Experimental Stress Analysis

Assignment # 5

Photoelastic Coatings

1. Why the use of strain-optic law is desirable in photoelastic coating analysis?

2. List the engineering approximations made in the data acquisition and interpretation of photoelastic coatings.

3. Why are correction factors needed in interpreting the result of photoelastic coatings? Discuss your reasoning with the help of two examples.

   How would you handle regions of stress concentration?

4. It is proposed to conduct a photoelastic coating test of an aircraft landing gear. One of the first steps in a photoelastic coating test is to determine the strain coefficient K of the coating. Displacement controlled cantilever beam is an ideal model for calibration. The cantilever beam (thickness 5 mm, width 25 mm and length 250 mm) is of the same aluminium alloy (E_s = 71 GPa; ν_s = 0.33) as that of the landing gear.

   A small strip of photoelastic coating material (E_c = 2600 MPa; ν_c = 0.38) of thickness 3 mm is bonded onto the Aluminium alloy cantilever specimen. The model is illuminated with white light and the fringe orders obtained at a section 50 mm from the fixed end is as follows:

Displacement, mm	1	2	3	4	5	6
Fringe order, N	0.3	0.5	0.8	1	1.3	1.6

   Determine the strain-optic coefficient K.

   Instead of white light (577 nm) if the experiment is conducted with Sodium Vapour lamp (589.3 nm) what modifications need to be done for data interpretation?

5. Can you find the region of yielding in the test specimen from the interpretation of the fringe patterns? If so mark the line demarcating the elastic and plastic region approximately.

6. It is proposed to find the stress concentration factor of a finite plate with a hole subjected to uniaxial tension. As experimentalists, one needs to anticipate what could be the trend of the result. From your knowledge of Strength of materials can you guess what way the result will be?

   A photoelastic coating test performed on an Aluminium specimen (E_s = 71 GPa; ν_s = 0.33) with a PS-1 photoelastic coating (E_c = 2.5 GPa and ν_c = 0.38) revealed a maximum fringe order of N_{max} = 4.5 and the far-field fringe order is found to be $N_{far\text{-}field}$ = 1.2 Determine the stress concentration factor.

   If the test has been done directly on the photoelastic coating, what is the ratio of fringe orders you should have observed?

7. Correction factors are important in data interpretation of photoelastic coatings. They are the functions of the loading, thickness ratios and also depend on the elastic properties of the coating and the specimen materials. Consider that the specimen material is an aluminium alloy (E_s = 71 GPa; ν_s = 0.33, h_s = 8 mm) and the coating is the PS-1 material (E_c = 2.5 GPa and ν_c = 0.38, h_c = 3 mm).

   Determine the correction factors for various types of loading situations such as (i) Plane stress, (ii) Beam of 25 mm thickness (iii) Bending of plate (iv) Torsion – assume a tube of 75 mm inner dia (v) Pressure piping of 30 mm inner dia.
