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5.13 ULTRASONIC PULSE VELOCITY

5.13.1 Introduction

Ultrasonic Pulse Velocity testing (UPV) is used to evaluate the internal (volumetric) condition of materials. It differs from Ultrasonic Testing (UT) in that the stress or sound wave is not directly used to determine the internal boundaries of defects. UPV uses the velocity of the sound wave to determine the internal characteristics of the member. Specifically, it is used in concrete and timber inspection to determine voids, density changes and concrete strength properties.

Contrary to UT, UPV does not use the echo of the sound wave off internal boundaries to detect deficiencies. Rather it determines the velocity of the pulse. With the distance between the transducers known and the pulse speed determined from the material's mechanical properties, the velocity is calculated. By comparing the velocity from one location to another, the internal composition of the material can be determined. This test can be performed throughout a member during one inspection or over a period of time to detect any changes.

Refer to Chapter 5 of Part 3 for an in-depth description of how sound waves and transducers work.

UPV makes use of two transducers, similar to the "pitch-catch" method of UT. One transducer is the emitter and the other, the receiver. There are two set ups that can be utilized, direct transmission mode and semi-direct transmission mode. This allows for a greater range of inspection. Refer to Figure 5.13.1-1 for an image of direct vs. semi-direct transmission. In either case the distance between the transducers must be known for comparative results.

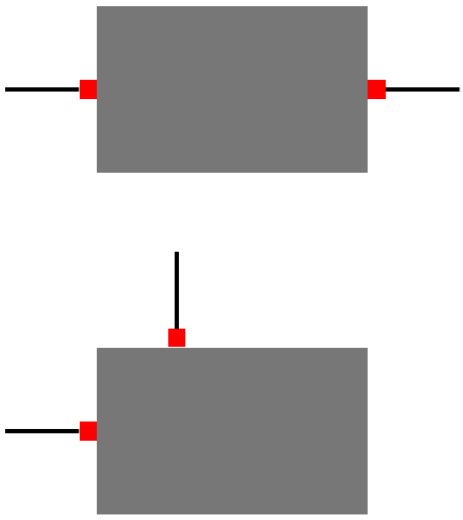

Figure 5.13.1-1: Illustration of Direct Transmission (Top) and Semi-Direct Transmission (Bottom).

The velocity of the pulse is dependent on the material's mechanical properties, specifically the elastic modulus. Speeds are higher in stiffer (high elastic modulus) materials. Moreover, when a stress wave passes through a void, honeycombed, or poor quality material, the speed is significantly reduced. With this information the inspector can compare areas to determine if a deficiency is present within the material. If a crack or debonded area is present within the test material, the emitted stress wave will reflect back or around the crack, depending on the location of the crack tip. Stress waves that are reflected back are not picked up by the emitting transducer and therefore results as no reading. Stress waves that a closer to the crack tip may manage to travel up or around the crack to the receiver transducer. This would show up as a decreased signal and longer pulse time. Refer to Figure 5.13.1-2 for an illustration of several stress wave interactions with defects.

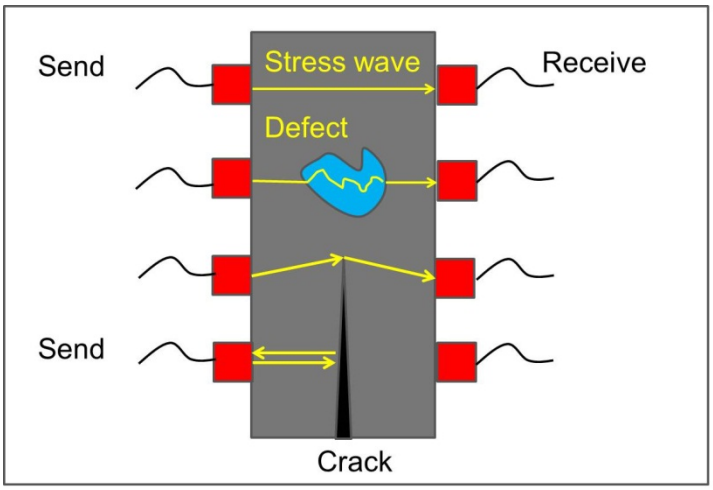

Figure 5.13.1-2: Illustration of Several Stress Wave Interactions with Defects.

5.13.2 Applications

Perhaps the most advantageous aspects of Ultrasonic Pulse Velocity (UPV) are it is highly portable and highly repeatable. As stated before, this method is most commonly used on concrete and timber materials. In concrete is offers in-situ testing of concrete strength. It is used to identify poor quality or damaged concrete. It is effective at determining if an internal deficiency, such as void, crack or poor quality is present. In some instances UPV is used to determine the effectiveness of repairs. The method can be used to determine whether a structural concrete patch is adequately bonded or if the quality is suitable to the sound material.

Similarly, UPV is used on timber members to determine any internal voids or decay that may be present. This method is also used in underwater inspections of timber piling. Refer to Figure 5.13.2-1 for an image of an inspector using UPV on a concrete pier cap.

Figure 5.13.2-1: Inspector Conducting UPV on a Concrete Pier Cap Using Semi-Direct Transmission.

5.13.3 Limitations

Ultrasonic Pulse Velocity (UPV) should not be performed on rough surfaces, on parts with complicated geometries, or highly attenuated materials. Rough surfaces may require grinding in the surface preparation. Other factors, which limit the successful application of UPV are: lack of properly trained personnel, over estimation of the accuracy of flaw locating and sizing, and poorly written testing procedures. Typically a certified Level III nondestructive evaluation (NDE) specialist should evaluate and develop written testing procedures for uncommon applications.

Unlike UT, UPV must have access to more than one side of a member being tested. This may disqualify UPV in certain applications. When UPV is used for strength determination of concrete, typically a correlation is created by using other testing methods. When testing timber, the effectiveness of UPV is compromised in certain species of wood.