Course Outline

Title: Experimental Stress Analysis

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Department: Mechanical Engineering Dep.

Prerequisite: no prerequisite

Overview

Experimental Stress Analysis is the analysis of the mechanical stress state in materials, which is performed through experiments using strain gauge measurements. Learn the existing types of stress, their origin and states, or how to determine stress from measured strains by reading about it below.
Experimental stress analysis is a three-unit theoretical course and is part of the main courses of the master's and PhD courses of the mechanical engineering department. In this lesson, besides presenting analytical relationships for determining the stress and strain, experimental methods of measurement and points around it are discussed.

Goal

The course covers the basic aspects of experimental stress analysis that includes strain gauge and photoelasticity and also a brief introduction to the emerging techniques like Digital Image Correlation (DIC). In addition it also provides the fundamental aspects of different experimental techniques such as Geometric and Interferometric Moiré and Holographic interferometry. It also covers new experimental stress analysis applications such as measurement of residual stress and its applications in new materials (Composites, MEMS, …).

Objectives

After completion of this course, students shall be able to
(a) Understand the different experimental techniques for stress analysis,
(b) Select a suitable method for experimental determination of service stresses for a problem on hand.
(c) Interpret the results obtained from different experimental methods.
(d) Understand the concept of residual stresses and understand different experimental techniques for its analysis.

Materials

Week	Subject	Table of Contents
1	Introduction	Introduction, Overview of experimental stress analysis, Physical principle behind various experimental techniques, Brief introduction of experimental stress analysis methods (Strain gauge, Photoelasticity, Moiré, Holography, etc.) and

		new applications (Residual stress, Composites, …)
2	Theory of experimental stress analysis	Basic concepts of elasticity, Concepts of stress and strain, General equations of elasticity, Stress-strain relationships, Principal stresses, Principal strains, Mohr's circle.
3	Strain gauges: Theory	Principles of operation of strain gauges, Gauge configuration, Materials and methods of joining strain gauges, Gauge factor and Transverse sensitivity correction, Environment effects, Manufacture and application of strain gauges, Strain Gauge Alloys, Carriers and Adhesives.
4	Strain gauges: Circuitry, Transducers and Data analysis	Introduction, Wheatstone bridge, Quarter bridge, Half bridge, Full bridge, Correction for long lead wire, Strain gauge transducers, Strain gauge rosette data analysis and correction, Correction for Wheatstone bridge nonlinearity, Temperature Compensation, Two wire and Three-wire Circuits, Criteria and recommendations for strain gage selections, Class experiment.
5	Photoelasticity	Theory of photoelasticity, Nature of light, Polarization of light, Wave plane and photoelasticity principle, Analysis of a stressed plate in a plane and circular polariscope, Tardy method, Calibration of photoelasticity method, Separation of principal stresses, Class experiment.
6	Photoelastic coating method	Introduction, Reflective polariscope, Basic principles of photoelastic coating applications, Strain-light or stress optic law for coatings, Calibration of photoelastic coating, main strain isolation methods: oblique incident method and strain gauge separation method, Coating sensitivity selection.
7	Moiré's geometric method	Fundamental property of Moiré , Geometric method of Moiré fringe analysis in two dimensions, Displacement method of Moiré fringe analysis in two dimensions, Instrumentation, Out-of-plane displacement measurements, Out-of-plane slope measurement.
8	Moiré interferometric method	Principles of Moiré interferometric method, sample grid, optical systems, Moiré interferometric equations, strip counting and strain analysis, insensitivity to out-of-plane deformation, applications of Moiré method in mechanical, thermal loading, etc., equipment and characteristics of Moiré interferometer, application of interference Sampling in the microelectronics industry.
9	Holographic interferometry	Introduction, History of holography, Interference and Diffraction, Wavefront recording and Reconstruction by holography, Displacement measurement by holographic interferometry, real-time holographic interference, vibration analysis using time average holography, equipment and

		main methods in creating holograms, Comparative holographic interferometry.
10	Digital Image Correlation (DIC)	Introduction, Operating Principle of 2D Image Correlation, Typical Arrangement of a DIC System, Case Study, Class experiment.
11	Residual stress measurements	Residual stress measurement, Experimental methods for assessing residual stresses: Incremental Centre-Hole Drilling, Neutron Diffraction, Contour, Ring Core, Sachs Boring, Slitting, Synchrotron Diffraction, Ultrasound, X-ray Diffraction, Technique selection.
12	Special topics: principles and applications	- Experimental analysis of stress in Composites - Experimental analysis of stress in Fracture mechanics - Experimental stress analysis of MEMS/NEMS systems - Experimental stress analysis in Biomechanics

References

1. Sharpe, W. N. (2008). Springer handbook of experimental solid mechanics, Springer Science & Business Media.
2. Khan, A. S. and X. Wang (2001). Strain Measurements and Stress Analysis, Prentice Hall.
3. Doyle, J. F. (2004). Modern experimental stress analysis: completing the solution of partially specified problems, John Wiley & Sons.

Classroom Methods (policies)

- Attending the classroom on time
- Delivery of all assignments (three series of assignments: selected questions of chapters 2 and 3 / use of strain gauges / selected questions of chapters 4, 5, and 6)
- Presentation of the project in class
- Attending practice, quiz, mid-term and final exam, end-of-semester meetings.

Course Assessment

- Activity in class — 2 Marks
- Class exercises and quizzes — 3 Marks
- Mid-Term exam (subject of strain gauges) — 4 marks
- Literature search report and presentation — 4 marks
- Final exam (other subjects) — 7 marks

Project

According to the suggested subjects in the classroom, each student is required to register his subject by choosing one of the subjects based on the following steps.

1-Determining the subject by sending an email (name and surname, supervisor and subject of the MSC/PhD project and the proposed subject of the experimental stress analysis course).

2- Selection of references and study topic.

3- PowerPoint presentation in class (for 20-30 minutes)

4- Sending documents (PowerPoint, full report and attachments including video and photo) files in word and pdf format.