A COMPARISON OF TWO TEST METHODS FOR MEASURING YOUNG'S MODULUS OF BUILDING MATERIALS.

Wing T. Chu
Acoustics Laboratory, Institute for Research in Construction
National Research Council Canada, Ottawa, Ontario, K1A 0R6

1. Introduction

For building noise control problems, solid materials such as sheet metal, wood, gypsum board, and oriented-strand-board (OSB) are frequently used. These materials are characterized by the following parameters: density, Young's modulus, Poisson's ratio, and the loss factor. The current ASTM standards for the measurements of Young's modulus are designed specifically for ceramics, bricks, carbon and graphite materials, and concrete[1]. The techniques used are based on measuring either the longitudinal wave velocity or the resonant frequency of the flexural mode of vibration of a specimen of the material. These techniques have been applied to the bar shaped specimen of some building materials.

2. Longitudinal wave velocity method

The technique used was an adaptation of the procedure specified in the ASTM C 769 - 80 standard. Two accelerometers were mounted one at each end of a 1.3 m long bar shaped specimen of a building material. An impulse was generated at one end of the bar by tapping it with a stick. The signals from the two accelerometers were captured simultaneously with a two channel A/D board operating at 50 kHz sampling rate. Knowing the exact length of the bar and the transit time of the impulse between its two ends, the longitudinal wave speed was computed. The Young's mudulus (E) was then calculated from the wave speed (C) and the density (ρ) of the material according to the following formula,

$$E = \rho C^2$$

3. Sonic resonance method

The method used was an adaptation of the procedure specified in the ASTM C 747 - 93 standard. The 1.3 m long bar shaped specimen was freely supported at its transverse fundamental nodal points (0.224 L from each end) using two slings. A light weight accelerometer was placed at one end of the bar to pick up the transverse vibration of the bar when it was tapped at the other end by the rubber head of a pencil. The signal was captured by an A/D board. The resonant frequency (f) of the fundamental flexural mode of vibration was determined from the frequency analysis of the captured time signal using FFT. The Young's modulus was then determined according to the following equation,

$$E = k M f^2$$

where M is the mass of the specimen and k is a constant which can be obtained from Table 8 of Ref 2.

4. Conclusions

Based on a number of measurements using different building materials, the following conclusions can be drawn. (1) Either methods can be used. (2) The sonic resonance method is better than the wave velocity method. It requires only one detector, where as the wave velocity method requires two and needs careful calibration for zero-time correction between the two detectors. Results also indicate that the sonic resonance method has better repeatability.

References

1. ASTM C1198-91, ASTM C885-87, ASTM C848-88, ASTM C747-93, ASTM C623-92, ASTM C25-91, ASTM C769-80, and ASTM C597-83.
2. Robert D. Blevins, Formulas for Natural Frequency and Mode Shape, Van Nostrand, 1979.