Four Point Bending Experiment
Experimental Stress Analysis

Submitted as Part of Course Requirement of Experimental Stress Analysis Course

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1 Four Point Bending Experment

The four-point bending flexural test provides values for the modulus of elasticity in bending E_f, flexural stress σ_f, flexural strain ε_f and the flexural stress-strain response of the material. This test is very similar to the three-point bending flexural test. The major difference being that the addition of a fourth bearing brings a much larger portion of the beam to the maximum stress, as opposed to only the material right under the central bearing.

This difference is of prime importance when studying brittle materials, where the number and severity of flaws exposed to the maximum stress is directly related to the flexural strength and crack initiation. It is one of the most widely used apparatus to characterize fatigue and flexural stiffness of asphalt mixtures.

Now We are going to Measure this using photo elastic Technique For Measuring stresses.

1.1 Photo Elasticity

Photo-elasticity is a visual technique for measuring stresses. When a photo elastic material is strained and viewed under polarized light, beautifully colored pattern can be observed. This colored pattern provides information on stress-state of the strained material.

1.1.1 Plane Polariscope

It consists of two linear polarizer (which transmit light only along their axis of polarization) and a light source. The linear polarizer nearest the light source is called the polarizer, while the second linear polarizer is known as the analyzer.

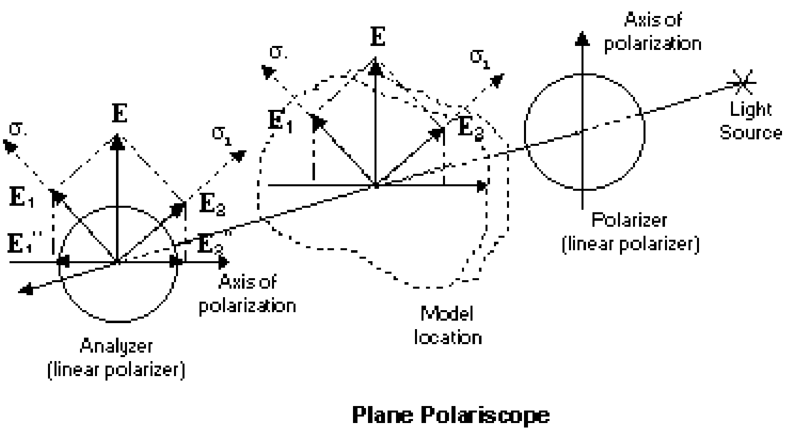

Figure 1: Plane Polariscope

1.1.2 Circular Polariscope

This polariscope employs circularly polarized light. The photo elastic apparatus contains four optical elements and a light source.

1.1.3 Experimental Setup

The Fourpoint Bending Specimen Experimental setup is As follows.The straight beam is subjected to tranverse loading.The beam is supported at two ends and downward load is applied at the two points shown in figure

- Light source emits light waves vibrating in infinite number of planes.
- Polarization Filter (Polarizer): Polarizer restricts the vibration of light waves to a single plane.

Analyzer : Second polarizer used to analyze polarized light passed through material in testing. Doubly refracting lights which passed through the birefringent are resolved by analyzer. Speed difference in the refracting lights causes that a certain color from the light disappears (wave shift).

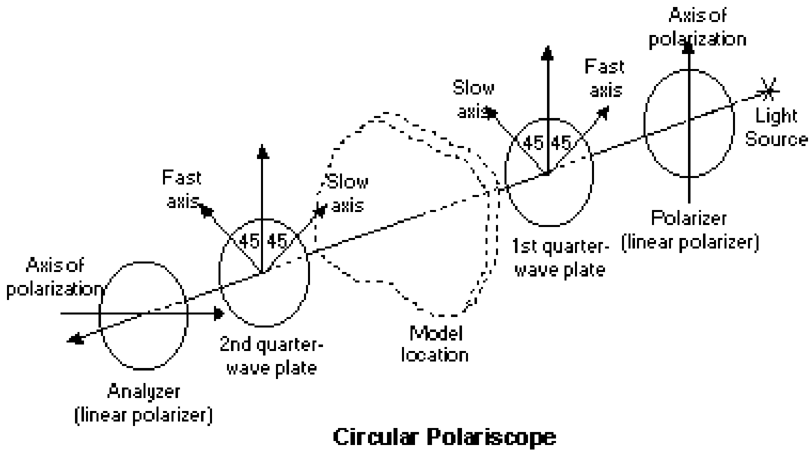

Figure 2: Circular Polariscope

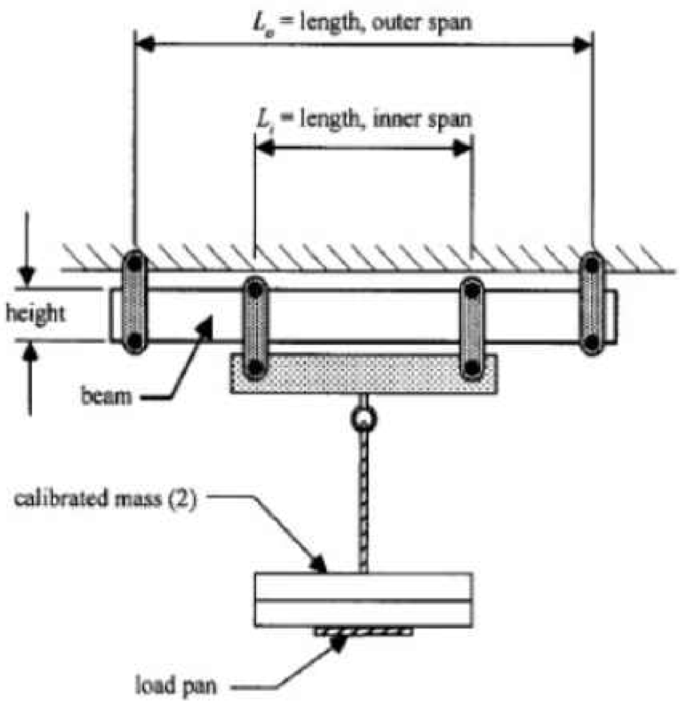

Figure 3: Specimen Setup

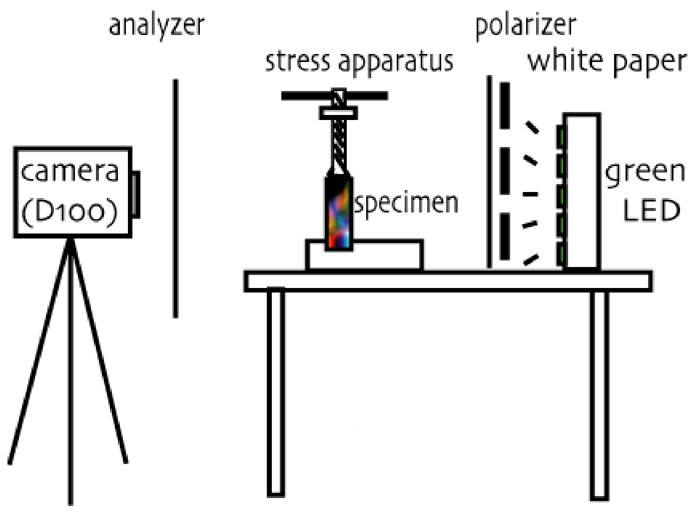

Figure 4: Experiment Setup

Steps To Determine Stress

When stressed, some transparent materials behave as bifringent material. The speeds of the refracted lights are directly proportional to the principal stresses σ_1 and σ_2, major and minor principal stresses, respectively.

Interpretation of 2-D photoelastic fringe patterns is based on the stress-optic law:

$$\sigma_1 - \sigma_2 = \frac{N \times F\sigma}{b} \tag{1}$$

Where b is thickness of photo elastic model.

Now In the Presenst Experiment in the middle sextion we have

$$\sigma_1 = \sigma_x = \frac{My}{I} = \frac{F_s(L_o - L_i)y}{4I} \tag{2}$$

$$\sigma_2 = \sigma_y = 0 \tag{3}$$

$$\sigma_1 - \sigma_2 = \frac{N \times F\sigma}{b} \tag{4}$$

Now From the Above we van write that

$$Z = (f_\sigma)N \tag{5}$$

$$Z = \frac{F_s(L_o - L_i)y}{4I} b \tag{6}$$

f_σ canber determined by plotting the qunatitiy Z versus the fringe order, N.

Now Some Examples of the Results will look like following

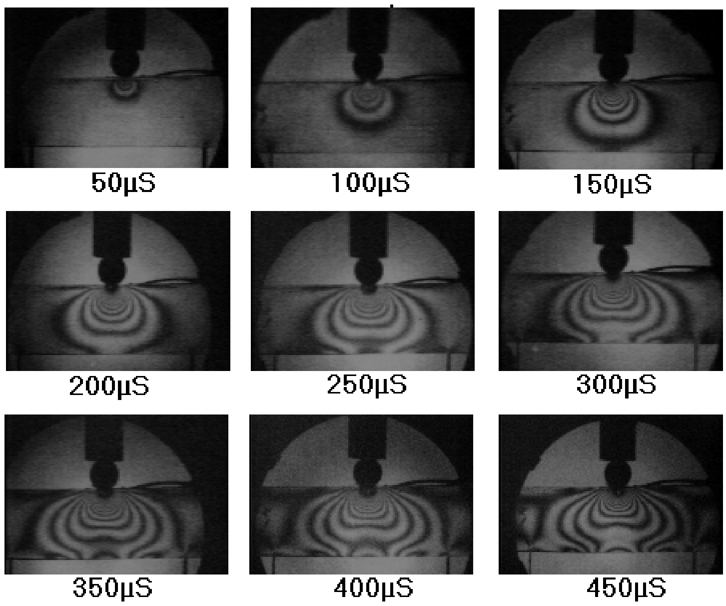

Figure 5: 2D Photo Elastic Fringes under Mono chromatic light

1.2 Analytical Approach

Now we can Derive the Stress Analytically. Now For the Four Point Bending Shear and the Moment Diagrams are as follows in the Differenct sections of the Axis.

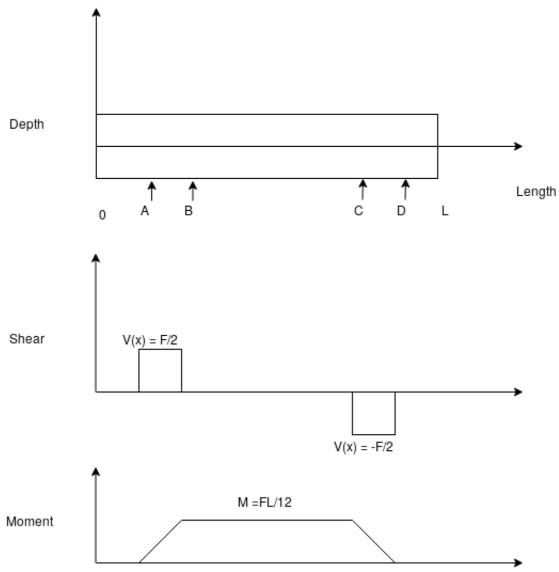

Figure 6: Moment and Shear Diagrams of Four point Bending

In the Mid section There will be no shear stress and there only exist the bending moment

$$\sigma_{max} = \pm \frac{FL}{2Bh^2} \tag{7}$$

1.3 Finite Element Anaysis