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EVALUATING NONDESTRUCTIVE TESTING TECHNIQUES TO DETECT VOIDS IN BONDED POST-TENSIONED DUCTS

PROBLEM STATEMENT

The use of post-tensioning in bridges can provide durability and structural benefits to the affected system. In bonded post-tensioned construction, Portland cement grout is used to form a sheath around the steel tensioning strand that acts as a solid impermeable barrier to the ingress of chlorides to keep them from reaching the steel and initiating corrosion. Too often, voids are formed in the post-tensioning duct from incomplete grouting, trapped air pockets, or the evaporation of bleed water due to poor grout design or poor grouting procedures, or both. Due to the substantial tensile stress to which the tendons are subjected, tendon failure due to corrosion would result in the failure of the concrete member, which would lead to severe damage to the whole structure and, potentially, disaster. It is for these reasons that those types of structures need to be adequately tested to ensure acceptable performance during their service life.

OBJECTIVES

The objective of this research is to evaluate nondestructive testing (NDT) techniques to detect voids in bonded post-tensioned ducts. NDT techniques have been practically used for testing concrete elements, but there is a need to speed up the field test process and to improve the analysis procedures. Moreover, it would be useful to identify the advantages and the disadvantages of each technique and to compare the effectiveness and the accuracy of their results and outputs.

FINDINGS AND CONCLUSIONS

The results of the Survey of State DOTs (including the District of Columbia and Puerto Rico) revealed that none of the responding DOTs (63%) use nondestructive testing to evaluate their bonded post-tensioning systems, nor have they experienced any failure with them.

Scanning Impact Echo (IE) tests showed the most promise for assessing internal grout conditions of steel ducts. Identifying grout conditions in plastic ducts was more difficult due to partial debonding conditions between the plastic duct and the concrete wall. In this investigation, the internal conditions of grouted ducts were successfully evaluated using the IE thickness results together with a shift in the IE peak frequency and an impactechogram. The impactechogram was particularly useful for the internal grout evaluation of the fully grouted plastic duct where multiple fundamental frequencies occurred.

The Spectral Analysis of Surface Waves (SASW) tests also showed promise for assessing the internal grout conditions of steel ducts. The surface wave velocity results from the fully grouted steel duct showed the highest velocity, while the velocity results from the empty steel duct

showed lowest velocity. However, the test results from the plastic duct did not yield similar results.

The image results from the Ultrasonic Tomography Imaging (UTI) tests showed the locations of the ducts but not grout condition details inside the ducts. This limitation occurred because the frequency of the transducers used in this investigation was 54 kHz, which is standard for concrete. This range of frequency yielded a wavelength longer than the diameter of the ducts; therefore, higher frequency/shorter wavelength transducers should be used on 3-inch I.D. ducts.

Only Impact Echo (IE) Scanning was used to evaluate the internal grout condition of steel and plastic ducts as a function of time. By day four, 96 hours after grout had been introduced into the duct, the first indication of a difference between true voids and grouted sections of the ducts could be seen. By day 24, scanning along the steel duct showed a significant difference between the grouted and the empty ducts. Scanning IE results of the plastic duct were considered to be inconclusive due to debonding between the plastic duct and the concrete matrix.

BENEFITS

The findings of this research strongly support the use of non-destructive test methods as a means to evaluate the effectiveness of post-tensioned grouting operations and the adhesion of the grout to steel ducts. Post-tensioning grouts can be evaluated within a few days of the grouting operation to determine the effectiveness of the grouting process. In addition, current impactechograms can be compared to previously recorded impactechograms to determine if voids have developed. If voids are detected, further evaluation can be performed to mitigate any potential failures in the strands before they become catastrophic. Another benefit is that the equipment is easily portable and can be operated by a single trained individual (in many locations in the structure).

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