39th IABSE Symposium – *Engineering the Future*
September 21-23 2017, Vancouver, Canada

Geometric effects on Ultrasonic Pulse Velocity Method for Structural Assessment – Experimental Study on Mortar Specimens

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Abstract

Non-destructive ultrasonic evaluation (NDE) is commonly used for assessment of civil infrastructures and characterization of construction materials. Among the acoustic methods impact echo, ultrasonic pulse velocity (UPV), and surface waves analysis can be distinguished. The UPV method, as it is an ASTM standard test method for concrete specimens, is investigated in the article. The standard specifies the applications of UPV as: assessment of relative quality of concrete, presence of imperfections (i.e. voids, cracks, and the effectiveness of its repairs). UPV can be also applied to monitoring changes in the condition of a specimen. In spite of an easiness of the method the obtained results highly depend on the transducers used, the coupling quality, and the specimen dimensions. In this article the authors focus on the sensor and the dimensions effects. The results for UPV tests on 5 mortar specimens of different heights and diameters are presented. The specimens are tested with 54 kHz and 850 kHz resonant frequency (f_c) transducers and the state-of-the-art laser vibrometer (response measurements).

Keywords: Non-Destructive Testing, Ultrasonic Pulse Velocity, Laser Vibrometer, Size effects.

1 Introduction

Concrete is a popular structural material used in Civil Engineering applications. As for any material, condition of concrete may be affected by the quality of design, manufacturing, loads applied to a structure, character of the loads, environmental deterioration, or aging. Condition of concrete plays a key role for safety of structures [6]. Non-destructive ultrasonic evaluation (NDE) is commonly used for assessment of civil infrastructure and characterization of construction materials. Among the acoustic methods the impact echo, ultrasonic pulse velocity (UPV), and surface waves analysis can be distinguished [8, 10]. The latest trends focus more on an attenuation of a wave front [1,7] and more sensitive methods for detecting changes in a velocity (e.g. Coda Wave Interfefometry [4,9,11]). Wave velocity depends on the medium properties, therefore UPV method is a very popular technique used in NDE in Civil Engineering. Propagation velocity of the longitudinal (P-wave) through the material (V_P) can be calculated as:

$$V_P = \sqrt{\frac{E_d(1-\nu)}{\rho(1+\nu)(1-2\nu)}}, \qquad (1)$$

where E_d is dynamic Young's modulus, ν is the Poisson's ratio, and ρ is the density. Major benefit of the UPV is its simplicity. The method is based on the concept of measuring time of a first arrival of ultrasonic wave from one side of the specimen to another. Moreover, UPV is an ASTM standard test

https://doi.org/10.2749/vancouver.2017.3084
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