Preliminary Research on Stress Pattern Analysis

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April 14, 2004

During Week 1, I researched some mathematical theory behind analyzing stress patterns (ISOCLINIC, stress patterns along the physical directions of stress, and ISOCHROMATIC, patterns from same wavelength light). Specifically, from [1], I learned about how the intensity of light $I$ which emerge from the analyzer is a function of the properties of the light (its amplitude) and the strain in the specimen...

Below is a list of new concerns that I have, now that I have a better grasp of what was being said:

1. It seems that our specimen needs to be a BIREFRIENGENT material. (Otherwise, how do we account for multiple extraordinary rays.) Else, I need to do further research on the derivation of the Eqn., which seems to stem from Maxwell’s Optic Laws.

2. Specifically, the equation they give is: $I = Asin^2(2\theta)sin^2(\alpha/2)$. I’m confused by this equation because it seems clear that a ray of light goes through a birefringent material at some given point, at which the ray is broken up into two separate components which go off into two different directions. Thus, is $I$ the intensity of the ordinary ray? I wonder if someone could help me out here...

3. Anyway, assuming that the equation given only analyzes the intensity per given point in space, it seems that we would need a LASER light source to analyze data at a given point. Else, we could consider how the light intensities at every point is a superpositioning of its corresponding ordinary ray and perhaps extraordinary rays from other points. This seems to be a fairly ugly problem even if the birefringence in the material can be described in some smooth mathematical equation. (Or at least, so it seems to me at 2:am on a night following little sleep.)

By doing some google searches on ”photoelasticity and phase shifting,” I came across [2], written by the same people who are referenced in [1]. In this paper, they outline a procedure in which they are able to separate the ISOCLINIC and ISOCHROMATIC fringes. The main approach they have is (1) use circular (as opposed to linear) polarizers (which means that the equations they have are different), (2) obtain data from three different loads (on notched specimens) and rotate the analyzer, and (3) solve a system of equations.

The paper lists from prior rearch which has been done:
1. W/ lighter loads + a different algorithm to analyze the data, OR

2. W/ three different wavelengths as opposed to three different loads.

I have yet to figure out how the equations were derived and even what some of their symbols stand for (for example \( I_b \) and \( I_m \)). Currently, my thoughts are (1) email the author of the paper, (2) look through the earlier papers on the subject (which may explain more of the terms), and (3) e-mail/contact Prof. Wierzbicki’s grad students on how they analyze stresses.

Finally, I found that using Matlab to analyze digitized pictures and their intensities per pixel can trivially be done using Matlab [3]. Specifically, we can do the following:

1. Convert a digital picture to a .gif.

2. Import to Matlab using the following command:
   
   `>> [x,map] = gifread('filename.gif');` (x is a intensity matrix and map is RBG matrices)

3. Do the mathematical calculations on x. Let the output matrix be \( x' \).

4. Export from Matlab using the following command:
   
   `>> gifwrite(x’, map, 'filename2.gif');`

5. Open filename2.gif, using any image viewer. Neat, huh?

References

