**MARMARA UNIVERSITY**

**FACULTY OF ENGINEERING**

**DEPARTMENT OF MECHANICAL ENGINEERING**

**ME4111/ME4011/ME411 EXPERIMENTAL METHODS IN MECHANICAL ENGINEERING**

**EXPERIMENT NO. 1**

**DESIGN OF AN EXPERIMENT FOR DETERMINING THE FLEXURAL RIGIDITY AND MODULUS OF ELASTICITY OF A CANTILEVER BEAM**

1. **Objective**

In this experiment, the flexural rigidity and modulus of elasticity of a cantilever beam are aimed to be determined by using a strain gage.

1. **Introduction**

There are basically two types of strain gages – mechanical and electrical resistance strain gages. In this experiment, an electrical resistance strain gage will be used to measure strain under a known load. Once the strain is measured, the flexural rigidity and modulus of elasticity of the beam can be calculated by using the well-known Hooke’s law and bending stress formulas.

1. **Theoretical background**

***3.1. Analysis of a cantilever beam under transverse loading***

Hooke’s law and bending stress formulas will be used in the calculations of this experiment. Consider the cantilever beam given below.

Strain gage

*d*

*h*

*b*

*P*

**Fig. 1** A cantilever beam under transverse loading

Referring to Fig. 1, recall that the bending stress *σ* at the gage location is given by

(1)

where *M* is the bending moment at the gage location due to the applied load *P*, *c* is given by *c* = *h*/2 and *I* is the second moment of area about the neutral axis. Recall also that the bending stress and strain are related to each other through Hooke’s law, which can be expressed as

(2)

where *E* is the modulus of elasticity of the beam material, and denotes the strain.

***3.2. Wheatstone bridge***

The Wheatstone bridge circuits are used in strain gage measurements. Depending on the number of active strain gages to be employed, they can be configured as quarter-, half- or full-bridges. Since single active strain gage will be used in this experiment, a quarter-bridge will be used [1] as shown below.

*R*1 = *Rg*

*R*2

*R*3

*R*4

*Vex*

*Vout*

**Fig. 2** A quarter-bridge (see, e.g., [1])

Under balanced condition, the voltage output *Vout* is zero [2]. The change in the output voltage due to a change in the resistance of the gage (i.e. *Rg*) can be related to the value of strain through the following expression [3,4]:

(3)

where *Fg* is the gage factor. The value of *Fg* for the particular gage to be applied in this experiment will be provided in the laboratory session.

1. **Experimental procedure**

* Measure and record the distance *d*, beam thickness *h* and beam width *b*.
* Apply the given known load to the beam.
* Measure and record the voltage output of the bridge.

1. **Required calculations**

* Calculate the strain by using the provided gage factor.
* Calculate the flexural rigidity of the beam (i.e. *EI*) by a combined use of Hooke’s law and bending stress formulas.
* Calculate the modulus of elasticity of the beam.

1. **Required report format**

* The report should be organized as follows: Title Page, Introduction, Theoretical Background and Calculations, Discussions, Conclusion, Appendix (if any).
* Measured and calculated quantities should be presented in tabular form.
* Show all details of your calculations.
* Discuss the possible sources of errors.
* Make recommendations for improving the experimental procedure.

**References**

1. J.G. Webster and H. Eren (2014) *Measurement, Instrumentation, and Sensors Handbook, Second Edition: Spatial, Mechanical, Thermal, and Radiation Measurement*. CRC Press, Taylor & Francis Group
2. T.R. Padmanabhan (2000) *Industrial Instrumentation: Principles and Design*. Springer
3. N. Mathivanan (2007) *PC-based Instrumentation: Concepts and Practice*. Prentice-Hall of India
4. M. Kutz (2013) *Handbook of Measurement in Science and Engineering, Volume 1*. Wiley