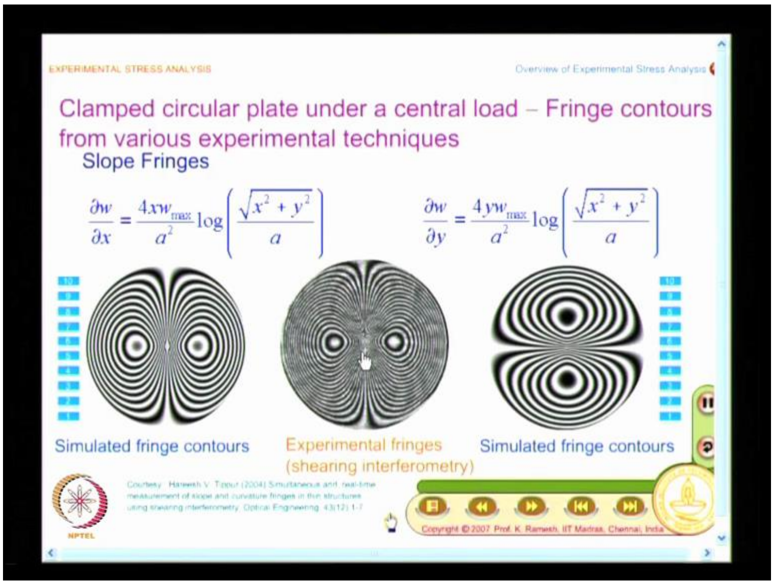

And what you find here is, a very recent experiment on speckle interferometry as given very nice set of contours on thin wafers. And you know in fact it matches very well with what you have as the simulated patterns. This is how you see in the experiment, and this is from the work of Hareesh V. Tippur, he is a best friend of mine.

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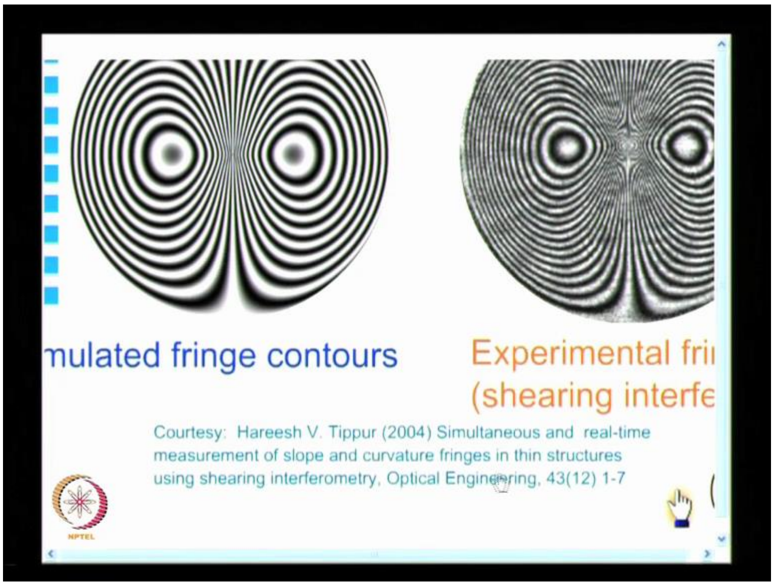

This has come in the general of optical engineering you will get more details of these fringe patterns from this and courtesy goes to Optical Engineering and the Society for Optical Engineers, SBIE. You can note down this reference, you could look for more details of this fringe pattern. This was very recent work, this is on a silicon wafer so it is a simultaneous and real time measurement of slope and curvature you see only slope fringe here. What we would see now is, we would also see the curvature and curvature information is looks like this.

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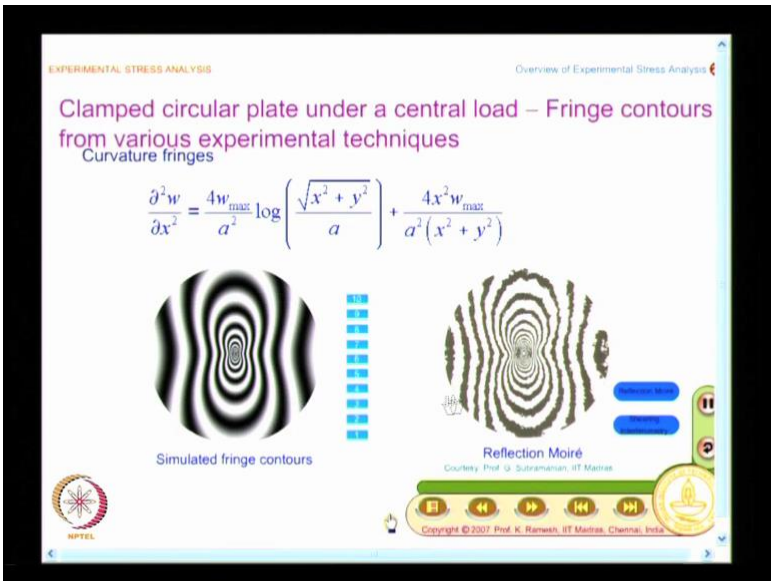

And the simulated fringe contours are like this. If you go to experimental technique you have a nice sort of curvature fringes up time.

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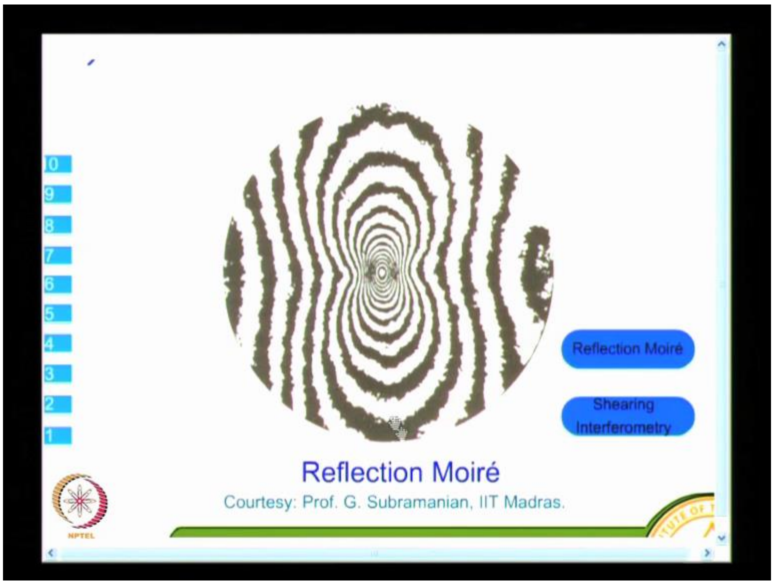

And you may think from the experimental fringes we have seen earlier this borders are not smooth they are jagged, but you see the shape as what you have seen here, this result is from Prof. G. Subramanian. He was an exponent on moiré interferometry in the country and this is from reflection moiré. What you will have to know is, even to identify an optical technique to get this is a challenge and you will know the difference only when you want to find out the curvature in shearing interferometry.

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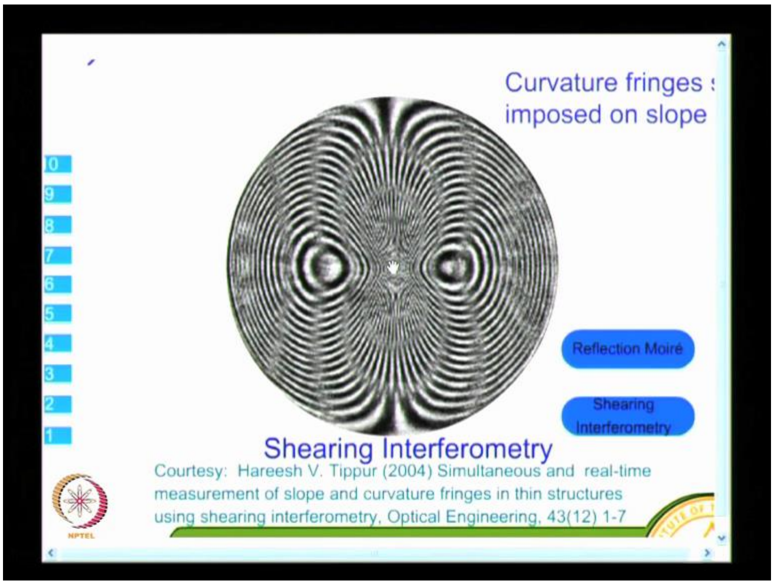

Shearing interferometry gives the information like this. What you see here? Do you see the curvature, I will magnify it further. What you see here is, I have on the backgrounds slope fringes on the slope fringes you see faintly the curvature fringes. When I had shown sigma 1 minus sigma 2 contours super imposed with isoclinics you felt uncomfortable. Now, you will say that was much better because it had very good contrast, here I get curvature information. But the advantage here is, though it looks little dull the advantage is the optical arrangement used, gives both slope in curvature information in one shot. That is why the optical paper work this is again the work from Prof. Tippur and this is from Optical Engineering. You can get more information on this from reading a paper like this.

So, I can say comfortably now you have fairly good idea on how do the optical patterns look like. Optical patterns essentially give certain physical contours and these physical contours are dictated by the physics exploit and the experimental technique. You have seen individual experimental contours, you have also sample of super imposed contours. In some cases you will get only super imposed information, only in certain cases you will be able to separate it and from an experimental point of view you need both. Suppose, I have a time vary in phenomena I would like to record both, I would record both slope and curvature by a very different optical arrangement though the quality of information is slightly of a poor quality I would record both the information together.

I am sure at the end of this lecture you have a fairly reasonable idea how do the whole field representation of stress field, particularly sigma 1 minus sigma 2 contours and displacement fields by and large look like that gives you certain level of familiarity certain level of affinity and as we go further you would be able to find out how to get these contours by yourself, what is the principle that is used? And also how to interpret not just be happy with the shapes of the contours, but also get the actual magnitudes with essence of confidence.

Thank you.