Experimental Stress Analysis - An Overview
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Lecture - 1.5
Visual Appreciation of Field information - Part-1

In the last lecture, we have looked at the direct information provided by various experimental techniques.

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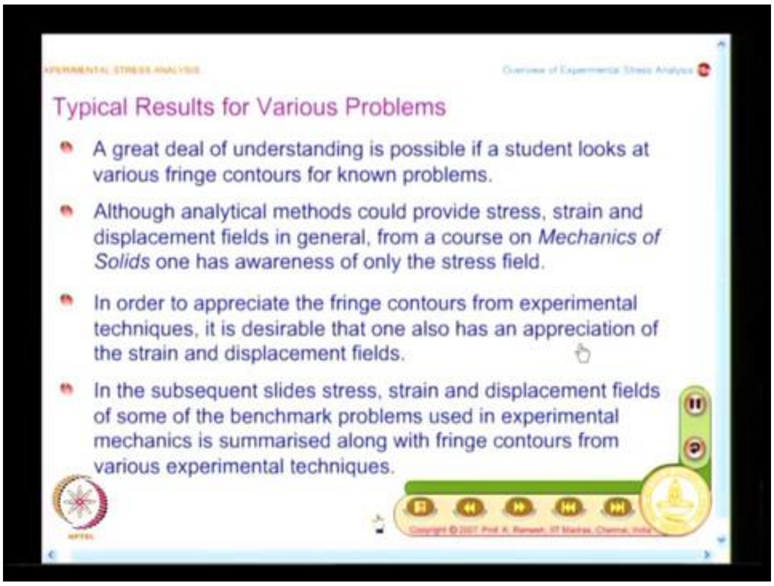

What we are going to now focus upon is there is a fundamental difference. See, when you do a course in strength of materials you find out what is stress and your focus is essentially based on stress at a point. Rarely you come across, how does this stress vary from point to point and you have ever had an opportunity in a first level course to even plot how the variation is in and look like because you are concentrating more on stress at a point, at best you would have done a Moiré Circle where, you find out as a function of orientation. How does this stress component vary at a point of interest?

On the other hand, if people are using numerical technique you have very many post processors that have been developed, which actually display the result in a form where a human being can react. If you see red color, you find it is more. So, there is a danger signal you have to do some correction about it. So, only when you had come to numerical technique and with post processors, you have been able to see those and that happen some where an eighty's you can say.

Though computers are developed in nineteen sixty's the post processors developed for a plotting results became user friendly and became easily available only in nineteen eighty's, but if you look at an experimental technique they have always been giving only hole field information. They were not giving point by point most of the optical techniques give all these information. So, as an experimentalist, when you want to go and look at you need you get sensitized how to react to this optical patterns.

For example, you go to a doctor and then he finds out your temperature. He finds it is a 105, he will react immediately that you have a very high temperature. Even as an individual you should know that, you should react, you should take some ices and put some cold bath and remove the temperature. He should not go to the encyclopedia of medicine and then find out what does 105 degree means then you will never go to the doctor.

So, numbers are very important in engineering and you should react to that. So, similarly when you come to optical techniques you should react to when you see, high density fringes you should get and understanding that there is something wrong. I mean such levels are very high and you should also develop certain affinity towards how these patterns develop. How they are distributed? What kind of qualitative information you can get out of it? So, the idea here is although analytical methods could provide stress, strain and displacement fields in general. From a course on mechanics of solids, one has awareness of only the stress field this is another point which I would like to mention.

We have said that you want stress components, strain components and displacement components you go back and look at your notes in strength of materials. Except deflection of beams you would have only worried about stress information everywhere. So, you learnt in a first level course only those pertain an information which is required for you to apply in normal simple problems where, you come across in an around you.

Only when you go to advanced level of studies, where you would like to make certain decisions based on strain or based on displacement then you look for how to get all these information.

Though you are solve all this problems you may not have the solution of stress the strain field or the displacement field. Because I have already pointed out that experimental methods do not give only stress. See, if you go to strength of materials, you find out by force balance and equilibrium condition you find out only stress. If you go theory of elasticity, you have stress formulation. So, you first find stress. By the time you find out the stress you are tired you do not want to look at strain and displacement. If you go to finite elements, essentially there are methods which you stress, but essentially it is a displacement base, initially you find out displacement. Then your software itself converts or displacement into strain and also converts this as stress and with modern post processors it also shows the variation like what you seen in an experimental technique dynamically.

So, what you need is, when you want to have appreciation of experimental technique, for simple problems you also need to know, stress field strain field and displacement fields. So, you become sensitive to appreciating field information, rather than point information. See while developing stresses the tensor you need to know, how does it changes from plane to plane. If you take a point how does it change from plane to plane is very, very important. So, from that that was the focus. And you know a rudimentary knowledge that is stress concentration, you do not go beyond that, but once you come to experimental technique you need to have this appreciation and I want you to be good engineers and not refer reference books for simple things.

So, what we are going to look at is we are going to look at in the subsequent slides; stress as well as strain and displacement information for some of the benchmark problems. Because it is always better you go from known to the unknown you have already done some of these problems in your course in strength of materials and look at again those problems with a different perspective. See what all you have got and how the contours will look like. So, this will also indirectly say, that whatever the contours I have seen in an experiment by pattern matching you can say that, yes I have if I plot sigma 1 minus sigma 2 it looks this and I see the same thing there. So, this should be sigma 1 minus sigma 2.

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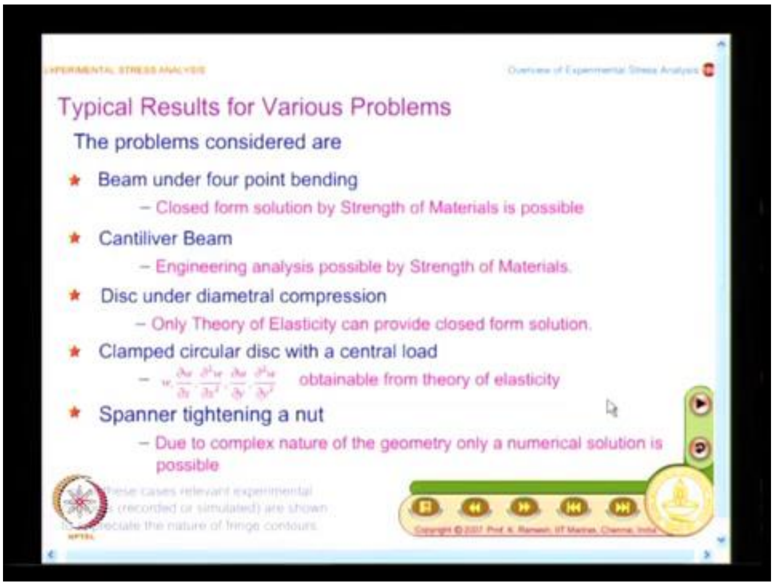

I can go and I have taken in all five problems, and they are also done with graded level of complexity. So, one of the simplest problem which I have taken is a Beam under four point bending. That is a first problem to start with and why I have taken this is you have close from solution by strength of materials. So, that is what you have done in a course in strength of materials.

So, you know completely the story of beam, leaving the points of loading regions away from it you know what happens in beam. I am sure you would have just looked at stress field I do not think you might have looked at a strain field or displacement field. We would see all that. Then the next problem is Cantiliver Beam. Why I have taken this is see, in a cantiliver though you apply flexure formula and so on. You actually have shear which makes the plane do not remain plane before and after loading because shear effects and bending effects are not coupled, still the solution strength of material is valid and that is why good books term this as engineering analysis of beam there is a subtle different between analysis of beams, where you say mathematically correct engineering analysis and understand engineering means approximation.

We cannot do engineering without approximation and you do that right at cantiliver beam. You know you have done cantiliver beam, Simply supported beam, Clamp prepared beam all those problems except Beam under four point bending they are all only engineering analysis. So, you make approximation. The next problem is Disc under diametral compression see what you have is this is what we had see in the last class I have a shape like this, when I have the bar when I pull it strength of material is good. The moment I put a hole I cannot do by strength of material.

Suppose, I change the shape to a circle and I put compression and this is the most celebrated model that you use in a photoelasticity. You do not have a solution from strength of materials, but you can definitely find out a close formed solution from theory of elasticity I can use (Refer Time: 09:12) solution and get the stress field at every point in the model. Every point in the model I can find out. I can find out at every point in the model. This solution is also very important for you to note it down. Then I will have clamped circular disc with a central load and I will show this a little bigger and what you have here is.

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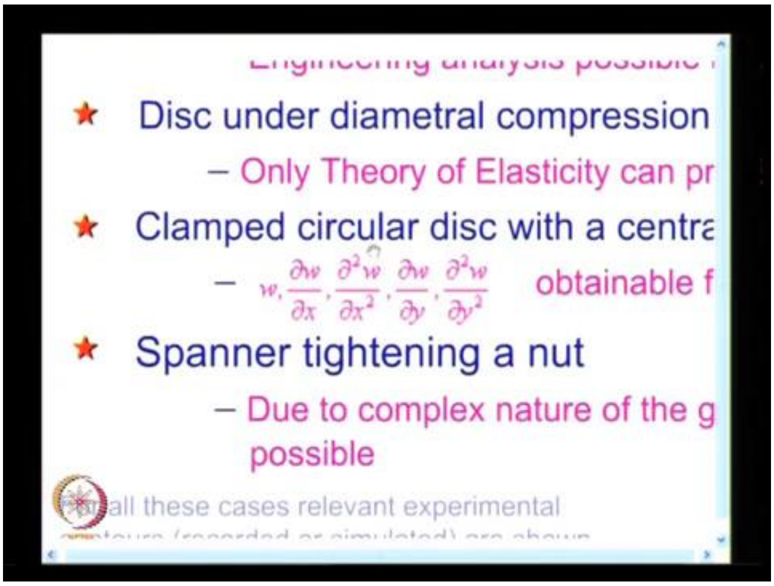

I can find out w that is out of plane displacement, dou w by dou x is slope, dou square w dou x square is curvature, similarly I have curvature in the other direction dou w by dou y and dou square w by dou y square. Because this is a standard benchmark problem when you want to go and establish techniques to measure out of plane displacement.

And for this also you can get the solution, available from theory of elasticity possible to find out solutions and finally, we come back where the celebrated problems spanner tightening a nut and due to complex nature of the geometry only a numerical solution is possible. Experimental solution is always possible for all this problems, understand this. Analytical problems gives you conceptual understanding, if you are able to solve it analytically they are the best, but the reality is beyond certain simple geometry and simple learning conditions analytical methods are not possible to attack all problems on hand, numerical method solve it approximately.

When you go to experimental methods it gives you truth. If my numerical method does not match with the experiment I should go and find out, have I applied the boundary condition correctly. If my analytical method does not match with experiment, then I should go and verify whether the analytical method has made certain approximation and you have to refine that approximation. So, finally, experimental methods are the truth, it provides you truth.

So, you have to judge the other techniques based on experiment methods alone. And for all this cases relevant experimental contours also will have a look at it. So, the idea is to get yourself sensitized on appreciating whole field visual information. I want you to react. See as towards the end of the course we will see the necessary optical arrangement, we will also mathematically develop how these contours are. All those development we will do, but this knowledge will become reinforce even to start with for simple problems how this contours look like. That gives you certain level of familiarity and also makes you comfortable for you to go and involve in yourself in the experimental technique. And in then subsequent classes, we will see for simple problems to start with what each experimental technique will give. Not only this, we will also look at the stress field, strain field as well as displacement field.

In this lecture, we have discussed a graded list of problems of different complexity which serve as bench mark problems in solid mechanics.