DEPARTMENT OF CIVIL ENGINEERING

IIT DELHI

VIRTUAL SMART STRUCTURES AND DYNAMICS LAB

EXPERIMENT 7

Damage Detection and Qualitative Quantification Using Electro-Mechanical Impedance (EMI) Technique

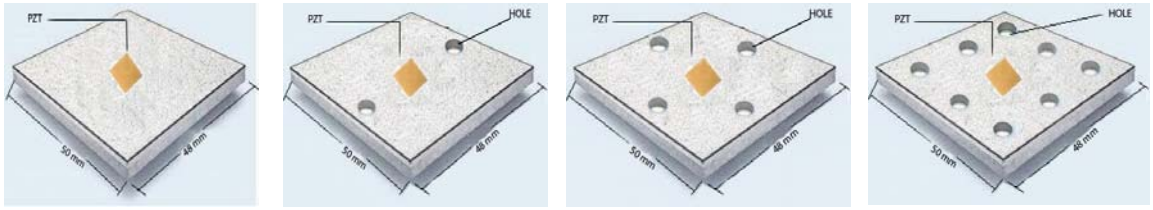
OBJECTIVES

This experiment aims to teach user, through a database of measured data, about how damage in a structure changes the conductance signature (EMI technique). Test structure is an aluminium block (50 x 48 x 10 mm), having a surface bonded PZT patch (see Fig. 1a). To learn more about the EMI technique, click (http://strlab.iitd.ac.in/SSDL/piezo.pdf).

EXPERIMENTAL METHODOLOGY

In this experiment, user gets an option of drilling multiple holes of 5 mm diameter in the block to induce damage of three different severities:

1. Incipient Damage : 2 Holes (see Fig. 1b)
2. Moderate Damage : 4 Holes (see Fig. 1c)
3. Severe Damage : 8 Holes (see Fig. 1d)



Pristine (a) | Incipient Damage:2 holes (b) | Moderate Damage:4 holes (c) | Severe Damage: 8 holes (d)

Fig.1: Illustration of various stages of damage.

User has the facility to acquire signature of the structure in pristine as well as three damaged conditions. The signature acquisition is simulated to occur in same fashion as in the case of real experiment performed through LCR meter. You can acquire signatures in this fashion for any damaged state and can download the signature as delimited data file. The data file for any condition has three columns: frequency (kHz), conductance (S) and susceptance (S). You can compare the signature of any two stages for example: pristine and incipient damage, pristine and moderate damage and pristine and severe damage. Alternatively, you can plot signatures of all four stages in a single graph and appreciate how the signatures change with increase of damage severity. Describe your observation.

To statistically quantify damage, compute root mean square deviation (RMSD) in conductance by following equation directly in MS excel:

$$\text{RMSD (\%)} = \sqrt{\frac{\sum (G_i - G^0_{i)}{}^2}{\sum (G^0_i)^2}} \times 100$$

Where

G^0_i = Baseline conductance value at i^{th} frequency.

G_i = Conductance value after a damage at i^{th} frequency.

As an exercise plot a histogram of RMSD for various damaged states. Describe your observation.

REFERENCES

Bhalla, S. and Soh C. K. (2004),"Structural Health Monitoring by Piezo-Impedance Transducers. Part II Applications", Journal of Aerospace Engineering, ASCE Vol. 17, No.4 (October), pp. 166-175.

Literature on piezoelectric sensors: **http://strlab.iitd.ac.in/SSDL/piezo.pdf**

Literature on Smart Materials**:** **http://strlab.iitd.ac.in/SSDL/smart.pdf**