NON-DESTRUCTIVE EVALUATION METHODS FOR GROUTING CONDITION IN TENDON DUCTS IN EXISTING PRESTRESSED CONCRETE BRIDGES

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This study describes two nondestructive methods for evaluating the grouting in the tendon duct joints of prestressed concrete bridges: the impact-elastic wave method and the electromagnetic pulse method. The two methods were applied to the lateral prestressing steel bars in prestressed concrete bridges (Figure 1) in order to evaluate the condition of the grouting in the tendon ducts. Using the impact-elastic wave method, the elastic wave velocities were measured to determine the condition of the grouting. Using the electromagnetic pulse method, the maximum amplitude of received elastic waves were measured to reveal voids in tendon ducts just below the measurement points. These non-destructive evaluations were verified by drilling and visually inspecting the grouting in the tendon ducts. The non-destructive evaluation results show good agreement with the visual inspection results.

Figure 1. PC bridge

The two non-destructive evaluation methods used in this study are briefly described below.

Impact-elastic wave method

This method uses a hammer, steel balls, or similar objects to mechanically strike a concrete surface and detect the resulting elastic waves with a sensor. The conditions inside the concrete are evaluated from the velocity of the wave propagation (Figure 2). This method produces input elastic waves with greater energy than the ultrasonic test waves and includes low-frequency elastic waves. The impact-elastic wave method, therefore, is less affected by attenuation and scattering, and can measure wide component areas.

Figure 3 shows the principle underlying the evaluation of PC grouting. If the sheath is not filled with grout, elastic waves propagate very rapidly through the steel bar. Therefore, the apparent elastic wave velocity approaches the propagation velocity in a solid steel bar. If the sheath is filled with grout, however, elastic waves propagate through the composite steel bar/ grout structure, and the propagation velocity is smaller than that for an unfilled sheath.

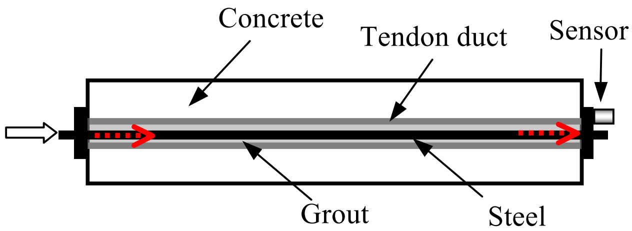

Figure 2. Method for propagating elastic waves in the axial direction of a PC steel bar

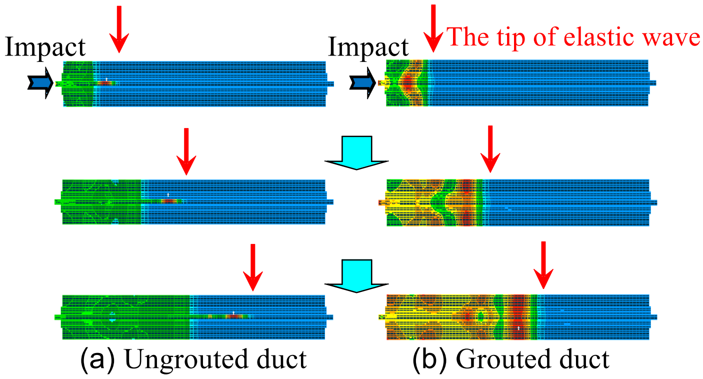

Figure 3. Principle underlying the evaluation of PC grouting using the impact-elastic wave method

Electromagnetic pulse method

Unlike the impact-elastic method, which measures the velocity of input elastic waves, the electromagnetic pulse method uses an exciting coil in a noncontact manner to measure the maximum amplitude of elastic waves in PC steel components. The coil consists of a magnet wire wound around an electromagnetic steel plate. An instantaneous magnetic field is created by applying a pulse current to the coil. The electromagnetic force created by the magnetic field induces vibration in the magnetic materials contained in concrete. A sensor placed on the concrete surface detects the elastic waves created by the vibration of the magnetic materials in the concrete, and the maximum amplitude of the received waves reveals the state of the magnetic materials itself or interfacial defects in the magnetic materials (Figure 4).

Figure 5 shows the principle underlying this evaluation method. When a sheath is filled with PC grout (Figure 5 (a)) and pulsed electromagnetic force is applied to a concrete surface in a noncontact manner, the sheath beneath the exciting coil vibrates. Because the sheath is confined by the grout, the vibration of the sheath is more or less suppressed. Moreover, the PC steel bar inside the sheath vibrates very little because of the magnetic shielding effect. If the sheath is not filled with grout, i.e., not confined by grout (Figure 5 (b)), the sheath appears to vibrate more than a sheath filled with grout. By placing a sensor on the concrete surface to detect the vibration and comparing the maximum amplitude values, it is possible to identify areas that are not filled with PC grout.

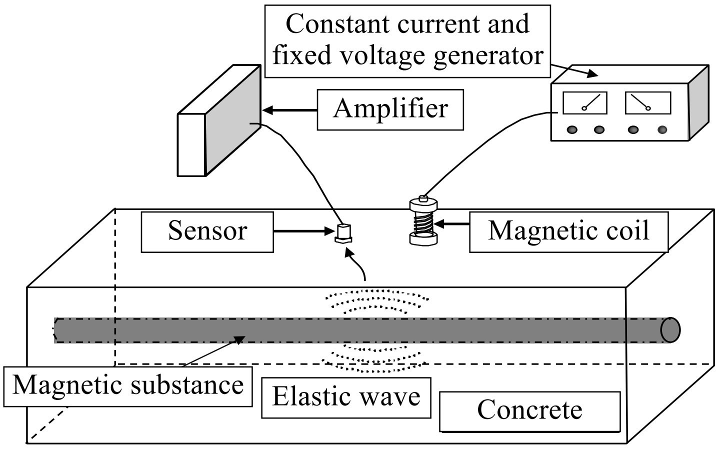

Figure 4. Outline of the electromagnetic-pulse method

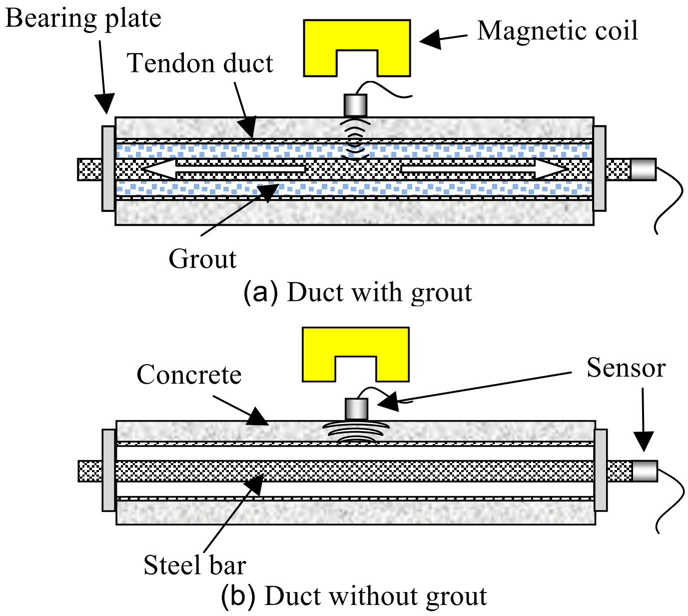

Figure 5. Principle underlying the evaluation of PC grouting using the electromagnetic pulse method