

Experimental Stress Analysis

Question Bank

UNIT - 1

Introduction: Mechanical, Optical, Pneumatic, Acoustic strain gauges. Electrical Resistance Strain Gauges – Gauge factor, types, properties of an ideal gauge material, backing material, adhesive material, protective coating; Method of bonding strain gauges, strain gauges lead wire and connections, semiconductor strain gauges problems.

1. Explain the procedure involved in the bonding of an electrical resistance strain gauge on to the surface of machinery.
2. Sketch and explain the principle and operation of mechanical-optical extensometer.
3. Explain the various factors affecting the performance of foil strain gauges
4. Sketch and explain principle and operation of an optical strain gauge. Name few strain gauges.
5. Derive an expression for the gauge factor of an electric resistance strain gauge.
6. Briefly discuss the various types of strain gauges and their application
7. Derive the expression for strain sensitivity and discuss the factors affecting the sensitivity.
8. Discuss briefly the properties of an ideal gauge material
9. Explain the procedure involved in Bonding of strain gauge
10. Sketch and explain pneumatic strain gauge for single pressure output.
11. State the functions of backing materials
12. State the factors to be considered while selecting strain gauges.
13. State the factors to be considered in choosing an adhesive
14. Classify the strain gauges and explain with a neat sketch the working of a Marten's Optical gauge.
15. Classify the strain gauges and explain with a neat sketch 'TUCKERMAN' Optical gauge
16. Write short notes on
 - a. Strain gauge materials
 - b. Various types of strain gauges
 - c. Semiconductor Strain gauge
 - d. Strain gauges lead wire and connections
 - e. Electrical strain gauges
 - f. Unbounded Gauges
 - g. Bonded gauges
 - h. Weldable gauges
 - i. Piezoresistive gauges

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UNIT - 2

Strain gauge Circuits, Wheatstone's bridge, Error due to input impedance of measuring instrument, temperature compensation, multiple gauge circuits, calibration of strain measuring system, loadcells, problems.

1. Describe the potentiometer circuit used for strain measurement and derive the expressions for sensitivity of the circuit.
2. Explain two methods of achieving temperature compensation in measurement of strain.
3. Explain with sketches, design of a torque transducer using strain gauges and strain gauge circuitry. Also show the location of strain gauges on the shaft and discuss methods of calibration.
4. Define and explain in brief wheat stone bridge sensitivity.
5. Sketch and explain the method of calibration of strain measuring system.
6. Show that the no load potential in a four armed wheatstone's bridge for measurement of strain is reduced by a factor $\frac{1}{1 + (R_B/R_L)}$ Where R_b & R_L are Bridge and Load Resistance respectively.
7. Explain with neat sketches construction of a load cell for measurement of torque giving location of four strain gauges and strain gauge circuiting, using four-arm Wheatstone bridge.
8. Explain multiple gauge circuits w.r.t the wheatstone bridge for measurement of strain

UNIT - 3

Strain Gauge Rosettes: Necessity, analysis, problems.

1. Define a Strain rosette and mention the different types of strain rosette configurations
2. Explain the construction of the three elements Delta rosette and derive the expressions for the principal stresses and their orientations in terms of strain measurement readings.
3. Explain the construction of the three elements rectangular rosette and derive the expressions for the principal stresses and their orientations in terms of strain measurement readings.
4. A rectangular strain gauge rosette is bonded at a critical point onto the surface of a structural member. When the structural member is loaded, the strain gauges show the following reading:

$$\epsilon_0 = 850 \mu\text{m/m}, \epsilon_{45} = -50 \mu\text{m/m}, \epsilon_{90} = -850 \mu\text{m/m}$$

The gauge factor and cross sensitivity of the gauges are 2.80 and 0.06 respectively. Find:

- Actual strains
- Magnitude and directions of principal strains.
- The error if indicated strains ϵ_0 , ϵ_{45} , ϵ_{90} are used to calculate the principal stresses.

Given $E = 200\text{GPa}$ and Poisson's ratio of the material of the strain gauge is 0.285.

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5. The observations made with a delta rosette mounted on a steel specimen are $\epsilon_A=400\mu\text{m/m}$; $\epsilon_B=-200\mu\text{m/m}$; $\epsilon_C=200\mu\text{m/m}$. Determine the principal strains & principal stresses & the principal angles ϕ_1 & ϕ_2 .
6. The following observations were made with a delta rosette mounted on a steel specimen
 $\epsilon_A = 460 \mu\text{m/m}$; $\epsilon_B = -200 \mu\text{m/m}$; $\epsilon_C = 200 \mu\text{m/m}$
Determine the principal strain, the principal stresses and their orientations. Take $\mu = 0.3$, $E = 200 \times 10^3 \text{ N/m}^2$.
7. The following readings of strain were obtained on a three-element rectangular strain rosette mounted on a Aluminum for which $E=70\text{GPa}$, $\nu = 0.3$, $\epsilon_a = +285 \mu$ strains $\epsilon_B = +65 \mu$ strains $\epsilon_C = 102 \mu$ strains
Determine:
i. The Principal stresses and its direction
ii. The Principal strains and its direction
iii. The maximum shear stress
8. Three strain gauges are applied to an area; at a point in such a manner that gauge “B” makes a +ve 30° with the gauge “A” and gauge “C” makes an angle of 45° with gauge “B”. The strains obtained are as follows.
 $\epsilon_A = -600 \mu\text{m/m}$, $\epsilon_B = -400 \mu\text{m/m}$, $\epsilon_C = 400 \mu\text{m/m}$
Take $E = 2 \times 10^5 \text{ N/mm}^2$ & Poisson’s ratio $\mu = 0.3$. Calculate principal stresses, strains and their directions.
9. A rectangular rosette mounted on the surface of a structural member indicates the following reading, when the member is stressed $\epsilon_0 = +500$ strains $\epsilon_{45} = +50$ strains $\epsilon_{90} = -500$ strains. Modulus of elasticity (E)= $200 \times 10^9 \text{ N/m}^2$, Poisson’s ratio (μ)= 0.30. Gauge factor and cross sensitivity of the strain gauge are 2.80 and 0.06 respectively.
Determine:
i. Actual strains along 0° , 45° , 90° directions.
ii. Principal strains and maximum shear strain.
iii. Principal stresses and maximum shear stress.
iv. Directions of principal stress.

UNIT - 4

Nature of Light: Harmonic wave, phase, amplitude, polarization. Crystal optics: Passage of light through crystalline media, absolute and relative phase difference, quarter wave plate, half wave plate, production of plane polarized light and circularly polarized light.

1. Explain and classify the polarization of light.
2. Explain polarization and the working principle of a polariscope
3. Differentiate between relative and absolute phase difference and derive the necessary expressions
4. What are the various methods of production of plane polarized light. Explain atleast two methods in detail
5. Explain the importance of passage of light through crystalline medium.
6. Write a short note on Waveplates

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UNIT - 5

Two-dimensional photo elasticity: stress optic law, plane polariscope, isochromatics and isoclinics, circular polariscope, dark and bright fields arrangements, isoclinic and isochromatic fringe order at a point, methods of compensation, separation technique.

1. Define
 - a. Isoclinic
 - b. Isochromatics
 - c. Plane polarized light
 - d. Circularity polarized light
 - e. Material fringe value
2. Derive stress optic law used in Photoelasticity and state the significance of each term involved.
3. Describe how you would make a circular polariscope, identify all its components and derive an expression for the intensity of the light wave in a dark field arrangement.

or

Under plane stress conditions, explain the arrangement for a circular polariscope for dark field arrangement

4. Describe two simple compensation techniques to determine fractional fringe order at a point in a stressed model.
5. Explain the formation of iso-chromatic fringe pattern for a stressed model in a circular polariscope
6. Mention any four methods of separating principal stresses in experimental stress analysis. Explain the method of oblique incidence in detail
7. Derive the expression for the intensity of light emerging out in a plane-polariscope.
8. Derive the expression for the intensity of light emerging out in a circular polariscope.

or

Obtain an expression for intensity of the light in a circular polariscope and show that isoclinics are eliminated.

9. Enumerate an experimental procedure for determination of fractional fringe order in two dimensional photoelasticity and derive an expression for fractional fringe order.
10. Explain the shear-difference method for separation of principal stresses in a 2-D photoelasticity
11. Give a physical interpretation of formation of isochromatics and isoclinics in a plane polariscope interposed with a two-dimensional photo elastic model in a plane stress condition.
12. Show how “Tardy’s” method of compensation is used to measure fractional fringe order & derive suitable expression for fractional fringe order.
13. Describe oblique incidence method of separation of stresses in two dimensional photoelasticity.
14. Write short notes on
 - a. Isoclinics & isochromatics
 - b. Scattered light polariscope.
15. Sketch and explain a scattered light polariscope.

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UNIT - 6

Photo Elastic Analysis: Calibration of photo elastic model material, properties of ideal photo elastic material, casting of photo elastic models, machining, stress relieving, scaling model prototype relation, two dimensional application, problems.

1. What are the various methods of calibration of a photoelastic model material? Explain any one method
2. Explain a method of calibration of photo elastic model material using circular disk under diametral compression.
3. Explain the procedure for casting a photoelastic model of a plate
4. List out desirable properties of a photoelastic model material
5. What will be relative angular retardation Δ in a quarter-wave plate designed for operation at $\lambda=546.1\text{nm}$ if it is employed with sodium light where $\lambda=589.3\text{ nm}$.
6. A fringe order of 2.5 was observed at a point in a stressed model with light having $\lambda=589\text{nm}$. What fringe order is observed at the point in consideration when light with $\lambda=548\text{nm}$ is used.
7. The material fringe constant is tension for a given photoelastic model is 18KN/m when calibrated with sodium ($\lambda=589.3\text{nm}$). the model has a thickness of 6mm . if the model is observed with mercury light ($\lambda=548.1\text{nm}$) & the stress ($\sigma_1 - \sigma_2$) at a point is 18KPa , what fringe order will be observed? Assume C is independent of λ
8. Explain with a neat sketch the calibration procedure using tensile photo elastic model.
9. Enumerate the properties of photo elastic material & discuss in brief
10. The fringe order observed at a point in a stressed model is 3.45 with mercury light of $\lambda=548.1\text{nm}$. the value of material fringe constant in tension is 20KN/m . if the model has a thickness of 6mm and if a sodium light of $\lambda=589.3\text{nm}$ is used, calculate
 - a. The maximum shear stress at the point
 - b. Fringe order observed assuming C is independent of λ
11. A tensile photo elastic model Cr-29 of 8mm thick produces an isochromatic fringe order 6 at a point. Compute the maximum shear stress developed, take the material fringe value $f_0= 17.5\text{ N/mm}^2/\text{fringe}$ and also calculate the maximum number of fringes that can be produced if the breaking stress is 60 N/mm^2 .
12. The maximum shear stress at a point in a model of 5mm thick is 9MPa . The fringe order observed is 4.5 when observed with sodium light. Another model made of the same material and having a thickness of 7mm is subjected to a plane state of stress observations of this model under mercury light reveals that the fringe order is 5. Find σ_1 & σ_2 if $\sigma_1= 2\sigma_2$
13. A circular disc of diameter $D = 40\text{mm}$ and thickness $t = 5\text{mm}$ compressed diametrically is used as a calibration specimen in photoelastic test. The fringe orders at the disc centre and corresponding loads are:

Load P	25	48	73	124
Fringe order (N)	1	2	3	5

Find the model and material fringe values. The principal stresses at the disc centre are given by, $\sigma_1= 2P/ \pi Dt$ & $\sigma_2 = -6P/ \pi Dt$

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UNIT - 7

Bifringent Coating: Theory, photo elastic data for stress analysis, reflection polariscope. Moire techniques: Phenomenon, moiré fringe analysis, geometric approach, displacement approach, moiré techniques for inplane problems, sign and order of fringes, problems of moiré gratings, moiré fringe photograph.

1. Write short notes on Birefringent coating materials
2. Derive an expression for the principal stress difference at a point on the surface of a machine component in terms of photoelastic data obtained from bifringent coating and material parameters.
3. Explain the mechanism of formation of Moire-fringes and establish the relation for the strain measurement
4. Explain the birefringent coating method and derive the expression for stresses and strains in the specimen in terms of fringe order, material fringe value & coating thickness
5. Derive an expression for the angle of rotation of a specimen grating with respect to a master grating in terms of pitch of grating, interfringe spacing and the angle of the moire fringes and x-axis
6. Enumerate an experimental procedure with sketches to determine the sign and order of moire fringes.
7. Sketch and explain the working of a reflection polariscope.
8. Explain with a neat sketch, the different types of crack patterns in brittle coating.
9. A moire grating of pitch p is rotated by an angle of θ with reference to a master grating of pitch p and distance between Moire fringe along the X-axis measured to be δ_{xx} . Show that $\theta = \sin^{-1} (p/\delta_{xx})$
10. Explain the set up for out of plane displacement using Moire technique.

UNIT - 8

Introduction to holography. Introduction to brittle coating technique. Introduction to computer techniques and fringe analysis.

1. Explain brittle coating techniques with sketches for strain analysis.
(or)
Explain the principle of brittle coating technique and enumerate the advantages and disadvantages.
2. Explain the principle of holography and its application for stress analysis
3. Explain the spatial coherence with the reference to interferometer holography
4. Write short notes on Brittle coating materials & enumerate the properties of a good Brittle coating material
5. Explain with sketches recordings and reconstruction process in holography
6. Explain with sketches the principal of measurement of strain at a point on the surface of loaded machine element from the brittle coating technique.