The Ohio Department of Transportation
Office of Research & Development
Executive Summary Report

Evaluation of Stay-in-Place Metal Forms

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Research Problem

The fundamental problem addressed was to determine if the use of Stay-in-Place Metal Forms (SIPMF) resulted in reduced bridge deck concrete quality over the life of the bridge compared to bridges without SIPMF.

A corollary problem addressed was to determine the potential for using ground penetrating radar (GPR) to inspect the bridge deck concrete immediately above the SIPMF.

The use of stay-in-place metal formwork (SIPMF), instead of the conventional plywood forming methods offers several advantages including: significant time saving in bridge deck construction, lower labor costs, minimal interruption to the environment or traffic below and safer construction. Due to these advantages, the Ohio Department of Transportation (ODOT) is investigating using SIPMF to meet the strategic initiative to speed bridge construction.

Objectives

The primary objective of this study was to use an experimental study, literature review, and discussions with vendors and Departments of Transportation of the surrounding states to assess the impact of SIPMF on bridge deck concrete quality. Experimental studies were carried out on three northern Ohio bridge that were constructed approximately 40 years ago partially using SIPMF. The quality of the concrete in the regions with SIPMF was compared to the quality of the concrete in regions without SIPMF.

The main disadvantage to using SIPMF is that the bottom of the bridge deck can not be visually inspected during construction or service. GPR is a fast safe nondestructive way to examine a bridge deck from the top side. A secondary objective was to determine if a state-of-the art GPR system could be used to accurately and efficiently inspect the concrete just above the SIPMF. An experimental study was carried out that compared the predicted concrete quality from a GPR survey to the concrete quality measured by testing verification cores.

Description of Research

The research for assessing the difference in concrete bridge deck performance between bridges with and without SIPMF was carried out as follows:

a) An extensive literature search was completed. This was greatly facilitated by the fact that Dr. Grace has conducted a parallel national study on SIPMF and is engaged in a SIPMF research study for the Michigan Department of Transportation.

b) Cores were extracted from three northern Ohio Bridges that had been partially constructed using SIPMF approximately forty years ago. All these bridges had regions where there was no SIPMF. Photographs from the bridges studied are presented below.

c) The visual inspections and compression, chloride, permeability and ultrasound tests were carried out. Ultrasound testing is somewhat unusual, but it is a very discriminating technique to use for comparison.

d) Analysis of the inspection and test data showed no significant difference between the concrete quality in regions with and without SIPMF. This is consistent with the literature review.

The research to assess the potential for using ground penetrating radar as an inspection tool was carried out as follows:

a) A literature search was carried out. Resource International, Incorporated assisted in this research and, also, provided background discussions and information on GPR.

b) A GPR survey was carried out on a bridge constructed with SIPMF. Figure 6 is a ground coupled GPR image. A GPR signal attenuation map was developed to predict the quality of the concrete in the bridge. This attenuation map was also used to select the locations of the verification (ground truth) cores to be harvested.

c) The visual inspections and compression and ultrasound inspections were carried out on the ground truth cores. Ultrasound, when coupled with compression testing, is a well established technique to assess concrete condition.

d) Analysis of the inspection and test data showed that the GPR was effective in locating delaminations above the top layer of rebar.

e) However, GPR was not effective in locating delaminations between the bottom layer of rebar and the SIPMF.

Conclusions and Recommendations

Analysis of the data showed no significant difference between the concrete quality in regions with and without SIPMF. This is consistent with the literature review.

SIPMF near expansion joints and SIPMF with holes in it experienced localized rusting near these water sources. It is recommended the number of holes be minimized and steps be taken to prevent water from flowing around the edges of the SIPMF. It has also been reported that SIPMF on underpasses in urban areas experienced deterioration from water being continually thrown on the bottom of the bridge. Localized rusting is illustrated in the following figures.

Analysis of the data showed that the GPR system used was not an effective inspection tool for the concrete immediately above the SIPMF. The GPR was effective in locating delaminations above the top layer of rebar. However, the GPR gave false indications of delaminations for the concrete below the top rebar.

The data did reveal a correlation between concrete condition and GPR signal attenuation. This correlation supports the hypothesis that using GPR for bridge deck inspection may be possible in the future. However, it will require additional research to develop a relationship between bridge deck condition and GPR signal attenuation.

Implementation Potential

Nothing in the present research indicates that implementation of SIMPF in Ohio will be less successful than in the neighboring northern states of Michigan, Pennsylvania, or Indiana. Reaping the full benefits will require some time as the Ohio contractors and bridge inspectors become familiar with SIMPF. Important aspects of implementation are inspection, materials, repair and specifications.

SIPMF conceals the bottom of the bridge deck during construction and service. At the present time, there is no nondestructive inspection technique that any state uses to completely replace visual inspection during construction or service. Typically, states have handled the construction issue by rigorous topside inspection during the pour, controlling rebar location, controlling aggregate size and possibly post-pour sounding of the deck bottom. For service, it is generally felt there is a very low probability of a serious flaw which is not reflected in the top surface of the concrete or visible deterioration of the SIPMF.

Typical materials are galvanized steel of various grades (grade 80 is the most common) in accordance with ASTM A653/A653M with tolerances governed by ASTM 924. Deck thicknesses run from 22 gage to 16 gage. The most common coating is G165 (Z505) with some G235 (Z720) manufactured for more corrosive environments.

Repair to damaged galvanizing on SIPMF is straightforward. ASTM 780 is a specification for repair to galvanized coating which has provisions for field repair and some states provide additional direction.

Specifications must address the needs of designers, contractors, inspectors and bridge maintenance personnel. The overall requirements should be in appropriate ODOT design, construction, inspection, and maintenance documents. Key state provisions in a specification are minimum thickness for the SIMPF, minimum coating thickness, and welding restrictions. The specification should prohibit admixtures containing chloride salts.

Figure 1. 40-year old SIPMF on Precast Girders. Note Localized Rusting Near Expansion Joint

Figure 2. Localized Rusting Near a Scupper Hole and Drain Pipe

Figure 3. 40-year old SIPMF on Steel Girders

Figure 4. 40-year old SIPMF on Steel Girders

Figure 5. Localized Rusting Near Expansion Joint

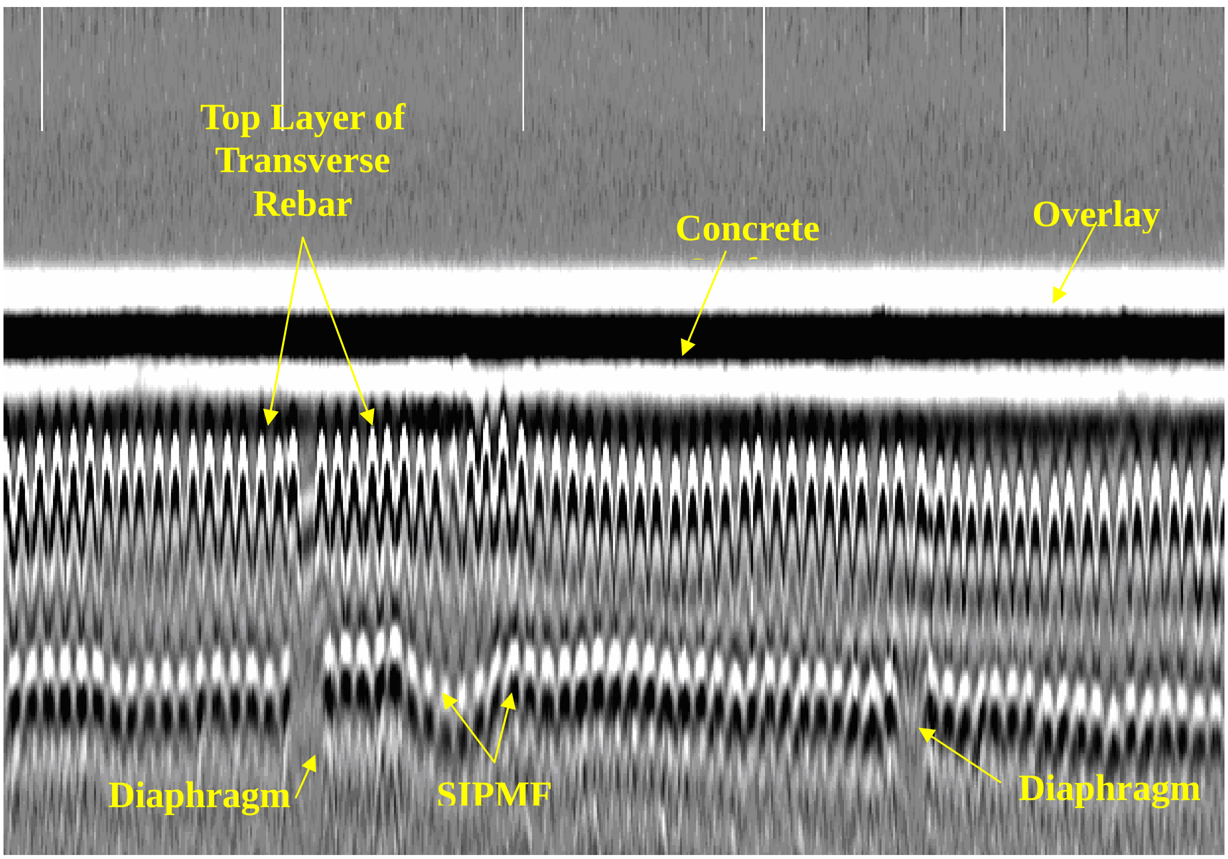

Figure 6. Ground Coupled GPR Image